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MAKING FORECASTING DYNAMIC
The Soviet project OGAS

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In 1964, Soviet cyberneticist Victor Glushkov first proposed a National Automated System for Computation and Information Processing (EGSVC/ ЕГСВЦ) (the term "OGAS" appeared in 1970s). The system was meant to neutralize the deficiencies of the Soviet planned economy but failed to find extensive government support. In addition to making strategic long-term forecasts (both economic and scientific), OGAS was to gather and process the information that was needed for monitoring and coordinating the work of the economy by creating a nation-wide, automated computer network. With his colleague, Dobrov, Glushkov developed a new method of scientific and technical forecasts that the system was to use. A project initially as important as the national space program, OGAS was nevertheless gradually ignored. Still, Gluskov sought to keep improving the way that scientific-technical forecasting was done. Using original project documents and memoirs, this article shows that its essence, the OGAS project was a project of the information society. Although never realised in the Soviet Union, something like OGAS is extremely relevant to today's problems of setting priorities in science and technology research.

The pioneer of Soviet cybernetics and founder of the first Computer Center in the Soviet Unvion, Anatoly Kitov, launched the first effort to network the Soviet Union. In 1958, he wrote, "a unified network of information and computing machines will allow us to quickly and efficiently collect the necessary information about the condition of individual enterprises, the availability of materials, money, labour, etc., and quickly use processed results to plan and manage the economy."[1] Kitov's discussion of "widespread exchange of knowledge on an international scale with the help of special translation electronic digital machines, the use of a single automated information service and the connection of numerous subscribers by telephone and

1 Kitov, *Electronic computers* (Elektronnve vvchislitel'nye mashiny), 25.

other types of communication" in his book *Elektronnye vychislitel'nye mashiny* (*Electronic computers*) reminds one strongly of the Internet.[2]

On 7 January 1959, Kitov sent a letter about "sozdanii avtomatizirovannoj sistemy upravleniya narodnym hozyajstvom" the creation of an automated system of managing the national economy) to the Central Committee of the Communist Party of the Soviet Union (addressed to Nikita Khrushchev).[3] This was the first proposal in the USSR and in the world to create a nationwide multi-purpose computer network, primarily for managing the national economy. The Soviet government responded by passing an Act to speed up Soviet computerization, but the country's bureaucratic managing structures remained the same.[4] Although the government was apparently supportive, Kitov's idea didn't get very far.

As a result, in the autumn of 1959, Kitov sent a second letter to Khrushchev, which contained sharp criticism of a number of leaders and particularly of the Ministry of Defense for its slow speed in developing and implementing computers. The main part of the letter described his information society project, the first to be proposed in the Soviet Union, which was meant "to overcome the lag in the creation, production and introduction of computers in the Armed Forces and the national economy."[5] The project provided for the integration of all computers in the country to solve both national economic and defence tasks. The computers were integrated into a "Unified State Network of Computer Centres." In case of martial law, the network was to switch completely to military tasks. Kitov called this national computer network a network of "dual-use" of computing centres. The project, however, was rejected and Kitov was expelled from the Communist Party. Kitov was also removed from his prestigious general's post in Computer Centre 1 of the Soviet Ministry of Defence. The goal of integrated computing remained unfulfilled. (Although Kitov consulted Glushkov on his plan (their son and daughter even get married) and conversely influenced development of OGAS.)

The founder of the Institute of Cybernetics in Kiyv and author of the OGAS project, Victor Glushkov, made several new and more successful attempts to start a

2 Kitov, *Electronic computers* (Elektronnve vvchislitel'nye mashiny), 25.

3 Letter from the Deputy Head of the Computing Canter of the USSR Ministry of Defence A.I. Kitov to the Central Committee of the CPSU N.S. Khrushchev on January 7, 1959. File "Anatoly Ivanov Kitov" (f.228), storage unit KP27189/20, Polytechnical Museum of the Russian Federation.

4 Communist Party of the Soviet Union Central Committee, "Ob uluchshenii rukovodstva vnedreniem vychislitel'noj tekhniki i avtomatizirovannyh sistem upravleniya v narodnoe hozyajstvo" (About improvement of management by the introduction of computer engineering and automated management systems in the national economy).

5 The first project was called "Red Book", but no sources remain that describe it.

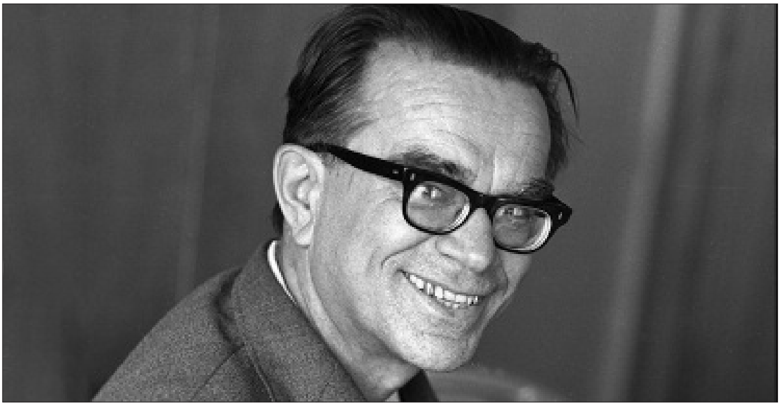

Fig. 1. Victor Glushkov is the founder of the Institute of Cybernetics in Kyiv and author of OGAS project.

new Soviet computerisation project after Kitov's failure. Glushkov claimed that "building such a network would allow collecting and making optimal use of economic, scientific-technical and any other information, as well as sharing it in the interests of consumers, which is very important in our time [1982] for the transition to the information society."[6] So it perhaps unsurprising, that although the mathematics continued to be developed to enable scientific-technological forecasting, their plans never developed into real programs with government backing.

In the world famous *Encyclopaedia of Cybernetics* (1972), Gennady Dobrov, working in the Institute of Cybernetics, defined scientific-technical forecasting as a direction of scientific research on the development of principles and methods of scientific forecasting, as well as the process of developing forecasts. The forecast is a probabilistic assessment of possible options for the development of science and technology, as well as the resources and organizational measures required for this. A generalizing feature of a scientific-technical forecast is its systemic nature, which takes into account both the changing nature of scientific innovations and the quickly updated initial needs, incentives and conditions for the development of science and technology.[7] Planning future activities often require the use of forecasting in order to evaluate different scenarios and model decisions made. Scientifically based

6 Malinovsky, *Ocherki po istorii po istorii komp'yuternoj tekhniki v Ukraine* (Essays on the history of computer technology in Ukraine*)*, 111.

7 Glushkov, Amosov and Artemko, *Enciklopediya kibernetiki: v 2 tomah* (Encyclopedia of Cybernetics: in 2 volumes), 70.


Fig. 2. Dobrov, important cyberneticist and colleague of Glushkov.
He founded a renown scientific school in Kiyv.

fore-casting is especially important in a planned economy for providing an alternatives to the "self-regulation" of a market economy. In the Soviet economy, information could be used to inform forecasts and therefore to help in planning. (It therefore might threaten political planners by producing a source of authority apart – and one that is "objective" rather than politically informed.)

In order to carry out a prediction, however, methods of scientific and technical forecasting need to be based on a great deal of data – the better the data, the better the forecast. Thus Project OGAS, in its essence was a project of the information society because it combined computerized methods of forecasting with computerized data collection. Gathering information was important for monitoring and coordinating the work of the economy as well as for strategic long-term forecasts in economics and science, or, in modern terms, creating an "innovative economy."[8]

The large number of methods for scientific-technical forecasting (100–150 basic methods in different variations and compilations by the 1970–1980s) indicate that there is no generally accepted method for scientific-technical forecasting. Dobrov, who went on to found a scientific school of his own, distinguished the following methods: extrapolation, expert method, mathematical method, engineering method (patent search) and building a system of continuous scientific-technical forecasts using a computer.[9] (Unofficial scientific schools – "science of science" schools founded around a prominent figure, were crucial in Soviet society because they allowed members to exchange ideas freely.[10])

8 Mikheev and Lisitsin, *Eskiznyj proekt* (Preliminary design).

9 Bestuzhev-Lada, *Rabochaya kniga po prognozirovaniyu* (A workbook on forecasting), 70

10 For example, Nobel laureate Soviet physicist Landau founded the "Landau school." He developed a famous comprehensive exam called the "Theoretical Minimum," which students were expected to pass before admission to the school. The exam covered all aspects of theoretical physics. Between 1934 and 1961 only 43 candidates passed the exam, but those who did later became quite notable theoretical physicists.

Fig. 3. Map of the basic centers of the computer centers state network (ГСВЦ) and communication lines between them (planned by 1990). Levels of centers: (1) all-state, (2) republican, (3) territorial.

Igor Bestuzhev-Lada and his collaborators in the "Workbook on Forecasting" (1982) provided a three-level classification of methods for scientific-technical forecasting. The three levels were determined by the degree of formalization, the general principle of operation, and the method of obtaining forecast information. The degree of formalization divided all methods into intuitive and formalized.[11] E. Jantsch, who gave a detailed three-level classification of approximately one hundred methods for scientific-technical forecasting methods, did not distinguish between qualitative and quantitative methods since he believed that in many cases it is impossible to draw a clear boundary between them. He found that the same method, furthermore, can be based on either – or both – of these approaches.[12]

There is no universal method for scientific-technical forecasting, and each method has a serious drawback. The main flaws of the extrapolation method, for example, are the impossibility of anticipating a new facts, based only on the development of an existing process (for example, increasing the power of devices, and not inventing new types). In addition, the method is limited because it only produces reliable results for short periods – up to five years.

The engineering method of forecasting also has problems with time, since the objects of a patent search are existing inventions and discoveries. Furthermore, most patents are not used or can be used only after many years, which reduces the accuracy of the forecast further. For example, Polytetrafluoroethylene (or simply – Teflon) was accidentally invented in 1938, but a frying pan with a Teflon coating appeared on the

11 Jantsch, *Prognozirovanie nauchno-tekhnicheskogo progressa* (*Technological forecasting in perspective)*, 131–4.

12 Glushkov, *Ob odnom metode prognozirovaniya* (About one method of forecasting), 15.

American market only in 1961. The time between the discovery of liquid crystals in 1888 and the appearance of the first liquid crystal indicator in 1968 was even longer.

In mathematical modeling, the main disadvantage is that the model is a virtual and simplified reflection of reality, and the simpler it is, the less it reflects reality. But even relatively accurate computational models need experimental verification. In this case, not even the most perfect mathematical model can take into account what has not yet existed.

Expert iterative methods (in which specialists in a given field are questioned to provide the model's data) have flaws too: the authority of leaders, which can simply reproduce authorities (this is partially solved by anonymity, but at same time excludes useful contacts); information noise; exceeding the competence of the expert; experts are annoyed by wasted time; the influence of group pressure on the opinions of individual participants who may be right. A flaw of expert iterative methods is the problem of the accuracy of the questions themselves. These methods to suffer a strong drop in accuracy when making long-term forecasts (say for a decade).[13] It is difficult to estimate the likelihood and degree of desirability of events, thus, it is better to ask questions about the time of the emergence of a new technology.[14] The power of these methods lies in the fact that specialists and scientists (the experts) can more accurately predict the future of science than average workers. Almost every scientist is constantly looking for new goals and asks himself the same question: "What is possible to accomplish in the near (or distant) future?" Thus the main advantage of predictive research based on a synthesis of opinions and ideas is that scientists, being at the forefront of scientific research, can really see something that is still hidden from others.

For this reason, despite the flaws of the expert method, Glushkov and Dobrov continued to research an expert method. And it produced good results. In 1969, they oversaw the development of a long-term forecast for computing technology in the 1970s and 1980s, which showed good accuracy. It was based on interviews with computer science specialists. The forecast stated that the further development of science, technology and the economy of the country would be largely determined by the state of electronic computers and the level of organization of their use. Experts

13 Dobrov, Smirnov, and Glushkov, *Razrabotka dolgosrochnogo prognoza razvitiya vychislitel'noj tekhniki na period 1970-80 gg. s uchetom potrebnostej narodnogo hozyajstva strany* (Development of a long-term forecast of the development of computing technology for the period 1970-80. Taking into account the needs of the national economy), 169.

14 Mihalevich and Glushkov, *Razrabotka metodiki obrabotki ekspertnyh ocenok dlya perspektivnogo planirovaniya vychislitel'noj tekhniki* (Theme 1. Development of a methodology for processing expert assessments for advanced planning of computing equipment), 3.

emphasized that Western countries were trying hard to increase the efficiency of using computers and predicted an "information explosion" to come.[15]

Despite this strong recommendation, the Soviet government did the exact opposite of what their experts recommended. The government decided not to indigenously develop new computers, but to copy foreign equipment from IBM and DEC (Digital Equipment Corporation). In addition, they planned to use the foreign machines' software. The branch bureaucracy played its role here – it seemed simpler and more reliable to them. "Calculations" were even performed that confirmed that this way was cheaper.[16] Yet commentators do not see the decision as a good one – perhaps even a costly mistake. Dutch systems scientist and pioneer in computing science Edsger W. Dijkstra stated: "I characterized the Russian decision to build a bit-compatible copy of the IBM 360 as the greatest American victory in the Cold War."[17] Although Glushkov's forecast was correct, he was unable to influence policy. This occurred again, when his newest method was approved by the government, but the computer system needed to make it dynamic (improving the forecast) and to translate the forecast into policy never materialized.

In 1971, the new foresight method ("the method of concept development of science and technics") of the Institute of Cybernetics of the Ukrainian Soviet Socialist Republic Academy of Sciences (based on the "Delphi"[18] and "PERT"[19] methods), which Glushkov and Dobrov had developed, was approved and recommended to the ministries and departments for the preparation of scientific and technical forecasts. Glushkov called it the "method of building a forecast tree" or "building a forecast graph", or "a method of continuous forecast" or "a method of dynamic forecast."[20]

15 Dobrov et al., Report on the research topic: "Razrabotka metodiki dolgovremennogo dlya celej perspektivnogo planirovaniya nauchno-issledovatel'skih rabot" (Development of a forecasting methodology for the purposes of long-term planning of research works"), 253.

16 State Committee for Science and Technology. *Metodika programmnogo prognozirovaniya razvitiya nauki i tekhniki*.

17 Frana and Misa, "An Interview With Edsger W. Dijkstra."

18 The Delphi Method (named after the Delphic Oracle) is a series of surveys of anonymous independent experts, the organizational group before each stage introduces the experts with the generalized data of the previous one, attempting to develop a consensus.

19 PERT (Program Evaluation and Review Technique) is a method for analyzing tasks by the time factor and the necessary resources necessary to complete a project. The analysis is performed mathematically and graphically with the construction of a network graph.

20 State Committee for Science and Technology. *Metodika programmnogo prognozirovaniya razvitiya nauki i tekhniki*.

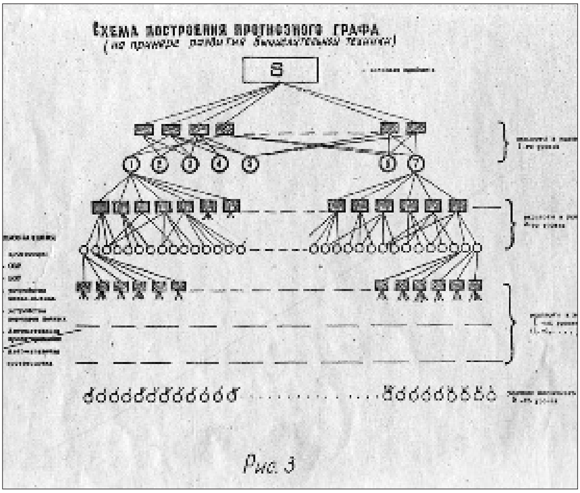

Fig. 4. The scheme of building forecast graph about computer development (three levels or stages). It was called "graph" (in Russian "граф") or "tree" in Glushkov's works. (Source: State Committee for Science and Technology. *Metodika programmnogo prognozirovaniya razvitiya nauki i tekhniki*. Moscow, 1971.)

The dynamic nature of the science-technology forecast was the most important: if forecasting were a sub-system of a nation-wide computer system, the system could predict changes in the probability of events in real time, and calculate the needed allocation of resources needed before the event in question. At the very least, such a changing forecast could signal the need for a deeper investigation into a particular problem using many different methods of forecasting.

To create a forecast using the new method, experts were asked to rate various items in light of their own experience. In the example of the "man machine" problem, to rate the importance of: improving the elemental technology base; improving external devices and communication technology; development of information processing methods; software improvement; improving the structure of computers; improving the organization of computer use; development of methods of computer development; development of engineer-psychological research.[21] The questionnaire also contained free space, so experts could propose new directions. In other spreadsheets, experts wrote their self-rating (including intuition) or could recommend new experts to ask. This information from experts (who were asked several times) was processed into a tree graph.

21 Taken from The spreadsheet in the questionnaire about the R&D needed for solution of the "man and machine" problem, 1969.

The new method of forecasting developed by Glushkov and Dobrov distinguished three stages: research, concept and organization. The result of the research forecast is to determine the goals of future scientific and technological development in the form of some scientific and technical problem, or a number of scientific and technical problems to be solved during the period for which the forecast is done. As a result of the development of a forecast, possible ways of achieving future goals of scientific and technological development are formulated: this is the concept forecast. The organizational forecast is useful for the determination of possible options for the allocation of resources and the organizational and technical measures necessary to achieve the goals of future scientific and technological development. As a rule, attempts at scientific-technical forecasting did not go beyond the research level, both the above-mentioned project for forecasting computing technology[22] and in more recent projects[23].

The importance of the scientific-technical forecasting for the Soviet Union is shown by the fact that (like the OGAS project) it was identified in directives of the government in 1971, which called for "forecasts of scientific and technical progress, growth of the country's population, natural resources and others" in order "to improve the methods of long-term planning of the development of the national economy" and "to carry out the elaboration of a long-term plan for the development of the national economy."[24]

Already since 1972, a comprehensive state program of scientific and technological progress and its socio-economic consequences for a period of fifteen years was formed in the Soviet Union. However, the link between forecast and planning was designed much later. In 1979, the government planned for a comprehensive program of scientific and technological progress to be developed forecast twenty years in the future.[25] In reality, although the five year plan called for it, a massive, comprehensive program to do this was ready only at the end of the five-year plan,

22 State Committee for Science and Technology. *Metodika programmnogo prognozirovaniya razvitiya nauki i tekhniki* (Methods of concept forecasting the development of science and technology).

23 Malitsky, Popovich, and Onoprienko, *Obosnovanie sistem nauchno-tekhnologicheskih i innovacionnyh prioritetov na osnove "forsajtnyh" issledovanij* (Grounding of systems of scientific, technological and innovation priorities based on "foresight" research).

24 24th Congress of the Communist Party of the Soviet Union, Stenograficheskij otchet. 30 marta – 9 apr. 1971 g. (Stenographic report. 30 March – 9 April 1971), 307.

25 Communist Party of the Soviet Union Central Committee, *Ob uluchshenii planirovaniya i usilenii vozdejstviya hozyajstvennogo mekhanizma na povyshenie effektivnosti proizvodstva i kachestva raboty* (About Improving Planning and Strengthening the Impact of the Economic Mechanism on Improving Production Efficiency and Quality of Work), Act 695.

in 1985, when it was impossible to take it into account in the five-year plan. Although some people in the government showed great interest in forecasting, the implementation of the method was too slow and most of the state's officials did not believe in the revolutionary insight of Glushkov's OGAS: computers, used to collect and process information, could vastly improve the efficiency of the production and science.[26]

Glushkov believed that many of the drawbacks of their method of forecasting could be partially neutralized by the use of other methods. He wanted to make the process of forecasting dynamic and continuous using the computer network to process information, forecasting shorter periods (one or five years) as well as longer terms.[27] This was one of the key principles in designing the OGAS system. It supposed – revolutionary in the 1960s to 1980s – that computer networks could help coordinate, search and process information. OGAS was partly adapted in order to be built, but without changing the manging structures of the country, a computer scheme could only go so far.

The dynamism of models of scientific and technical progress needed computer hardware and networks. Dynamism was crucial to allow the models to respond to the high susceptibility of scientific and technical ideas to change.[28] Without machine processing, a change in the opinion of one expert would necessitate a titanic amount of work to recalculate the entire forecast. A desire for good forecasts would therefore necessitate a large computer network.[29] Yet while the government continued to support forecasting this investment in computerization never materialized.

OGAS was faced with the following forecasting tasks: capital construction; reproduction of fixed assets; population reproduction; reproduction of labour resources and distribution of labour; the forecast of the dynamics and structure of the national income and consumption of the population, as well as the development of the non-production sphere; forecast of scientific and technical progress and its socio-economic consequences; forecast of foreign economic relations; forecast of financial flows, prices; forecast use of natural resources and the environment; forecast of interregional exchange and development of individual regions. The system of scientific and technical forecasting was a vital part of OGAS. Compared to the Internet (USA), which started as a connection of users, the Soviety project of OGAS

26 Glushkov, "Forecasting and management of scientific research."

27 Glushkov, *Introduction to Automated control systems;* Glushkov, *Basics of paperless informatics* (Osnovy bezbumazhnoj informatiki), 290–5.

28 Glushkov, "Forecasting and management of scientific research."

29 Mikheev and Lisitsin, *Eskiznyj proekt* (Preliminary design), Chapter 5.

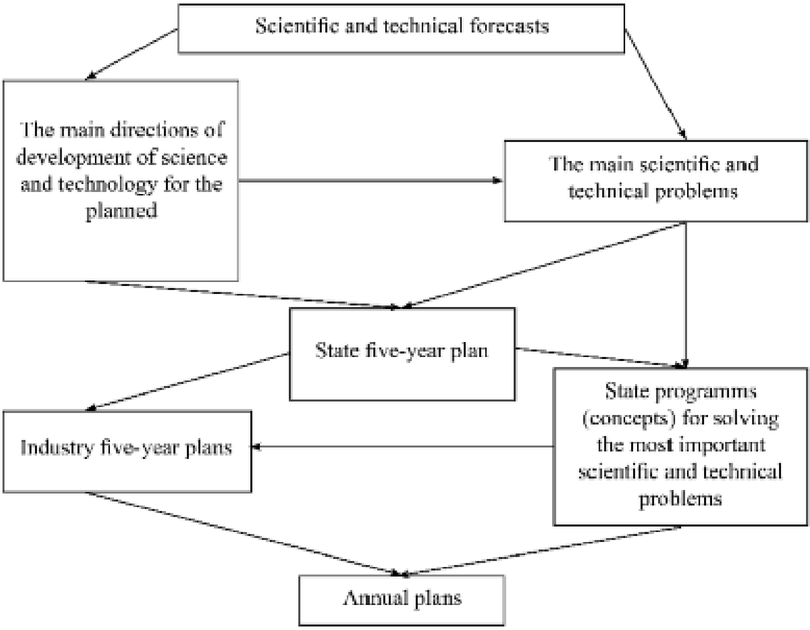

Fig. 5. Structural diagram of how plans for the development of science and technology were made. (Source: Mikheev and Lisitsin, *Eskiznyj proekt* (Prelimiary design), chapter 5.)

was designed to make deep changes in the society: connecting users, collecting statistical data, establishing e-money, providing e-documents, doing forecasting, enabling planning. Currently, the Internet is actually moving towards the main principals of OGAS. [30]

The most important issue was the question of how to connect forecast and economic plan – the actual management of science. One problem was when forecasts seemed to contradict common sense, which informed economic planners. The forecast graph is dynamic and consists of both the opinions of the majority and alternative opinions. V. Glushkov jokingly called the latter "the opinion of the heretics."[31] Sometime mathematics suggested ignoring the majority. In the forecast, opinions are weighted according to the probability of their implementation. Thus if there is a large spread in the opinions of the majority, the value of alternative opinions increases. In some cases, the programmers will end up dismissing all of the experts and continue to work only with the "heretics." This was a problem because economic

30 Mikheev and Lisitsin, Eskiznyj proekt (Preliminary design), 109-11.

31 Glushkov, "Forecasting and management of scientific research."

planning includes material factors that influence scientific work (control over the distribution of specialists, money, equipment) and can therefore greatly influence the final determination of the model (in some cases against a desired outcome). How could mathematics overcome bureaucracy?

One problem solved by Glushkov's new method that made it easier to apply to actual economic planning was the possible lack of mathematical convergence of the branches of a forecast tree. The problem of a lack of convergence was that a lack of consensus which indicates an increased risk of making the wrong decision. If the opinion of most experts in the dynamic planning system reached the limit of the minimum difference, then the forecast suggests that the time has come to make a decision. Lack of convergence could be avoided by using the newest Glushkov Dobrov forecasting method which allowed programmers to select important events that, according to many experts, are close to the solution, to get increased attention and more resources.

Similarly, the new forecasting method made forecasts more realistic and ambitious by including new scientific discoveries. Despite the distances (in time) of the fantastic opportunities connected to a new scientific discovery, Glushkov argued that such events should be included by the forecast team in their graphs. For example, the theoretical possibility of using radio could be put in a graph when, in 1887, Hertz experimentally confirmed the possibility of the existence of radio waves. Of course, using radio was a distant prospect in 1887, but, as new discoveries later appeared, it was concretized until it became an immediate prospect.[32] And, as we know from the history of the Russian Empire, its leadership was not ready for the invention of the radio receiver by Alexander Stepanovich Popov, a Russian teacher at a naval school, in 1895. Successful attempts to use radio were made in the navy, but the industrial production of radio devices was not pursued in Russia (unlike Marconi's invention).

OGAS was supposed to create a unified state automated system for developing forecasts of scientific and technological development using the new government approved forecasting method. This didn't happen, but there continued to be interest in scientific and technical progress. In the 1980s, the OGAS project, which had failed to attract funding before, was re-named ACSST (automated control system for science and technology). In the project, the management of scientific and technological progress was in the authority of the Soviet State Committee on Science and Technology (see Fig. 6).[33]

32 Glushkov, "Forecasting and management of scientific research."

33 Malinovsky, B.N. *Essays on the history of computer technology in Ukraine.* Phoenix, 1998. "Ocherki po istorii po istorii komp'yuternoj tekhniki v Ukraine" [4, p. 120]

Fig. 6. The block diagram of the management of scientific and technical progress in the USSR. (Source: Mikheev and Lisitsin, *Eskiznyj proekt* (Prelimiary design), chapter 5.)

Reorganization of the government meant that instead of a direct connection of technical forecasters with the government, intermediaries arose: the State Committee for Science and Technology and the State Planning Committee, commonly known as Gosplan.[34] This meant that information about scientific forecasts could not be sent to the government level, which had real power to make necessary decisions.

The government was thus cut off from all planning. This may be another reason that Glushkov did not put his signature on the project OGAS proposal in 1980 – he saw that it was doomed. Yet even the earlier five-year plans (now aging) were better for officials than the absence of any long-term planning for the economy.

34 Mihalevich and Glushkov, "Razrabotka metodiki obrabotki ekspertnyh ocenok dlya perspektivnogo planirovaniya vychislitel'noj tekhniki" (Theme 1. Development of a methodology for processing expert assessments for advanced planning of computing equipment), 302; State Committee for Science and Technology, Metodika programmnogo prognozirovaniya razvitiya nauki i tekhniki (Methods of concept forecasting the development of science and technology), 64; Malinovsky, *Ocherki po istorii po istorii komp'yuternoj tekhniki v Ukraine* (Essays on the history of computer technology in Ukraine), 124.

OGAS had been downgraded by government officials resistant to technical innovation, who had tried to adjust the automated control systems and networks of the OGAS project to the existing hierarchy only as a technical service. Added to this, the bureaucratic desire "to lead problem solving" slowed the construction of OGAS and prevented the introduction of dynamic scientific-technical forecasting. Also working against Glushkov's ideas was the increasing "liberalization" of the Soviet economy from the late 1960s: the move towards "free" markets under economists like Evsei Lieberman. This clearly contradicted Glushkov's efforts to create an optimally functioning socialist economy by improving planning through forecasting and contributed to the eclipsing of his ideas.[35] Still today there is a debate about whether embracing "free" markets made the Soviet economy unstable.

Despite his lack of success politically, Glushkov continued to state that forecasting was important. In one of his latest and very famous works, he reviews the use of scientific-technical forecasting, once again emphasizing the thesis of the continuity of the forecast with the work of experts in the technical system.[36] The process of improving a forecast could be sped up by ranking the goals of scientists (both main and intermediate) according to their informational significance. By adjusting the indication of the most valuable information, main goals of the forecast can change. The concept of information value helps programmers to focus on those goals for which the refinement of the forecast is most important. The refinement process itself can use various procedures for additional information: additional appeal to experts, targeted supply of information to them, meetings with relevant expert groups, etc.

Forecasting was crucial to steering the country's economy because the essence of management is to choose between alternative paths to achieve a final goal. These alternatives contain the sets of all the goals that must be achieved in the process of achieving a final goal. A forecast can help to choose between alternatives. The main thing that a forecast gives managers is the degree of confidence that a given alternative will lead to the desired final goal. A measure of confidence is based, first of all, on the probability of an alternative, which depends, in particular, on the number of experts who spoke in favour of it. In addition, the model quantifies the degree of consistency of the opinions of experts who spoke in favour of a given alternative. The model also gives a measure of the time predicted to achieve the final goal, but this takes into account only a given alternative, discarding all other possible alternatives. In other words, a forecast that can respond to changing conditions dynamically, does a lot of work helping managers chose the best possible route to take.

35 Lisovitsky, "Evsei Liberman, An Ideologist of the Kosygin's Economic Reform."

36 Glushkov, *Basics of paperless informatics*, subsection 11.8.

Even if a forecast cannot provide sufficient grounds for choosing a single alternative, the model gives two main methods for choosing one. First is to put into the plan the immediate goals with the greatest coefficients of significance (or with the greatest relative weights) without predetermining the subsequent development of the plan. The second technique is the combination of close alternatives (which differ in a small number of elements).[37]

Despite the political failure of OGAS, Glushkov continued to argue that the initial tool for setting the targets of national and departmental programs was a continuously operating forecasting system. The most important role in such a system is played by the scientific-technical forecasting system within it. This system provides not only the goals of scientific and technological progress, but also the ways to achieve them. In other words, it is a permanent source for the formation of targeted programs. Forecasts of social development, foreign policy, and prices on the world market can be carried out by means of computerized modelling. The inclusion of rapidly changing information about natural resources and demography means that such forecasts must be dynamic.[38]

Conclusion

Carrying out scientific-technical forecasting with the help of expert methods in a dynamic mode remains an urgent task to help allocated resources in the modern development of science and technology, which is much more complex and extensive (not to mention expensive) than the science of the 1970s and 1980s.[39] At the same time, modern IT-technologies facilitate the task of scientific-technical forecasting. When OGAS was being developed, building networks and software and hardware solutions were much more important, but today the issues of communication and data storage have been resolved.

Four problems remain to be solved to be able to carry out forecasting today: developing a modern method of continuous scientific-technological forecasting, building on Glushkov and Dobrov's ideas (because many of the things OGAS depended on are coming into being with the passing of time); translating the method into software; preparing a list of problems for the launch of the forecasting system; gathering teams of relevant experts. It is no longer necessary to develop an internet to facilitate forecasting. In the future, forecasting could be used to coordinate the efforts of scientific experts and attract new ones and to communicate with governments and scientific organisations.

37 Glushkov, *Basics of paperless informatics*, 453–459.

38 Glushkov, *Basics of paperless informatics*, 471–472.

39 Nature Materials, "Research Funding: the problem with priorities."

The difficulty of using something like OGAS to meet this need lies in that the Soviet Union, where these ideas were first developed, was a single country with a closed economy that had a wide group of scientists and a well-developed industry capable of introducing the latest developments. With economic globalization and the internationalization of science, difficulties may arise even in finding the necessary (to create a forecast) group of experts in one country, which OGAS depended on. Despite globalization resources are still apportioned on a national basis. Thus specialists' scepticism about domestic developments compared to other countries, will bring new challenges to forecasters and planners. So although the dynamic forecasting that informed OGAS can help today setting priorities in science and technology research, its future will likely be international. But despite the challenges, today's information society makes it even more plausible that the ideas that Glushkov and Dobrov developed for dynamic expert forecasting will finally be used to shape practice.

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