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FORECASTING AND LONG-TERM PLANNING OF BASIC DIRECTIONS IN THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yë or ë. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

FOLLOWING ARE THE CORRESPONDING RUSSIAN AND ENGLISH

DESIGNATIONS OF THE TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}
rot	curl
lg	log

I. Popov (USSR)

FORECASTING AND LONG-TERM PLANNING OF BASIC DIRECTIONS IN THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY

A central problem of scientific policy is that of the long-term and current planning of the development of science and technology. The extraordinarily profound and diverse differentiation of scientific disciplines characteristic of modern science and the increasing scale of scientific research make the problem of the planning, and consequently the forecasting, of the development of science extremely urgent. The long-term planning of the development of science and technology is an important factor in the regulation of scientific and technological progress. Through planning, the state guarantees the concentration of scientific and material resources in the major areas of the nation's economic development and provides for a steady increase in the efficiency of social production.

In recent years in the Soviet Union much work has been done on the development of the forms and methods of organizing the planning and regulation of science. In 1966 there was introduced for the first time a system for the complex planning of research on important scientific and technological problems and the introduction of new technology into production. Until the introduction of this system state planning covered only individual problems in the development of science and technology without consideration of their interrelations or any attempt at the complex solution of the problems which were the most important for the national economy. This occasionally resulted in diffusion of efforts, inefficient use of scientific

personnel and delay in the solution of the most important problems. The planning of individual measures gave rise in a number of instances to a split between science and production, especially at the stage of the final engineering and realization of results already achieved. It also did not sufficiently facilitate the introduction of a unified technological policy with regard to the development of the productive resources of the country, i.e. the elaboration of an optimal program for the utilization of the nation's resources for the accelerated development of social production.

The transition to a system of overall planning of the development of science and technology makes possible the realization of a direct connection between planned measures for the creation and introduction of new technology and the developmental requirements of social production, and permits the efficient use of scientific and technological achievements in the national economy. The basis of the planning of the development of science and technology are the five-year plan and longer-range scientific and technological forecasts--covering 10-15 year periods--as well as the overall treatment of the most important scientific-technological and national-economic problems.

It should be noted that interest in forecasting under current conditions is determined not only by the immediate requirements of long-term planning but also by the desire to define the future social role of science. The problems of forecasting can and should be studied not only in their applied aspects, but in their broader social aspects as well.

The planning of scientific research is a component part of the general state planning of the development of science

and technology. Scientific research plans are approved by the government of the USSR, the soviets of ministers of the Soviet republics and the corresponding general state and republican organs as governmental acts having obligatory force for all scientific research organizations.

In our system scientific research efforts of significance in the area of the national economy and planning methods are divided into four groups:

--those forming part of the general state plan for scientific research and the introduction of scientific and technological achievements into the Soviet economy;

--those forming part of the plan for the development of the economies of the Soviet republics;

--departmental scientific research efforts forming part of plans governing the functioning of ministries and other agencies; and

--efforts initiated by scientific organizations and not specifically approved by the above organizations.

At the present time the basic form of scientific planning in the USSR is the general state five-year plan. In the five-year plans are formulated the major scientific problems awaiting solution and the final results expected. The basic goal of long-term plans is to stimulate scientific research efforts on those problems which are considered the most urgent. The most important goals of long-term plans are the generation of a body of scientific works, the elimination of duplication in scientific research, and the guaranteeing of the proper specialization of scientific institutes.

The current procedures for planning the development of science and technology constitute a system of plans compiled at various levels of regulation and differing in their operative times, content and level of detailedness.

The general state system for planning the development of science and technology entails the following stages:

--the development of scientific and technical forecasts for periods of 10-15 years and longer with regard to the most important problems in the development of the national economy and its individual branches, as well as the basic lines of development of science and technology during the period in question, so as to permit elaboration of a conception of scientific and technological development in the form of systems of reasoned positions for the purpose of selecting directions of technological progress and effective means of developing the national economy and its individual branches;

--the development of a state five-year plan for scientific research and the introduction of the achievements of science and technology into the national economy;

--the development of coordination plans for solving the basic scientific and technological problems entailed in the state five-year plan, and providing for the performance of an entire complex of tasks, from scientific investigations to the introduction of their results into the national economy, financing and capital investments and the correlation of the executors' efforts;

--the development of a state annual plan for scientific research and the introduction of the achievements of science and technology into the national economy;

--the development of five-year and annual scientific research plans for individual republics and branches of industry and the introduction of the achievements of science and technology into production;

--the development of five-year and annual plans for scientific research organizations, institutions of higher education, and research and planning and technological organizations on the basis of the tasks specified in the coordination plans in accordance with fundamental scientific and technological problems, as well as the proposals of scientific soviets and individual specialists regarding the performance of research investigations;

--the development of five-year and annual plans for scientific research in the natural and social sciences.

This organization of the planning of the development of science and technology creates the conditions required for the optimally efficient coordination of the efforts of branch ministries, scientific research, research and planning, construction, and production organizations in the formulation of basic problems and the solution of the problems entailed in raising the technical level of production.

National-economic plans for the development of science and technology permit fuller use of scientific and technological achievements both in individual branches of production and on the level of the national economy as a whole.

At the present time the overall planning of the development of science and technology is accomplished in the Soviet Union in three stages.

In the first stage the technical level of the branches of the national economy are evaluated in comparison with the leading achievements of world industry, and the practicable possibilities for utilizing the expected results of scientific and technological research are elucidated. At the same time scientific and technological forecasts regarding the most important economic problems for the ensuing 10-15 years are compiled, and the basic directions in the development of science and technology and the most important scientific and technological problems to be solved during the five-year period in question are selected in accordance with the goals of the economic development of the country. At this stage coordination of joint scientific and technological research with other socialist countries is carried out. In the overall planning system this stage precedes the compilation of the five-year plan, which makes possible the earlier establishment of the basic goals of technical progress and the selection of better means of solving the most important national-economic and scientific-technological problems.

The development of scientific and technological long-term predictions is carried out as a result only with regard to the most important national-economic problems of nation-wide significance. The development of forecasts regarding technological and economic development of individual branches of the national economy and of scientific and technological forecasts regarding the most important problems of significance to these branches is carried out by ministries and departments, and by research and planning organizations affiliated with individual branches of industry, while forecasts regarding major inter-branch problems in the development of the national economy are made by scientific and technical commissions convened by the State Committee on Science and Technology, and consisting of leading scientists and specialists in production.

At this stage of the planning process the basic directions which the development of science and technology will take during the next five years are set; the scientific and technological problems which will have to be solved are defined, and the ministries and departments responsible for solving them are specified. The basic directions of scientific and technological development approved by the directive organs and the problems entailed thereby are the basis of the subsequent compilation of long-term and current plans for the development of the national economy and of science and technology.

During the second stage a state five-year plan for scientific research and the introduction of the achievements of science and technology into production is developed, including assignments for the solution of basic scientific and technological problems and the introduction of the achievements of science and technology into production, and plans for the financing of scientific research and the education of scientific personnel. At this stage coordination plans for the solution of fundamental scientific and technological problems are compiled. The complex of measures specified in the five-year plan for the solution of basic problems is taken into account in the general indicators of the national economic plan. The expediency of including the selected problems in the plan should be supported by technical-economic calculations demonstrating their economic efficiency and the prospects for the usefulness of the expected results in the national economy.

In working out plans for scientific research special attention is devoted to advanced scientific research and planning and design developmerts in those branches of industry which determine the technological progress of the entire economy.

The solution of selected problems, as a rule, is associated with the performance of a large complex of scientific research and planning and design tasks which are necessary for the completion of the final stage of the industrial application of results. The coordination plan is compiled in order to guarantee proper timing of the fulfillment of individual assignments and the correlation of the efforts of the various executors.

In the general system for the planning and development of science and technology coordination plans are the basic working instruments on the basis of which are compiled the more detailed annual plans for research and planning and design projects by the organizations which are to carry them out.

The third stage is the practical realization of research and planning and design projects in the national economy; this stage is the final one and consists in the application of the achievements of science and technology in production. During this stage plans are developed for introducing the achievements of science and technology into production; these plans specify the tasks which must be performed in order for industry to assimilate new forms of production, progressive technology, the mechanization and automation of industrial processes and automated control systems. Plans of this type are developed at various levels of control. The initial basis for the compilation of the yearly plans is formed by the goals deriving from the five-year and coordination plans for the solution of scientific and technological problems, as well as the continuing requirements of production and science with regard to the creation of a reserve stock of scientific achievements.

The overall planning system provides an organic link between technological progress and the development of the overall economy of the nation. This link permits orientation of the long-term prospects for development of the economy, not only with regard to contemporary achievements of science and technology, but also, in a scientific manner, with regard to their future development tendencies.

Under current conditions of material production the combination and coordination of the efforts of the many organizations taking part in the solution of scientific and technological problems are increasing in importance. An apparatus for effecting this correlation of effort in the area of production and technological progress at various levels of control of the national economy has therefore been created in the Soviet Union. The realization of a unified state policy on scientific and technological progress has been made the responsibility of the State Committee on Science and Technology, the major tasks of which are determination of the basic directions in which science and technology will develop, organization of efforts to solve scientific and technological problems arising between branches of production, state control of the introduction of the achievements of science and technology into production, raising the efficiency of scientific research and guaranteeing the rapid introduction of the achievements of science and technology into the national economy, organization of scientific and technological information and the establishment of links with foreign countries in the area of scientific and technological cooperation.

In the various branches of the national economy the coordination of work in the area of technical progress is effected by the ministries and departments responsible for the technical level of production in each branch.

A system of interaction between institutes and industrial enterprises is being constructed on the basis of the spheres of activity of these organizations as established by the ministries. As a rule, leading research institutes and planning and design organizations are attached to the specific branches of industry for the technical level of which they have responsibility.

In the area of the natural and social sciences coordination of the activities of scientific institutions, independently of their departmental subordination, is effected by the Academy of Sciences of the USSR. For this purpose the Academy has as part of its structure a Scientific Soviet for Coordination. Work on the most important problems in the basic sciences and the correlation of these efforts between the scientific institutions affiliated with individual branches of industry and the institutes of the Academy of Sciences of the USSR and the academies of sciences of the various republics of the Soviet Union are carried out primarily by the appropriate scientific soviets organized by the Presidium of the Academy of Sciences of the USSR. The scientific soviets of the Academy of Sciences also establish the required links with the scientific soviets of the State Committee of the Soviet of Ministers of the USSR on Science and Technology and the scientific and technological soviets of ministers and departments.

In the general system of long-term planning and forecasting of the development of science and technology, scientific information takes on special significance. The Soviet Union has branched information services in the area of science and technology.

Forecasts of technological development should cover a 10-15 year period. It is inexpedient, in our view, to predict for longer periods, since human knowledge is increasing so fast that forecasts can fail to coincide with the trends of technological progress. At the same time short-term forecasts covering a 3-5 year period cannot take into account price fluctuations, conditions governing availability of material supplies, or complex interactions between branches of production and within individual branches. It is for this reason that the 10-15 year period is the optimal one for forecasts in the area of science and technology.

Scientific and technological forecasts are required to guarantee:

--scientific forecasts of directions and tendencies in the development of science and technology in a given area for a given period of time; and

--mutual compatibility of goals in the solution of problems in the future with the goals of technical progress in the national economy, its individual branches and constituent republics.

The inventory of the most important problems in the area of the development of the national economy, and on the basis of which scientific and technological forecasts should be elaborated, is approved by the State Committee of the Soviet of Ministers of the USSR on Science and Technology, while Gosstroy SSSR deals with problems in the area of construction and construction materials. This inventory includes problems of an interbranch character which influence the technical progress of the various branches of the national economy of

the USSR as a whole. Taking into account the fact that each of the problems included in the inventory is a complex assemblage of forecast research, workers in the above agencies proceed to carry out this research, having discovered as completely as possible the nature of the changes in the object of the forecast the mechanism of these changes which reflect the state of the object at various stages of its evolution. The selection of a problem as an object of a forecast begins with the definition of its significance not only within a given branch of production, but also in the general system of the national economy; its connection with other branches, with affiliated and specialized enterprises, is considered. Before the forecast research begins on the relations between the object of the forecast and social production as a whole, the level of development of productive resources, and the scientific and technological level of achievement not only in the branch in question, but also in neighboring branches, are examined.

Contemporary scientific forecasting makes use of a large number of methods and procedures, differing in their content and degree of scientific grounding, for the probabilistic evaluation of the future level of development of science and technology. These methods and procedures may be grouped into the following classes:

--extrapolation methods, including extrapolation of data on the dimensions of the parameters of the object of the forecast, extrapolation of functional characteristics and extrapolation of system and structural characteristics;

--expert opinion methods, including individual and collective expert opinions;

--modeling methods, logical, mathematical and information models.

Each of these classes in its turn consists of several groups of scientific-technological forecasting methods.

In spite of the existence of a large number of methods, the economic forecasting system requires the further elaboration of scientific, technological, and economic hypotheses which will make the practical process of long-term planning easier.

The process of performing forecasting research in the area of science and technology includes the following stages:

--the definition of the forecasting goals with regard to the problems selected for forecasting research, including definition of final designations, scales of application of future forecasts and time required for its elaboration. At this stage preliminary information is collected and systematized and the technical-economic and social bases of the problems selected for forecasting research are given;

--analysis, comparison and appraisal of the level of development of science, technology and production in the areas under consideration in the most technologically developed countries.

Analysis of the level of development and appraisal of the results of scientific research projects and their practical applications are conducted, as a rule, along two lines: basic research, directed toward the discovery of new processes, laws and previously unknown phenomena, and applied research, carried out on the basis of already known principles and methods and

pursuing more concrete goals. Design projects follow, aimed at the creation of new forms of industrial production, technological processes and construction decisions on the basis of previous research work. Of greatest value at this stage of the forecasting process are not the indicators of level (of, for example, quality) achieved during various periods, but the dynamics of their time variations, the nature of the curves reflecting variation in the maximum and minimum quality level in various periods, as well as time variations in the magnitude of the difference between the current quality of the best and worst samples. The range of variation in quality established by analysis of the best foreign and Soviet production samples permits fairly precise determination of the basic lines of scientific and technological progress in a given industry during the period of the forecast. In the process of analysis, comparison and appraisal of the level of development of science, technology and production, investigations are also conducted of the most typical examples of the introduction of new technology, new products being put into production, and typical calculations of the time required for the introduction into mass production of new designs. As a rule, such calculations should cover 5-10 base years and the current period.

Their purpose is the elucidation of the long-term trends of scientific research in the area in question. At this stage alternatives in scientific and technological development are defined and the most valid selected. At the same time the approximate levels of financial, labor, and material expenditure which will be required to achieve the desired results are determined:

--definition of the basic content of scientific and technological tasks during the period of the forecast and

possible ways of fulfilling them. At this stage the most expedient methods, scales of operation and content of scientific and technological research in each of the chosen directions, with more extensive appraisal of their technical and economic efficiency, are determined;

--balancing of the system of quantitative indicators included in an overall prediction with data on economic potential, resources, etc. Since it is intended that factors of an economic nature will be taken into account at all stages of overall forecasting, the balancing procedure has the purpose of achieving more complete matching, primarily through the system of expanded indicators of scientific-technological development;

--the adoption of scientific recommendations and the introduction of the results of scientific forecasts into the practice of long-term national economic planning.

Completed scientific-technical forecasts are usually transmitted to the planning organs at various levels accompanied by the analytical documentation essential for the adoption of a final decision on the concrete positions of the forecast in the process of its application for purposes of planning and managing the national economy. This analytic documentation facilitates, and often to a significant degree guarantees, the more complete utilization of the results of forecasting research in the practice of long-term planning.

In order to elaborate scientific-technological forecasts, the State Committee of the Soviet of Ministers of the USSR on Science and Technology organizes temporary scientific-technological commissions on each of the problems selected for

forecasting research. With regard to certain problems these commissions are organized by the Committee jointly with the Academy of Sciences of the USSR. The commissions consist of leading scientists and qualified specialists from various industrial enterprises and scientific organizations, members of the appropriate ministries of the USSR and specialists in the area of forecasting, patenting, scientific-technical information and technical-economic research. In certain instances the members of the temporary scientific-technological commissions are exempted from their normal activities for the duration of their work on the forecast, although they continue to receive their regular salaries. Similar commissions are created by the ministries and departments of the USSR, as well as by the soviets of ministers of the individual republics, in order to work out forecasts of the technological and economic development of individual branches of industry and of the economies of the republics as a whole, as well as scientific-technological forecasts with regard to the problems of greatest concern to the industries or republics in question. Often the development of individual portions of a forecast is assigned to scientific research and planning and design organizations.

Reports and proposals are compiled in accordance with the forecasts, and, after having been examined and edited by the relevant organizations, submitted to the organs charged with fulfilling the forecast--the State Committee on Science and Technology, the Academy of Sciences of the USSR, Gosstroy SSSR, a Soviet ministry or department, or a Soviet of Ministers of one of the republics.

The reports describe the state of the object of the forecast in question as compared with the level of development achieved abroad, define the trends of scientific-technological

progress in this area and on this basis designate paths of development for branches of the national economy, as well as the corresponding areas of science and technology. The reports also contain the results of calculations characterizing changes in the structure of the production and consumption of the basic types of raw materials and equipment, and technical-economic indicators of productive potential expected at the end of the forecast period. The proposals contain recommendations regarding the most efficient means of developing scientific research and raising the technological level of production and indicate the measures to be taken in the period of the forecast.

This is the approximate structure of national scientific-technological forecasting, which is an extremely important preplanning stage in the general system of national economic planning.

A large volume of forecasting research is carried out in the framework of the branch COMECON commissions. The general materials of forecasting research carried out within the COMECON framework and the scientific recommendations made on the basis of them will undoubtedly permit, when they are introduced into the practice of long-term national economic planning in the socialist countries, the making of important and fundamental decisions with regard to the development of the various branches of science and technology.

The increasing importance of scientific and technological progress in the building of the economy gives rise to new requirements with regard to the further deepening, on a planned basis, of cooperation between the socialist countries in the area of scientific and technological research of mutual

interest to them, and with regard to the raising of the level of this research through the concentration of scientific and material resources on the solution of the scientific and technical problems of greatest importance in the development of these countries.