annual report to the nasa administrator by the aerospace safety advisory panel

part I—apollo soyuz test project

section 1—observations and conclusions

february 1975

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ANNUAL REPORT TO THE NASA ADMINISTRATOR

by the

AEROSPACE SAFETY ADVISORY PANEL

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CONTENTS

1.0 INTRODUCTION

1.1 Objective

The objective of the Panel's review of the Apollo Soyuz Test Project is to examine the management systems, hardware, and operational aspects of the Apollo mission affecting the safety of the astronauts, and provide NASA our observations, conclusions and recommendations. The mission includes joint operations with Soyuz during the rendezvous, docking, docked, and separation phases.

1.2 Panel Activities

The Panel does its fact-finding through detailed discussions with NASA and contractor personnel knowledgeable in the technical and management areas considered significant for crew safety. For instance, the Panel visited both the spacecraft contractor and the contractor for the first stage of the launch vehicle as well as NASA sites responsible for program management. In the case of Soyuz, the Panel talked with NASA personnel who are working most closely with the Soviets.

The fact-finding activities covered the following areas significant for crew safety:

(a) NASA and contractor management systems for Apollo/Saturn and new elements.

(b) The basis for confidence in the Soyuz management approach and in joint testing of Apollo/Soyuz hardware.

(c) Mission operations' planning and crew training.

(d) Hazard analysis and contingency planning.

The abbreviated agendas for these fact-finding activities are provided in Attachment 1.

The Panel also has had available to them joint documentation pertinent to these areas. They have examined, where possible, ASTP hardware mock-ups and test facilities.

In addition to the normal on-site activities, the Panel was represented by a member, Dr. Charles D. Harrington, at the final compatibility tests on the Apollo and Soyuz flight docking systems. These tests were held at the Soviet Academy of Sciences in Moscow. Dr. Harrington's observations are provided in Attachment 2.

2.0 OBSERVATIONS

2.1 Apollo

2.1.1 Management

The management systems are essentially those developed during the design and production of the successful Apollo, Skylab and Saturn vehicles as well as Apollo and Skylab mission operations. Adaptation of these management systems to the reduced size and bi-national aspects of the Apollo Soyuz joint mission appears to have been accomplished competently. NASA and contractor personnel bring to this program a very high level of experience. This continuity of key personnel at all program levels and their dedication to achieving safe and successful missions is encouraging.

2.1.2 Basic Apollo Hardware

The Command and Service Modules, Saturn launch vehicles, and ground support equipment are all proven hardware from the successful Apollo and Skylab series of missions. Necessary modifications to accommodate experiments and joint mission requirements have been subjected to detailed safety assessments and the hardware qualified in the same manner as used on the Skylab vehicles. Appropriate attention is being given to the age-life effects and to the storage and activation requirements of this hardware. In summary, the quality of the prime spacecraft (Command and Service Module 111) and of the backup spacecraft (CSM 119) appears to have been maintained. The quality of the launch vehicle hardware and ground support equipment appears to be at least equivalent to previous systems.

2.1.3 New Hardware

The principal new flight systems are the Docking Module and the Docking System. The design approach for the Docking Module applied safety margins significantly greater than those used in prior manned vehicles. The structure of the Docking Module is constructed of 5/8 inch aluminum plate, which possesses inherent strength considerably greater than that required to meet any known mission loads. The environmental control system high pressure gas vessels are designed with a safety factor of 4. Qualification of the Docking Module hardware was made by analysis and physical testing, which provides a basis for confidence in the flight systems meeting mission requirements.

The Docking System is designed primarily for stiffness requirements, where it is desirable to minimize structural deflections and strength becomes a secondary factor. Because the Docking System is the direct interface with the Soyuz spacecraft, it has been analyzed and tested independently and in joint tests with the Soyuz spacecraft's docking system. In view of the Panel's specific interest in the USA/USSR interfacing hardware, a Panel member observed a portion of the joint American-Soviet compatibility testing of the docking systems. These tests took place at the Soviet Academy of Science in Moscow in mid-November 1974. This also provided further insight into the Soyuz hardware, joint working relations between technical and management personnel, and the joint testing program. The Panel examined the test program and its results to assure that the qualification testing was adequate and that no residual safety problems for the flight personnel could be identified. Of the many key system components, the docking system seals, locking latches, and alignment pins and sockets were of particular interest. Development tests and qualification tests have been conducted on these items to assure proper operation within the joint phases of the mission. All known problems have been resolved.

The communication system for the Apollo spacecraft has two significantly new facets: the use of the ATS-6 satellite relay system and the Apollo Soyuz inter-spacecraft system. These systems have been tested both from the NASA side and as a part of joint compatibility tests. Results of these tests confirmed the acceptability of the systems. Additional communication tests will be conducted prior to the Flight Readiness Review with flight equipment in the flight vehicles. A cable communication system is hooked-up during the docked phase, providing hard line voice and video from the host spacecraft back to the visitor's spacecraft. Tests and analysis indicate proper operation of the communication systems during the joint mission.

2.1.4 Mission Design

The Apollo portion of the joint mission, from lift-off to splashdown, follows the pattern of prior earth orbital Apollo and Skylab flights. The Panel has not identified any new hazards to the crew in the Apollo/Soyuz flight systems.

2.2 Soyuz

2.2.1 Soyuz Management

We discussed at length with the NASA Working Group Chairmen those inferences that they drew about the Soviet management system based on their knowledge of available Soyuz technical information. They cited, for example, that the description of the Soyuz manufacturing, test and checkout flow in their Safety Assessment Report 20206 is similar to NASA's. NASA's Working Group Chairmen had found no management situations which would compromise NASA's ability to provide for crew safety during the joint phase of the mission. To be conservative, since we did not have first hand data, the Panel in its discussions with our ASTP managers placed particular emphasis upon NASA's knowledge of the Soyuz flight systems and on the mission and contingency planning that would further support crew safety. Our observations in these areas are found in those sections that follow.

2.2.2 Hardware

The Soyuz design being used in the Apollo Soyuz Test Project has a long test history. It appears suitable to the joint mission requirements. The Panel examined available information which it felt could be applicable to the safety of the astronauts. Since the basic vehicle was designed for unmanned as well as manned flights, the Soyuz design philosophy has minimized the role of the crew. Most systems on the Soyuz spacecraft for the ASTP flight are either automatic or semi-automatic. Soyuz hardware appears to be comparatively simple. Joint tests demonstrated the functional compatibility of the Soyuz docking system and its ability to meet overall joint mission requirements. In addition to the docking system, the Soyuz has the following new and modified hardware: ranging and communication system for rendezvous; Apollo radio communication system; external light system and docking target assembly; cable communications; and modified thermal control, life support and internal structural components.

From the information given the Panel it appears that the Soyuz systems are being qualified for flight through a ground and flight test program combined with analyses similar to the verification program used by the USA on their ASTP hardware. The Panel examined system verification work such as: communication compatibility tests; environmental control system and life support system tests; docking system tests; guidance and control system tests; available flight records; Soviet analyses applicable to systems of interest; and the report from our Panel member on his observations of joint docking system tests conducted in Moscow. The hardware appears to be meeting test objectives and further appraisals of hardware will be made during program reviews culminating in the Flight Readiness Review.

2.2.3 Mission Design

Soviet mission design, as observed from their performance, demonstrates that in the event of an onboard problem they tend to terminate the mission rather than take the risk of continuing the flight. This indicates their interest in crew safety. From the standpoint of crew safety this mode of mission operation is compatible with NASA's contingency planning fo this mission.

2.3 Joint Apollo/Soyuz

2.3.1 Working Groups

The joint aspects of the ASTP are exemplified by the joint USA/USSR working groups. This arrangement is new to both sides and is a principal element in the management of this mission. These five groups bring engineers, mission operations personnel and system safety personnel into discussions with their counterparts. The working groups are divided according to the following responsibilities:

(a) Mission Operations and Training

(b) Guidance, Control and Docking Aids

(c) Mechanical Design

(d) Communications and Tracking

(e) Life Support and Crew Transfer

These working groups conduct an average of three to four meetings a year in addition to continuing exchanges of information carried out through other communication channels. Systems and operations that are involved in the joint phases of the mission have been extensively discussed by these groups. The USA personnel have had every opportunity to ask pertinent questions of their Soviet counterparts. The information appears sufficient for NASA technical personnel and managers to make decisions concerning astronaut safety. The Panel feels that these working groups are effective.

2.3.2 Mission Design

The mission design for the joint phases of the project minimize the possible impact of Soyuz actions on USA spacecraft and crew. Typical of those items that minimize Soyuz impact on Apollo are:

(a) The Soyuz vehicle is passive during most of the joint operations.

(b) Apollo Command and Service Modules have sufficient propulsive power to override or take-over the attitude and direction of the combined vehicles.

(c) Launch of the USA spacecraft is predicated upon the successful orbiting of a fully functioning Soviet Soyuz vehicle. In addition, the control centers are in extensive communication with each other and with the spacecraft.

NASA is continuing its systematic review of Apollo and Soyuz systems for potential hazards. The results of this review will be used in contingency planning.

3.0 CONCLUSIONS

3.1 The Panel sees no increase in hazards during the Apollo phase over prior earth orbital missions.

3.2 During the joint phases of the mission confidence in crew safety must be based upon:

3.2.1 Test experience for Soyuz systems involved in the joint phase.

3.2.2 Thorough contingency analysis and planning.

3.2.3 Mission design that minimizes the impact of the hardware and operational procedures of one spacecraft on the other.

Thus, the Panel concludes that confidence in crew safety for the joint phases is essentially equal to that for prior manned earth orbital flights.

4.0 RECOMMENDATIONS

The Panel recommends that the following topics should be among those included in the Administrator's own reviews.

4.1 Docking Module reentry and dispersion.

4.2 Assurance against electromagnetic interference, in the absence of fully-mated EMI test of the Apollo/Soyuz system.

4.3 Assurance against premature undocking of the Apollo and Soyuz spacecraft.

4.4 Contingency planning, including:

4.4.1 Contingency plans for loss of ground communications between Moscow and Houston control centers and alternate plans for doing without ATS-6 coverage.

4.4.2 Protocols to assure respective lines of authority, and no conflict of authority, in the event of unforeseen contingencies.

4.5 Joint crew training and simulations for off-nominal conditions.

ATTACHMENT 1

PANEL ACTIVITIES ASSOCIATED WITH THE ASTP

4/10/73	ASTP Familiarization Project Objectives USA/USSR Hardware Crew Transfer Guidelines Ground and Flight Crew Training Experiment Selection Working Groups Agreements with Soviets	NASA Hqs.
9/11/73	Cooperative Activities and Major Events Major Items of Compatibility Real-Time Operations CSM Additions and Modifications Docking Module Hardware and Requirements ASTP Experiments and Their Posture Project Management, Schedules and Personnel Project Safety Assessment Activities and Reports	NASA/JSC
11/19-20/73	CSM Additions and Modifications for ASTP Manufacturing Status(New and Modified Hardware) Significant problems and their resolution Test Program and Results to Date Hazard Analyses (Failure Modes and Evaluations) Review of Mockups and available hardware	RI/Downey, CA
5/14/74	Launch Vehicle Hardware and Support Personnel, Organization, Experience Stage History and Current Open Work Age-Life studies, problems and solutions Stress Corrosion Stage Storage, Inspections, Controls Summary Assessment	Chrysler at Michoud. LA
9/10/74	ASTP Safety Philosophy Safety Organization, Personnel and their Role Safety Assessment Reports Unilateral Safety Efforts Open Safety Issues Mission Level Assessments	NASA/JSC

(Attachment 1 Continued)

10/15-16/74	Mission Profile Soyuz Familiarization Soyuz Flight History USSR ASTP Program Current Safety Assessment Reports Approach to Soyuz Reliability and Quality Working Group Briefings covering: - areas of responsiblity - major areas of joint work - information exchange - details of hardware covered by each group - test programs and test results - safety activities CSM 111 and 119 SAL and Truss Docking Module and Docking System Experiments	NASA/JSC
11/11-12/74	Detailed update and certification of hardware Detailed discussions with Working Group Chairman Detailed discussions with JSC Safety Personnel Briefing on ASTP Design Certification Review	NASA/JSC
11/15-23/74	Panel Observer and Participant in Joint Docking Tests conducted at the Soviet Academy of Sciences in Moscow	Russia
12/9-10/74	Progress Report on Safety Activities Details of Hazard Tree Analyses Report from Panel Member on his work during the joint USA/USSR docking tests in Moscow Results of Working Group No. 1 meetings at JSC Contingency Planning	St. Louis, MO
1/7/75	Conclusions of Unilateral System Safety Reports on Soyuz Progress Report on Mission Safety Assessment for Joint Phases	NASA/JSC

ATTACHMENT 2

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TRIP REPORT

OBSERVATION OF WORKING GROUP No. 3 AT ACADEMY OF SCIENCES MOSCOW USSR

GENERAL I was in the USSR from Sunday, Nov. 17, 1974 through Friday, Nov. 22, 1974 inclusive as observer for the Aerospace Safety Advisory Panel. The work being observed was the testing of the actual hardware of the Soviets and the U. S. which is involved in the docking, the so-called DS 5 and DS 7 of the U. S. and the CA-1, CA-2 and CA-3 of the Soviets. The test work of this WG 3 is taking place over approximately an eight week period, from about the third week in October to past the middle of December. This particular week of my observation was an especially interesting one because the final change of pin and socket was made and most of the final mating checks were being carried out. Since any of the two U. S. docking systems and any of the three USSR docking systems may be used in actual flight, a total of six complete sets of mating checks must be made. Approximately half of these were completed during this week, complicated somewhat by repetitions required after the change out of pin and socket. While I did not get copies of the test records (nor had they been digested and approved before I left), from my own observations and discussions with the test directors it would seem that all tests went smoothly with all results within test limits.

We met on Sunday,Nov. 17, with three of the USSR leaders, including the Chairman of their WG 3, and three of the U. S. team, including the interpreter from Rockwell. The subject discussed was the newly discovered potential hang up of the alignment pin and socket. This could be remedied either by putting in a socket with a longer, more gradual, slope, or by changing the pin to give it a rounded head so it would not hang up on the existing socket. It was proposed by the U. S. that the change be made only on the U. S. hardware. That is, to change the U. S. pin so it would work smoothly in the USSR socket, and to change the U. S. socket so it would accept smoothly the USSR pin without the rounded head. This suggestion was made because the U. S. pin and socket are readily replaced with just a screwdriver in a few hours, whereas the USSR would require complete disassembly to make a change out. It was apparent that the USSR team did not have authority to agree to the change. They kept making the point that this was a U. S. caused difficulty (translated "unpleasantness" by the interpreter), and that as far as they were concerned the original design was all right. After both sides had repeatedly explained their positions it was left that there would be further discussions on Monday. I was not in on those discussions but apparently by Wednesday morning agreement was obtained and we changed out the U. S. equipment by noon. Meanwhile tests on Monday and Tuesday were done with the old pin and socket. Tests continued Wednesday afternoon, Thursday, and Friday with the new hardware.

<u>TEST PROCEDURE</u> The test procedure for each mating check is extremely detailed and set forth in a document about one inch thick. It involves many measurements at each step. I will describe it only in its broad features. I have a copy of the procedure and it can be made available to any Panel Member who wishes to study it in detail.

The tests take place in a clean room with a marble slab floor, walls covered with stainless steel sheet, and a poured concrete ceiling. The room is equipped with a standard overhead crane manually controlled by a pendant with inching provision. All persons entering the room wore smocks, hats, and clean shoes. I was told the room was supplied with filtered air. The temperature appeared uniform and comfortable.

The U. S. docking system was mounted on a fixed rack on the floor with minor horizontal translation movements possible by screw jacks so it could be centered under the USSR system precisely. The USSR system was suspended overhead by the hoist with heavy springs to give a slight floating effect.

To make the tests the USSR system was precisely centered over the U. S. system, the proper docking ring extended, the system lowered to engage the docking latches, the docking ring retracted to engage the pins and sockets and bring the sealing rings into contact, and the structural latches engaged to get full sealing pressure. The system was later released to test the release mechanism.

While the docking will take only a few minutes in actual flight, the test required a few hours. After each step the operation was halted and precise measurements and visual observations were made. Particularly important were the strain gage measurements around the sealing surfaces after the structural latches were engaged. There are several of these (eight?) and all readings were extremely uniform. I was told that as many as three latches could fail to engage (presumably not in a row) and the other five could make a pressure tight seal.

HARDWARE The long time between steps in the tests, and setting up for new tests, gave ample time to study the USSR hardware in detail. Unfortunately they had a green cloth cover over most of the externals of the docking system, not including of course the docking ring, docking latches, docking ring extension mechanism, and the structural latches. The inner hatch opening mechanism was also fully exposed. In general I felt the workmanship was quite good, but they do not put on the fine finishes that we do. For instance, the docking "petals" are apparently milled out of solid aluminum alloy leaving structural ribs (as we do), but the milling cutter marks can still be seen. They do not fine finish for appearance. However, the working mechanisms are apparently finished to tolerances similar to ours, and in the gears, pulleys, cables, drives, and so forth there was no visible quality difference. All of their fasteners (screws, etc.) are sealed in place with some red plastic so they cannot loosen. I believe their design for the docking ring extending mechanism is superior to ours and will give more positive control.

INTERACTION During the tests the Soviets had a team of technicians on the floor and a test director and quality assurance man at the control table, as did the U. S. The interpreter was supplied by Rockwell. All test instructions were given in Russian by the Soviet test director, then translated into English by the interpreter. Similarly, all observations from the floor were called out, translated as required, and repeated by the test directors, who recorded them, following exactly the inch thick procedure manual referred to earlier.

It is my understanding that much of this quality assurance discipline was copied from us by the Soviets, and that they actually made up their record sheets using ours as a model. They had apparently not applied this kind of discipline before, but appear to feel that they have learned something and that this is a good procedure.

The interpreter (a native Russian, long since living in the United States and a full time employee of Rockwell) did an excellent job, and I do not believe there was any problem in communication. Also, the key Soviet people have learned quite a lot of English in the past two or three years and could communicate with our people when necessary without the interpreter.

I took occasion to meet privately with the U. S. WG 3 Chairman (a NASA man) to enquire how he felt about the effectiveness with which the two teams were cooperating, and to ask if he saw any need for improvement. He is fully satisfied with all aspects of communication and cooperation. From what I saw I fully agree with him.

RECOMMENDATIONS The present intent is to make the first docking on the actual flight with the active structural latches of the U. S. system engaging the passive hooks of the Soviet system. The bulk of the experiments will be carried out with this latching mechanism. Toward the end of the experiments another docking will be tried with the Soviet active latches engaging the U. S. passive ones. The tests in Moscow are therefore being carried out both ways. In addition, some tests were made in which after engaging the U. S. active with the Soviet passive, the Soviet active were then engaged with the U. S. passive, although this is not the intent for the actual flight.

With only one set of hooks engaged it is possible for one false signal to release the hooks, either by exploding the pyros releasing the Soviet passive latches, or by actuating the mechanism releasing the U. S. active latches. If both sets of latches are engaged it would take two signals, false or deliberate, before the docking system could release. Both of these signals could come from either the Soviet or U. S. control module, so each side would have full control in case of some unforeseen abnormal situation.

It is my belief that the most likely potential cause of a total disaster on this flight is the accidental release of the latches, however remote this possibility may be. I would therefore recommend that very serious consideration be given to having both sets of latches engaged while the crews are exposed to this hazard.