Justification for Manned Mars Mission, Technical Options for Flight

18660184 Moscow PRAVDA in Russian 24 May 88 p 3

[Article by Academician V. Glushko, USSR Academy of Sciences Corresponding Member Yu. Semenov, and Doctor of Technical Sciences L. Gorshkov under the rubric "Fantasy on the Drawing Board"; "The Road to Mars"; first six paragraphs appear in italic in source, as introduction to article]]

[Text] The short letter by Professor F. Volkov, "Do We Need to Fly to Mars?" (Pravda, 10 February 1988) evoked a stormy reaction. Responses have come by the dozens. From Moscow, Odessa, Voronezh, Sverdlovsk, Minsk, Tbilisi, Kherson, Ryazan, and the remote Krasnoyarsk Kray. People are taking turns being "for" or "against."

"It is naive to think that we should successfully overcome our problems on Earth today and only then venture to Mars and to other planets," writes S. Shardyko, research associate at the Institute of Thermophysics of the Ural Division of the USSR Academy of Sciences- "That is an illusion, because solving certain problems gives rise to others that are more complex and more threatening. Solving global problems requires of mankind space power, and it would be unreasonable, to say the least, to postpone indefinitely the attaining of that power."

The citizens of the Earth, people of many earthly professions, are upset. But what about the specialists? And the leaders of space science? How do they feel? Or are they indifferent, looking upon the project as Utopian in our age? As it turns out, no, they're not. This article addresses the fact that leading scientists in the field of cosmonautics are seriously concerned with the concreteness of this project. And wasn't F. Tsander, the wise companion of the young S. Korolev, in earnest when he began every working day in the basement of Reactive Propulsion Study Group [GIRD] with the exclamation, " Onward, to Mars!"

And there is one more important note from S. Shardyko's letter:

"The problem, obviously, is not in clarifying how many are 'for' and how many are 'against' this or that space program, but in a wider and freer access for the scientific and technical community to the results of space research and to space equipment and technology. The solution lies in the democratization of the historically inevitable process of space expansion."

In a conversation with the publishers of the Washington Post and Newsweek, M. S. Gorbachev said: "I will propose to President Reagan collaboration in setting up a joint flight to Mars....That would be worthy of both the American and the Soviet people."

Since ancient times, the interest in Mars has been associated with a dream of encountering intelligent life. Today, we can't expect that within the boundaries of our solar system.

Nevertheless, Mars rivets our attention because of a natural desire to take a peek at our neighboring planet, a world completely unfamiliar to us and, probably, a world unlike our own. We rightfully count on finding traces of the history of Mars and of interesting natural formations. Many of the discoveries that await us on Mars will probably bear a direct relationship to discoveries on our planet.

You sometimes hear the question, Do we need to fly to Mars? Some feel that we have so many pressing tasks that manned flight to Mars can wait. But if we had judged that to be true, there wouldn't have been the first satellite or the flight of Yuriy Gagarin. None of cosmonautics would have come about. Why, when it started, no one thought that space flight would begin to have direct benefits so quickly.

All this, it would seem, is common knowledge. And still we hear: Do we need to arrange a flight to Mars today? Couldn't we, indeed, postpone it until we solve all our pressing problems? We must admit here that, in all probability, we will always have pressing problems, and that approach could actually stop the development of science and technology.

What kinds of technical possibilities do we have at our disposal here? What kind of spacecraft could deliver man from planet to planet?

Figure 1 presents a diagram of one version of such a craft. An interplanetary vessel consists of three basic components: a propulsion unit for flight along interplanetary trajectories; living quarters, where the crew works during the course of the entire flight and which include equipment for keeping the crew active as well as the primary flight-control gear; and the lander, in which the crew descends to the surface of Mars and returns to a Martian satellite orbit, to the interplanetary craft.

The interplanetary craft is assembled in near-Earth orbit from individual units that are delivered from Earth by boosters like the Energiya boster. After the serviceability of all the systems and assemblies of the craft is checked, the expedition heads for Mars. The crew (4-6 people) may include representatives of the various countries that participated in preparing the expedition.

Figure 2 shows a diagram of the flight of the craft. Using its propulsion unit, the interplanetary craft races from its near-Earth orbit to a near-sun orbit, crossing the orbit of Mars. It takes several months to fly to Mars. At the point at which the flight trajectory crosses the orbit of Mars, the craft begins orbiting Mars and becomes an artificial satellite of the planet. Since landing the entire interplanetary craft on the Martian surface would be a rather

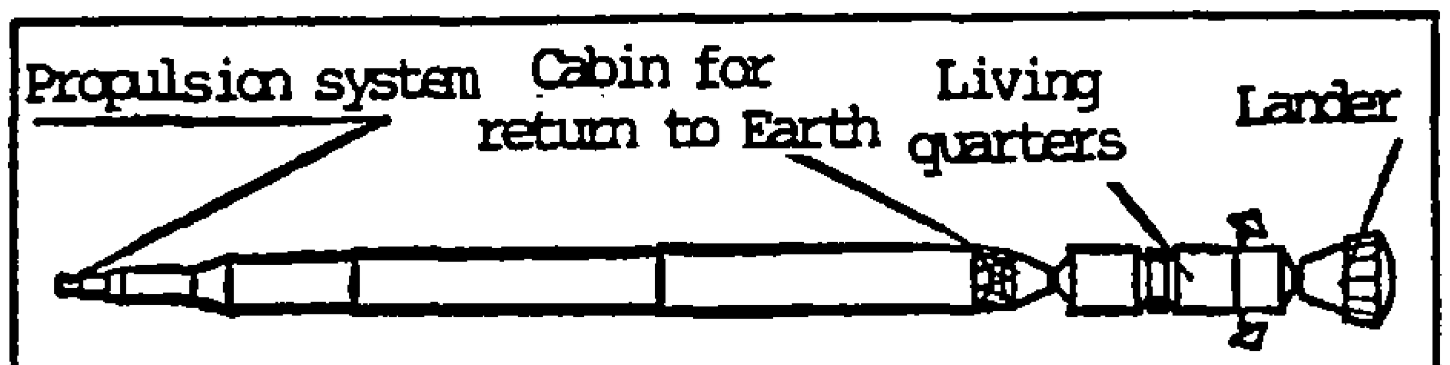

Figure 1. Design of the interplanetary craft

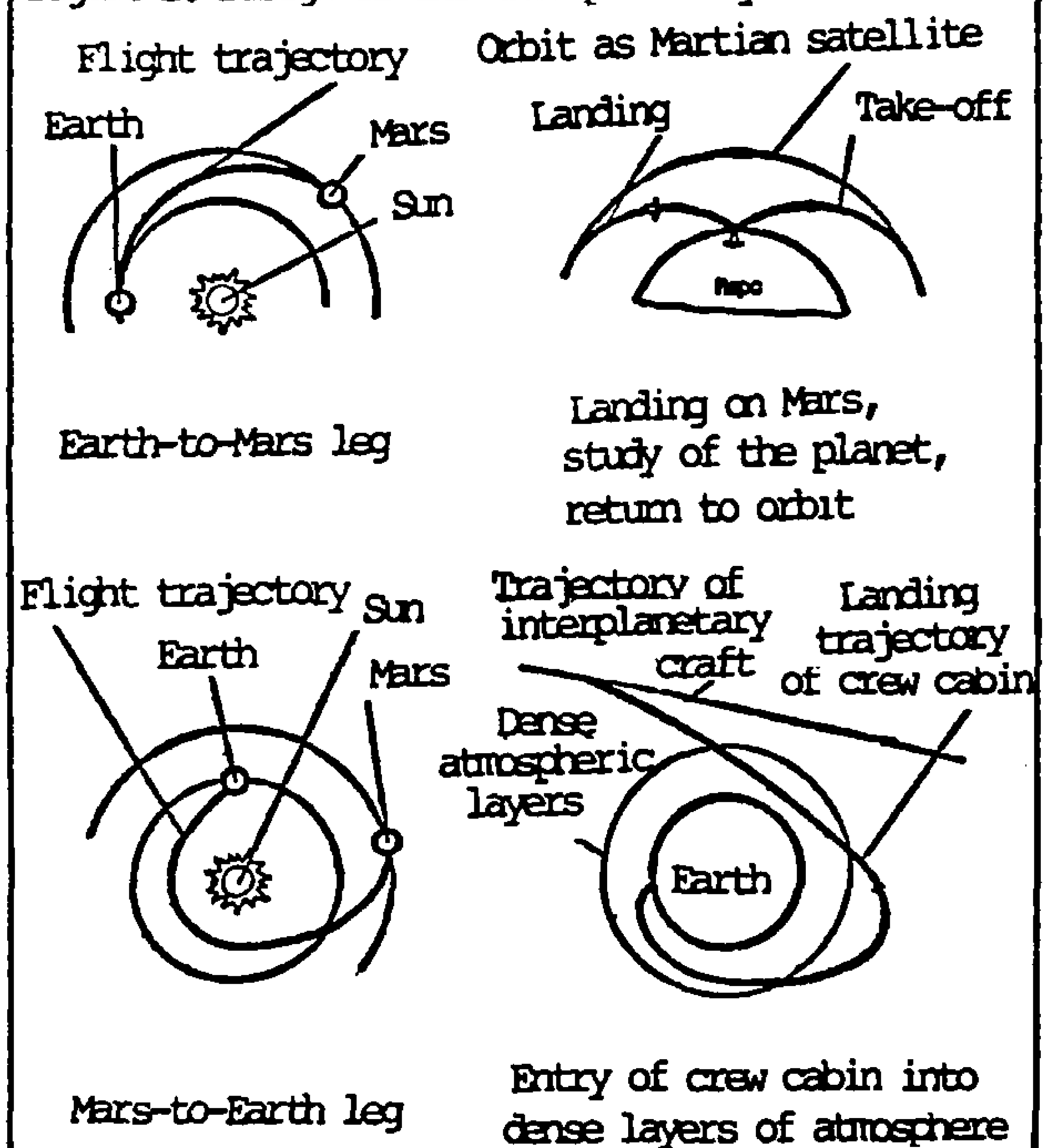

Figure 2. Flight configurations to Mars

complex task and would require a large amount of fuel, a comparatively small lander, with the crew or part of it, will make the descent. After completing its work on the surface, the crew will launch itself into orbit, transfer to the interplanetary craft, and return to Earth. The diagram shows a version in which, over the course of the flight to Mars and back to Earth, nearly one and a half revolutions around the sun are made, which means the expedition lasts about one and a half years.

The overall duration of the flight could be shortened, but the required fuel reserves would be markedly greater and, consequently, the mass and size of the craft would grow, along with the problems associated with developing such a vessel.

For increased safety, the flight to Mars could be made with two interplanetary craft traveling at the same time. The crew of each could, if necessary, come to the aid of the other.

One of the principal questions centers on the choice of the propulsion unit that would be used to accelerate the craft from its Earth orbit to Mars, transfer it to a Martian satellite orbit, and then remove it from that orbit and send it back to Earth.

We could, for these purposes, use the rather well-refined liquid-fuel reaction-propulsion systems that use the chemical energy of rocket fuel consisting of, for example, two components—hydrogen and oxygen. That is the most efficient fuel in use today for such systems (it is used, in particular, in the new Soviet booster rocket, Energiya). Developing such systems for the flight to Mars does not, at first glance, present serious problems. But since the amount of energy needed for the Martian expedition is rather high (the Mars-bound craft is considerably heavier than the automatic interplanetary probes that have already flown), the fuel reserves for the propulsion systems would be large. And assembling such a craft in near-Earth orbit would be quite complicated. Suffice it to say that the initial mass of such a vessel would be greater than 2,500 tons.

Naturally, the more efficient power sources are used for flights along interplanetary trajectories—nuclear sources. Nuclear reactors serve as a heat source that, after warming a gas, forces it through the nozzles of the engine and creates a reactive thrust. The required fuel reserves—or, as they say in rocket technology, the "working fluid" (the gas that is ejected from the propulsion nozzles)—are substantially smaller than those of liquid-fuel propulsion systems (by a factor of 2 or 3). The initial mass of such a craft would be about 800 tons.

A still more efficient system is the nuclear electro-reaction unit. In this system the thermal energy of the reactor is converted into electrical energy, and the working fluid is accelerated by an electrical field to create the necessary thrust. For a given task, these units require less working fluid than the fuel required for liquid-fuel units (an amount 15-20 times smaller). The initial mass for this kind of craft could be as small as 450 tons.

Let's take a look at the features of the other components of the interplanetary craft. The living quarters are the central component. They consist of a hermetically sealed compartment or comparments than contain the crew cabins and the equipment racks.

The crew must have oxygen for breathing, water, food, and some means of removing waste. The development of these systems is already at a level that completely satisfies the requirements of interplanetary flight.

The living quarters contain equipment for maintaining radio communications with Earth. The craft must have the equipment necessary for autonomous navigation and flight control. Which means that the flight can be carried out by the crew itself. Comfortable temperature levels are maintained in the living compartment by an air-conditioning system similar to those used aboard orbital stations. Either a nuclear reactor or solar batteries can serve as the source of electrical power for the systems in the living quarters.

To reduce radiation exposure during the flight, equipment and system assemblies are located along the hermetic shell of the living quarters. For additional radiation safety, the living quarters must have an area that provides a higher level of protection from cosmic radiation, i.e., a special radiation shelter for the crew in the event of, say, solar flares. On orbital stations, the crew is protected from such flares by the Earth's powerful magnetic field. On interplanetary flights, however, there is no such protection, and additional measures must be taken to protect the crew. It is not at all necessary that the crew remain in the shelter during the entire time of a solar flare. It is important that it spent the bulk of its time there, including sleeping hours, and the total dose of radiation will not be hazardous for health.

Another important safety question involving the living quarters centers on protection from meteor fragments. In space flight, including that in near-Earth orbit, encountering meteor fragments is highly probable. The most effective means of protection is a special shield that envelops the shell of the living quarters. When a meteor fragment is encountered, the shield is pierced, but only a stream of gas—which the fragment and the shield material become when they collide—reaches the shell. The Salyut and Mir orbital stations, by the way, were designed in this manner. The chances of encountering a meteor whose mass would have enough energy to pierce both the shield and the shell are extremely slim, but such an event could be taken care of by dividing the living quarters into separate compartments, and the crew could have all the necessary equipment for repairing the external shell if the seal were ruptured.

The next component of the interplanetary craft is the lander. It has an appropriate aerodynamic shape, because the landing is performed in the atmosphere. Since the atmosphere at the Martian surface is several times less dense than that of Earth, a liquid-fuel propulsion unit is used for the landing. The lander includes a take-off rocket, on which the crew, in the cabin, returns to the interplanetary craft.

Different flight variations can be used for the return to Earth: using engines to brake the craft near Earth and entering a near-Earth orbit (this requires substantial additional amounts of fuel) or using the Earth's atmosphere to brake and entering it at escape velocity. In the latter instance, the Martian craft must have a special cabin (see Figure 1) into which the crew transfers itself just before reaching Earth. This cabin separates from the Martian craft and enters the dense layers of the atmosphere on its own. Subsequent descent is with parachutes.

In choosing a return configuration, one must also think of protecting the Earth from dangerous biological Martian forms, the possibility of which cannot yet be discounted entirely. After the return to Earth, the crews and anything that came in contact with the Martian atmosphere must be thoroughly examined. A long quarantine will be necessary. If the return is to Earth orbit, the quarantine can be carried out on an orbital station. The advantage of that is the adequate, natural isolation from Earth; the disadvantage, the limited possibilities for medical and biological studies. A quarantine that follows a direct landing on Earth at escape velocity can be carried out in a special, insulated structure, where the crew can exit the craft only after it has been brought to this "hangar." The medical and biological quarantine studies can be more thorough on the ground than in an orbital station.

Now let's take a look at just how prepared world space technology is to organize the first interplanetary mission. What problems must be solved before a small group of Earth's representatives set foot on the surface of another planet?

One may consider the assembly of the craft from individual components in near-Earth orbit to have been worked out at this point. A great deal of experience has been garnered in this area by the USSR, whose system of automatic assembly in space has been in use for more than 20 years. Manual docking, used both by the USSR and the United States, also has applications in the Martian expedition.

Both the USSR and the United States have experience in measuring the parameters of interplanetary trajectories and in flight control. Unmanned craft have been launched to the closest planets—Mars and Venus—as well as to remote planets of the solar system.

The flights of orbital stations (Salyut, Skylab, and Mir) have made it possible to develop means for man to spend lengthy periods in space. An important part of this is developing reliable gear. Counting on the Earth for help here will be difficult, so all the equipment, including the repair equipment, must be aboard the craft.

As far as the lander goes, similar problems have already been solved. The United States has a great deal of experience in landing crews on the surface of the Moon and bringing them back up: in 1969-72, American astronauts in Apollo landers made six landings and take-offs on the Moon. Unmanned Soviet craft have landed on the Moon and taken off. Unmanned Soviet and US spacecraft have landed on planets (Mars and Venus).

Liquid-fuel propulsion systems are widely used in space technology. The USSR and the US are developing promising propulsion units that use nuclear energy: nuclear electro-reaction units, for example, and nuclear units that use direct conversion of heat to a propulsion stream.

Many countries of the world that have participated in space flight have gathered a good deal of experience in designing and developing various equipment and gear that can be used aboard an interplanetary craft.

The question also arises, Can a crew work for such a lengthy period of time in weightlessness? For many years now, the USSR has been doing work in this area. The road has been long and bumpy. There have been moments when it seemed that weightlessness was an insurmountable barrier to lengthy space flights. After the 18-day flight of A. Nikolayev and V. Sevastyanov, for example, readapting to Earth was so difficult for the crew that increasing the duration of flights beyond that length of time was a problem. But means for keeping the crew in good physical shape were developed that exercised the muscular system and cardiovascular system. The work continued. The length of the flights was gradually increased over a period of several years among the crews of orbital stations, and, in December of last year, Cosmonaut Yu. Romaneko, who holds the record for time spent in weightlessness, returned to Earth after a 326-day flight—and he returned in excellent physical condition. The success of the lengthy flights is one of the results of a special program of physical training aboard the stations. Thus, we have every reason to be optimistic about the possibility of long-term space flight.

Of course, we must not simplify the problem: space specialists must still solve many technical and medical problems in organizing such a grandiose event as a flight to Mars.

The flight to the planet nearest us is on today's agenda. It is not only a scientific and technical issue; it is also an issue associated with the progress of civilization on Earth.