Concatenated JPRS Reports, 1989



| | | | |
|---|---|---|---|
| **Classification:** | UNCLASSIFIED | **Status:** | [STAT] |
| **Document Date:** | 01 Jan 89 | **Category:** | [CAT] |
| **Report Type:** | JPRS Report | **Report Date:** | |
| **Report Number:** | JPRS-USP-89-007 | **UDC Number:** | |

**Author(s):** PRIRODA correspondent with Roald Zinnurovich Sagdeyev, academician, specialist in the field of plasma physics and space research, chairman of the Soviet Scientists' Peace Committee, Hero of Socialist Labor, recipient of the Lenin and State prizes, member of the U.S. National Academy of Sciences , the Swedish Royal Academy, the Max Planck Society and a number of other academies, under the rubric ''The Organization of Science. Space Research'': ''Let Us Not Put Ourselves in the

**Headline:** Sagdeyev Discusses Space Missions, Policy, Mars Plans

**Source Line:** 18660073a Moscow PRIRODA in Russian No 1, Jan 89 pp 33-46

**Subslug:** [Interview by PRIRODA correspondent with Roald Zinnurovich Sagdeyev, academician, specialist in the field of plasma physics and space research, chairman of the Soviet Scientists' Peace Committee, Hero of Socialist Labor, recipient of the Lenin and State prizes, member of the U.S. National Academy of Sciences, the Swedish Royal Academy, the Max Planck Society and a number of other academies, under the rubric ''The Organization of Science. Space Research'': ''Let Us Not Put Ourselves in the Position of the Junior Partner!''; first paragraph, given in boldface as printed, is PRIRODA introduction]

**FULL TEXT OF ARTICLE:**

1. [Text] Space research, despite its relative youth (the 30th anniversary of the beginning of the Space Age was observed not that long ago), has become a well-established part of our lives. We have become accustomed to regular launches of manned craft and unmanned cargo craft into near-earth orbits and no longer remember very well how many people make up the cosmonaut contingent in our country, not to mention those in the USA. It is true that we continue to be enraptured as we view the magnificent photographs on which have been imprinted the Earth or, for example, the giant planets Uranus, Jupiter or Saturn. But this is a glance from the side. But what is actually going on in this field of science and technology whose actual state of affairs we have long known less than we would have liked to have known? What problems are troubling the specialists who have devoted themselves to cosmonautics? Academician R. Z. Sagdeyev, who headed up the USSR Academy of Sciences's Space Research Institute

for more than 15 years, shares his own thoughts in this connection in an interview with our magazine's correspondent, N. D. Morozovaya.

2. [Correspondent] For the two great space powers--the USSR and the USA--the year 1992 will be rich in major historic events: it represents the 500th Anniversary of the discovery of America, the 75th Anniversary of the Great October Socialist Revolution and the 35th Anniversary of the beginning of the Space Age. Is it true that, at the suggestion of these two countries, it has been proposed that the year 1992 be declared World Space Year?

3. [Sagdeyev] In fact, such an idea is being discussed now in the various international unions and, evidently, the ICSU--the International Council of Scientific Unions-- is supporting it. (I would remind you that all scientific unions belong to the ICSU, including our COSPAR--the Committee on Space Research). Everyone recalls what a colossal success the International Geophysical Year was (1957-1958), during which the earth's very first artificial satellite was launched. This year brought together, in an unusual manner, scientists from many countries, and the international scientific community welcomed the news about the launching of the Soviet satellite with enormous enthusiasm. And now, 30 years after that event, the very same ideas are guiding the scientists who are proposing this time that an International Space Year now be declared. If such a resolution is adopted, I am certain that UNESCO will also support it.

4. It is difficult to overestimate the significance of so important a measure; it will produce an occasion for exchanging views about what has been done in space in the past and what needs to be done in the future. Above all, this should strengthen international cooperation. Additionally, it is now very important that an active promotional campaign be conducted among the broad masses regarding the achievements of cosmonautics and space science, because, on the one hand, space science and technology can play an enormous role in solving many contemporary global problems, and I have in mind, first and foremost, ecological and economic problems, not to mention space science itself, which is experiencing a period of turbulent growth. And, on the other hand, the expenditures for space research are extraordinarily great. At one time, Academician L. A. Artsimovich defined science as a means for satisfying the curiosity of scientists at the expense of the state. But space research is not at all an inexpensive means for satisfying this curiosity. Therefore, the adoption of decisions regarding the main directions to be taken in the development of space research has always been coupled with a heavy burden of responsibility.

5. During the development of the Soviet space program, we had an

opportunity to discuss our own approach at the International Space Forum, which took place in October of 1987, in Moscow. At the forum, we stated to scientists from 35 countries our own firm conviction that space research should not become an arena of competition and rivalry. And the economic aspects are by far not the least important factor. For that very reason, it is very important to explain why so much effort is being expended and enormous amounts of resources are being spent, while, within the framework of the scientists' international cooperation, it is necessary to look for ways to do this more cheaply.

6. [Correspondent] Thus, it is possible to say that space research is already quite a ''mature'' field of science that, in your words, is now blossoming. What would you list as its most fundamental achievements in our country and abroad?

7. [Sagdeyev] I consider one of the biggest yet achievements in the field of space research to be the discovery of the earth's radiation belts and magnetosphere. It is no accident that, even today, the earth's magnetosphere, with its own complex plasma dynamics, particle acceleration and instabilities, continues to interest many scientists. A great deal of work is being performed in that field, and special satellites are being launched. A number of hard-to-measure processes, such as shock waves, the recoupling of the magnetic field's force lines and turbulence, make it necessary to perform new generations of experiments. In order to understand the cause-and-effect connections between events in the complex solar magnetosphere-ionosphere system, it is necessary to probe its various critical regions simultaneously, using a broad network of satellites and ground stations which operate in conjunction with them.

8. Thus, the Interbol project currently being prepared is intended for investigation of near-earth outer space using a system of probes. This project, planned for the years 1990-1991, includes two Prognoz-type satellites, each of which will have its own subsatellite. Interbol's basic task will be the study of the physical mechanisms responsible for the transfer of the solar wind's energy to the magnetosphere, for the accumulation there of this energy and for its subsequent dissipation in the magnetosphere's auroral regions, in the ionosphere and in the earth's atmosphere during magnetospheric substorms. One of the satellites--the ''tail probe,'' with its own subsatellite--will be placed into an orbit which will pass through the tail of the earth's magnetosphere, which is an energetic reservoir of magnetospheric substorms; whereas the other (the ''auroral probe,'' with its own subsatellite) will be placed into an orbit which passes through the region above the so-called auroral oval at an altitude of 5,000-15,000 km. Typical of this region are the charged-particle acceleration processes and the presence of

electric currents, which couple the electromagnetic field in the magnetosphere 's tail with the conducting ionosphere. Along with these experiments, studies will be made in the Interbol project of the plasma and the magnetic structures of the far regions of the magnetospheric tail. In order to do this, plans have been made to use instruments on board the Relikt-2 astrophysical satellite.

9. Furthermore, in answer to your question, I want to note that our ideas about the solar system's planets have changed considerably. Now we have an opportunity for making direct contact with them. And this applies primarily to Venus, which we began to study using space technology resources more than 25 years ago, over which time we have sent 18 spacecraft to it. We managed to obtain, first, black-and-white images and, later, color images of the planet's surface at the landing sites of these craft. The elemental composition of the soil was determined in situ, i.e., a quite complicated technical problem had been solved. The use of radars made it possible to obtain a radar map of the planet's surface and to determine its typical morphological features. A great deal of attention has been paid to the investigation of the atmosphere and the cloud layer on Venus. A lot of new and interesting data--not just about Venus, but also about Halley's Comet--was obtained during the Vega mission, but that has already been recounted in detail in PRIRODA, and I will not dwell on it.<sup>1<reset> Thus, summing up certain results, I can say that the study of the planets will remain a very important area of research for several decades to come; of this, I have no doubt.

10. Astronomy, in going out into space, has received an opportunity to see the universe in a new way: ultraviolet and x-ray observations have been added to the observations in the optical and radio frequency ranges, and { quanta are being recorded very reliably. At this very minute, the x-ray telescopes of the Kvant observatory are making observations of the supernova which exploded in 1987 in the Large Magellanic Cloud. For the first time, astronomers can investigate directly the processes which occur, it can be said, at the nearest approaches to neutron stars and black holes.<sup>2<reset>

11. [Correspondent] In your opinion, what has space research given and what might it give to the other fields of science? And, in connection with this--is it possible to speak even today of some kind of practical return from the biological or, for example, production experiments in space?

12. [Sagdeyev] From my point of view, the biological experiments are an independent field of space science. First of all, they have made it possible to get an idea about the capability of the human body, or generally any living thing, to exist and function in zero-gravity

conditions. I cannot begin to say what practical importance they will have in the coming decade (in addition to, of course, those relatively brief--several months--cosmonaut flights, of which we are currently witnesses). But, if, after about 20 or 30 years, a manned flight to Mars still takes place, it will be a rather complicated mission, since it will require that man's stay in space be extended to as much as two to three years. I reiterate that, for the time being, it is difficult to talk about some kind of practical return from, for example, space biology for medicine, but, as a physicist, I would say that it is extremely interesting to study a substance under extreme conditions--at high pressures and high, or conversely, extremely low temperatures; this immediately helps extend the limits of our ideas about the phenomena under study. If, for contemporary medicine and biology, the absence of gravity is an example of such extreme conditions, then I think that interesting discoveries are possible on this path, but, I reiterate, it is difficult for me to make a judgment about this.

13. I would apply this very same principle of evaluation to technology as well, in particular, to the growing of crystals under the conditions of weightlessness. Unfortunately, no decisive step has been made in this direction. Every now and then, there are reports about certain minor achievements, but it seems to me that we are still a long way off from any substantial knowledge or any serious incorporation of those achievements into our earth-bound practices. I would say that a vacuum developed for a period of time in this field, and serious specialists in solid-state physics--the ones who determine the direction of development of this science here on earth--did not enter the field. As a result, the vacuum was filled by engineers hurrying to get something introduced a little faster. For the time being, unfortuately, the situation is changing very slowly. Apparently, it is our academy who needs to take decisive steps to correct the situation that has developed.

14. [Correspondent] After a brief hiatus, the Soviet space program has again turned toward Mars. I am referring to the Phobos project, which got under way in June of 1988 with the launching of two unmanned interplanetary vehicles to Mars and its satellite, Phobos. As is well known, this is a multipurpose program which provides for an variegated investigation of the planet and its satellite, the sun and interplanetary space. Phobos should be the first small body of the solar system whose surface will be reached by a space vehicle. More than six months have passed since the launch of the spacecraft. Have you managed to get any kind of interesting results over this period of time?

15. [Sagdeyev] I would like to remind you that, on the flight path to Mars, the majority of scientific instruments have not yet been

turned on; nevertheless, the first and, it seems to me, interesting data have already begun to arrive.

16. For example, included in the project's scientific mission were Soviet-French experiments on the study of gamma radiation from solar flares and gamma bursts from neutron stars. Conducting these measurements simultaneously aboard near-earth satellites and interplanetary probes will make it possible to locate very precisely space sources of gamma bursts and to make stereoscopic measurements of solar flares (indeed, now, besides the Phobos vehicles, gamma bursts are also being recorded by two American satellites--SMM and Pioneer Venus). On the flight from Earth to Mars, the Phobos vehicles' instruments were working continuously and were recording gamma bursts over an interval of 1-3 days. Thanks to the high sensitivity of the detectors and the use of microprocessors for preliminary processing of the data, it has been possible to measure the time structure of the { bursts with a resolution of around 1 ms. It is already clear that the bursts' spectra have a complex, multicomponent pattern and change in a matter of fractions of a second. After joint processing has been performed on the data obtained from all the space vehicles, the experimenters hope to determine the location of unknown { radiation sources (both in the sky and on the sun's disk) with an accuracy of several seconds of arc.

17. And I would like to talk about one more result obtained, since it concerns plasma physics--a field that is closest to my scientific interests. The Phobos vehicles' instruments have located the intersection of the shock wave front at the boundary of the earth's magnetosphere, and the intersection was a repeated one. This affected the relatively slow motion of the spacecraft in such a fashion that it seemed as if the shock wave front would run ahead and then drop back. As a result, we have obtained approximately a dozen such intersections. It must be said that, in and of itself, the intersection of the shock wave front is not of much interest on earth. But, for us, this was an extraordinarily important test which proved that the instruments aboard the spacecraft were operating properly. We are now firmly convinced that the equipment's sensitivity is so high that we have reached a world-class level in plasma measurements. I am talking about the APV-F instrument--the plasma wave analyzer.

18. Similar such instruments were also on the Vega probes, but the situation was different at that time: the plasma activity of Halley's Comet was so great that we were not the least bit concerned about whether the sensitivity of the detectors was adequate or not. But in the Phobos project, a number of very delicate tasks had been set up which require that the equipment have enhanced sensitivity. The

specialists have no doubts that we will be able to study the shock wave in the vicinity of Mars; but it will be much more interesting to observe how a small satellite, with a diameter of 20 km all told (I am talking about Phobos), moves within the plasma--after all, it will create disturbances of a much lesser intensity.

19. This experiment turned out to be the last one in which Frederic Scarf--the well-known American physicist and researcher of the solar wind and the magnetosphere and a great and long-time friend of our institute--participated. He was also engaged in the Vega project: Phobos became his last creation--Scarf died suddenly, literally several days after the launching of the vehicles. We are now preparing for publication the materials that were obtained. I recall this because it was Scarf who, several years ago, discovered a very interesting graphic method for representing the results of the investigation of plasma oscillations with these types of intersections of shock waves or other similar regions. The idea is a simple one--the spectrum of the electrical and magnetic oscillations which are characteristics of these types of processes lies in the region of what for us are the customary sound waves. Scarf simply converted the electromagnetic noise into sound, and an unusual polyphonic music was obtained--an actual ''sound picture.'' This technique was used for the first time during the investigation of Jupiter's magnetosphere by the Voyager interplanetary probe. I hope that this time we will also reproduce the ''music'' of Mars and Phobos according to Scarf's recipe.

20. [Correspondent] Unfortunately, on 2 September 1988, contact was lost with the Phobos 1 probe. How will this affect the entire research program,and what is being done in connection with this?

21. [Sagdeyev] Of course, this was a heavy blow for us. On 6 September 1988, at 5 pm Moscow time, a telegram with the following content was sent to the members of the international cooperative who were participating in the project: ''The Control Center has informed us that Phobos 1, because of an error in a command, lost its attitude and is not responding to signals from earth. The Control Center is attempting to re-establish contact with the spacecraft. We will keep you informed of the situation.''

22. So far, the situation has not changed. All kinds of measures are being taken to re-establish contact with the vehicle. Evidently, it will be very difficult to do this. But, so long as there exists even the slightest theoretical possibility of getting in contact with Phobos 1, such efforts will not cease.<sup>3<reset>

23. With regards to the scientific program of research, I would like to remind you that two vehicles are taking part in the project and,

to a large extent, they duplicate one another, although, unfortunately, not in everything. There are several instruments on Phobos 1 that are not on Phobos 2. Primarily, I am talking about the Terek instrument, whose tasking included investigation of the sun's x-ray radiation. It was developed by specialists from the USSR and the CzSSR. Now we are deprived of a lot of unique scientific information, and this is extremely disappointing.

24. [Correspondent] One cannot help remembering how successful the Vega mission was just two years ago, despite the fact that this was the first multipurpose project. Undoubtedly, the performance of such space projects is a very difficult matter in which nothing is trifling and it is too expensive to have to pay for errors. Obviously, the role of the scientists must increase. Is this not what you had in mind in your speech at the International Scientific Council on the Phobos project, which took place at the USSR Academy of Sciences' Space Research Institute in June of 1988, when you called for an end to the ''hegemony of the producer?''

25. [Sagdeyev] I would say that everyone is familiar with the concept of the hegemony of the producer in our economy, on a personal basis, and all it takes, for example, is to go into any store. In actuality, this phenomenon is, of course, much more widespread and, unfortunately, those who work in cosmonautics also feel the effects of the faulty system which has come about in our economy. For example, the numerous--from the first to the sixteenth--Venera-series craft appeared not at all because our scientists were reaching out toward Venus so very madly; rather, it was simply a matter of this: it is either Venus (in the extreme case, Mars) or nothing. And quite often, it was necessary to contend with the fact that there was no real competitiveness between the industrial enterprises which specialized in this area. In each specific field, monopolies emerged, and, as a result, the scientists had almost no choice.

26. Moreover, it was even necessary to put up with them banging their fists on the table at you. Unfortunately, this practice still persists, as was demonstrated by the recent events associated with the analysis of the situation on the Phobos 1 craft. Evidently, glasnost and democracy will come to the aerospace industry last. It seems to me that all too often, in general, people take refuge in ''secretiveness'' in order to make life easier for themselves. I attribute this primarily to those managers who lack adequate capabilities for conducting their own affairs in a professional (and--as a consequence--successful) manner.

27. [Correspondent] Nevertheless, one would very much like to believe that, in the end, glasnost and democracy will come to all the

spheres of our life just the same. But, it is still not clear to me why, before recently, it was Venus or Mars that was selected as the research project?

28. [Sagdeyev] For each space project, with its own scientific or technical sparkle, it is necessary to develop an appropriate spacecraft. In order to do this, the designers, together with the scientists, create technical specifications that, each time, are new. But, in our case, the task consisted of trying to use an already existing ''machine'' over and over again. We were simply lucky that, in its time, the craft of the Venera series was thought up and its first models developed by such a remarkable enthusiast as G. N. Babakin. One can only marvel at the longevity of these craft: after all, with a design developed on the basis of them at the end of the'60s for the flights to Mars (recall Mars-3 through -7)--with certain modifications, of course--we managed in the middle of the'80's to pull off such a complex, multipurpose project as Vega.

29. That is why I want to emphasize once again that competitiveness should be incorporated in the system from the very start, and then it's a matter of the consumer (in this case, the scientist), based on his own interests, selecting the best, the optimum version of the design effort.

30. [Correspondent] Then, will what is now being planned to be done during the Mars 94 project also be an example of such competitiveness?

31. [Sagdeyev] Everything depends on how perestroyka goes. In fact, there are still a lot of little nooks and crannies (quite a few) into which, for all practical purposes, it has not yet penetrated because of ''secretiveness.'' But, I am hoping all the same that, by 1994, we will develop a good project. And it is very important that, from the very beginning, the principles of scientific democracy and glasnost extend to all our international cooperation among scientists. In fact, we have managed to establish at the Space Research Institute quite a remarkable, informal scientific association which includes the laboratories of 15 countries, and, in certain projects being developed at this time, the number of participants is even greater. The main thing is for everyone to realize that each member of such international cooperation has a right to his own opinion.

32. And, in my opinion, it is quite unimportant that competing versions developed by two industrial enterprises for the Mars 94 project propose the use of different launch vehicles--either the Proton or the Energiya, i.e., the space probes will differ in the overall weight of the scientific package sent into space. The main thing is that, during the process of the preparation for this

project, the element of competitiveness emerge immediately. Indeed, each of the groups, in proposing its own design version for the flight to Mars, is now trying to find the most interesting features of its own scenario in order to show that its design is the one which will enable science to get what it wants, and to the fullest extent.

33. [Correspondent] There are differing schools of thought on manned flights, particularly to Mars. Do you count yourself among the proponents of such flights, or are you for the unmanned probes?

34. [Sagdeyev] I consider manned flight a very important measure. It cannot be based only on the need to solve certain scien ific problems. It also has a very important political aspect, inasmuch as it is its own kind of counterweight to purely military projects such as, for example, SDI. But, at the same time, it must be clearly understood that this is also still a very complex project. It is clear that no one is ready to do it today: the equipment needs to be developed, and more information must be obtained about Mars itself and about what we call its ''engineering model.'' I am talking about the collection and assembly of the data which must be available to the engineers and designers in order to develop the unique equipment, put it into a Martian orbit, and then perform the flight and landing through the planet's atmosphere under little-known conditions.

35. Now in this first stage, as a precursor to manned flight, there absolutely must be unmanned missions by robot vehicles. They need to be planned as the first links in a long chain of flights. In fact, even today, we need to think about a general line of research and not simply ''snatch out'' some individual flights.

36. [Correspondent] But does such a general line exist at the present time? And can you say something about the difference between the strategy of the space program in our country and that in the West?

37. [Sagdeyev] I can freely assert that we have such a line of research. Thanks to glasnost, which made its way into our space science very swiftly, we simply were prepared for this, understanding that it is impossible to work otherwise. We have been able to express and approve our own point of view on the development of space research (of course, this point of view is not something hard and fast--it is continuously developing, and we are taking into consideration our partners' suggestions as well). This point of view has now become, I would say, a generally accepted concept.

38. Good orbital craft must first be developed, then descent modules must be landed on the surface of Mars, and then the landing craft must be made to move about the planet's surface, i.e., turn it into a

Martian excursion vehicle and teach it to overcome obstacles and traverse the various geological and climatic zones of Mars. It is possible that, along its path, it will detect some signs of life or, at very least, traces of organisms which existed at one time.

39. [Correspondent] Do you consider the question ''Is there life on Mars?'' still open?

40. [Sagdeyev] Yes, it seems so to me. In any case, our duty is to use all of the flights to this planet to obtain a definitive answer. A negative answer will also be extraordinarily important.

41. Subsequently, in the course of a discussion on the Mars 94 project, our foreign colleagues proposed adding to the above-described scenario yet another launching of balloon probes and even advanced a very interesting idea for their design: a double envelope--one filled with helium and one with hot air--which would ''lie down to sleep'' at night and then, in the daytime, through the action of the solar rays, rise up once again and continue its own flight.

42. The next stage, also unmanned, involves the return of soil samples from the most interesting regions of Mars to Earth. If, by this time, equipment has been developed for travelling across the surface of Mars (and it requires not only an unusual design for a self-propelled vehicle, but also, in essence, actual artificial intelligence, which would control the Martian excursion vehicle), then we can count on such a vehicle to gather samples of material in the most diverse regions of the planet and deliver them to a rocket waiting to be dispatched to Earth.

43. This is one such scenario and sequence of operations which, in my opinion, can quite realistically be accomplished in this century. It is very important that the projects be international ones--then they will cost each of the participants a lot less. After all, we can no longer allow ourselves the luxury of thoughtless competition-- who will get a launch off first--with the parallel expenditures of enormous sums. But, the main thing is for all of us--the project's participants--to feel that we are the ambassadors of a single, small and, unfortunately, rather fragile planet, the planet Earth.

44. [Correspondent] In the spring of 1988, you were in the USA, where you met with American scientists and politicians. Was the possibility of a joint preparation and flight to Mars discussed? If so, what was achieved in these talks?

45. [Sagdeyev] To date, our meetings with the American scientists are proceeding in this manner: we are exchanging ideas and, I would

say, working out what are still just speculative scenarios. There is enormous interest on both sides (by the way, it's in Europe also). But the matter of an agreement is already being touched upon by the highest leaders of both countries. You know that M. S. Gorbachev, in his own speeches, has several times dwelt specially on the subject of joint Mars research. Of course, his interest inspires us. But that the same kind of enthusiasm needs to be displayed by the American administration. It had no time just then, for as you know, the election campaign was going on in the United States, but we are hoping that the new administration will regard these space projects with greater interest.

46. Yet, all the same, after the Moscow meeting, some changes had begun to show in the top levels. For example, we were given the opportunity to discuss officially the approaches to this problem (I am talking about the flight to Mars) with NASA administrators. For the time being, we are exchanging views on the unmanned scenarios of the Soviet flight to Mars, with an eye to starting up, sometime in the future, a discussion on joint missions.

47. [Correspondent] As is well known, the cost of both multipurpose space projects--Vega and Phobos--is quite high. Errors and malfunctions in the program can cost dearly. Would it not help here to have mathematical modeling of the planned experiments?

48. [Sagdeyev] In any field of science, not just in cosmonautics, mathematical modeling is now becoming an imperative and a necessity. That is how it was during the Vega project: we attempted to model a large number of phenomena and processes long in advance of the launch of the space vehicles. The very same thing occurred during the preparations for the Phobos project as well. Thus, all the ballistics were constructed on the basis of mathematical modeling; the same can also be said about many other experiments. And the farther we go, the more we need to resort to mathematical modeling. Therefore, we are counting very much on the appearance of the supercomputers. For us, they are not prestigious toys, but rather, primarily, instruments with which it is possible to carry out a considerable portion of the operations. Of course, this does not replace actual physical modeling, but, it assists it to an enormous degree. And who knows, it is possible that it will replace it in the future! Unfortunately, for the time being, we can not get domestic supercomputers.

49. [Correspondent] What's the reason for that?

50. [Sagdeyev] During the notorious stagnant years, when the progress of our entire society was slowed down, including the development of many important areas in science as well, there

appeared yet one more sad feature--reports to the leadership which embellished reality extremely skillfully. This created the semblance of well-being, at both the top and the bottom. And, as a result, entire scientific areas were neglected. Now they need to be developed vigorously.

51. But this problem has another, no less terrible aspect-- the young scientists and engineers who are working on various projects and witnesses their supervisors skillfully ''pulling the wool over people's eyes,'' are simply losing heart. Or what is worse--they themselves are beginning to work differently, and the same ''wool-pullers'' are emerging among them. And that is the most terrible thing!

52. [Correspondent] Nevertheless, one would like to believe in the enthusiasm and reasonable optimism of our youth and to count on their creative potential. And so, the research on the Phobos project is now in full swing. But, certainly, discussion of and, possibly, preparations for other, no less important space programs are going on at the same time. Which of them in our country and abroad would you take particular note of?

53. [Sagdeyev] In fact, right now, the Phobos project is, without a doubt, at the center of the international community's attention. As the interplanetary probes get closer to Mars, interest in it will only increase.

54. But one more remarkable scientific event is taking place in 1989--the American Voyager spacecraft, after its encounters with Jupiter and its satellites, Saturn's system and Uranus, will approach the planet Neptune. This is an example of unusual space longevity. We are all extremely delighted and, to be honest, terribly envious. But I want to emphasize that, in this instance, to an enormous degree, everything is being determined by the extremely high production efficiency with which this craft was developed. Indeed, its entire system, as a whole, and each individual small component--be it a microcircuit or a capacitor--needs to be able to operate for many years under extreme conditions (increased radiation, enormous temperature differentials and so on), without human intervention.

55. [Correspondent] Just how long has this space ''Methuselah'' been functioning?

56. [Sagdeyev] It was launched in 1978, so it has already been in flight for more than 10 years. But even this is not a record. Sometimes, as a joke, we are sent invitations to a banquet for the occasion of, for example, the 15th anniversary of Pioneer 6's continuous operation. That craft is a predecessor of Voyager; and

there are many such craft. And our mouths are just watering--after all, we don't have anything like that!

57. In the next few years, one more remarkable project is supposed to be accomplished--the placement into space of a 2.5-meter space telescope which has been named the ''Space Telescope'' or ''Hubble Observatory.'' It is a unique instrument; as soon as it is placed into orbit, astronomers will see much farther than they can with any powerful ground-based telescope; but the main thing is, they will see in a different way, because the telescope has a completely different wavelength reception range (not only the visible band, but also the ultraviolet band of the spectrum), and, in addition, gigantic angular accuracies are characteristic of it, inasmuch as the atmosphere does not interfere and does not create scintillations.

58. But this instrument has become a victim of the Shuttle project. The fact is that, in the last decade, the American space program has contained an innate flaw--all the space projects have been tied to a reusable craft, the shuttle. This represented direct political interference (an example of command-and-administrative methods of leadership), the result of an unfortunate decision and the fact that the opinions of scientists and engineers were not taken into consideration. Now even the NASA administrators have found within themselves the courage to acknowledge the error (and what is more, they consider it to be history) and now, along with the reusable ship, they are developing (and re-establishing) a whole range of ordinary, single-use launchers. But the space telescope and its mechanical interfaces have been constructed in such a fashion that they are all tied only to the shuttle, and, therefore, it is difficult to say exactly when the telescope will be placed into space. I can only note that our American colleagues have been extremely perturbed by the existing situation.

59. Several other projects are also in a similar situation. For example, Galileo, which involves the flight to Jupiter and the release of a ''landing party'' into the planet's dense atmosphere. It is such a pity that the American specialists did not take advantage at the time of our suggestion that they order Soviet launch vehicles for their program. Now it is already too late, but, certainly, a year and a half to two years ago, it would have been possible to consider this.

60. [Correspondent] But why is it too late now?

61. [Sagdeyev] The reason is the very same one--the complicated mechanical interfaces which I spoke of in connection with the space telescope project, and, in the case of Galileo, very extensive changes are required, while the shuttle flights have already

recommenced.<sup>4<reset> But there are a whole series of other space projects--and not just scientific ones, but also commercial ones--which we are preparing in our country, in which the West could participate, and which would also be very beneficial for them. This would be mutually advantageous. But, again, political considerations are interfering. For purely political reasons, the United States did not want to take advantage of the services of our space industry.

62. [Correspondent] You have listed the most interesting American space projects. But how do things stand in our country?

63. [Sagdeyev] We currently have ready two astronomical satellites (one may be launched in early 1989, and the other in mid-1989). Primarily, I am talking about the Gamma Observatory (a joint Soviet-French project). Its launch dates have already been postponed several times. This is very disturbing to us, and it is with great reluctance that we are agreeing to the routine postponement of the dates about which Glavkosmos is reporting. We are very hopeful that, this time, the launch date for the Gamma Observatory will not be postponed.

64. [Correspondent] Why are the dates being postponed?

65. [Sagdeyev] I think it is a result of the same basic problem from which our entire economy suffers--a lack of responsibility.

66. The second astronomical satellite is the Granat X-Ray Observatory. This project was born several years after Gamma, and, therefore, it is more modern and has instruments that are more precise and sensitive. This is also a joint Soviet-French project. I think that, if both observatories are placed into orbit without further delays, they will make their own mark in space science. But the United States may surpass us, as they have ready the GRO [Gamma Ray Observatory] satellite for gamma ray astronomy; the weight of its scientific instrument package is four times greater than what is on the Gamma Observatory. It is also waiting for a launch vehicle--the shuttle is also supposed to place it into orbit.

67. [Correspondent] More and more countries are beginning to develop their own space research. The establishment of international cooperatives in this field is no longer a rarity; you yourself have repeatedly mentioned this in our discussion. Is it not already time now to develop clear-cut international statutes on space?

68. [Sagdeyev] Regardless of what the international legal norms are, relations between the space powers will depend on the political goals which the partners pursue. But frameworks within which these goals could be accomplished, reliable and firm, are undoubtedly necessary.

69. Even now, there is a whole series of international legal norms (for example, the ban against placing nuclear weapons or other weapons of mass destruction into space). From my point of view, they need to be supplemented by a rejection of the militarization of space in the broad sense, i.e., also banning the testing of any weapon in space. A proposal has been made that a series of legal agreements be concluded regarding the use of outer space in the national economy or for economic purposes.

70. Thus, this field already has its own science--international space law. This science is developing and, from time to time, there are international conferences and seminars, and everyone associated with space is interested in the development of this sphere of activity.

71. [Correspondent] Roald Zinnurovich, in our conversation, you have talked about those space projects which are either already in full swing or will be conducted in the next few years. But what about a look into the future? What kind of space projects do you foresee for the 22nd century (in fact, there are only 11 years left until the beginning of the 21st century)?

72. [Sagdeyev] It is a shame to admit it, but the realities of our practical economic affairs reduce the role of the leader of any scientific collective involved in space, be it the director of an institute or the head of a laboratory, to one of spending nearly 90 of the time on the solution of immediate problems--''forcing through'' orders, and not just such grandiose ones as an order for a satellite or a subsequent launch, but also for an instrument which is supposed to go up; getting the individual component assemblies which may or may not be produced by our industry--and all of this represents an enormous amount of work. And, in the end, it turns out that, in that set of everyday current affairs, which, with proper organization of the country's economic system, should not eat up so much time, we are not in a position to even think about projects in the 21st century, let alone the 22nd century.

73. Nevertheless, I am hopeful that, in the 21st century, we will witness the free travels of man within the limits of the solar system, even though, true, it may not be us, but rather, our descendants. I think that, during the next approach of Halley's Comet in 2061, mankind will certainly succeed in unraveling its mystery. Certainly, it would be dangerous to land a manned spacecraft on the surface of the comet's core, but, who knows, it is possible that, by that time, protection against the dust streams will have been developed. In any case, taking a sample of material directly from the comet's core and delivering it to earth will turn out to be a readily

solvable problem for our descendants (and I do think that our children's children will live to see this event).

74. [Correspondent] What do you mean by the mystery of Halley's Comet?

75. [Sagdeyev] Today, we can not answer many of the questions about the physics of comets--for example, why this comet behaves so unusually. All it has to do is approach to a given distance from the sun, and then, over the course of several weeks, it continues to ''stew'' with tremendous intensity. Such thermal ''memory'' of a comet is retained for a long time. Inasmuch as we know the heat capacity of its matter, we can make approximate estimations, but, based on them, such an evaporation process is not supposed to last so long. Meanwhile, the comet continues to ''stew,'' and much more intensely than it did at the same distance from the sun during its approach. The nature of such asymmetry is not understood. Evidently, there occur on the surface of the comet's core some unknown physical and chemical processes which we have not yet been able to investigate fully.

76. And finally, there is the matter of the comet's origin. It has yet to be solved. In order to do this, it will first of all be necessary to deliver cometary matter to earth.

77. [Correspondent] The next question extends beyond the framework of our present conversation. Keeping in mind the social and political events and the process which are taking place in our country, what is your understanding of democratization and glasnost in science and how, in your opinion, should the USSR Academy of Sciences reorganize its own work?

78. [Sagdeyev] It seems to me that our academy has its own unique and special place in the worldwide family of scientific societies. Once elected into the academy, its members receive such a bouquet of privileges as is not possessed by a member of any other academy in the world. I am not talking simply about additional material goods; in the final analysis, the processes which are going on in the country (including the inevitable inflation) are gradually diminishing this difference and, later, it will be reduced even more. What I am talking about is that, in addition to the respect, which is also enjoyed by members of foreign academies (in fact, election itself is an act of recognition of their services), the members of our academy receive levers for influencing scientific policy as well. As a rule, the academicians head up institutes and, if one of the institutes is unable to secure for itself an academician as the director, it simply considers itself a poor relative. Very frequently, regardless of the scientific merits of the director of

such an institute, an attempt is made during the regular elections to the academy to ''correct'' the situation. Moreover, influence on the scientific policy is achieved through the USSR Academy of Sciences' Sections, Departments and Problems Councils, which are headed up by academicians. As a result, thousands of first-rate scientists--doctors and candidates of sciences, those who, because of an unfortunate twist of fate, did not manage to become members of the academy (and there are many such cases)--have, to a large extent, have been excluded from the actual process of conducting scientific policy.

79. Therefore, democratization in science, first and foremost, should liberate the gigantic creative potential of the main group of people who create science.

80. [Correspondent] What, specifically, do you suggest be done?

81. Possible measures are being discussed rather widely and the president of the USSR Academy of Sciences, G. I. Marchuk, has repeatedly spoken out about this, particularly in the press. There was talk about greater and greater autonomy for the departments and about transferring authority from the level of the presidium and the sections to the level of the departments. This idea immediately received support, but it became clear rather quickly that, if the departments concentrate all the absolute authority in their own hands, then, in the final analysis, it will be a restoration of the ministerial main administrations which are being condemned currently.

82. At the present time, the process of revitalizing the institutes is going on; they should receive greater autonomy. Therefore, in my opinion, the next step is the institutes' use of the obtained rights and genuine democratization inside the institutes. Many different measures exist for bringing this about. First of all, elections of the institute's director and the members of the academic council. It should be said right off that I am against these elections being turned into an uncontrolled veche [ancient Russian public assembly]. Because then the opinions of people who are not competent and who are somewhere on the periphery of science are, in essence, equal to the opinions of the specialists, and, as a result, the election process (just like any other) becomes uncontrolled. But, of course, the voice of each scientific associate must be heard.

83. Furthermore, I feel that the democratization of the institute's scientific affairs should include the further transfer of authority (including financial and economic) to the laboratories, which should become the basic unit in the scientific community. It is necessary to conduct a search for new forms for financing the scientific collectives on competitive bases and to develop competitiveness

between them. And then our scientists, many of whom have worldwide recognition, will actually be able to influence scientific policy in this country, and it will not be controlled by only a narrow, private circle of academy members. It is then that our science will actually take a real step forward.

84. At the same time, of course, it is also necessary to improve greatly the material conditions in which science is developing. Because, granting a laboratory autonomy without giving it the capability of acquiring, for example, a computer, is the same as just doing nothing.

85. [Correspondent] You were a delegate to the 19th party conference. What made the greatest impression on you at that most important event in our country's affairs last year?

86. [Sagdeyev] The speech by M. S. Gorbachev, and for the scientist--especially that section of his report which was devoted to science. At that time, I got the impression that, in that report on the problems and needs of our science, everything was said that I myself wanted to say. Perhaps, to some degree, the lackluster reaction of the party conference delegates to the speeches by the leaders of our academy can be accounted for by the fact that it was difficult to add anything new.

87. But what really annoyed me was the offhand manner in which many delegates ''wiped their feet'' on science. As an example, I will refer to the speech by the general director of the Ivanovo Machine-Tool Production Association imeni the 50th Anniversary of the USSR, V. P. Kabaidze. I would even say that, in some sense, such a style would be more appropriate at a Gennadiy Khazanov concert. With such an attitude toward science, even the organizational and economic talent which Comrade Kabaidze undoubtedly possesses will not help our industry to move Soviet technology to the leading edge.

88. I understand what the roots of such an attitude toward science are. Indeed, over the course of many decades, particularly during the period of stagnation, our science was a ''pocket'' science--nobody thought about us until, basically, it was necessary to substantiate, for example, a routine decision about a new general assault on nature. And now, a reverse wave has emerged. It is completely legitimate to question the moral and social integrity of the scientist. It is no accident that discussions centering on specific facts--for example, the polluting of Lake Baykal or the notorious diversion of rivers--and on the names of the specific scientists who personally participated in those sadly familiar decisions are not fading away.

89. In many respects, we ourselves are to blame for the fact that a loss of interest in science and skepticism with respect to it are now being observed. And here, an enormous role belongs to the promotion of the achievements of science, since science and its importance are served by the mass media's resources. One idea is to publish a special USSR Academy of Sciences newspaper; the president of the USSR Academy of Sciences made such a proposal at the conference.

90. [Correspondent] Are you talking about one more popular science publication, of which, it would seem, there are quite enough, or something totally new?

91. [Sagdeyev] The basic aim is to make all the scientists and all the members of the scientific community feel that they are one family and to see to it that feedback is faster and not as slow as, for example, the feedback with the currently published magazines. This is why it is necessary to have, if not a daily paper, then at least a weekly paper.<sup>5<reset>

92. But even that sort of newspaper will not solve the problem of the promotion of the achievements and role of science among the broad masses, since the scientists will basically be the ones reading it. Here also, I support the idea expressed recently by Academician L. I. Abalkin: it is necessary that one of our major newspapers, for example, PRAVDA, once a week, set aside a whole page for science. It is possible that IZVESTIYA would be better suited for this purpose (but not SOVETSKAYA ROSSIYA!).

93. In general, it should be noted with regret that there was recently a page in some publications for para-science. But it is not new. I remember, about 12 years ago, I gave a popular lecture in Gosplan's large lecture hall. An enormous hall, and hundreds of workers. My speech was devoted to the use of the achievements of cosmonautics in the national economy. At the end of the speech, they began to put questions to me--orally and in the form of notes. There were about 20 notes, and they were all devoted to one topic--flying saucers! I opened one after another, expecting a question actually relating to the theme of my speech. But when I opened the last one and saw that it contained that very same question, I could not take it anymore and shouted in a fit of temper: ''Now that I know what kind of space research interests Gosplan's workers the most, I understand why we have such a mess in the national economy!'' Academician M. V. Keldysh laughed for a long time when I told him about it all, but then he noted: ''But you really acted very carelessly--the financing of scientific research depends on them.''

94. I think that, back then, we put ourselves too often in the position of the junior partner, and we did not courageously defend

the interests of science. I hope that those times are gone for good.

95. [Correspondent] In conclusion, Roald Zinnurovich, all that remains is for me to thank you for an interesting and substantive interview. I hope that PRIRODA's readers will have the chance to hear from you again and again about the achievements and problems of space research--one of the youngest and most promising areas of science.

96. Footnotes

97. 1. L. S. Marochnik, G. A. Skuridin, ''Rendezvous With Halley's Comet,'' PRIRODA, 1982, No 2, pp 2-18; V. M. Balebanov, V. I. Moroz, L. M. Mukhin, ''The First Stage of the Vega Mission: the Study of the Venusian Surface,'' PRIRODA, 1985, No 6, pp 3-12.

98. 2. Yu. N. Yefremov, ''The Explosion of a Supernova in the Large Magellanic Cloud,'' PRIRODA, 1987, No 6, pp 102-104.

99. 3. Communications with the Phobos 1 vehicle have not been re-established. (Editor's note)

100. 4. On 15 November 1988, our country also accomplished the launching of a reusable ship, Buran. It was placed into orbit by the Energiya rocket, and the landing was accomplished in an automated mode. (Editor's note)

101. 5. Beginning in 1989, the weekly NAUKA I VYSSHAYA SHKOLA [Science and Higher Education] will be published. (Editor's note)