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Goncharov, V. and Vasko, T.

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Proceedings of Task Force Meeting "Organizational Structures in Innovation Management" Prague, 30 May - 3 June, 1983

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PREFACE

The papers in this volume are the proceedings of the Task Force Meeting on "Organizational Structures in Innovation Management" held in Prague from 30 May to 4 June, 1983, within the framework of the IIASA Innovation Management Case Study. This study is not primarily the result of IIASA inhouse research but is based on collaboration with various organizations from IIASA's National Member Organization (NMO) countries. At present the study has more than 70 collaborators from 17 countries, including 9 international organizations (among them 5 international management organizations), and 14 industrial firms from 9 countries (see Appendix 4).

Though there are myriad innovation studies on-going around the world, IIASA has the unique advantage of bringing analysts together in a comparative international setting. The study has been organized as a partial input to a representative final monograph on "Innovation Management in Electrotechnology: Adapting to a Changing Environment". Different issues included in the study are planned to be discussed at separate task force meetings and the proceedings and discussion materials from these meetings will be integrated and used as basic information for a final Vienna conference next year and for preparation of the monograph (see Appendix 5).

The first of the above events was held in Leningrad in June 1982 and selected papers from this meeting were published as a IIASA Collaborative Paper CP-83-29. These proceedings are from the second in the series of task force meetings and the program is attached as Appendix 1. This program was used by the participants as a guideline in preparing their papers. A total of 8 countries (4 East and 4 West) were represented by 16 participants from both industry and research. Five Directors from electrotechnical firms were present (from Austria, Bulgaria, Czechoslovakia, Finland and Yugoslavia) delivering papers on the accumulated experience of their companies.

Representatives from 5 management organizations, i.e., the Institute of Management in Prague, the Institute for Systems Studies in Moscow, the

International Research Institute of Management Sciences in Moscow, and the Department of Business Administration from the University of Gothenburg, also presented papers reflecting the results of their work in the design of management organizational structures. Representatives from 2 additional organizations, the firm "Electrosila" (Leningrad) and the Polytechnical Institute (Leningrad) sent their papers as contributions to the meeting. (For a complete list of participants see Appendix 3).

The first report, presented by Prof. Holec, at the first plenary session was a general overview reflecting most of the papers and its object was to describe the trends of development in the organizational structures of the electrotechnical industry. This report helped in focussing the other presentations and discussions on the most important and mutually interesting problems within the framework of organizational structure issues.

All other papers are arranged in the same order they were presented at the meeting (see Appendix 2 for the Agenda of the meeting). The discussions are presented in summary form and reflect the character of the productive and creative environment of the meeting.

Finally, although we are indebted to many people who contributed towards the success of this meeting, special mention must be made to Helen Vyshinksaya for translating and language editing some of the papers and to Susie Riley who played the crucial roles of administrative assistant, language editor, typist and conscience during all stages of preparation for the meeting and these proceedings.

Vadim Goncharov

ACKNOWLEDGMENTS

This Task Force Meeting was made possible through the generous support and help of the electrotechnical firm ČKD Praha, Prague, the Institute of Management, Prague, and the Czechoslovak Committee for IIASA, to whom we extend our thanks.

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OPENING ADDRESS

Miroslav Holec
Director, Institute of Management
Prague, Czechoslovakia

Allow me on behalf of the Czechoslovak Committee for IIASA to welcome you to this meeting in Prague. The Chairman of the Czechoslovak Committee for IIASA, First Deputy Ministry for Technological Development and Capital Investment asked me to extend his apologies to you for not being able to attend this meeting but he must be present at the session of the IIASA Executive and Finance Committee Meeting in Laxenburg.

Our international meeting is a follow-up of the international seminar that served as a basis for a case study on innovation management in electrotechnology, held in Leningrad in 1982. That seminar was arranged by the USSR State Committee for Science and Technology in cooperation with the Leningrad Production Amalgamation "Electrosila" with IIASA acting as coordinator.

The Leningrad seminar was, to my mind, a great success. It was the first step made within the framework of the IIASA collaborative innovation management studies. It resulted in an exchange of valuable experience in innovation management in electrotechnology in general, and aroused great interest on the part of participants for continued cooperation. It led to an agreement to continue investigation in three directions (as evolved from discussions):

- Strategic management of innovation processes.
- Influence of human factors on innovation.
- The role of organizational structures in the innovative process.

All these three directions will be realized in international task force meetings organized by IIASA. The first of them—the role of organizational structures—is being opened now. It is the responsibility of the Czechoslovak Committee for IIASA, who authorized the Prague Institute for Management Sciences and the company CKD Praha to organize the meeting.

I am sure our meeting will help us achieve a certain goal, that is, apart from the exchange of experience, to identify some spheres where through organizational structures one can influence the course of innovative processes. We have an excellent opportunity for informal exchange of experience. We can assimilate our points of view, identify similar and divergent characteristics in the development of organizational designs in different countries, in the firms represented here. In my opinion, we can continue discussion not only at the meeting itself, but also during the breaks and at leisure. It will all contribute to the achievement of the goal of our meeting. Despite the fact that we speak different languages, I am sure there will be no barriers for mutual understanding.

I am confident that our meeting will provide opportunities to lead the discussion in such a way as to produce useful practical outcomes; recommendations for the further development of this sphere of activity at IIASA.

I wish the meeting great success.

SOME SPECIAL TRENDS OF DEVELOPMENT OF THE ORGANIZATIONAL STRUCTURES IN THE ELECTROTECHNOLOGY INDUSTRY

Miroslav Holec
Institute of Management, Prague, CSSR

1. GENERAL CONSIDERATIONS

The general aim of this meeting should be exchange of opinions and viewpoints concerning the position, task, and significance of organizational structures in the management of innovation processes in industrial enterprises manufacturing electrical engineering products. We should not only evaluate the present state-of-the-art in theory and practice, but also try to identify tendencies and needs for perspective development of organizational structures. It is even quite logical to ask this meeting to help specify the conditions and algorithms that could ensure effectiveness of organizational structures in the innovation management processes of an advanced electrical engineering business organization.

We know in advance, however, that a significant part of our discussion will concern problems which, until now, have not been solved satisfactorily and completely, either practically or theoretically. At the same time, these will not be the problems of organizational structures themselves, understood only as an isolated phenomenon. We all would agree, I am sure, on the initial presumption that organizational structures constitute only one component of the enterprise's entire management system. This relatively inert component is, by its form and function, qualified by the interaction with other parts of the system, such as the operational, medium- and long-term planning, decision making by the operational managers, instruments of direct and indirect management and involvement, etc. The innovation processes do not stand isolated from the basic technical economic activity of an enterprise. More accurately expressed, these processes underlie the enterprise's dynamism and just because of this dynamism they actively interact with the seeming "inertness" of the organizational structures and eventually with their insufficient flexibility.

In this opening report we would like to reflect on the pieces of knowledge—verified, confirmed by experience or still open to be solved—arriving from everyday practice of the enterpises that take part in our study. This

is the reason why our initial knowledge has been based on the essential information included in the reports submitted by our colleagues from Austrian Siemens, Bulgarian ELPROM, Czech ČKD Praha, Finnish Strömberg, Hungarian Ganz, Soviet Electrosila, Yugoslav Rade Končar.

The methodological recommendations of general theoretical studies to be found in special literature on the subject or derived from the experience of other enterprises not directly participating in our study are, however, not included in this report. I believe we would rather discuss the viewpoints, especially after listening to presentations based on theoretical research by W. Goldberg, A. Nomoto, V. Rapoport, etc.

Unfortunately, I have to admit at the very beginning of my report, that we faced a string of difficulties while analyzing the basic materials submitted when compiling them and bringing them together. The major problems consisted in that the majority of the materials were sent after the deadline. Nearly all of them were received close to the opening session of this meeting, which as you can appreciate did not allow enough time for any great contribution to the deep understanding or a comparison of different opinions. Secondly almost every report only very slightly observed the recommended guidelines which meant a certain amount of incomparability; in some cases the data and characterization needed were simply missing altogether.

The third problem we should mention was the fact that only a relatively small number of enterprises participated in the generalization of available material. Therefore, the statistic significance or the value of the derived analytic conclusions is less than we would like to admit. However, the problems mentioned should not lead us to scepticism as to the possibility of obtaining a mass of knowledge, already verified and being of certain use to us. I believe that this material, as well as frank open discussion especially concerning the problems mentioned in my report, could become one of the most suitable means of achieving our goal.

I do believe that by the end of our meeting we will succeed in summarizing the results of these discussions, no matter where they were received: within the frame of our meeting or informally.

I will now pass on to the analytical part of the report devoted to the characterization and evaluation of the sumitted papers.

2. ANALYSIS OF GENERAL ORGANIZATION PROBLEMS OF INNOVATION MANAGEMENT

The preliminary examination of the presentations submitted for our meeting has shown that our approach to the concept of the case study with respect to organizational designs was correct. It should also be pointed out that the methodological materials distributed by the working group, despite their preliminary format, proved to be of practical use to many authors. These materials served as a basis for some presentations prepared by the firms. The authors concentrated their attention on common problems and situations which make it easier to study and generalize these materials.

We have tried to classify the likely situations that may occur in the process of implementing the innovations and generalize the authors' opinions as to which organizational problems arising as a result are most urgent. The evolving conclusions are quite interesting, and we would like the participants to respond to them in the course of the discussion.

The majority of authors consider products and process innovations (i.e., those connected with development and promotion of new products, changes in the processes and structure of production), to be the most important as they give rise to the most complex problems. This point of view is shared by Ganz, Strömberg, Electrosila and ČKD.

This is quite understandable and clear in that external environment needs urge that firms should first of all modernize and expand the assortment of their products. Along with this, as is shown by the presentations, the development of new products and transition to new processes, requires concerted action by all units of the firm. Their relationship is constantly changing and therefore a larger degree of coordination and harmonization of effort is required.

We would like to draw your attention to the presentation by Mr. Wolf (Siemens) where he speaks of the need not only for technological but also social, organizational and economic innovations to be introduced by the firms. His arguments are very convincing. It should be pointed out that organizational solutions of the problems related to various types of innovations are, to a large extent, similar. A comprehensive solution to the above problems is very effective and opens up better opportunities for management improvement. This point of view is also shared by Dr. Karttunen and Dr. Vodachek.

The presentations go further to show that the level of complexity in organizing product and process innovation management is as high in piece-wise or small-series production as in mass production. In the first case, the scale of cooperation is usually smaller but there are more rigid requirements as to the product development time limit, more dynamic and varied quality standards. In the second case there is typically a large amount of preproduction and R & D work, and more need to coordinate the efforts of the firm's numerous specialized units internally and externally.

The organizational problem, as is justly pointed out in Mr. Karttunen's presentation, consists in delegating the operational decision making authority to the levels engaged in performing the basic work: R & D, design, production. The modes of such delegation based on decentralization of day-to-day management are described in the presentations by Mr. Papp and Mr. Flieger.

All the participants of the meeting agree that the dominating form of coordinating the joint effort in innovation implementation is employed of a matrix organizational structure. Each firm has its own experiences of their applications; they are sufficiently effective and can be further developed in many ways.

As can be judged from the presentations by Prof. Nomoto and Prof. Rapoport a matrix organizational structure of management has great difficulties of its own. It is based on deep qualitative changes in the management/organization relationship. If research and experiments in this sphere are continued, the firms can obtain additional useful recommendations for innovation management improvement.

We would now like to draw attention to a very interesting circumstance. The general management organization patterns in different firms, despite certain differences in the scope and spheres of activity, have much in common. This refers to firms functioning in both market economies (Siemens, Strömberg) and planned economies (Ganz, Electrosila, ČKD). Consequently, one can firmly believe that the most essential factors for organizational development are clearly manifest in all countries, and, very often, in similar ways.

If we are right in our assumptions (and this is a topic for serious discussion), the firm's general organizational pattern is not so much influenced by specific features of some innovations as by other factors. Among them, as indicated by Mr. Wolf, Dr. Karttunen and Dr. Vodachek, one of the most important factors is the innovation strategy. This largely determines the requirements of the organizational structure. Although this conclusion is prompted by our practical activities, it should be emphasized that the relationship between strategic planning and organization development has not yet been sufficiently investigated. If the participants of the meeting agree with this conclusion, we would recommend that IIASA concentrate more effort on a profound investigation of this topic.

3. THE SPECIFIC FEATURES OF ORGANIZATIONAL STRUCTURES OF ELECTRICAL ENGINEERING ENTERPRISES

At the beginning we would like to point out that we are not going to explain the basic concepts used in this report: innovation and organizational structures, for these are, as we believe, fully characterized in the report written by Prof. Rapoport. We would rather concentrate our attention on some problems, in particular, on the influence of technological innovations on the organizational structure.

The organizational structures of electrical engineering industry present a multilevel mechanism for allocating authorities and responsibilities in certain spheres of activities and establishing relations between those activities. The electrical engineering industry is characterized by specific traits that to a certain extent determine selection of some or other type of organizational structures. These are:

- large and complex production units (most frequently the ones being explored in this case study), some of them producing other products than electrical engineering ones (compressors, locomotives, etc.);
- long cycle of many innovation processes (2 years or more);
- high capital demand for ensuring the technology;
- need for rationalization caused by the existing strong international competition;
- social problems arising as a result of mechanization and automation of production.

The organizational structures are considered to be adequate when they are consistent with the essential factors of the basic processes. In the electrical engineering industry these factors constitute conflicting forces, which can certainly be found in other industries too.

On the one hand, the organizational structures should be flexible and capable of promptly introducing R & D results into practice, as well as responding to alterations in the composition of the participating units. On the other hand, they should allow contiguous development ensuring the realization of the management system's long-term strategy and bringing down the possible risk of incorrect decisions.

Owing to various pressures on the organizational structures, the mixed type structures have proved their resilience in practice. There are mixed components formed under the influence of internal factors-relative stabilization and organizationl relations with the operational environment. Under those "classical" conditions, the operational structures possess the following attributes:

— relatively high degree of centralized decision making;

— functional arrangement.

During the past 20 to 25 years, the conditions for electrotechnology's functionings have gradually changed. This was reflected in forming more flexible operational structures—rather as complementaries to the existing ones and not completely replacing them.

In the reports submitted it can be clearly pointed out that the pressures on the organizational structures for better flexibility to be able to adapt to prompt introduction of R & D results and respond to market requests led to divisional organization and to decentralized management. These two features are to be considered as major changes in the organizational structures. The divisional organization is widely considered as more flexible in comparison to technologically specialized organizational units, especially owing to a larger degree of management decentralization and to greater complexity of products.

Further organizational changes forced by faster adaptation to the R & D realization are project and matrix organizations. It appears that these organizations are mainly used in the environments where faster application of scientific and technical knowledge in industry is needed. The project and matrix organizations can be considered as two different structures complementary to the classical line and staff structure.

It seems rather difficult to make any certain conclusions concerning the ways and degrees of application of organizational structures for innovative enterprises in the electrical engineering industry. It can be definitely said that production division is considered as more flexible in comparison to the technologically organized unit.

If it were possible to take the Strömberg enterprise as a typical example of electrical engineering enterprises of the West, we would say that these Western enterprises are more advanced in realization of tighter linkage between development, production, and products marketing by employing the organization form of a product division than, for example ČKD Prague. In the product divisions decision making is more decentralized. Operational decisions are made on the lowest possible level of management. In such organizational arrangements the supporting units play a significant part, such as R & D, financial and sales unit, etc. These units are normally arranged in a classical style—as staff formations.

There is no significant difference between single enterprises in the average span of control. This span appears in the range of 5 to 10. The largest spans of about 40 are likely to be found on the lowest management levels.

Creating a divisional organizational structure one can obtain not only the right degree of operational decentralization but simultaneously prevent

excessive centralization on the top management level. This is an important function of organizational structures.

For the enterprise's strategy and total effectiveness of a company of great importance is the technological change. In this context it is possible to observe an obvious trend towards collective decision making. As it is really difficult to communicate to arrive at technically valid decisions, collective decision making becomes a very powerful and important instrument. The matrix organizational structures, as the most rational organizational instrument of this collective activity, enables a team to solve very complex tasks. It is interesting to mention that the main part of submitted reports emphasize the matrix structure significance for the R & D relationship with production.

In R & D the tendencies to centralize the planning and checking of R & D results becomes stronger, while application of its results to production gets more decentralized. There is difficult communication between production and R & D units in general, therefore collective methods imply direct participation of the R & D and production staff, or other formations, if necessary, when decisions are taken.

The efforts to establish a more effective linkage between production, R & D and other units are emphasized in all reports, for this is one of the substantial sources enhancing the effectivenss of any industry.

4. BACKGROUND AND PROBLEMS

We believe our meeting provides a good basis for obtaining new and interesting results as an outcome of discussions. What is meant by this? First of all, there is a number of points where we all agree. It is very important for mutual understanding. What are these points?

All the authors recognized in their papers that organizational structures play a significant role in innovation management (subject to availability of all other prerequisites). One may also assert (as is univerally recognized) that there are no pure forms of organization to be found—line, functional, or project. As a rule, all firms employ a certain "symbiosis" of organizational forms where one or two characteristic features prevail. These can be specialization, centralization, diversification, etc. No one is likely to insist that this pattern should be discarded and elementary, simplified organizational management forms be employed again.

All the authors are unanimous in that the major problem of innovation management is coordination of effort among the units participating in the innovation. At the same time there is no single universal mode of coordination. Many of the well-known modes of coordination are quite effective but they also have their weak points. Naturally, it becomes very important to us to find better modes of coordination. It is still more important (and I think many participants will agree with me here) to identify the conditions where each time-tested mode of coordination is the most preferable and suits best the other management tools used.

I hope everybody will agree that among the factors that determine selection of some or other management organization, top priority belongs to innovation strategies. Of course, within a certain strategy framework one should

consider many other circumstances, especially ways of the strategy implementation—current planning, available resources, time limits. And, naturally, the most decisive is the human factor—top managers, experts, middle-level managers.

This means that the degree of uncertainty in the selection of organizational structures has been and will always be very great. Consequently, it becomes still more important for us to study the most likely situations in the future activities and discuss collectively the ways of overcoming possible difficulties.

All agreed too, that in an uncertain environment and in the context of dynamic development, ever more flexible and adaptive structures are needed. Therefore, all organizational designs that allow for better adaptability towards the changing requirements will be preferable.

I have pointed out some positive constructive aspects that can serve as a foundation for our further deliberations. But of great use, I think, will be to point out some controversial points as well, those that are very important but where there is no consensus among the participants so far.

For example, we cannot yet say with confidence what degree and form of specialization of electrical engineering firms are preferable. There exist different tendencies and viewpoints but it is difficult to arrive at a unanimous decision. The same is true for a rational degree of centralized decision making. Obviously, there are so many subjective factors at play here that one can hardly expect any agreement on the problem. Diversification of production and management, optimal sizes of firms, etc., refer to the same group of "difficult" topics. If these conclusions are correct, by applying them we can facilitate fulfillment of the tasks of our meeting, i.e., concentrate effort on discussing the topics that have more chance to achieve positive results.

In view of the above I conclude my report by giving a list of topics for discussion and further study. Among the most important ones are:

- The need for changes in the organizational structures corresponding with innovation activity.
- The criteria and characteristics of flexible structures, in particular the relationship between reasonable stability and flexibility of the structures.
- The conditions and manner of cumulative or running organizational changes.
- The mutual influence of organizational structures and modern communication technology in innovation management.
- The integrative tendencies connected with the complexity of using centralized forms, project teams and other integrative bodies.
- The relationship between the enterprise development strategy (especially of innovation processes) and the organizational structure.
- The evaluation of the effectiveness of organizational structures with respect to the quality and duration of innovation processes.

SOME METHODOLOGICAL ASPECTS OF COMPARATIVE STUDIES OF ORGANIZATIONAL STRUCTURES

Vladimir Rapoport
Institute for Systems Studies, Moscow, USSR

In studies of organizational structures very few attempts, to my knowledge, have been made at comparing various management organization structures and trends of their change, and none at all on an international level in the context of a long-term development of an entire branch of industry. You would ask why. It would take me very long just to mention the existing methodological difficulties to do that.

Yet, we have gathered here to find some solution to this problem. However, before starting a discussion of methodological aspects, it is important to agree on the purpose of the proposed study and comparative analysis.

We all understand that every electrical engineering firm—large or small—is to a certain degree unique and has its own specific features. Therefore, there can be no universal recommendations as to the organizational design, especially with our various and constantly changing environment. So what use will there be in our discussions?

There is ground for optimism, however. Study of the present situation shows that with a wide variety of organizational designs one can find many common traits—essential ones. One may suppose that there exists a certain regularity of organizational development, and it will be reflected in the sufficiently clear trends of organizational structure change. We can study these trends and apply the results of the study to our practical work: it will provide criteria for the evaluation of the correctness of the organizational decisions to be taken. This alone would make our present efforts worthwhile.

Besides, we have come to the conclusion that in both Western and Eastern economies, especially within one branch of industry, there are many similar economic situations of key importance to an effective business. These situations are standard and are likely to occur very often in the coming decade. What about standard organizational designs corresponding with such situations? Good standard designs to be used by firms, do they exist? The answer is yes, as many people think.

If it is true (and we can discuss it here), we could try to describe such designs and the environment providing for their successful application. Here is a second problem whose solution would undoubtedly be of great use to the firms represented here. To solve both problems we must satisfy at least two requirements.

First, obtain descriptions of the management organization patterns in different companies and countries. It is important that the description be uniform both in substance and analytical approach. We would appreciate it if all reporters and participants in the discussion would pose the same questions and then, during the preparation of the meeting try to formulate their own assessment of the management organization state-of-the-art, its dependence on the objective factors for the firm's developments and the changing needs of its environment. It is also important to have a general picture of the expected changes and requirements of the management organization.

To obtain such uniformly structured descriptions of the management organization state-of-the-art and its assessment, we proposed patterns, including a list of facts and evaluations recommended to be included in future presentations.

We proceeded from the understanding that even in the case of a nonadequate approach to the problem the preliminary acquaintance with it and its careful consideration will help make our discussion more problem-oriented and constructive.

The second stipulation for an objective comparison is the comparability of management organization elements and factors influencing their choice. From a methodological point of view the task is not an easy one. It requires considerable analytical effort at the pre-comparison stage. Several iterations might be required before we reach a satisfactory level of accomplishment.

Making a preliminary assessment of the degree of comparability in the organizational structures of electrical engineering firms from different countries, we proceed from the assumption that the characteristics of business entities, their organizational patterns and the innovations to be introudced, have certain interdependencies. The task is to identify the independent characteristics and their relationship.

To make this possible, we proposed several sets of classification elements for: (a) business organizations (Appendix 1 to the general concept); (b) innovations (Appendix 2); and (c) management organization structures (Appendix 3).

To introduce some structure into the preliminary analysis and to facilitate preparation and generalization of the presentations we have also elaborated and circulated a general list of basic types of organizational change aimed at improving innovation management (Appendix 4).

I do not think that there is any need to comment on the above materials. From the analysis of the presentations already submitted, not all participants considered it necessary to utilize all of them. Some authors introduced their own classification schemes and additional characteristics to the objects under investigation. This will help us specify and develop the suggested approach.

At the same time we can see from Professor Holec's report that the preliminary work yielded satisfactory results. First, we now have a somewhat generalized picture of management organization and ways for its improvement. Second, we can make well-based comparisons and conclusions, which is also interesting and useful.

In my report there are also some generalizations and conclusions made on the basis of my own experience and the literature I have studied. We expect every speaker to give an evaluation of both the methodological approach to a comparative analysis of organizational structures as well as the generalizations and conclusions already presented. It will allow all of us to extend our own conceptions of the object of discussion and utilize it in our further practical work and theoretical studies.

We could also agree on extending the list of characteristics and criteria to be used for comparing organizational structures. It will serve as a guideline for the firms participating in this project. They can send additional material to IIASA which will be analyzed and used as a basis for new conclusions and generalizations. If the material is submitted promptly, it could be included in the proceedings of this meeting.

Moreover, we plan to include the material of the discussions at this meeting in the general report for the final conference on the project to be held at IIASA in 1984. The conference will consider improvement in organizational structures of innovation management in their systemic relationship with strategic planning and general style of management (socio-psychological aspects). The final product of the IIASA conference should be a monograph reflecting both the results of our meeting here and a comprehensive analysis of all aspects of innovation management system improvement in electrotechnology.

I have drawn your attention to the above points so that your opinions can be heard in the forthcoming presentations and discussions. Collective discussion will help us specify, extend and improve the proposed program of studies.

ORGANIZING FOR INNOVATION IN PRODUCING ORGANIZATIONS/ENTERPRISES

Walter Goldberg
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1. OBSTACLES TO INNOVATION IN LARGE ENTERPRISES

Enterprises in the electrotechnology industry are usually of large size. According to a rather rich and fairly unanimous literature on the innovation capacity of large organizations, they carry the stigma of being poor innovators, for a variety of reasons. It must be stressed here, that generalizations generally to be found in conclusions of research on the innovation capacity of large enterprises, tend to disregard several important criteria beyond size (e.g., project complexity), which may have an influence on the innovation capacity of such organizations. It should also be remembered that conclusions to be drawn from research do not have the properties of "laws": organizations are "individuals." As such, they behave individualistic, equal to different ways. Their behavior is hardly consistent over time. Organizations also "learn" from experience—although the learning is vested in their numbers.

In general, one cannot invalidate the suspicion that a good deal of the empirical research showing the mediocre or even poor innovative behavior of large organizations is confirming the researchers' prejudice, rather than objectively depicting the obstacles which may impede innovative behavior in large organizations, but also pointing out the advantages large organizations may have, over smaller ones, to innovate.

The reader is reminded of the generally accepted definition of *inventions* meaning new ideas, new ways to solve old or new problems, whereas *innovations* are inventions, which have been carried through the phases of laboratory design, prototype development, introduction into production, introduction to the market to fully-fledged products or services, that are accepted by the market as novelties in demand by users/customers.

The following obstacles are often quoted as being specific innovation blockers in large organizations/enterprises:

1. The advantage of large organizations is to *organize* and *maintain* patterns of success: they foster resistance to change.

2. Innovation challenges established success, disturbes well-designed processes and procedures, carefully and skillfully streamlined towards the *achievement of high productivity*.

3. Hierarchy fosters *compliance* and *conservatism*. Innovation requires risk-taking, and entering of roads with uncertain outcome. By their very nature, innovations in some cases must end in failure. Persons/managers identified with failures will be punished or even expelled from the organization. Large organizations thus disregard the risky character of innovations as normal features characterizing novelties. Large organizations do not provide safety nets to persons in charge of failing novelties. Career-conscious persons will thus avoid becoming responsible for innovations.

4. The *sectorization* of products and markets, e.g., the so-called product organization, may hinder innovation.

5. The *functional differentiation* normally found in large enterprises fosters "boundary" problems. They are the main cause of the so-called "not-invented-here" syndome (NIH). R & D undertaken without "due" involvement of production and/or marketing departments may experience considerable difficulties in phases of implementation.

6. *Power policies* often to be observed in large enterprises, may inhibit or impede innovative attempts. It is usually easier to put brakes on dynamic attempts of other divisions or departments, etc., than to develop and maintain higher levels of innovative performance in one's own part of the enterprise.

7. Large, formalized organizations emphasize *short-term objectives:* the *here* and *now* matters more than long range achievement. The formal methods and procedures of performance monitoring and control, e.g., budgets, production plans, marketing plans, etc., foster the short term achievement/fulfillment of short term goals. Longer term plans are hardly ever formalized. Peoples' or departments', etc., performance is judged against formalized goals as established in budgets, etc. A failure to meet short term goals hardly ever is excused, even if it means securing a more long term but not formally measurable success for the organization.

8. Large organizations regularly adopt *rotation schemes* for young managers, to have them to learn about the organization and to get indoctrinated in the culture of the firm. The rotation principle implies rather short stays in different parts of the organization. The duration of those stays is usually too short to give the young managers time enough to understand the need for long term development and innovation in the visited parts of the organization. Thus even the rotation principle, however necessary, good and efficient it is, tends to emphasize short term, rather than long term objectives and thus disregards the necessary understanding of need for innovation.

9. Large organizations tend to *disregard smallish opportunities*. The full extent of the potential of an innovation is hardly ever comprehensible, when the invention originally is taken up. Economic history is full of examples of large organizations discarding innovations, which later proved to be great successes, by judging their potential against existing demands. Innovations at the margin of the range of activities of large enterprises thus frequently do not attract the necessary attention. Large organizations thus frequently forego opportunities, which to them appear marginal, even if they may have an—unrecognized—development potential.

10. Large organizations are *trend-followers* rather than trend-setters.

11. Large enterprises often prefer to buy and integrate smaller *innovative enterprises* as a strategy to enter new products/markets rather than to innovate themselves.

12. Large organizations tend to avoid the risks naturally inherent in innovative ventures, as failure is harmful to the prestige of a large organization. Watching the prestige, nurturing the gold-framed image of a large organization is more important than innovativeness.

The above enumeration is certainly not complete, but rather takes up examples of the most frequently heard cases and reasons explaining the generally held low innovative behavior of large organizations. There may be a great deal of prejudice in this list, but also a good deal of rather common experience. There are, however, no "laws" implying that large organizations would be entirely uncapable of innovating. There are many striking cases of innovative behavior, even of break-through type, in large organizations. Large organizations, as well as smaller organizations, have the capacity to learn and to improve. Large organizations often also have the slack to cater for change and improvement, thus also for innovation.

Nevertheless, large (as well as not so large) organizations ought to be aware of the risks of falling into e.g., productivity traps, and thereby neglecting long term innovative behavior, which is necessary for the survival and continued success of the firm.

2. ATTITUDE DIFFERENCES BETWEEN INNOVATIVE AND OPERATIVE UNITS

In the above list of obstacles to innovations in large organizations, attitudinal differences between operative and innovative units seem to play a rather important role. Let us try to analyse those differences for a moment. In order to hammer out the differences, again, a "black-and-white dichotomy" is used, in order to stress the major obstacles or deficiencies so they may stand out clearly and thus become the focus of attention for remedial or improvement action.

In the first place there are basic differences in the characteristics of the activities undertaken between operating and innovative units. Operating units have to take care of activities with the aim of achieving high levels of productivity for usually repetitive and thus programmable tasks, often being cast into rather rigid mechanical-machinery dominated production systems. The organization in which the production takes place is highly formalized, with well worked out, highly rational and efficient monitoring and control systems, clearly defined tasks, job descriptions, etc.

Innovative activities take place in an atmosphere, in a climate, which is rather opposite: the objectives are often rather vague, only generally described. The ways and means to achieve the innovative performance are open and insecure. Often a range of different alternative solutions is available with rather uncertain outcomes as to the achievement of the objectives of innovation, which are set in rather general terms. It is up to the personnel employed in such activites to be creative, inventive, to search for new solutions, and to enter new paths with often uncertain outcomes. The always necessary achievement orientation is not given here by prescribed productivity goals, but rather by inert achievement drives and motivation, present in the innovation personnel or created in the "spirit of the team." The means of production, the *technology* used is consequently different.

Operative units use either standard equipment of the industry, in many cases also standard multipurpose equipment, or in cases where long runs are involved, even highly specialized mechanized or automated equipment, which either is bought from outside or has been developed by technology suppliers in cooperation with the firms, it's R & D and production personnel or which is adapted from "first line innovators" outside of the firm, often through the channels of technology suppliers/production machinery producers.

Innovative units use very little standard equipment (except measurement devices and general laboratory or test equipment). They may themselves also be operating near the frontier of technology, employing more or less complex and novel equipment. They may have to design their own equipment or at least develop general ideas and principles, how the innovative product may be produced in larger quantities, within the premises of the firm. Very often also, the innovation unit must think in terms of service and maintenance in the premises of the user-customer-final consumer of the product.

The above two characteristics (activity characteristics and technology characteristics) form prototypes of managerial problem solving approaches. *Operating units* are managed, monitored, and controlled by means of plans and budgets emphasizing a short time horizon performance, quantitatively as qualitatively. The emphasis is on intrafirm, that is internal criteria to be met. In cases of mass production often very elaborate systems of "microcriteria" are used for suboptimization and compound optimization at the different levels of the production organization.

The management methods applied in problem solving in *innovative units* are much less standardized and even known. The orientation is much more long term and long time horizon directed. Methods of boundaries spanning, novelty search, risk and opportunity assessment, externally as well as internally are necessary or desirable components of problem solving styles. The general orientation is external, often also international. The decision processes follow the problem solving patterns just developed.

Operating units employ frequently explicit quantitative models depicting productive and organizational processes. The models make possible analysis of improvement potential as well as analysis of deviations from plans or desirable behavior.

Innovative units also use analytical methods, although with different aims and of different character. They will also try to use synthetic methods, that is combining known models for partial processes with new aims, assembling them to new patterns. The main emphasis, however, is on intuitive modes of decision making, sometimes in even explicitly suppressing known requirements of rationality and critique.

The *management styles* or mangement behavior will vary consequently: the management style in operating units will follow the Weberian model of the rational bureaucracy as the ideal model for foreprogramming for the achievement of highly streamlined productive efficiencies. The general style is rather authoritarian. The organization is preprogrammed in so far as uncertainties about what will happen in certain actions are triggered, are to be minimal.

The management style in innovative organizations is drastically different: innovation does not appear by command. Authority is rather achieved by exemplary performance and creativity. Fomral roles are suppressed rather than emphasized. The style is participative. Decisions about steps to be taken are made jointly. The prestige lays in the achievement of the group rather than in individual performance, even if individual performance is necessary and must be stressed and awarded (otherwise the individual will seek external rewards for outstanding performance).

Coordination in the operative organization takes the form of plans, memoranda, formal reports, reporting of deviations from plans, in order to trigger managerial activities. In innovative units evaluation is much more differentiated: it is a peer evaluation both internally but very often also a professional peer evaluation through external evaluation centers (e.g., professional journals, symposia, etc.). To some extent evaluation is also a self-evaluation and a group evaluation.

The *personnel resources* selected to operative units are more frequently assessed as to their records of discipline, performance orientation, compliance to the hierarchy. Other preferred recruitment criteria are capacity to operate in standard productive environments or to be capable of operating in high technology environments, e.g., process control equipment, computerized on-line control systems, etc.

Innovative units will tend to recruit highly trained professionals as the activities are brain and intelligence intensive. Some emphasis will be on the recruitment of so-called "gate keepers", i.e., persons having access to rich and relevant contact networks, persons knowing the pertinent technology in depth, persons capable of spanning over the boundaries of "normally" employed technology or methdos, spanning into more or less adjacent alternative fiels of science and technology, but having the discipline to keep to the mainstream objectives, of the innovative task to be performed.

The *risk taking attitude* sought for and fostered of managerial, as well as operative personnel, in the two sorts of units are consequently different: in operating units the control and monitoring of the system to keep uncertainties at low levels are very important. The causes of deviations are to be analyzed quickly. Remedial actions are to be applied at short notice. Innovative units will look for persons who have exposed themselves as "calculated risk takers" of being failure tolerant, of being persistent, keeping up a high motivation, even if they have happened to enter a cul-de-sac now and then, in attempts to look for novel solutions.

The *reward systems* in operative units are tied to performance. Rewards are given in the form of economic incentives (pay, premiums, bonuses, etc.). Status is associated with position and title. Thus, career patterns are an important feature of the reward system. Rewards in innovative units are the self-actualization experienced by the achievement of a breakthrough, the possibility of working and performing in an intellectually stimulating environment, the role-autonomy, but also the team spirit and environment. Further

rewards are internally, promotion to nonadministrative, science or development/innovation oriented higher position in the innovative organization of the enterprise. Externally, innovative personnel will seek for confirmation of achievement in the form of publications in professional journals, participation at symposia and scientific conferences, etc.

3. THE ORGANIZATIONAL CONTEXT FOR INNOVATION: SOME GENERAL OBSERVATIONS

The aim of the above characterization of the widely differing conditions for innovative activities in a large electrotechnological firm was to draw top management's attention to the very fact that innovation activities are not only contingent upon different competitive conditions inside and outside the firm, but also to prepare some foundations for deliberate managerial policies and strategies to the furthering of the innovative capacity of the firm. To start with, attention is drawn to some general organizational conditions and instruments to furthering innovation. The final part of the paper is devoted to a discussion of an empirical investigation of the practical application of idea monitoring, a method to improve the innovation consciousness of a firm's employees and to prepare and improve the climate for general or specific innovative ventures.

3.1. What is an Innovation?

An idea, the discovery of a basic law of nature or of major principal opportunity to improve product or processes is by no means yet innovation. One speaks of an innovation if such an idea has been taken through stages of development, design, prototype development, production and introduction to the market, until becoming a success on the market. Thus, having an idea does not imply that one has got an innovation at hand. It only means that one has a seed, out of which an innovation can be nurtured. A number of conditions must be fulfilled, in order to get the idea through a range of steps onto the market. The focus in this context is on organizing for innovation, i.e., preparing the various aspects of the organizational context favorable to carrying ideas through to successful innovation.

It must be emphasized that a favorable organizational context is just one, albeit important, condition. Other conditions may be the availability of technical solutions and, perhaps still more important, the access to technical solution at reasonable cost, so that the innovation will become attractive to the market not only for its functional properties but also as far as price and maintenance costs are concerned. Last but by no means least, that the innovative product will render good profits to the innovating firm, improving its profitability, survival capacity and stability; the ultimate aims of innovative activities of firms*.

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* The following are a few examples of major inventions, which took a long time to mature. The basic principle for the radar technology was discovered by Heinrich Hertz in Berlin in 1883. One of his assistants developed the principle to a patent, which was awarded in 1904 for a "method to improve satety at sea at night and under conditions of reduced visibility." The first radar prototype was developed in 1936. Radar came into commercial use after World War II. The major breakthrough came during the War for military

3.2. Under Which Conditions May an Invention be Developed Into a Successful Innovation?

In order to carry through an idea to an innovation, one not only needs an "environment" in the shape of an organization with access to resources in the form of technology, but also to capital. Still more important is the presence of an entrepreneur (in the Schumpeterian sense, i.e., a person who is capable of understanding the importance of an idea, but also having the enthusiasm, the persistence, the courage and the spirit to carry through the idea to become a product on the market, overcoming all obstacles that for many different reasons appear along the path from idea to innovation and that may impede or even make realization of the idea impossible). We have reason to develop the concept of the entrepreneur and the entrepreneurial environment further. Here, it may suffice to mention that the entrepreneur will shape and induce, influence the environment in which the idea is taken through to the stage of an innovation. He will "organize" the context for his project (although not necessarily invented by him, which is rarely the case). The presence of an entrepreneur (or group of entrepreneurs or entrepreneurial environment) as a rule is much more important than the mere availability of an idea or, e.g., access to capital.

The entrepreneur may be, and often is, the wrong person to later organize the regular production, marketing, etc., of the product, i.e., for organizing and running a division or an enteprise. Entrepreneurs, who are a rare species, should not be "promoted" to higher administrative or managerial positions in the same way that inventors or excellent scientists/technicians should probably not be. We will return to this problem later.

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purposes.

The principles of both the basic oxygen process and the continuous casting process in steel making were discovered by Bessemer during the 1950s. Bessemar received a patent on the continuous casting principle as early as 1867. The patent for the basic oxygen process was applied for in 1939. It was awarded in 1942. The basic oxygen process was employed on an industrial scale in 1954. It replaced older iron to steel conversion processes worldwide and within less than 15 years because of its superior economy and its qualitative improvements in steelmaking. The continuous casting process was employed on an industrial scale by Thyssen in 1967, i.e., exactly 100 years after the patent was granted. It has since become the most widely used technology for liquid to solid steel conversion in modern steel plants.

The common features of the above three cases are: (a) the availability of a principle solution and (b) the presence of an outspoken market demand for the products/processes in question. The missing links were the nonavailability of reasonably priced technology for some processes, e.g., a cheap method for mass production of oxygen.

3.3. Personality Types Needed for Innovation

We have been stressing the importance of entrepreneurs being available in innovative organizations, i.e., people who get things moving, who find ways and means to overcome obstacles, who motivate others in favor of an idea, and who are capable of obtaining and organizing resources. We have also mentioned that it is important to have access to *idea generators*. Two types of idea generators are essentially needed (which need not necessarily, but may well be, the same person). The first type of idea generators are those who trigger *action* because they recognize that something must be done in order to change an otherwise given development, e.g., the decline of the profitability of a firm, the viability, and the survival capacity of the firm in question, e.g., through the appearance of competing products, etc. The second type of idea generators needed are people who find *solutions* to problems of action, i.e., people who generate ideas on how to act when action is needed.

A third category is also needed particularly in larger organizations of the type we are specifically interested in, the so-called *gate-keepers*. They search the organizations and its environment for ideas (both action and solution ideas). They transmit ideas and information to relevant parts of the organization and keep themselves informed about the actual and potential needs of the organization as well as of developments outside the organization, which may have a bearing on the organization's visibility and profitability.

As will be demonstrated later, some medium to large size technology-instense firms organize the "gate-keeper function" systematically in the form of technology agencies or scanning agencies. The gate-keepers or gate-keeping agencies may also be entrusted with the task of organizing and stimulating the flow of information within the organization, and to furtherance of innovative attitudes and activities.

Innovation organizations will also need *project leaders*, i.e., people formally or informally entrusted with the task of monitoring defined projects. The difference between an entrepreneur and project leader is that the projects are often better defined and more clearly delineated than innovative ideas are. One may very well find a combination of entrepreneurs and project leaders, where the project leaders may act on behalf of the entrepreneurs, taking care of certain subsets of the innovation such as carrying through the development of certain parts or process developments necessary within the framework of more complex innovative ventures. Project leaders have to develop, plan, organize, coordinate and control the project or processes entrusted to them. Project leaders often also have the task of bridging the gaps between different parts of the organization, e.g., between different departments or other subsets, but also to act as interorganizational gap-bridges, e.g., when it comes to organizing projects in cooperation with subsuppliers, subcontractors, etc.

Innovative firms regularly need clever people, we may call them *organizers* who, in principle, are imaginative people who are able and capable of finding ways and means to visualize or materialize fuzzy, sketchy or imaginative ideas, i.e., to transfer something from a sketch pad into a gadget, a real piece of hardware, or (to start with tentatively) a software program. We may also call them *problem solvers*, i.e., people who are mainly capable of solving local (sub) problems. A principal trait characterizing these types of people is an experimental spirit, which, once they have a rough idea of a (local) problem, enables them to produce one or a set of prototype solutions.

Innovative organizations, it should not be forgotten, need *sponsors*, i.e., managers in top positions, who provide the necessary top management support, who act as Godfathers, who keep an open door for the entrepreneurs or the project leaders when they need assistance at this level to overcome obstacles. Sponsors often assume the final responsibility for the innovative venture to be carried through.

3.4. Organizational Structure and Organizational Processes

The organizational *structure* is based on a definition of tasks to be performed within organizations/enterprises, the combination of functions and tasks into "bundles", the division of such bundles to logical subsets, and the arrangement of subsets to units. Further, the combination of units to a hierarchy; the establishment of communicational links between the different subsets in the hierarchy whereby the need for horizontal and diagonal communication is to be observed, thus not only the vertical one which is the only one usually depicted in (simplified) organizational charts.

The organizational structure has to be manned, i.e., the positions have to be filled by *people*. People are to be given tasks, responsibilities, the authority to act, report and communicate, to motivate, stimulate, control, monitor, correct and to innovate.

The sequence described above is artificial in so far as tasks, positions and persons/individuals are interdependent. It is thus not only that people are recruited to certain positions. Positions are created around people. Organizational subsets are formed by the persons acting in them. Thus, an organizational structure is very much dependent and contingent upon the persons, individuals and groups acting in them.

A third major component influencing the structure, but of course also influenced by the structure and by the people acting in the structure, are the organizational *processes*. These processes are the acts of, e.g., planning, designing, acquiring, organization, committing, employing resources to products (semi or final), to find markets to sell, to create, monitor and change flows of resources, products, orders, means and finances, and cash flows etc.

Normally the organizational structure, the organizational processes, and the manning of the organization are directed towards the fulfillment of productive objectives with economic aims. This rather cryptical statement implies that firms normally see their main task in acquiring resources, converting resources, selling products to markets that they develop, but also which they scan for product needs, for services to be performed by the organization. For simplicity's sake we may call this the "productive" organization, which takes care of "given" tasks.

Generally, an organization will not be capable of surviving in the long run if it does not change, adapt and innovate (we are talking here of course of economic organizations not about idealistic organizations such as, e.g., the Roman Catholic Church). It is generally recognized that the organization for production, i.e., the performance of "regular" activities, is being streamlined in order to achieve high levels of productivity and economy as well as rationality in general. One principal aim of such productive organizations is to suppress, eliminate, and minimize risks and uncertainty. The organization for innovation is basically different from productive organizations as it deliberately ventures into risky, uncertain novelties. In order to organize for innovation, we will thus create a type of "overlay" to be superimposed upon, or rather integrated into, the productive organization.

Reality as well as theory recognizes the existence of both *formal* and *informal* organizations as far as structures and processes are concerned. The dichotomy formal and informal applies just as well to innovative organizations. The *formal* organization for innovation aims at building a network into the productive organization of an enterprise to make changes possible in an "orderly manner". It implies the definition and assignment of authority, the legitimation to act, to commit resources, and the responsibility for proper utilization of those resources; it means the establishment of budgets, accounts and reports, and other means to plan, monitor and control. The formal part of the organization further means the employment of knowledge and skills needed and the establishment of a hierarchy of command and accountability.

The *informal* part of the innovative organization aims at nurturing ideas, stimulating creativity and creating enthusiasm and initiative to cater for a problem-solving climate and a positive attitude to risk taking and venturing into new roads and methods. It aims at creating a generous, permissive atmosphere to stimulate risk taking, to make it possible for the organization and its members to break new paths, permitting failure and providing safety nets for people and groups identified with failures which are the natural events of innovative processes. The informal organizations thus in principle aim at keeping a high rate of motivation, and high morale and ethical standards. In general, it may be identified as providing an atmosphere of freedom under responsibility.

3.5. Innovative Climate Leadership Criteria

A first and primary principle to be established is that an innovative climate should not only be pointed at creativity and innovativeness but should also be designed towards achieving economic results, quantitative as well as qualitative, and economic performance through the creation of new products or services and through the creation of new values and functions to be offered to the market. The leadership criteria generally identified with innovative climates are essentially of the following types.

Team building capacity, through the creation of an open, permissive atmosphere for idea penetration and free flow of information. The leader will act as a motivator, as a goal setter. There are difficulties of a particular type to be experienced in this context: complex innovations require team work. The success of a project is critically dependent upon the functioning of the team. However, the individual performance within the team must also be stimulated and awarded. There is thus an inherent conflict between group performance and individual performance, in particular in

connection with the reward system to be applied. Rewards are not only of a financial nature but also consist in the form of praise and incentives, such as promotion, travel, participation in conference, publication of articles, etc.

Creative leaders are expected to be *convincing*, to employ their authority by superior knowledge and attitude rather than by rank, position or title. It is their exemplary and highly creative performance, individual discipline and ethical standards which make up their leadership criteria. They will have to combine permissiveness with decisiveness. They will act with "fists of steel in silk gloves" in order to be efficient and productive.

Innovative leaders will be listeners and problem solvers, in cooperation with teams inside and outside the task force, with management, with the production organization, with marketing, etc. The meaning of "listener and problem solver" is to be understood as a style different from the "tell" and "tell and sell" styles. The listening and problem-solving attitude is a basic prerequisite for a creative atmosphere in so far as it stimulates all the members of the team to contribute. A leader who tells people what to do and sells his idea essentially, does not invite participation and may possibly kill the ideas and creativity within his team.

Innovative leaders are generous, permissive and take the blame for any mistakes and failures which are always connected with innovative ventures. They will also share the praise with the team and lift the team's performance as well as the individual members' performances to the forefront, rather than his own achievement. Creative leaders shape an atmosphere of reliance, of trust and of support. They stimulate ideas and participation, not only within the team but also from other parts of the organization or externally, e.g., with subsuppliers, the marketing or distributing systems, channels and servicing centers. They will also stimulate the flow of ideas and the participation from external research organization, laboratories, university institutes, etc.

In general, creative leaders will be low-key actors, with high ethical standards, they will be decisive persons who stand up for decisions taken and who show persistence and perseverance.

4. THE LINKS AND INTERDEPENDENCIES BETWEEN ORGANIZATIONAL STRUCTURE AND PROCESSES, ORGANIZATIONAL CLIMATE AND INDIVIDUAL PARTICIPATION

Enterprises are contingent upon the environment they exist in in a wide range of aspects, namely, the legal, political environment, closely connected to the social and cultural environment. There is also the technological environment, e.g., given by the line of work the industry is in, which is closely connected to the economic environment, i.e., to the market situation of the business they are in. There are other external and internal properties, such as the tradition of the industry, its size, geographical dispersion, and also its degree of internationalization. All these *environmental contingencies* will be reflected in aspects of the organization, either formally or in the definition of tasks to be performed, or in attitudes, held by the management or by the members of the organization.

Within the organization, as already mentioned, there are links between influences and cross influences between elements of organizational structure,

the organizational climate and the individuals in the organization. Those major factors influence each other. They, individually as well as jointly, have a major influence on the performance of the organization. The performance of an innovative organization, which is the focus of our interest, the type and quality of ideas which are being proposed in the organization, the number of projects which are taken up in the organization and carried through, the new products and processes as well as markets being developed and last, but not least, the effectiveness and efficiency of the innovative achievement in the form of an improved profitability and survival capacity of the organization.

Amongst the organizational structural elements, we have already recognized some major features as the degrees of formalization/informality, centralization/decentralization, openness/closeness, complexity, degree of hierarchy, degree of structuralization, the division of tasks, the communication between assigned tasks, i.e., organization of units both horizontally, vertically, diagonally and sequentially. There are also other factors influencing the organizational structure such as the size and age of the organization.

The features of the *organizational climate* fostering innovativeness are the propensity to take risks, to respond to challenges; the support given to ideas, the relibility of the organization, its record in taking care of failures/failing projects, and the people as well as organizational units identified with failures; the organizational climate with respect to the "pressure" for performance; the firm's future orientation; the firms applied, practice personnel policy.

The *individual features* at play are personality, attitudes, knowledge, skills, goals, needs, age, training, experience, leadership capacity, motivation, to mention a few central ones.

A critical problem in organization research is that the measurability of the influences and cross influences is most difficult. This is a dilemma in so far as management often will request clear cut instruments to be placed at its disposal. The instrumentality of organizational features and parameters is, however, not given in a clear cut cause-effect relationship or a set of such relationships. Organizational criteria most frequently appear in cross inducing relationships rather than in one-way causal relationships.

5. IDEA GENERATION: A SIMPLIFIED FLOW MODEL

The generation of ideas has, for clarity's sake, been dichotomized into two subsets:

- o the generation of action ideas: the recognition of the need to act
- o the generation of solution ideas: ideas about how to act.

It may be trivial to claim that there must be a kind of balance between action ideas and solution ideas. Action ideas are of limited value if one does not have ideas at hand on how to act. This situation is by no means unusual. An organization or firm may have recognized too late that it is running out of steam, that it is losing markets, that its products are becoming out-moded or that competitors have appeared on the market with superior

products. Thus the seemingly trivial balance between action ideas and solution ideas to some extent is a matter of timing, of deliberate foresight and planning. A prerequisite for action ideas is an insight into the need for action. Such insights are suppressed by inertia, by the burden of routine workload of daily tasks and problems to be solved. If the insight into the need to act comes too late, the organization/firm may not have time and resources enough to act, even if it has solution ideas at hand, which however require resources/time to be carried through to innovations.

The recognition of a need to act usually follows from the identification of a performance gap in the future. A performance gap can be recognized by extending trends of e.g., the firm's own performance (product-, function-, economy- and profit-wise) over time and requirements as well as performance of the environment as constituted, essentially by the markets, by competitors and by other critical elements of the firms economic, political, etc., environments. Such performance gaps, leading to the development of action ideas, require general problem awareness and goal consciousness. They make necessary (realistic) assessment of the situation, its development, the potential of the firm, its competitors, its markets, the capacity and capability of the organization to change, to adapt, to exercise leadership. It means the identification of gaps, of strengths and of weaknesses.

In summary, the generation of action ideas is the main outcome of what usually is called and applied as strategic planning. Strategic planning takes place in firms within frameworks created by enterprise policies, which include market policies, product, production, and technology policies, as well as innovation policies. As the IIASA project foresees a specific task force for strategic issues, this will part will not be elaborated upon further here.

As mentioned above, the presence of action ideas will trigger the development of solution ideas. The process should in principle be designed and controlled by an innovation policy of the firm, see below. (Although the innovation policy of a firm is also part of the strategy task force assignment it will be—albeit briefly—treated here.)

The search triggered for ideas must be controlled, in order to achieve high effectiveness and efficiency. A keystone is the definition of the area of search, which implies both a delineation market or technology-wise, but also a definition if one is, in principle, controlled by technology (or science), which would lead one into the direction of *technology push* oriented innovation activities, or by functional needs of customers, or the market which, consequently, would lead the search into the direction of *technology pull*. The definition of the area of search is contingent upon the experience of the firm, its traditions; its personal as well as financial resources; the context within which the firm is operating as constituted by its markets, its physical environment, its legal, political and most of all its industrial/technological environment; a further major controlling factor is the time horizon of search: which time is available for change or adaption, within which time frame a solution could be available; how long foreward looking, market-wise, technology-wise should the solution be, and what the aimed lifetime of the sought innovation should be.

After the area of search has been defined, search is stimulated, internally as well as externally, according to the policy, but also the needs as defined in the area definition. In order to make the search process effective and efficient, *targets* will have to be set: time targets, including the creation of "stress", i.e., time pressure to stimulate achievement. (Time

pressure can, however, inhibit radical solutions. One should be aware of this and cater for "easy" communication of ideas for radical solution that go beyond the established time limits.)

Further target criteria may be the type of achievement aimed at, how radical, how thorough, how deep and broad the solutions looked for should be; what markets, what customer groups, what principle functions one is aiming at. Again strict target setting may, however necessary it is, inhibit certain types of ideas, in particular the more radical ones. The search process must then be organized, taken care of and given resources to.

The *assessment* of ideas must be organized. The assessment of ideas is a most crucial element. It means the early weeding out of inappropriate or unfeasible ideas so that the major attention and the resources can be given to the development of the promising ideas. Again, however, the assessment process lends itself in general more to critical, negative, conservative judgement. It is thus necessary to cater for a positive, stimulating, permissive assessment procedure. This is necessary for at least two reasons:

1. One should be careful not to reject novel, radical ideas, which may carry the potential of giving the firm a lead over its competitors.

2. The motivational aspects of the assessment process are very important: the innovative climate will be much more influenced by actions than by words. The way in which submitted ideas are assessed and treated will be regarded as one of the most important signals as to how creative and innovative the climate in the firm really is. A key problem thus is that rejected ideas lead to negative motivation. If the search has involved many generators of new ideas, consequently many ideas will be rejected. This will leave behind many disappointed, negatively motivated individuals in the organization and thus be counter-intuitive, possibly even hurting the organization more than if it had not stimulated the search for ideas internally.

Problems pertinent to these issues will be treated in some detail below in the empirical part. One instrument of considerable potential in the course of assessment should be mentioned here: the contributors-idea generators should be asked to develop their ideas further. If possible they should be given the opportunity to do this under favorable conditions as far as resources of different types are concerned.

Adopted ideas, after the assessment process, will then be *developed.* This usually means that somebody, an entrepreneur is given responsibility for developing the idea further, or eventually to take it through to full implementation.

6. INNOVATION POLICY

As already mentioned, the development of strategic issues within the IIASA electrotechnology innovation project is the responsibility of a different task group. The issue of innovation and innovation policy will thus be treated only briefly here and only because we quite frequently refer to either the importance of the existence of an innovation policy or to certain subsets of it.

The value of an innovation policy as that of any other policy, is not the paper it is written on, but how it is implemented and adhered to, and what function it plays in the managerial strategy of the firm. If a policy document is to remain a dead piece of paper it is not worth the effort invested in it. The value of a policy is its application, utilization, life and vitality as a set of principal guidelines for the organization. An outline of an innovation policy might cover the following list of subsets:

- *Aim of the policy*, its relation or ties to other subsets of the corporate policy.

- Definition of the *degree of leadership* the firm wants it to exercise or maintain.

  Does the firm want to be the number one in its industry in the country, on the continent or world wide (an expensive and rather risky policy, but, as reality shows, also often a necessary and profitable strategy). Or, does the firm rather aim at being a "good second" in industrial leadership. This is many times a quite relevant level as it does not force the firm into extremes. It is of course not without risks. The firm may miss the opportunity to get the key patents or the key processes. On the other hand, it may have an opportunity to invest into "second generation" processes, which often are much more efficient than the earlier generation is. Or, does the firm aim at the industrial average. This is not exactly a low risk strategy, as the firm will then have many competitors. It will also not be enjoying the attention of the interesting and rewarding segments of the market, because of its low level of leadership.

- A most important segment of the innovation policy will treat and define the *fields of search* to be covered: what technology segment will the firm want to apply or occupy, or, perhaps rather, what kinds of problems does the firm want to be able to solve. It means at the same time choosing whether to put the major emphasis on market oreintation or on technology orientation.

- Closely related to the previous question is the selection of *time horizons*, i.e., how far ahead to search, how long should the product life or process life of the solutions searched for be, but also how thorough, how deep, how "big" or small may or should the solutions searched for be. What emphasis is to be placed on product-, process-, and social-innovations.

- The policy will also take up the problem of goal setting in *financial* terms (with due attention paid to other subsets of the corporate policy), further it will contain principle rules for the ways in which resources are put at disposal for innovative activities. It will also contain the basic principles of investment budgeting for innovative activities.

- A major subset of the innovation policy will be confined to the *organizational aspects* of innovation: the creation of a climate favorable to innovation, the formal and informal aspects of organizing for innovation, the assignment of responsibilities, targets to be set and also the principal rules for organizing and monitoring, controlling innovative process.

- The *instruments* to be employed in innovative activities in the firm, the instrument mix will be treated.

- The *handling of risks*, physical, technological, financial and individual risks will be taken up. Also the handling of spin-off ideas and projects should be covered.

- The *patenting, licencing* and *leasing* policy aspects will be laid out.

- The reward, incentive and *stimulation systems*, as well as the training, creation of experience aspects for individuals and teams are established and linked to the firm's personnel policy.

- The *implementation* rules for the policy including its updating, usually will be treated.

- One important aspect to be covered in an innovation policy document is the establishment of a frame of reference for the enterprise's innovation management, linking together the different aspects, formal and informal instruments and features to an entity, a "design for innovation syngergy".

6.1. Idea Monitoring for Innovation in Producing Organizations (Firms)

The aims of idea monitoring are:

- to define areas of search for new ideas

- to stimulate and engage the organization members/the employees (thus not only the R & D personnel) to participate in creativity and search for new ideas for the organization

- to search for ideas both internally and externally

- to take care of ideas in early phases, before they become established, to nurture them, to channel information, to assess, to direct, to promote the implementation of ideas

- to create or to find adequate organizational structures to implement the ideas which are selected during the process of idea monitoring

- to carry through the idea to realization in production and in markets, which means the achievement of the ultimate goal, the introduction of an innovation.

6.2. Idea Monitoring Alternatives, Their Objectives and Characteristics

There is a range of idea monitoring instruments in application in enterprises. The aim of this section is a short principal overview.

Free Search

Free search means undirected search at large, e.g., competitions, idea drives, etc. An *idea drive* means a temporary (or also repeated) campaign to look for ideas, attempting to stimulate creativity either in the enterprise as a whole or in parts of the enterprise. It implies both search for and collection of ideas by either interviews, broad campaigns, e.g., competitions. Usually the drives are not entirely "free" as they often rather broadly specify what is sought for: description of needs in the enterprise, e.g., in the form of machinery, systems development; or outside the firm, e.g., specifying or defining the markets' needs or customers' needs. Similarly one looks for solution ideas in this rather broadly specified way.

Unspecified search will create a rather broad flow of unspecified ideas. This means that the necessary assessment will have to deal with quality wise highly differeing proposals. It will be kept quite busy by having to assess many often quite unqualified ideas. One major problem with such drives has already been pointed out: in the short term such a drive may create motivation and interest. As, however, many ideas will have to go into the waste paper basket, there will follow disappointment when the campaign is over. This disappointment may imply more harm to the firm that the initiative has created in positive values.

Some firms employ *idea banks*, that is, systematic recordings of ideas which have been generated and collected in the organization and which are being classified according to some system, making possible the retrieval of information available in the data bank by using certain search criteria, e.g., key words. Idea banks are often organized by the means of computerized search systems. Idea banks easily become dead files.

Directed Search

A type of directed search which is quite frequently applied by high technology firms are (*scientific*) *advisory councils*, aiming at systematic access for the firm to branches of science and technology as a base for new or early ideas, by means of experts to be tied to the council, which are highly qualified in the field and which have access to very good and rich but also "deep" information networks. They give access to early warnings about technological or scientific breakthroughs about risks, etc.

Only relatively large firms can afford to establish an advsory council. It requires not only resources for the council itself but rather high competence in the enterprise, in its organization and amongst its management to both communicate fruitfully with the advisory council, but also to transfer the yields from the council's activities into the organization, to follow up and to give the council feedback so that the council members feel motivated to engage themselves to the benefit of the firm.

A method widely used, bur rarely ever as efficient as it could be, are so-called *reading assignments*, aimed at directed news coverage in scientific literature and journals. The reading assignments not only give quick access to highly qualified news material, but also have educational goals for the organization in so far as it keeps its employees informed about new developments of interest. It can imply a rather broad engagement within the organization. It fosters openness. What is however, most frequently forgotten are the organizational aspects.

Mere circulation of journals is not nearly as efficient as organized reading assignments are. High technology firms are successfully employing organized reading assignments along the following lines: groups of five or six people are asked to continuously read certain scientific journals and to extract briefs, to be compiled and circulated. Competition amongst the groups is introduced, in order to stimulate attention and assessment of the news's relevance to the firm, by giving different groups overlapping reading assignments, so that several journals, in particular the more important ones, are covered by more than one group.

Further means to improve the efficiency is to have the groups meet regularly to discuss their findings and to compile their reports, to be circulated in the organization or even to be specifically addressed to persons who ought to be interested in the findings. Further, periodic summaries are being prepared and circulated in the organization. Usually this means that a "secretariat" will have to organize and monitor the assignments, but also to make sure that there is feedback to keep up motivation. The readers might lose their motivation to do their best if they feel that nobody actually cares about what they have to report.

A side effect report by Sjölander (1983)* is that such a system, if properly monitored brings up many policy relevant questions amongst the innovative personnel in the firm, e.g., definitions or redefinitions of areas of search, of areas on fields the firm should move into or out of. This leads to a rather vivid communication between the readers and the managerial levels responsible for the firm's strategic performance.

Career and Incentive Methods

A general problem, particularly in large organizations, is that high performers in specialities will be promoted to managerial positions, which in most cases means that they soon lose their professional proficiency and competence as they will not have an opportunity both to stay in touch with the progress their speciality is making and with the task and problems of actual research undertaken. In particular, the larger firms, e.g., in the chemical industry, have created specific *career systems* for the promotion of highly experienced technical specialists, including the promotion of gate-keepers. By creating career ladders similar to the managerial hierarchy but not belonging to it, status and pay compatible to managerial careers are awarded to scientific personnel.

Another inducement, to further the development of competence in the organization and its individualists, are *incentives* of the type stipendly for participation in symposia, study abroad, at high level universities, visits to research institutes, for shorter but also longer periods. The effects are not only the further development of the competence within the organization, but also that networks are created and developed, to improve the flow of most recent information to the organization.

Organizational Means to Monitor Ideas

The role of *gate-keepers* has already been mentioned. Their central task is to search for ideas internally and externally as well as to

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*S. Sjölander (1983) Idéhantering i stora företag (The handling of ideas in larger companies). STU-project 79-5817. Goteborg.

communicate those ideas, to stimulate the flow of ideas within the organization and also to support odd ideas. Gate-keepers will act on behalf of top management and will be attached to the central managerial function. They are given high flexibility in the fulfillment of their tasks. The effectiveness and the efficiency of the gate-keepers very much depends on the individual's capacity, and to some extent on the resources at their disposal. There is a slight risk of bureaucratization or creation of a monopoly and, if not enough resources are made available, of a bottleneck situation.

The gate-keeper may be further developed into *development agency* having the task to keep an open door for internal and external ideas, for proposals as well as for complaints, to be available at request to discuss or develop ideas; to be available for quick action when and wherever needed, in order to shorten the time elapsing between ideas being proposed, investigations made, tests undertaken, assessments conducted and decisions being made; development agents are given the task of keeping a special eye on odd ideas, to investigate their potential value, in particular when they fall between established domains within the organization or when ideas do not necessarily fit the enterprise's present sphere of activity. Development agents may also undertake periodic systematized searches for ideas or administer directed search programs. They organize workshops, task force meetings, symposia; act as "linking pins" i.e., fulfill coupling functions between different departments, but also between new product and process ideas etc.

Development agencies perform boundary spanning, in particular in the field of technological and scientific development, perhaps also in the spheres of marketing, process development, etc. The tasks of development agencies may also include idea monitoring activities, e.g., of the type mentioned in this account.

Information centers, e.g., libraries, often perform systematic professional search of literature, etc., for new ideas. Sometimes so-called literature engineers are employed in libraries, fulfilling similar functions as gate-keepers. They may also organize reading assignments of the mentioned type.

Some enterprises maintain *task pools* both for the nurturing of gate-keepers and entrepreneurs, but also as a means of creating slack for the development of entirely new lines of activities. Task pools may also be organized as a type of "fire brigade", to take care of certain opportunities or even emergencies.

Of a similar type, but more precisely confined, are *task forces*, e.g., in order to carry through projects or solve major problems in rather short time of technical character or of more comprehensive nature. The task forces usually have fairly strong task and result orientation (at least as compared to the so-called task pools). They are not necessarily innovation oriented.

To give innovative projects large degrees of freedom to develop outside of the constraints of the hierarchy or of the existing production system, firms occasionally organize *butt firms* or *sprout firms* (or, if organized within the firm, so-called *new product departments*), in order to bring a refined idea to maturity and eventual implementation, without having to climb over internal obstacles. The success of such ventures is highly dependent on the entrepreneurs taking care of them as well as of the resources being made available.

Product and process improvement projects, but also innovative projects often make use of *product councils* or *project councils*, to collect ideas, to promote changes, to assess the adequacy of proposals to the organization, to its technology, to its markets, but also to take initiatives for new products or projects. The task of such councils is not only stimulation and assessment. It also makes possible a "matrix" representation that is, of various enterprise functions being represented in the same committee or council, so that relevant communication networks are established and maintained, in order to facilitate and rationalize the introduction of novelties. The councils may also have advisory functions to top management. The councils are often of multidisciplinary type. They occasionally may become bureaucracies of their own or even reject orientation, particularly if there are strong animosities existing between different departments of divisions in the firm.

As a means to organize/monitor a rich flow of ideas, e.g., in connection with drives, firms may find it necessary to develop *priority assigning systems* for the systematic handling of improvement needs or improvement proposals, but also for systematic search for information on competition, users needs etc. Ideas collected are listed as to their urgency and their relatedness to the problems or to their urgency as far as strategic solutions are required. The highest priority is given to projects which have been selected for development or implementation. An intermediate level after assessment, is the organization of feasibility studies. The lowest priority is a listing of ideas and proposals of interest. Such priority systems are rarely used for innovations, in particular for radical innovations.

Financial Means

In order to stimulate outside researchers and inventors to place their creativity or their ideas at the disposal of the enterprise, firms, in particular larger ones, may establish a type of *research foundation*, which gives a very loose, open relation to the enterprise's present problems. Research foundations may rather be seen as a demonstration of a firm's interest in future development but also in the possibility of attracting and testing scientific personnel and inventors without an obligation to both parties to engage in contractual situations. The research foundation organizational form means little influence and control over the utilization of the results of performed research.

In order to take care of ideas not immediately applicable to production systems or products, i.e., to so-called spin-offs from regular research and development or from projects, some firms establish so-called *spin-off funds* to make further development of interesting ideas and innovations not presently employed in given portfolios possible. The aim is diversification orientated, e.g., the nurturing of bud projects to be developed into separate firms. It may be a step towards the creation of a sprout firm.

A most powerful financial method to stimulate creativity and innovativeness in organization is the so-called *President's fund*, which not only demonstrates top management interest in breaking new ways and to stimulate the flow of ideas. Funds from the President's funds are awarded to interesting ideas either on application or by proposal. This means the involvement of the President's prestige and implies a short decision span; i.e., quick decisions.

6.3. The Assessment of Idea Monitoring Activities

Idea monitoring activities have both direct and indirect effects on the organization. The direct effects are the ideas put forward, taken up and perhaps implemented. There are thus potentially some measurable effects of the achievements from idea monitoring activities, e.g., a count of the number of ideas put forward, measuring or assessing their economic value, their radicalness, their patentability. However, there are perhaps more direct effects that are hard to measure, e.g., top management involvement; refinement, development, actuality, relevance of the enterprise's innovation policy, the resources for research and development and innovative activities are generally made available, the type and mix of incentives at hand in the organization.

The growth and profitability of the organization are ultimate measures, of course. It will, however, be very difficult to establish causal links between the different idea monitoring activities and such general measure. The existence of idea monitoring systems in an organization may have impacts on the performance of its members as they feel stimulated or even under stress. The concentration or dispersion of resources over different activities will be changing, certainly also the speed of action or reaction to challenges and opportunities from the market, but also agreement on ideas collected and selected.

One problem is the balance between short and long term activities (as indicated in the earlier discussion of needs for action and ideas for the solution of action needs).

The efficiency of the idea monitoring activities will be dependent upon, e.g., the status of the person responsible for idea monitoring policies and activities; on the number of functions more or less covered by the monitoring activities; the width and depth of coverage, the focus, the ease of communication, the internal versus external idea monitoring orientation, its character whether permanent or repetitive or even one-off, and the formal and analytic idea assessment procedures and their relation to corporate policy.

Starting innovation monitoring activities will commit management in a range of different ways. Top management will see itself confronted with many questions or requests, not only for making resources and slacks available, but also to become more explicit on, e.g., areas of search, making the innovation policy more relevant, explicit reality-oriented, and to give mental motivational support, beyond financial support, to innovation. In general too management will see itself much more involved in innovation related decision making if it undertakes to implement different types of idea monitoring systems in the organization. The manager or managers concerned with innovation monitoring will have to devote considerable time not only to internal activities but also to the developing external networks that may result from more deliberate actions in this field.

Innovation monitoring should aim more for quality than quantity, as quantity may bring a number of negative side-effects as, e.g., the disappointment due to rejected or not accepted ideas and the "noise" involved with handling quantity in a proper way, which may mean diluting resources because of having taken care of many relatively unrelated and irrelevant ideas.

The reader should be reminded of the rather well known not-invented-here syndrome. Management should be aware of this syndrome when organizing for

innovation monitoring, as ideas or even projects may meet resistance from parts of the organization that were not involved in their development. It is thus particularly essential that both marketing and production departments be involved fairly early or, through organizational arrangements, be regularly kept responsible and informed about idea monitoring activities.

Attention is again drawn to the importance of the assessment procedures, not only to the motivational effects, but also to its stringency: explicit criteria should be used, criteria which should be in the innovation policy of the firm and which might be organized into formal assessment procedures or models. The advantage is that the existence of such criteria will help to specify and define the direction of search (of course at the expense of radical innovation ideas, which may be witheld or rejected, because of the availability and application of explicit criteria). It should, however, be kept in mind that concentration of search and idea production improves the competence within the organization to handle new ideas and utilizes the scarce resources of the organization in a better way.

Firms employing idea monitoring systems should also design carefully thought-over incentive systems.

And last, but not least, the ultimate test of the effectiveness of idea monitoring is the improvement in profitability and survival capacity/competition situation of the firm. Idea monitoring is not a matter of curiosity or intellectual interests. Its aim is strictly for a better performance on the market.

INNOVATIONS IN ELECTRICAL ENGINEERING: ORGANIZATIONAL STRUCTURES FOR THE 1980s

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1. SPECIFIC FEATURES OF ELECTRICAL ENGINEERING DEVELOPMENT IN THE 1980s

Forecasts of social development and consumption indicate that the forthcoming decades will be characterized by the extended use of electrical engineering equipment, implying a substantial and stable demand, a wider range, and higher quality of products. In this context, a further concentration of production in electrical engineering is feasible. Sufficiently large firms and corporations with various production units and a well-developed infrastructure will be most effective.

Despite a highly and ever increasing demand, part of the products will have to be continually updated, primarily necessitated by the consumer's need for energy efficient, lighter and smaller products with a wider application range. The need for combined facilities featuring compatible equipment that can use the same electrical motors, transformers, control devices, etc., is increasing. High rates of assortment renovation will necessitate a shift from traditional finished-product specialization. Instead preference will be given for specialization in production units, processes and parts which provide for a faster and cheaper switchover to new products.

If this forecast turns out to be true, the production structure of firms will have to undergo essential changes. Instead of relatively closed production units making a limited number of finished products, there will be shops and assembly lines producing a wide range of general-purpose parts easily readjustable to a different assortment. The use of more powerful and efficient technological equipment will be economically justified: production units will be enlarged and their capacity increased. This will be accompanied by an extended scale and form of production cooperation, as well as by the increasing interaction and coordination of product units' activities. On the other hand, the number of such units will decrease and their structure and cooperation will be simplified.

Electrical engineering products fall under the category of sophisticated goods with regard to both the manufacturing process and the number of component parts involved. Essential changes in the degree of sophistication are hardly to be expected in the next few decades which means that every firm will have to continue purchasing large quantities of various materials and parts, using sophiticated technological equipment, fittings and tools, and conducting special costly tests. The application of electrical engineering products will also be more complicated in that it urges firms to undertake after-purchase service, i..e, to set up extra production units located long distances from one another.

The pre-production stage for electrical engineering products is very complex and labor-intensive and involves special R & D, process equipment design, mockups, prototypes and installations, as well as special test runs, of all which necessitates the establishment and continual extension of large design and research centers. The share and scale of R & D allocations will continue climbing, and R & D in manufacturing processes is expected to gain the special importance and momentum warranted by the economic situation of the 1980s. This will obviously call for a sharp increase in labor efficiency and lower inputs of raw materials, fuel and energy through improved technology at lower investment costs. Greater emphasis will also be put on longer life and modernization of equipment, as well as updating and retooling production facilities. All this will involve an accelerated growth and greater role for engineering services.

The above changes in the production and technological structure of electrical engineering companies will be accompanied by essential changes in the economic environment under which they will have to operate. High international competition, limited resources for investment, and more sophisticated requirements will dictate strict control over all production costs to prevent stock-piling, require better interaction between cooperating units, and allow for minimal risk taking in the development and manufacture of new products and processes. On the other hand, the concentrated production within a company, the increased capacity of individual production units, the switchover to specialized technology and manufacture of parts, the extended range of products and speedier assortment renovation, all warrant improved coordination of all the company's activities. In this context centralized administrative management fails to be effective and ought to be combined with decentralized self-regulation of the lower levels employing economic incentives and control. It also means a delegation of resource management authority to production divisions and units, the establishment of additional cost control centers, and rigid supervision over the many distributed functions on the part of the company's top executives.

Increased attention should also be given to the social aspects of management. Mechanization and automation will lead to a relatively lower number of employees but higher standards will be expected of their skills, conditions and content of work, and to the levels of compensation. Higher general and per unit efficiency of the equipment will increase the contribution of each operator to the final product and economic result of a division's activity, and make quality control a more complicated affair. Enhanced specialization will result in increased job interdependence and warrent new organizational forms for primary groups and greater individual responsibility for the groups' final results.

All the above points will have a direct bearing on the company's aims, nature, and content of innovations, as well as on the methods and forms of management organizational structures in the 1980s (see Table 1).

Table 1. Factors and trends of electrotechnoloy development.

Most significant factors	Types of development			
	Production	Technological	Economic	Social
1. Increased product demand and larger scale production	Concentration of production; increased capacity of production units	Application of more productive and powerful equipment	Increased consumption of resources and larger turnover of capital	Growth of manpower.
2. Higher quality and extended assortment requirements	Diversification of production; switchover to specialization in process and product; increased intracompany cooperation	Faster rates of product and technology modernization; R & D expansion	Larger degree of economic risks; higher costs per unit of production	Higher skills of workforce; enhanced role of work groups and collective labor in quality standard provision
3. Greater sophistication of products and production	Greater complexity of production structure	Greater emphasis on research; more sophisticated preproduction stage	Larger assortment of purchased materials; growing number of suppliers and higher cost of purchases	
4. More complex economic situation	Increased interaction of production units; coordination of plans	Economy in labor, materials and energy inputs; greater accent on mainte	Delegation of authority in resource management to lower echelons and the latter's greater responsibility for productivity	Increased contribution of each operator to final results of economic activities

2. MAJOR TYPES OF INNOVATIONS AND THEIR CHARACTERISTICS

Study is made here only of those innovations which are related to essential changes in the nature, content, and results of a company's own activities or the activities of its large divisions. As a rule, they involve decision-making and control of implementation at top management level, considerable additional resources, mobilization of internal resources, and coordinated activities on many managerial and production units. Many firms implement such innovations in the form of programs or projects.

The nature of an innovation pre-determines the method of its implmentation, as well as the form and content of a respective project. In many scientific works (e.g., Barreyre 1980 and Zaltman and Holbec 1973) innovations are classified by their major factors and according to their goal orientation which is determined by the final result as follows:

Commercial innovations aim to change market policies, prices, and relationships with suppliers and consumers; offer new goods and services; receive or grant loans; introduce new procedures of profit distribution and different uses of savings, etc.

Production innovations involve extending production capacities, diversification of manufacturing activities, and changing the production structure and proportions between the capacities of individual production units, sections and assembly lines.

Technological innovations are oriented towards development and manufacture of new products; development and application of new processes and materials; updating of equipment; streamlining and modernization of production facilities and structures; implementation of environmental protection measures.

Economic innovations are intended to change the methods and techniques of planning in all types of economic activities, eliminating and accounting production costs and results, providing economic incentives and compensation, realizing mutual settlements between units and divisions, etc.

Social innovations are designed to improve working conditions and the manner of labor, social security and services, the psychological climate and interrelationships within a company or its individual divisions.

Management innovations are aimed to improve organizational structures, the style and methods of management; employ new methods of information and documents processing; streamlining clerical work, etc.

It is easy to see that the above-specified types of innovations can be closely related to each other, specifically, commercial, production, and technological ones. Adoption of one type of innovation often calls for many others, which is why comprehensive programs may be drawn up within a company contemplating several types of innovations at the same time. However, the forms and methods of work meant to achieve each specific result vary and it is therefore necessary to define special subprogrms (projects) within the framework of comprehensive programs for each of the above types of innovations.

Another important indicator of innovations and their projects is their scale, characterized by who and what are involved in implementing the project and what its contribution to the company's total activity is expected to be. A three-level classification can be applied here:

—*total* innovations that involve most units and personnel with an essential effect on the process and results of the company's activities;
—*local* innovations that are implemented in one or several closely related units but do not effect the entire company's activities; at the same time these innovations influence essentially the results of a unit's functioning, the volume of consumed resources, or ways of interaction with other units and, consequently, require supervision and control on the part of the company's top executives;
—*medium-scale* innovations that involve varying contributions on the part of several units to the company's overall performance; they are intermediate between total and local innovations.

Another indicator closely related to the classification of an innovation's scale is the influence of its results on specific cases of the company's performance and hence the achievement of strategic objectives. As a rule, total innovations are characterized by a *wide* sphere of influence; medium-scale innovations affect the activities of production units and functional subdivisions and have a *limited* sphere of influence; local innovations have a *narrow* sphere of influence related to the activities of individual units. There may be exceptions when, for example, the results of a local project can, at a later stage, affect the performance of many units (particularly in combination with other local innovations). An organizational structure analysis can also address total or medium-scale projects as a set of local projects, specifically if they lack in value and goal orientation.

With regard to their results, innovations can be classified as *ordinary*, *urgent* or *extraordinary* (special). Ordinary innovations are not very essential for the company as a whole and their deadlines can easily be postponed. Urgent innovations are sufficiently important for the company's performance to be implemented within strictly fixed time limits. Innovations which are of vital importance to the company (or require very large resources) can be viewed as extraordinary and it is clear that total projects are most likely to fall in this category, although they may be regarded as medium-scale innovations as well. At the same time, total projects may, in certain cases, be rated as ordinary.

In many cases, an analysis of innovations requires an insight into the volume of financial resources used and their sources. From this angle, projects can be classified as follows:

— *operational* (financed from their own working capital and/or profit deductions);
— *credit* (based on short-term loans);
— *capital supply* (based on large, long-term investments).

In the context of organizational structuring, duration and frequency are also important characteristics of innovation projects. Duration criteria can be based on the standard planning period used by a company. If a project is to be implemented within a current planning period (in most cases one year)

it will be *short-time*. If two or more current planning periods are required for it to materialize then it would be classed as *long-term*. Experience indicates that there is little call for intermediate time characteristics. The frequency of innovations can be broken down into three groups. Innovations that are introduced without long breaks inbetween (for instance in design and technology improvements) fall in the category of *regular* projects. If innovations have to be repeatedly reintroduced even with long breaks inbetween (for instance, change in renumeration or organizational structures) they may be called *periodic*. Finally, innovations that are most unlikely to be repeated are *single-time*.

One special criterion by which innovations can be differentiated is the character of relationships (interaction) emerging in the course of their implementation. It is important to identify such relationships. Some innovation projects may involve several units without warranting close cooperation between them, for example, improvement of working conditions and management styles, or the introduction of new methods of accounting and reporting. Such projects are named *discrete*. Other innovations call for close interaction and coordinated efforts of the numerous parties involved, for example, in the mass production of new goods, improvement of quality standards, and organizational structure changes. These projects are called *interrelated*. The character of interaction between the parties implementing innovations may be *neutral* (denoting no change in routine relationships), *moderate* (where operational relationships between a limited number of units have to be stepped up), and *active* (with constant and multifarious cooperation between a wide range of units).

Also taken into account should be how many, if any, external organizations and parties are involved in implementing the innovation. If an innovation is developed and implemented by the company alone it may be called *independent*. If an innovation originates with a consultive firm or an outside design organization that assumes responsibility for the R & D and project management, it may be called *client-oriented*. Innovations based on purchased technology, licenses and outside documentation, as well as large external subsidies and extensive amounts of supplied goods and services, are called *dependent*.

All the above factors and characteristics of innovations, projects and their implementation predetermine the organizational forms and methods selected for the management of electrical engineering companies. (See Figure 1.)

3. SPECIFIC ORGANIZATIONAL FEATURES OF INNOVATION PROJECT MANAGEMENT

Before any changes are made to a company's organizational structure with a view to implementing a wide range of innovations, it is necessary to first consider the major requirements. It is universally recognized that project management offers new organizational opportunities for more effective innovation implementation. However, both in practice and in scientific literature, experts more often than not address only a few of the organizational forms of project management bearing on a certain class of innovations.

In the large organizational systems of today, all the classes and forms of innovations described above can be carried out simultaneously with a wide margin of difference in the forms of specific project implementation. It is important to define a variety of these forms, to see the extent of their

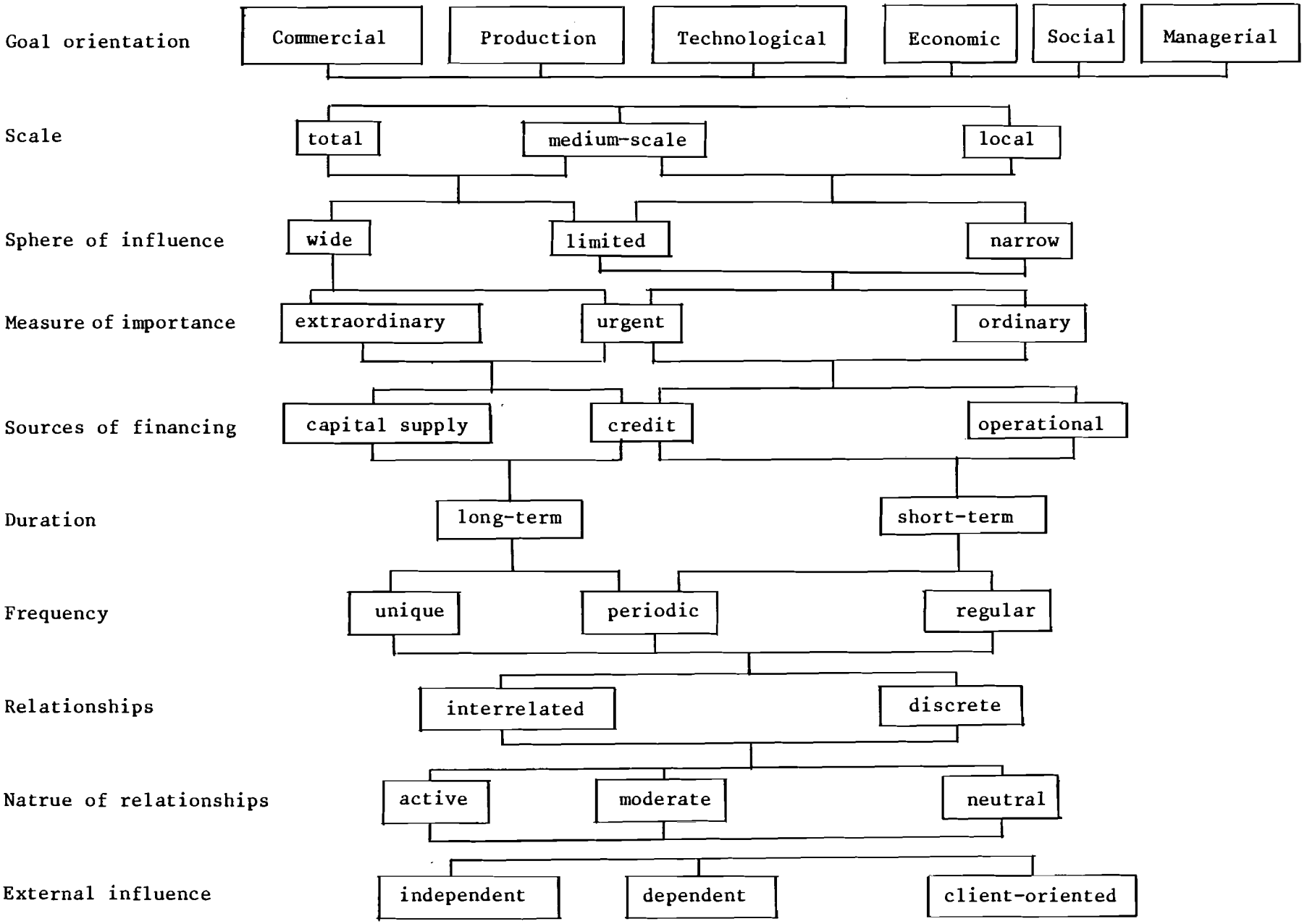


Figure 1. An integrated classification diagram of innovations and their implementation.

compatibility or incompatibility, whether or not and how they can be built into the traditional management structures, and whether all types of project management requirements can be met simultaneously without affecting a company's normal activities (Knight and Kenneth 1977, Milner et al. 1983).

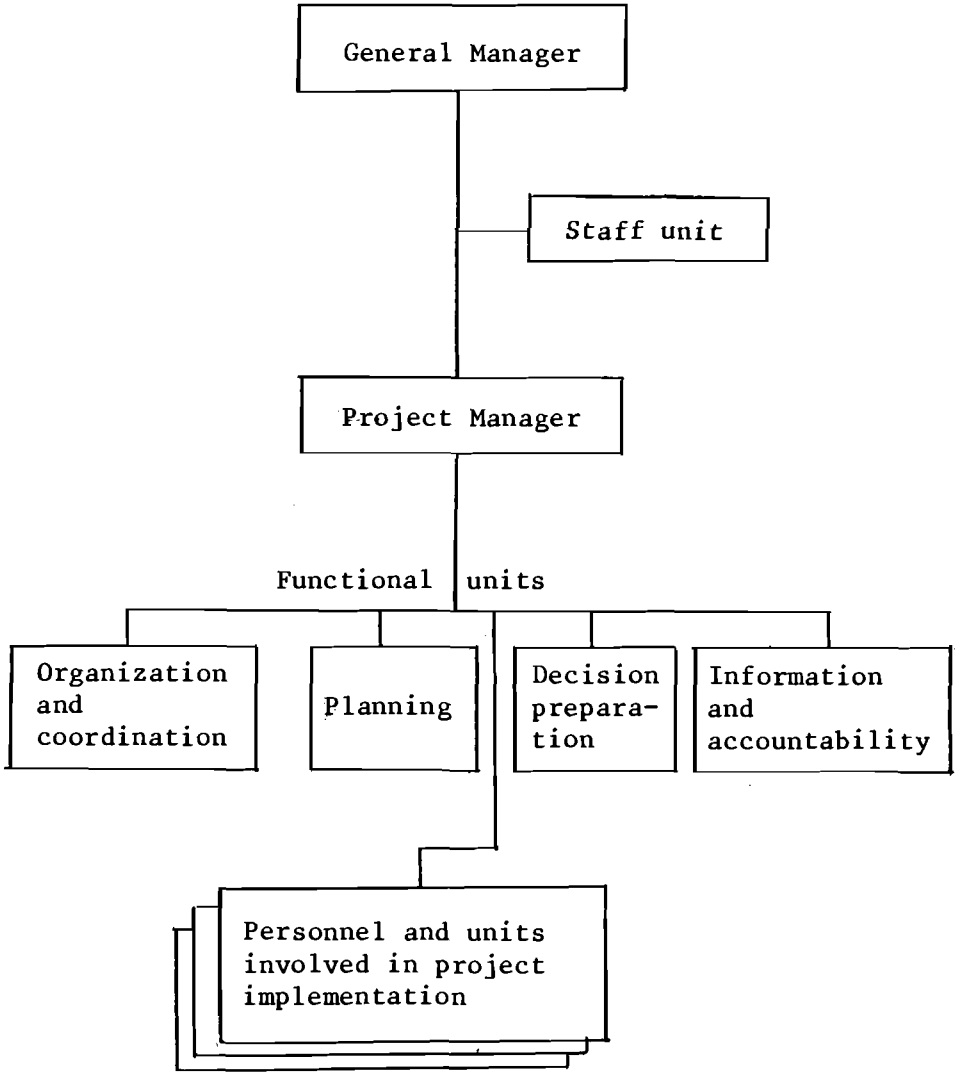
In our analysis we shall act on the assumption that the process of implementing an innovation is a specific operating subsystem that in each case requires an organizational system adequate to the complexity and content of the project. A typical structure of such is given in Figure 2. The composition and size of the staff and functional units in the chart depends on the volume and complexity of work required for the implementation of the project and may differ, but the hierarchy in the allocation of management functions always remains invariable. The choice of project management organizational forms is governed by the following considerations.

On the one hand, the goal of the innovation may well be compatible with the tasks of a specialized functional or production unit of a company and its implementation is achieved through routine interaction with other units. In terms of the suggested classification it is a local project, normally of operational type, of short duration and with neutral relationships. No changes are required in the company's existing divisional structure for its implementation. In this case the head of the respective unit or his deputy is appointed project manager. On the other hand, the innovation goal may rank as a major company goal and its implementation necessitates involving a larger part of the company's units and personnel. These are usually total projects of extraordinary significance, with a wide sphere of influence, of long duration, capital supply and with an active relationship. In this case the organizational system of project management is identified with the entire company's structure, and the project manager is usually a first deputy of the company's general manager. All other innovation projects lie within these boundaries of choice, and their management calls for specific organizational decision (Martin 1976, Rapoport 1979).

The simplest and most easy-to-use form of project management organization is to set up working groups as independent structural units reporting to a project manager. All those concerned with the execution of the project are included in these groups, irrespective of their former job placements, and are fully subordinated to the project manager. This approach is justified when the innovation implementation takes a sufficiently long time and the personnel transferred to the special project units have enough work to attend to. This form is usually employed for medium scale, intensly and actively interrelated, long-term projects of long duration. The working groups of the above type can also be formed to carry out short-term regular projects that occur frequently enough to provide a stable workload for those involved.

In all other cases the most rational organizational form of project management is the matrix organizational structure based on an organic interaction of the program and functional structures. The general principles of the matrix organizational structure are as follows (see Figure 3).

The project manager is given authority by the organization's top administrator to control the resources and personnel required for the project. To limit the project manager's sphere of control and avoid disrupting the organization's traditional line and functional structure, a dual reporting mechanism of responsible (chief) officers is instituted. A responsible officer is the chief of a unit or group in charge of an independent part of the project. and he reports content, deadlines, and fulfillment of assignments related to



Formulation of the goals of innovation; appointment of project manager and his staff; allocation of resources.

Identification of need for innovation; analysis of situation; definition of alternative decisions for general manager.

Operational management to ensure achievement of the goal; management of human and material resources.

Selection of project teams and distribution of assignments and resources between them; supervision and assessment of performance; durrent regulation of project progress.

Figure 2. Typical structure of a project management system and general distribution of functions.

Project management bodies

Bodies of general (line) management structure

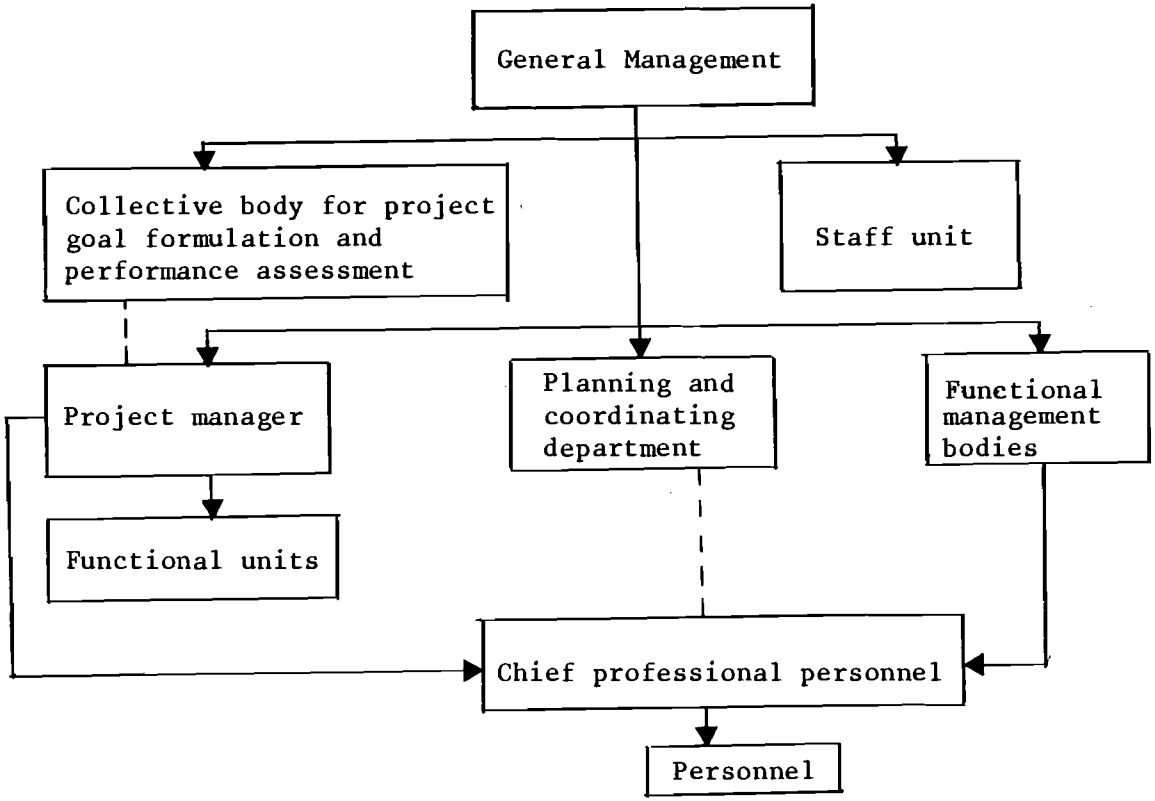


Figure 3. Diagram of matrix organizational structure in program management.

project to the project manager. On all other aspects of his activities he reports to his superior in the company's hierarchy.

To harmonize and coordinate interfunctional activities related to the project special bodies are set up. At the top level it is a collegiate body such as a committee of the Board of Directors or a council under a vice president of the company. At the middle level it may be a staff body such as a planning and coordinating unit or office. The latter seeks to achieve a balanced distribution of resources between the projects and other normal activities of the company. Depending on the class and type of innovations, organizational forms of project management may differ. For example, according to the goal-orientation of the project (commercial, production, technological, etc.), different types of collegiate bodies are set up to look into the goals, assess the degree of their achievement, approve the project terms and the project managers, as well as allocate resources. As a rule, a staff unit is formed under the auspices of a company's vice president to analyse the situation and prepare decisions on various classes in innovations, as well as to attend to normal functioning of the project collegiate bodies. The staff functions may be assigned to some company's acting management units whose specialization is best suited for the purpose.

The status and role of project managers depends, with a wide margin of difference, on the scale and nature of the innovation. Managers of total, extremely important (extraordinary) and capital-supply projects are given maximum authority; in their sphere of competence they are empowered to act as deputies to the company's general manager. Managers of smaller projects with a limited sphere of influence and a smaller team have less authority. These functions can be assigned to managers and experts of some units under the general guidance of the company's vice president responsible for this task. Finally, local, ordinary and operational projects, with a narrow sphere of influence, can be run routinely without special redistribution of functions between the existing units, provided the volume of alloted resources is specified and control over their use is intensified at a higher management level.

The size of the staff unit to help the project manager run the project again depends on the status and authority of this manager. In the case of a long-term, large-scale, independent and active project, which requires vast activities related to collection and analysis of data, preparation of decisions and control over their implementation, the manager is provided with a large staff body that may consist of several units. If the role of the required supporting work is insignificant (for example, in the case of client-oriented and dependent innovations) the relevant functions can be performed by existing units from different functional divisions (blocks) of the company that do not report to the project manager.

The organizational forms of project management depend to a large extent on the volume and nature of the innovation relationships. Interrelated, active projects require a plenipotentiary manager and an effective matrix structure. Alternatively, most discrete projects can do with a clear-cut coordination of planned decisions and strict control over their fulfillment, which can be effectively handled by the existing planning and coordinating bodies and specialized units of the functional blocks. These principles underlie many an innovation oriented to achieve economic and social aims, to maintain quality standards and to protect the environment (Milner et al. 1983, Rapoport 1979).

4. ORGANIZATIONAL PRINCIPLES OF MANAGEMENT IN AN INNOVATION-ORIENTED CONTEXT

The existing and expected requirements for management organization arising from the development of electrotechnology in the 1980s, and the need for extended innovation activities will lead to essential changes in organizational structures. Due account ought to be taken of the time-tested objective principles, regularities and trends in the development of management systems. These fundamentals are not going to lose their value in the future. Most noteworthy among these principles and trends are the following ones (Milner et al. 1975):

- unity of management in the mission-oriented allocation of all resources
- centralized, strategic and total decision making delegation to the lowest possible level
- divisionalization into large production and functional units oriented towards achieving relatively independent final results through independent use of allocated resources
- specialization of units and personnel in specific management functions and technologically similar types of operations
- greater degree of coordination necesitated by specialization of management units in certain functions and types of work, and of production units in products and types of service
- observance of organizational span of control for line managers, and extension of the organizational hierarchy as the organization expands.

These principles and trends manifest themselves objectively and attempts at ignorning them adversely affect the results of the entire company's activities. In this context, the employment of only functional (divisional) structures produced too many contradictions, conflicts and organizational headaches (Galbraith and Nathanson 1978). These include, for example, problems of discrepancy between the goals of the hierarchical levels of management and horizontal units, inadequate flexibility and adaptability of the management system, etc. The effects of such problems and conflicts are all too well known: lower effectiveness of the company's functioning, slow-down, and unsatisfactory implmentation of innovations.

The use of a matrix organizational structure for project management makes it much easier to improve organizational designs and to eliminate or reduce many organizational difficulties. The general guidelines to improve management systems, based on traditional and new organizational forms, are given in Table 2.

In choosing a specific organizational design, in accordance with these guidelines, it is expedient to lean on some of the following general criteria (Rapoport 1979):

- each management body must be fully responsible for the achievement of its managerial objectives (subgoals)
- objectives of all units of various levels of management must be balanced with respect to the goals of a higher level
- performance of the combined managerial functions related to each objective must be comprehensive (both in "vertical" and "horizontal" interaction)
- the organizational framework of project and product management subsystems must provide for minimal duplication of functions and work operations

Table 2. Key organizational problems of management and major principles for their solution.

Problem	Negative effects on the company's activities	Major guidelines for management system's improvement
1. Discordance of goals of the hierarchical levels of management	Contradictory administrative effects on personnel and their economic motivation. Excessive concentration of authority at higher management levels. Poor discipline on the part of the personnel. Lack of incentives to achieve higher performance and quality	1.1. Responsibility for the economic results of the production and economic activities ought to be assigned to higher and middle management levels. 1.2. Economic responsibility for qualitative and timely solutions ought to be introduced and a switch-over to normative management effected. 1.3. Longer-term and current management functions ought to be divided. 1.4. Concentrated management support of production units at the middle level and more rigid demands that assignments and norms be fulfilled.
2. Discordance of goals of the company's functional subsystems	Subsystems are oreinted at maximizing their results at the expense of the entire company's interests. Excessive and unbalanced consumption of resources. Adequately coordinated functional activities cannot be ensured. Frequently conflicts between managers of subsystems and units.	2.1. The tasks of the functional subsystems ought to be strictly reoriented towards the company's final goals. 2.2. Bodies and procedures ought to be set up for current coordination of functional activities. 2.3. Goal-oriented distribution of resources and control over their proper use ought to be instituted.
3. Inadequate flexibility and adaptability of the management mechanism to changing tasks and conditions	Slow and inadequate innovation activity. Use of obsolete forms and methods of business. Constant deficit of resources; substandard quality of products.	3.1. A switch ought to be made from functional regulation of the management mechanism to normative goal regulation. 3.2. Linear and functional forms (divisional) forms of mangement systems should be combined with programe management. 3.3. Middle management ought to be given more independence and responsibility.

Table 2 continued.

Problem	Negative effects on the company's activities	Major guidelines for management system's improvement
4. Lack of correspondence between the content of planning and coordination decisions on the one hand, and supervisory administrative activites on the other.	Planned decisions are inadequately substantiated and supported. Unsatisfactory use of reserves. Failure to fulfill assignment both as regards deadlines and range of products.	4.1. Management contour ought to be closed through compulsory feedback. 4.2. Decision making authority ought to be delegated to management levels directly in charge of the project.
5. Organizational boundaries of operating subsystem do not coincide with the sphere of mangement bodie's responsibility and assignments.	Management bodies cannot fully control fulfillment of the tasks; Overlapping of functions performed by different bodies; Conflicting interests of units and bodies oriented towards the same tasks	5.1. As far as possible all executive units handling the same task ought to be subordinated to a respective management body. 5.2. Decisions for tasks handled by organizationally independent executives should be made at a higher level. 5.3. Leading management bodies ought to be authorized to coordinate and guide the activities of all executives handling the same task.
6. Functional bodies' structure at all levels of management is not adequate to the structure and content of functional tasks	Units at different levels perform the same management functions; Uncoordinated activities of units at the same hierarchical level; Functional units are scattered.	6.1. Forecasting, long-term planning and analytical functions ought to be centralized at the highest administrative level. 6.2. Individual managers of subdivisions and units ought to be empowered to coordinate similar functional activities. 6.3. Specialized functional units should be switching from procedural technological to problem goal orientation. 6.4. Servicing and supporting functions ought to be concentrated in middle-level units. 6.5. Complex subdivisions and units performing combined functions and types of activities aimed at achieving the common result ought to be set up.

Table 2 continued.

Problem	Negative effects on the company's activities	Major guidelines for management system's improvement
7. Administrative authority exceeds the economic interests of subordinated units	Inadequate responsibility of higher level managers for decision making; Unstable planned targets, economic norms and incentives; Production units are not supported by adequate services.	7.1. A supervisory inspectorate under the Board of Directors must be set up. 7.2. Managers must bear economic responsibility for the quality of decisions. 7.3. Economic norms and their observance ought to be supervised by the Board of Directors' Economic Council. 7.4. Computers must be used in elaboration and control of fulfillment of production assignments.
8. Overzealous strive to reduce the management expenses.	Low-paid clerks are substituted for highly paid skilled labor; Analytical and forecasting functions are performed unsatisfactorily; The range of functions of managers and specialists is not rational; Services offered to managers are not satisfactory; Adopted decisions are of low quality.	8.1. Assessment of management effectiveness and maintenance costs ought to be based on the final results of the company's performance. 8.2. Resources for analytical, service and supporting functions should meet substantiated norms.

— existence of conditions for specialization of individual operators and primary units in integrated divisions
— concentration of responsibility for the achievement of each subgoal and the handling of each independent managerial task in one management body (manager)
— balanced responsibility for the achievement of the goal and hence decision-making authority in each unit and at each level of management.

An extensive use of project management organizational forms in combination with traditional ones based on matrix organization is necessitated not only by the creation of new jobs and positions but also of new subdivisions, the appearance of new functions or re-distribution of old ones, etc. It is also caused by the revolutionary changes in the nature of management relationships, a transition to a new style of cooperation between individual management bodies and employees, resulting in an organizational system of new type (Chandler 1977). As far back as 20 years ago Burns and Stalker (1961) defined some essential differences between systems oriented to function in stable conditions and those to operate in a changing environment that necessitated innovations.

The first type of systems which they called "mechanistic" uses traditional line and functional structures. Their main characteristic features are as follows: functional specialization of units and personnel; no relationship between the tasks of an operator and the final goals of the organization; strictly regulated authorities and responsibilities of personnel in the performance of each function; mostly vertical interaction of structural subdivisions, etc. The second type of systems, called "organic" requires matrix management structures. Burns and Stalker describe its distinguishing features as follows: personnel and units are oriented at the specific tasks arising out of the organization's goals rather than at functions; quality of control over the results is not strictly regulated; interaction of structural units is mostly horizontal; etc. The experience in the use of matrix structures has accumulated new characteristics of the organic systems' style of functioning (Davis and Lawrence 1977, Knight 1977, Martin 1976).

Practical experience indicates, however, that in contemporary conditions greater effectiveness is achieved by combining the mechanistic and organic types of systems. Project management cannot develop without a stable basis in the form of a rational line and functional structure. Therefore, the principal trend in the development of organizational structures over the period under review will be simultaneous and interrelated improvement of management relationships both in the *vertical* hierarchical divisions of functional or project specialization, and in *horizontal* project or problem-oriented subsystems. The same conclusion was arrived at by American specialists (Kerzner 1981, Steiner and Miner 1982).

Of what nature and how comprehensive should be organizational changes in a company is an overriding challenge in the forthcoming period. Here opinions vary. One of the most widespread views is that an organizational structure must be very flexible and instantly responsive to the changing environment. This approach necessitates continuous restructuring of the organization to react to the outside changes and do away with internal disproportions and discordances. In this context resistance to changes is regarded as something negative, a sign of obsolescence, bureaucracy, etc.

However, any restructuring, even if intended to achieve a justified goal, interfers with an organization's normal functioning and the interaction of personnel and units, and makes the status of many a person very indefinite and unstable. Moreover, the majority of small changes in the structure produce a very insignificant effect but interfere with traditional relationships and proportions involving at the same time a series of subsequent secondary alterations. On the whole, all this leads to the following: losses from the destabilized relationships caused by continuous organizational restructuring often exceed the effect achieved through re-organization. This is why we fully support D. Miller's (1982) opinion that infrequent, but important in nature and scale restructuring should be preferred to endless, continual, step-by-step changes and modifications in the organizational structure and activities of a company. No wonder that this approach cannot help affecting most essentially selection of organizational structures: the decisions must be more radical and comprehensive.

5. SOME GENERAL DIRECTIONS OF CHANGE IN ORGANIZATIONAL STRUCTURE

It is safe to assume from what was said above that the major development trend of management organizational structures in electrotechnology over the next decade will be a more organic combination of line and functional as well as project forms based on matrix management organization. Let us see how this will be reflected in the basic characteristics of organizational structures.

5.1. Complexity of Management and the Scale of the Managerial System

As an organization grows larger, its products and their manufacturing technology become more sophisticated, specialization and cooperation of production becomes deeper, management becomes increasingly more complex. Matrix management organization will also add to this complexity. This will be manifest in increased volume of managerial work, particularly high-skilled, in number and variety of management units and multiplied relationships and interactions inside the management systems. First of all, there will be a larger number of employees, mainly experts and middle-level managers. Besides, a relative share of white-collar workers in the total contingent of employees will go up. The rate of this change will also be determined by a faster growth of the labor productivity of blue collar workers as compared to that of white-collar employees, specifically the high-skilled.

5.2. Type of Organizational Pattern

The general structural pattern of electrical engineering companies will correspond most of all with a divisional scheme, but with a great deal of possible variations. Product divisions with a closed cycle of production may prevail at large diversified firms. Classical functional patterns seem to be most expedient to be used in such divisions, whereas monoproduct divisions are better suited for product management patterns (II).

Medium-sized and some larger companies may find it more preferable to set up both product and functional (technological) divisions which are, as a rule, supporting (supplying or servicing). Inside such divisions functional structures (for larger firms where functional management is decentralized) and staff units (for medium-size companies where some management functions need centralizing) are employed. Mülfer-Berghoff (1981) describes a large West German electrical firm which uses an original matrix-divisional structure.

It has the following product divisions: electric transport, power generating equipment, etc.; electrical appliances and means of automation and communication; electric motors and measuring equipment; and mass production of smaller items. There are also the following managerial functional units: sales and supplies; technology development; finances and commerce; and personnel. A combination of these two types of specialization results in a matrix of 400 squares. The scheme described is undoubtedly most flexible and economical. At the same time, it is based on a highly centralized management and, as the author admits, imposes a considerable workload on the top management to achieve coordination of all activities. Our study indicates that local, medium-scale and interrelated projects may cause plenty of hard-to-solve problems within such structural frameworks.

5.3. Levels in the Organizational Hierarchy

Classical divisional and functional structures have, as a rule, a three-level hierarchy: top (management of company and its staff), middle (management of divisions and their functional machinery) and bottom (linear managers of production units).

In medium-size and larger firms, especially those diversified, the number of product divisions and functional units becomes so large that span of control standards requires an intermediate coordinating staff level (group management) between the top and middle levels. The structure thus becomes a four-level hierarchy. It ought to be borne in mind too, that in view of the huge amount of managerial work and the continuous specialization of functional units the management system of the middle and bottom levels have, in their turn, a multi-level structure (sometimes up to 3 or 4 levels).

The establishment of project management systems, aimed particularly at introducing total long-term innovations, in terms of top management span of control, is equivalent to an increase in the number of divisions. Therefore, more often than not application of a matrix organizational structure leads to the formation, sometimes in an implicit form, of an extra management level with most project managers actually operating in the third or even lower levels from the top management. Depending on the project scale and complexity, its internal structure may also be multi-level. A subprogram manager (coordinator) may be an intermediate link between the project manager and the personnel responsible for the work, whereas the number of intermediate levels between the responsible personnel and lower level units (primary groups and employees) may be quite a few.

5.4. Centralized Decision Making

Decentralized decision making conduces to increased span of control for top and middle-level managers. However, specialized manufacture and management, as well as a more pressing economic situation, lessen opportunities for decentralization. Therefore, large and medium-size firms should normally avoid full centralization, as well as maximum decentralization. The most preferable option is partial decentralization (when operational decisions are largely made at the level of division managers) and distributed decision making (when the top level approves major goals, limits and norms, the middle level develops strategies and formulates innovation projects, and the bottom level performs the actual managerial functions).

The same approach to centralized decision making is exercised to organization of project management. However, with regard to individual extremely

important projects that have to be implemented within very short time limits and in view of limited resources, fully centralized management is possible irrespective of their scale.

5.6. Differentiated Leadership

As the nature of an organization's general goals does not change, the structure of leadership at the top level remains stable. However, the middle level is characterized by increasingly differentiated tasks and a growing number of units, functional divisions and projects. Hence, a growing variety of managers of different position, orientation, professional and organizational skills: also, more conflicts of interests, limited direct contacts, and more complicated coordination.

5.7. Concentration of Functional Activities.

There are two opposite trends. For medium sized firms, as their scope of activities expands, concentrated efforts related to functional services and enlarged specialized units are sufficiently effective. Moreover, enlarged managerial divisions provide services to various production and business units. However, for larger firms, larger amount of managerial work results in excessive growth of functional divisions. The benefits of specialization give way to discomforts caused by the complex, multi-level structure of divisions, their deteriorating relationships with the relevant production units and lower efficiency of functional management. In this situation, it is more preferable to disintegrate large units and transfer them to production units or problem-oriented subsystems. It stands to reason that the diffusion boundaries lie within such dimensions of functional units which allow for the full benefits of specialization.

5.8. Span of Control

The general trend towards increased managerial work and the inevitable division of labor significantly extend the span of top and middle level managers' control. In this context retention of traditional span of control would add so many extra levels to the hierarchical structure that the efficiency and reliability of the system will be seriously jeopardized. To avoid this every opportunity must be used to extend the span of control. Among the most effective measures to achieve this there are application of technical data monitoring and processing facilities, decentralized leadership, and setting up staff and coordinating bodies under managers.

5.9. Extension of the Sphere of Project Management

Practically every activity which calls for the interaction of a certain number of organizationally isolated units can be based on project management organizational principles. Considering the great variety of project management forms and the mounting need for innovations the number of organizational subsystems for project management may be expected to go up, but not infinitely.

Though project management bodies are temporary agencies, their establishment is equivalent, from the point of view of differentiated leadership and extended sphere of top level managers' control, to creating new units and divisions. Project managers, in charge of coordinated activities of many units and executives to achieve a definite goal, need to be controlled

and coordinated themsevels. If we are aware that matrix structures contemplate multiple subordination with thorough and precise terms of reference and responsibilities, regulated interaction procedures and strict control over the use of resources and performance, it is easy to see how increasingly complex the structure becomes with the extension of the project management sphere.

One of the trends to reach a certain compromise and reduce the number of project management bodies is to establish project management organizational systems of a group type covering certain classes or types of similar programs. Nevertheless, in all cases the number of simultaneously implemented projects at each hierarchical level and in every vertical subsystem of the organization ought to be limited.

5.10. Coordinating Bodies

Increased volumes of coordinative effort is a most tangible trend in organizational structures for the coming period. In this connection, many line and project managers of top and middle levels are not in a position to independently perform all the required coordinating functions and have to set up ad hoc staff units. As was mentioned above, coordinating units help extend the span of control and prevent excessive multi-levelling of the hierarchical structure.

A special feature of coordinting bodies' activities is vast functional relationships in collection of the required data, control execution, and harmonization of decisions. Therefore, strictly regulated procedures of line and functional units' interaction, effective and prompt documentation service, and maximum use of data processing computer facilities are indispensable for their normal functioning. It is also very important that the extending spheres of matrix project management organization generates new coordinating centers which have to be integrated into an orderly, strictly hierarchical system. At the same time companies' traditional general coordinating centers—planning department and controller's offices—will continue to play a key role.

Coordinative functions can also be assigned to units which traditionally are not concerned with them, but which objectively begin to play an integrating role when innovations are launched. A special term "boundary spanning" units (Callahan and Salipante 1982) is now current to designate some of these units, specifically departments or groups of experts that integrate the relations of all company divisions with external agents: customers, suppliers, and R & D organizations.

5.11. Collective Leadership

Innovation management requires extended collective decision making at the top and middle management levels. As a rule, medium-scale and total projects with a wide sphere of influence are based on complex decisions affecting practically all spheres of functional activities. No wonder that even most skilled specialists who manage projects or specialized divisions are unable to make independent competent decisions on complex problems.

For competent and prompt decision making on such matters, special collegiate advisory bodies are set up under vice presidents, as well as division and project managements. They are composed only of those managers and

experts who are compentent in specific matters relating to a project. In most cases collegiate advisory bodies are temporary agencies; sometimes they are even ad hoc panels. Their major feature should be adequate competence in a minimum size panel with high expert responsibility for performance evaluation. Strict observance of the rules and procedures of collective discussion and keeping official records of the proceedings are an important prerequisite for achieving this aim.

5.12. Forms of Communication

Larger organizational sizes and differentiated management involve longer and more complex communications. Among the means of ensuring high reliability of the system are formalized and regulated relations, procedural and documental control, and maximized use of technical facilities. The communication share in the job of project managers and responsible officers in matrix organizational structures is extremely intensive. At the same time effective project management necessitates simpler and fewer communications, extended direct contacts, and departure from traditional communication schemes and procedures.

As can be seen, the above mentioned requirements are contradictory and cannot be fully satisfied. Communication forms inherent in organic systems may be expected to be most fruitful. First of all, bureaucratic subordination in relationships between staff experts and bottom level or the appropriate units' managers ought to be rejected. An extended sphere of direct contacts and personal relations between responsible project officers and top level managers considerably facilitates communication, and the system remains sufficiently reliable.

It is also important to shift, wherever possible, from directive and regulated management to normative and indicative management, with the executive having more room for maneuvering within the present goals and constraints. Communication should be resorted to only in case of deviation. If everything is under control no special confirmation and, consequently, communication, is necessary. At the same time, communication ought to be continually improved to ensure direct operational links with project managers everywhere whenever possible.

5.13. Effectiveness of Management Organization

There is no general or universal criterion for assessment of management effectiveness and ways to improve its organization. However, for analytical purposes a set of criteria can be used.

In the first place, management is considered effective if the goals of the organization have been achieved: adequate profits, development of new products and provision of a certain market, effective use of resources, etc. Of course, due account should be taken of the objective and subjective factors involved. More specific criteria are the management costs or the number of white collar workers employed. However, there are no absolute indicators that can be used to assess effectiveness because it is difficult to appraise the volume and quality of the work performed. Relative criteria are therefore preferred: the share of management costs in the total volume of sales or the share of white collar workers in the total number of employees. The share of management costs in total sales is probably the most objective economical characteristic indicator of management activity. With

due account of the change in the range of products, the indicator is comparable for different firms or it can be applied to an individual firm if its growth is viewed retrospectively from year to year. Final assessment should be inclusive of the overall performance (results) of the firm.

Taking into consideration the general situation and trends of organizational development, one can hardly expect that the 1980s will witness higher management effectiveness, but nevertheless, efforts to retain the present level are worthwhile.

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STRÖMBERG'S EXPERIENCES OF ORGANIZATIONAL SOLUTIONS IN DEVELOPING NEW PRODUCTS

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INTRODUCTION

When organizing research and development work, the solution chosen should promote the following points to be taken into consideration:

- the real needs of the market and the direction in which these needs will be changing during the coming years;
- that the strategic policy of the company be followed;
- that R & D activities are in close contact with production and marketing units;
- that R & D personnel are motivated to active working and cooperation.

The principal organizational solution by our company is to distribute the product development to product divisions. Every division has the responsibility of taking care of modernizing old products and creating new ones. For special needs there is also a Research Center in the company that provides testing and research assistance to divisions according to their orders.

1. GENERAL CHARACTERISTICS OF THE COMPANY OY STRÖMBERG AB

The manufacturing program mainly includes heavy electrical equipment and power electronics for industry, electricity boards, power plants, ships and rolling stock. The program also includes heating and cooking equipment. The company employs 6500 people and its sales (1982) were approximately 300 million dollars. One third of production is exported with Scandinavian countries being the biggest export market (45%). The company is an independent, private company, the majority of shares being owned by Oy Kymi-Kymmene Ab, a Finnish wood-conversion and metal company.

The company cooperates greatly with other companies inland and abroad and buys parts and materials from different suppliers. It is itself a sub-contractor for industry needing electrical components for its products or in bigger projects combining products from several manufacturers. The main part of company production comprises of complete equipment for the different uses, production and transmission of electrical energy. A growing part is formed by bigger projects and customer service.

Because the range of products is extensive, it is deemed necessary to distribute the R & D facilities to profit centers as much as possible. In addition, a separate Research Center performs R & D activities in special fields, mainly on the orders from the profit centers. Roughly one-quarter of R & D is carried out in the Research Center, the other three-quarters in the profit centers. The company is divided into 11 profit centers and their names and main products are as follows:

— *Machine Division*

motors, generators up to 20 MW

— *Power Electronics Division*

speed control of motors
excitation equipment for generators
instruments and automation of electric drives and
traction equipment

— *Transformer Division*

power transformers, range of deliveries 16 kVA...
800 MVA, highest voltage 420 kV

— *Apparatus Division*

high voltage apparatuses
circuit-breakers and disconnectors
for the voltage range 12...420 kV

— *Switchgear Division*

low-voltage distribution apparatuses, low and medium
voltage switchgear
stations and switching units

— *Electronics Division*

static protective relays
alarm systems
frequency converters

— *Motor Division*

squirrel cage motors
0,06...315 kW

— *Division for Heating and Cooking Equipment*

electric cookers, heaters and water heaters for household use

— *Installation Division*

electrical installation work for total deliveries

— *Service and Repair Division*

service, repair and spare-parts

— *Project Sales Division*

complete electrical projects for industry and for distribution, transmission and generation of electrical energy.

The total funds used for R & D activities vary from 4 to 6% of the turnover.

2. CHARACTERISTICS OF TECHNOLOGICAL INNOVATIONS BY OY STRÖMBERG AB

Innovations in a company like Strömberg are usually technology-oriented and related to the introduction of new products or new models of old products, new materials and new processes. Most of Strömberg's products are of own design and this requires continuous work to up-date constructions. Product developed is based more on small, numerous improvements; big changes occur seldom.

The sphere of application of most innovations is local and usually involves only one product or product family. Important exceptions to this rule are, e.g., the introduction of new electronics and new plastic insulating materials that change the solutions and products of many divisions. The time during which a new innovation can be implemented depends on the life-time of the products and may vary from less than one year to several years.

The required resources of innovations are the well-equiped design departments and laboratories of divisions and the Research Center of the company. Financial resources are mainly supplied internally by turnover and profit charges.

Most innovations are based on internal efforts. However, in may cases collaboration with clients, technical universities and the State Research Institute becomes a vital part of the R & D work. Strömberg very seldom purchases licences.

3. MAJOR PROBLEMS IN CONNECTION WITH INNOVATION DEVELOPMENT AND IMPLEMENTATION

One of the most important problems in relation to R & D is to decide the direction and goal of the work. Without goal-setting the R & D may get lost in useless and nonmotivating wandering. The goal-setting is a continous process and should be up-dated at least once a year. Goal-setting should also be done as a team effort, where the opinions of all parties (R & D, production, sales) should be taken into account before making decisions.

The human resources of R & D also require continuous care. Finding the right people, training them to special professional abilities, and motivating and promoting them takes a considerable part of management time.

In practical R & D work trouble sometimes arises because of deviations from time-tables. Most estimated time-tables tend to be too optimistic. When creating new products, the production and sale points of view must be taken into consideration and it is therefore important to create close cooperation between all parties during product development. Problems related to quality should already be taken into account during product development, including comprehensive testing, documentation, and creation of a system for taking practical experiences into consideration for further development work.

4. RESOURCE REQUIREMENTS FOR MAJOR INNOVATIONS

If an innovation causes changes in the strategic plans of a firm it requires decisions at the enterprise level. The executive direction decides in which part of the company and with which financial and human resources the realization of the innovation starts. In several cases such a start is located in the Research Center, where a small group is formed to develop the innovation. After a few years' work it is possible to decide if the innovation is useful and can be transferred to divisions or if it is better to stop any further activities on the innovation.

Most of the financial resources for major innovations also come from the company's turnover. Official R & D funds are also used but their share is less than 5% of the total R & D investment.

5. INNOVATION AND THE DEGREE OF CENTRALIZATION IN DECISION MAKING

There are several viewpoints which should be taken into account when finding the optimal degree of decision making centralization relating to R & D activities:

- company strategy should be followed;
- new products should be created according to the possibilities of production lines and marketing;
- decisions should be made close to the personnel performing the development work in order to ensure motivation.

It seems that in an optimal situation all levels have the possibility to influence decisions. On the other hand, the most important decisions (to start or stop a project, accept a product for production, etc.) should be made at a high level. R & D personnel themselves are often too engaged in their projects to look impartially at the benefits and drawbacks of a new product.

It seems clear that more efficient and better-oriented R & D work is performed in fairly simply organized groups than in a system requiring more administrative paper work and managerial organs that are not taking part in the actual R & D work. Responsibilities in a simple organization are well-defined and better motivated.

6. CHARACTERISTICS OF THE FIRM'S ORGANIZATIONAL STRUCTURE

A detailed description of the company's organization and characteristics of divisions is given in the Strömberg Report 1982. As a summary, general characteristics are given below.

The number of employees in divisions varies from 100 to 1000 people in the managing system scale. Complexity of management measured by the relative number of salaried personnel compared to the total personnel is high (35%). The organizational design can be characterized by stating that the divisions are very independent in operational decisions. Every division takes care of the development, production and sales of its products.

The number of hierarchical levels in line varies in divisions depending on the division's complexity and size. A typical number may be six:

- The board of executives
- The division director
- The construction office managers
- The construction project leader
- The construction engineer
- The designer

Decision making is distributed and decentralized, with operational decisions made at the lowest possible levels.

In addition to product and project divisions, there are several supporting departments in the company such as the Research Center and financial, administrative, personnel, purchasing, labor and works service departments. The average number of subordinates under one manager varies from five to 10.

Programs related to the product development are independently up-dated yearly by each division. The supporting departments also make yearly programs according to the services that the divisions plan to use during the coming year. In each division, the program-making bodies are composed of construction managers, and production and marketing offices. They report to the division director. In addition to the supporting departments there are many working groups that handle interdivisional matters or matters common to all divisions. Working groups normally report to a member of the board of executives, which makes final decisions. Collective decision making (i.e., voting) is not used in technical matters.

The company's top management controls company and division strategy. When innovations and product development are involved they also follow the advancement of important projects.

Communication in the management system includes circulars giving rules for different operations and, on the other hand, reports giving the state and result of operations. Important managerial tools in R & D work are documents stating the start and goal of development work, intermediate progress reports and the final reports on completed work. This written material serves as a basis for operations, with the main part of information changes occurring through personal contact or in different internal meetings.

7. ORGANIZATIONAL CHANGES AIMED AT FACILITATING INNOVATION IMPLEMENTATION

During recent years many changes have been made in the organization of the company. The main reasons have been the efforts toward better economic results, increasing export, and changes in the relative importance of different products. Although facilitating innovation implementation has not been the main reason for changes, it can, however, be seen that some changes have clearly had a positive influence in that direction.

- Increased independency of product divisions also increases the motivation to keep the division products competitive.

- The efficiency of R & D work increases when its expenses are divided as much as possible according to the cause of the expenses.

- Creating new product divisions or dividing old ones into smaller units according to change in production selection also often has a beneficial affect on R & D activities.

There are also other measures which directly affect the efficiency and quality of R & D activities:

- Promoting connections between R & D people and other sources of knowledge outside and inside the company.

- Personnel changes in order to widen people's range of knowledge and to prevent the dangers of stiffening opinions.

- Operational decisions are made closer to the actual places where the R & D work is performed.

ORGANIZATIONAL STRUCTURE OF ELECTRICAL ENGINEERING ENTERPRISE AS A TOOL OF ITS INNOVATIVE ACTIVITY *

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Modern science offers comprehensive and exact definitions of general laws governing the formation of organizational structures.

Numerous papers on the subject give the following scientifically termed requirements for the structure of a firm:

— flexibility, dynamism and conformity with the firm's changing objectives;
— rapid adaptation to unforeseen changes in the environment;
— alignment with specific traits of production and sales, possibilities and needs for centralization and decentralization of some types of production, nature and scope of R & D, etc.

The organizational structure must be formed as an effective multi-level mechanism for the assignment and allocation of responsibilities in the "R & D-manufacture and sales" cycle and adoption of a mode of interaction and mutual responsibility of various structural units.

Many recent theoretical studies consider as criteria of rationality of a structure its orientation towards not only the current but also the long-term goals, ability for effective self-organization of units as the goals change, use of horizontal channels of communication and ability to allow for and to make use of both subjective and objective social factors, in particular, the "human factor" in management and production, behavioral motives within individual professional and age groups, etc.

Apparently, we may say that the acute problem pertaining to criteria of evaluating the organizational structure of an enterprise has now been studied rather fundamentally and comprehensively.

However, another problem arises in this case: what explanation can be offered to the fact that the problem of creating effective organizational structures not only remains on the agenda but becomes even more acute and significant.

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*This paper was not presented orally at the meeting but was prepared especially as a contribution.

The character of the IIASA research project, we are participating in, prompts an answer which can be formulated as follows: *the theoretically discovered general laws governing the formation of modern organizational structures are not sufficiently accompanied by useful practical recommendations.*

As a result, we often know very well what should be done but very rarely have adequate information as to how it should be done.

For example, how to make a structure more dynamic when the production mechanism which is managed through this structure is objectively characterized by inertia.

How to correlate properly strategic and tactical units within the structure and make their efforts correspond with the common ultimate goal?

How to create and regulate within the structure computer-aided rational management techniques, certain procedures, etc. without curbing at the same time creative initiative and endeavors of the personnel?

How to correlate within the structure the human (subjective) and objective factors which in many respects dictate the choice of a structure?

Many similar questions arise before everyone who wants to design an effective structure in accordance with the theory of management science. However, it is management science itself that fails to translate its theoretical findings into the language of everyday practice, the result being that the initiative in this case remains with the managerical staff of enterprises and management consultants.

In our opinion this situation is not accidental and results from a number of objective reasons. The most important of those reasons are extremely diverse specific conditions of production at different firms, and it is very difficult to compare organizational environment at various enterprises, even within the same branch of industry and of similar industrial specialization. In such a situation, a reasonable approach would be a systems study of the experience acquired by the best firms. It will provide a basis for some or other solutions and give an impetus to further improvement of their own practice. Modern enterprises, especially related firms in developed countries, in planning their organizational development, cannot and must not miss such an opportunity as exchange of experience. Since direct transfer of somebody's experience is of questionable value, the only way to success is, to our mind, a deep analysis of a wide range of specific problems. Based on this, we outline further Electrosila's practical steps towards improvement of the firm's management organization structure.

Electrosila—Leningrad electrical machine manufacturing firm—includes an R & D center and three factories closely related as to their products and manufacturing techniques but situated in different locations, all three being engaged in low-series and piecewise production. The firm produces mainly turbogenerators from 200 MW to 1200 MW, including turbogenerators for nuclear power industry; hydroelectric generators of above 600 MW, large-size motors practically for all fields of the national economy, low-voltage switchgear and controlgear, electrophysical equipment, household appliances and installations of the "Angara" and "Tokomak" type for the study of controlled nuclear fusion. The detailed characteristics of practically all the major

aspects of Electrosila's activities are described in the appendix. Therefore, here we shall discuss now only those having a direct influence on the choice of methods for innovation management. Equipment produced by Electrosila is not only sophisticated but, for the most part, unique. In the field of large-size electrical machine production, especially, turbo- and hydroelectric generators, 40% to 50% of the most important products are actually made to individual orders; as a result, new machines always differ in capacity, design, scope of tests or manufacturing techniques from similar machines produced earlier. The annual introduction into the plan of a great number of unique machines not produced previously, implies a multi-attribute decision-making. From 10 to 20 basically new developments are introduced simultaneously by Electrosila, all of them requiring considerable changes in the production processes, erection of new equipment, reconstruction of shops, training of personnel, extra efforts to ensure higher quality and reliability of new machines, broad patent check of designs, purposeful organizational reinforcement of certain units and other no less important measures.

The figures cited below comprehensively characterize the pace and intensity of the innovative process at Electrosila.

The maximum unit capacity of the turbogenerators produced by Electrosila has increased for the last decade from 500 MW to 800 MW and then to 1200 MW, i.e., 2.4 times.

Electrosila required only five years (from 1976 to 1980) to implement three basically different cooling systems for rotors of large turbogenerators: traditional hydrogen cooling, full water cooling and finally (for an experimental prototype) helium cooling for a superconducting generator.

For the first type of cooling radical changes in the production process were needed. In two other cooling systems, employment of full water cooling involved alterations in the design of the main parts of the machine, and helium cooling implied basically new physical processes. It should be pointed out that in all those cases Electrosila followed its strategy and pursued the goal of creating an efficient production prototype useful to the customer.

Such type of innovation is Electrosila's everyday practice. This is confirmed by the fact that during the period of speeding up the progress in the turbogenerator industry, the world's largest hydroelectric generators with unit capacity of 640 MW were designed and manufactured by Electrosila for the Sayano-Shushenskaya hydroelectric project. More than 20 improvements in the design and manufacturing techniques of those machines have been recognized as inventions and patented in the USA, France, FRG, Japan and other countries. As compared with its predecessor—the Krasnoyarsk machine, the Sayansk generator's capacity is 28% higher, and at the same time it is one of the most economical generators in the world from the viewpoint of weight-to-power ratio (metal consumption per unit power). However, the Sayansk generators are accompanied by other innovative designs realized by Electrosila within the last decade: unique electrical equipment for atomic ice-breakers, super-powerful rolling mills and drilling rigs, as well as with high-power accelerators of "Tokomak" and "Angara" type made to bring to light the secrets of atomic nucleus.

Electrosila's direct orientation to expedient innovations in all spheres is reflected in the history and current functioning of its organizational structure.

This structure is flexible and adaptable. It ensures reliability, high potential and relative stability of the basic units.

For illustration purposes let us analyze the organizational mechanism of the technological progress management. It comprises a number of basic structural untis: R & D design; testing and preproduction.

These basic structural units are supplemented with a well-developed infrastructure part of which are the patent, information and standardization units.

The top-to-bottom coordination of the engineering efforts is accomplished by a special "brain" unit directly subordinated to the top management represented by the chief engineer of the firm. All principal functions required for management of the technological progress are concentrated in this particular unit, viz.:

— planning and control of new product development;
— management of quality and reliability of machines and instruments;
— organization of the state quality certification procedure for the equipment produced by the corporation;
— handling of problems related to scientific and technical cooperation of Electrosila with its foreign counterparts.

The engineering unit is headed by the chief engineer of the firm--the second person in the firm's top management.

Such an unusually high status of the engineering manager is due to a number of factors. One of them is that the firm's activities cover the entire "R & D — manufacture" cycle from the stage of search for ideas to give birth to a new machine, associated R & D work, design, preproduction, testing and installation of the machine at the customer's site. Another factor which stresses the importance of the engineering efforts is the commensurability of expenses for engineering and for manufacture of main products and special significance of the first stage for attaining the firm's ultimate objectives.

Besides (as it was also mentioned earlier), the orientation, character and pace of the innovative activity of the firm are such that they continuously require deep and rapid readjustments and development in the course of R & D, design and improvement of manufacturing techniques, process machinery and testing facilities. Under such conditions, the strong, flexibly organized engineering unit which is duly authorized and able to respond quickly to any task dictated by the growing demand is of vital necessity.

The present-day R & D center of the firm has "stepped" internal structure which makes its coordination somewhat more complicated, but this is totally compensated by higher responsibility for the decisions taken and by better adaptability of primary sub-units to rapidly changing goals and operating conditions. It incorporates the research division capable of carrying out independently almost any fundamental research required for the design or technological units.

The research laboratories ensuring a close contact between science and production interact directly in all respects with sub-units of the same

orientation engaged in applied research. Such type of communication is always provided for by the structure and contributes primarily to the correct orientation of R & D and, secondly, to the quick and effective use of the obtained results for new machines and new manufacturing techniques.

Integrated management of R & D efforts is ensured by the deputy chief engineer responsible for R & D. Since the R & D efforts are oriented primarily to the innovative projects, i.e., to the firm's most important objectives, the deputy chief engineer is vested with certain rights which enable him to have influence upon design activities, development of new technology and organization of testing. Such key sub-units as the patent and standardization ones also report to him.

The management of Electrosila's design activities has also some specific features. The design units participating in the innovative process not only create up-to-date designs of new products, but also ensure adaptability of the designs to industrial production since all the design activity at Electrosila as well as at other larger electrical engineering firms in the USSR is oriented to the needs of its own production facilities, as well as the terms and conditions of the delivery of the machines.

The decisions taken in respect of the design and engineering in such a complex enterprise as Electrosila are extremely important since it is these decisions that eventually determine both the performance characteristics of the manufactured products, i.e., the good reputation of the firm in the domestic and foreign markets, and the economics of the firm itself, i.e., the amount of profit gained by the firm through successive reduction of labor and material expenditures.

Taking into account a specific significance of design, Electrosila and a number of other electrical engineering enterprises in the USSR whose activities cover the entire "R & D - manufacture" cycle are striving to create adaptive computer-aided design systems.

To this end line organizational structures in the design management are strengthened. Apart from the chief design manager (at Electrosila he is the deputy chief engineer for design) and heads of the product-oriented design units, the line organizational structures of the design units in some of the Soviet electrical engineering firms include also chief designers. In the design management hierarchy, the chief designer occupies an intermediate position between the deputy chief engineer for design and heads of the design units and, as a rule, is in charge of several design units dealing with related problems. The chief designer does not handle tactical tasks, the latter being within the competence of heads of the design units, and focuses his attention only on such strategic aspects as the interrelationship research and technological units development of the most advanced and adaptable designs, analysis of the long-term development prospects, etc.

For products of utmost importance, permanent chief designers are assigned, their functions and responsibilities being outlined in a special document.

In projects where complex problems arise periodically, the chief designers of the project are assigned for a certain period of time. Then, some authority of the design unit manager (deputy chief engineer for design) or, in some cases, some authority of the firm's top management are temporarily delegated to him.

At Electrosila, the chief designer of the project is vested with additional powers (and, consequently, assumes additional responsibilities) as to the choice of design solutions and management in respect of design and engineering aspects of the manufacture of a particular product. At other electrical engineering enterprises in the USSR, in particular, at Uralelectrotjazmash, the project managers are involved not only in the design sphere but also deal with renovation of shops, switch over to production of a new critical product or introduction of a complicated manufacturing technique. At that firm, the project manager enjoys greater authority and assumes higher responsibilities: for example, the design project manager has the right to approve the working programs of the manufacturing shop; the operating plans of the preproduction unit are to be agreed with him; the materials supply services are not allowed to distribute limited materials among the shops unless they have his approval for that, etc.

Sometimes, provisional horizontal structures are formed around the chief designers of the project. In this case, for a period of work on the project, groups of technologists, specialists on tooling and non-standard equipment are transferred from other units under direct subordination to the chief designer of the project. As a rule, he has the right to take personal charge of a certain financial incentive fund, and, in addition, he is vested with certain rights concerning the personnel and, sometimes, in the social and welfare spheres.

In the USSR horizontal, organizational structures in electrical engineering where the leader of the innovative project and not a representative of the firm's top management is an authorized project manager, are used most successfully for carrying out certain important long-range intrafirm production programs involving dozens of shops and units. An example of such programs at Electrosila is implementation of the integrated quality management system, computer-aided design system, computer-aided system for comprehensive control over the work discipline, etc. In all these cases, it has been necessary to introduce new methods of work into dozens of structural sub-units. For that purpose, in the sub-units concerned some specialists have been made responsible for implementing innovations. Each of them, though remaining in subordination to the head of the unit, at the same time has been transferred under the functional subordination to the task group in the unit responsible for a particular innovation. All those specialists have had a short-term training course in that unit, have been appropriately instructed, have received working means, necessary aids and manuals describing the techniques and procedures and, where required, they have had direct access to computers used in the system.

The task group in the department in charge of the innovative project has been made responsible for planning and coordination of the efforts to implement the innovation, for providing technical means and appropriate aids and instructions to the sub-units involved, for the formation and further development of the general ideology of the innovation, for control over the sub-units' activity in the introduction of the innovation, for contacts with the firm's top management, etc.

The current structure of Electrosila's R & D center and methods of organizing the innovative activities and design work, discussed above, are the results of comprehensive systems studies of various approaches to the

problem of management of the technological progress at the firm. The history of creating the R & D center within the firm is a vivid illustration of the dynamic development of its organizational structure with further complication of innovative tasks.

Initially, this key unit in the firm's organizational structure, that actually promotes the technological change was formed as a group of interrelated design units and applied research laboratories directly within the structure of the central management body. This was expedient only in the period when the firm had not yet started large-scale research and largely dealt with problems of ensuring full-scale production of the already developed machines.

Later on, when the most acute problems of the national economy were solved, the USSR launched the world's largest complex programs aimed at utilizing the available hydropower resources and creating a nuclear power industry. To cope with the new and more complicated tasks, quite a different approach to organization of the firm's research and design was needed. The design units were used as a basis for establishing a self-sufficient research and design insitute with a better planning and financing system and broader authority. The creation of a self-sufficient institute provided greater possibilities for better R & D organization, improvement of technical and laboratory facilities and employment of scientists and highly qualified engineers.

The results of managerial innovations fully confirmed the correctness of the decisions made. During a relatively short period of time Electrosila solved successfully the problems of equipping electric power stations in the new power systems and producing machines for a number of nuclear power stations. At the same time, the firm's products became much more competitive in the world market, which permitted to increase several times the exports of the products.

Dynamic development of electrical engineering and its novel specific applications in the late 1970's brought about a number of new problems calling for radical intensification of the "R & D - manufacture" cycle. Accordingly, the structure of the firm's R & D center was reorganized again. Within this new organizational structure, the heads of engineering sub-units were given significantly greater possibilities in production, and a number of administrative functions that interfered with the work of scientific and engineering staff were transferred to the central management body. Concurrently, this contributed to enhancing the responsibility of researchers and designers for the firm's end products.

The present structure of the firm's R & D center, whose core is formed by two major management blocks having different tasks, but closely interacting, one for R & D activities, the other for engineering efforts at the preproduction stage, meets to the greatest extent the requirements for adopting technological innovations at the firm.

Those blocks of the management structure responsible for the organizational development, economics, infrastructure of the firm and social activities, have been formed and developed very carefully on a systems basis and with due account of the firm's changing objectives.

Improvement of the management organizational mechanism is coordinated by the special management organization unit directly subordinated to the

general manager. Based on the firm's objectives as defined by the top management, this unit formulates long-range plans of improving the organizational environment, revises allocation of decision-making authority and responsibility among the managerial staff at all levels, provides guidance in formulation and implementation of plans aimed at improving the management processes and procedures.

Despite a vast experience in the improvement of the firm's organizational structure and management techniques, we nevertheless do not consider the organizational structure to be the only means of ensuring the correct organization of innovative process.

The innovative process is the most complicated aspect in the firm's activities, and the character of that process, in particular, its pace, general tendency and individual trends are determined by a great number of factors. The majority of those factors cannot be practically taken into account in the organizational design, and they can be controlled by systems methods only when the entire and extremely intricate economic mechanism of an enterprise is mobilized for the purpose, the long-range objectives are defined correctly, the "human factor" and style of management characteristic of the leaders at various levels of the management hierarchy are taken into consideration in a flexible manner.

None of the above mentioned and other factors making a significant impact on the innovative process cannot be directly and explicitly reflected in the structural mechanism. Because of that, as was discussed earlier, the organizational structure of the enterprise should not be regarded as the only means for management of innovations.

Also justified is another statement that all the factors influencing considerably the innovative process must be somehow reflected in the organizational structure. This circumstance defines, in our opinion, the role and place of organizational structures among the most important aspects of intensified innovative activity at large-scale research-and-production firms.

APPENDIX 1

Quantitative and Qualitative Characteristics of
Leningrad Electrical Machine Manufacuring
Firm Electrosila

Electrosila's orientation - development of designs and manufacturing techniques of serial-made and unique products, production, testing and installation of manufactured equipment, R & D in production and application fields.

The firm's main task is to meet the principal demands of the USSR national economy for heavy electrical equipment (large-output hydroelectric generators and turbogenerators, large-size a.c. and d.c. electric motors, low-voltage switchgear and controlgear, electrophysical equipment, household appliances) and to expand continuously the export market where only highly competitive equipment can be sold and which urges speedy improvement of designs and performance characteristics of products. To cope with this task, Electrosila has to constantly update its products and develop production facilities to suit the rapidly changing requirements for the best items of electrical equipment.

Type of Production - Electrosila's products are either of piece or small-lot type, made to individual orders.

Specialization - product or fabrication type. In the case of pre-production shops (foundry, stamping unit, welding shop), specialization is of fabrication type, in the case of assembly and machining and assembly shops --specialization is or product type.

Scale of Production Activities - Electrosila employs more than 10,000, annual product sales amount amount to 1,000 million roubles.

It does not seem possible to evaluate more or less accurately a degree of product diversification at the firm using traditional criteria and estimation scales. The range of manufactured products is extremely wide: from the simplest household appliances to super-large generators, accelerators and other powerful physical equipment. The firm's "R & D - manufacture" cycle

is also extremely versatile and includes not only different kinds of laboratory studies (which are carried out practically in any field thay may interest the design and production units) but also the entire complex of design, technological, experimental and testing efforts and the production structure (assembly shops specializing in 6 to 8 kinds of the most important products: preparatory shops specializing in each of the most important intermediate process operations: welding, casting, electroplating, stamping, machining, plastic moulding, etc.). The firm has a well-developed infrastructure: maintenance units responsible for power and service supply, tools and dies making, press-moulds, other jigs, fixtures and non-standard equipment; transport and storage facilities, one of the world's largest test beds and its own social and welfare infrastructure including dozens of therapeutic, health-improving, children, sporting and other establishments some of which are located in different regions of the USSR.

Manufacturing techniques used at the firm may be assessed as highly efficient, integrated, based on the latest know-how and, what is more important, continuously and actively updated to suit changes in performance characteristics and kinds of manufactured products. The level of production process allows, with certain approximation, to regard it as having no bottlenecks directly inhibiting or slowing down the progress, though, at every given moment of time there may naturally be one or several intermediate process operations, whose development and improvement would have been most expedient from the point of view of the long-range (strategic) objectives.

Pace of Technological Progress - in this respect, Electrosila most probably belongs to the firms which actively update their products (up to 15% - 18% annually). This necessitates the continuous improvement of manufacturing techniques, which involves their radical change approximately once very 7 - 10 years (an example illustrating dynamic development of Electrosila's products and manufacturing techniques - realization within 15 years of three principally different systems of cooling in turbogenerators: by hydrogen, fully water cooling and with the use of liquid helium). At Electrosila, according to the data summarized every decade, the product increment rate 10 - 15 times exceeds the accession rate.

As to the customers, the firm with its wide range of export orders is an indisputable leader among the home large-size electrical machine manufacturers and should be placed into a category of firms with a widely changing range of customers imposing the stringent and continuously varying requirements for the products (70 - 75%) and also with a range of the regular customers having the uniform, naturally progressing (i.e., in pace with the general progress) requirements (25 - 30%).

Degree of Organizational Indpendence and Self-Sufficiency - Electrosila, as all other Soviet enterprises included in the sectoral management system, has line subordination to the management body of the specialized sub-industry for production of large-size electrical machines and through that body--to the top management of the electrical engineering industry.

APPENDIX 2

Enlarged Classification of Principal Innovations Implemented by Electrosila*

Goal Orientation of Firm's Innovative Policy - envisages continuous introduction of design and technological innovations (up to two-thirds of the personnel are direcly involved in it annually), continuous production innovations (with up to 50% of the personnel directly involved; these innovations are introduced periodically but on a very wide scale), economic, commercial (with 10 - 15% of the personnel involved), social (up to 10% of the personnel involved annually), and managerial readjustments carried out continuously with practically all groups of the personnel involved directly or indirectly.

Scope and Sphere of Innovations Implementation - at least once or twice during each five-year period, Electrosila prepares and adopts innovations which embrace the entire organization (introduction of quality management system; introduction of integrated organizational structure for the R & D and manufacture management, etc. In other respects the structure of the firm's innovative activity may be characterized as consisting mainly (to 70%) of the average-scale long-term innovations covering most frequently from 20 to 40% of the organization and of the local (though long-term) innovations adopted continuously in the production units and periodically--in the engineering and managerial units.

Resources Utilized - the firm's innovative activity is very diverse and is financed mainly from the following sources: large long-range investments (reconstruction, construction of new shops and buildings, implementation of the long-term research and engineering programs aimed at developing radically new technology, long-term state credits (the least used source) and deductions from the firm's profits for innovative projects (social programs, procurement and erection of new process equipment, improvement of work conditions).

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*Annex 2 is based on criteria and classification suggested by the Organizing Committee of the IIASA Task Force Meeting to be held in Prague.

Influence of Innovations on Firm's Activities - the majority of innovations adopted (even those realized on a limited scale) may be in accordance with the suggested criteria placed into the group of measures having a profound effect because Electrosila's top management is keen to plan and finance only those innovative projects which, irrespective of their scale, exert a favorable influence on the firm's end products.

Importance of Results Gained from Innovations - it should be pointed out that Electrosila deals mainly with topical innovations (see classification of the Organizing Committee), and many times during each five-year period it adopts extraordinary innovations specifying simultaneously very strict but justifyable time limits for their implementation and sufficient (mainly budgetary) funds. No less than 70% of the adopted innovations should be regarded as causing a moderate need for strengthening some operational links and for coordinating the functioning of several units. Some 20% of innovations (it is an achievement and there is a tendency for a further increase) are adopted without departure from the established order (due to careful readjustment and new routines for individual procedures; for example, the introduction of the environmental protection system described in the author's paper presented at the IIASA-Leningrad Task Force Meeting). The overwhelming majority of innovative projects is carried out, for the most part, by the firm's research and engineering staff, assisted by external research, commercial, economic and other organizations in accordance with centralized plans.

APPENDIX 3

Criteria of Estimation and Characteristics of Electrosila's Management Organizational Structure

1 - 2. The strength of the firm's engineering and managerial staff, including research design, production process engineers, engineering staff of large shops, etc. (more than 1,500) and a substantial percentage of non-production and office workers in the firm's total strength (over 30%) allow to classify the firm's management mechanism as highly complicated in respect of line relations and occupational composition.

3. The firm's organizational setup has been formed and is developing as a structure involving both line and functional relations (naturally, line relations predominate) and using, where required, horizontal and matrix organizational structures.

4. As to the internal hierarchy, the firm's management structure may be placed into a category of multi-level structures for both line and functional relations.

According to the line hierarchy, the structure contains the highest level (the firm's top management), the middle level at which there are managers of the factories and particular-type production activities, and the lowest level--supervisors of main production shops.

The functional hierarchy with the same highest level (the firm's top management) has the second level formed by chief specialists for main types of products (in the sphere of design), engineering service (infrastructure), materials supply preproduction activities. Heads of the leading functional units within the firm's central management body are at the third level, and heads of functional units of the factories form the fourth level.

5. As to the degree of centralization in decision-making there are more reasons to classify Electrosila as an organization with the limited (in some cases, partial) centralization rather than with full centralization

of decision-making. Suffice it to say that all the factories included in the firm are to a great extent independent in the operating sphere, and the management of each factory has the necessary authority in order to take an active part in developing long-term objectives.

6. From the viewpoint of specific management differentiation, Electrosila's management organizational structure may be classified as consisting of several basic structural units, including the R & D center with its own highly developed internal structure combining both line and functional relations, as well as production, sales, economy, personnel, social- and welfare units. All these units have line organization and are manned by less than 500 people each. Besides, the firm's management organization structure comprises relatively small supporting services organized on the line principle: engineering service for production, safety engineering and environmental control. Directly subordinated to the general manager are structural units responsible for control, organization and computerization of the firm's management processes. The matrix-type structures are used in the R & D center to organize properly the product quality management, to implement the CAD system, etc. Within the framework of the R & D center, use is also made of the horizontal management organization in order to ensure a high technological level of the developed designs. This is achieved by assigning chief designers for certain types of products.

7. A percentage of the engineering and managerial staff according to their specific functions can be derived from the above description of the basic units in the organizational structure.

8. It is difficult to estimate the actual span of control in Electrosila's management system even using a number of criteria because, due to varying specific features of management at different levels, it changes irregularly from 4 to 9 subordinates reporting to one superior (the highest level and a number of middle-level structural units) to 20 to 30 subordinates (the lowest shop level).

9. In our opinion, an adequate and relatively satisfactory determination of the line personnel share in the firm; total managerial staff for an international case study can be performed only after elaboration of common precise criteria of the staff classification for the related firms engaged in the research. Otherwise, the obtained results will not be comparable. For example, there may arise a question whether a large group of managers in charge of research, testing and other similar units in the R & D sphere should be classified as executives or the staff of the R & D center should be considered as the personnel providing a "line" support of decisions made by the production managerial staff.

10. On the average, Electrosila participates annually, in the implementation of at least 10 external (with respect to the firm), programs: sectoral, intersectoral and regional. Accordingly, a relevant in-house program coordinated as to the target dates and efforts with a particular external program is formulated. An average annual number of independent in-house programs implemented by Electrosila differs with periods of time. However, there is a stable correlation between this number and the intensity of the manufacture of the most critical new products (if only for unique super-powerful equipment, such programs are undertaken several times every five years). Such programs carry a number of important measures aimed at fufilment of the firm's general reconstruction plan (e.g., commissioning of new production shops, introduction of a radically new production process, etc.).

It is impossible to determine precisely the number of the operating management systems with organizationally independent programs, as one should first define whether such subsystems fall under those complicated managerial procedures defined by the traditionally circulated documents (orders, instructions, structural division function regulations, etc.--the number of these highly regulated managerial procedures adopted at the firm is more than 200). Or, conversely, we should consider as independent programs with autonomous organizational system only those which due to their high complexity are regulated not by traditional but special, more complicated documents, for example, the organizational and technical standards system (the quality management system), the system of special regulations (the computer-aided system of progress control, etc.). The number of such independent programs carried out annually by the firm is an order less than the former ones.

11. In all cases, except for the personal top control on the chief project designer's part, the programs are managed by an operating structural unit vested with the authority of the project leader and with the adequate responsibility for the implementation of the program.

12. Described below are the coordination bodies accomplishing the interfunctional management: the firm's board which is most often employed at Electrosila, especially, when the most significant strategic problems or acute, vitally important present-day problems are involved: the coordinating boards whose function is to assist the firm's top management in coordinating the process of decision making concerned with important long-term problems confined to a relatively small scope of objectives and structural units; permanent or interim commissions whose function is to assist the top management in controlling a concrete local program with a limited time of implementation; the working coordination groups run by the heads of structural units playing a leading role in solving the specific problem (with a relatively small amount of organizational coordination work, each of these groups is substantially engaged in design, research and similar efforts).

13. Among the collective decision making bodies is the firm's board (dealing with the most important strategic problems in all spheres of the firm's activity), the scientific and technical board (determining the major trends of future R & D development of the firm), the regional and sectoral board of directors headed by Electrosila's general manager (by the order of the Minister for Electrical Engineering Industry, this board has to tackle some problems of the joint coordinated work of more than twenty electrical engineering enterprises and R & D centers located in the USSR North-West region).

In the process of management the boards with not so high authorities are also employed. In the majority of cases their task is not participation in the decision-making process but assistance for the firm's top management to select decisions (an example is the coordination board for computerization of managerial procedures).

14. As a rule, no more than two significant factors are under control (adequate personal responsibility) of the highest-level operational managers in all the units of the structure, e.g., the assurance of the product quality, high level and up-to-date designs--in R & D management; the observance of the contract terms of delivery by installments and target dates of complete supply of the most important products in production; fulfilment of the materials supply plan and control over the financial position in purchase and sales, etc.

15. Practically all the well-known means of communication between structural units and individual specialists are used at Electrosila. Preference is given to the more explicit forms of communication. Where possible, centralized systems of document circulation are widely used (the function is performed by a special unit in charge of the control and regulation of document circulation). In progress control use is made of the computer-aided system with a control capacity permitting the handling of up to 50,000 orders, instructions, etc. per year.

ORGANIZATION OF INNOVATION MANAGEMENT IN RADE KONČAR

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1. MAIN FEATURES OF RADE KONČAR

An understanding of the organization of innovation management is difficult without first becoming acquainted with the organizational structure of the firm within which the innovation process operates. The Rade Končar Electrical Engineering Works, manufacturers of electrical products, equipment and plants, is a self-managing, multiplant system organized for modern production and business operation. It is based on original research and applications of technology, high-quality production, and has a skilled workforce of more than 22,000 employees in 11 work organizations (WOs; i.e., divisions), 51 basic organizations of associated labor (BOALs; i.e., plants and departments), and 16 general administrative and technical departments in three Socialist Republics of Yugoslavia.

The services common to all the manufacturing WOs in the system are handled centrally by two general administrative and technical divisions and three service WOs. The basic structure of Rade Končar is presented in Figure 1, with manufacturing WOs on the left. For the purposes of this paper, the WOs "Development of Products and Production" and "Domestic and Foreign Trade" are of special interest (see Figure 1, top right). Within each WO there are several BOALS that work in accordance with the basic organizational structure, which is based on consistent applications of production specialization, i.e., in accordance with the respective functions of each WO and BOAL.

The main activities of Rade Končar include the design, construction, manufacture, testing, installation, putting into operation, maintenance, repair, service, and overhaul of electrical equipment for the production, transmission, distribution, and consumption of electric power, such as

- electrical rotating machinery
- equipment and generating sets
- transformers and transformer stations

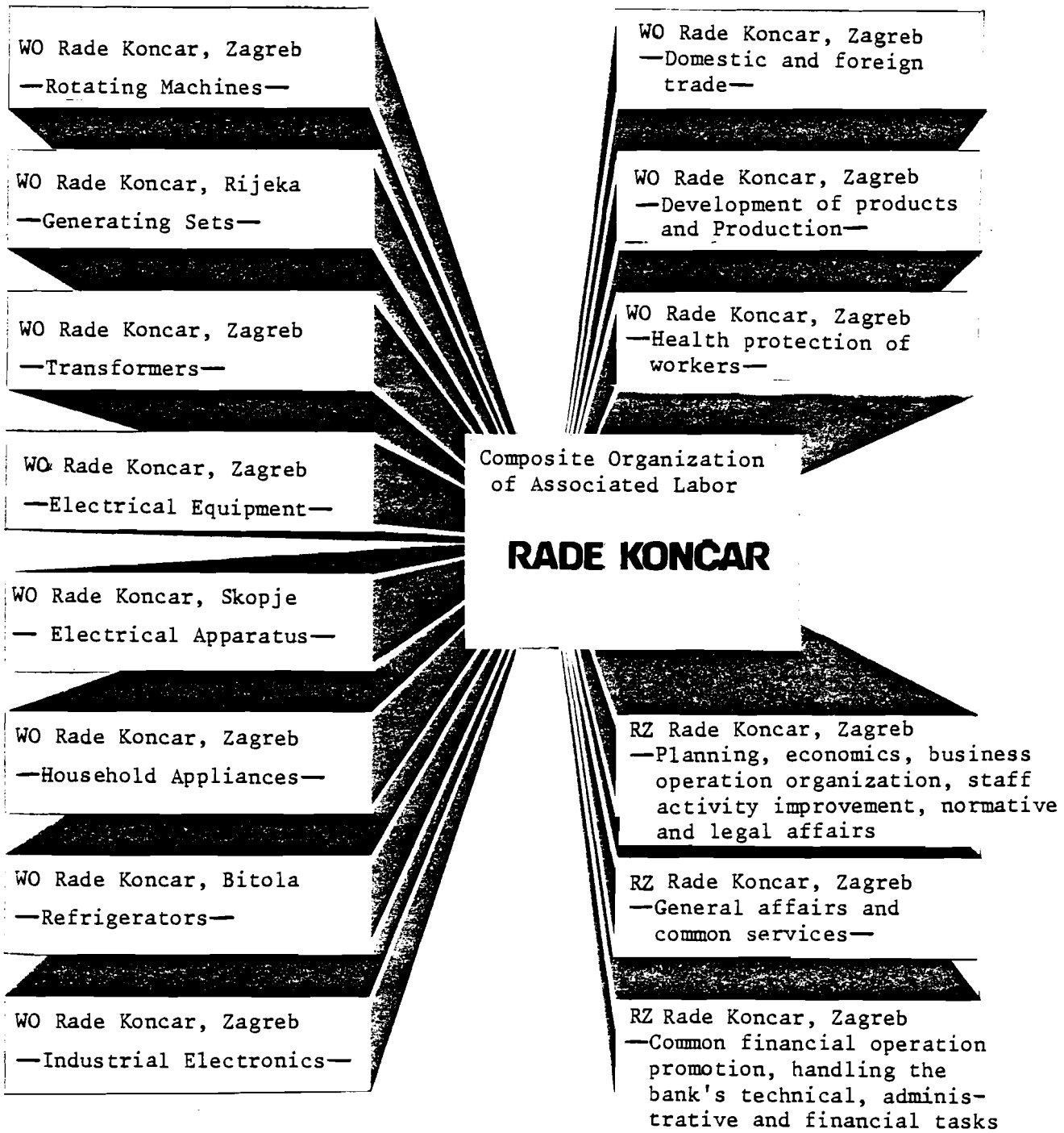

Figure 1. The basic structure of the firm Rade Koncar. WO = work organiza-organization, RZ = service organization.

- o electrical apparatus, low- and high-voltage equipment and installations
- o electrical ceramics
- o equipment for catering, the retail trade, cooling, and refrigeration
- o equipment for civil engineering projects
- o transport equipment
- o technical products and plants
- o household appliances and components
- o industrial electronics, measuring and testing instruments
- o explosion-proof electrical equipment

Other activities include the design, construction, and reconstruction of projects, plants, and parts of plants for power generation, industry, transport, the building industry and other sectors of the economy, including complete execution of engineering projects in Yugoslavia and abroad.

2. CHARACTERISTICS OF TECHNOLOGICAL DEVELOPMENT IN RADE KONČAR

Self-reliance in technological development is a permanent and fundamental objective of Rade Končar, and this has led to very signficiant results. About 85% of the present total annual income of Rade Končar is based on internal technical and technological developments, and annual payments for technology to foreign partners amount to less than 0.1% of the total income. The attainment of business objectives is almost entirely achieved on the basis of technological self-reliance in an exceptionally wide area of production, and this has implicitly necessitated the introduction of an innovation management system on an organized basis.

Obviously, the innovation process has a variety of forms, and it is difficult to determine its exact limits. The process is, of course, present in all its complexity in Rade Končar, and in order to present its basic aspects within this firm, it is necessary to consider only two basic forms in which innovations appear:

(a) the creation of new products (either entirely new or substitutes for existing ones; this also applies to plants, systems, technologies, etc.); and
(b) the improvement of products currently in production.

2.1. The Creation of New Products

The organizational structure of Rade Končar has been developed in response to the fact that the creation and timely introduction of new products, as the main result of the innovation process, provides an impetus to overall development. The following three essential activities form the framework and presuppositions of this structure:

- o development programming
- o development implementation
- o realization of development results (introduction of developed products).

Figure 2 illustrates these activities, with their performers and fields.

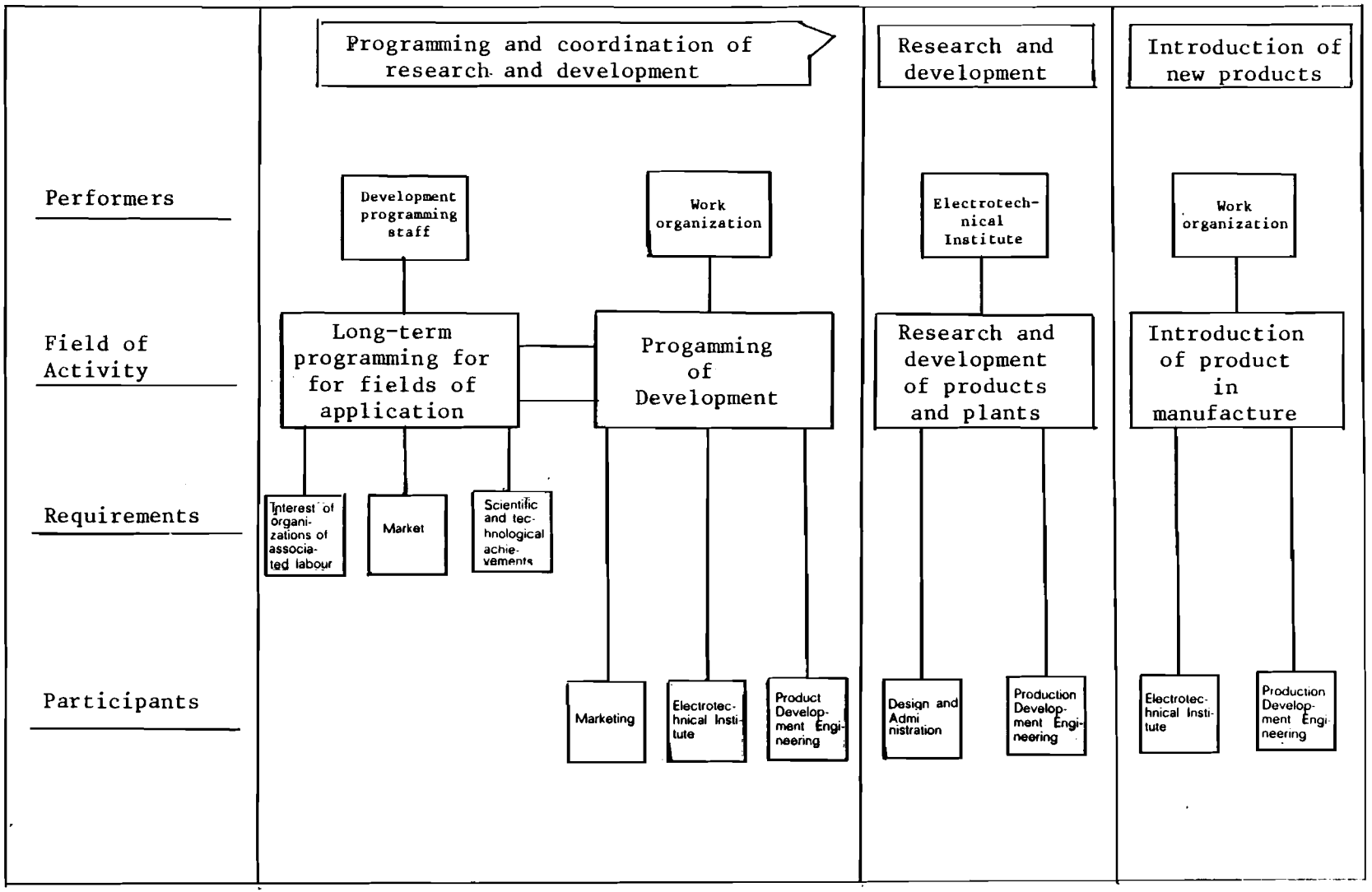

Figure 2. Programming and realization of product and plant development.

2.1.1. Development Programming

Basically, short-, medium-, and long-term aspects of development programming are carried out at the level of the entire Composite Organization (CO), at the level of WOs (where the role of the WO "Development of Products and Production", with its two BOALs—the Electrotechnical Institute and Engineering for Investment and Technological Development, is particularly prominant), as well as at the level of BOALs.

In accordance with the established division of labor, development programming is carried out cooperatively using results from other functions, particularly marketing, engineering, promotion of management and economic-financial functions, with which it attempts to meet the following basic requirements as far as possible.

(1) To unify technical and technological development within the entire CO, which is based on a consequent specialization of production according to the function of each WO.
(2) It is the right and obligation of every BOAL to ensure the adoption of up-to-date and profitable methods of production, making use of the entire technological development system in the CO. BOALs, however, cannot be compelled to introduce in their production any solutions that are not acceptable with respect to technology, manufacture, or the economy. This fundamental self-managing right is an essential regulator of the system, because it forces the entire organizational pyramid (from BOALs to the CO as a whole), to take into account first of all the interests of basic manufacturing units. This system is especially important, and sometimes very complex, if the development of plants, systems, and facilities involving other WOs or BOALs is involved. Therefore, two dimensions inevitably have to be considered, which have to be in equilibrium, in order to maintain and strengthen the efficiency of the entire system and to guarantee the rights of each self-managing entity.

2.1.2. Development Implementation

The annual plans and development program are made on the basis of medium-term plans of the Composite Organization. The responsibility for all development implementation, as a rule, is born by the WO Development of Products and Production, with its two BOALs—the Electrotechnical Institute and Engineering for Investment and Technological Development. However, in actual development implementation, the participants are:

- the Electrotechnical Institute, at the R & D stage of plants and products;
- manufacturing WOs and BOALs (particularly their design and engineering departments), at the stages of development, design, construction and technological testing of products, and in setting up new production processes;
- Engineering for Investment and Technological Development, at the development and design stages of new production processes and equipment.

In the sequence of development implementation (the innovation chain) there has to be interaction between all the participants. For example,

engineering and design departments of manufacturing WOs carry out some development activities, and vice versa, for some programs, the Electrotechnical Institute provides designs and constructions. A rigid framework is here neither useful nor possible, so that the participants and tasks in individual development programs are determined by their dependence on their specific subjects and conditions. Experts from the Electrotechnical Institute have to be sufficiently attentive to production requirements, while experts in the production units have to be creative and able to introduce the insights gained from development programs. Priority is given to well thought-out programs, and participants are chosen according to their expertise in the particular subjects and conditions.

It is evident that a successful development implementation is primarily influenced by the BOAL Electrotechnical Institute, which collaborates with the BOAL Engineering for Investment and Technological Development, within the WO Development of Products and Production. The present organizational structure of the Electrotechnical Institute (Figure 3) is the result of the need for an organized model to enable optimum implementation of current and long-term product development, plants, and complex systems on the basis of exchange of labor within the Composite Organization, Rade Končar, and even further. The organizational structure comprizes 12 divisions consisting of 40 departments and 130 sections and laboratories. They are organized to cover the development of the entire range of Rade Končar products, technological innovation, the development of special materials, application of computer techniques, and also to provide technical back-up for development in general (standardization, industrial design, information and documentation services, industrial proprietary, scientific-technical cooperation, etc.).

The starting and dominant requirement in establishing the structure and mechanisms of interactions between the main participants in the innovation cycle, is to maintain the recognized and generally accepted effort to achieve the best possible results in the following:

(1) development implementation

- o in terms of quality, and
- o timeliness in respect of current plans

(2) realization of development results

- o their adoption by manufacturing units, and
- o their introduction into production.

Here, the principle is applied that the business achievements of each participant have to be evaluated primarily on the basis of indicators of the final aims of the innovation cycle, i.e., on the basis of indicators obtained after comparison with production developments of the respective BOAL.

2.1.3. *Realization of Development Results (Introduction of Developed Products in Production)*

The adoption of new methods of production is a natural and important function of manufacturing WOs. It also includes a large amount of effort with respect to design, construction, and technological elaboration. Experts from the Electrotechnical Institute and Engineering for Investment and Technological Development participate in accordance with set programs.

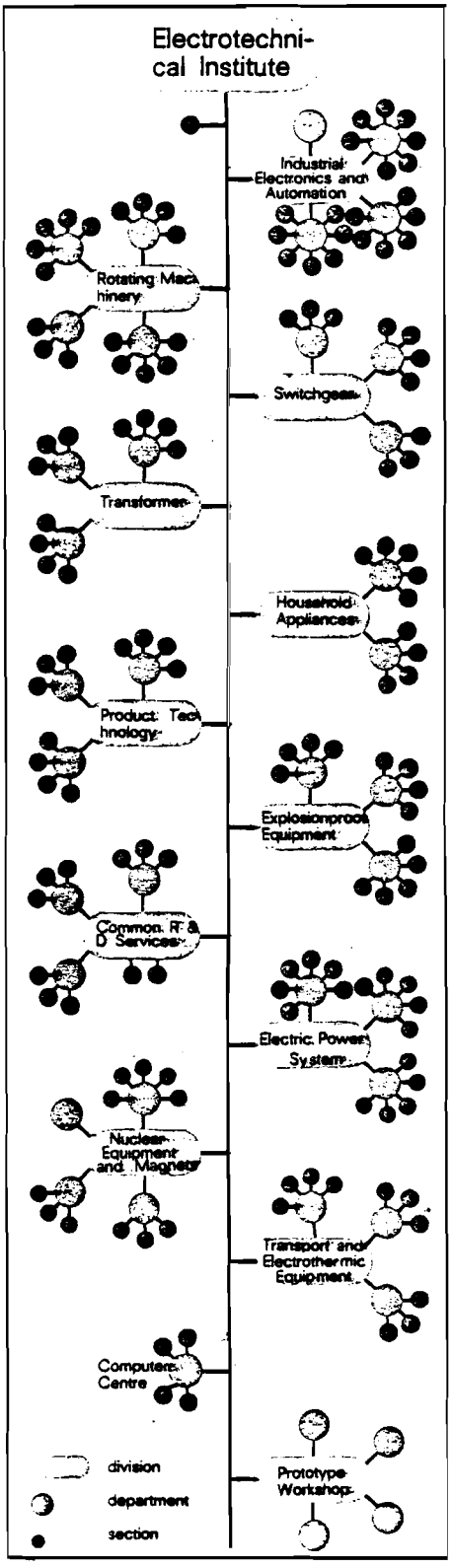

Figure 3. New organizational structure of the Electrotechnical Institute

2.1.4. *Synthesis of Activities Related to Development: Implementation and Realization of Development Results*

Because of the division of labor, new developments are researched in separate organizational units (as a rule, in the Electrotechnical Institute), while realization, i.e., the application of development results, is carried out in basic manufacturing units. By the very nature of such a structure, however, difficulties might arise that could cause an unnecessary prolongation of the time required for realization of development results by the BOALs. On the other hand, if the organization allowed autonomous development implementation or adoption of innovations, it is possible that certain trends could appear that may prove (partly or evenly entirely) to be undesirable in terms of the innovation cycle as a whole.

In order to reduce these possibilities to a minimum, in practice a model is applied by means of which the activities related to the implementation of new developments and realization of results may be synthesized in the course of their progress (Figure 4).

There are many advantages in the application of such a model:

(a) from the outset, the future users of development results are kept informed of progress being made, so that the possibility of exerting a certain influence on trends, if required, can be ensured;
(b) the appropriate involvement of experts from manufacturing in development implementation ensures that they can contribute their knowledge and experience gained primarily through control of production processes;
(c) experts from manufacturing are thus directly informed at least about the basic particulars of developments, and thus it is largely ensured that they will adopt development results, master the new technologies and techniques, and introduce these into production;
(d) an efficient realization of development results in production is ensured by the participation of the experts responsible for the development;
(e) in addition to improvement in the quality of the whole innovation cycle, the time required for the realization of these results is considerably reduced by the application of this model.

2.2. Improvement of Products and Processes in Current Production

After developed products are introduced into production and the technological processes established, there is a constant endeavor to improve them by applying new experiences and findings. This task is primarily assigned to the manufacturing BOALs, although other participants may also be engaged, particularly experts from the Electrotechnical Institute and Engineering for Investment and Technological Development.

3. AN INCENTIVE SYSTEM WITHIN THE INNOVATION CYCLE

All the activities directed to the achievement of planned business goals are also carried out in Rade Končar in an organized manner, taking into

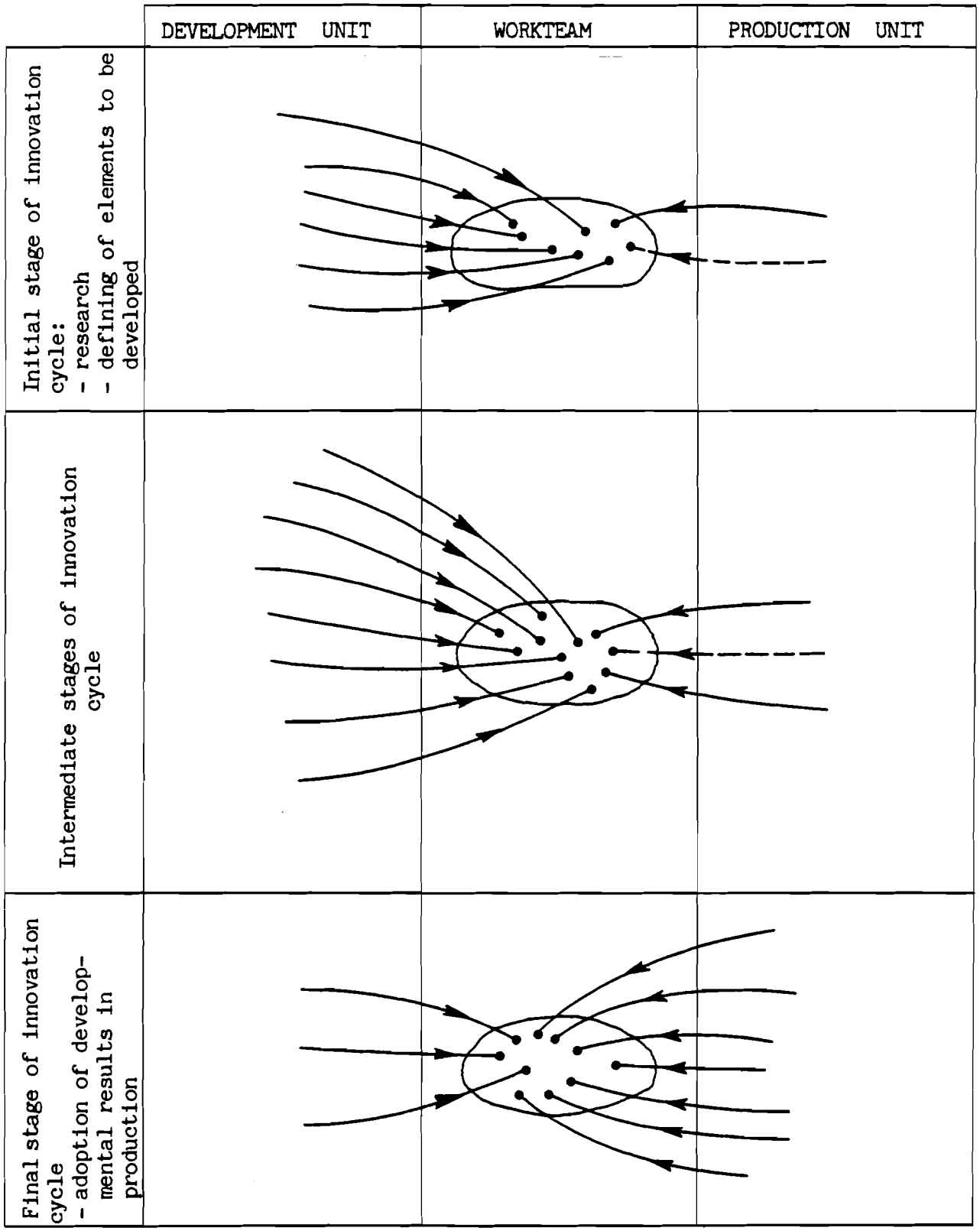

Figure 4. Model of synthesized implementation of the innovation cycle.

account the organizational structure, the division of labor, levels of competence and responsibilities. In this way, a high degree of performance of the activities in relation to planned tasks is ensured.

Because of its importance in the dynamics of technological development and some of its specific features, however, the innovation process deserves special attention. The entire process has to be observed in relation to the organizational units, which are leveled within the process, and also in relation to the individual taking part as a performer of certain activities.

Investigating and establishing an incentive system for the promotion of the innovation process have been realized in Rade Končar at the levels of both the organizational units and of the individuals who are involved in diverse activities at all stages of development.

3.1. Organizational Units and the Innovation Process

The involvement of organizational units in the successful implementation of the innovation process is encouraged by applying the principle that their business results are directly dependent on the final results of the innovation process. In this way, a maximum level of interest on the part of organizational units in promoting innovation implementation can be achieved.

At the level of manufacturing units, the application of this principle has resulted in a high degree of readiness to accept innovations, which, by increasing incomes, contribute to better business results and, consequently, increase the potential for further development and improve all aspects of the working standards of employees.

A virtually identical principle to that described above has also been applied to organizational units—the executors of developments (the Electrotechnical Institute and Engineering for Investment and Technological Development), whose annual incomes are directly dependent on business results achieved by the manufacturing units. Thus, a confluence of interests is achieved between the development executors and the interests of manufacturing units, which consequently ensures the close interest of the former in well chosen and well implemented, high-quality developments, as well as in the timely and rapid introduction of development results in production.

3.2. The Individual and the Innovation Process

The evaluation of the contributions and activities of individuals, within the given organizations structure and divisions of both functions and responsibilities, belongs, in general, to a special category of problems whose solution may be approached from various standpoints. However, all these diverse approaches have in common the aim of achieving a positive response to activities applied.

The difficulties arising in connection with the evaluation of contributions increase roughly with the degree of mental work involved in the total activity of an individual. In general, it has to be taken into account that there is always a danger that a certain total intellectual activity will be of little use from the viewpoint of current business objectives. This necessitates a constant checking of how far each scheduled task is justified

as well as undertaking adequate corrections, but due to the use of appropriate indicators, which are mostly determined unambiguously, these needs do not present unsurmountable difficulties.

However, the whole matter becomes very complex at the stage when, on the basis of an evaluation, an attempt has to be made to locate the contribution of an individual on a scale, whose upper limit is the maximum possible contribution. It is evident that the degree of expected (i.e., required) contribution with respect to the timely communication with other individuals in activities plays an important role.

All the considerations and experience gained so far lead to the conclusion that it is almost impossible to avoid a direct linking of the degree to which an individual is truly motivated with the results of his mental work. Using this as a starting point, a system of incentives for individuals to achieve better results within the innovation process has been independently investigated and established at Rade Končar. Self-managing actions regulating the entire renumeration mechanism have also been studied at the level of the Composite Organization and at that of the BOALs. Funds have been allocated to enable individuals to earn additional income on the basis of their proven contributions to the innovation process. The principal condition under which such addition payments are granted is whether an innovation has been adopted and used in production. On this basis, data reflecting the effects of applications of such innovations are gathered, and these in turn determine the level of payments. From the viewpoint of the participating individual, this means that an innovation has to be implemented in the particular manufacturing unit, which collects and forwards the data on the effects of the innovation. In this way, the interest of individuals is maintained in:

- supporting the innovation chain as a whole
- high-quality implementation of all parts of the innovation process
- maximum reduction of the time required for completion of the implementation process in each particular case, and
- the best possible effects of the application of innovations in production.

A principle that is virtually identical to the above, is also applied to experts in WOs and BOALs who participate in innovation implementation to a relatively small degree, but who almost daily contribute to the improvement of products and manufacturing processes.

In every BOAL and WO, and also at the level of the entire Composite Organization, special boards have been set up specifically to evaluate creative work. These boards act in accordance with effective self-management rules regulating the creative work, thus implementing set policy in this field, and consequently encouraging creative work in general. The activities of the boards are of course directed primarily towards the organizational units to which they belong. At the same time, they also coordinate their activities with the entire boards system for the evaluation of creative work in Rade Končar, and thus contribute to the formulation of a common management policy.

A large part of the work of these boards consists in evaluating the effects of innovations in production, on the basis of which the levels of

payments to individuals who creatively participated in the formulation and application of innovations are determined. As an illustration, the boards that evaluate the creative work at Rade Končar, after due consideration, decided in 1982 to reward about 300 innovations, formulated by numerous experts from development and manufacturing units.

4. CONCLUSIONS

The innovation system in Rade Končar has been investigated and described, starting, first of all, from the endeavor to promote all current business objectives as far as possible and to recongize the contributions of individuals based on the results of their work. The organizational structure and all the findings and experiences obtained in the promotion of the innovation implementation cycle have been taken into account.

MAN AND ORGANIZATION AS BARRIERS TO INNOVATION

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Barriers to innovation are usually erected by the existence of several factors, which are either of an endogenous nature (i.e., lying within the sphere of power of a company) or of an exogenous nature (i.e., lying outside the sphere of power of the company). This basic premise is the point of departure for assessing product and process innovation as a strategy for problem solving and problem avoidance and a strategy for utilizing opportunities.

1. PRODUCT AND PROCEDURE (PROCESS) INNOVATION AS A STRATEGY

Innovation as a change, as renewal in the widest sense of the word will have to be interpreted in the sense of J.A. Schumpeter:

> "Innovation, i.e., the process of finding economic applications for inventions,"

which means that innovation goes beyond invention as such. As product innovation it comprises the economically successful creation of new products and services; as a process innovation it is the new and economically successful combination of relevant production factors. Its characteristic features are the degree of novelty (technological push, demand pull), complexity (emergence of causal relations), uncertainty and risk (threat of failure), and conflict potential (factual and personal).

By placing innovation within the strategic concept of a company, we arrive at the concept of innovation strategy. Strategy (according to Carl v. Clausewitz "the arrangement of engagements for the purpose of war...") thus demands planning and identification of objectives (target planning and search field determination), and consequently inference of procedural concepts (planning of measures, definition of action programs). So far, in identifying search fields for innovation strategies deliberations have practically been limited to the area of products and markets (new products, new markets) (Figure 1).

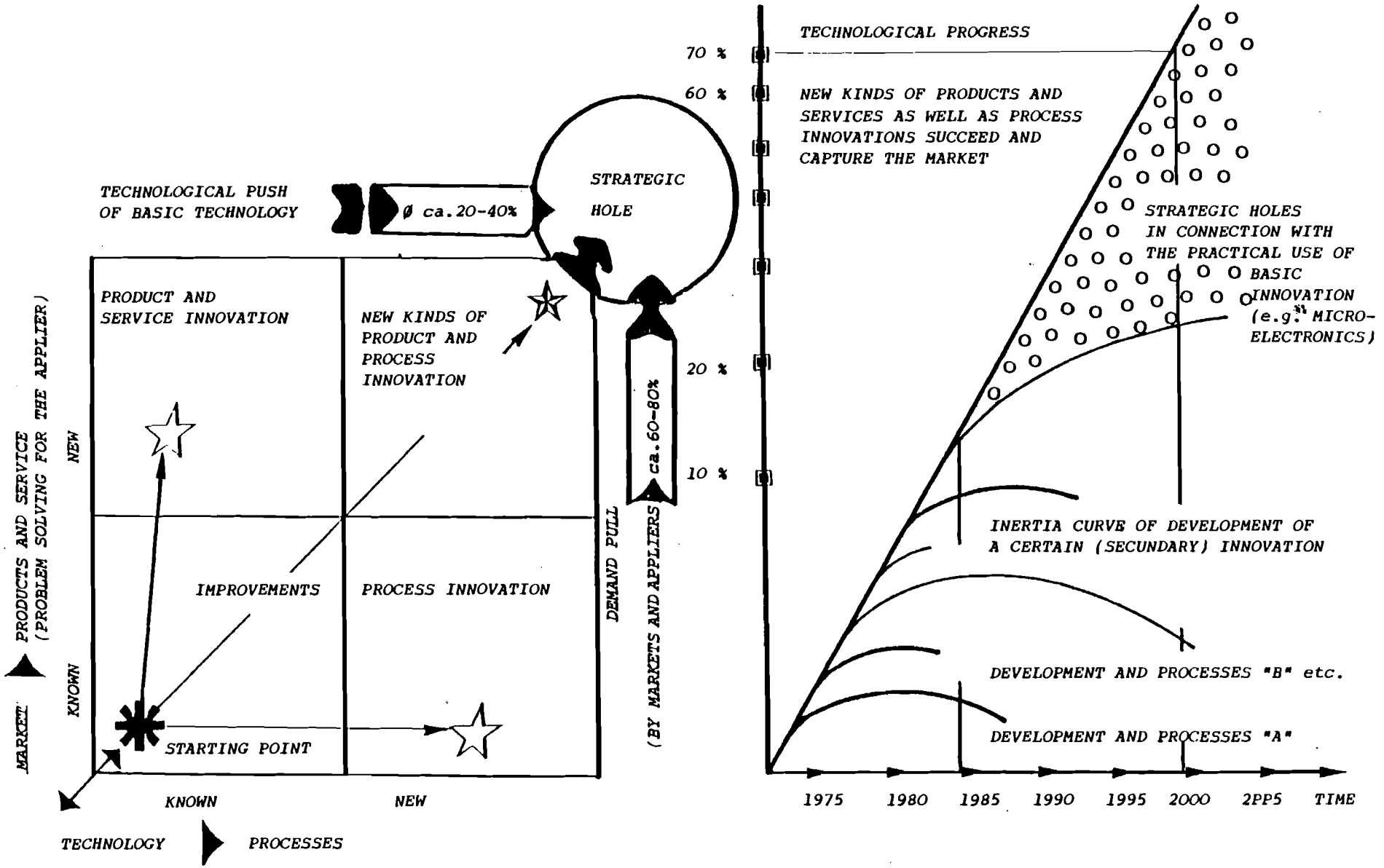


Figure 1. Innovation, that is, the process of finding economic application for the inventions (Schumpeter).

But, two further areas are necessarily of importance:

— The resource area (preliminary work) with the requisite utilization factor/procurement market strategies (new materials, new procurement markets);
— The area of production (actual performance) with corresponding production technology/production program strategies (new technologies, new lot sizes).

In addition, an overall company concept must also provide for innovative approaches in the controlling sector.

The planning of measures requires an implementation strategy as its basis. The choice is between internal company-developed strategies or external collaborative strategies.

Under such circumstances, product and process innovation may be viewed as a strategy to handle problems, and even more as a strategy to seize and use opportunities. However, it must not be overlooked that the definition of a strategy does not yet guarantee satisfactory results. Thus, an innovation strategy eventually demands systematic implementation of measures in order actually to attain the prescribed objective (Figure 2).

When comparing current situations within a company with such considerations, we usually find a field of tensions with a series of barriers to innovation, which are, however, at the same time major departure points for improvement. This applies not only for the improvement of external environmental conditions (by the state, local authorities and institutions) but also, particularly so, the generation of an internal attitude and capability of innovation and an operating climate favorable to innovation. Strategic thinking, target-oriented project management, functional problem solving approaches, consistent flexible development of the organization, collaborative attitude and situational leadership by an effective innovation management are important factors for the success of product and process innovations.

2. THE ORGANIZATION AS A BARRIER—BARRIERS OF ORGANIZATION WITHIN THE COMPANY

Planning requires an organization to give it a concept, since it demands systematic procedures and clear-cut responsibilities for its preparation, implementation and control. The organization must provide motives and freedom for strategic and planned thinking and acting, and must then combine individual plans to an overall planning concept. In other words, predictive planning and decision-making are indispensable for companies and successful innovation projects.

An effective innovation management must continuously make decisions which, while taken today, will have far-reaching consequences for a usually uncertain and only partly analyzable and predictable future. Our thinking and acting is also shaped by experiences collected over time. While we apply current situations to various areas of decision-making, we find it difficult to adapt the organizational structure accordingly. Instead of having innovative flexibility, the organization increasingly shows a rigidification of established structures.

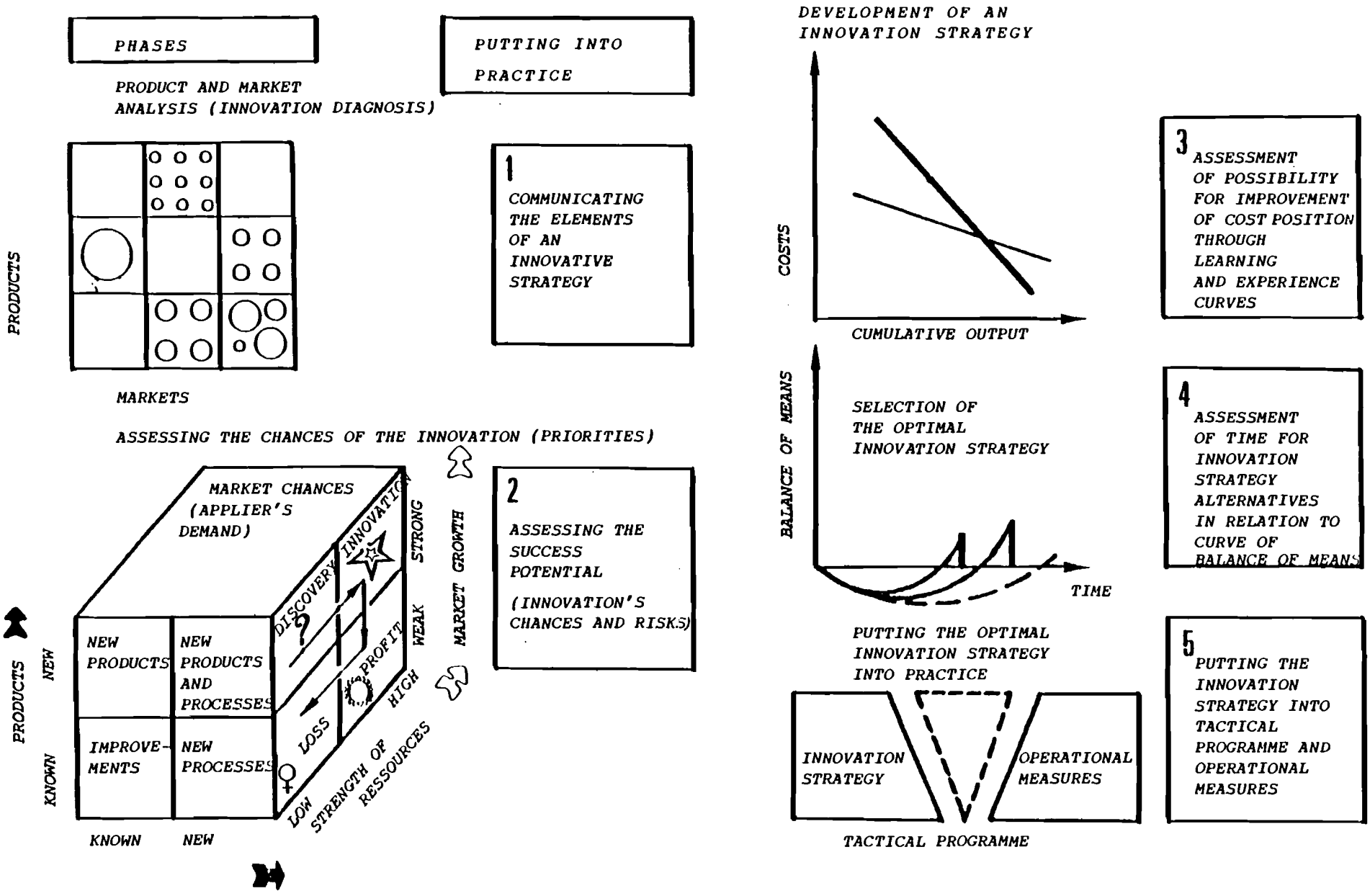


Figure 2. Phases and realization of an innovation strategy.

Each company has created its own culture depending on the values and standards developing in its national and societal environment. Past experience is carried over to the present by unwritten laws, tradition, as well as environment, exerts its influence on the present situation. This traditional order has so far been widely neglected in organizational analyses and has led to the failure of many projects of innovation.

The organization frequently does not meet the demands of an effective innovation management. The bureaucratic pyramid usually forms an "hourglass" where the sand of information squeezes through slowly and laborously. In some companies with a strong desire for security, the bureaucratized "distrust organization" is confronted with the necessity—and opportunity—of an innovation management striving for effectiveness and the demands of innovative staff for mental breathing space.

Even large-scale company organizations can realize clear and flexible organizational structures and an innovation management culture by the creation of (partially) autonomous units. This development goes hand in hand with a strong emphasis on teamwork, which becomes the instrument of management and staff development.

> Successful innovations require flexible organizational cultures with autnomous scope for creativity and conscious reduction of bureaucracy!

3. WHAT MUST BE DONE?

3.1. Innovation Planning Must be Organized

Any deliberations for organized innovation planning must start with an evaluation of the position and the definition of the target for all company efforts: "If we first knew where we are and where we want to go, we would be better able to judge what to do and how to do it" (Abraham Lincoln), since "If you do not know where to go, any way will take you there" was already known to Alice in her Wonderland. A basic precondition for realistic innovation planning is "the knowledge of the current state of development based on an analysis of strengths and weaknesses." The evaluation of position and definition of targets is then followed by the design of and agreement on the strategic concepts selected to attain the objective.

Apart from strategic planning of investments and staff as well as organizational and leadership planning, organizational development is concerned with product program planning. It is supported by special instruments such as life-cycle analyses, experience curve concepts, portfolio matrixes, and scenario techniques (Figure 3).

3.2. The System of Innovation Planning Must be Designed as a Part of the Company Management Concept

Company concept and policy, leadership style and behavior, employment principles and guidelines for personnel structure, incentive and reward systems, evaluation, promotion and training of staff, information design and organization all follow the management's company philosophy. "Point of departure and basis of overall company planning" thus present a formalized "company philosophy".

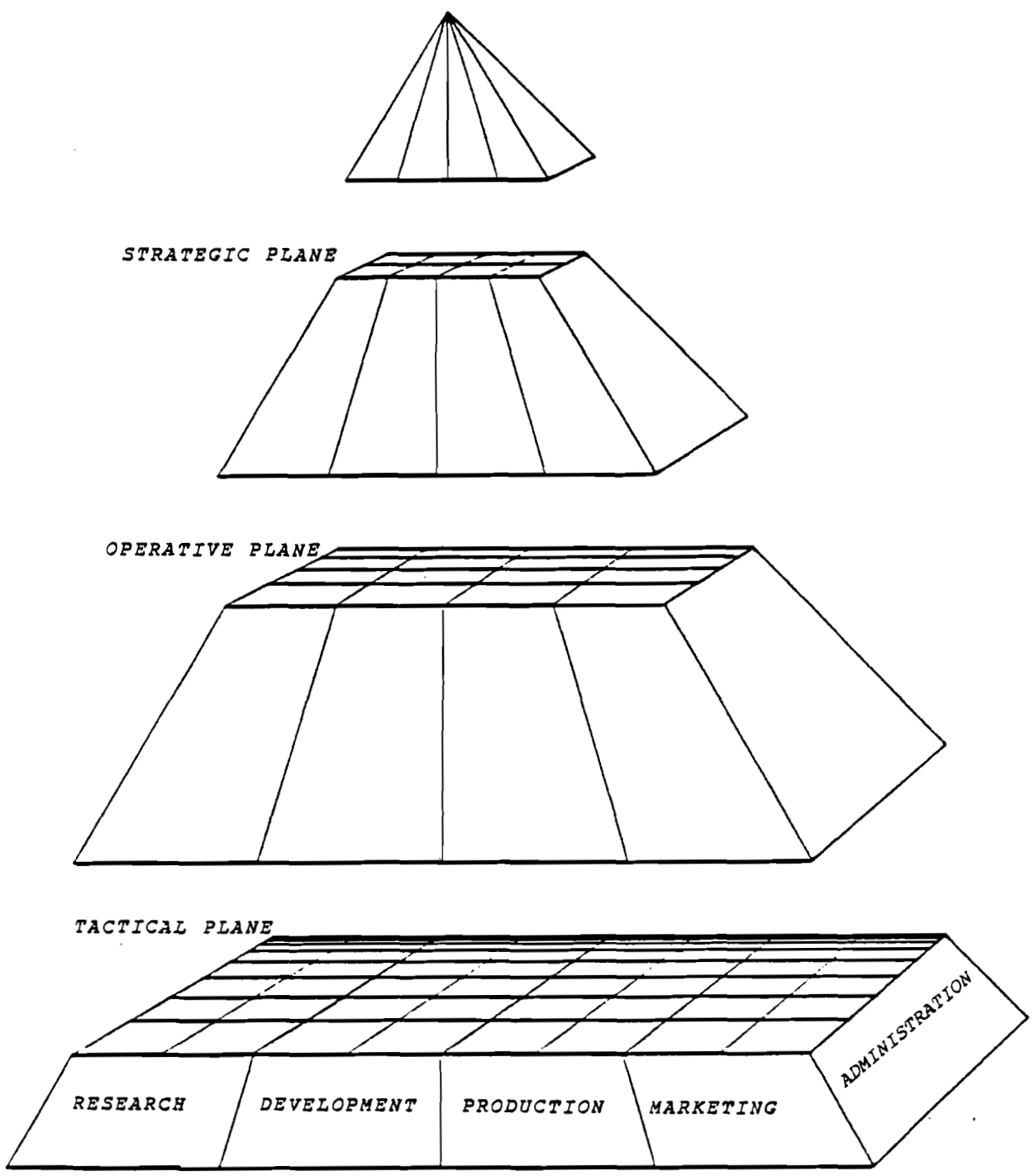


Figure 3. Planning levels and subject of the innovation concept.

Planning is always system-dependent—not only in combination with other management systems. Planning is discussion, planning preconditions discussion; it is a specially suitable field, even a compelling motive, for cooperative exchange, for collaborative leadership. "Incorporation of existing management potential into the planning processes leads to the preparation of more realistic, i.e., realizable, plans. Collaborative planning work also emanates significant motivational effects that go beyond planning motivation to ensure improved motivation to realize and implement plans." Figure 4 shows four basic styles and five situational elements of innovative planning.

3.3. Responsibility for Innovation Planning Must Not be Delegated

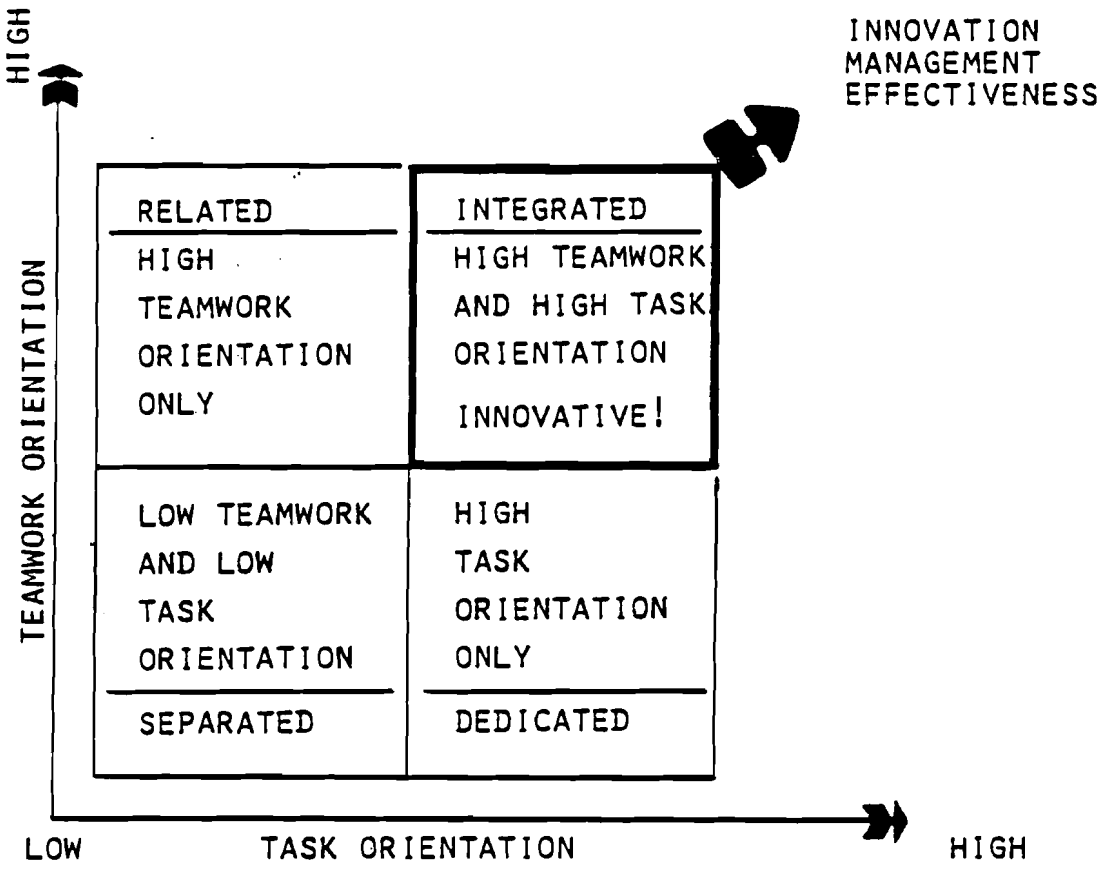
Responsibility for innovative planning can never be assigned to auxiliary staff. Planning responsibility is always line responsibility! Shaping the future of the company—after all the actual objective of innovation planning—is primarily the task of the company management at all levels. Staff may assist the company management in the preparation, harmonization, and supervision of plans by contributing their specific expert knowledge. Still, the definition of the innovation plan contents remains the task of the innovation management that has to accept final responsibility for their realization.

Within the line management itself, the question arises of the appropriate level to which to assign responsibility for the innovation plan contents. Basically, the American planning experience should be applied: "Operating management is its own best innovation strategist" — which, however, requires proper training of the operating management in strategic thinking and acting, which is not self-evident in the sense of Gresham's Law of Planning (operative action of urgent but unimportant nature gets priority over strategic action of important but nonurgent nature). The operative line management, being responsible for the implementation of the plans, usually knows most about the opportunities and risks of various planning alternatives which enables them to contribute closely to the planning process. Also, they are the ones who should identify with planning since it is their task to realize plans through their daily activities. Figure 5 shows the innovation process for new products and processes.

4. BARRIERS TO INNOVATION

An innovation, the transformation of an invention into a successful product or process, requires many small steps: strategies, plans, ideas, discussions, decisions, information, analyses, assessments, tests, calculations, investments, marketing.

While inventions may be spontaneous, born from a brilliant idea, or the result of a long and laborious series of tests, innovations can never be created by chance. Innovations require a target-oriented will to transfer an invention into a process or market it as a product. Even the will in itself does not yet produce an innovation—the ultimate decision rests with the consumers who accept or reject it. The path from the idea to the employment of a new product or the application of a new process is obstructed by barriers.



THE LABELS SEPARATED, RELATED, DEDICATED AND INTEGRATED DESCRIBE FOUR POSSIBLE BASIC STYLES OF INNOVATION MANAGEMENT BEHAVIOUR

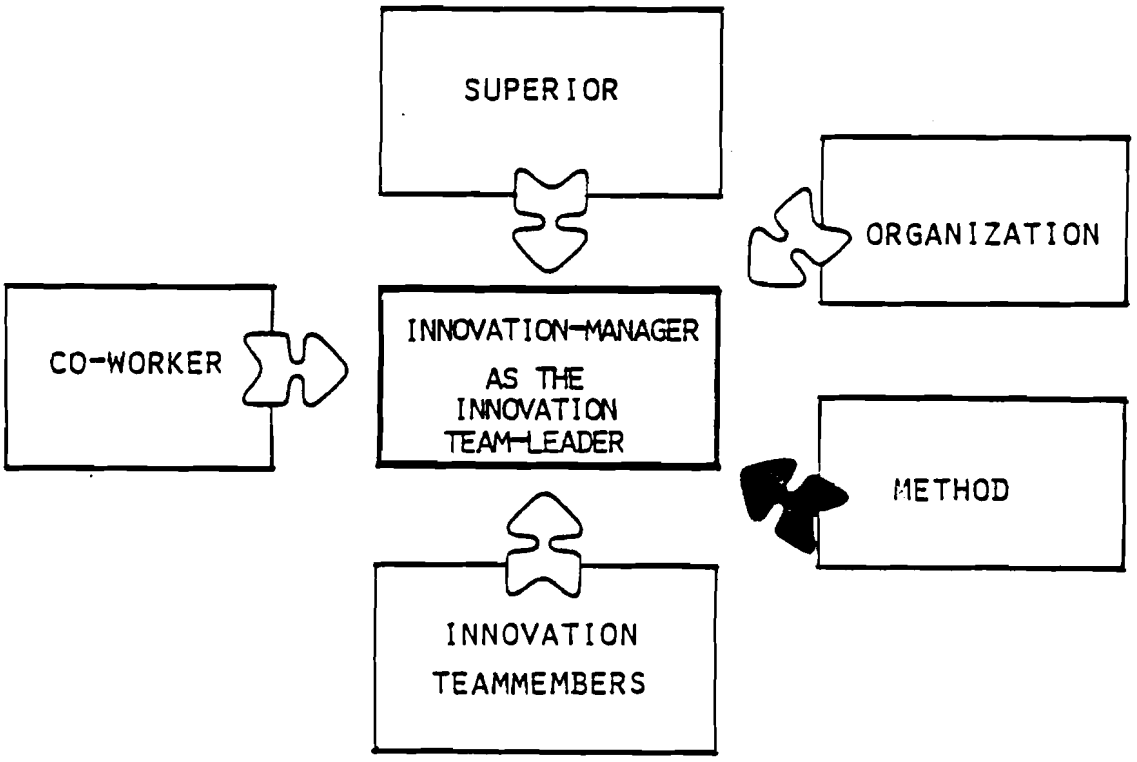


Figure 4. Four possible types of innovation management behavior and five situational elements.

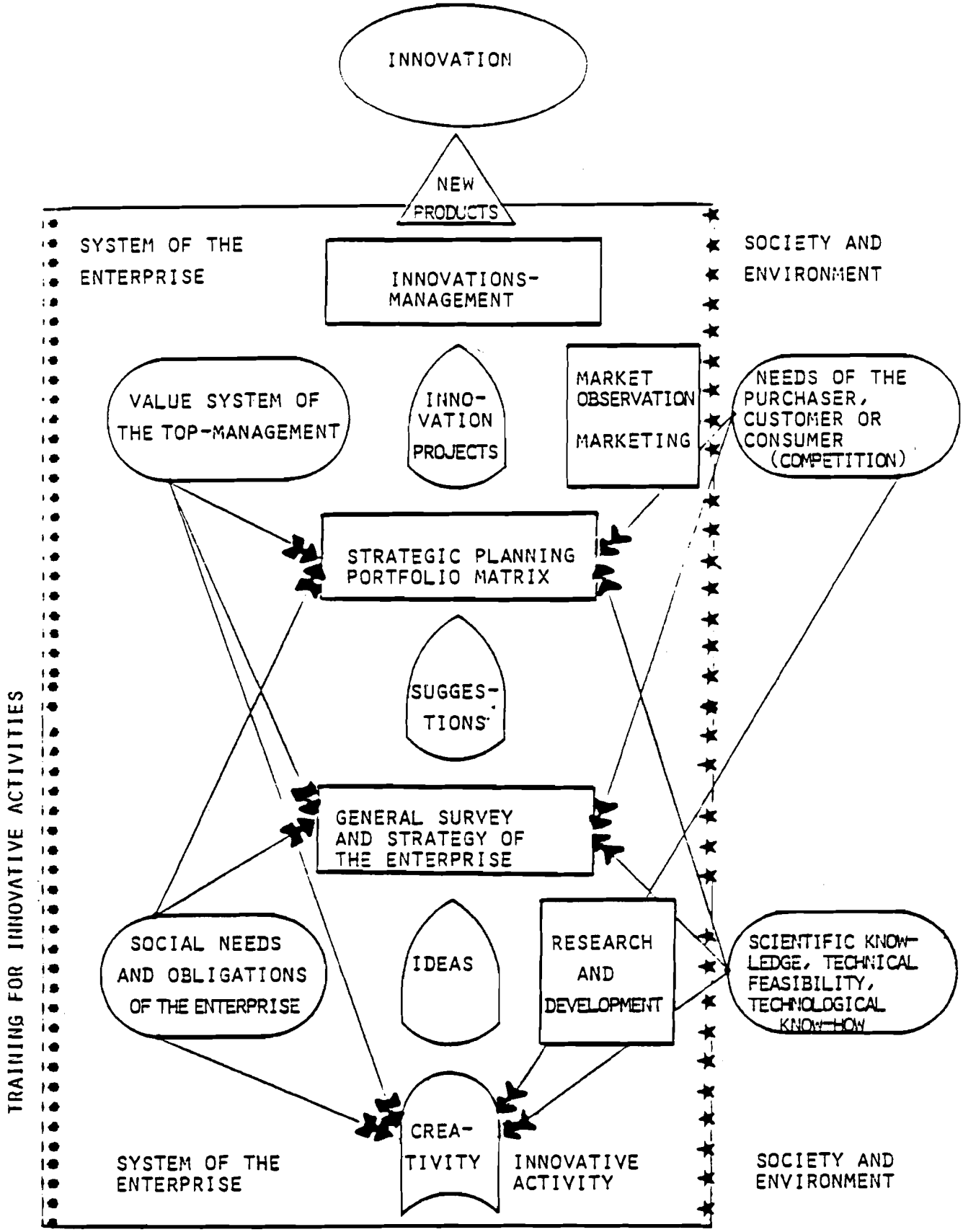


Figure 5. Basic schedule of the innovation process for new products and processes.

As mentioned before, two large groups of barriers may be distinguished: those of an internal and those of an external nature. While the companies themselves are responsible for the internal barriers, and are thus able to eliminate most of them, external barriers are usually not amenable to direct company influence. Any thinking and rethinking may only be stimulated indirectly by indicating the problems to the public and assigning them their societal and political context.

4.1. Internal Barriers to Innovation

The fate of an innovation is decided not only by market and user acceptance, but also by the internal attitude of company management and staff who, as the carriers of innovation, put together the many pieces of an innovation mosaic. The realization of an innovation requires personal skill and creativity, imagination and the readiness to change, to break away from established patterns of thinking—similar to the creation of a work of art. Evidently, such talents are statistically distributed among the individuallly participating managers and staff of a system.

Usually, resistance to innovation, which is primarily a change of customary processes, is not so much conscious but unconscious. Still, the two sources of active and passive barriers of nonimplementation cannot be clearly separated from each other. Certainly, there are few active individual barriers to innovation. They may be activated by lack of knowledge as well as by the pursuance of egoistic objectives. Envy, status seeking, career thinking may have a negative effect on the innovation process, may even stop it. Yet, ambition, properly channelled, may act as a stimulus for innovation. Passive barriers erected through inertia, clumsiness and inattention are much more frequent. "Doing and waiting" is the maxim of any innovation strategy, but the "waiting" part must not predominate.

4.2. Organizational Structures

The company organization is charged with the task of combining the many divergent characters and natures into a successful innovation process. Today, successful innovations are mostly the result of team efforts. Depending on its form, an organization may be either supportive or suppressive of innovation. However, this distinction is relatively theoretical since the decisive factors are the availability of managers and staff and their various talents. Figure 6 presents a product-oriented organization where each product group symbolizes a profit center; such an organization is more innovative than a functional organization (Figure 7) where the functions of development, production, marketing, and administration are each separately managed and overall product responsibility is in the hands of the company management. Concentrating responsibility, from development to marketing, in one hand removes functional confines, and thus information barriers.

But what should the bottom level of verticalization be? Excessive splitting up may lead to ineffective use of workshops and facilities. What is more, economically-oriented product centers must be headed by acting managers in the true sense of the word and not by "solely administrative" managers order to train such managers, engineering students should receive mandatory instruction in the relationship between market, economy and technology. Vocational training programs of innovative companies, such as the Siemens Group in Austria, offer special seminars, e.g., business management for engineers economic thinking and acting, company planning games, etc., that meet this requirement.

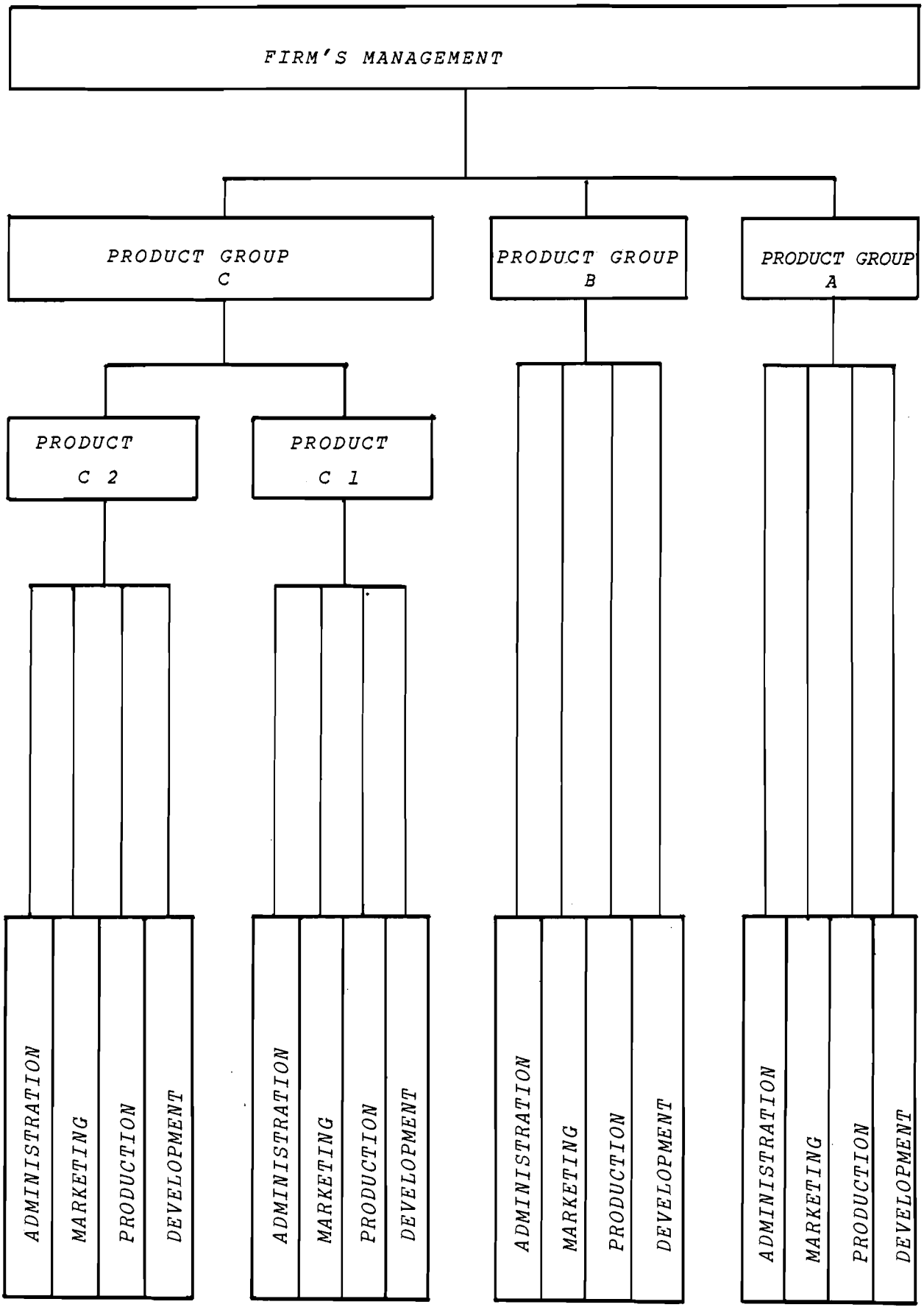


Figure 6. Product-oriented organization where each product group symbolizes a profit center.

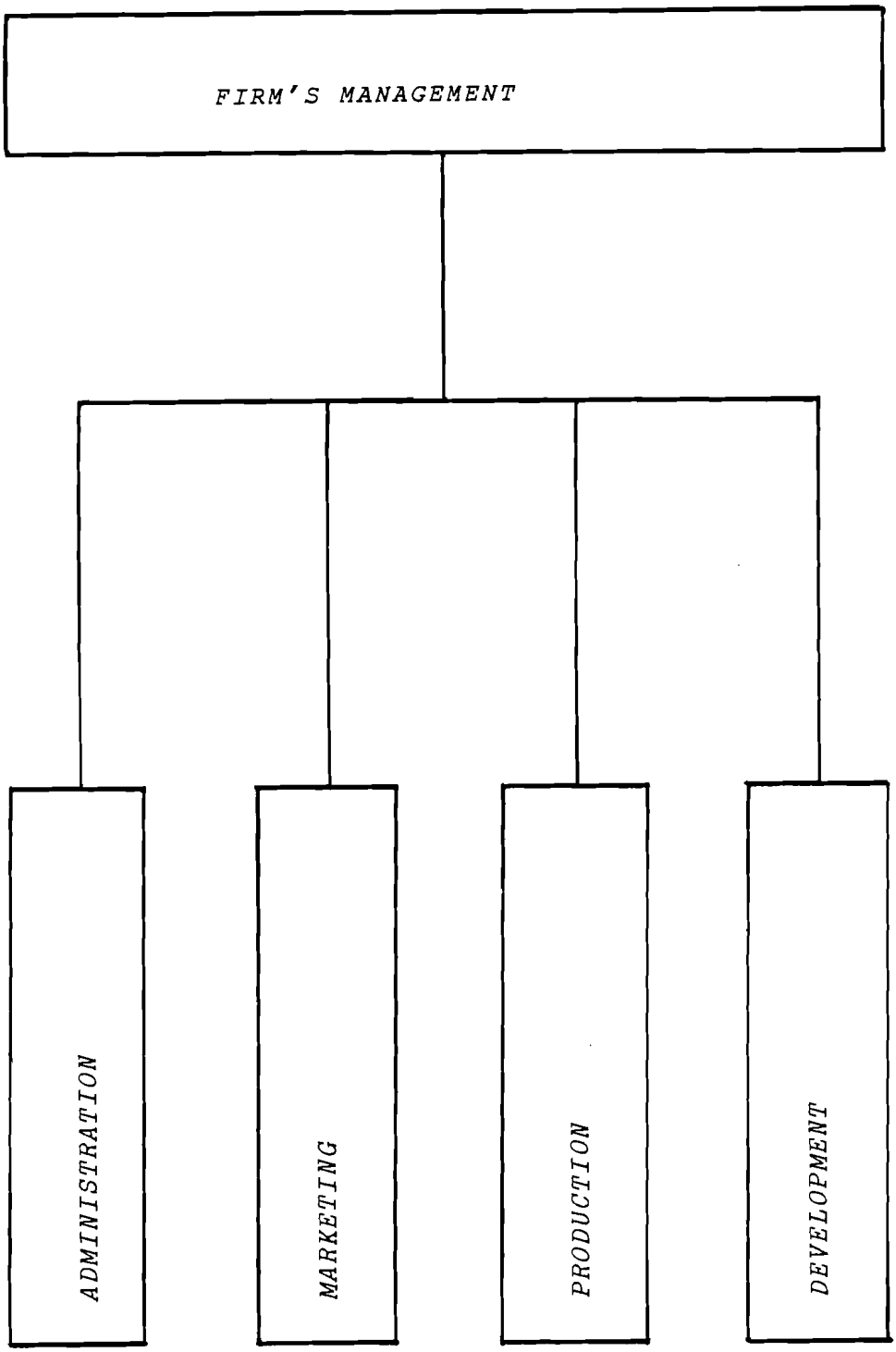


Figure 7. Functional Organization.

Some innovation strategies prefer the matrix organization (Figure 8) to the vertical and horizontal structure. The matrix organization combines the advantages of both forms of organization if "the managers and staff of the matrix organization have or acquire a maximum of willingness and ability to collaborate." Concentrating functional and product-related responsibility in one person or one team requires both a high task and involvement orientation and the ability of integrative leadership at all levels of management.

It is often recommended to choose a horizontal organization for the phase of invention, and a vertical organization for the phase of implementation, and to separate the two sectors. Research labs may lose their inventive power if they are too close to production and are exhausted by the day-to-day business. But if the distance is too large, researchers will be out of touch with reality, i.e., the link to manufacturing techniques and to the market. Figure 9 shows the basic issues of the innovation process (doing more with less). In order to prevent the interfaces between research and product sectors from becoming barriers to innovation—a possible risk—coupling must be ensured by special coordinative elements of the organization.

According to N. Thom, "slack" in the organizational structure—i.e., a certain excess of people and organizational units—may increase system flexibility by acting as hidden reserves, and may have an important function in the realization of innovations. Slack is highly useful in the phase of idea generation, in the R & D field, as well as in marketing, market research, and product planning. If no time or organizationally institutionalized reserves are available even at the management level, the demands of day-to-day business will erect barriers to innovation. Obviously, slack will increase overhead—and just when a company passes through a critical phase where it would be in urgent need of innovation, it lacks the funds, and sometimes the courage, to maintain spare capacities.

Evidently, the form of organization depends on the size of the company as well. The bigger the company, the higher the risk of bureaucratization, the more extensive the network of checks, the stronger the inhibition of individual initiative. Here, personal involvement, embedded in a climate favorable to innovation, is a key factor.

4.3. Motivation

What is meant by a climate favorable to innovation? It is a climate of openness and willingness to cooperate. Enthusiasm and interest in one's work are just as necessary as the readiness to accept changes. Delight in things new, be it out of curiosity or out of the basic human drive to improve and perfect things, must be given free rein—as long as it fulfills market requirements. Recognition and criticism must come just as natural as the feeling of shared responsibility and success. An open and innovative climate also means that the managers will discuss deviating ideas of their staff, and will not play the wise guys who have a monopoly on knowledge by virtue of their office.

If openness is suppressed, creativity evaporates. The consensus method of decision making, such as is successfully used by the Japanese, promotes this openness. Openness thrives only where different opinions are respected and accepted. An innovative attitude means being motivated, and motivation is mainly a question of leadership style. The wrong style of leadership may paralyze everthing.

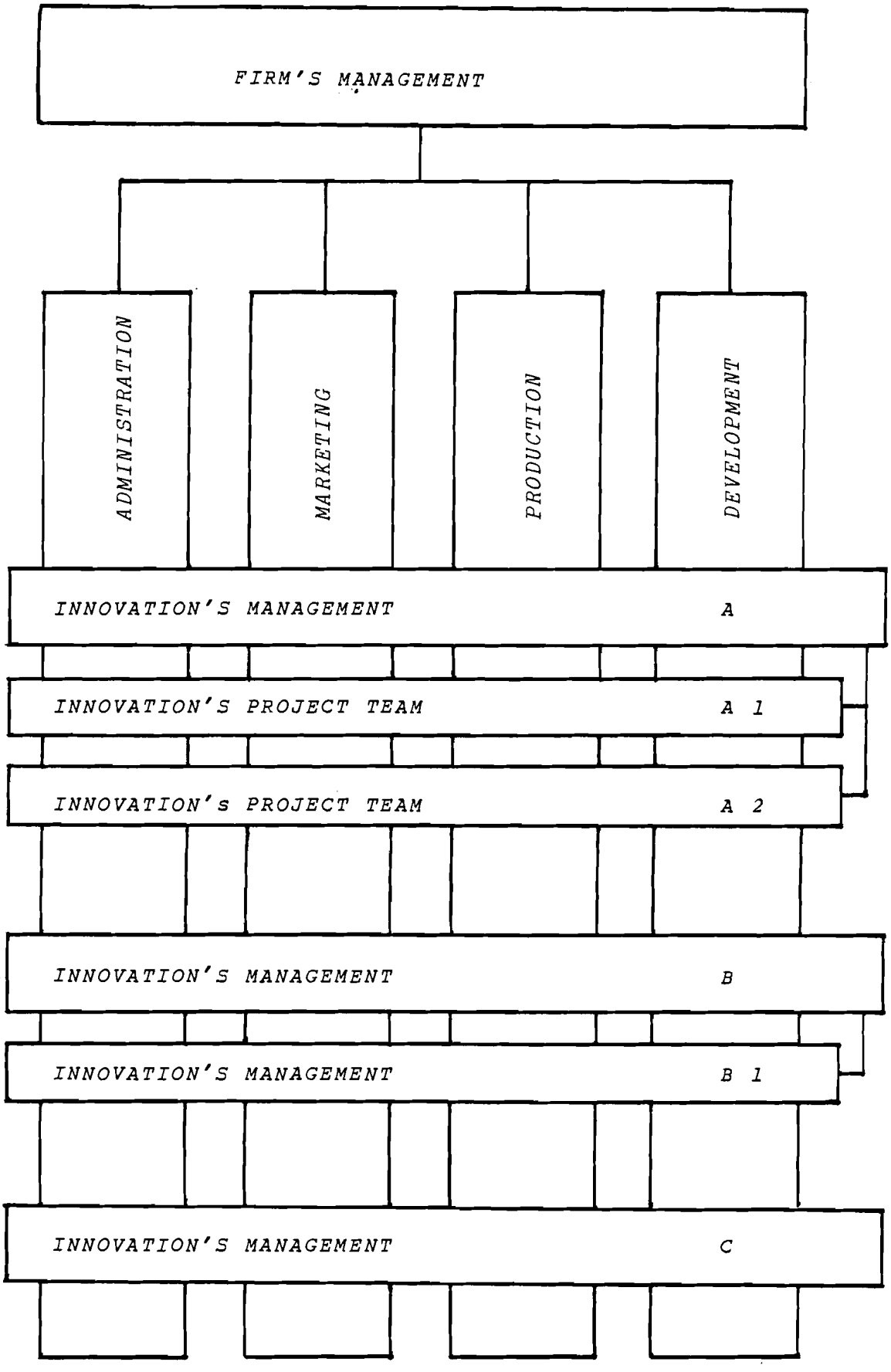


Figure 8. Matrix organization, where innovation management and innovation project teams overlay functional organization.

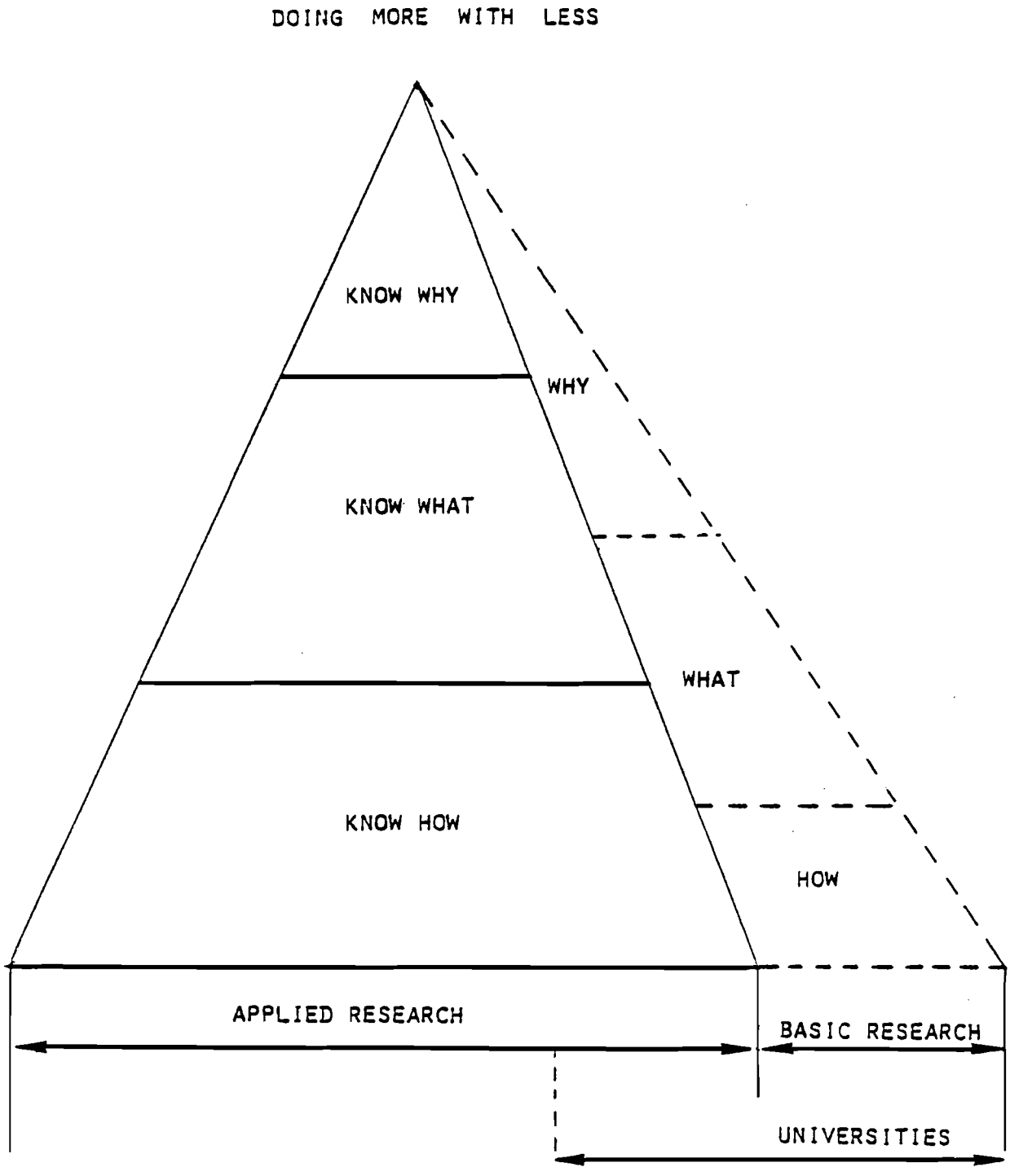


Figure 9. Basic issues of the innovation process "doing more with less".

Creativity is defined as "the developable ability for thought operations leading, by a combination of known elements, to results previously unknown to thinking man." N. Thom distilled this definition from the current knowledge of creativity research, concluding that creativity is not a characteristic of a small elite of organization members, but is an innovation potential, a widespread reserve of power. The creativity potential varies in strength between different people. Consequently, creativity cannot be learned, but if the disposition does exist, it may be stimulated and developed. Creativity may be roused or buried. It is the task of an innovation management to generate a creative and innovative climate in their companies.

We may therefore say that the organization form that is best is one that stimulates creativity. As already mentioned, it may be useful to choose different organizational structures for different phases of innovation. According to Mueller Philipps Sohn, the inability to generate innovation is due to the creative restriction of system elements by a higher degree of specialization, rigid formalization, limited communication, centralized organizational structures, and a high degree of supervision, and an unbalanced ratio of incentives and contributions for proposals. The generation of innovation is impeded by a complex system of barriers. Aside from their inability to generate innovation, such systems usually show no sign of successful implantation during the phase of implementation. Since they frequently do not even attempt to copy, it might be concluded that all members of the system are in an economic position that is satisfactory to them. Since they do not perceive any subjective need to change, the system as such will erect barriers against any attempt to change.

In his book *Das technologische Patt* (The Technological Stalemate), Gerhard Mensch outlines that innovations will fail to break through as long as the existing range of products and processes achieves satisfactory results. Companies that drift along in their satisfaction may be in for a surprise. Konrad Lorenz considers passivity from complacency to be the eighth cardinal sin of civilized humanity. In a time of technological change such inertia may be fatal for any company.

4.4. Strategic Planning

The lack of strategic planning may be a disastrous barrier to company innovations. The success of Japanese companies is due to a major extent to their mastery of planning methods and their steadfast pursuance of planning results. However, an excess of planning may in turn become a barrier to innovation, mainly if planning results are evaluated disproportionately to the imprecision of the output data. Just as planning in the R & D sector will always be a delicate balancing act between creativity and target-orientation, strategic planning will have to be viewed solely as a device to find the appropriate company objectives. The decision again rests with the innovation management.

The choice of the form of organization always depends on the quality and quantity of managers available to the company. If the organizational structure is adapted accordingly and with due consideration to organization theory, we find the further criterion that the most innovative organization is the one that accelerates the flow of information.

4.5. Information and Communication

According to Rothwell and Robertson, "information and good communication then, are highly important to successful technological innovation." The decisive relations within an innovation system are of an informative nature, and the quality of an organization depends greatly on the quality of its channels of communcation.

Pfeiffer and Staudt find that information runs through the levels and functional areas like a "chain of impulses" where each piece of information is based on the input of existing information. When interrupted, the information process stops as well. A letter not written, a discussion not held, a telephone call forgotten for lack of time, stress or lack of motivation, may become a barrier to innovation if it breaks the chain of impulses. Like the interdependent elements of a chain, the participants in a chain of information need each other.

A key role is assigned to the time factor of the continuous impulse. Delayed innovation may lead to the death of products in a market governed by remorseless competition. Many publications express the mortality rates of innovations in curves similar to the one of Figure 10. One hundred ideas eventually produce two or three successful products or processes. But this elimination must not be the consequence of an obstacle course over innovation barriers. Innovation processes should be suspended by a conscious act, but should not expire due to too many barriers in their courses.

The fight against such innovation barriers, which luck in all forms of organization, must be carried on by the innovation manager. By a combination of authority and knowledge he must overcome inertia and the lack of experience during the implementation phase. It is the task of innovation promoters and managers to accelerate the process of innovation and to prevent any contingent obstructions or changes of directions.

4.6. Diagnosis and Treatment

Diagnosing innovation barriers is the first step to improving the ability to innovate. This is frequently a very difficult step, especially if the system itself has to take it.

One of the principal tasks of the innovation management is to motivate the members of an innovation team. If it succeeds through example and proper leadership, it will eliminate the main barrier to internal innovation processes. The selection of the right organizational structure with a smooth flow of information and establishment of strategic planning are the next steps towards the removal of barriers. In summary, the main internal innovation barriers to be removed are:

- Lack of motivation, frequently due to wrong leadership or lack of incentives;
- Innovation-inhibiting organizational structures, such as excessive spatial and hierarchical distance between units of innovation and decision center;
- Insufficient communication, preventing the flow of information;
- Inertia, caused by ignorance of the need for innovation;
- Insufficiently supported innovation-decision processes;

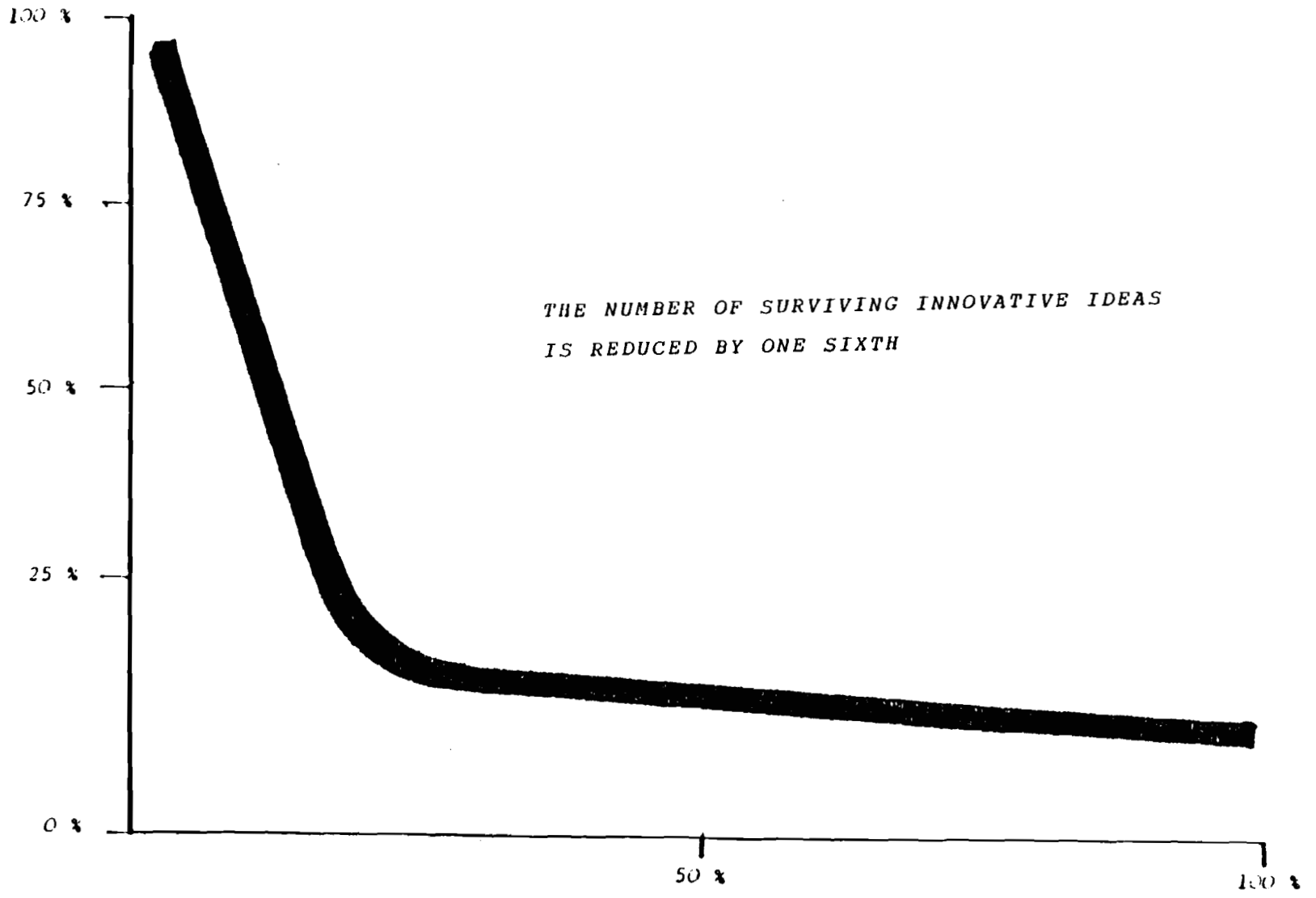


Figure 10. Mortality rates of innovations. (Source: K. Holt, "Innovation" IMT, Mailand 1973.)

— Lack of strategy and target;
— Insufficient enforcability;
— Lack of worker reserve (slack) mainly in the phase of idea generation;
— Inflexibility of the system structures and staff immobility;
— Divergences in objectives between subsystems;
— Lack of expert staff;
— Lack of funds.

Most of these factors are interdependent, which complicates diagnosis. In short we might say for most of the items listed that: a lack of mental acceptance, which may go as far as mental resignation, be it for lack of knowledge or lack of will, is the main reason for a system's hostility towards innovation. The last two barriers, lack of experts and lack of funds, are obviously other key reasons, since "funds" and "work" are the pillars of any innovation. The ability of suitable staff, however, depends to a large extent on the training and is thus predominantly an external factor. Still, gaps in staff requirements may, to a certain extent, be filled by internal training and retraining, which at the same time offers new opportunities to workers affected by structural changes.

4.7. External Barriers to Innovation

Many of the internal parameters for innovation are applicable to the external economic system. Openness, acceptance, motivation, flexibility, and creativity of the environment encourage innovational impulses within the company. Frequently, there are no clear-cut role models for internal and external barriers. Although the market, which has the final judgement over a product innovation by accepting or rejecting it, is external to the company, its problems rank among the internal barriers that have to be surmounted by the marketing sector. It is part of the management system and its actions, covering all activities from the idea to the customer. To include their behavior into the planning strategies, to predict it, to foresee the actions and reactions of the competitors—that is the art of management.

To be aware of the opportunities and risks offered by market and consumers, is a basic premise of successful innovation. Where blindness rules, creativity cannot gain a foothold.

At present, people frequently marvel at the Japanese export power. The analyses that examine the country's rise to a top position among industrial nations cite many reasons. Let us take just one of them: the favorable attitude towards innovation prevailing in Japan. State, unions, employers and society together show the will to rank at the top, a will that has integrated individual desires and group interests to pursue this objective, and has thus contributed significantly to the technological and economic growth of the nation. Reaching the top technological position became a national concern.

Innovation is discussed world-wide. While the innovational context is staked out, the external barriers often impede the will for innovation, sometimes unconsciously, sometimes intentionally. Among the external barriers to innovation in general are:

— Intervention in the market and demand structure;
— Excessive and cumbersome approval procedures;
— Excessive amount of legislation;
— Ignorance of economical and technical connections that generate resistance;
— Hostility towards innovation;
— Hostility towards technology;
— Lack of experts;
— Lack of tax incentives;
— Difficult funding;
— Limited domestic markets.

Not all these barriers can be removed. If removal is impossible, external barriers to innovation must be compensated by other measures and activities, i.e., to be more innovative to surmount the barriers to innovation. Evidently, in some cases this requires the Munchausenian art of pulling oneself out of the swamp by one's own pigtail, a trick hardly possible without external assistance, i.e., cooperation.

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FLEXIBLE ORGANIZATIONAL STRUCTURES FOR R & D AND INNOVATION MANAGEMENT STRATEGY: THE EXAMPLE OF CKD PRAHA

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1. INTRODUCTION

The organizational structure of an industrial firm like CKD PRAHA may be considered as one component of the firm's management system and includes a subsystem specially devoted to innovation. Together with other components, such as tactical and strategic planning systems and the management of preproduction and production processes, the organizational structure contributes to the integrated complex necessary for the successful functioning of the firm.

Without ignorning the importance of the interdependence of these components, it seems to us that the choice of an organizational structure is primarily affected by long-term development strategy and the human resources available. Therefore in this paper we analyze the interrelations between organizational structures for R & D and a strategy for innovation management in CKD PRAHA as a whole, and in its Research Institute in particular.

2. THE CKD PRAHA PRODUCTION PROGRAM

CKD PRAHA ranks as one of the largest engineering firms (known as *amalgamations*) in Czechoslovakia. Within our planned economy, the firm is subordinated to the Ministry for Metallurgy and Heavy Machinery.

The demands on innovation policy in CKD PRAHA are fairly complex, reflecting the wide product range and specialized technologies involved:

— the production program is substantially diversified and includes products of high complexity, such as diesel-electric locomotives, tramcars, thyristor controlled electric motors with static convertors and transformers, semiconductor power components and industrial applications thereof, high-performance turbocompressors and engineering cooling systems, high-capacity piston compressors, etc.

— almost two thirds of all commodities produced meet the international quality standards and are directly or indirectly exported to the international market; the rest are commodities specified as obligatory targets of the state plan, i.e., those having a high degree of economic priority for the central planning system within the Czechoslovak socialist economy;
— the high rate of scientific and technological progress required for the efficient production and sale of CKD PRAHA products cannot be easily realized if professionally suitable staff and highly qualified technicians or workers are scarce or if investment for modernization and reconstruction of the existing production structure is significantly restricted;
— the major part of the production is of individual units or small series of units; this involves special R & D work and sophisticated control during manufacture and assembly;
— quality control is complicated by extensive internal and external cooperation and the outside subcontract purchase of substantial quantities of components and materials.

3. THE ORGANIZATIONAL STRUCTURE OF CKD PRAHA

The organizational structure of CKD PRAHA is illustrated in Figure 1. Using current Czechoslovak terminology, the amalgamation CKD PRAHA is composed of the so-called *branch enterprise* CKD PRAHA and the *subsidiary enterprise* Prerov Engineering Works. Very close organizational relations and informal personnel links exist between the amalgamation and the Foreign Trade Corporation (Pragoinvest); these are economically advantageous for the management of our extensive export activity. These close ties also have a positive effect on innovation policy.

The branch enterprise CKD PRAHA comprises about 20 production plans within a framework of line organizational structure. All these plants report directly to the general manager of the amalgamation, who is at the same time the general manager for the branch enterprise.

In principle, the individual production plants of CKD PRAHA may be considered as profit-making units, with their own technical and economic plans (which of course constitute subsystems of the amalgamation's overall plan) and responsibility for their own results. Production plants of CKD PRAHA are allowed to handle their own planning and manufacturing and part of their sales effort.

The complexity of many of the final products leads to a situation where some groups of CKD plants are interconnected through interplant supplies and mutual cooperation. This is, for example, the case for diesel-locomotive and tramcar production, and in fact some aspects of divisional structure are present within the amalgamation. This topic, and primarily the complex management of innovation within the *transportation branch* of CKD PRAHA merit further analysis. The need for integrated higher management is particularly evident here; therefore the top management of CKD PRAHA is frequently involved to ensure that the complex overall requirements of innovation policy for the amalgamation are not obscured by the local interests of individual production plants.

The so-called *special-purpose units* occupy a special position in the organizational structure of CKD PRAHA. There are about 10 such units and their organizational position is indicated by "S" in Figure 1.

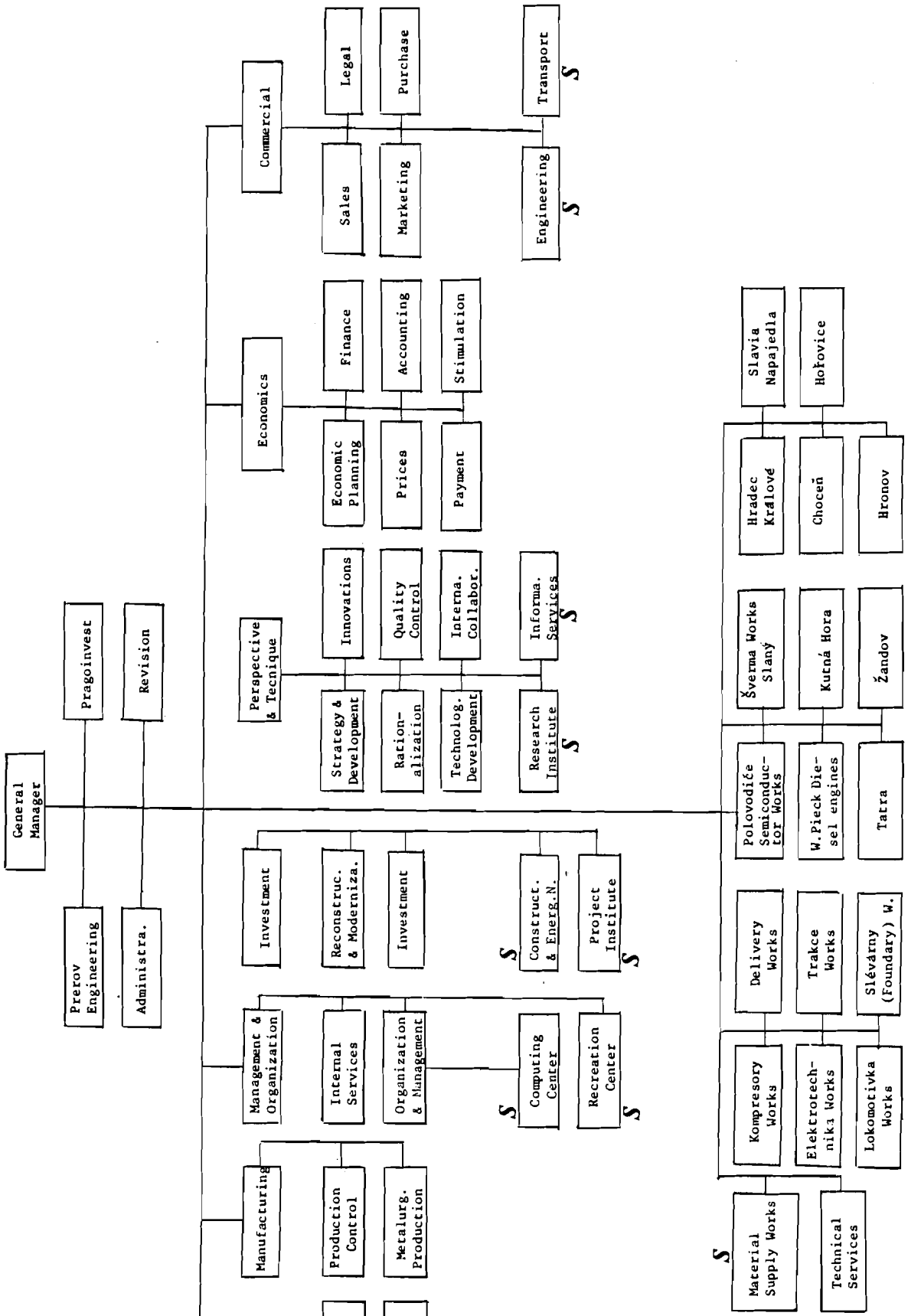

Figure 1. The organizational structure of CKD PRAHA.

The formation of the special-purpose units during the decade 1960-1970 was accompanied by many discussions and analysis; these had the principal aim of determining criteria for reasonable and theoretically optimal degrees of centralization for research, computing services, means of transport, projected enterprise investment requirements, supplies of materials and components common to a number of production plants in a certain area, etc. All these questions could be the subject of separate discussion, but we will restrict our attention here to the fact that all these units carry out specialized auxiliary services and activities for certain local groups of production plants. We shall return to these problems in more detail later in our analysis of R & D activities of CKD PRAHA.

The staff of the general manager are, in principle, organized in a line or functional structure. In practice, it is almost impossible to identify distinct types of structure in their pure form; various mixes or combinations of management philosophies, communication, authorities, responsibilities, etc., are prevalent in different areas of the firm's complex organizational structure. A number of key managers exert considerable influence on the functioning of the organizational structure and on how decision making (for example, concerning authority and responsibility for allocation of resources and tasks) is actually implemented.

The typical features of the line structure (line management) are mostly found in production management. The features and interrelations characteristic of the functional structure are those typical of other activities, such as personnel matters, investment, engineering and perspective development, economics, and commercial considerations. For the purpose of our analysis we focus attention primarily on engineering and perspective development, since in this area of activity innovation management constitutes the bulk of the work.

The inclusion of special-purpose units in the functional structure of the general manager's staff in fact modifies the way the staff works. Their activity is a mixture of advisory activities, as well as decision making and process implementation activities that directly contribute to the main production activities of the plants (for example, transport, the purchase of materials and components, etc.). A great deal of work has been done in setting up and systematizing goals and fields of activity or responsibility in decision making and in implementing and checking the results of managerial work. For these purposes *organizational orders* have been devised, both at the level of the general management of the amalgamation and subsequently at the level of individual plants and the subsidiary enterprise. Naturally, there are also other substantial inputs, primarily resulting from the decision making activities of the general manager and his advisory bodies (the operative council of the general manager and the board of directors).

With regard to innovation, the organizational orders are an attempt to discover the optimal levels for innovation decision making and to determine the most effective distribution of strategic and operational tasks (including supervision and control) among various bodies and levels of management.

Although the organizational orders are regularly reviewed and necessary corrections are made, the complexity and diversity of real management processes cannot always be clearly and uniquely decomposed into sections of the existing line and functional structures. This is particularly true for the area of innovation, with its dynamic and often discontinuous development trends.

The organizational structure of individual production plants corresponds in principle to one of two unified organizational orders issued for these purposes by the top management of CKD PRAHA and is of the line and functional types.

4. ORGANIZATIONAL STRUCTURE AND INNOVATION MANAGEMENT

Innovation management is, in one sense, the expression of the firm's deep concern for its future. The firm's strategy for future development is of prime importance for the orientation of its innovation policy, and vice versa. At the same time, the firm's long-term strategy may be considered as the principle determinant of its organizational and management structure. To illustrate this for CKD PRAHA, we will first outline the firm's strategic management concept.

The basic objective of strategic management in CKD PRAHA is to identify a set of goals and effective ways in which the amalgamation could attain these goals under expected conditions over various time horizons. In other words: how can the firm adapt to changing conditions and requirements over the next 10-15 years, taking into consideration both desirable aims and probable constraints. The innovation policy of CKD PRAHA is considered as an integral part of the firm's strategy. Particularly in the area of product and process innovations, one may encounter evolutional discontinuities; these discontinuities greatly reduce the usefulness of earlier extrapolative methods (typical of classical long-range planning), which have proved to be too inflexible for the surprises in the firm's operating environment.

The strategy of CKD PRAHA is formulated in the so-called *long-term developmental concept*. In some detail and with a considerable level of reliability and accuracy this calls for various developmental problems to be solved by 1990; more generally, it outlines broad development directions and probable discontinuities to be expected up to the year 2000. It has close links with forecasts and concepts worked out by Czechoslovak central planning management bodies (the State Planning Commission, relevant Ministries, etc.).

The complex long-term developmental concept is based on the creative synthesis of *partial concepts* for various spheres of the reproduction process within the amalgamation, namely concepts for the development of:

- the production program
- the production-technological base (the production structure)
- research and development
- sales
- manpower and socioeconomic activities
- organization and management techniques

The complex concept is at the same time the obligatory basis for more detailed *partial perspective studies* for the development of individual production plants and special-purpose units. In principle these studies have structures analogous to the complex concept and observe the same interrelations between the forecast-concept, long-term-planning, and medium-term-planning subsystems. To a certain extent, the relation between the complex concept and the subordinate partial perspective studies reflects the degree of centralization or decentralization in the management system of CKD PRAHA.

To find the right balance between strategic and operating (i.e., tactical) decision making is no easy matter for the top management of CKD PRAHA. In general, a large proportion of strategic management functions are allocated to the higher echelons of the hierarchy, and both the complex concept and the partial perspective studies are evaluated and approved at the top level. But the implementation of medium- and short-term planning decisions calls, of course, for the decentralization of some decision making; therefore the need to determine a reasonable measure of centralization or decentralization appears again and again as a constructive challenge to the top management of the amalgamation. Moreover, in everyday life the urgency of current tasks sometimes comes into conflict with the position of top management on strategic problems.

As mentioned earlier, organizational problems are considered as a subsystem within the complex concept (for the amalgamation) or partial perspective studies (for individual production plants and special-purpose units). In one sense, solutions of organizational problems are predetermined by the choice of strategy, with the important qualifier that feedback and two-level iteration do of course exist. From this point of view the *partial concept* of organizational and management techniques covers such problems as:

- the choice of basic organizational configuration for the management system (number of organizational levels, forms of organizational structures, basic compositions and functions of organizational units, basic distribution of responsibility and authority);
- the conceptual construction of information interrelations and flows between organizational units in both vertical and horizontal dimensions of decision making and implementation management (including assumptions made about significant *informal* communication links);
- the establishment of principles of mutual cooperation between organizational levels and units in handling complex, integrated decision making problems, their implementation and checks thereon.

Analysis of experience in CKD PRAHA leads to the interesting conclusion that the choice of organizational structure in many ways determines—or is at least highly relevant for—the design of medium- and short-term planning systems, including those for innovation planning.

The planning of innovation processes essentially involves a two-level system within the functional organization structure. In fact, the long- and medium-term planning of innovation may be considered as an interactive process, with several iterations through various management levels before a final plan is completed, approved, and implemented. An analogous arrangement is used for the supervision and control of the planning, implementation of various development and production stages for new products, utilization of resources, checking the effectiveness of results, etc.

The major responsibility for long- and medium-term innovation planning is concentrated in three departments of the section for perspectives and technique of the general manager's staff: these are the innovation, strategic development, and technological development departments. In close collaboration with the Research Institute of CKD and the production plants, a two-level system of planning, resource allocation, and control of innovation processes has been introduced.

In the interactive sequence from the level of the amalgamation to the plants and back again, all the significant innovations required are specified. The principal arrangement of goals is already formulated in the perspective studies for the development of individual production on plants, or even—for the most significant innovations—in the complex concept for the amalgamation as a whole. The relative significance of each is established in terms of its impact on forecast indicators of the economic plan for the amalgamation or its plants (probable impact on sales policy, competitiveness, consumption of resources, etc.).

5. ORGANIZATIONAL STRUCTURES FOR R & D ACTIVITIES

In recent years, the increasing scope and pace of R & D activities in CKD PRAHA has led to the reevaluation of existing organizational structures. In particular, the organizational units with a higher proportion and greater diversity of R & D work have become more and more aware of the *insufficient flexibility* of existing structures and, at the same time, the need for a *greater concentration of human and material resources* on R & D activities for innovation. This was especially true of the Research Institute of CKD and the production plants working on industrial applications of semiconductor power components, custom-built, high-performance turbocompressors, engineering cooling systems, and high-capacity piston compressors.

The types of change that were introduced can be illustrated by reference to the organizational structure of the Research Institute (Figure 2). The Research Institute of CKD PRAHA carried out R & D work ordered by several production plants of CKD. There are two basic groups of R & D activities:

- *problem-oriented research*, for example, metal and nonmetal materials science, testing, metrology, ecological factors, acoustics, special electronics, and measurement and computation techniques;
- *branch-oriented research*, specifically, the R & D activities for the four CKD plants manufacturing diesel engines.

The question of which R & D activities should be carried out in individual plants and which in the Research Institute has been examined several times by top management and was explicitly addressed in the complex concept for CKD PRAHA. Nevertheless, since the implementation of R & D results has always been at the level of individual production plants, it is impossible to completely avoid certain problems, such as:

- how exactly to involve the specialists of the Research Institute with the innovation policy goals of the production plants—how they should take part in their formulation and implementation; and on the other hand, how to engage plant managers, who are responsible for implementing the innovation activities, in the day-to-day actions necessary to realize them;
- how to organize the continuous and creative collaboration (including informal collaboration) of people from the Research Institute with their partners in the production plants throughout the whole cycle of work, from framing the goals for research through elaborating common plans, to introducing R & D results into production processes;

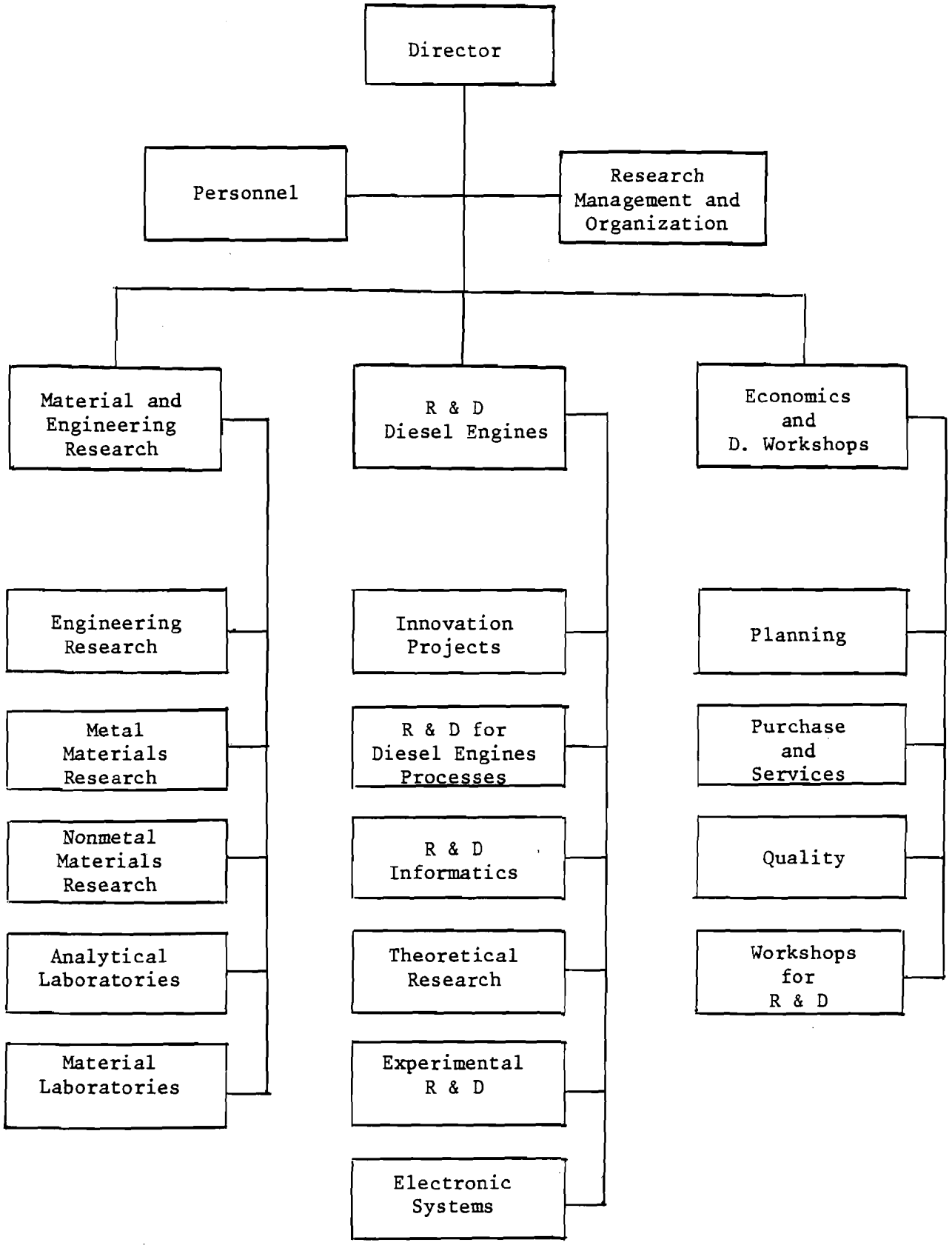

Figure 2. Organizational chart of the Research Institute of CKD PRAHA.

— how to set cost limits for R & D work and generate the right economic incentives for projects to be carried out better and more efficiently;
— how to use and coordinate the results of *basic research* and the participation of external research organizations, including various institutes of the Czechoslovak Academy of Sciences, universities, and state research institutes.

As a reasonable compromise for the solution of these and other problems a *matrix organizational structure* has been chosen. Within the framework of the Research Institute's organizational structure, illustrated in Figure 2, the work is organized into seven *complex research projects*, covering metal and nonmetal material research, testing, special electronics, etc., and innovation projects related directly CKD PRAHA diesel engines. Of course, the planning and allocation of resources for these seven projects no longer corresponds directly to the formal organizational structure.

The choice of a matrix structure has led to the need for more detailed coordination between the Research Institute and collaborating bodies (production plants and external research organizations) and within the Research Institute itself. In addition to the hierarchical (vertical) channels, more and more horizontal information channels or flows have to be established, all with the fundamental goal of facilitating the execution of R & D projects and their implementation in CKD PRAHA plants. The multiproject scheduling ICL-PERT software package has been introduced as a planning tool and also for checking purposes.

Project teams are organized on the decision of the Research Institute director and each is headed by a project leader. Each team assembles personnel from different departments under functional managers. All the usual problems of coordination between project leaders and functional managers, such as capacity problems, problems of incentives and rewards, responsibilities for different tasks assigned by different leaders, etc., are of course encountered. One successful approach to the solution of these problems has been the organization of a "Director's Council". Once every two weeks, all project leaders and department managers and a few outstanding specialists from the Research Institute meet to discuss ways of solving tactical and strategic problems so as to ensure the effective and timely execution of CKD PRAHA projects.

Project teams are established for a limited and fixed duration, and their personnel structure is intended to change over time, including the participation of specialists from production plants and external research organizations. Therefore the matrix structure has an intentionally *restricted stability and durability*. To improve the functioning of the project teams, a system of *goal-programming methods* and *project budgeting* has also been introduced.

6. CONCLUSION

Organizational structures play a partial but vital role in the management of innovation processes. On the one hand they constitute only a subsystem of the operation but on the other they are essential to the continued existence and efficient functioning of the whole complex. The correct design and performance of organizational structures is also important because of their synergistic interactions with the rest of the system and ultimate effects on the firm's economic performance.

MATRIX MANAGEMENT: MANAGEMENT INNOVATION FOR INNOVATION MANAGEMENT

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INTRODUCTION

In recent years, matrix management has spread rapidly and its field of application is not only in the high technology area but in almost every type of business. It is also very remarkable to observe that matrix management is adopted irrespective of differences in economical systems—in the market economies as well as in the planned economies.

1. MATRIX MANAGEMENT IN TRANSITION

Matrix management is occasionally taken as an elaborated organizational design, however, it is also regarded as a phenomenal apparition of a metamorphosis in managerial mutation. Centralizations to decentralization in structure, and defensive to offensive in style, or opposite changes for each, are moderated by the matrix structure. The different dimensions of an enterprise's activities—functional and divisional and possibly regional (especially for multinational corporations) are converted by each other and the matrix is observable in the transitory stage. Of course, the matrix management is a denomination given to a rather permanent organizational form, however, its transitional character is also inherent due to the instability caused by the assymetry in power balance attached to each dimension.

2. GROUPING BUSINESSES

Grouping or utilizing different businesses in a corporation is institutionalized in several firms to expediate decisions and to promote coordination and interchange among business units. In a sense, such grouping produces a mere increase in the hierarchy echelon to enable the reduction of span of control by a general manager (Figure 1). However, in most cases of grouping divisions for each business and product, the divisions retain the status of profit-center, reporting directly to the general manager; so that the role of the group manager seems rather consultative for coordinating the division

activities. In that sense, groups structures can be viewed as two-dimensional where lateral and horizontal reporting channels are equally authorized, therefore forming a matrix (Figure 2).

The most prevalent principle in grouping divisions is market centering. and the concept of a strategic business unit and strategic business group are on this line.

3. CLASSIFICATION OF MATRIX MANAGEMENT

Connections within a firm are always observable if we disregard the formality of the connecting channels, and the ordinary line and staff structure can be expressed in matrix presentations. In matrix management, both vertical (hierarchical) and horiztonal (traversing) channels are authorized, so that a double command is built into management (Figure 3). Most original matrix management starts from the task force or project team assigned to perform a specific business or product. This is to overlay project management on line functional or divisional structures to realize so-called organic interaction between two dimensions in corporate activities (Figure 4). If such a two-dimensional structure is established rather permanently, it will be acknowledged as a methodical matrix management. Two dimensions will be assigned to different sets, however, function and business are the most fundamental in the construction. In so-called global matrix, a new dimension, i.e., geographical area, needs either to be added or to replace one of the existing dimensions, possibly the function dimension.

In ordinary management two fundamental line functions—manufacturing and marketing—form a matrix which may be called the operational matrix management (Figure 5). As already mentioned, the characteristics of interactions, i.e., cooperating efforts and conflicting tension between two dimensions, activate the impetus in such systems.

From the viewpoint of innovation, the objective matrix management is proposed, in which two fundamental objectives of an enterprise, vis. profit and growth, are assigned to different dimensions (Figure 6). These two goals are temporal factors produced respectively from the daily operation and the innovation plan, and are occasionally traded-off in the allocation of management resources.

Matrix structure traverses hierarchy, however, it is by no means incompatible with hierarchical structures. For instance, in objective matrix management, where every matrix unit is assigned to profit and investment centers, they have their own supra- and infrastructure in different hierarchies. Although a matrix is deployed at a specific level, i.e., at the division manager's level, relations in the upper and lower levels are also conceivable because interaction at any level seems quite natural (Figure 7). If such a multilevel matrix is not always institutionalized in the management, it is operative for rationalizing operations on in informal basis.

4. CONCLUDING REMARKS

Matrix management structures appear tacitly during the managerial mutation as a transitory form. It is also built-in intentionally to realize effectiveness and efficiency. In viewing the future of matrix management, besides its transitory character, its organic intelligence possibility, which would be reinforced by further development of its information ability, will be favorably taken into consideration.

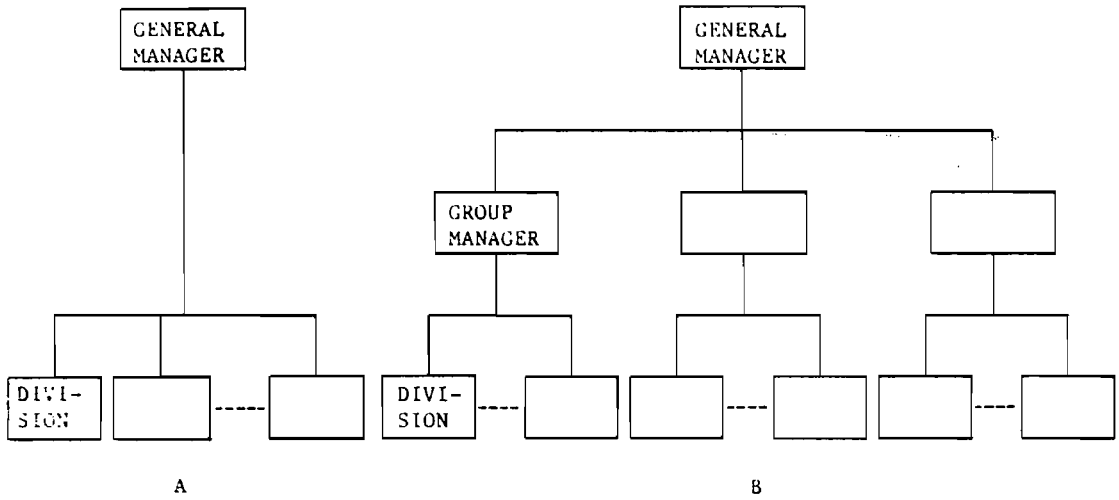


Figure 1. Grouping divisional structure

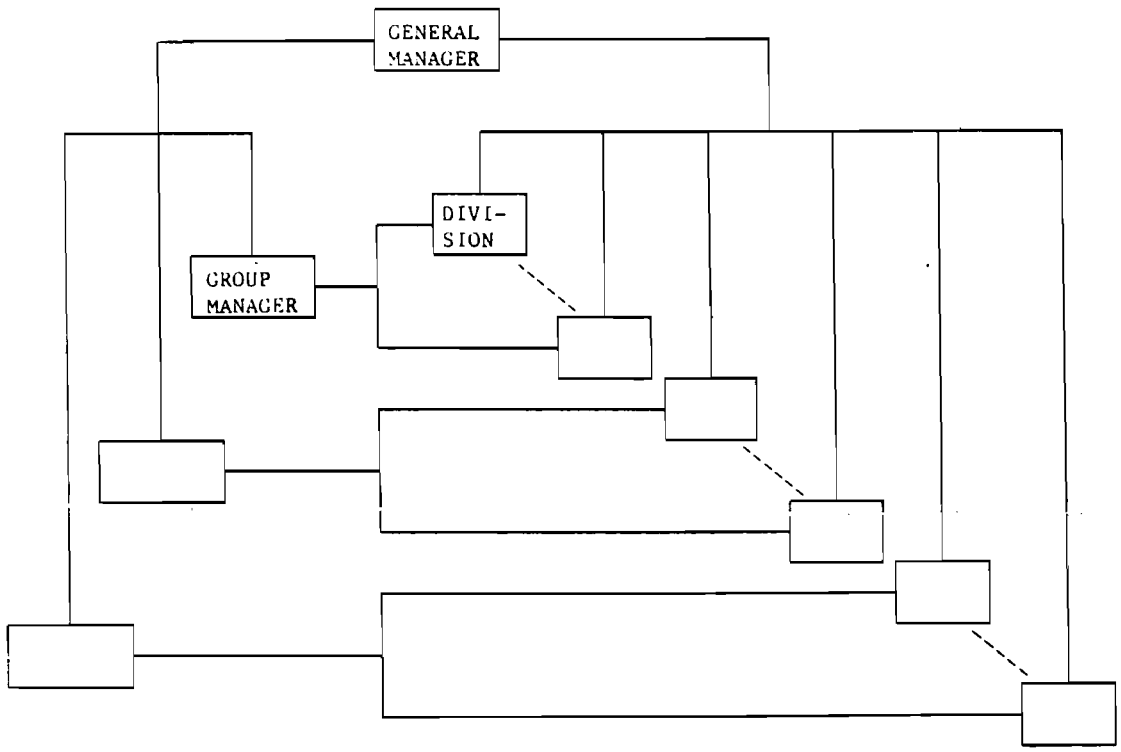
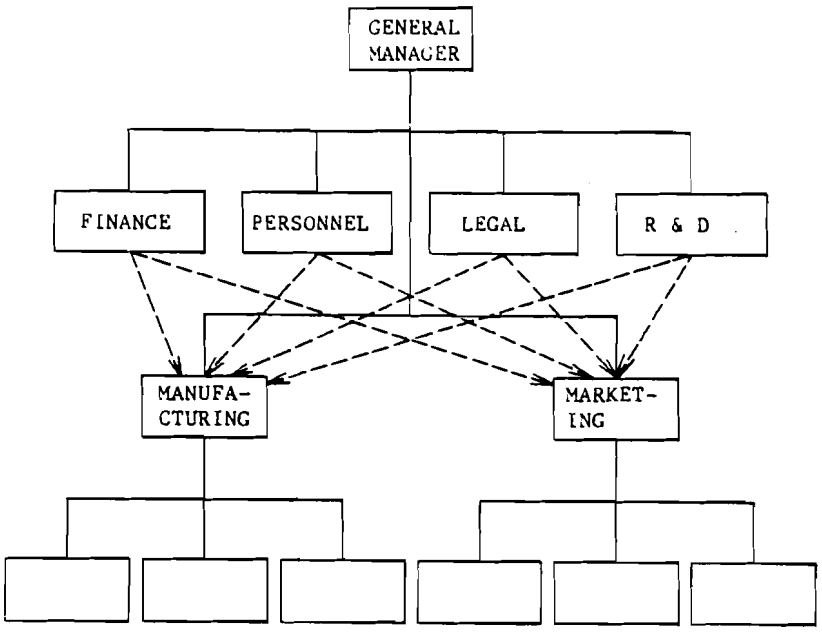


Figure 2. Representation of grouped divisional structure.



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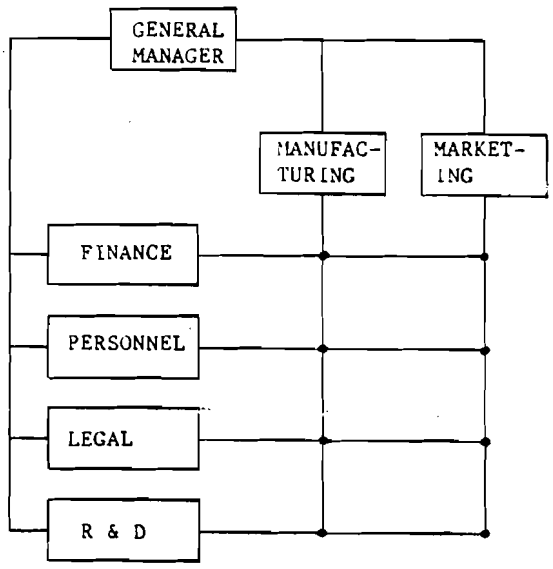

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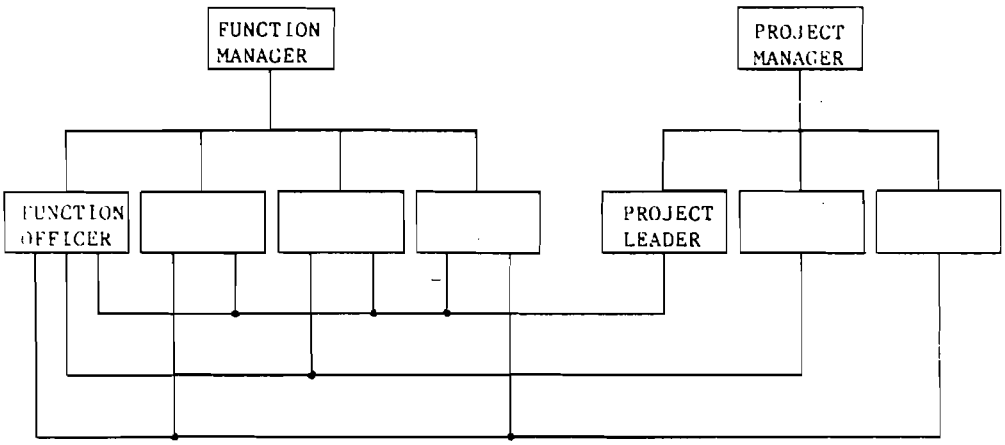
Figure 3. Line and staff structure.



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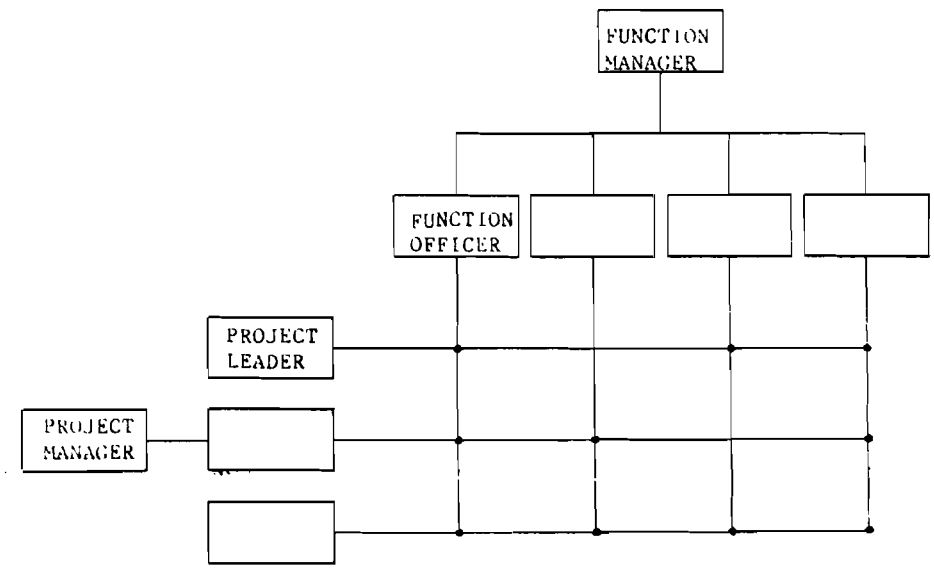

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Figure 4. Project teams.

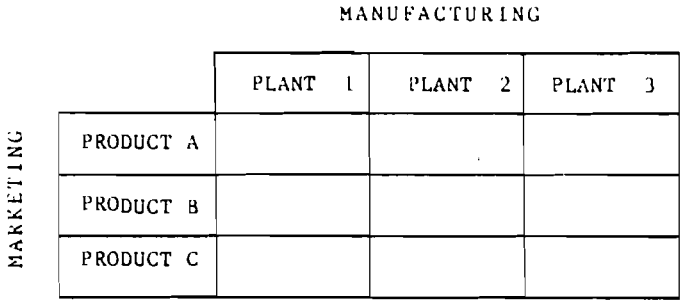

Figure 5. Operational matrix structure.

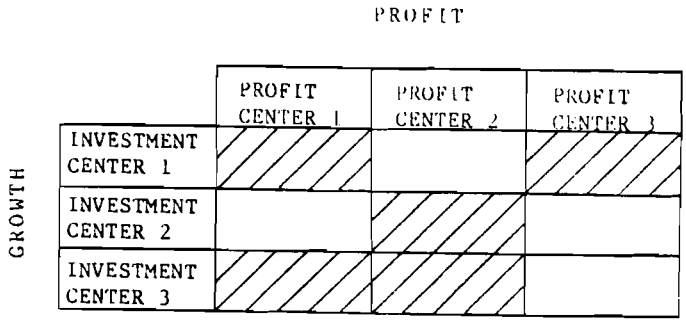

Figure 6. Objective matrix structure.

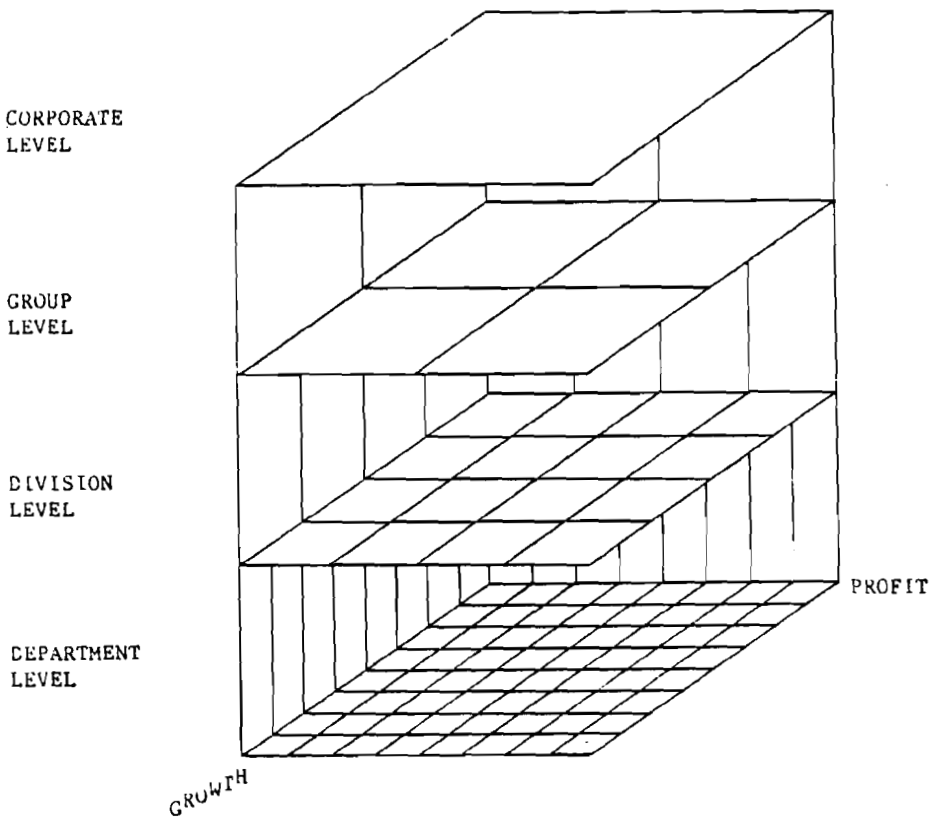

Figure 7. Multilevel matrix structure.

AN APPROACH TO ORGANIZATIONAL STRUCTURING IN INNOVATION

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In the theory and practice of business management, there are diverse approaches to examining and developing organizational structures for management. In a most general way they may be defined as functional, sociological, or goal-oriented. All these approaches are employed to a greater or lesser extent within the framework of economic enterprises. They are notable, however, in that they treat the organizational structure as an isolated phenomenon.

The application of the so-called "technological approach" in the analysis and synthesis of organizational structures provides, as a major advantage, the possibility of their systematic and comprehensive analysis and development. Management technology in such a case is looked upon as an intrinsic system-generating factor bringing together the characteristics of the functional structures and the organizational structure, as well as those of the methods and modes of management. For that reason, this method allows order and system in the process of improvement and development of the organizational structure.

Being a working process, management within social organizations can only be performed according to a certain technology process. The resulting relationship of all the elements of organizational systems—structures, methods, functions and activities—is based on this initial principle.

Each economic enterprise accomplishes an assigned task through its management system by performing certain functions. Each function implies a set of activities, connected in various ways (logical and chornological). Depending on the case, the activities can be executed in different organizational units, whose combination (i.e., organizational structure) responds more or less adequately to the content of the management process. The correct choice of organizational unit in which a group of activities is to be performed and selection of an appropriate method guarantee high effectiveness of the management process.

The proposed approach to organizational structuring can be applied both to particular functions and to subsystems (e.g., innovation mangement, supply management, etc.), and to the organizational structuring of the entire system. This approach is based on the assumption that in social systems the management is accomplished only in a technological mode. The concept of management technology implies a set of activities and functions as well as the methods of their realization according to the logic of the management process.

The advantage of the elaborated approach consists in the applicability of its instruments equally well both for the analysis of the existing organizational structure in the economic enterprise as well as for the synthesis and improvement of those organizational structures.

This approach considers the activities and the results of their accomplishment to be fundamental elements of the process*. In this case the result of management activity is considered as a basic product of management technology, bearing its specific characteristics and taking its proper place in the management process. Treating the management decision as a basic feature typical of each activity and function, the results are nothing but management decisions made within each function and activity in the system. It is common practice for economic enterprises quite frequently to use a subjective approach, or rather a sociological criterion, when designing an organizational structure. The approach cited above offers the possibility of making the subjective judgement of superiors and experts more objective. Thus it will reflect to the greatest extent their own experience and judgement of the system's functioning. This is achieved through the wide application of expert judgement in evaluating the results of particular activities in ranging them within the management process, and in assessing their relationship and interaction. When making an expert judgement, experts and superiors forget about the structure itself and concentrate on the examination of management process. A further advantage of the approach to be noted is that even when applied to a particular function or to a group of activities, the approach allows that they be treated as part of the whole (enterprise, entire management process, entire management level, etc.). In the second place this approach can be applied equally well both to the structuring of management activities and functions and to the production process.

The innovation processes management in the economic enterprise is accomplished at two levels—the company level (central administration) and the plant level. Sometimes an intermediate management level is formed—the management of specialized research, development, and designers' units (organizations, research institutes, etc.). Analysis of innovation management at those two or three levels using the technological approach offers the possibility:

— of studying and improving decentralization of decision making and decentralization of particular activities and of securing a certain degree of freedom for each level and unit.

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*In the Institute for Social Management, management activities have been used as an initial element for an organizational design by the technological method. On the basis of such analysis, a group comprising the authors has developed a method for organizational structuring by means of combining technological criteria, applied to management activities— "Management Game", "Synthesis of Organizational Structures of Management": Institute for Social Management (1982).

— of considering all the functions and activities, accomplished not in the course of innovation process management per se, but in connection with all the other functions in the system (planning, supply, personnel training, production, etc.).

— of analyzing the connection of innovation management and the relationship of local management cycles with the entire system's management.

It should be noted that this approach does not result directly in management organization structure but it allows a rational grouping of activities and functions with respect to the standards of organizational structuring set in advance. Additional criteria and other factors influencing organizational structure such as staff compatability or their qualification and specialization should also be taken into consideration, and then through expert judgement a final organizational structure should be reached. This allows the attainment of the highest degree of concentration and internal coordination within the framework of organizational structure and the avoidance of additional coordination among the units.

The application of the technological method requires the definition of the particular activities and decisions and their relationship and connection with the production units and with the environment. Each of them is fixed through a set of parameters reflecting its place in the management process as well as the possibilities for their comparison with other elements of the management system.

When solving this problem the most important thing is the identification and definition of the particular decision. It has been pointed out that management technology represents a set of functions and activities and their interrelations, including different kinds of characteristics (information links, the nature of the result obtained, methods and modes of decision making, participants in the process, etc.). It is obvious that there is a great number of criteria on the basis of which one could proceed to define particular elements. It is difficult to choose a single criterion, or the most important one. However, when studying a functioning management system, the best thing to do is to start with its objectives, pass through its essential tasks, and end up with concrete results meant either for "internal" use or directed to the production units and to the environment. For the purpose of the present study it would be best to direct attention to the particular "technologically defined" results—decisions. On this basis the following relations could be determined:

(a) initial elements of the management process are the technologically defined and completed results;

(b) any of these results is a component of a particular management activity and, respectively, a management function;

(c) the nature of the particular results provides the ground on which the characteristics of the respective activities are to be judged as well as the possibilities for an effective organizational structuring in view of the attainment of a particular result;

(d) one and the same set of technologically defined results can be analyzed by diverse crtieria and on this basis different

(d) one and the same set of technologically defined results can be analyzed by diverse criteria and on this basis different structures can be built (technological, functional, organizational, personnel, etc.). The analysis of the particular structures allows the tracing of a number of common characteristics, i.e., to accomplish the establishment of an unified effective management structure, reflecting diverse aspects of the economic enterprise.

For the solution of this problem one should decide first of all how to study the relations between the different results. In this connection, the characteristics of the particular decision are used as a basic feature of the relations in the management process (i.e., depending on whether they are intermediate decisions used by the system itself, or final decisions meant for the production units, or for the environment). In this case each technoloigcally defined result is examined as a multitude of various decisions meant for use within the system or beyond it. When the decision is for "internal use", what counts is the level for which it is intended. It has already been noted, for example, that the economic enterprise has two or three internal levels and for this reason every decision should be analyzed in relation to each of these levels.

The typology of decisions in a given economic enterprise could be determined by different criteria and constraints. In this case just one criterion has been used, reflecting the nature of the particular decisions according to the "intensity" of their impact. From this point of view the decisions may be divided into three types:

(a) Directed decisions—they take for granted that the respective result is technologically defined, needs no additional treatment, and should be executed straight away.

(b) Technological decisions—these are technologically defined results requiring additional treatment and are just a stage in the elaboration of some final decision.

(c) Informing decisions—these are not decisions but informative data or auxiliary results securing the attainment of technological and directive decisions.

With a view to the concrete analysis the following statements are made in this case:

(a) The economic enterprise under study is assumed to have two internal levels of management and of production units. All the enterprises and organizations within its relationship are considered as its environment.

(b) As a subject of analysis the set of technologically defined results achieved at the first level of management is accepted.

(c) Ranks have been established for the management levels of the system, for the production units and for the environment. The significance of each result is different depending on the fact for what level of the management system it is meant or whether it is intended for the production unit or the environment. The rank of the first level is the lowest one (this is

a level of accomplishment of the results studied). The rank of the second level and that of the production unit are higher. The rank of the environment is the highest one.

(d) The particular types of decisions have also been ranked: the directive decision having the highest rank, the technological one a lower one and the informing decision the lowest one.

(e) The combination of the level ranks and the decision rank predetermine the intensity of every different result. A given result, for instance, has the greatest intensity if it is meant for the environment and represents a directive decision. In this case the particular result refers to some strategic decision affecting not only the enterprise under study but a number of other organizations too.

Thus, in accordance with the nature of the components of each single decision and its destination to the different internal levels, the production unit and the environment, a number of combinations can be obtained. This is a basis for functional and organizational structuring of the system. The analysis of the set of all possible combinations of parameters for each single result and their distribution among the levels reveals the necessity of imposing some restrictions and requirements to prevent the appearance of "illogical" combinations. The restrictions and requirements are normally to be derived from the practice of economic management and from some general regularities in the behavior of the hierarchical management systems. One of the restrictions, for example, may run as follows: If the result is a directive decision meant for the environment, it is then a mandatory directive decision for the organization too. The idea of a similar restriction is obvious—the elaboration of a directive decision towards the environment means that the system under consideration plays a major role in the solution of a given problem and the decision therefore should affect all its levels. The restriction in the forming of a technological or an informing decision may be analyzed in a similar way, so as to arrive at noncontradictory combinations.

Through the system of ranks of different decisions and levels and the multitude of restrictions, a technological analysis of the relationships between the results may be performed. Thus, technological "chains" of results connected with the performance of a certain management activity or function can be differentiated and a number of qualitative priority characteristics of each of them can be analyzed. On the basis of this analysis, specific management cycles are determined, referring to a relatively independent decision of a particular problem or group of problems. This gives a relatively clear idea of the distribution of the activities within the system and of their relationships with the production unit and the environment. The main purpose of this study is to identify the entire management cycle and the priority and intensity of its elements. This is very important as the analysis is based on expert judgement and reflects fundamental conceptions as to its meaning and mode of functioning. The functional relationships of elements is a basis for organizational structuring. In this connection the proposed approach has an auxiliary role and its significance should not be overestimated. The formalization of the expert judgements provides managers with data concerning the priority and the relations between decisions and activities of each element. This is why the organizational structure should be finalized by the formulation of a number of additional crtieria and requirements.

One of these criteria in the organizational structuring is related to an effective combination of technologically defined results in the management activities and functions. This alone, however, is not sufficient for the effective organizational structuring. It should be complemented by the methods through which human factors can be introduced. Thus, the formal characteristics are complemented by the role of the human element. The next step in the development of methods would be the search for criteria bearing on coordination possibilities between particular individuals and groups of workers and the requirements for specialization and concentration of management activities, as well as qualification and the competence of respective ministrative bodies and officials. It should be noted in conclusion that the analysis of the technological characteristics is of primary importance but at the same time treatment of organizational structure problems of each particular system is not fully covered by this analysis. Many other problems, reflecting the part and the place of human element in the management process, should also be taken into consideration.

From the application of this approach to innovation management in business enterprises some conclusions may be drawn in three basic fields:

— Assessment of the judgements of experts with regard to the indispensible ranging and integrating of activities while solving particular problems in innovation management. Since the experts are of diverse specialization and have different ranks and places in the hierarchy of the management system, it becomes possible to learn the points of view of different levels of the enterprise and their approach to the problems. In the case of conflicting views, an additional analysis could help in formulating the basic problems in innovation management and in the search for improvements inmethods and techniques.

— It is possible to establish the degree of centralization and decentralization of decisions, their distribution over the different levels, as a result of the analysis of organizational structure and on the basis to search for improvement and change.

— On the basis of the established degree of centralization and decentralization conclusions can be drawn as to management functions in the functional structure of innovation management in the business enterprise, and to functional hierarchy aimed at improving them.

— Problems resulting from the nonexpedient integration of activities in innovation management are identified and a possibility is offered for their solution by methods other than organizational structuring.

MANAGEMENT STRUCTURES OF INNOVATION SYSTEMS IN THE STATE ECONOMIC ASSOCIATION "ELPROM"

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State Economic Association ELPROM, Sofia, Bulgaria

The State Economic Association "ELPROM", established 35 years ago, has undergone many organizational changes at different stages of its life. It has had its present structure since the beginning of 1978 when by an order of the Council of Ministers of the People's Republic of Bulgaria, R & D, design, production, trade and engineering in the electrical engineering industry were assigned to it. Along with the above the Association performs other activities thus ensuring a most efficient utilization of the allotted state resources.

At present the following main groups of electrical engineering products are manufactured in the enterprises of "ELPROM":

1. Electric power equipment. A large group of products covering equipment designated for generation (generators), transformation (transformers), distribution (high voltage apparatuses, complete switching stations and transformer stations) and conversion of electric energy (powerful electric engines). This group is also responsible for performance results of complete projects in the field of energetics.

2. Induction motors of general (predominantly) and special designation.

3. Complete controllable electric drives for metal-cutting machines with digital and program control, including DC motors (at present) and AC motors (in the future).

4. Elevators (residential, loading, hospital, etc.).

5. Manual electric tools (ordinary and accelerated boring machines, edge grinding machines, etc.).

6. Low voltage appliances covering a wide range of commutation units (automatic and nonautomatic), protectors, plug connections, electric installation products, control boards, complex semiconductor protectors, complete units, etc.).

7. Electric and electronic automobile parts (generators and starters, ignition coils, relays, electronic systems and equipment).

8. Electric procelain products (practically all types of electric porcelain products required for the manufacture of the products already listed).

9. Technological equipment (electric resistance furnaces and drying cabinets, assembly lines, etc.).

The direct production and economic activities of the SEA "ELPROM" is carried out by two types of divisions:

- o Combines with in-house production divisions, covering the manufacture of the list of products of the same type.

- o Production divisions of direct subordination, representing individual enterprises (including an institute and engineering organization).

The Association organizes the development, introduction and adoption of the innovations in its system and is responsible for the development of the in-house research, development and installation potential. In accordance with its technical policy the Association performs the entire cycle of research, development and production activities.

Innovation activities are implemented through engineering, R & D, design, and project divisions as well as technical, development and other units within the production division.

The scientific and research institutes are engaged in applied research on a self-supporting basis. Their finances mainly come from projects already implemented.

The Association includes two institutes, one scientific and production enterprise, one engineering organization and eight divisions for development and implementation (two at the combines and six at the enterprises that directly report to them).

One of the institutes, the Institute of Electric Industry "Nikola Belopitov" is located in Sofia and is directly subordinate. The other institute, the Institute of Power Technology, is within the structure of the combine "Elprom-Energo" and is also in Sofia (until recently it was a branch of the "Nikola Belopitov institute). The only scientific and production enterprise, "Balkan" is within the structure of the combine "Electric appliances factories" and is located in the town of Plovdiv. The engineering organization "Elpromcomplekt" is located in Sofia. Two of the development and production facilities—elevator building (in Sofia) and high voltage equipment (in Tolbukhin) are part of the other two combines in the Association. The remaining facilities are part of the factories:

- — "N. Kirov" in Rousse;
- — "V.I. Lenin" in Nikolaevo;
- — induction motors in Plovdiv;
- — manual electric tools in Lovetch;

— "Avangard" in Sevlievo;

— electric motors in Troyan;

— "Dinamo" in Sliven;

— electric engines in Teteven.

Within the framework of the enumerated engineering units, the following activities are carried out.

Research. Specification of the technical, economic, technological and organizational level of production and other activities; study of the national and foreign scientific and technological achievements and new experience; study of consumer demand (to what extent the technical and qualitative standards satisfy the consumer's requirements and preferences); market research (product effectiveness and competitiveness).

Basic and applied research connected with the introduction of new and modernized products, technologies, production organization and management systems, assimilation of foreign know-how and the perspective development of the production, economic, and other activities.

Development of project, design, and technological documentation for the new technology, equipment and products; for reconstruction, modernization, expansion and construction of new production capacities, and resources for production automation, computer-aided design, improvement of labor organization and management, etc.

Elaboration of perspective and routine normatives and norms for labor costs, raw materials, materials, fuels and energy, and for the use of equipment and machines, including limitation prices and normative prime cost by products, group of products, type of activities, etc., as well as their continuous conformity with modern technologies, designs, organization and management of production.

Elaboration of samples, prototypes, instrumental equipment, nonstandard equipment, including trial series of the adopted products as well as unique, single or low-series ones.

Implementation of reconstruction and modernization of production and other facilities.

Updating repairs functions to conform with technological requirements.

Adoption of new and improved prototypes for regular production, as well as improvement of technologies, organizational designs and management systems.

Assembly and starting-setting work connected with the introduction of new equipment and processes.

Activities connected with the purchase and sale of licences, know-how, patents, technical documentation, etc.

Establishment of technical information system.

International activities in the field of scientific and technological cooperation; establishment of production cooperation with corresponding organizations and firms abroad.

Training and retraining of management personnel according to the requirements of new technologies, products and labor organization, etc.

The management of the innovation process that involves the above activities is supervised by the Deputy General Manager of the SEA "ELPROM" who is responsible for the R & D and investment activity. Direct management and control of innovation implementation is performed by the subordinated department "Scientific Service and Implementation" that implements the Association's policy in the R & D field through the deputy general managers (in the combines) and deputy directors (in the divisions, mainly directly subordinated divisions).

The concrete objectives for R & D and design activities aimed at development of new products, processes, and management organizations and industrial engineering are assigned in conformity with the present economic mechanism through contracts. The Association is the contractor, the corresponding engineering unit (institute, scientific enterprise of R & D center) is the executor, and the production division (either directly or through the combine's hierarchy) is the customer. The final dates for the completion of the projects are determined by the innovation plan in the SEA "ELPROM". At present, the engineering organizations and the production units annually account for about 18% of the volume of output (expressed in value terms) by new products developed and assimilated during the calendar year and the two preceding years against the total volume of the Association's products. An organic part of the 3-party contracts are the followint documents:

— *programs* indicating the dates for finalization of work, the individual types and stages of a problem (task) by pointing out what part of the contracted price is covered after the fulfillment of the intermediate and final stages;

— *accounts* of the costs, planned within the contracted price;

— *technical and economic targets* where the main technical and economic indicators of the product are pointed out, the process of manufacture and organization, orientation of development, limitation price (of a new product or a product existing after the adoption of a new technology or industrial engineering), expected annual economic effect of the project to be reached during one of the first three years after the finalization of the task. The contract price ensues from the degree of economic effect. The contract contains the clauses with respect to its increase or decrease, according to the achieved annual effect after the project initiation.

Naturally, with the varied products of the SEA "ELPROM", one does not use the same approach to determine the ratio between the expected annual economic effect and the contract price. In such cases when the object of development is products, manufactured in large lots, a requirement is set for a continuously increasing effect over the price. Vice versa, in the development of a single product or small lots giving small economic effect for the Association but considerable for the national economy as a whole, or from the social policy viewpoint, in certain cases it can be admitted that the expected annual effect will be lower than the project's price. An analogical approach is used in determining the price of contracts for development of industrial engineering and technologies.

In many cases, due to the nature of the projects themselves, they are not directly implemented. In such cases bilateral contracts are made between the Association (the contractor) and the engineering organization (as executor). Such tasks are mainly assigned to our two institutes, best equipped for these projects within the framework of the Association and sometimes to external organizations (for example, to higher technical schools).

In the present economic conditions in our country, the Association is oblidged to ensure through contracts the occupation of the engineering organizations to the extent of not less than 60-70% of their capacity. To fill up their capacity the engineering organizations can make contracts with external contractors thus extending their sphere of activity and receiving additional possibility for the improvement of the economic indicators. In the same way, the Association assigns to external engineering organization such tasks which cannot be performed by its own units.

In a paper of this length it is impossible to cover all the aspects of the innovation management organization in the SEA "ELPROM". We hope that the above description gives a clear idea about the activities, organizations and the mechanism, providing for the adoption of innovations in our production divisions. For further clarification of the typical features of innovation management in the Association "ELPROM", three appendices/questionnaires developed by IIASA are enclosed with this report, containing classifications of the general characteristics of the Association and of the innovations introduced. A description of the criteria and characteristics of the organizational structure of management in the SEA "ELPROM" and its production units is also included.

APPENDIX 1: CLASSIFICATION OF THE STATE ECONOMIC ASSOCIATION "ELPROM" BY ITS GENERAL CHARACTERISTICS

Classification Criteria	Quantitative and Qualitative Definitions of the Main Characteristics
1. Orientation of production objectives (by content)	A. Manufacture of industrial products about 90% of total volume. B. Rendering services in product utilization about 2% of total volume, solely for elevators. C. Output of spare parts is small. D. Elaboration of product design, process of production, R & D activity related to manufacture and use of products, about 3% of total volume. E. Other characteristics related criterion-engineering activity in the sphere of the complete electric power sites, representing about 5% of total volume.
2. Orientation of objectives (by nature)	B. Development of manufacture and expansion of sphere of influence (market)—70%. C. Extension and rennovation of range of products, or extenion of nomenclature of manufacture—20%. D. Adaptation to unstable and changing requirements of environment—10%.
3. Type of production	A. Single pieces or small lots by job orders —8%. B. Large lots for definite users—52%. C. Mass production for a wide market.

Appendix 1 continued.

Classification Criteria	Quantitative and Qualitative Definitions of the Main Characteristics
4. Type of manufacture specialization	C. By product.
5. Scale of business activity	C. Large: over 10,000 employees; over 100 million US dollars.
6. Diversification of production	C. Great variety of products, many branches of industry, multistage production cycle, well-developed infrastructure and many types of activities (R & D services).
7. Level of technology in use	B. Mainly modern but "bottlenecks" demand considerable investment for modernization in most cases. C. High productivity, comprehensive, based on latest know-how in some cases.
8. Complexity of products	B. Common products of medium complexity without labor intensive R & D or sophisticated control, rather simple in use—about 30% of the nomenclature. C. Unique products of high complexity involving special R & D sophisticated control during manufacture and assembly also observance of rules in operation—about 70% of the nomenclature.
9. Degree of international cooperation of production units	A. Independent units with closed cycle, producing certain types of end products (under "closed cycle" is meant a cycle closed within the framework of the association and the country)—in most cases. B. Nonregular, insignificant cooperation of production units with minor influence on the results of the fimr's activities—in a few cases.
10. Degree of external cooperation	B. Involvement of substantial quantities of purchased standard products and materials by special orders—50% of the cases. C. Exclusive assembly of products involving specially delivered parts and units—in about 50% of the cases.
11. Spatial allocation of production units	C. Dispersed in many locations with heavy transport flows from one to another.

Appendix 1 continued.

Classification Criteria	Quantitative and Qualitative Definitions of the Main Characteristics
12. Availability of in-house technology and processes	A. Manufacture of products based on licences, purchased processes and know-how—a small part of the volume. C. In-house design of individual products and processes of their manufacture. D. Independent implementation of the entire R & D production cycle. (C and D a greater part of the total volume.)
13. Rate of technological development	C. Regular up-dating of entire range of products, accelerated development of processes to maintain most advanced level.
14. Character of sphere of consumption	B. Constant range of users with uniform requirements of products. C. Variable range of users with changing requirements of products and services in their operation. D. Exclusive user of products with active and constantly developing requirements of products. (C and D groups are typical of the sphere of consumption.)
15. Degree of organization and economic independence	B. Subordination to governmental institution.

Note: The answer to the unindicated definitions of the main characteristics is negative or are not related to the production organization of the SEA "ELPROM".

APPENDIX 2: CLASSIFICATION OF INNOVATIONS INTRODUCED IN SEA "ELPROM" ENTERPRISES

Classification Criteria	Qualitative Definitions of General Characteristics of Innovations
1. Goal orientation	A. Technical: assimilation of new products (manufacture) new processes, up-dating of equipment, employment of new materials. B. Production: extension of industrial capacities, change of production structure, elimination of bottlenecks. C. Economic: improvement of planning techniques, accounting, work payment, settlement of accounts between production units. D. Commercial: change in marketing policy, relationship with producers and consumers, supply of new products and services. E. Social: improvement of working conditions, social security, style of services, style of organizational relationships. F. Managerial: improvement of organizational structure, application of new methods of information and paper processing, improvement of management style.
2. Scale of implementation and sphere of application	A. Total: innovation is implemented in the largest possible way and involves most of the organization.
3. Duration of implementation	B. Medium-term: implemented within 6-18 months. C. Long-term: implemented longer than 18 months.

Appendix 2 continued.

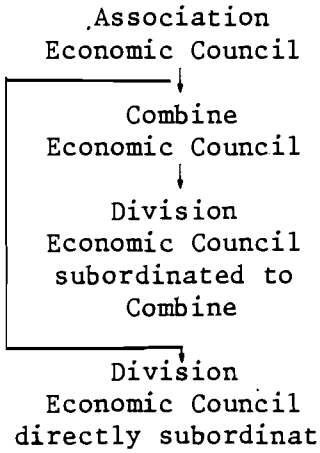
Classification Criteria	Qualitative Definitions of General Characteristics of Innovations
4. Regularity of introduction	A. Continuous: frequently in short intervals (shorter than one year) for different products (or modifications of basic product) in a single production unit.
5. Volume of required resources and their sources	A. Supplied by internal turnover of capital and profit charges. C. Financed out of long-term investments.
6. Sphere of influence on the results of activities	C. Wide: affects the results of the entire organization or its larger part.
7. Significance of accomplished results	A. Ordinary: innovation is insignificant and terms of implementation can be postponed without harm—this relates to a comparatively small part of the innovations. B. Timely: innovation provides for achievement of results important for organization, terms of implementation should be strictly observed. C. Extraordinary: innovation is vital, terms of implementation or available resources very limited. (B and C related to the predominant part of the organization.)
8. Nature of interaction of internal units in innovation implementation	B. Moderate: intensification of operation relationships between a limited number of units is needed. C. Active: continuous and varied relationships of a large number of units is required.
9. Degree of involvement	A. Innovation is implemented by internal effort only in most cases. B. Innovation is based on purchased process licences, documentation. C. External organizations and agents supply large part of resources, items and services required for innovation implementation. (B and C related to a comparatively small number of implemented innovations.)

Note: The answer to missing definitions of basic characteristics is either negative or not related to innovations introduced in the SEA "ELPROM".

APPENDIX 3: DESCRIPTION OF CRITERIA AND CHARACTERISTICS OF MANAGEMENT ORGANIZATIONAL STRUCTURE IN THE SEA "ELPROM" AND ITS UNITS

Classification or Grouping Criteria	Quantitative or Qualitative Definitions of Criteria (Characteristics) of Management Organizational Structures within Classified Groups
1. Scale of management system	Large: over 1500 employees.
2. Complexity of management	Low: ratio of clerks under 10%.
3. Type of organizational design	Line and functional
4. Hierarchy	Association Management ↙ ↘ Combine Management → Divisions of Direct Subordination ↓ Divisions of Combine Subordination
5. Degree of centralization of decision making	Partial: operational decisions are made at the middle level of management division, production unit (responsible R & D unit) Distribution of decision making: normatives and constraints are fixed (adopted) at top levels, operational decisions at lower levels.
6. Management differentiation	Line Blocks: production, technological, supporting Functional Blocks: engineering, R & D, financial, personnel management, planning, distribution These blocks are represented in varying degrees at different levels

Appendix 3 continued.

Classification or Grouping Criteria	Quantitative or Qualitative Definitions of Criteria (Characteristics) of Management Organizational Structures within Classified Groups
7. Concentration of functional activity	—
8. Actual span of control	10-15 people
9. Degree of functional support for line managers	—
10. Degree of program management	—
11. Description of program management bodies	—
12. Description of coordinating bodies	—
13. Degree of collective decision making	
14. Span of control (for top management	A full control of general management of all activities in the Association, connected with the implementation of innovations.
15. Communications in the management system	Direct and through papers (letters, reports, orders, instructions).
16. Effectiveness of management organizations	—

Note: The answer of the missing definitions of the criteria (characteristics) of the organizational structure is either negative or cannot be applied to the structure of SEA "ELPROM".

COOPERATIVE AND SUPPORTIVE STRUCTURES*

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The majority of contemporary electrical engineering enterprises are firmly based on technical inventions going back to the end of the last century or the beginning of this century. Since then products and technologies have been further improved but not quite dominated by radically new innovations. Organizational structures of such enterprises were likewise created in the second half of the 19th century and since then they have been improved and developed but not replaced. Only in the last 10 to 15 years have new trends in organizational design appeared that are likely to call for fundamental alterations in the organizational arrangement of basic units, so-called profit centers, and in their relationship with the organizational environment. The most important factors urging changes in organizational structures are:

- complex tasks and complicated communications required to solve them;
- shorter innovation cycles;
- higher skill of personnel especially in production.

At the initial stage of the electrical engineering industry development, communication between people of different professional backgrounds was easier as more time was available to gain control of new and complex targets and there was greater stability in both internal and external technical, economic and social conditions. The lack of skilled personnel led to a concentration of the major decisions at the top of the organizational hierarchy. The middle management levels largely helped top management prepare complex tasks and enforce their realization by means of operational management.

With increasing communication complexity and shorter time allocations to realize the tasks, the organizational structure ceases to attain former objectives. In the meantime, a partial compromise answer was found: a matrix structure and divisional organization. A divisional arrangement attends to the needs of delegating decision-making authority to lower management levels

*This report was presented by Dr. Smrčka during the General Discussion Session.

and improving direct communication between various units that have to achieve the same targets. Matrix organization is complementary to the basic line and functional structures and stems from them. The matrix organization depends on the basic structure and principal conflicts usually arise in interfaces of both structures.

In years to come new types of organizational structures are expected to evolve that will reflect the new demands on the organizational arrangement. The specific functioning conditions of an organization will determine the choice of organizational structures. One direction, likely to be enforced in the future, is a tendency to cooperative and supportive structures, which will probably be employed when the working environment is characterized by:

- more complex communication problems due to complicated innovations, which will involve new knowledge from more disciplines (i.e., electronics, biology, chemistry, nuclear physics, mechanics, etc.);
- increasing pressure on the fast introduction of new inventions in production and promotion of new products onto the market;
- higher professional qualifications and skills of production unit personnel and other spheres of the enterprise activities as a result of automation and use of computing techniques;
- increasing motivation for people to perform interesting tasks and importance of self-realization in a job.

Due to the above, the hierarchical structures now being used will probably change to more cooperative and supportive ones. Until now vertical communication was primary with horizontal communication second. This will probably now change to the contrary.

In temporary organizational structures the responsibility for own performance and appropriateness of certain parts of the organization are emphasized. Cooperation to achieve the goals of the entire organization is likely to be emphasized in the future. Direct cooperation can only take place between the smallest group of people with the smallest cooperation existing between two people. The upper boundary of an effective cooperation varies and depends on a lot of differing factors, e.g.,

- the complexity of communication, of effort and time spent on gaining understanding, analyzing, decision making and transference of information;
- the time and effort spent on integrating partial activities with final goal achievement;
- the spatial arrangement of cooperating partners;
- the integration level of individual interests with the interests of the entire organization.

If these conditions are favorable (e.g., short integration time, individual and organization interests match), one hundred or more people can communicate directly without the need for any intermediate organizational unit. Under very demanding conditions, however, up to 15 people can successfully communicate.

So far development has implied the creation of ever larger and more internally differentiated organizational units. Only in the last couple of years has this tendency begun to recede. It becomes obvious that over-large organizations are unmanageable and ineffective and the need for creating smaller, considerably independent units—so-called profit centers—arises. This tendency to create smaller basic units will probably continue in the future.

A basic organizational unit, where horizontal (cooperation) communication is primary may be called an operation efficiency center. Its principal criterion for the utilization of resources will be effectiveness, not profit. The measure of the organization's performance will not be gain, but to effectively fulfill social needs. Only such centers, which effectively utilize resources and effectively transform materials into final products, will be allowed to exist and be supported.

Operation efficiency centers will probably exist in a lot of varieties. One, a complex center, will perform routine functions such as R & D, production, material procurement, maintenance, personnel, finance, marketing, etc. These functions will probably not be so distinctly delineated as nowadays. The trend to penetrate and fuse functions is already clearly enforced. In some cases it is rather difficult to differentiate development from production, production from marketing, etc. Modern production methods go beyond traditional boundaries between organizational functions. Cooperating organizations, for instance, deliver parts directly to production areas without sending them to be stocked first. Modern sale methods, such as leasing, erase a demarkation line between production and marketing: marketing becomes more a technical concern and production takes care of the product quality directly from the customer, trains the user personnel, or effects exchange of old products for new generation ones, if needed. This horizontal cooperational integration of organizational functions will probably lead to further integration along the vertical communication line down to the bottom level. While strategy is formulated and adopted outside the workplace where operational activities take place nowadays, in future the strategy may be defined in efficiency centers (where significant differencies may also exist).

"Complex" efficiency centers will probably formulate, approve and realize a proper strategy.

To achieve vertical integration of strategic, tactical and operational management, a high level of automation of production and of other components of efficiency centers must be achieved, including the application of computing technology. This would enable a leader to analyze and make decisions concerning complex problems in a fast and reliable manner. The reliability of decisions will still be enhanced by direct communication between people from development, production and marketing areas, etc.

Operational efficiency centers will not be large units in terms of the number of people engaged, but may be considered large with respect to the number and variety of manufactured products, or the economic and social effectiveness. Due to a direct communication between people performing different functions, this center will be adaptable to new customer requirements and will itself identify and realize important social needs. The existence of many unsatisfied needs becomes a good opportunity for such a center to be further developed.

Due to the transfer of implementation strategy to efficiency centers, the role of top management will change. Their objective changes in principle, and they will not seek to secure the realization of strategy through the hierarchical organizational structure but will support creation, functioning and development of their own efficiency centers. This is a fundamental function of a supportive structure and will complement a cooperative structure.

The supportive structure will include centers which share the tasks of efficiency centers. In some cases this will be general R & D, promotion or marketing. Later these tasks become part of the supportive structure's own objectives.

Single supportive units will differ from current units called centralized purchase or centralized data processing units, etc. Nowadays top management makes a decision about centralization or decentralization of these functions. If they are considered as common (i.e., units providing support to all) the efficiency centers must decide if they could make use of the services of these units or if they should engage their own specialists to do the job for them.

Supportive units will probably formally assign officers that will support efficiency centers. It will probably be collective management, such as a committee resembling the current board of directors. Its members may be representatives of banks, ministries, departments, party organizations and other organizations which take part in the supportive activities—so-called joint venture groups, etc.

These supportive units will not control operational efficiency centers in the sense we understand nowadays. They will give support by giving the resources which efficiency centers could not provide themselves or which should be shared by other units. Boards of representatives will probably make use of some instruments of indirect influence on efficiency centers (such as refusal to further provide services in case of their ineffective use). The board will of course need information, especially economic analyses of the center's activity, their future strategy, level of technology, personnel, etc. The board will have access to the data bases of the center and the right to use the data in the manner that suits them best.

Some of these supportive units may later grow into efficiency centers when it becomes necessary that they function on the effectiveness principle. In this case some sort of commercial relations based on financial exchange will probably be established between them and the original efficiency center. In this case the supportive units will adopt a cooperative form of organizational structure. The relations between supportive units working on an effectiveness principle and the normal operational units need not differ from the relations with the external environment units.

Supportive units will probably provide services to other organizations too if it proves advantageous (better use of computer time, specific analyses, etc.). The means for running supportive units may largely come from operational units; but there can be significant differences (e.g., operational units 30%, board of representatives 60%, external organizations 10%, etc.).

The operational efficiency centers will be allowed to make use of other service organizations as well if it proves to be advantageous. Modern computing technology allows continuous evaluations of different variants of services and other activities.

Creation of decentralized organizational structures, where integration along the horizontal and vertical lines becomes a reality, corresponds with the interests of skilled, highly qualified people. The technological progress makes it possible to employ machines for routine work. The position of man changes in both control and noncontrol activities. Skilled workers not only want to be able to participate in making decisions for complex problems but also want to know the meaning and significance of their work and future prospects.

A long time ago, sociologists, psychologists and others took up the problem which arose from over-specialized and monotonous work. The results of theoretical studies and current practice in enterprises show that it will be necessary to introduce further organizational changes for better use of human potential, creativity, self-realization and motivation.

The cooperation and supportive structures mentioned above might be regarded as one of the solutions to modifying activities and relations between poeple so that man's creativity and skill can be fully utilized.

Due to the transfer of strategy implementation authority and responsibility for the results of operational units, the difference between leaders and operators and between specialists of different units becomes insignificant. Due to the automation of routine activities, one of the leaders could devote part of his time to controling the automatic line. While cooperative sessions discussing new customer demands is going on, the work line can run independently. If an error occurs and there is a signal that the line has stopped, a leader can decide whether to continue the session or fulfill his operational duties and repair the line. For example, he could decide not to abandon the important session and let the automation line catch up in overtime.

The graphic representation of cooperative and supportive structures, and the means and manners of understanding the relationship inside the organization will probably also change. We demonstrate the organizational structure as a pyramid with top management at the top, tactical management on a lower level and the operational management at the bottom. The main relationships are superiority and subordination and are usually represented as little squares and oblongs on formation charts.

Cooperative structures might be represented in a different way. Above all the cooperation and dynamism in a work organization should be demonstrated. For that purpose round and ecliptic figures might be the best choice for formations moving freely in the organizational environment. Communication must also be made easier between the cooperating units such as the use of wireless transmision compared to existing telephone lines.

If the current top management and staff units change into a supportive position in the sense described above, it would be of great use to change the manner of relationship between operational efficiency centers and supportive units too. The term "support" creates an idea of "holding" something or helping it to proceed in its activity to reach the fixed target. If the main task of top management and other general (nonoperational) units remains to be the support of operational units it would be more suitable to place the current top management and other supportive units below the operational units on the chart, not above them.

The question arises, however, if it is necessary to demonstrate organizational structures on a chart. Easy-to-understand structures certainly need

not be charted in detail. It is enough that the idea of organizational structure exists in the minds of people.

In the future, organizational charts will be held in computer memory if their sophistication goes beyond a certain limit. Nowadays there is a significant retreat from complicated organizational diagams and charts and detailed descriptions of duties and responsibilities. It seemed to have sense at a time when stability and the accomplishment of routine tasks prevailed.

ORGANIZATIONAL STRUCTURES IN INNOVATION MANAGEMENT*

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1. CLASSIFICATION OF CKD PRAHA

CKD PRAHA consists of three units: CKD PRAHA; Prerovske strojirny—the Engineering Works of the City of Prevov; and the foreign trade corporation Pragoinvest. Production and internal sales are incorporated under the Federal Ministry of Metallurgy and Heavy Engineering, which does not include foreign trade handled through Pragoinvest. CKD PRAHA is oriented towards research, development, manufacture and trade in the areas of:

- electrical engineering
- mechanical engineering
- engineering metallurgy

Specific interests are as follows:

- In electrical engineering: electric motors, rotating machinery, power generation, electric sets, industrial power and special transformers, electric equipment for rail vehicles of mass municipal transport systems, for diesel locotmotives and special vehicles, power semiconductor elements, semiconductor rectifiers and converters, equipment for sub-stations in industrial branches and traction, semiconductor equipment for electric locomotives.

- In mechanical engineering: diesel locomotives, hydraulic gearboxes for rail vehicles, diesel engines and diesel sets, turbocompressors, screw and reciprocating compressors, refrigeration and freezing plants, gearboxes, shaft winding installations for underground mines, road equipment, full-portal gantry cranes, portal carriages, selected steel structures, especially for capital construction, tramcars, tramsets, high-speed railway vehicles and other nonconventional kinds of mass transport facilities.

- In engineering metallurgy: products of engineering metallurgy.

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*This paper was not presented orally at the meeting but was prepared especially as a contribution.

CKD PRAHA specializes in the design, manufacture, and installation of products, as well as those services involved in making use of the products. This particularly concerns the following equipment: refrigeration plants, compressor and turbocompressor stations, engine rooms for hoists, underground mining plants, substations, diesel engine power plants, electric drives for rolling trains, automation of rolling trains including systems for their automatic control. Agreements with customers using other products ensures the manufacture of spare parts as well as general overhauls, repairs, and servicing.

There is, in accordance with the purposes of the enterprise, a firm commitment to develop production and expand the home and, especially, the foreign market. This means it is necessary to conform to varying customer requirements for single-item manufacture and, in series manufacture, to strengthen specialization. Various types of manufacturing are undertaken, including piece-wise, low-serial, and serial production, according to the character of the product. Any manufacture undertaken is substantially covered by orders from the customers in advance. The varied manufacturing program is distributed among a total of 18 branch works with production specialization at each level of the works, while a predominant aim is to reduce the number of management levels in each of the works. At multiproduct works, specialization is centered in specific working divisions.

The range of production and trade activity of each unit, as well as of the enterprise as a whole, may be characterized as extraordinarly large. While single works have a relatively low number of employees, the volume of production and sales allows them to be counted among the big manufacturers. From the point of view of diversifying manufacture, units and individual works with piece and low-serial production can be classified as middle to big, so that advantage can be taken by standardization and unification. As to the technology used, progressive technology may be applied within certain limiting factors. In the area of electrical engineering, for example, a high-productive technology is that of semiconductor elements.

It is necessary to emphasize here that there is strong cooperation between the units of the enterprise. It may be stated that without this cooperation, a considerable part of the works would be limited to a middle range of marketing activities on a national level. The production of any single item equipment has to be associated with more complex activities in design, manufacture, inspection, and installation. This requires great cooperation among the various branches and levels at all stages of the process, and the existing cooperation is rather complicated.

Cooperation within the framework of the enterprise, as well as between individual works, is strengthened by the establishment of such services as Technical Services, Transport Plan, Engineering Services, Social Services, Technical Information Service, Apprenticeship Works, Computing Techniques, Construction and Power, Material Supply Works, Research Institute, etc. Examples of such internal cooperation include the following branches: engineering metallurgy in two works, electrical engineering/machinery and equipment in three works, final engineering production in 12 works, and assembly of the final product in one facility, whose activity continues development through delivery. External cooperation is provided through the purchase of materials and subdeliveries by the Material Supply Works (Prague 9) and the Works Supply Divisions for the predominant part of the materials used for electrical and mechanical engineering. Special orders for single works or their parts are handled separately. Most facilities are located in Prague.

For most orders, CKD PRAHA handles the entire cycle of design, manufacture, and operation from its own resources. Use is also made of the services offered by branch research institutes and technical colleges for research and application. Research and development is financed by the State (national interests), the enterprise, the works, or the customer, depending upon the specific task and product involved.

Modernization of products and production technology concerns continuing revision of the planned range of manufacture and adoption of new technologies. As the customers want a traditional range of products, the main thrust of modernization is concentrated on innovation of technology. CKD PRAHA customers include: *permanent customers* for traditional products with unchanging manufacturing requirements, such as tramcars, locomotives, diesel sets, ship engines, road mobile cranes, semiconductor welding machines, etc., and *monopoly customers* for one-of-a-kind products, perhaps eventually repeated with modifications, such as electric motors, transformers, substation equipment, positive displacement compressors, industrial refrigeration plants, automatic rolling trains, hoists for underground mines, etc.

There is full organizational and economic independence in the production and trade unit and in the firm. Organizationally, units have the right within the framework of delegated authority to negotiate in the name of their unit. Economic responsibility is determined by the specification of the technical and economic plans of individual facilities. The most extensive rights are in the area of manufacturing, and this considerably reinforces the independence of decision making at independent plants in terms of marketing activities. These are further regulated with respect to two main groups of customers: (a) final consumers of CKD PRAHA products and (b) internal customers (interfactory deliveries). Both are treated in accordance with financial needs as well as with the needs for development and improvement of manufacture.

Marketing and manufacturing functions, including technical, personnel, investment and other activities, are developed in accordance with perspective, medium-term, and annual plan directives.

2. CLASSIFICATION OF MODERNIZATIONS

There are many trends in modernization of CKD PRAHA and its units, to various extents and over various time scales. Technological orientation in almost all the branches is directed toward keeping pace with world trends. Concerning new products, emphasis is on the unique design of products of singular form and technology. There are wide measures undertaken in the area of manufacturing, namely modernization of machinery, applying new insulation materials, more extensive standardization and unification of parts and groups of parts, making use of more progressive technology, designing some serial rows of products (which has the advantage of using interchangeable parts), constructing the premises on the basis of economy of scale to manufacture products, parts of products, and prepare materials.

These measures are a source of growth not only in the volume of manufacture but also in productivity. Manpower being limited, economic effectiveness is improved mainly through reduction of the cost of materials as well as through intensification of work. Implementation of innovations occurs at all three stages in the production and trade units. Total innovations are introduced simultaneously with the construction and equipment installation of new facilities, and involves all spheres of activity from production to management.

An analgous innovation, at a relatively lower level of investment will take place in the Elektrotechnika Works which will result in improving the materials flow and speed up the entire production cycle. This covers an ample technological project of amalgamating and modernizing the machine shops, designing modern processing of insulation, modernizing the in-process stores and interfactory transportation system, extending the manufacturing and installation areas to create a considerable rise in production, including repeated production, so that inadequately used machines will be more fully utilized. This will not be done, however, without also improving the management structure on the level of the works and workshops. It implies application of computer systems for management purposes to improve the quality of flow and the processing of information for managers. And, last but not least, it helps elaborate the principles for the interfactory *Khozraschot* in the workshops and brigades*

Before realizing the above measures, it was necessary to improve operations in the structure of orders, automate the order ledgers, and enforce production planning for both quality and quantity through the aid of computing techniques in interfactory divisions. A considerable number of works will apply innovations of local character in the workshops or workshop groups. Such innovations will be implemented in smaller facilities of CKD PRAHA, for improvements in technologies of manufacturing, with partial adaptations of a production and technical base. The time needed for implementation of individual innovations depends upon the areas involved. The construction of a new plant is an affair of several years: for instance, almost one-half of the five-year plan will be devoted to the innovations at the Elektrotechnika Works. However, innovations need not be such long-term projects but can be executed in the short-term as well.

The introduction of innovations is connected with everyday activities, but this concerns, as a rule, innovations of a lower order. Measures to periodically realize innovations are a part of rationalizing plans extending over many years, defined with more precision for each single year. Some innovations are connected with the elaboration of integrated annual plans in terms of marketing, production, R & D, costs and gains. Others come as a consequence of quarterly and annual analyses of the progress of the works and their divisions. "Accidental" innovations are unlikely because all extensive innovations of a higher order are planned and require concentration of power and funds. Financing innovations depends considerably upon other claims made for funding. Construction of a facility or workshop cannot do without financing from external sources on a long-term basis. Financial cover for innovations through short-term credits does not often occur.

The order of innovation is taken into consideration, with three categories recognized. The broadest is for construction of an entire new facility, such as the construction of the Tatra Works. Expansion of an already existing production base for more rational production which simultaneously establishes a whole series of innovations in manufacturing is seen, for instance, in the case of the Trakce Works which manufactures tramcars, locomotives, and electrical equipment, and in the case of the Elektrotechnika Works cited previously.

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*Khozraschot denotes an economic accounting principle whereby an economic unit tends to be self-supporting.

There are also innovations in individual divisions or workshops such as technological specialization in machine shops, extension of capacities to develop serial production, strengthening of standardization and unification in in-process stores, aiding design and technological rationalization, improvement of management through computing techniques of the lowest management level.

Innovations, although they may be directed towards one end only, i.e., raising productivity, have considerable influence on the general situation of the entire works complex. One area of concentration is the avoidance of limiting factors that could brake the contribution of innovations. Such constraints could arise in management, technology, design, cadres. There must be appropriate steps to prepare personnel in good time for new processes, new approaches, new procedures and motivate them for the achievements.

Innovations of the broadest type affect a wide circle of the works divisions. Managing teams are formed at the level of the entire facility, divisions, workshops, and workplaces to provide an active atmosphere of mutual influencing. All innovations require inventive work of teams to solve all problems and to achieve a positive attitude towards the innovations, rather than the stereotyped acceptance of duties. Depending on the range and character of the innovation, some require joint cooperation with foreign experts or institutions. Usually, the higher the order of the innovation, the more likely active cooperation with external institutions will increase.

Diagram 1 shows the organizational set-up of the Electrotechnical Works. The organizational set-up for CKD PRAHA is shown in Diagram 1 of the paper by Vodachek and Mraz (this volume).

3. BASIC TYPES OF ORGANIZATIONAL CHANGES TO IMPROVE MANAGEMENT OF INNOVATIONS

The Head of the Board of Management is entrusted with managing perspectives and technical innovations, under the General Manager. This specialized Director has the following tasks:

— Long-term perspective conceptualization of the production and trade unit CKD PRAHA, and studies of organizational units' and works' innovations proposals submitted to the Director. This activity is executed in close collaboration with the employees concerned in individual works.

— Innovation of production branches through the introduction of R & D in plans, programs, specifications and supervision. This activity also proceeds in close connection with an individual unit or works. R & D units are established in some branches of specialization, such as:

  - o diesel locomotives at the Lokomotivka Works
  - o reciprocating compressors, turbo-compressors, industrial refrigeration plants at the Kompresory Works
  - o diesel engines for industrial purposes, stationary, ship and traction at the Research Institute of CKD PRAHA satisfying the R & D needs for several branches of industry
  - o heavy current semiconductor elements and appliances at the Polovodice Works
  - o tramcars and rail vehicles for urban mass transport at the Tatra Works.

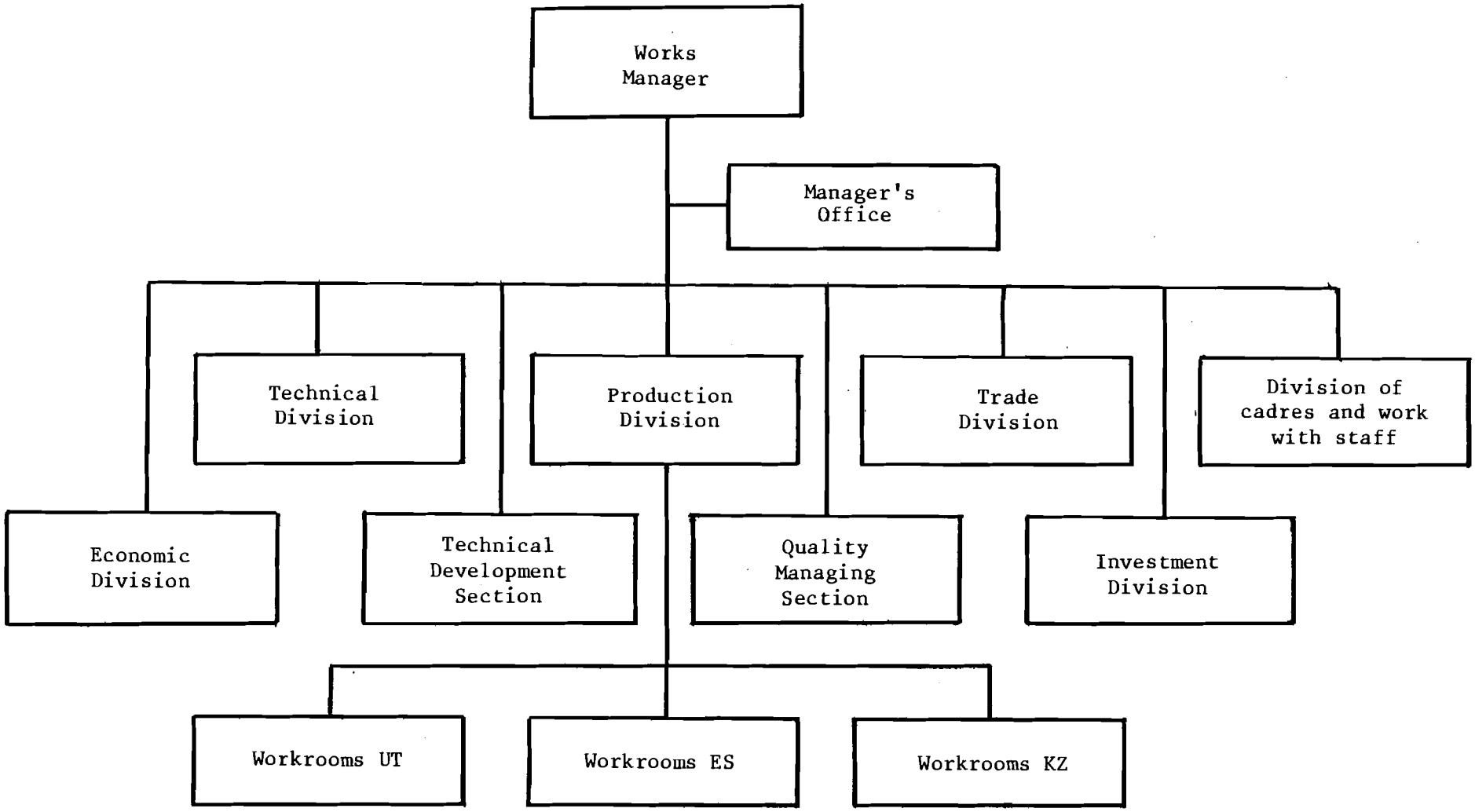

Diagram 1. Organizational set-up of the CKD PRAHA Electrotechnika Works.

— General development of rationalization activities and establishing work standards.

— Managing the development of technology and enforcing the management of internal technological specialization.

Moreover, the division is responsible for handling quality, international collaboration, technical and information services, and patents.

Some of these activities are managed by branch engineers, with possibilities of direct contacts with an individual facility. This is especially so where R & D departments are not located directly in the branch. With multibranch works, it has proved more effective to set up an integrated R & D center within the management body of the works and subordinated to it. Independent branch innovation development sections in individual works include the activities of branch engineers in strategic planning, managing product innovations and technical development.

While the arrangements for managing innovations in the area of technology and electrical engineering works well, the situation in multibranch works concerning projection and design in laboratories, scientific and technical calculations with the help of modern computer techniques, is more complex therefore organization of creative activities is much more difficult. A wider use of computing technique, not only for calculations but also in design and drawing, in close connection with program-controlled manufacturing techniques is seen as the method to surmount these obstacles.

With the broad assortment of product lines, it is not possible to merge the presently separate development activities in design and technology from operational functions. Application of computer control for the whole area of TPV is very ambitious, nevertheless, the modern computer technique known as "outfit activity" for the processing and issuing of manufacturing documentation will be used in the proper management of the production process. Specialized document and manufacture departments in electrical engineering have development laboratories and test rooms to verify the new solutions in the area of design and technology of parts. Team work is used when designing complex products or making use of modern methods of screen planning and screen analysis, especially when it is an ambitious task. In multibranch works like the Elektrotechnika Works, centralization of TPP planning at the level of the Head of Works' Technical Division works well.

Computer technique development concentrates on balancing both the capacity of the works and planning economic goals. For balanced capacity, there is an uniform system of the so-called "reserves for unforseen tasks" so that departments are not forced to determine reserve stocks as long as such reserves have not been identified by the TPP departments themselves. It is necessary to consider the qualitative aspect of the production process and its consequences for production economics. This assumes:

— reserve of adequate time for technical development activities

— reserve of adequate time to fulfill other orders

— regard to bring development activities to an end which can be measured by operational norms, calculations of tasks, and ensuring that cost limits are not exceeded.

Inventive technicians and technical development designers have the right to premium payments. The principle of the Khozrazchot brigade is applied when premiums and bounties are divided into two categories:

— time and merit in fulfilling the task

— limiting costs and fulfilling the economic aims.

Percentages of premiums are paid to differentiate the successful designers from the less successful, and the preferences as to tasks. The complete bounty cannot be paid until economic aims have been verified in the course of manufacturing.

ADAPTATION MECHANISMS OF FLEXIBLE ORGANIZATIONAL STRUCTURES

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The present stage of the development of production systems is characterized by the growing intensification of production processes, the limited resources, the dynamic external and internal environment. Effective adaptation of management systems to the changing tasks is the main requirement to the functioning of industrial enterprises (1).

The analysis of the individual and small serial products enterprises in electrical engineering and power machine building industries showed that their environment in most cases has dynamic, stochastic character.

In such conditions traditional management systems seldom provide for a timely solution of the emerging problems. We think it is necessary to form flexible organization structures with adaptation mechanisms in the elements of management system (information service, management procedures, organization structure) to the changing conditions of the production (2).

The formation of the flexible management organization structures with adaptation mechanisms is a further improvement of line and functional structures from a systems point of view (3).

A principle of adaptation is offered which is meant to be one of the main principles of designing flexible organization management systems--adaptation of the management system's elements to the changing environment. It should be noted that most of the socio-economic systems (including industrial enterprises) possess the ability to adapt to the changes in the internal and external environment.

However, the examination of the enterprise management system in electrical engineering and power machine building industries showed that nowadays the principle of adaptation has a local and "spontaneous" character, there are no formal and regulated procedures for reconstruction of the management system. Traditional adaptation methods are mostly based on the use of

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*This paper was not presented orally at the meeting but was prepared especially as a contribution.

extensive methods: employment of additional personnel, material and financial resources, establishment of new subdivisions, etc.

In modern conditions the rate of influx of new ideas is increased, and there is a need for their quicker implementation, so that the traditional methods of adaptation of the industrial organization become unsuitable (4).

Acceleration of the scientific and technological revolution, scarcity of all kinds of resources brings to the foreground the development of forms and methods of management that utilize most effectively labor, material and information resources. In such conditions the investigation of adaptivity of management systems becomes one of the main tasks of the management science. It is necessary to analyze the ability of the management system to react quickly and with minimum expenditures on the technical, economical and social changes in the enterprise.

The establishment and functioning of flexible organization management structures with adaptation mechanisms requires stability of the system. Under stable conditions we shall determine what provides a given mode of management (for example, minimum expenditures) in the context of external and internal changes of the environment. Hence the objectives to provide stability (5):

— maintaining the management system on a definite level of stability;
— transfer of the management system to a new level (changing of the organizational structure parameters).

The tasks of providing the stability of the management system are the tasks of the functioning of adaptation mechanisms.

The next aspect of forming the adaptation mechanisms is to determine and develop the parameter system describing the properties of the management system. It is suggested to divide all the family of adaptive properties of the management into three classes: variability of the information support, variability of the algorithm development, variability of the organization structure parameters.

Variability of the management information support is conditioned by the possibility to change the form and composition of management documentation, store and obtain information about the past and the future state of the management system, and provide consistence of the form and content of the management documentation with the changing industrial and management organization structures.

The possibility of changing the rules, decision-making (variability of the algorithmic supply of the management system) is determined by the ability of the management system to formulate new management tasks, redistribute them among the subsystems, change the order and method of planning and organization, plan and analyse the function of the enterprise over different horizons and in-depth.

Variability of the organizational structure parameters is conditioned by the management system's ability to change the rate of centralization and decentralization, number of management levels, span of control, form project teams as well as employ goal-oriented programming and matrix organizational structures.

One of the main directions of raising the degree of adaptivity of the management system is formalization of the adaptation processes. The following adaptation mechanisms are suggested as formalized adaptation processes: informational, algorithmic, and structural (6).

The informational adaptation mechanism provides identification, collection, forecasting and supply of information about changes in the internal and external environment, and the identification of problem situations in management. It improves the procedures of elaboration of decisions with respect to problem situations on all the management levels. The informational mechanism procedures ensures variability of the information supplied to the management system. The introduction of the management information system must be the first step towards creation and introduction of the information adaptation (management information system), different variants of which are widely used abroad and in the USSR (7).

The algorithmic adaptation mechanism is responsible for such adaptation property of the management system as a variability of the algorithmic supply. The procedures of the algorithmic adaptation mechanisms are necessary to permit restructuring the interrelationships between the units in the management system. The reconstruction of the algorithms and management procedures is aimed at rationalizing the management system and improving the interfunctional activity. The formalization of the adaptation processes and their complex character also pre-suppose the use of the information model system and business games. The information models of the subsystems in the entire mangement system (8) are the graphic representation of all the management processes of industrial enterprises. With the help of the information models it is possible to trace the consequences of changing the procedures and algorithms of management, estimate them and implement comprehensive restructuring of the entire management system. A mandatory preliminary approbation of serious changes of the procedures and management algorithms with the help of the business games is an important element of the algorithm adaptation mechanism (9).

The structural adaptation mechanism provides for the application of formalized procedures connected with changing the organizational structure parameters, i.e. introduction of the earlier developed and agreed organizational technological standards of project and matrix structures, creation of provisional project teams, changing the organizational configuration (number of management levels, span of control, degree of centralization and decentralization). The stage of approbation and estimation through business games preceeds the introduction of all structural transformations (or management innovations) according to the adaptation procedures. The above adaptation processes on the structural level are essential for reconstruction of the information and algorithmic supply of the management system. The adaptation process of the management system consists of several stages and is as follows:

1. Identification of management problems. The changes of the internal and external environments lead to deviations from the planned production activity. The analysis of the informational aspect helps delineate requirements to the content and format of management documentation.

2. Search for solutions to the above problems. The important element of the informational adaptation mechanism is "the bank of problem solutions" (BSP), accumulating the experience of making management decisions and estimation of their effectiveness. In the search and selection of management decisions the following factors are important; BSP data, and the existing organizational environment, information support, the management procedures and algorithms, the organizational structure parameters. The management system's stability is estimated with respect to the changing function. Then the adaptation tasks; the officers responsible for the management system restructuring and identification of problem situations are determined.

3. Updating of the information support to contribute to the management system's stability. After an analysis of the problem situation new requirements to the information support are defined so that the documentation format can be changed: introduction of new and elimination of the obsolete parameters, introduction of new documents, etc. Reconstruction of the information support is performed within the limits of its variability and is tested by means of information models of the management subsystems. A solution to a problem situation is determined with the help of the new information system. If it is impossible to solve the problem situation only by changing the format of the information, it is necessary to employ the procedures of the algorithm adaptation mechanism.

4. Change of management procedures. A further analysis of the problem situation reasons is performed in order to rationalize, improve the interfunctional activity and change management procedures. If the problem is not accidental and has an objective character connected with a change in the environment, a new management task is formulated, the stages and content of the management procedures are determined. On this basis a set of managerial steps aimed at introducing some changes into the decision-making process are mapped out. A change in management algorithms is made in accordance with the adaptation properties of the algorithmic supply that guarantees their quickest implementation at a minimum cost.

   Adaptation processes of the information and algorithm mechanisms solve the first task of the management system stability to keep it within a definite limit according to the given criteria (for example, minimum cost). If the change of the information and the algorithmic supply does not solve the first adaptation task, it is necessary to solve the second task--transition of the management system to a new state, change in its qualitative and quantitative parameters. It can be done with the help of the procedures of the structural adaptation mechanism.

5. Change of the organizational structure parameters. At a given adaptation stage, important decisions on the management system restructuring are made. It is necessary to analyze the alternative solutions connected with the change in the degree of centralization, span of control, the number of management levels, creation of the goal-oriented program structures, etc. It must be noted that the function of the structural mechanism is also connected with the

restructuring of the algorithm and information support, i.e. the adaptation processes of the management system have an iterative character and provide for comprehensive reconstruction of the entire management system.

CONCLUSIONS

1. In the dynamic environment of the enterprises it is necessary to improve adaptation methods guaranteeing rapid adaptation of the management system to the occurring changes.

2. It is necessary to develop a system of criteria permitting to estimate the adaptivity of all the management system's elements (information support, the management procedures, the organizational structure, etc.)

3. One of the possible directions in improvement of the adaptation methods is formalization of the information, algorithms, and structure.

4. The suggested adaptation mechanism procedures provide for a stable performance of the management system in the context of internal and external environmental changes on the basis of elaborated measures for its reconstruction.

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SUMMARY OF DISCUSSIONS

The report by Professor *Holec* (CSSR) that summarized the ideas and suggestions contained in the contributions aroused great interest on the part of the participants. His statements were discussed in detail. Everybody agreed that innovation activity cannot be isolated from the basic activity of an enterprise: production and marketing, which is closely intertwined with all the activities throughout the product development stages.

There was also general agreement about the importance of social aspects of innovation. Dr. *Smrcka* (CSSR) emphasized the contradictory relationship between the social and engineering aspects of innovation: it is in the nature of man to stick to the customary and well-known and resist anything new. Gradual and patient training for innovation is therefore essential for both decision makers and employees.

The participants were also in agreement with respect to the differences in the innovation processes between *special* and *standard* production: they involve different creative ideas to determine the engineering of the project and the required investment. It was pointed out that the innovation process depends on the product and might even involve external funding.

Dr. *Wolf* (Austria) described social innovation as a new situation, a totally new social climate in an organization or a country. Since the climate is constantly changing, management must try to keep up and innovate the organization they are responsible for.

Discussing the role of an organizational structure in innovation management, Professor *Nomoto* (Japan) emphasizes that the organizational structure ranks first among the means used for determining the right proportion between such constrasting factors as:

centralization vs. decentralization
flexibility vs. stability
formality vs. informality.

Turning their attention to the possibility of using a standard organizational design, the participants expressed the opinion that there can be no universally acceptable designs for similar situations. Professor *Rapoport* (USSR) pointed out, however, that since there is a certain regularity of organizational development, it will be reflected in the clear trends of the organization's structural change.

It was also agreed that an adequate organizational structure will provide for proper innovation activity but it was repeatedly emphasized that a proper organizational design *is only a means, not an end in itself.*

Dr. *Razvigorova* (Bulgaria) spoke of their experiments in teaching managers to use certain instruments to design an organizational structure adequate to their needs.

Part of the discussion was centered around such concepts as centralization and decentralization in an enterprise or firm. The participants agreed that with a divisional organizational structure there is more decentralized decision making with respect to minor innovations and operating matters. Major innovations (construction of a new factory, etc.) involving a change in the entire system, calls for centralized decisions by top management.

Among the major problems of innovation is coordination of effort among the units participating in the innovative activity. Professor Nomoto explained that the mode of coordination of effort between Japanese managers is similar to that of a matrix organization.

Attention was also given to organization of cooperation in innovative activity. Dr. *Karttunen* (Finland) and Dr. *Vassev* (Bulgaria) spoke of two ways to organize this:

1. One division has the biggest share of the project and is made responsible for it, receiving all the financing and possibly subcontracting other divisions or organizations (including external ones).

2. In the case of equal shares among the divisions, coordination is constantly effected by top management.

If the project deals with research, the production divisions become customers of the research center, while experimental work is done locally.

It was also emphasized that it is difficult to obtain cooperation between people dealing in theories and decision makers, i.e., between people who are more expert and capable of ideas and people of practice.

Although the human factor involved in innovative management will be given special attention at a future seminar in Helsinki, it was also touched upon here. Since several questions were asked on this topic here, Dr. *Goldberg* (Sweden) explained that technological change brings shorter technical cycles which, in turn, involves more complex and differentiated decision making at a faster pace. All this calls for a change in the managerial style. It is important to provide for the integration of new technology into managerial activity. Dr. Razvigorova stressed that future innovation management may lie in the sphere of management system improvements.

Questions concerning the role of computers in managerial decisions were also discussed. Mr. Wolf pointed out that his company motivated managers to obtain the basic knowledge needed to handle computers by themselves. Professor Rapoport said that the use of new technology would influence the organizational systems in many ways. One is the communication between middle and lower level managers, and that knowledge of management techniques will help make decisions on these levels.

Dr. Goldberg pointed out that computers can be used to forecast the future if the past is taken as a basis for extrapolation. There are models to assess the trends of the past and the future but it is up to management to decide how much it will stay the same or change. There have been models developed but the final responsibility for (a) changes, and (b) use of models, lies with the management. Computers tend to give cloudy answers to clear questions.

In conclusion, the participants spoke of the future paths of development by suggesting various ideas. Dr. Razvigorova thought it would be very useful to look into other elements of the relationship between organizational structures and forms of management systems as well as other insights into the modes of evaluating managerial effectiveness.

Professor Nomoto proposed an interface for a future meeting which would elaborate a structural planning system and strategic organization in innovation management to be systemically analyzed. The interface meeting should be organized around the following major issues:

1. Interdependence of organizational structure and innovation strategy.

2. Formulation and implementation of strategic policies with respect to organizational units.

3. Structural coordination of time factors—long-term planning versus operational schedules.

4. Impact of the information system development on the strategic faculty for innovation.

5. Further transformation of organizational structures in accordance with innovation-oriented strategy.

Following a presentation by Dr. Smrčka on proposed changes to Chapter 4 of the IIASA Monograph "Innovation Management in Electrotechnology: Adapting to a Changing Economic Environment" the following headings were agreed:

Chapter 4: Structures: Choice of Organizational Forms of Innovation Management in Electrotechnology

1. How are innovation management structures in electrotechnology classified?

2. What are the new approaches to analyze, project and evaluate innovation structures in electrotechnology?

3. How can organization structures support effective monitoring, evaluating, making and testing of new innovative ideas?

4. How can organization structures enable direct face-to-face communication and cooperation in the organization?

5. How can innovation management organization be made more flexible?

6. What are the methods to evaluate, to an optimal degree, centralization and decentralization of innovation decision making?

7. What are the main trends in further development of the organization structures in electrotechnology?

APPENDIX 1

CONFERENCE ANNOUNCEMENT

IIASA STUDY ON INNOVATION MANAGEMENT IN ELECTROTECHNOLOGY

TASK FORCE MEETING ON

ORGANIZATIONAL STRUCTURES IN INNOVATION MANAGEMENT

PRAGUE, 30 MAY - 4 JUNE 1983

(AS APPROVED AT THE PRAGUE PLANNING MEETING 13-17 DECEMBER, 1982)

ORGANIZATIONAL STRUCTURES IN INNOVATION MANAGEMENT

Prague
30 May - 4 June 1983

Program of Research

One of the main objectives of the innovation management in electrotechnology case study is to find a way for industrial organizations to be able to correspond with the conditions and requirements of developments characteristic of the 1980's, through a continuous improvement of management organizational forms and methods of large-scale technological innovations. This means:

— identification of the most effective lines of development for management organizational structures, and a search for the adapative modes of their construction and implementation under specific conditions. It also implies identification of the optimal levels of innovation decision-making, modes of assignment responsibility for the implementation of various stages of the development and production of new products, assimilation of new technology and its documentation and material support, rational composition of functional units in the management bodies, their interfaces, and approach to interfunctional problems of innovation management;

— organizational improvement in strategy and human relations in the innovation process, i.e., rational grouping and coordination of the most dynamic components in a single management system.

It is important to:

— identify how strategic and operational tasks are distributed among various bodies and levels of management;

— establish centers of supervision and control over the utilization of the innovation's resources;

— create a favorable psychological climate for the elaboration and discussion of creative solutions that will have a decisive influence on the effectiveness of new products and technologies.

To achieve the defined objectives in a fashion familiar to IIASA implies five different stages of research and analysis.

1. Preparation of a task force meeting on innovation management organization.

2. Discussion by the task force meeting of the organizational problems of innovation management and a joint definition of the ways to solve them.

3. Analysis and generalization of the patterns of innovation management organizational improvement adopted by the meeting, and elaboration of the methodological recommendations for their implementation in specific conditions.

4. Discussion at the planning meeting of the place and role of organizational development in the improvement process of innovation management, specification of the modes of organizational adaptation, as well as improvement of strategy and style of management.

5. Genralization of the accomplished results for the corresponding sections of the monograph on innovation management in electrotechnology, and an elaboration of the tentative recommendations for certain firms.

The objective of the first stage -- preparation of a task force meeting -- means obtaining systematized and complete information with regard to achieving higher effectiveness of innovation management through organizational transformations from the countries participating in the case study. In order to provide for adequate substance and comparability of presentations it is planned to circulate the following materials:

— a recommended format for presentations and a list of the key points to be covered, as well as guidelines regarding the data to be submitted (if necessary);

— a specification of characteristics to be used in the description of business organizations in those cases where data are unavailable or confidential;

- a specification of characteristics and basic rules for innovation descriptions that will allow for a uniform and sufficiently complete picture of the firm's innovation activity to be obtained;
- a list of the basic parameters of the management organizational structure, with recommendations for terminology use to avoid any ambiguity in understanding the character of the effected organizational changes;
- a list characterizing the features of the function, as well as the relationship with the external environment, to provide for a uniformity in the description of the firm's environment both current and predicted;
- a specification of the basic factors and parameters of the effect of the innovation activity to be employed for improved management of organizational transformations.

To provide for high quality and good comparability, it is suggested to elaborate and circulate the basic parameters to be described among the participants. That is, the object of the investigation, content of analysis, the time involved in the development, and a list of topics and properties to be analyzed and evaluated. To make the preliminary processing of the prepared materials for further meaningful discussion possible, it is necessary that the presentations be submitted to the organizing committee not later than one month before the meeting.

To perform the above preparatory wok it is deemed advisable to set up an international working group composed of IIASA experts, members of the national organizing committee for the task force meeting, and experts from other NMOs participating in the case study. The required meetings of the working group could be arranged in the host country of the task force meeting, or at IIASA.

The objective of the second state -- the task force meeting itself -- is to jointly determine the organizational possibilities for innovation management improvement. To make the discussion more constructive, in addition to the exchange of sufficiently structured information, it seems reasonable to prepare a special report which would include systematized and generalized materials. This general report would include possible comparisons, evaluations, preliminary versions of conclusions and recommendations, and a list

of the topics for discussion at the task force meeting. This report could be prepared by the NMO hosting the meeting.

In addition to the above general report it also seems advisable that two or three scientific presentations on the major organizational problems of innovation management be prepared. Each of these presentations should contain a theoretical analysis of innovation development trends, modern and prospective forms of innovation management organization in electrotechnology and similar industries, possibilities and methods of application, and a tentative assessment of the effectiveness of certain patterns of management organizational improvement. Different NMOs could take the responsibility for such presentations.

The third stage of the project is devoted to the analysis and interpretation of the results of the task force meeting, elaboration of practical recommendations on how to materialize the conclusions of the meeting, definition of the role and place of organizational improvement in innovation management, and the selection and processing of materials to be submitted to the final conference.

To finalize this third stage, a small ad hoc group may be set up at the task force meeting. Part of the work may be performed by individual members of the working group independently, and the final documents be prepared by the same group just before the final conference at IIASA. This means that the working group will interact closely with similar groups working on other tasks of the case study, and together they will constitute a single working group to prepare the final conference.

The objective of the fourth stage should be accomplished during the final conference by all participants of the project. In this connection, the conference organizing committee should provide a special report on management organizational improvement at the plenary session and corresponding presentations for various aspects of the subject. The report should be devoted to generalizing the overall work accomplished up to that point, a definition of the most effective (for the 1980s) patterns of organizational improvement and innovation management techniques, and an elaboration of the practical recommendations for their implementation. It is desirable that the report should also offer a conclusive assessment of the future prospects for studies in the field, and, if positive, a list of research topics.

It is also suggested that the working group of this task should make an appropriate contribution to the general report at the conference. Their contribution should describe an integrated approach to innovative management as a system of controllable components: strategy, organization, human relationships, etc. The materials should frame the requirements to the management organizational structure stemming from the objective, improve the innovation process as a whole and show the influence of organizational transformations on improvement possibilities for its other components.

At the conference section meetings discussion of the most representative presentations of the firms selected and streamlined as a result of the preliminary analysis, could be held, as well as theoretical presentations on the methodological aspects of innovation management organizational improvement.

The concluding fifth stage of the case study should be centered around the topmost goal -- the preparation of a single monograph on the whole subject. It is supposed that organizational improvement in innovation management will be an isolated topic within the whole monograph (although in close relationship and coordination with the other tasks), and reflect a systems approach to innovation completely. Though the monograph is the format for the overall results and conclusions of the case study, its framing is an independent creative activity and a specific stage of research.

Final decisions regarding the monograph's structure and authors can be made at the conference (IIASA). Depending on the nature of the results obtained in the process of the study, an additional task for the final stage of the project may emerge: elaboration of recommendations for organizational improvement of innovation management for specific firms. These recommendations could be undertaken as special assignments by the firms or by the working group set up by IIASA, or by certain NMO experts participating in the project.

Research Topics

(to be covered in the presentations submitted for the seminar on organizational structures in innovation management)

Prague, 1983

1. General characteristics of business organizations in which organizational changes occur (see Appendix 1):

   — production specialization (main purpose and variety of products);

   — type of production (mass, series, individual);

   — scale of production (volume of sales, output of basic items, number of employees, productive assets, annual capital turnover);

   — diversification of production (various stages of production: production of materials, manufacture of parts, assembly, customer service) and the relationships among the degree of diversification, the concentration of R & D facilities, and the character of innovations;

   — sphere of influence and the market (number and type of consumers, which foreign countries and domestic regions are served);

   — scope of cooperation with other firms on the manufacture of products and customer service (exchange of processes, equipment, special materials, complementary parts);

   — degree of autonomy (whether the firm is an independent entity or part of a larger corporation).

2. Characteristics of technological innovations adopted by the organization (see Appendix 2):

   — Do they affect output as a whole or its separate parts, equipment, or individual production units?

   — Are they introduced regularly or occasionally? What is the average time interval between innovations?

   — Can they be financed through profits or do they require external funds, loans, etc.?

- Are they implemented by the firm itself or through subcontractors? (For what kind of jobs, on what scale?);
- Are they based on the firm's own R & D or on purchased licenses, external know-how, and other technical assistance?
- Do they influence the general results of the firm's business activity?

3. Major problems arising in industrial engineering and management in connection with the development and implementation of innovations.

4. Resource requirements of major innovations that require decisions at the level of the enterprise, higher level management, groups of enterprises, the state, organizational and economic forms of resource centralization and organization of innovation management.

5. Assessment of the influence of specific aspects of innovation and the research-development-production cycle on the centralization (decentralization) of decision-making and resource allocation.

6. Characteristics of the firm's organizational structure (see Appendix 3):
   - composition of basic units, their objectives, quantitative characteristics (approximate number of employees and costs, the ratio between the unit's number of employees and the total personnel of the firm);
   - reporting of units to the firm's top management; general pattern of communication;
   - general procedures for interaction among management units during the implementation of a technological innovation; management problems and structural weaknesses.

7. Organizational changes aimed at facilitating the implementation of innovations (see Appendix 4).

8. Other considerations and facts which, in the author's opinion, extend and complement the knowledge of the influence of the organizational structure of management on innovation processes.

9. Assessment of the existing and required degree of interdependence and interaction of the organization structure and strategies, systems, and styles of management.

The sequence of the above topics to be covered in the presentations to be submitted is chosen at random.

APPENDIX 1

Classification of Business Organizations by their general characteristics [1]

Classification criteria	Quantative or qualitative definitions of general characteristics within the classification framework				
	A	B	C	D	E
1. Orientation of production objectives (by content) (2)	Manufacture of industrial products	Rendering of services in product utilization	Manufacture of parts or rendering of services in manufacture of parts	Elaboration of product design, process of manufacture, R & D related to manufacture and use of products	Other characteristics related to this criterion
2. Orientation of objectives (by nature) (2)	At stable functioning	At development of manufacture and expansion of sphere of influence (market)	At extension and renovation of range of products, at diversification of production	At adaptation to uncertain and changing requirements of external environment	
3. Type of production (2)	As single pieces or in small lots by job orders	As large lots for definite users	Mass production for a wide market		
4. Type of manufacture specialization	By process	By product and process	By product		
5. Scale of business activity	Small; under 3000 employees; under $30 million worth of sales	Medium: from 3000 to 10000 employees; from $30 to $100 million worth of sales	Large; over 10000 employees; over $100 million sales		
6. Diversification of production	Low profile: one branch of industry, one or two-stage production cycle	Medium: wide range of products, may branches of industry; production cycle of more than two stages	High: variety of products, many branches of industry; multi-stage production cycle; well-developed infrastructure and many types of activities (R & D services)		

Classification criteria	Quantitative or qualitative definitions of general characteristics within the classification framework				
	A	B	C	D	E
7. Level of technology in use	Obsolete, of low productivity	Mainly modern but "bottlenecks" demand considerable investment for modernization	High productivity, comprehensive, based on latest know-how		
8. Complexity of products (2)	Simple products, parts, semi-finished products simple assembly and control	Common products of medium complexity not requiring labor intensive R & D or sophisticated control, rather simple in use	Unique products of high complexity involving special R & D, sophisticated control during manufacture and assembly, also observance of rules in operation		
9. Degree of international cooperation of production units	Independent units with closed cycle, producing certain types of end products	Non-regular, insignificant cooperation of production units with minor influence on the results of the firm's activities	Constant, regular multi-aspect cooperation of production units in exchanging semi-products, parts, services		
10. Degree of external cooperation (2)	Involvement of limited range of purchased standard products and mater-materials	Involvement of substantial quantities of purchased products and materials by special orders	Exclusive assembly of products involving specially delivered parts and units		
11. Spatial allocation of production units	At the same site	Dispersed in several poorly commuting locatings	Dispersed in many locations with heavy transport flows from one to another		

Classification criteria	Quantitative or qualitative definitions of general characteristics within the classification framework				
	A	B	C	D	E
12. Availability of in-house technology and processes	Manufacture of products based on licences, purchased processes and know-how	Development of in-house processes	In-house design of individual products and processes of their manufacture	Independent implementation of the entire R & D production cycle	
13. Rate of technological development	Stable range of products, gradual improvement of processes	Occasional up-dating of individual products, maintenance of processes on the average (for industry branch level)	Regular up-dating of entire range of products, accelerated development of processes to maintain most advanced level		
14. Character of sphere sphere of consumption	Occasional, non-regular users with uncertain and non-active requirements of products	Constant range of users with uniform requirements of products	Variable range of users with changing requirements of products and services in their operation	Exclusive user of products with active and constantly developing requirements of products	
15. Degree of organizational and economic independence	Complete independence	Subordination to national company or government (management) body	Subordination to foreign or transnational corporation		

Notes to Appendix 1

1. If a firm (corporation) is composed of several independent units (divisions) that differ substantially in their general characteristics, it is desirable to describe each of them according to the above scheme, or, at least, to describe their specific features and place (role) in the production structure of the firm.

2. If (by the given criteria) the organization refers to several classification groups, the corresponding characteristics of each of them should be given indicating its relative significance (as to the share of resources consumed, or share of products marketed, i.e., A has 80 percent of sales; B has 20 percent of sales, C has 8 percent of annual turnover of capital, etc.).

APPENDIX 2

Classification of Innovations (by their general characteristics)[1] introduced in business organizations

Classification criteria	Qualitative definitions of general characteristics of innovation within the classification framework					
	A	B	C	D	E	F
1. Goal orientation (2)	Technological: assimilation of new products (manufacture) new processes, up-dating of equipment, employment of new materials	Production: extension of industrial capacity, change of production structure, elimination of bottlenecks	Economic: improvement of planning techniques, accounting, work payment settlement of accounts between production units	Commercial: change in marketing policy, relationships with producers and consumers, supply of new products and services	Social: improvement of working conditions, social security, style of services, style of organizational relationships	Managerial: improvement of organizational structure, application of new methods of information and paper processing, improvement of management style
	A		B		C	
2. Scale of implementation and sphere of application	Total: innovation is implemented in the largest possible way and involves most of the organization		Medium: considerable amount of activity is related to innovation involving 20 to 60 percent of the organization		Local: innovation involves 1 or 2 units only	
3. Duration of implementation	Short-term: implemented within several months		Medium-term: implemented within 6 to 18 months		Long-term: implementation of over 18 months	
4. Regularity of introduction	Continuous: frequently in short intervals		Periodically: in intervals with fixed regularity (i.e., annually)		Occasionally: returns to similar innovations are unlikely	

Classification criteria	Qualitative definitions of general characteristics of innovation within the classification framework			
	A	B	C	D
5. Volume of required resources and their sources	Supplied by internal turnover of capital and profit charges	Requires short-term loans	Financed out of large and long-term investments	
6. Sphere of influence on the results of activities	Narrow: affects the work of individual departments (units)	Considerable: affects the work of production units and functional blocks	Wide: affects the results of the entire organization or its larger part	
7. Significance of accomplished results	Ordinary: innovation is insignificant and terms of implementation can be postponed without harm	Timely (actual): innovation provides for achievement of results important for organization, terms of implementation should be strictly observed	Extraordinary: innovation is vital, terms of implementation or available resources are very limited	
8. Nature of interaction of internal units in innovation implementation	Neutral: innovation is implemented within the established routine relationship	Moderate: intensification of operational relationships between a limited number of units is needed	Active: continous and varied relationships of a large number of units is required	
9. Degree of involvement of external organizations and agents	Innovation is implemented by internal effort only	Innovation is based on purchased process, licences, documentation	External organizations and agents supply large part of resources, items and services required for innovation implementation	Consulting firm or design organization develops and effects management of innovation implementation

Notes to Appendix 2

1. Where large numbers and varieties of innovations are introduced by the firm, only their main classes are described, indicating the share of each in the total volume of work or costs of innovations.

2. If innovations bear a comprehensive character (oriented towards several goals) all the goals are indicated and the innovations are described in greater detail.

3. If the given criteria do not allow for distinct grouping, other criteria (appropriately defined and characterized) can be used.

APPENDIX 3

Description of criteria and characteristics of management organizational structures in economic organizations and their units[1]

Classification or grouping criteria	Quantitative or qualitative definitions of criteria (characteristics) of management organizational structures within classification groups						
	A	B	C	D	E	F	G
1. Scale of managing system (2)	Small: under 500 employees	Medium: from 500 to 1500 employees	Large: over 1500 employees				
2. Complexity of management (2)	Low: ratio of clerks under 10 percent	Medium: ratio of clerks 10 to 20 percent	High: ratio of clerks over 20 percent				
3. Type of organizational design (3)	Line	Line and staff	Line and functional	Divisional	Line and project	Coordination and project	Matrix
4. Hierarchy	The number and names of levels in line and functional management are indicated, especially the top and lower levels						
5. Degree of centralization of decision-making (4)	Complete: all operational decisions are made at the top level of management	Partial: operational decisions are made at the middle level of management division, production unit	Distributed: decision-making/normatives and constraints are fixed (adopted) at top levels, operational decisions at lower levels	Decentralized: operational decisions are made at lowest levels possible			

Classification or grouping criteria	Quantitative or qualitative definitions of criteria (characteristics) of management organizational structures within classification groups
6. Management differentiation	Organizationally independent, isolated line blocks (product, technological, supporting) and functional blocks (engineering, financial, marketing, etc.) are indicated. Each of them are described by criteria 3, 4, and 5.
7. Concentration of functional activity (2)	Proportions of clerical personnel allocation between functional blocks and levels of management are idicated.
8. Actual span of control	Average number of subordinates for one manager by levels of management both for line and functional blocks are indicated (see criterion 6)
9. Degree of functional support for line managers	Share of line managers (5) in total number of personnel. If there are distinct differences by line blocks, give their relative characteristics.
10. Degree of program management	Average number of programs implemented annual and of organizationally independent program management systems. If possible the programs can be classified by any other criteria (Appendix 2 can be used)
11. Description of program management bodies	Indicate all the permanent and temporary bodies of program management, their goal orientation, responsibility, authority, general functions, reporting.
12. Description of coordinating bodies	Indicate all the bodies coordinating the inter-functional activity, their responsibility, authority, reporting
13. Degree of collective decision-making	Indicate all the bodies of collective decision-making, their reporting, sphere of competence
14. Scope of control (for top management)	Describe which indicators are controled by the firm's top management with respect to line and functional blocks, which resources are allocated by top level management
15. Communications in the management system	Indicate the major forms of communicating the directing and reporting information, as well as modes of interaction between units and individuals
16. Effectiveness of management organization	Share of administrative expenses in the total volume of sales

Notes to Appendix 3

1. If the firm attaches the organization design, the information contained therein need not be described.

2. If the absolute data are not confidential, they are preferred.

3. If possible, indicate scale and scope of application of each organizational alternative by line and vunctional blocks.

4. If there are distinctions by management functions and economic activities their description is desirable.

5. Only managers of production units and general managers of firms are meant.

APPENDIX 4

Main types of organizational changes carried out with a view to improving Innovation Management

1. Composition change of production units and managerial departments:
   - — establishment of specialized production units;
   - — establishment of new managerial departments;
   - — integration and disaggregation of acting production units and functional departments;
   - — nomination of new managers, coordinators, responsible executives, etc.
2. Subordination change of some executive, groups, and divisions.
3. Change of responsibility, rights, and functions of some managers, specialists and divisions.
4. Change of rules and procedures of control, accounting, and interaction of departments and executives.
5. Change of methods and procedures of planning, financing, and calculations.
6. Change and utilization of new methods (rules) of salary structure, stimulation and estimation of quality work and personnel policy.

Institute of Management

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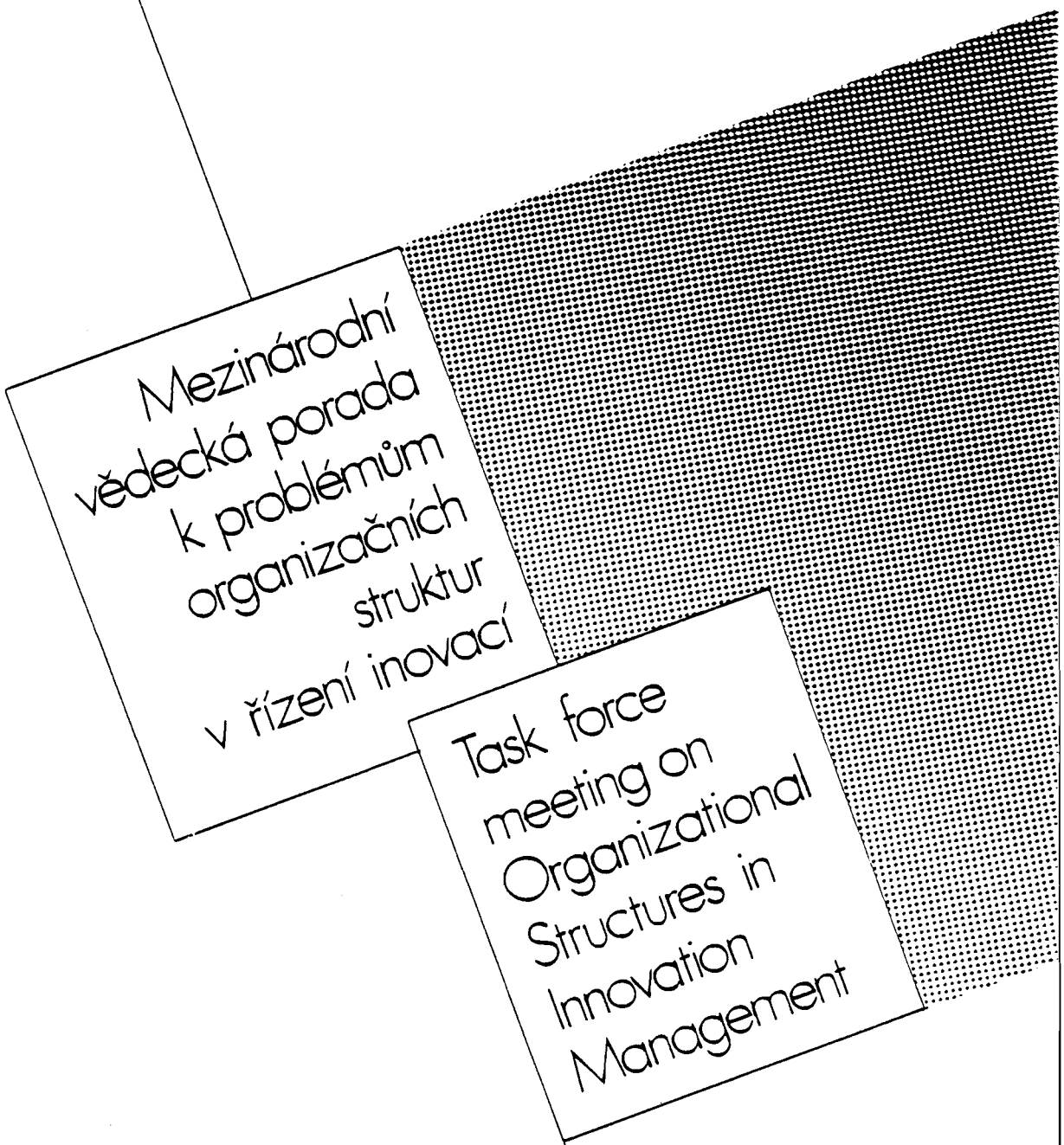

Prague, 30 May - 3 June 1983

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS

TASK FORCE MEETING ON

ORGANIZATIONAL STRUCTURES IN INNOVATION MANAGEMENT

HOTEL HUBERTUS, JÍLOVIŠTĚ NEAR PRAGUE

30 MAY - 3 JUNE, 1983

AGENDA

MONDAY 30 MAY

13:00	Lunch
14:30	Registration
15:00-16:00	INTRODUCTORY SESSION Chairman: *V. Goncharov* (IIASA, Laxenburg)
	OPENING ADDRESS *M. Holec* (CSSR) *O. Červenka* (CSSR)
	IIASA Plans of Electrotechnology Case Study Development and Main Goals of the Prague Task Force Meeting *V. Goncharov* (IIASA, Laxenburg)
16:00-18:00	PLENARY SESSION Chairman: *J. Smrčka* (CSSR)
	Some Special Trends of Development of the Organizational Structures in the Electrotechnology Industry *M. Holec* (CSSR)
	Methodological Approach to Comparative Study of Organizational Structures *V. Rapoport* (USSR)
	DISCUSSANTS: *M. Karttunen* (Finland) *A. Nomoto* (Japan) *E. Razvigorova* (Bulgaria)
19:00	Dinner hosted by the Czechoslovak National Member Organization of IIASA

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TUESDAY 31 MAY

9:00	Breakfast
9:30-13:00	PLENARY SESSION Chairman: *A. Nomoto* (Japan) Co-chairman: *V. Hrbek* (CSSR) Organizing for Innovation in Producing Organizations *Walter Goldberg* (Sweden) Innovations in Electrotechnology: Organizational Structures of Management for the 1980s *V. Rapoport* (USSR) Organization and People as Innovation Barriers in Innovation Management *G. Wolf* (Austria)
11:00-11:30	Coffee Flexible Organizational Structures for Research and Development and Strategy of Innovation Management *L. Vodachek* (IRIMS, Moscow) DISCUSSANTS: *W. Goldberg* (Sweden) *J. Smrčka* (CSSR)
13:00-14:00	Lunch
14:00-17:30	PLENARY SESSION Chairman: *M. Karttunen* (Finland) Co-chairman: *V. Rapoport* (USSR) Matrix Management as Metamorphosis in Managerial Mutation *A. Nomoto* (Japan) A Method of Approach to Organizational Structuring *E. Razvigorova* (Bulgaria) Organizing for Innovation in Producing Organizations: Applications *W. Goldberg* (Sweden)
15:30-16:00	Coffee DISCUSSANTS: *L. Vodachek* (IRIMS, Moscow) *G. Wolf* (Austria)
19:00	Dinner followed by an excursion to the old city of Prague

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WEDNESDAY 1 JUNE

9:00	Breakfast
9:30-13:00	PLENARY SESSION Chairman: *G. Wolf* (Austria) Co-chairman: *L. Vodachek* (IRIMS, Moscow)
	Management Structures of Innovations Systems in State Economic Enterprise ELPROM *V. Vassev* (Bulgaria)
	Strömberg's Experiences of Organizational Solutions in Developing New Products *M. Karttunen* (Finland)
	Management Organization of Innovations in Rade Končar *N. Kopčić* (Yugoslavia)
11:00-11:30	Coffee
	Recommendations for Future Research Plans of the Electrotechnology Case Study *A. Nomoto* (Japan)
	Discussion on Contents of the IIASA Monograph on Innovation Managmenet *J. Smrčka* (CSSR)
	General Discussion
13:00-14:00	Lunch
	Afternoon free for individual discussion or sightseeing in Prague. A bus will leave Hotel Hubertus for Prague at approx. 14:00.
19:00	Culture evening and dinner in Prague. (Arrangements are being made to see the opera CARMEN, details will be announced during the meeting)

THURSDAY 2 JUNE

9:00	Breakfast
9:30-13:00	Visit to the firm of ČKD Polovodiči
13:00	Lunch hosted by ČKD Prague
	Afternoon free in Prague
19:00	Banquet in Prague hosted by the International Institute of Applied Systems Analysis

FRIDAY 3 JUNE

9:00	Breakfast
9:30	Departure

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INNOVATION MANAGEMENT IN ELECTROTECHNOLOGY

CASE STUDY

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Draft Plan of a Monograph

INNOVATION MANAGEMENT IN ELECTROTECHNOLOGY: ADAPTING TO CHANGING ECONOMIC ENIVRONMENT

Chapter 1: PROBLEMS AND TRENDS OF INNOVATION MANAGEMENT: COMPANY VIEW

1.1. How does the role of innovation in the economic and social development of modern society change?

1.2. What are the new features of innovation policy of national and industrial firms in the 1980s?

1.3. How can the innovation potential of industrial firms be raised?

1.4. What are the new requirements and conditions for creating, developing, and assimilating radical innovations in the 1980s?

1.5. What is the advanced experience of innovation management at industrial firms?

1.6. How can the positive and negative implications of competition on innovation policy be raised or reduced, respectively?

Chapter 2: ADVANCED CASE STUDY APPROACH TO INNOVATION MANAGEMENT

2.1. What are the general principles of a case study approach to innovation management in the 1980s?

2.2. What is the difference between the approaches of mature and young branches of industry (including electrotechnology) to innovation management?

2.3. How do economic and other conditions influence the innovation management of industrial firms in the USA, Japan, FRG, Sweden, USSR, Hungary and other countries?

2.4. How can the advanced experience of innovation management be adapted to the specific needs and environments of a particular company's activities (taking into consideration the national, market, and intraindustry conditions, the scale of the company's activities, the type of innovation, and the technological potential, etc.)?

2.5. How can the consistency of the strategies, structures, and styles of innovation management be best achieved?

2.6. How can the effectiveness of innovation management be tested experimentally?

Chapter 3: STRATEGIES: LONG-TERM INNOVATION PLANNING IN ELECTROTECHNOLOGY

3.1. How important is the choice of innovation for industrial firms?

3.2. What methods and models of innovation strategy choice (with regard to risk and uncertainty) are considered the most effective?

3.3. How does the choice of innovation strategies influence the allocation and utilization of resources?

3.4. How can innovation strategies be made more flexible?

3.5. How can the communication system of long-term innovation planning be improved?

3.6. In what way can short-, medium-, and long-term innovation planning be combined?

Chapter 4: STRUCTURES: CHOICE OF ORGANIZATIONAL DESIGN FOR INNOVATION MANAGEMENT IN ELECTROTECHNOLOGY

4.1. How are innovation management structures in electrotechnology classified?

4.2. What are the new approaches to analyze, project and evaluate innovation structures in electrotechnology?

4.3. How can organization structures support effective monitoring, evaluating, making and testing of new innovative ideas?

4.4. How can organization structures enable direct face-to-face communication and cooperation in the organization?

4.5. How can innovation management organization be made more flexible?

4.6. What are the methods to evaluate, to an optimal degree, centralization and decentralization of innovation decision making?

4.7. What are the main trends in further development of the organization structures in electrotechnology?

Chapter 5: STYLE: HUMAN FACTORS IN INNOVATION MANAGEMENT IN ELECTRO-TECHNOLOGY

5.1. How does the style of innovation management change when human factors are most effectively utilized?

5.2. How can an effective relationship be built between the creative potential and the innovative (organizational) climate at industrial firms?

5.3. What models of personnel training are the most appropriate for innovation management?

5.4. How can innovation management incentives be made more effective?

5.5. What types of quality control systems are the most effective?

5.6. How can innovation management style be made more flexible?

Chapter 6: METHODOLOGY OF SYSTEMS STUDIES AND COMPARATIVE ANALYSIS IN INDUSTRIAL APPLICATIONS

6.1. How can the methodology of systems analysis contribute to the better understanding of innovation processes in modern society?

6.2. How can analytical tools for decision makers at firms be utilized concretely? What directions will future search take?

6.3. Why are international comparative studies more important in defining an effective innovation policy at a national and company level?

6.4. What are the specific features of international comparative studies using current and future systems analysis methodologies?

6.5. In which direction will systems methodology develop (with regard to innovation management)?

6.6. How can innovation management information systems be improved?

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