The Legacy of the Apollo-Soyuz Test Project

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President John F. Kennedy offered collaboration on the human lunar program with the Union of Soviet Socialist Republics (USSR) while addressing the United Nations on September 20, 1963, but this went unanswered by the Soviets. In April 1970, NASA Administrator Thomas O. Paine suggested, in an informal meeting with Soviet academician Anatoli Blagonravov in New York, that the two nations cooperate on astronaut safety, including compatible docking equipment on space stations and spacecraft to permit rescue operations in space emergencies. The development of the Apollo-Soyuz Test Project (ASTP) began with a letter sent from Thomas Paine to the Soviet Academy of Sciences in October 1970. This was followed by a space cooperative agreement signed between the United States (President Richard Nixon) and the Soviet Union (Premier Alexei Kosygin) in April 1972. The first meeting of the U.S.-USSR Joint Working Group on Space Biology and Medicine was held in 1971 under the leadership of Charles A. Berry, M.D., and Soviet academician Oleg Gazenko and has continued with meetings on an annual basis.[5–7] This working group provided a framework for the medical aspects of all future collaborations, including ASTP.

NASA selected astronaut Deke Slayton as the docking module pilot. Slayton was previously medically disqualified from spaceflight during Project Mercury due to intermittent atrial fibrillation. He had been requalified in 1970 for flight duties by the efforts of Charles A. Berry, M.D., in consultation with cardiologists Duddley White, M.D., and W. Proctor Harvey, M.D.[17] As a precautionary measure, digoxin and quinidine were carried in the Apollo medical kit. Cardiac monitoring of Slayton and the entire crew was performed using the nominal protocol during launch, inflight, and landing. A cardiologist (Earl Baird, M.D.), the crew surgeon, Dr. Nicogossian, and Dr. Charles Berry were present on console in the Launch Control Center at launch. The electrocardiogram recordings during the mission were consistent with preflight observations and there were no major arrhythmias.

The last Apollo spacecraft and other surplus flight hardware from cancelled U.S. lunar missions were used for the ASTP project.[10] Although the ASTP was conceived as the beginning of a series of joint flights, there were no further missions. To ensure a shirt-sleeve transfer between the spacecrafts, a multipurpose docking module called the Androgynous Peripheral Attach System (APAS) was developed based on requirements derived from hyperbaric chamber tests performed by NASA and the Soviet Institute of Biomedical Problems with Zvezda.[1,8,19] The Americans selected North American Rockwell to construct seven docking modules (two flight, four test, and one spare). This module was essentially an airlock, as the Soyuz cabin atmosphere was 21% oxygen (O_2) at 14.7 psi (it was lowered to 10.2 psi and the O_2 increased to 30% to help prevent decompression events) and the Apollo atmosphere was 100% O_2 at 5.0 psi (see **Fig. 1**).[12,14]

The protocols for compression and decompression of the crews during transfer worked well without any decompression syndrome events.[2,3,11] The APAS design was subsequently used on the Shuttle-Mir and the International Space Station. Prior to the mission, two unmanned and one manned (Soyuz 16) Soviet flights were flown to validate the spacecraft.

Soyuz 19 was launched from Baikonur on July 15, 1975, with Commander Alexei Leonov and Flight Engineer Valeri Kubasov. It was the first live telecast of a Soviet manned spaceflight launch. Both cosmonauts were fully

Fig. 1. An artist's rendition of the Apollo spacecraft about to dock with the Soyuz using the multipurpose docking module, which allowed transfer between the spacecraft despite the disparate atmospheres (NASA/Robert McCall).

*Retired

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DOI: https://doi.org/10.3357/AMHP.6263.2023

Table I. Timeline of Reentry, Landing, and Recovery Events.

TIMELINE	EVENT
50,000 ft altitude	• Loud noises associated with reentry causing difficult communications and affecting checklist callouts
30,000 ft altitude	• Switches not thrown by Brand to deactivate the RCS
24,000 ft altitude	• Switches for the Apollo apex cover ejection and deployment of the drogue parachutes are manually activated, causing the capsule to sway and the RCS thrusters to fire in an attempt to stabilize the spacecraft
23,000 ft altitude	• Red-brown cloud fills the Apollo cabin • Crew begin coughing, have difficulty talking, and experience skin and eye irritation • RCS switches thrown by Brand
10,000 ft altitude	• Outside air vent automatically opens and fumes quickly resolve • Cabin scrubbers remove remaining fumes • Total exposure time to NTO was 30 s
Splashdown	• Stafford deploys face masks and administers O_2 to all crewmembers • Brand becomes unresponsive but revives after Stafford places O_2 mask • Mask slips off Brand and he again becomes unresponsive but revives after mask is replaced by Stafford
Post landing on ship	• Stafford and Slayton both experience brief syncope, which is initially thought to be orthostatic • Crew disclose exposure event to crew surgeon

suited after the tragic depressurization deaths of all three crewmembers on Salyut 1/Soyuz 11.[9] Apollo was launched into a 217-mi x 231-mi, 51.7° orbit 7 h later with Thomas Stafford, Vance Brand, and Deke Slayton. The APAS docking module was extracted from the S-IVB upper stage by the Apollo crew. Docking then occurred 47 h later.

Upon opening the hatch of the docking module, the Apollo crew reported an acetone-like smell. The hatch was closed and the module purged. No further smells or ill effects were reported by the crew, and the three transfers of the crews visiting each other's spacecrafts and all joint activities proceeded normally.

During the final stages of reentry (see **Table I**), the Apollo crew was exposed to the reaction control system (RCS) oxidizer nitrogen tetroxide (NTO) gas reentering a cabin air intake through a switch that was left in an open position. Exposure to 50–100 ppm of NTO can cause delayed pulmonary edema. It is estimated that the Apollo crew was exposed to 250 ppm. Rapid reaction by Stafford, who deployed O_2 masks, mitigated the exposure.[18] Brand briefly lost consciousness until revived with O_2. After landing, the crew was diaphoretic with early signs of respiratory difficulties. General Stafford first informed the crew surgeon (Dr. Nicogossian) of the exposure on the ship hangar deck, and after a call with the U.S. President, the crew was admitted to the LPH carrier *New Orleans* recovery ship dispensary for observation. Initially, there was speculation concerning what the toxic gas was—hydralazine, NTO, or the pyros from the parachute deployment. The description of the color and odor of the gas quickly confirmed that it was NTO. The crew showered for decontamination and was administered oxygen and steroids. Initial chest X-rays showed no abnormalities, although the crew periodically woke up with bouts of unproductive coughing. About 6 h later, the crew developed classic symptoms, with chest X-rays showing diffuse opacifications and low blood arterial oxygen saturation levels indicative of chemical pneumonitis (see **Fig. 2**).[4,13,16] All three crewmen, after docking at Pearl Harbor, HI, were hospitalized at the Tripler Army Medical Center intensive care unit with supplemental O_2 and steroid therapy. The crew was discharged when symptoms improved after 5 d. Almost 2 wk after landing, the crew was flown back to Houston, TX.

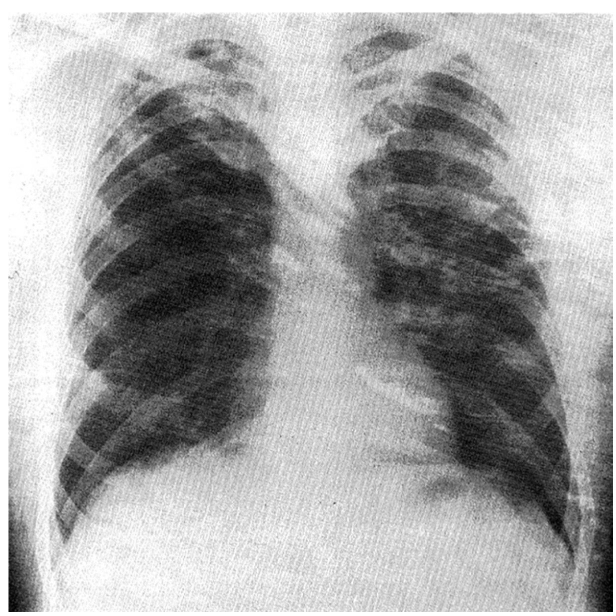

Fig. 2. Chest X-ray of an Apollo-Soyuz crewmember showing diffuse alveolar infiltrates.[13]

The project was an engineering, management, and political pathfinder for the U.S.–Russia space agreement in 1994 that led to the bilateral understanding of both countries' capabilities and infrastructure for human space exploration in low Earth orbit. The U.S. and Soviet crews cross-trained in both countries, became life-long close partners, and guided future cooperation in space. A major outcome was the sociocultural understanding and interactions, which facilitated future collaboration. By the time of the Shuttle-Mir project and the International Space Station, many workers at NASA and in Russia were fluent in both Russian and English. The ASTP medical working group was established late in program development. Nevertheless, a joint medical training and requirements document was produced. This document became the foundation for many future space missions and a useful tool for standardizing medical test protocols for joint NASA-USSR bed rest research and telemedicine projects.[15]

Despite the many political events and global changes over the last 47 yr, space collaborations between the United States and Russia, especially medical and biological research collaboration, have continued uninterrupted.[6] The ASTP crews remained strong proponents for increased collaboration by international partners and were effective ambassadors for the peaceful uses of space. This is the true legacy of the Apollo-Soyuz Test Project.

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