Soviet Science and Technology: Present Levels and Future Prospects

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Recently, there were discussions at the Agency Personnel Development Board of the work done by NSA personnel at the senior War Colleges. A question was raised whether term papers prepared at such schools might be suitable for publication in the Technical Journal. *It was generally agreed that where the subjects were of interest to NSA, such publication would on occasion be desirable.*

As a result, I hunted up the term paper which I had prepared in 1954–55 when I was a student at the National War College. On rereading it from the point of view of timeliness, I felt that the lapse of three years had not significantly affected its content or conclusions. Certainly some parts of it could be rewritten and sharpened, but there is perhaps interest in reading it with the hindsight of the additional information of the intervening period. For this reason I have felt that it would be appropriate to submit it unchanged rather than to attempt to bring it up to date.

I. INTRODUCTION

We are living in an age of science. The developments of science and technology during the past two generations have been of such breadth and of such magnitude as to overshadow human activity of all other kinds. The prominent position which the United States occupies today in world affairs stems directly from its technological capability just as that same capability was the prime factor to which we attribute our victories in the two world wars of this century. Considering how important science is, and considering that the Russians must assign to it the same position of importance, it is imperative that we keep as well informed as we can about the state of Soviet science.

The problem of doing so, however, is complicated by the behavior of the Communists: by their establishment of the Iron Curtain; by their secretiveness; by their restrictions on the movement of foreigners into and within their territory; by the strict control they manage to exercise over their own personnel abroad to prevent defections and disclosures; and by their methods of handling statistical information. These complications make it more difficult to acquire valid, properly interpretable data; they give rise to much speculation as to just what the picture is when only a few pieces of the jigsaw puzzle are in place and some of them blurred; they point up the inadequacies of our present

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intelligence and give rise to conflicting opinions. Nonetheless, there is considerable information available on which to form judgments. Let us examine the major sources of such information.

II. SOURCES OF INFORMATION

Open Literature

Under the heading of open literature there are included those sources of information which are openly disseminated, such as research journals, text books, occasional scientific articles in periodicals, and economic statistics. By a slight extension, we could also include those propaganda broadcasts which contain information bearing on science and technology. The main difference between these sources of information in the Soviet Union and elsewhere is that in the U. S. S. R., every bit of material is carefully scrutinized by government authorities, and only such items as are considered unclassified may be disseminated. Since the Russian standards of classification are much stricter than ours, a much smaller amount of material is thus permitted to get out.

At one time, most research papers in Soviet scientific journals carried abstracts in English and in French, but this practice has been discontinued.[1] The result is a reduction in usefulness to us, since the number of Western scientists who can read Russian is quite small. Although all universities in this country giving graduate degrees in science require candidates to demonstrate knowledge of two foreign languages, very few schools have included Russian as an admissible choice. A further point about this open literature is that some of it is printed in editions of limited number so that it is more difficult to get copies for use outside the Soviet Union.

Information obtained from CIA indicates how much scientific material is available From 1950 to 1954, 36 Soviet periodicals have been obtained for study; in some cases the files are complete, in others there are gaps and irregularities.[2] The approximate total number of volumes that have been received during this period has been constantly increasing from 180 in 1950 to 240 in 1953. (The figures for 1954 were not complete at the time this information was made available.)

The Soviet *Catalog of Periodicals and Journals for the Year 1955* lists four new periodicals that will shortly become available. It is of interest to note that one of these, about which there will be some comment on page 44, is entitled *Automatics and Telemechanics*. Scientific

[1] T. Dobzhansky, "Lysenko's Michurinist Genetics," *Bulletin of the Atomic Scientists*, Vol VIII, No. 2, February 1952, p. 43; J. R. Kline, *Soviet Mathematics Bull. of the Atomic Scientists* Vol. VIII, No. 2, February 1952, p. 46; E. Rabinowitch, *The Exchange of Scientific Information with the Soviet Union*, February 1953; p. 14.

[2] An interesting discussion of "The Exchange of Scientific Information with the Soviet Union," is given in *Bulletin of the Atomic Scientists*, February 1953, pp. 13 ff

papers, monographs and information on special scientific fields are also included in general periodicals such as *Reports of the Academy of Sciences*. Almost complete files of these general periodicals are available for 1950 to 1954.

Clearly, the information derived from the research journals and monographs is of high validity. It gives indication of the number and quality of research personnel, and the technical level of the problems investigated. In those fields requiring special facilities for experiment, it can indicate the number and character of such facilities, their variety, and the quality of their equipment.

The information that comes from published statistics and from radio broadcasts is of a different order of validity and must be examined much more critically. The figures which are released are often open to question:[3] they are manipulated and exaggerated; they are seldom given in absolute terms—rather as percentage changes and rates of change; the basic indices of comparison are subject to modification (published figures being sometimes the planned rather than the actual figures); harvest data may be in gross rather than in net terms; and, in short, information of this kind needs careful evaluation before it can be considered meaningful and acceptable.

Manufactured Items.

A second important source of information about Russian technology is found in the analysis of manufactured equipment—military, industrial, and consumer items.

The most fruitful source of such information in recent times was equipment captured in Korea, which has been searchingly analyzed in order to gain information about the effectiveness of Russian technology. For example, the Air Technical Intelligence Center has published a large number of studies of captured equipment. In addition to such basic considerations as effectiveness of aircraft and armament, quality of fuels and lubricants, capacity of communications and electronics equipment, these studies investigate the materials used,—metals, rubber, plastics—the effectiveness of design, the adaptability to mass production, the ease of operation and maintenance, the inter-changeability of parts, and sometimes even provide information about the quantities that have been manufactured, as well as the location of the plant where this was done. So important was captured Soviet equipment as a source of information that it gave rise to a special operation in which the inducement of $100,000 was offered in propaganda broadcasts to any pilot who would fly a MIG-15 over to the U. N. forces. That this also turned out to be a master stroke of psychological warfare was an incidental result of the quest for technical intelligence.

[3] Harry Schwartz, *Russia's Soviet Economy*, Prentice Hall, 1954, p. 129.

Other items of Soviet equipment available for study are those that can be bought in the open market in the Soviet Union or in countries to which it exports manufactured items. They can be seen, for instance, at international fairs and expositions, where they may be displayed for propaganda purposes. Such exhibitions have been held in the last few years in Milan, Bombay, Beirut, Bangkok, and Leipzig.[1]

In both kinds of instances—captured as well as commercial equipment—the number of samples available is not very large. Besides, the equipment may be several years old and so does not necessarily reflect a current situation. Nonetheless, the findings are significant and permit objective judgments of Soviet technological capability.

Observers

First-hand information from people who have been in Russia is naturally desirable and important. These observers may be official representatives of the Free World in a diplomatic or scientific capacity; they may be visitors; or they may be defectors from the Soviet Union.

Among those from the Free World who have visited Russia and have been able to provide useful technical information are people like the following:

1. J. C. Crowther, of England, who visited the Soviet Union on seven different occasions and spent most of the winter of 1934-35 as guest of several scientific bodies, including many of the major institutes concerned with physics and chemistry. His book[2] gives a great deal of detail about the specific research problems in which many individual scientists were engaged in at the time of his long visit.

2. Eric Ashby, who went to Russia in 1945 as an official scientific representative of the Australian government and who gives an objective account of a scientist's observations and impressions of the organization of scientific effort and education.

3. Mrs. Harding, an English zoologist, who accompanied an expedition of scientists and physicians on a specially conducted trip in 1951 to meet colleagues in Russia.

4. C. Thompson, General Electric Co. engineer, who supervised power installations in Russia on three separate occasions: 1928-29; 1932-33; and 1946.

Defectors who have come out of Russia have sometimes provided useful information. In the main though, these have been workers on lower levels who have been informed only about limited aspects of the work with which they have been connected. A major reason for such

[1] Information about the Leipzig fair is given in *U. S. News & World Report*, 24 September 1954, p. 148.

[2] J. G. Crowther, *Soviet Science*, E. P. Dutton & Co., 1936.

limited knowledge is the fact that the security-mindedness of the Russians causes them to compartment their classified research so that only a small number of people at the top are informed about the entire problem. All others are so restricted in their work that they become familiar with only one component of the final equipment. They may have general ideas from their part of the effort of the purposes of the over-all program, but they learn the details of only that part on which they are directly engaged.

III. ESSENTIAL FEATURES OF RUSSIAN SCIENCE

In view of the fact that the U. S. S. R. is approaching its scientific task by methods quite different from those used in any other country in the world, it appears desirable to attempt a description and analysis of the essential features underlying its approach.

Governmental Control

The first and most important aspect of Soviet scientific effort is the fact that it is completely under government control. The effects of this control will be discussed under three headings: planning, decentralization, and expansion.

Planning

State planning of the scientific effort includes not only its scope institutions, personnel, equipment, and finances—but also its content, i. e., the directions it will take, the problems it will work on, the materials it will use, and the goals it will attempt to achieve.

In this planning, the Soviet Academy of Sciences plays the prominent role. It is "not only an advisory and policymaking body on matters of learning, but also the most important operating agency for the huge amount of organized research" that is being conducted.[4] It has a voice in the planning of numerous university and industrial research laboratories operating outside its sphere; it even suggests that specific activities proposed for development be assigned to designated institutes outside the Academy. In establishing programs, the individual research workers presumably submit their own ideas and plans; these go up through channels to the research committees of the individual institutes and thence to the appropriate division of the Academy. The decisions that are then made set the patterns of effort for the succeeding year and are supposed to provide the necessary authority and financial support.

The technological program, i. e., the goals assigned to industry, agriculture and transport, is normally set by the recurring Five Year

[4] I. S. Sokolnikoff, "Organized Research in the U. S. S. R." *Scientific Monthly*, March 1951, p. 165.

Plans and within this general framework on a year-to-year basis in every one of the individual industrial establishments.

The outstanding consideration bearing on the Soviet government's attitude towards its science and technology is the great deal of encouragement which these have been given. The proportion of the national wealth which is being devoted to scientific endeavour is probably more than has been given by any other country of the world in recent years, or indeed at any time. The driving force which provides a major criterion in the decisions made is always the practicality of the effort under consideration—of how much service to the state will the results be. These decisions, which must perforce include a comprehensive examination of the order of priority of all the major portions of the year's effort, are also made to fit into a long-range program which is very broad and farsighted. As an example, it was realized, in Lenin's originally announced "Plan of Scientific and Technical Work," promulgated in 1918, that electric power would have to be expanded tremendously in order to cope with the ever-increasing demands that would be made on power sources. In keeping with this realization, a far-reaching program of large-scale power projects was given a high priority and pushed to such an extent that electrical output increased 25 fold between 1920 and 1940. And then, despite the war, the 1940 figure was multiplied by almost 2½ by 1952.[7] This was a big step in the transformation of the U. S. S. R. from an agrarian into an industrial country, a step sufficiently great to warrant its being highlighted by Stalin in a speech on 9 February 1946 to the voters of the Stalin Electoral District in the city of Moscow.[8] He referred to it as the accomplishment of a gigantic task in an incredibly short period.

Decentralization

The long-range plan of electric power development included an aspect that points up the controlled decentralization of Soviet science. A major purpose of this decentralization is the elimination of excessive dependence on any one area and the consequent enhancing of the national security. It has the additional advantage of establishing industry near the sources of its raw materials, thus reducing the strain on the entirely inadequate transportation system. The result of this planned decentralization is the development of new hubs of scientific activity; in the Far East, in Vladivostok; in the Urals, in Sverdlovsk; in Georgia, in Tbilisi; in Armenia, in Erevan; in Azerbaijan, in Baku; in Kazakh, in Alma-Ata. In these areas, new industries have been established, new sources of raw materials developed, new fuel and power

[7] A. V. Winter, *Soviet Electric Power Development*, Moscow 1952, p. 33.

[8] A. V. Winter, *op. cit.*, p. 35.

facilities made available.[9] The larger factories have been furnished research facilities. Moreover, large new research institutes have been set up in such places as Dniepropetrovsk, Sverdlovsk, Novosibirsk, and Tashkent.[10]

Expansion

A third aspect of Soviet science is the great increase that has been sponsored in numbers of universities, colleges and students.[11] The Soviet Union has deliberately set out to take the world lead in the scientific and engineering fields. Through a constant program of popularization and publicity, science is kept very much in the public eye. Many types of inducements are offered to attract the better qualified students into these fields of effort and the cream of the educational system is skimmed for this purpose. Qualifying students are exempt from military service until they graduate. The social prestige of the scientist is a powerful attraction. Scientists are well paid—ten to twelve times as much as an average worker,—they are provided with better housing facilities, they are given special consideration for their families, rest homes are provided for vacation activity, bonuses and prizes are given for important contributions. In short, the field of scientific activity is made very attractive.

The enormous expansion of the institutions of higher education in the Soviet Union may be regarded as a measure of the energy and resources devoted to the preparation of technical and scientific personnel. From all indications, the entire educational power of the Soviet state appears to be committed to the goal of overtaking and surpassing the U. S. in the scientific and engineering fields. The number of graduates per year in science in the U. S. S. R. is growing very rapidly. At the present time, it is almost twice the corresponding number in the U. S.

The program for training top-level scientists and technologists to carry out research and direction of industry is accompanied by a similar program for training a second echelon of subprofessional technicians. This corresponds in a general sort of way to our vocational schools and junior colleges. It is relatively new in concept and seems to have been introduced by the Soviets to cope with deficiencies that had been brought to light in the educational system. The schools established

[9] B. G. Holzman, *An Appraisal of Soviet Technological Capabilities*, Individual Study, NWC, 1st Semester, 1951–52, pp. 7–9.

[10] J. G. Crowther, *op. cit.*, p. 22.

[11] Benjamin Fine, "Moscow is Overtaking U. S. in Training of Technicians," *N. Y. Times*, 7 November 1954, p. 1.

for this purpose are associated with existing enterprises, such as factories, which provide the teaching staffs.[12]

Of course, quantity alone is an inadequate criterion. What about quality? All the evidence we have about curricula, standards of training, performance of students after graduation, and about the character and difficulty of published research work appear to indicate that the Soviet scientists are on a par with our own. If we grant that a like proportion of their graduates and ours develop into top-level calibre then it must be concluded that if they are training twice as many scientists and technologists they must be developing approximately twice as many first-rate ones.

An interesting point worthy of mention before we leave this topic is made by Dobzhansky on the risks that may accompany the granting of unduly great importance to science.

> "But the exalted position of science and scientists in U. S. S. R. is purchased at a high price. It carries serious risks and penalties. First of all, some of the more ambitious and unscrupulous types of persons who in the West would seek more remunerative and influential positions, in U. S. S. R. choose science for their careers. More important still, the very magnitude of the investment which the state is making in science, and the great influence which science may secure on the popular mind, render it inevitable that a government of the type which exists in U. S. S. R. will tightly control science and will seek to exploit it for political propaganda purposes."[13]

Effect of Communist Ideology on Science

We come now to the consideration of a second feature: the Communist ideology and its effect on the scientific effort. This is a subject that has been given a great deal of attention over many years and about which some sweeping statements have been made. The general tone of most of these statements is to the effect that Soviet science is due to collapse, that the regimentation of Soviet scientific effort will cause it to fall flat on its face. The immediate cause of these remarks and of a great deal that was written on the subject was the now famed Lysenko controversy. To put it very briefly, Lysenko was a charlatan who succeeded through the use of politics in getting control of the field of genetics. With this control, he accomplished the deposition of geneticists. A few of them, including the brother of the President of the Academy of Sciences, disappeared from the Soviet scene and have not been heard of since.

The effect of this occurrence on the West was striking indeed. It gave rise to statements by some of the world's leading scientists that here was clear indication that science could not flourish in a regimented

[12] Clifton Daniel, "Vocation Schools Opening in Soviet," *N. Y. Times*, 22 September 1954, p. 31.

[13] Dobzhansky, *op. cit.*, p. 40.

society. Professor Sirkle, of the University of Pennsylvania, who wrote a historical account of what had happened—insofar as it could be pieced together from such information as he had been able to get—entitled his book *Death of a Science in Russia*. Vannevar Bush in his book *Modern Arms and Free Men* said:[14]

> "Dictatorship can tolerate no real independence of thought and expression . . . No true fundamental science can flourish long under such a system, no matter what the individual genius may be . . . Science will eventually become a collection of superstitions and folklore. Men of genius will languish and succumb to discouragement . . . The system with which we contend cannot . . . even apply science to war in the forms it will take in the future, without mistakes and waste and delay."

Julian Huxley wrote a detailed examination of the Lysenko controversy in which he stated that:[15]

> "Nazi Germany paid for its attacks on scientific work. The U. S. S. R. will doubtless in due time pay an equally heavy price."

These points of view are still being expressed by some who continue to assert that the Soviet system contains within itself the seeds of its own destruction. And they point to similar detrimental effects of ideology on philology, economics, and statistics. But events of the last five years have raised some doubts. For example, the success of the Soviets in the production of nuclear bombs, of both the fission and the fusion types, in unbelievably short periods has confounded the predictions that it would be many years before the Soviets could hope to have atom bombs, if ever. We shall demonstrate in Section IV that the Soviets are making considerable progress in both the pure and applied fields of science. Vannevar Bush now says:[14]

> "We have now had some pretty convincing demonstrations of the success of Russian applied science. It's true, Russian weakness lies in the rigidity of its political system, but its application of science is evidently able to accomplish much."

Note also that the type of action which resulted in the Lysenko affair is definitely not irreversible. Indeed, Lysenko is on the way to being discredited.[16] Khrushchev, in February 1954, ridiculed a "so-called scientist" named Dmitriyev, whom he explicitly identified as a protégé of Lysenko. A few days later, Pravda printed a letter which referred to Lysenko's use of ideological arguments as a "mockery of Soviet science." Other critical statements about him have recently gone unchallenged. These developments may merely mean that Lysenko's ideas are not producing results and that he may have to make way for someone who can do better.

[14] "Red Science," *Newsweek*, March 1, 1954, p. 46.

[15] J. Huxley, *Soviet Genetics and World Science*, London, 1949, p. 196.

[16] "Lysenko Criticism Gains Volume," *Soviet Affairs*, OIR Report No. 4800.64, May 1954, pp. 13–15.

Without attempting to interpret such developments it remains true that we are really very poorly informed about just what effect Soviet ideology has on its scientific effort. Is it conceivable that the Soviets are actually succeeding in evolving a kind of existence which can simultaneously regiment politics and have little effect on science? Is it not true that the effects of ideology are felt only in limited areas of the entire scientific field? And is it not clear that where the concern is with obviously demonstrable applications of science (e. g., to military affairs), ideology plays a secondary role? Our present information furnishes no satisfactory answers to these questions.

Inculcation of Determined Attitude.

It is proposed now to discuss one further feature of the Soviet situation, *viz* the apparent existence of a spirit of determination and drive which spurs the people on to unusual achievements. Not much is known of the method by which this attitude is implanted but it certainly seems clear that when the Russians set themselves a goal they head for it with an amazing tenacity.

The recruiting of science students is a case in point. If a field of effort is considered to warrant a sufficiently high priority, the authorities go to great lengths to sponsor it.

Consider for a moment a field of activity entirely unrelated to science, the field of sports. For a long time, the Soviets did not compete at all in the Olympic Games. We don't know what their reasons were, and there does not seem to be any point in speculating about them. But once they decided that they would compete, they sent teams that really distinguished themselves; and it begins to appear probable that they may easily lead the field in 1956. Some aspects of their behavior in 1952 caused comments to the effect that the Soviets were approaching the Olympic Games with an attitude very different from that of all other countries. It was said, for example, that their entrants were not always sporting, and that they competed with a deadly sort of grimness. It was noted that the Soviets deliberately entered competitors in the less common events since they could thus have greater prospects of scoring points. The behavior of their team managers, who sometimes acted like MVD officials rather than sports coaches, was quite puzzling to their Free World opposite numbers. They argued about scores and about methods of tallying points.[17] They argued about procedure.

All this and much more provoked comment. Perhaps these were merely the excuses of Free World apologists who even questioned the amateur status of the Soviet entrants. In any event, the Soviet fanaticism did produce remarkable results.

[17] *Time*, 11 August 1952, p. 70.

A similar instance is found in the game of chess, which the Soviets have built up into a national pastime.[18] It is played very widely and great honor accrues to the players who distinguish themselves. The result of this attention to the game is that the present chess world is dominated by Soviet players. In a recent international tournament whose purpose was to pick a challenger for the world's championship (the present champion is a Russian, Botwinnik) and in which there were fourteen entrants, nine were Russians. Only two non-Russians ended up in the first half. All nine Russians had been sent at government expense to a special rest camp for almost a full month before leaving for the tournament. At the camp, they studied, attended lectures and were given special exercises to condition them physically. This last point may seem a humorous matter except for the fact that the scores during the tournament showed that the Russians performed significantly better against the non-Russians in the second half than they did in the first half. This can surely be attributed in large measure to the fact that they stood the strain of the competition better than those who had not been so well conditioned physically.

Psychologists may adduce in explanation of all this that the Soviets have a tremendous inferiority complex and are forcing themselves unduly by way of compensation. Be that as it may, this same kind of determination seems to pervade other aspects of the Soviet effort and, in particular, much of the Soviet scientific effort. Properly stimulated, such a drive can produce unbelievable results, as we have seen in the matter of the A- and H-bombs. Of course, it has its drawbacks too. It may well be that one result of such an attitude is that in those cases when they go off in a wrong direction, they go miserably wrong, so that their errors are really big errors. There have, in fact, been some apparently big blunders that call for an explanation. The important question for the Soviets in such instances is how long it will take them to realize that they are going in a wrong direction, and how much damage they may have done by that time.

How can we evaluate such a feature of the Soviet? Especially when there may be a real question as to whether the Soviets really have, in any unique sense, a greater drive than is found among people devoted to a cause in any other country. Assuming that it does exist, a quantitative evaluation is hardly possible. From a qualitative standpoint, suffice it to observe that a country is surely favored if it can profit from the inculcation in its people of a driving force towards those goals which its leaders have indicated to be of value to the country.

[18] P. Romanovsky, "Chess in Russia," *Soviet News*, London, 1946.

IV. PRESENT STATUS OF SOVIET SCIENCE AND TECHNOLOGY

We come now to the point where we try to find out from the evidence available to us what is the present status of Soviet science and technology. The distinction between these two terms is difficult to make and is sometimes artificial. In a very general sense, technology means applied science as distinguished from pure science, particularly such applications to methods and techniques as are used in industrial engineering, and agriculture, to improve and increase production. A fact, a theory, and a material can pass very quickly from the field of science to the applied field—so quickly indeed that it has become a commonplace among scientists. Much depends, of course, on the amount of emphasis and support which is given to sponsoring the advance of the concepts which have been developed. A Manhattan Project can save many years in going from a laboratory demonstration of uranium fission to the successful construction of an atomic bomb.

Such government support in terms of funds, facilities, and personnel becomes all the more necessary the greater the scope of the over-all program. This is a fairly recent type of development in the history of science and represents what is probably the greatest change from scientific effort of the past. Just think how long it took to go from the earliest discoveries in electricity to the commercial applications of electric power. There is a classic story about Benjamin Franklin, who, after one of his lectures on electricity, was asked by a kindly old lady, of what good was electricity. He answered, "Madam, what good is a new born baby?" This particular child matured very slowly. Large scale support by government or industry of scientific effort is a modern means of achieving a greatly accelerated aging of newborn babies. And the Soviets, in effect, have made a monstrous Manhattan project of all science.

There is undoubtedly a tendency for sponsored scientific effort to overemphasize applications of new knowledge at the expense of basic research. This is more apt to apply in industrial, private effort than in government. In either field skillful direction and understanding are required to derive the greatest long-range benefit from a program of scientific effort. Such capability and understanding have been present in U. S. industrial and university circles and have been important factors in our scientific and technological advances. Since in the Soviet Union, the programming must stem entirely from governmental direction, there is imposed upon such centralized, governmental control an increased responsibility for effectiveness.

How well they are coping with this responsibility can be gauged to some extent by the material that follows on the present status of the Soviet effort.

Pure Science and Research

There is considerable evidence from the open literature to demonstrate that the Soviets are doing quite well in pure science and research.

> "From being an extremely backward country in science only a generation ago, Russia has become an extremely important one. In some sciences, . . . it is already producing as good work as any country in the world, in older disciplines, in which other countries had already a long start over it, it has not yet been able entirely to catch up. But, on any standard, its achievement is remarkable."[19]

Their published work in mathematics, physics, chemistry, astronomy, and meteorology is very good indeed. So long as the field of effort is one which has no possible connection with Communist ideology, the work being done seems comparable to that in the Free World, and it can probably be said that in these fields the Soviets have pretty well pulled even with us. An idea—albeit, somewhat out of date—of the range of their researches in physics, chemistry, and biology can be obtained from the excellent and detailed presentation by Crowther.[20]

Let us consider some specific instances:

An extensive project conducted by the Air Technical Intelligence Center surveyed the entire field of Slavic geophysics between 1945 and 1952.[21] The primary interest of the study was to determine what work was being done in the investigation of the physical laws of the atmosphere which affect the operation of air-weapons systems. Thus papers in the following fields were examined:

- Terrestrial Electricity and Magnetism
- General Atmospheric Properties
- Meteorology
- Upper Atmosphere
- Night Sky and Aurora
- Meteorities
- Solar Physics
- Cosmic Rays

Over 800 publications were examined, at least in abstract. The following conclusions are drawn from the ATIC reports:

> "Over-all Soviet activities in the selected fields of geophysics are comparable to those of the United States. Soviet geophysicists are more active and their work appears to be of more significance than many people concerned in the U. S. may have realized. This is based on the large number of Soviet geophysical facilities that exist, the variety, number, and apparent technical level of problems investigated, and the number and apparent quality of the research personnel.

[19] C. H. Waddington, *The Scientific Attitude*, Penguin Books, 1941, p. 76.

[20] J. G. Crowther, *op. cit.*

[21] ATIC, Initial Report on the Status of Selected Fields in Geophysics in Foreign Countries, Project No. 9974, 15 June 1954, (SECRET)

"The importance of some of the Soviet geophysical investigations to air operations, as is the case with U. S. investigations, is not directly evident However, since most of the Soviet research is basic in nature, the U. S. S. R. may be in a good position to make future developments, as such geophysical developments are largely predicated on previous fundamental research."[22]

As a second example, consider a field of activity which has recently attracted considerable interest in the U. S. It includes such aspects as linkages, mechanisms, servomechanisms, control and computing circuitry, and allied fields. The name that has recently been coined for it in our own literature is Automation. The Soviets are especially prolific in this field and publish most of their unclassified papers in a journal with the title *Automatics and Telemechanics*, which will soon become available to the U. S A special study by the ATIC states that the extent of the Soviet literature in these fields suggests[23] "that Russian design of mechanisms is based on better theoretical grounds than accepted practice in either England or the United States." As an interesting sidelight on the applicability of these ideas there is a paper by a Soviet scientist named Levin which discusses an automatic factory. In this paper, the author foresees the extension of automatic computing techniques to industrial processes.

Additional examples of capacity in other fields can be adduced. As a general statement, it can be said that the published material indicates that the Russians are clearly holding their own in pure research and are making important independent contributions. There are many who grant that this is so but who still insist that pure science cannot flourish in a regimented society, that such a society contains within it the seeds of its own destruction. Only time will demonstrate whether they are right. For our purposes though, it should be noted that those fields which are "out-of-favor" are directions of effort furthest removed from military applications and therefore have the least effect on the Soviet capability to wage war.

Technology

In technology, the general picture is not as clear as in pure science. The evidence, which is available to us in considerable quantity, leads to conflicting and contradictory implications with regard to Soviet capacity. In discussing such evidence, we shall list first indications of efficiency and competence, followed by indications of inefficiency and lack of competence

Evidences of Competence

Let us first examine some general indications of demonstrated competence.

[22] *Ibid.*, p. xii.

[23] *Soviet Capabilities in the Field of Computation Machinery*, Air Technical Intelligence Study, No 102-EL-6/52-34, 31 January 1952, p. iii (SECRET)

A basic requirement for an efficient technology is availability of plant capacity and raw materials. Although the Soviets are probably endowed with resources comparable in many senses to those of the U. S., they have nonetheless always been far behind the U. S. in their development and exploitation, but the extent of this handicap has been very considerably reduced in recent years.

Consider some key figures from Malenkov's report delivered 5 October 1952 at the 19th Communist Party Congress.[24] These are placed alongside U. S. data for comparison. (The figures are in millions of metric tons, except for electric power which is in billions of kilowatt hours.)

TABLE I

	U. S. S. R.			U. S.
	1952	Percentage Gain over 1940	Goal 1955	1951
Pig Iron	25	70	34	64
Steel	36	90	44.7	95.5
Coal	300	80	377	523
Oil	47	50	70*	307
Electricity	117	140	162	482

* (almost)

Granting that the Soviet Union has a long way to go before she can rival the U. S., it must be admitted that her gains are impressive. Further, it should be noted that Hitler challenged the world with only 22.7 million tons of steel production (1938). Beria, Bulganin and many other Congress speakers referred in this Congress to the Soviet Union's ability to convert rapidly to a war economy. In other basic materials, aluminum, copper, rubber and chemicals, similar impressive gains have been made.

The smaller quantities of basic materials at their disposal force Soviet engineers to conserve and make more effective use of their limited allocations. This they do very competently. Thus, conservation of materials is often revealed in their product design without

[24] The Documentary Record of the 19th Communist Party Congress and the Reorganization after Stalin's Death —from the translations of the *Current Digest of the Soviet Press*, Edited by Leo Gruliow, 1953, p. V, (Introduction).

significant effect on the resulting equipment.[25] When special alloys require critical materials, these are used sparingly. We know that the Soviets are familiar with most of the special alloys that we use, but it can be demonstrated that they use them much more sparingly when critical materials are involved. Voznesensky makes a virtue of this necessity.[26]

In this same connection, their designs are generally simpler and less versatile than ours, thus making the equipment easier to produce, operate, and maintain. The requirements for spare parts appear to be reduced below the levels that our corresponding equipment would normally require. On those occasions when it has been possible to examine the same type of item produced at different times, indications have been noted of definite improvement in technological competence.

The accusations sometimes expressed that the Soviets are mere copiers are entirely unfounded.[27] Even in those instances where they are known to have copied foreign equipment, the copying has been cleverly done, with enough aspects of redesign to show improvements in strength, performance, ease of production and cost of assembly. Although the general procedure has been to downgrade the quality of individual materials whenever feasible, there are instances known in which they have substituted higher grade materials than those used in the original equipment.

They have effectively mastered the general principles of mass production, for they have risen in the field of industrial production from fifth place in the world to second, in one generation.[27] Cressey indicates that if the industrial index for 1913 is set at 100, that for 1938 is 908.8.[28] Even if we allow for some error in these figures, we have indication of improvement of a very high order of magnitude.

Let us now consider some specific examples in detail:

Russian communications equipment is relatively effective. Those items we have captured and studied seem to serve their purpose well. Note the following evaluation of a captured airborne transmitter:

> "The equipment is manufactured with all indications of high production run. Components are well arranged for accessibility of soldering and easy assembly. The frame of the transmitter is so designed that it can be placed in any position, i.e., top, bottom, side, etc., on the assembly line thus eliminating the necessity for a special fixture which normally would be used to carry the equipment along the line.

[25] Soviet Technological Skill Revealed by Materials Tests, *Soviet Affairs*, Aug. 1954, (OIR Report No. 4800.67) pp. 24–27 (SECRET)

[26] B. G. Holzman, *An Appraisal of Soviet Technological Capabilities*, Individual Study, NWC, 1st Semester, 1951–52, p. 8.

[27] Harry Schwartz, *op. cit.*, p. 622.

[28] G. G. Cressey, *The Basics of Soviet Strength*, McGraw Hill, 1946, p. 126.

> "The set designers succeeded in achieving fair performance as simply as would be possible for a transmitter of this type.
>
> "Circuitry is basic, and there are no exceptionally good or poor design features in the set.
>
> "Good stability which ordinarily is not attributed to a modulated oscillator-variable frequency transmitter, was achieved by careful design and selection of components.
>
> "Because of the design simplicity, the equipment would be easy to produce, operate and maintain, and would require a smaller stock of spares than U. S. World War II equipment used for a similar purpose."[29]

A further instance of their effectiveness in communications techniques bears on their design and use of radio transmitters for jamming purposes. Apparently the broadcasts put out by VOA must be considered by the Russians to constitute a real threat, since they devote a considerable effort to jamming them. The Russians' jammers appear to have no other function: it is estimated that the jamming network employs roughly 10,000 scarce technicians and costs approximately 5 times more to run than the total cost of U. S. broadcasts to the orbit.[30] The point of interest from the technological view is that although U. S. stations often change their frequencies to get away from the jamming signal, the Soviets get on to the new frequency and retune their transmitters with a speed indicative of excellent equipment and excellent operation.

The Communists have also been expending considerable money and energy in broadcasts as a propaganda instrument.[31] Many broadcasts are clandestine and so well handled as to appear to the listener to be of local origin.

In the field of construction engineering, the Soviets have undertaken gigantic projects equal to anything found anywhere else in the world. This calls for large scale equipment which they have designed and produced. A caterpillar excavator designed and produced at Novo-Kramotorsk has a bucket with a capacity of 19 cu. yds. A drag line excavator with a similar capacity of 18 cu. yds. can cut into the ground at a distance of 50 yds. and dump a full load once a minute as far away as 130 yds. A crew of 15 engineers on such a machine can do the work of 7,000 or more men.[31] There are many other types of new machines scrapers, dump trucks, etc. On one major project, these and other machines will enable four billion cu. yds. of earth to be moved in 5 to 7 years—about 16 times the amount moved for the Panama Canal. In the construction of large buildings, the conspicu-

[29] Analysis of Communications Equipment, ATIC Technical Report No. TR-EL-44, 6 December 1951, p. VI, (SECRET).

[30] "Soviet Bloc Improves Foreign Radio Net," *Soviet Affairs*, Dec. 1953, pp. 23 ff. (SECRET).

[31] S. M. Manton, *The Soviet Union Today—A Scientist's Impressions*, London, 1952, p. 87.

ous features are the giant crane and the simplicity of scaffolding.[32] Bricks are sent up to the bricklayers on conveyor belts or lifts from ground level.

Many more instances can be cited to indicate a highly efficient, favorable state of Soviet technology. It would appear probable that they can produce anything we can, provided they assign it a high enough priority. The rate of progress they have made during the five or six years immediately following the war has been phenomenal. Extrapolating with this rate over a long period, we can—and sometimes have[33]—come up with predictions that are frightening. But such a process of extrapolation is inadmissible. Apart from the point that high percentage increases are more easily accomplished on a smaller base, these rates of improvement include such special factors as the receipt by Russia of a great deal of U. S. equipment during the war, the acquisition of a large number of German scientists and technicians and the removal to the Soviet Union of entire industrial plants from occupied countries.

Besides, there is quite a case to be made for the view that Soviets are far from being supermen, and not anywhere near as good as the preceding evidence would lead us to believe

Evidences of Lack of Competence

There have been numerous indications of Soviet error, lack of efficiency, inability to meet planned goals, mistakes in allocations and in programming of effort, failure to achieve worker cooperation, unsatisfactory end products, etc. Despite the strict censorship imposed, despite the controlled handling of the dissemination of information, despite the constant propaganda efforts always to paint in bright colors even when the pigments were tarnished, information has regularly got out proving that there are lots of problems.

Thus, there has been repeated acknowledgement by the Soviet leaders of acute housing shortages,[34] this despite the fact that inadequate housing has been one of the most consistently dark aspects of the Soviet standard of living. Various estimates available for several different periods since the Revolution indicate that the average per capita housing space has been of the order of 4 to 6 square meters. The larger of these figures represents the space occupied by a square 7 to 8 feet on a side. The estimate for 1950 is somewhat under that for the mid 1920's when it was very poor. At that time the typical housing available for a small or medium sized family in a Soviet city was only one room, in an apartment containing three to six families, all sharing the kitchen and bathroom, if any.[35] According to a recent article in *Voprosy Ekonomiki*, the 1954 housing construction goal is 37.8 million square meters—9.8 million more than in 1953. The figures given for actual construction in 1951, 1952, and 1953 are 27,27,28. It appears most unlikely that Soviet construction industry will be able to achieve the expressed goal. Scattered data indicate that even the foremost Soviet building enterprises are lagging behind plan. And suppose the goal could be met, it would represent a per capita increase of approximately 2 square feet for the entire year. Compare this with U. S. figures. We have been building over a million homes a year. A conservative estimate would allot 1,500 square feet on an average to each home, thus making a per capita increase of almost 10 square feet—an actual accomplishment five times as great as the expressed Russian goal, despite the fact that our requirement is nowhere near theirs.

A continuing series of Soviet press articles during recent months indicates that the growth of the Soviet coal industry is being hindered by technological difficulties, essentially a need for a radical change in mining technology.[36] Although coal output in gross tonnage terms has been increasing steadily since the end of World War II, and the industry has met or exceeded its production targets every year except one since 1947, the rate of progress does not appear to satisfy Soviet authorities.

In the peace terms of 1944, the Soviets acquired from Finland about seventy industrial concerns. They imported Soviet staffs to manage these going concerns and found, with the passage of time, that competitive conditions were too rough for them. Well over half were sold during the past year—all to Finnish buyers.[37] A Finnish official who has been keeping a close eye on these developments says there's hardly any doubt now that the Soviets are out to sell them all. Their management staffs are just not up to the tasks that have been assigned them.

The production goals set in the 5-year plans are seldom achieved. Perhaps it is because they are deliberately exaggerated as a mechanism for spurring on endeavour, but if so then it is not easy to explain the constant carping and criticism that gets into official pronouncements.

[32] *Ibid.*, p. 22, fig. 6.

[33] Soviet Air Forces, *Air Technical and Scientific Capabilities*, Air Intelligence Study, AIS 2-23, 1 April 1953, Def 1, USAF and ONI, p. viii, (SECRET).

[34] "U. S. S. R. Steps up Efforts to Improve Housing," *Soviet Affairs*, November 1954, pp. 16, 17

[35] Harry Schwartz, *op. cit.*, p. 453 ff.

[36] "Technological Problems Plague Soviet Coal Industry," *Soviet Affairs*, November 1954, pp. 17–19.

[37] M. Gordon, "Soviet Plants in Finland Find the Capitalist Competition Too Tough," *Wall Street Journal*, 2 December 1954, p. 1.

"As late as September 11, 1950, *Pravda* found it necessary to print a long article complaining about the frequently low productivity in Soviet plants."[38]

Other manifestations of inadequate productivity are seen in the Soviet Union's failure to meet commitments in foreign trade. For example, in September 1954, reports from Argentina indicated disillusionment in her attempts to do business with the Soviets.[39] A trade agreement with the Soviet Union was supposed to do big things for Argentina and was to serve as the basis for expanded Soviet trade in Latin America, but it is not working out that way. Argentina started shipping exports to the Soviet Union shortly after the agreement took effect. The Soviet deliveries, if made at all, are falling far short of promises. In particular, the Soviets are failing to deliver promised capital equipment—farm machinery, generators, transmission equipment, and oil-field equipment.

Finally we need but mention, without going into detail, such considerations as the effects of regimentation and compartmentation, the disadvantages of bureaucracy, the omnipresent MVD and its detrimental effects on freedom of thought and inquiry, the low living standard of workers, the serious inefficiencies of Soviet transport and many other deficiencies which must have detrimental effects on their technology.

When we try to weigh in the technological balance the evidences of efficiency and capability in the one pan against those of inefficiency and lack of accomplishment in the other, we find that the pointer of the scale wobbles so violently—now tipped one way, now the other—that it is not possible in our present state of intelligence to arrive at a satisfactory reading. This naturally complicates our problem of prognostication.

FUTURE PROSPECTS

What then shall we say about the future of Soviet science and technology? It is a difficult subject in which to make predictions. Some highly competent people in this country have made very wrong guesses. Witness the testimony in 1945 of Vannevar Bush and General Groves before a Senate Committee that was studying the possibility of the Soviets' producing nuclear weapons. Other instances can be cited of relatively recent opinions about Soviet capability which have already been shown to be far wide of the mark.[40]

We cannot doubt in any event that the Soviet Union is a ranking power in science and technology. She is advancing at the present time

[38] Harry Schwartz, *op. cit.*, p. 652.

[39] *U. S. News & World Report*, 24 September 1954, p. 85.

[40] Harry L. Hillyard, *Soviet Science and Technology: Present Levels and Future Prospects*, Individual Study, NWC, November 1953, (SECRET), pp. 2-6.

at a rate faster than that of the U. S. and if these relative rates remain unchanged for any lengthy period, then it follows that with time the Soviet Union could pull even with and then surpass the U. S.

In this matter of comparative rates, the point should be kept in mind that much of the work done in the Free World is readily available to and being utilized by the Soviet Union. An idea of the vigor with which such information is sought and collected by Soviet representatives in the U. S. can be gained from an article in the *ONI Review for Mid-summer 1954*, entitled "Soviet Intelligence Collection in the U. S."[41] A much smaller percentage of Soviet results is getting to the Free World and our scientists are not giving that smaller amount as much attention as it may deserve. This is an additional factor making for long-term advantage to the Soviet Union.

As the Soviet technological situation improves and the production of consumer goods is expanded, the general living standard of the Soviets will continue to rise. We might hopefully look forward to a time when the Soviet situation is sufficiently improved to change their outlook on world affairs and cause them to live in greater harmony and cooperation with the rest of the world. But this is clearly a kind of wishful thinking and not justified on the basis of anything we have seen since the end of the war.

Assuming an indefinitely continuing cold war, there will be continued emphasis on research into military weapons, both offensive and defensive types. From all indications, the Soviets are devoting a relatively greater percentage of their budget and of their national capability to these matters than we are.

Now science is not static. Advances are being made continuously. Despite the fact that nuclear weapons represent a tremendous advance over anything that had preceded them, it is an error to think of them in their present form as representing any sort of ultimate accomplishment. They can be improved on and no doubt will. Of the total energy available in the uranium of an atom bomb, only one tenth of one percent is actually utilized in the explosion.[42] There is considerable room for improvement in the power of nuclear weapons.

Improvements can also be anticipated in the methods of delivery of bombs. After all, the intercontinental guided missile is already in sight. Such developments then as increased size and improved delivery are readily conceivable. In the light of the present stalemate, I do not believe that nuclear weapons will be used by either side in the forms

[41] "Soviet Intelligence Collection in the U. S.," *ONI Review*, Supplement, Mid-Summer 1954, pp. 7-11. (SECRET).

[42] Samuel Glasstone, *Sourcebook on Atomic Energy*, van Nostrand, 1950, p. 418.

now known to us or even in the forms to be anticipated in the near future.

What should really worry us is not the weapon or the method of delivery that we can conceive. What we ought to be concerned about is the next step that we cannot now forecast. Just suppose that the basic development in science within the next ten or twenty years is a new weapon as decisively superior to the A- and H-bombs as they were to their predecessors.

That such an idea is far from fantastic can be easily demonstrated. In June 1937, the Science Committee of the National Resources Committee submitted to the President a report entitled *Technological Trends and National Policy Including the Social Implications of New Inventions*. Contributed to by many eminent scientists, it was intended to consider aspects of national policy which had to be kept in mind as a result of new inventions which might develop within the next ten to twenty-five years. It does not even mention atomic energy. The date warrants repeating—June 1937, and it was not considered that atomic energy would be a matter of concern in the succeeding 10 to 25 years!

Suppose then that the next basic military development is a new military weapon decisively superior to nuclear bombs or an effective defense against nuclear weapons. Suppose the Soviets develop it first and push it to an advanced stage or produce it in quantity even before we become aware of it. What could we do if we were suddenly threatened with such a situation. That to my mind, is the real danger that confronts us, and which we must aim to prevent by every strenuous means in our power. We must not lose the scientific race against the Soviets for to do so means losing the war—be it cold or hot. We feel certain we have the ability to win; we are convinced we have the better system; if we make proper use of our ability and our system we will win.

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