~~SECRET~~

Defense Intelligence

7RØ473
PERX
FDIA/DID/JUL/9/N/Z

NO FOREIGN DISSEMINATION

DIGEST

(U)

~~JULY [illegible] · Volume 7 [illegible] Number 7~~

M-3 search

SUBJ 10X TDS

No. 0458472

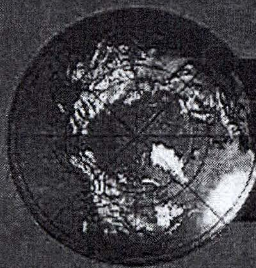
DECLASSIFIED UNDER AUTHORITY OF THE
INTERAGENCY SECURITY CLASSIFICATION APPEALS PANEL,
E.O. 13526, SECTION 5.3(b)(3)

ISCAP APPEAL NO. 2009-068, document no. 279
DECLASSIFICATION DATE: May 14, 2015

~~EXCLUDED FROM AUTOMATIC REGRADING: DOD DIR. 5200.10 DOES NOT APPLY~~

DEFENSE INTELLIGENCE AGENCY

~~SECRET~~



Contents

MANAGING EDITOR........ Andrew Pasternak
ART EDITOR........ Robert L. Burleigh
SR. ILLUSTRATOR........ Brian W. McMullin
SENIOR EDITORS........ Francis A. Dohn
Philip McDonnell
D. Edwin Schmelzer
EDITORS........ Jane R. Hooper
Susan F. Hirschmann
EDITORIAL ASSISTANTS........ Mary Mattison
Elizabeth Foreman

July 1969 • Volume 7 • Number 7

Soviet "N" Class SSN. An overall view of the Soviet Navy in 1968 begins on page 4. [U]

FOREWORD

MISSION: The mission of the monthly *Defense Intelligence Digest* is to provide all components of the Department of Defense and other United States agencies with timely intelligence of wide professional interest on significant developments and trends in the military capabilities and vulnerabilities of foreign nations. Emphasis is placed primarily on nations and forces within the Communist World.

WARNING: This publication is classified secret because it reflects intelligence collection efforts of the United States, and contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18 U.S.C., Section 793 and Section 794. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law. Although the publication is marked "No Foreign Dissemination," certain articles are releasable to foreign governments; however, such release is controlled by the Defense Intelligence Agency.

Joseph F. Carroll

JOSEPH F. CARROLL
Lt General, USAF
Director

Effects of Zond Vehicle Re-entry on Soviet Space Program

Two important vehicles lead the Soviets closer to manned Lunar flight

DURING a 59-day period in their 1968 space program, the Soviets proved they could: recover a lunar orbital spacecraft within the Soviet landmass; demonstrate effective heat-shielding during re-entry; and bring back data from the moon without intermediate processing.

Zond 5 was launched by an SL–12 launch vehicle from Tyuratam on 14 September and three and a half days later passed around the back of the moon at a distance of 1,050 nautical miles. The spacecraft continued past the moon's back side along a free earth-return trajectory, entered the earth's atmosphere along a ballistic re-entry trajectory, and was picked up by a Soviet recovery ship in the Indian Ocean.

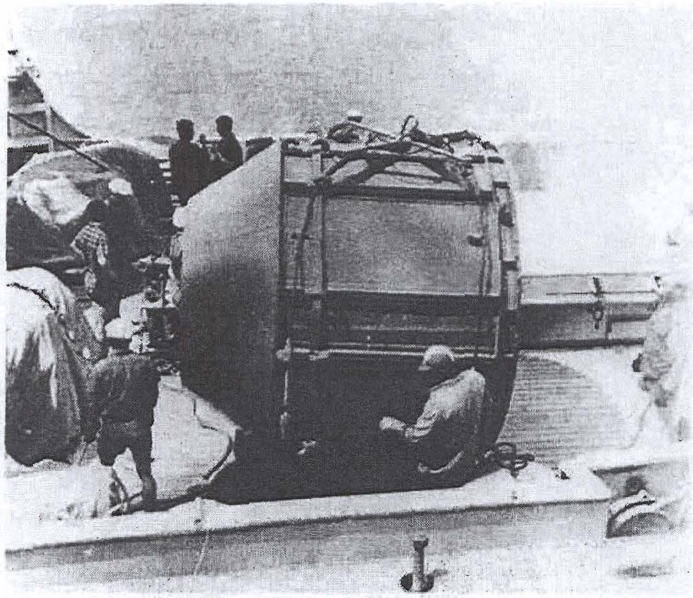
On 10 November the Soviets launched an unmanned Zond 6 from Tyuratam—again with an SL–12—and essentially duplicated the previous mission, with the exception of final re-entry. Zond 6 flew an aerodynamic "skip-glide" re-entry trajectory and landed within the Soviet Union. The skip-glide was similar to the US Apollo 8 re-entry; however, the Zond 6 range from atmospheric re-entry to touchdown was 4,800 nautical miles, compared to a 1,300-nautical-mile downrange distance for Apollo 8 re-entry.

Zond spacecraft design. Both Zond 5 and 6 circumlunar spacecraft comprised two sections—an instrument section and a re-entry vehicle. The instrument section contained an orientation and stabilization system for attitude control, a guidance and control system, and a rocket engine system.

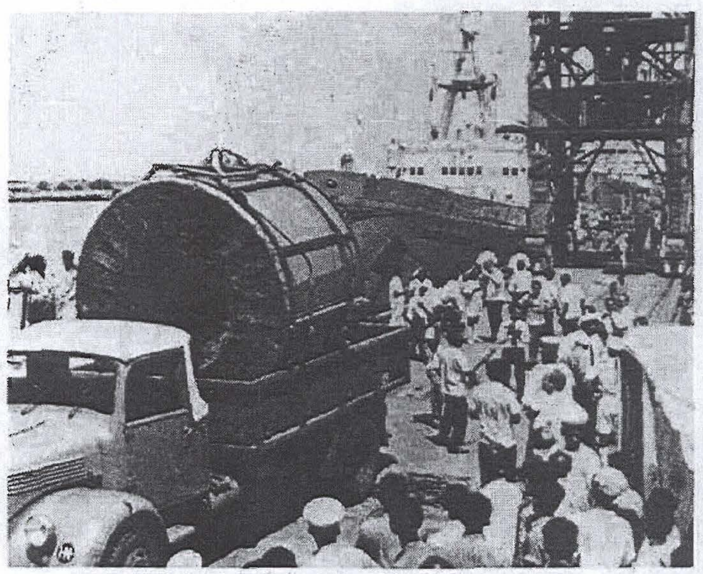
The latter two systems provided trajectory corrections during circumlunar flight and ensured re-entry conditions.

The re-entry vehicle contained the scientific equipment and recorded data, an orientation and stabilization system for re-entry trajectory control, and a parachute system for soft landing. During both the Zond 5 and 6 events, the re-entry vehicle separated from the instrument section prior to re-entry. The re-entry vehicle was coated with a layer of ablative heat-shield material and thus survived re-entry while the instrument section, which was not protected, burned during its descent through the atmosphere.

Prior to the Zond 5 and 6 missions, lunar-related scientific and photographic data obtained from spacecraft were not recovered in the originally recorded form. The data were first received on board the spacecraft, then processed or recorded in a given format, and finally transmitted to earth. The recovery of the two Zond re-entry capsules provided Soviet scientists with the first originally recorded data about the moon; therefore the degradation of data inherent in the on-board processing and transmission process was eliminated.



Zond 5 capsule container on board Golovnin (top), headed for Bombay; arriving (below) 11 days after recovery in Indian Ocean. (S)



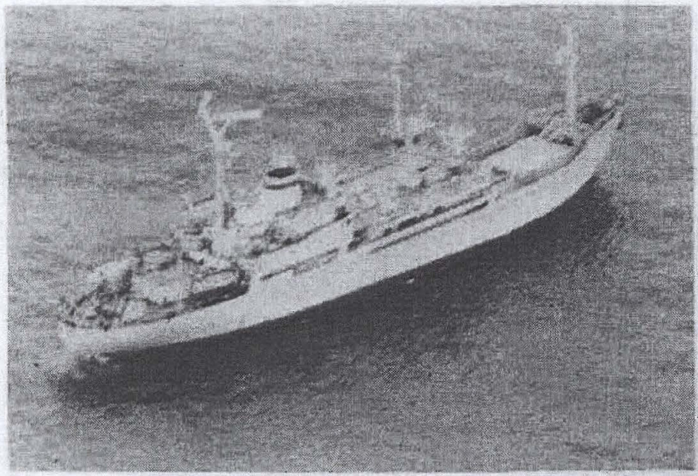
Lunar return constraints. In contrast to the atmospheric re-entry of earth orbital craft, no retro engines are used to reduce the velocity of spacecraft returning from lunar missions. Such engines are not practical because of the amount of propellant they would require to slow the craft to near orbital re-entry velocity. Thus, the atmospheric entry velocity for a lunar return re-entry is approximately 11,000 feet per second (about 40 percent) greater than that for a typical earth-orbital re-entry.

Since aerodynamic deceleration (G load) is proportional to the velocity squared, a spacecraft returning to the earth's atmosphere from a lunar mission presents more severe thermal environment than the re-entry of an earth orbital spacecraft. More precise control of the initial re-entry conditions is desirable to ensure that aerodynamic deceleration and heating do not exceed payload tolerance levels.

To achieve these initial re-entry conditions, a lunar return spacecraft must enter the earth's atmosphere within an "allowable re-entry corridor."

The upper (overshoot) boundary of this corridor is defined by the trajectory whereby the vehicle is slowed just enough to ensure that the spacecraft returns to earth and does not skip-out back into space in an elliptical earth orbit.

The lower (undershoot) boundary of the allowable corridor is defined by the trajectory path below which either atmospheric deceleration or atmospheric heating exceeds the spacecraft design limits. Thus, the width of the allowable re-entry corridor is defined as the distance between the overshoot and undershoot boundaries measured at the atmospheric re-entry point. For each mission, an atmospheric re-entry location and a "prescribed re-entry corridor" (within and less than the allowable corridor width) are chosen to target the spacecraft into a predetermined recovery zone.



SSESS Borovichi, using radio and illumination, was first to locate and draw alongside the Zond 5. (S)

Steaming toward the Zond 5 is Soviet tanker Hanoi, second ship to arrive at September splashdown. (S)

The Soviets used what they call a "southern variant" re-entry for the recovery of their circumlunar spacecraft. This means the atmospheric re-entry location was in the southern hemisphere and the spacecraft was traveling in a south-to-north direction. This is the only type of re-entry profile that will allow the Soviets to recover their circumlunar spacecraft within the USSR without exposing the vehicle to extremely high decelerations.

Should the Soviets attempt a "northern variant" re-entry from a circumlunar mission, the spacecraft would not enter the atmosphere until it was beyond the southern border of the USSR and would be traveling in a southerly direction. A landing within the Soviet Union using the northern variant would therefore be impossible.

Zond 5 re-entry and recovery. During the return phase of the Zond 5 flight, trajectory measurements were made and the operation of the on-board systems and scientific equipment was checked out. To ensure that Zond 5 would enter the atmosphere at the predetermined point and within the prescribed re-entry corridor, a final trajectory correction was made at a distance of 77,300 nautical miles.

The prescribed ballistic re-entry corridor for the Zond 5 was between 5 and 6 nautical miles wide, with the atmospheric re-entry point located in the southern part of the Indian Ocean. For a ballistic re-entry trajectory of the Zond 5 type, the prescribed re-entry corridor chosen corresponds to maximum aerodynamic deceleration evels of between 10 and 16 G's. Computations indicate that deceleration loads did not exceed 16 G's and that loads in excess of 10 G's lasted for about 50 seconds. Therefore, Zond 5's re-entry trajectory apparently was within the prescribed re-entry corridor and close to the desired trajectory. The G levels attained during the re-entry were greater than those desired or liable to be planned for a manned flight, but would not be prohibitive.

A future manned lunar return mission using a ballistic re-entry as the primary recovery mode is not anticipated. A Zond 5-type ballistic re-entry is, however, applicable to future unmanned lunar and planetary return missions and could be used as a back-up recovery mode for manned lunar missions.

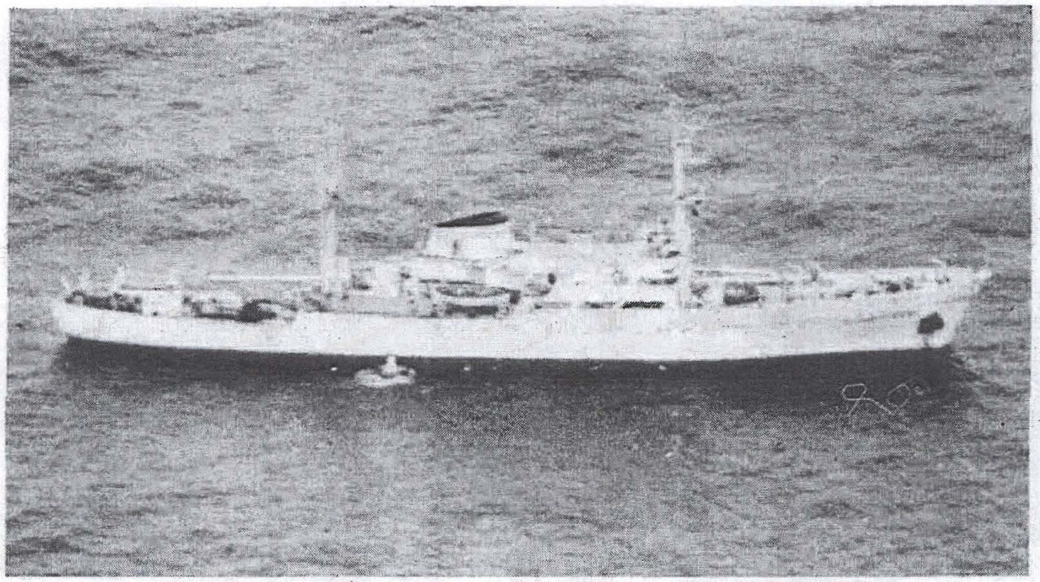
After withstanding the extreme conditions imposed by its lunar return ballistic re-entry, Zond 5 used a parachute system to soft-land in the Indian Ocean at a point approximately 950 nautical miles downrange from the atmospheric re-entry location. The parachute system was employed at an altitude of 23,000 feet when the velocity was 650 feet per second—resulting in a total time from re-entry to touchdown of approximately 15 minutes.

Several Soviet Space Event Support Ships (SSESS) and a number of ships of the search and rescue service were detailed to locate and recover the spacecraft. Re-entry occurred at night with adverse weather prevailing throughout the recovery. The SSESS *Borovichi*, using both radio and illumination, was the first to locate and draw alongside the craft. Subsequently a Soviet tanker *Hanoi* approached the Zond. The *Golovnin* initiated retrieval operations using a small boat and lifted the Zond aboard with a cargo net.

Eleven days after recovery the *Golovnin* delivered the Zond 5 capsule to Bombay, India, where it was loaded into a metal shipping container. An An–12 transport aircraft carried the Zond back to the USSR.

Zond 6 re-entry and recovery. Zond 6 scored another Soviet first in space achievements—the use of an aerodynamic skip-glide re-entry technique.

The final trajectory correction before re-entry was made at a distance of 64,700 nautical miles and the spacecraft entered the earth's atmosphere over the southern Indian Ocean, along a "southern variant" re-entry trajectory. The southern variant allows the aerodynamic deceleration loads to be reduced from that of a ballistic re-entry.



SSVRS Golovnin initiated retrieval operations and lifted the Zond aboard. (S)

Prior to entering the prescribed corridor, the re-entry vehicle was separated from the spacecraft instrument section and stabilized by an on-board attitude control system which oriented the vehicle for re-entry.

The shape of the Zond 6 re-entry vehicle—an axisymmetric truncated cone with the center of gravity displaced from the centerline—permitting the vehicle to stabilize aerodynamically with a given angle of attack. This attitude creates a nonsymmetric airflow around the vehicle and produces an aerodynamic force. The measure of aerodynamic maneuvering capability (L/D value) is the ratio of the lift force to the drag force. When using a re-entry vehicle with an aerodynamic maneuvering capability, the initial re-entry attitude must be precisely controlled to insure that the aerodynamic force is in the proper direction of the lift vector. Zond 6 was controlled by rotating the spacecraft about the centerline (roll) axis.

The Zond 6 prescribed re-entry corridor was only 5.4 nautical miles wide. The re-entry vehicle apparently entered the atmosphere within the prescribed re-entry corridor at an approximate velocity and flight path angle of 36,100 feet per second and minus 6.8 degrees respectively, and performed a shallow aerodynamic skip trajectory within the atmosphere before exiting along a ballistic path.

During the first immersion, the re-entry vehicle remained within the atmosphere for slightly less than three minutes, during which time the drag force reduced flight velocity to below earth orbital velocity, ensuring return to earth. The primary task of the re-entry trajectory control system during the first immersion was to control the exit velocity and flight path angle so as to provide the required downrange distance during the ballistic portion of the re-entry trajectory. During the ballistic trajectory above the atmosphere, the vehicle reached a maximum altitude of approximately 120 miles and the attitude control system was again used to orient and stabilize the re-entry vehicle for the second atmospheric immersion.

The primary task of the re-entry trajectory control system during the second immersion was to achieve an accurate landing at a predetermined impact point within the Soviet Union. At an altitude of 25,000 feet and a velocity of 650 feet per second the parachute system was activated; shortly thereafter the capsule landed in the USSR, 4,800 nautical miles downrange from its first atmospheric re-entry point. Computer simulation indicates that an approximate L/D of 0.3 was used to perform the Zond 6 skip-glide re-entry trajectory.

Aerodynamic decelerations generated during the Zond 6 skip-glide trajectory reached peak levels of between 4 and 7 G's during the first atmospheric immersion, and deceleration levels remained below 4 G's during the second immersion. These levels are well within the tolerable range from manned re-entry. Aerodynamic maneuvering re-entry vehicles of the Zond 6 type are particularly applicable to Soviet manned lunar return missions, since they can provide both tolerable G levels and the required range extension for recovery within the USSR.

The Soviets have apparently solved the critical problem of heat shielding during lunar return re-entry. Zond 5 re-entered ballistically and successfully withstood simultaneous high peak heating and high G level conditions. Zond 6 re-entered aerodynamically, and while the maximum G's were less than for the Zond 5 re-entry, the total heat load was greater because of the longer flight time within the atmosphere. The double immersion of the Zond 6 skip-glide re-entry trajectory subjects the heat shield to two distinct heat fluxes causing additional heat shield problems.

The Zond 5 and 6 re-entry successes substantiate the validity of both the Soviet lunar return re-entry techniques and hardware designs. Zond 6 verified a recovery technique that could be used to recover a returning manned-lunar vehicle within the USSR while Zond 5 demonstrated an acceptable back-up recovery mode. [END]