Executive Summary

The launching of Sputnik 1 initiated a space race that led to the landing of astronauts on the Moon; today the United States and the Soviet Union are well aware of their relative strengths and weaknesses in space activity. In most areas of space science and space applications—best exemplified, respectively, by the Voyager missions to Jupiter and Saturn, and the burgeoning satellite communications industry-the United States, through steady, long-term effort, seems to have gained a substantial lead over the Soviet Union.

In human spaceflight, the picture is less clear because the countries have taken quite different approaches. In some respects, the activities of the two countries in this arena have resembled the race between the tortoise and the hare: while the Soviet effort has featured apparently steady, incremental progression along well-defined lines of development, the United States has typically played catchup, using its strong technological capacity to produce space achievements of startling virtuosity. Continuing development on both sides has been fueled by a combination of political, economic, and military motives, in different order of importance at different times.

The divergent approaches of the two countries have led to two very different types of current human spaceflight capability. The Soviet Union has, since 1971, pursued a more-or-less continuous program of development of space stations in low-Earth orbit (LEO). with the sixth Operational model of the Salyut series now flying, Soviet cosmonauts have logged over three times the U.S. total of crew-hours in space, and accumulated extensive experience in the conduct of flight operations, experimentation, and Earth observation in trips that last for months. However, they are currently restricted to the use of relatively small, expendable launch vehicles for crew transportation and resupply. The United States, on the other hand, has an operational space Shuttle which permits the routine ferrying of crews and large payloads into orbit for over a week, currently at the rate of some 5-6 flights per year. The Shuttle is reusable, its staytime in orbit could be increased, and the planned fleet of four Orbiters could provide staytime on the order of months per year. But an individual unmodified Orbiter does not provide a habitation combining large volume, high power, and long duration needed for many of the in-orbit research and development activities of interest, particularly to the life sciences and some in the private sector.

The National Aeronautics and Space Administration is now considering “the next logical step” for its space program: the establishment of a potentially permanent human presence as part of an actually permanent LEO infrastructure, i.e., what NASA describes as a civilian space station. If the administration formally proposes to begin work on such infrastructure, then Congress may find that a detailed examination of the Soviet human presence in space, the Salyut space stations, and their associated space vehicles, can provide a useful frame of reference.

Early in this century, Konstantin Tsiolkovsky, a Russian scientist and engineer, provided the theoretical underpinnings for the Soviet space program with his visionary writings about the use of orbiting stations as a springboard for exploring the cosmos. One can still find the influence of his theories in the statements of modern-day Soviet leaders.

But Soviet scientists and technicians have found that the road to realizing their dream is a long and difficult one. After initial successes with Sputnik and the early orbital flights of cosmonauts in the one-seat Vostok capsule, the Soviet space program began to feel the limitations of its technology. The 6-metric-ton (tonne; one tonne = *2205* lbs) Voskhod flew only twice, Voskhod 1 with three crewmembers, Vockhod 2 with two. Two years later, in 1967, a new space vehicle debuted with Soyuz 1. Despite the death of the first Soyuz pilot in a crash landing, the Soyuz-class ship eventually became the principal means of putting cosmonauts into space. After 12 years of Soyuz operations, a new design, Soyuz T, made its inaugural flight in *1979*.

In the late 1960’s, the Soviets appeared to be intent on sending cosmonauts to the Moon, but, in view of the success of the U.S. effort to do so, they eventually settled for landing automated

probes on the lunar surface. Subsequently, the focus of the Soviet manned space program shifted exclusively to the establishment of a strong capability for near-Earth orbital operations, i.e., the development of space stations and associated space vehicles. When Soyuz 4 docked with its sister ship Soyuz 5 in January 1969, the Soviets called the resulting complex "the world's first space station, " although the two craft had no connecting passageway between them. Salyut 1, which provided one continuous volume capable of supporting human habitation for time-periods of the order of months, went into orbit in 1971; the most recent of the series, Salyut 7, was launched in 1982 and remains operational today.

Some of the Salyut stations were apparently military in function; others seem to have been primarily civil. With Salyut *6* and 7, the distinction became blurred; it may be that the military no longer has a separate Salyut program. The Soviets have maintained total secrecy in military operations, but they have gradually become more open with their civilian programs, broadening the makeup of their crews to include members from Eastern Europe and other Soviet-bloc countries, France, and, soon, India. Although any joint U.S.-Soviet effort (e.g., the symbolic joining of the Apollo and Soyuz in orbit in 1975) currently seems unlikely, future Soviet missions will probably continue to be international to some degree.

The fact that the Soviet technological base remains relatively narrow seems to be closely coupled with the infrequency with which rapid innovation is achieved, both in Soviet industry generally and in the Soviet space program in particular. Although Soviet spacecraft designers rely heavily on automated control with cosmonauts as backups, crewmembers have, in many instances, assumed broader duties to make up for failures in automation. In any case, Salyut has afforded its crews of engineers and cosmonauts extensive experience in conducting operations in space. Precisely how this experience will be put to use in future operations is unclear,

Salyut may be the penultimate step leading to a permanent, large-scale human presence in space. Before that can be accomplished, the Soviets may have to achieve success in developing a heavy-lift launcher, similar to the U.S. Saturn V, which would allow for the construction of a second-generation station out of much larger modules, A vehicle along the lines of the U.S. space shuttle to provide routine access to a near-Earth station would also be desirable, and indeed Western sources believe that the Soviets may be developing a heavy-lift, reusable shuttle that could carry twice the payload of the American craft. In addition, the Soviets have already conducted tests for a l-tonne prototype of a 10- to 20-tonne space plane.

With such spacecraft in their fleet, the Soviets would possess both a "space truck" and a light-duty ferry vehicle to provide routine service to an expandable infrastructure in space. With this infrastructure as a hub of operations, extension of human activity to geostationary orbit, the Moon, and even Mars becomes technically feasible—indeed Soviet planners have frequently mentioned each of these as an objective. That previous U.S.S.R. efforts to reach Mars have met with failure may, in the near term, have militated against their initiating programs to send vehicles to the outer planets and deep space. But it is unlikely that the Soviets see these failures as anything more than temporary setbacks, especially in view of U.S. success in planetary exploration generally and their own success in the very difficult task of returning data from the surface of Venus—a feat that the United States has yet to match. Indeed, a Salyut space station may provide the core element of a future base necessary to ensure success of future trips to Mars.