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Concept for a Case Study of a Large Electrical Engineering Enterprise

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PREFACE

This concept for research on problems of innovation management of electrotechnical firms emerged from two ideas, the cores of which cut close to those set forth in the research proposal. One of these was to spread the interest over several sectors that differ in the character of their development. Electrotechnology, a notion yet to be widely accepted, and used here to denote an industrial branch producing products for electro-engineering (power engineering, consumer goods produced with basically the same technology, etc.), is considered a mature industry with a steady and relatively stable growth. Determining what role innovation has played in this development and what problems it gives rise to promises to be a challenging task.

The second idea was that in several countries similar but uncoordinated studies are underway and that in fact similar structures can be observed. The object of the study--in this case an electrotechnical company--is being studied by an external research institute, through close collaboration of course.

Data on gross production and value added in this branch show similar trends in many countries, although there are differences in external factors, such as processes of capital formation.

The many similarities in the organization and structure of production processes could be useful in preparing a more reliable view of future development of this industrial branch. Electrotechnology will not be able to escape the effects of computer-aided design, robots and flexible manufacturing systems, power semi-conductors, new materials, better testing methods, and of course changing price structures.

This concept will also serve as a blueprint at the first task force meeting in Leningrad where through discussion it will be possible to order the individual issues according to participants' priorities.

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The case study in the field of electrotechnology was proposed in IIASA's Research Plan for the research area "Management and Technology", 1981-1985. The paper "Innovation Mangement: Toward Methodological Guidelines for International Collaboration" (Harman 1981) specifies the level of an enterprise for the first year or two of research activities in the field of innovation management. Research efforts will be focused at the level of the large-scale enterprise. It was also proposed that problems of innovation in a mature indusry be examined.

Applied research usually provides good opportunities for both developing and testing new systems and analytical techniques and application of the traditional ones and for a comparative analysis of economic and social systems functioning in different environments (planned, market, and mixed economies). Studying the same processes in different systems may lead to a better understanding of the structure and properties of a system. It also allows full use of the advantage possessed by IIASA: participation in and coordination of collaborative research by numerous research institutions of various countries with the aim of tackling common scientific and practical problems.

For a number of years the leading research institutions of the USSR, i.e., the Institute for Systems Studies, the Central Economic and Mathematical Institute of the Academy of Sciences, the Moscow University Center for Management Problems, and sectoral (electrical engineering industry) research institutes, have been conducting wide-range studies on technological change and management problems in electrical engineering. In conformity with the existing agreement between the Committee for Systems Analysis and the Ministry for Electrotechnology, a large-scale production amalgamation "Electrosila" was proposed as the object of the

investigation in the USSR.

A lot of data have been accumulated and systems parameters identified, etc. in anticipation of analysis and generalization, if and where feasible.

Taking heed of IIASA's proposals, the Soviet NMO has done the required preparatory work. The Institute for Systems Studies (ISS) has formulated the concept of cooperative research involving the Ministry for Electrotechnology. The Ministry has considered the proposals elaborated by the Institute and given its approval. Jointly with Electrosila, the ISS has done the preparatory methodological and organizational work and commenced its first-stage studies. B.I. Fomin, the general manager of Electrosila, has confirmed his readiness to contribute to the case study and receive specialists from IIASA and collaborative institutions who will study the Soviet experience, and exchange and discuss the intermediate results of the joint research.[1]

THE OBJECT OF INVESTIGATION

Electrical engineering is one of the most important sub-branches of the national economy as a whole. The level of its development determines the development of many other branches of industry.

The per capita consumption of electric power is considered to be an important indicator of the nation's economic and social potential.

The main reason for the choice of the sub-branch is the comparatively high rate of innovation in the field of production of heavy electrical machines, in spite of the fact that electrotechnology in general is quite a mature branch of industry. This rate is determined by certain objective factors, one of which is the ever increasing requirements of society to the industries producing energy and its means of production in the face of a world energy crisis.

The heavy demands of society stimulate more intense implementation of research and development in this field, aimed at the creation of new machines that can produce more energy at lower costs.

On the other hand, society contributes greatly to the development of industries producing means of energy production. This includes larger amounts of resources allocated into the sphere of basic research (e.g., chemistry, physics), as well as applied research and development implemented within the branches producing means of energy production. It also includes higher amounts of resources allocated to the R & D effort in other industrial branches producing machines, materials, testing appliances, and metrological services, vital for the branches producing means of energy production.

Experts believe that the branch of heavy electrical machinery could in the near future face drastic changes in the productivity and reliability of its products due to the progress of science and technology and the appearance of new products (e.g., isolation materials).

1. For the first result of this cooperation, see Fomin (forthcoming).

So we stressed the fact that heavy electrical machinery is an important sphere of production, being research-intensive and sensitive to the progress of science and technology. It is implementing continuous changes in products and technological processes and it is looking forward to some new still more important changes in the future.

Starting the investigation of innovation management processes in a large enterprise producing heavy electrical machinery, one has to take into account some specific features that influence the whole management process of such an enterprise:

1. The uniqueness of some types of products.
2. The increased requirements to the quality and reliability of the products, which is determined by the high capacity of the produced machinery and the scale of possible negative consequences to the violation of such requirements.
3. The large proportion of small-lot and single-unit production.
4. The long duration of the "research-manufacture" cycle, which sometimes reaches five or more years.
5. The large amount of resources allocated to the R & D field.
6. The large amount of highly qualified personnel employed at every level of the enterprise.
7. Difficulties with the testing of some types of machinery in the process of production, due to high capacity and large dimensions.
8. The heterogeneous character of production. Any large enterprise producing heavy electrical machinery would have foundry, metal-working, welding, galvanic production, punching production; forge shops, as well as large testing facilities. These types of production can be combined into separate plants or shops within the machinery-producing plants.
9. The complex and intensive relationships and consequent dependence on many other branches of industry and non-material production spheres.

THE AMALGAMATION ELECTROSILA

The electrical machine production amalgamation Electrosila, which was named after S.M. Kirov, was set up in 1972. Its main factory was founded in 1899. Electrosila is now the largest enterprise of its kind in the USSR. It has already accumulated some experience in the manufacture of turbogeneraors of 1500 Mw (1500 rpm) and 1200 Mw (3000 rpm), as well as hydrogenerators of 500 Mw (93.8 rpm) and 640 Mw (142.8 rpm) of good technical quality in rather short periods of time. Its products range from simple domestic electrical appliances to large hydroelectric generators, serial-produced turbogenerators of 500 and 800 Mw, unique large turbogenerators of 1000 Mw and above, and sophisticated electrophysical equipment of the "Tokomak" type for the study of controlled nuclear fusion. As a result, various types of production are combined at the amalgamation ranging from predominantly single-unit and small-lot

production to serial and mass production. Total production includes some 2000 articles, but its main line is the manufacture of large-size electrical machines. Turbogenerators, hydrogenerators, and individually-produced large-size electrical machinery make up 70% of the amalgamation's total product volume.

Electrosila generators produce more than half the electrical energy consumed in the USSR. Alone in 1978 and 1980, the amalgamation produced and supplied 191 turbogenerators with a total capacity of 44,000 Mw, including a 1200 Mw turbogenerator, a 1000 Mw four-pole generator, and 500 Mw output turbogenerators for nuclear power stations. In the same period, five 640 Mw hydrogenerators were manufactured.

The amalgamation is developing a new series of electrical machines, including low-speed, frequency-controlled synchronous electric motors with power ratings between 4,000 and 20,000 kW and 10-12 rpm, intended for the cement-making and mining industries, and marine synchronous brushless generators rated at 400 to 1000 kW with speeds of 750, 1000, and 1500 rpm.

The amalgamation also produces single-armature electric motors with power ratings of up to 12,500 kW, which develop a torque of up to 200 tm and are used in metallurgic engineering. Electric motors for the drive units of walking excavators, generators with power ratings of up to 9500 kW for feeding the drives of rolling mills, electric DC motors, as well as low- voltage equipment and commodities for domestic purposes.

Electrosila is a rapidly developing firm. Its output grows one and a half times every decade. More than 11% of its products are updated annually as production items become more sophisticated and the materials used become more diverse. Thirty-five to forty new products are put to production every year. A large part of them can be considered inventions; this is a new word in electrotechnology. The same trends are characteristics of the technological process of the amalgamation.

Electrosila uses some unique equipment in the production process. Thus it has one of the world's largest test beds, which makes it possible to simplify and accelerate significantly the changeover to the production of a new series of large turbogenerators with ratings in excess of 1000 Mw. Besides, due to the use of this test bed, related turbogenerators of 500 Mw and 800 Mw were created within a very short time.

The test bed is equipped with up-to-date computers, which allow the turbogenerator operation to be monitored and studied by means of 1500 sensors. Thus apart from having a direct impact on inspection control, the test bed has increased significantly the capacity of the firm's experimental facilities for conducting scientific investigations and experiments. The time needed from the commissioning of a turbogenerator to its commercial operation at rated output has been reduced from about 1.5 years to a few weeks.

The share of exports in the firm's output is growing steadily, and Electrosila products are supplied to more than 80 countries all over the world, including England, Canada, the USA, France, etc.

The amalgamation comprises the R & D center and three factories, which differ substantially in size and are located separately. The amalgamation's activities cover all stages of creating new machines and apparatus, from the scientific search of the general concept for a particular product to its dispatch to the customer, erection supervision, and operational tests at power projects.

The amalgamation's R & D center meets all the demands of production units in applied research. The volume of work at the center amounts to more than 10,000,000 rubles annually. During a five-year period, more than 400 inventions were registered, half of which were implemented in the production process.

In its management structure, Electrosila uses large units, each of which is fully responsible for its own activities. They are: R & D center with the pilot production and up-to-date testing facilities; production and pre-production units, quality control, infrastructure, commercial, economic and personnel units as well as reconstruction, capital construction, and social development units. Key units have in their internal structure special subunits (departments, sectors, etc.), which are responsible for planning, internal job coordination, and the development of the unit itself.

The management of Electrosila combines both functional and project management structures (see Fig. 1). Examples of such combinations are the integrated product quality control system, a computer-based preproduction system, a centralized store-to-ship materials transportation system, and task-teams of the R & D center.

The internal organizational structure of the amalgamation's key unit management, as well as the entire organizational mechanism, is readjusted as soon as new or more complex objectives are set.

THE RESEARCH TASKS

The selection of a large-scale electrical engineering business entity as the object of investigation seems quite appropriate, as it provides a good basis for identifying problems common to various economic systems.

While these systems have many similar elements, there is also some diversity. This diversity must be revealed so that the case study will be more productive from the point of view of its practical application.

Looking at innovation management, of major importance are the degree of similarity (or difference) in the following aspects of organizational functioning and some external factors influencing the organizations:

- major goals of innovation activity at the sectoral level
- the impact of government policy on sectoral strategy for innovation, direct or indirect
- the interaction of different spheres of activity: government and business; organizational structures of enterprises, corporations, and ministries

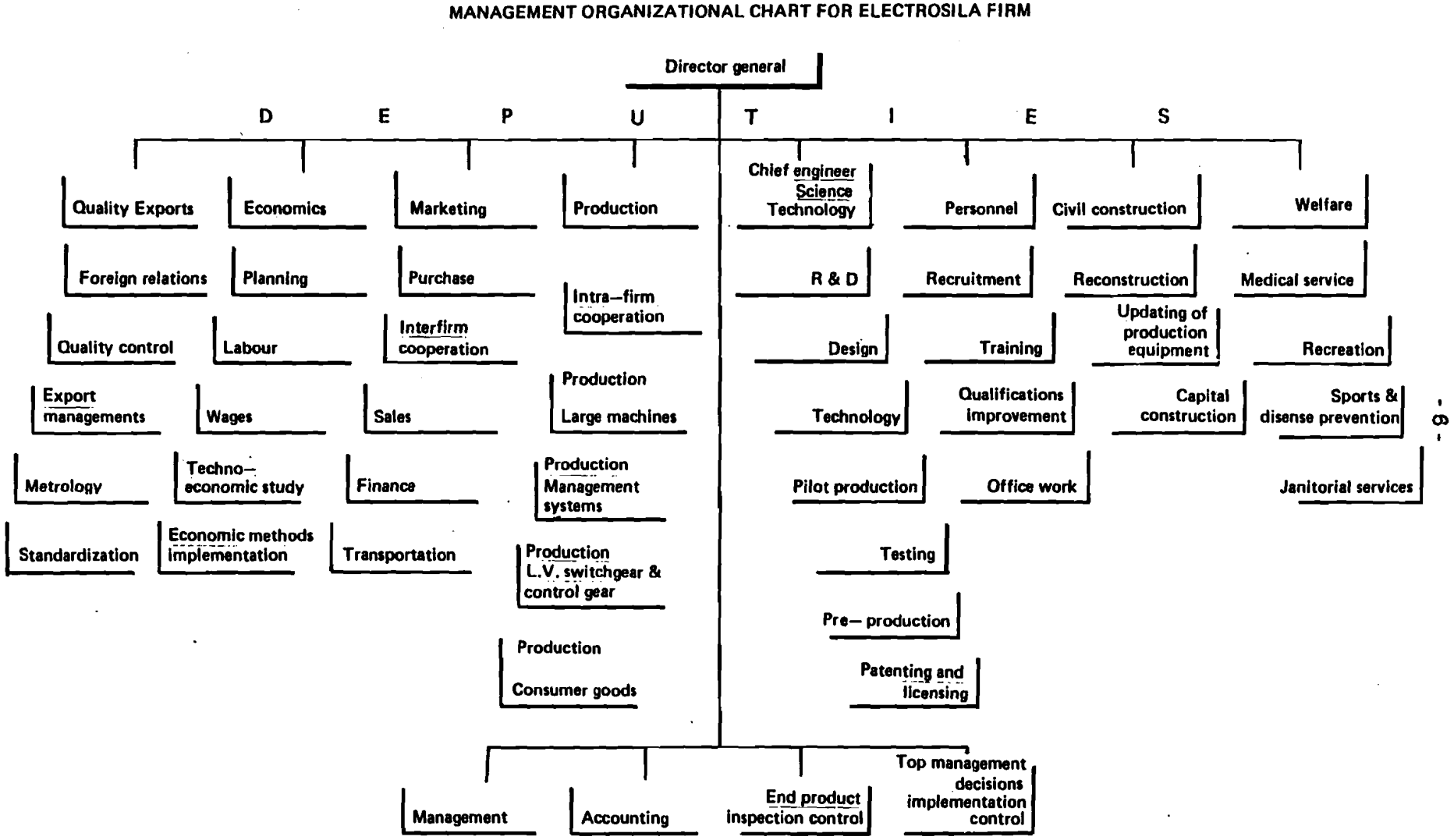


Figure 1. Scheme showing how management is organized at Electrosila.

- the trends of organizational development (at the level of the enterprise, corporation, and branch of industry)
- the economic mechanisms determining innovation policies
- the role of different structural elements on the planning and implementation of innovations
- the influence of end users in market and planned economies and the innovation strategies of the industrial branches and enterprises

So the comparative analysis of these aspects must be the starting point of the case study. The "core" case study must be focused on the innovation activity of the organization, which may include the development of new products or processes, as well as organizational development undertaken to make the organization more effective and adaptable to innovations. It must cover all the stages of innovation activities, including:

- determining the needs for innovation
- formulation of the innovation strategy
- provision of the proper engineering and organizational base for innovation
- provision of the necessary labor resources
- control and assessment of the results of innovation activities
- the correction of innovation processes

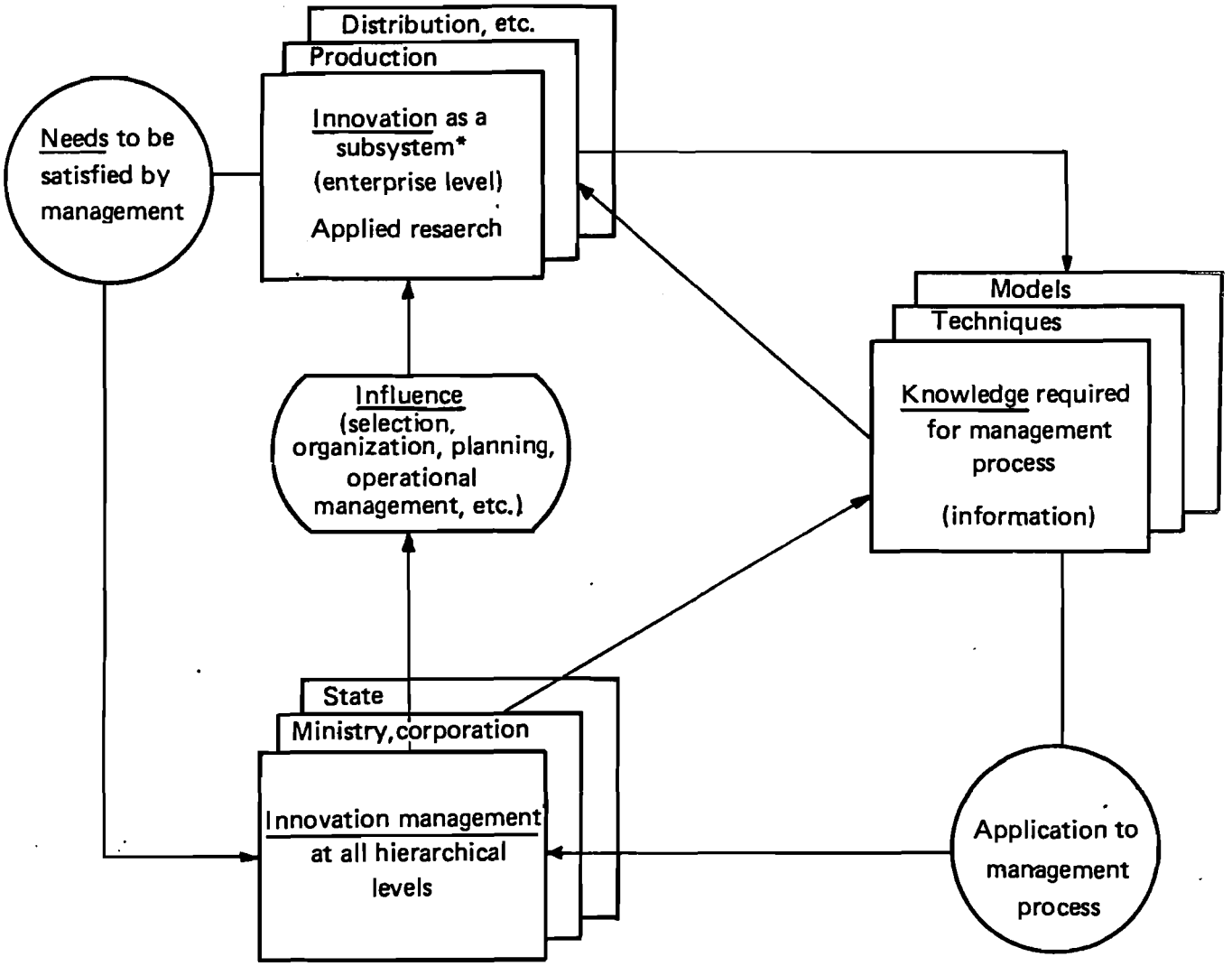
Innovation management can be seen as a subsystem of the total management system, and as such has to pursue its goals and policies and interact with other subsystems of the organizational management. This concept was developed at IIASA by Haustein and Harman and is shown in schematic form in Figure 2.

There is a wide range of problems that can arise in the process of planning and implementing the innovation. This range is determined by a number of internal and external factors. These have to be structurized and thoroughly analyzed in the early stages of the innovation process.

However, one cannot predict all the problems that may occur in the process of implementation of some innovations. But an investigation of the major factors influencing the organization can help to determine quite a number of them.

The investigation of any of these problems can lead to the discovery of some useful instruments or techniques for dealing with them. So we see the main tasks of the case study in innovation management as follows:

1. An analysis of innovation management as one of the subsystems of the total management system of the organization, including the delineation of different stages of the innovation process, as well as the expected results of each stage and the interrelations between the functions performed by innovation managers (or units) and the functions of their management subsystems;



*This structurization of innovations as a subsystem by types and stages was proposed at IIASA (Haustein, Harman).

Figure 2. The management of innovations as a subsystem of the entire management system.

2. The analysis and structurization of the whole range of internal and external factors influencing the innovation processes;
3. Specification and structurization of problems handicapping the innovation processes;
4. Finding the possible instruments for solving the problems.

RESEARCH METHODOLOGY

The totality of approaches employed in countries with different economic systems, which are aimed at keeping a healthy balance between normal production activity and innovation throughout its life cycle (from birth to maturity), will make it possible to cross-fertilize the expertise that has been amassed so far by individual countries of different economic order.

While due account will be taken of the existing differences, the study will make a real attempt to identify universal problems in R & D development and formulation of innovation management policy.

To be more productive, the case study pursued by different countries should be based on a similar methodology, focused on similar key problems of management, and aimed at similar goals. By definition, these aim at a deeper understanding of the operation and development of vehicles and mechanisms for managing an enterprise under conditions of accelerated change. The results of the research can be applied in the NMO countries for better formulation and implementation of innovation management policies (see Harman 1980).

Research in the field of innovation management can be organized in two major ways:

1. By investigating the stages of the innovation process management
2. By focusing attention on the most urgent problems of managing the innovation process.

The first way supposes the detailed analysis of the innovative process and a whole range of minor and major problems as they occur at each stage of it. So we look into the problems from the point of view of the possible results of each stage of innovation.

The second way supposes the choice of the most urgent problems occurring during the innovation process as a whole and the investigation of the process of their development and solution through all the stages of the innovation process.

We prefer the second way, believing it to be the more productive, especially from the point of view of keeping balance between research and the practical interests of the case study.

The full process of investigation may include the following stages:

1. The accumulation of experts' opinions on the range of problems to be investigated. Both practitioners and researchers are welcome to act as experts on this question.
2. The choice of the most urgent problems (the criteria for which would be the frequency of choosing the problems and higher weights given to it by the experts).

3a. The development of a theoretical approach to the analysis of a problem.

3b. The development of a practical approach to the analysis of a problem, accumulation of empirical data on the solving of such or analogous problems in different organizations.

4. The combination of developed approaches.
5. The elaboration of a theoretical basis and techniques, as well as practical means of coping with the problem.

THE CHOICE OF THE PROBLEMS

The identification of the problems hindering successful innovation management and their impacts is one of the tasks of future studies. Here we can name a few of them:

1. The necessity to cope with a great degree of uncertainty while planning technological innovations (caused by uncertainty about the development of science and technology, changing requirements of the society, the possibility of a negative impact on the natural environment, changing needs of the users of new products or processes, etc.
2. possible failure of industrial branches, enterprises, etc., to produce the goods, processes, and services required to implement the planned innovation
3. inadequate engineering base for the innovation
4. lack of necessary material, finances, or labor resources
5. lack of incentive to implement the innovation on the part of the organization's personnel
6. lack of the qualifications necessary to implement the innovation
7. the existence of psychological barriers to the innovation
8. lack of necessary criteria and measurement for assessment
9. the existence of organizational barriers and so on.

These problems as they are stated here are common to most industrial enterprises involved in the process of innovation management. In determining the problems for specific branches or enterprises, both practitioners and researchers will add some individual characteristics to them.

Identification of problems common to the majority of countries engaged in the innovation management network (INNOVNET) as well as identification of their links and interrelationships is of primary importance. At the present stage of knowledge, we think that the problems can

be grouped into the following major points:

1. An analysis of the basic technological and economic parameters of specific innovations as subsystems (e.g., manufacture of powerful generators and electric machines using the principle of superconductivity, etc.) and the requirements to be satisfied by the research-development-production cycle and its management organization.
2. Formulation of the amalgamation's (firm's) R & D goals in the concept of long-range planning.
3. Improvement of management organization and management techniques in rapidly innovating amalgamations (firms).
4. An analysis of the relationship of the organizational structure and economic mechanisms used for implementing R & D policy.

The frame of reference for a comparative analysis includes the following:

- major goals of R & D activity at the sectoral level (with possible differences in priorities)
- impact of government policy at the sectoral level, direct or indirect; the interaction of different spheres of activity; government and business
- multi-level hierarchic organization of enterprises, corporations, and ministries
- similarity of problems in organizational development (at the level of the firm, corporation, and branch of industry)
- similarity of economic mechanisms for implementing R & D policy
- similarity of functions of production and economic units
- influence of end users in market and planned economies, and differences in how it occurs
- possibility of identification of common units and modes of their functioning; innovation management at all levels of an organization: performance of the basic functions of management, existence of direct and indirect means of influence, possibly with different proportions and interrelationships.

CONCLUSIONS

The research conducted at research institutions in the USSR and the above-mentioned initial studies of innovation management may be of interest to industrial firms in countries with both planned and market economies. Other industrial firms concerned with similar problems, the counterparts of Electrosila, have already become involved in a continuation of the case study. They include CKD (Czechoslovakia), Elin-Union (Austria), Ganz (Hungary), Rada Konchar (Yugoslavia), and Siemens (Austria). IIASA's main responsibility in the case study will be to coordinate the cooperative research and to make a comparative analysis and generalization of the accomplished results. If necessary, this could involve individual specialists and teams of experts from the NMO countries.

Three major stages are contemplated for the case study. The first stage will be devoted to pre-project activities, such as the selection of the firms and national research institutions who will participate in the case study, the elaboration and final approval of the core tasks and the methodology of research, and the program of the study. It will also include the determination of the amount of effort required. All of this will be performed at both the national and international levels. A task force meeting in Leningrad in the spring of 1982 will conclude the first stage.

The second stage will be the project proper, which is expected to last the remainder of 1982 and into 1983. It will consist of studies centered around the core tasks (the last of which should be of an integrative character), and will include the development of approaches and the methodology for the comparison, the description of the management mechanisms, and an evaluation of the experiences of different industrial organizations in tackling innovation problems. Research reports from the working groups (composed of IIASA and NMO researchers) will be submitted at the end of this stage.

A third stage is conclusive (generalization of the results). A conference at IIASA on the findings of the case study is suggested. During the course of the project, materials on specific aspects and problems will be presented in the form of papers by individuals and groups participating in the research. These might be published later as IIASA publications. A final report on the case study will cap the project's efforts.

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