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LETTERS & COMMENT

We welcome comments on articles and, more generally, on issues related to science and global security.

Editor's note: the February 1990 issue of the NTR Tribuna, *published in Moscow in Russian, contained a two-article spread under the common title "Reactors Overhead" on the issue of the use of nuclear reactors in space. The first article by Academician Roald Sagdeev, professor at the University of Maryland and director of the Center for Analytical Research at the Space Research Institute of the USSR Academy of Sciences, summarized the dangers of reactors in earth orbit, drawing on the special section on space reactor arms control in the first issue of* Science & Global Security, *of which Sagdeev was a co-author. The second article, replying to Sagdeev, was by Academician N. Ponomarev-Stepnoy, deputy director of the Kurchatov Institute of Atomic Energy of the USSR Academy of Sciences. We present below a slightly edited version of Ponomarev-Stepnoy's article.*

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Accidents with Soviet and US satellites carrying nuclear power sources have greatly agitated world opinion. This alarm became especially acute after the mishap with Cosmos 954 in 1978 and the almost disastrous failure of Cosmos 1900 ten years later. The result: a strong movement against nuclear reactors in space.

People's fear of another Chernobyl—wherever the threat might be, in space or on earth—is a very grave matter that cannot be assuaged with assurances like "My word of honor, there won't be any more explosions."

As strange as it may seem, my position and that of Roald Zinnurovich Sagdeev are more similar than they are different. We both consider the first and essential condition for development of space-based nuclear technologies to

be their safety, but we use semantically opposite imperatives: one side says "Yes, they may be used, with the exception of such and such instances;" the other actually reiterates that by saying "In such and such instances, they may not be used." The main difference is in the intent: "to prohibit, because it is dangerous" versus "to permit when it is safe."

Really, I have no faith whatsoever in the effectiveness of such prohibitions. However enticing from the standpoint of safety the slogan "Back to Nature!" may appear, it is not true, if only because it cannot be carried out. Much more logical, in my view, is the slogan "Onward to Nature!"—to a Nature protected against the sinister consequences of scientific and technical progress by scientific and technical progress itself.

Man's drive to outer space, like the process of learning itself, may be prohibited, but it cannot be prevented. In one way or other, space will be developed. On this score, it would appear, no one expresses any doubt. The main training ground for the space program today is low earth orbit. A multitude of problems are being worked out there at present—problems that are both pure science and applied science (communications, meteorology, geology, navigational support, development of revolutionary technologies, etc.). The next step is the conquest of distant orbits and flight to other planets. None of these missions can be performed without a suitable energy supply, and the greater the distance, the more necessary this becomes.

The energy requirements of the space program today are measured in kilowatts and, at rare times, in tens of kilowatts. Tomorrow, hundreds will be needed. And expeditions will require megawatts. Where will we get them? Neither wood, nor coal, nor wind engines, nor heated water are, of course, appropriate. The energy sources available in space can be counted on the fingers of one hand. There are three—chemical, solar, and nuclear.

Chemical energy sources are good when it is a question of a short time of operation in space (on the order of several days or weeks). When the spacecraft is required to operate for months or years, the weight of the chemical fuel that must be placed in orbit becomes a serious hindrance. The best solution in this case is to use the energy of the sun. All of this relates to comparatively low levels of energy consumption (on the order of 10 or 20 kilowatts). As soon as more energy is needed, one must also abandon solar arrays. Not only because of the increasing weight, but also because the

controllability of the space vehicles is drastically impaired by the large areas of the photocells.

Thus, for long periods of time and large energy expenditures, nuclear energy sources have no replacement. Of course, that does not mean that they should be used everywhere, if there is a reasonable alternative. The important thing is the question of safety, and therefore we should immediately reject nuclear power for those cases in which it might lead to fallout of a dangerous quantity of radioactive substances on earth. For example, satellites with nuclear reactors on board should not be launched into low earth orbits, since over time they might lose altitude and return to earth in the form of radioactive fragments.

The safety of a space vehicle with a nuclear energy source on board is automatically secured, however, if the ballistic characteristics of its orbit prevent the vehicle from reaching earth for several hundred years. Our opponents declare that even here, in high orbits, nuclear engineering should be prohibited, since there exists a finite probability of the space vehicle colliding with fragments of defunct satellites and subsequently returning to earth. Such an argument, in my opinion, does not suit a scientific debate. The magnitude of such a probability, although it is finite, is very small at present. Unfortunately, I am not myself able to give the specific figure either, since it is the result of very hypothetical calculations; but neither that probability nor the present experience with outer space (since 1957, despite a huge number of launches, not a single collision has been detected) gives us reason to believe that the likelihood of a collision is large enough that one may be expected for, say, centuries. This probability must be computed, of course, and we are working on that today. In January 1990, at a conference in Albuquerque, we talked with US scientists about organizing this work together.

Naturally, the safety of space vehicles with nuclear reactors on board has not always gone smoothly—this is evident from the list of accidents presented in *Science & Global Security* **1**, 1–2 (p.99). But over the course of time the safety systems have been improved and continue to be improved, (as a result of which, incidentally, the Cosmos 1900 accident had a good ending). Cosmos 1900 was outfitted with several emergency systems. It was to be expected that one of these might fail (the first system failed), but it is much harder to imagine a situation in which all systems would fail. Of course, equipment

failures like that which occurred in Cosmos 1900 are intolerable, but I would not, as did our opponents, declare the satisfactory outcome of the incident a miracle. The opposite, perhaps, would have been a miracle.

As a matter of fact, in my opinion, the arguments presented against nuclear power in space are not always justified, nor are they always valid. For example, it is hard for me to understand how a person who is competent in engineering could compare the long-term effects of an accident involving a space nuclear reactor and the long-term effects of an accident involving a reactor like the one that blew up in Chernobyl. The capacity of the first is around 100 kilowatts, whereas the capacity of the Chernobyl power unit was 1,000 megawatts. The total radioactivity of the reactor is proportional to the energy produced.

For already a year the scientists of the USSR and the United States have been studying very carefully the issue of changing-over space technology, including nuclear power engineering, from military to peaceful objectives. Last year, the US company Space Power Inc. came to us with a proposal to create by joint venture a satellite for worldwide broadcast of high-resolution television programs, for multichannel telecommunications, and for navigational support for all kinds of air and marine transport. The value of such a satellite to all the inhabitants of earth is hard to exaggerate—it represents a qualitatively new level of communications, an immeasurably greater degree of safety for airplanes and ships. But such a multichannel system requires power that can be provided only by a nuclear reactor. In January 1990, at a conference in Albuquerque, these negotiations were resumed. Incidentally, one other very interesting and, in my view, extremely imaginative project using nuclear reactors was discussed there—use of nuclear reactors not in outer space, but on the surface of the moon, to provide the energy for future colonies.

I repeat: I can only welcome any open debate on the possibilities and dangers of nuclear power in space. I do not at all consider my point of view to be the last and final truth, and I am ready to change it, if reasonable and scientifically grounded objections are presented. But I have yet to hear any. I have always felt, and still do, that it is more proper to safeguard the operation of a needed piece of equipment than to ban it.