Saguaro Astronomy Club

Metro Phoenix, Arizona

SACNEWS

January 1994 — Issue #204

v1.3

The Great Moon Race: The Final Lap

by Andrew J. LePage

Part 2

This article is Copyright © 1993 by Andrew J. LePage. The author gives permission to any group or individual wishing to distribute this article, so long as proper credit is given and the article is reproduced in its entirety.

This article from the November, 1993 (Volume 5, Number 4) issue of the Electronic Journal of the Astronomical Society of the Atlantic (EJASA) of the Astronomical Society of the Atlantic (ASA).

The Mystery of KOSMOS 159

The Soviets' only lunar-related mission to make it beyond Earth parking orbit in 1967 was the mysterious flight of KOSMOS 159. Some Western analysts thought that this mission was some sort of L-1 propulsion module test, but recent Soviet references tell a much different story. The first two L-1 test flights in early 1967 — KOSMOS 146 launched on March 10 and KOSMOS 154 launched on April 8 — were intended to be sent into highly elongated Earth orbits aimed 180 degrees away from the Moon. Unfortunately, both spacecraft were stranded in low Earth parking orbits when the new Block D escape stage of the PROTON launch vehicle failed to operate.

While the Block D stage was being re-evaluated, the Soviets decided to modify one of their surplus LUNA spacecraft buses to conduct much-needed communications tests from lunar distances. On May 16, KOSMOS 159 was launched into an Earth parking orbit by a MOLNIYA launch vehicle. The MOLNIYA's Block L escape stage fired after a short coast to send the spacecraft into an orbit away from the Moon to avoid its trajectory complicating influences. Its intended orbit is not known, but KOSMOS 159 was placed into a 160 by 37,732-mile (257 by 60,710-kilometer) Earth orbit inclined 51.7 degrees to the equator. Unless this modified LUNA spacecraft was much heavier than its predecessors, the MOLNIYA could have easily boosted this payload much higher. At this time it is not known what, if any, objectives were met during this flight.

SURVEYOR 4

The Soviet lunar program continued to suffer problems for the rest of 1967. Only American spacecraft would successfully venture into cislunar space for the balance of the year. The next lunar mission was that of SURVEYOR 4. Launched on a direct ascent trajectory to the Moon on July 14 by ATLAS-CENTAUR 12, the year's second lunar landing attempt was targeted for Sinus Medii, almost dead center of the Moon's near side. The landing site would be the roughest of the series to date. The descend-

Quick Calendar

SAC Star Party
Buckeye Hills Recreation Area
Saturday, January 8

SAC Meeting
7:30, Friday, January 28

SAC Deep Sky Meeting
Constellation: Gemini and Lupus
7:30, Thursday, February 3

SAC Star Party
Buckeye Hills Recreation Area
Saturday, February 5

Membership Renewals Are Due

Renewals: 71 of 114 — Have you renewed?

See Member Services Form on the back page.

SAC Officers

President	Bob Gardner	274–5046
Vice President		
Treasurer	Carol Lee	946–9206
Secretary	A.J. Crayon	938–3277
Properties	Pierre Schwaar	285–9634
SACNEWS Editor	Paul Dickson	841–7044
Public Events	Rich Walker	997–0711

ing spacecraft would have to contend with an approach angle of 36 degrees to the local vertical.

Like the previous mission, SURVEYOR 4 was equipped with an SMSS experiment along with a pair of 2 by 0.5 by 0.125-inch (51 by 13 by 3-millimeter) bars mounted on Foot Pad 2. Only one bar was magnetic. By observing the response of the lunar soil to these bars, its magnetic properties could be ascertained.

A single mid-course correction during the long coast up nudged SURVEYOR into its target area. On July 17, the quickly descending lander aligned its retrorocket with its flight path and began firing as planned. At an altitude of about seven miles (eleven kilometers), just two seconds before the retrorocket was to burn out, all transmissions from the probe ceased.

What exactly happened was never determined. It is possible that SURVEYOR 4 automatically landed intact 2.5 minutes later as scheduled. It is also possible that the retrorocket suffered a burn through, destroying the spacecraft. Whether as a mute robot or only twisted wreckage, SURVEYOR 4 came to rest at 0.4 degrees north, 1.33 degrees west longitude just 2.4 miles (3.9 kilometers) southeast of its target. Attempts to contact the spacecraft continued for another six hours before the mission was declared a loss. Unknown at the time, this would be the last unmanned American lunar or planetary mission to fail in flight until the demise of MARS OBSERVER in August of 1993.

EXPLORER 35

Without losing a beat, the next American lunar mission was launched just two days later on July 19. This mission was the second attempt to launch an Anchored Interplanetary Monitoring Platform (AIMP) into lunar orbit. EXPLORER 35 was quite similar to its sister EXPLORER 33, launched one year earlier. This new 230-pound (104-kilogram) AIMP carried a total of ten instruments: Two flux gate magnetometers mounted on the ends of two six-foot (1.8-meter) booms with one sensitive to fields in the 0.1 to 64 gammas range and the other 0.2 to 200 gammas. Three radiation detectors and one plasma probe examined the Moon's radiation environment, looking for spatial and temporal variations. Measurements made by these instruments would be correlated with measurements made by the other IMPs and space probes. A micrometeoroid detector, two passive tracking experiments, and an engineering test involving solar cell degradation rounded out the list of cosmic investigations.

Just like the previous AIMP, EXPLORER 35 would have to rely on the accuracy of its DELTA E launch vehicle, since it possessed no course correction capability. Unlike the previous mission, however, DELTA 50 put AIMP E on course towards the Moon. Starting about 38 hours after launch, the probe used its attitude control jets for three hours to align the 79-pound (36-kilogram) retrorocket. On July 21, just sixty hours after launch, the retrorocket fired for 23 seconds, placing EXPLORER 35 into a 500 by 4,780-mile (800 by 7,692-kilometer) orbit inclined 147 degrees to the equator and revolving about the Moon once every 11.5 hours. Two hours later the spent retrorocket case was jettisoned and the mission began.

Early findings indicated that the Moon possessed virtually no magnetic field and lacked any sort of radiation belts. The only effect the Moon had on the solar wind was to punch a hole in the flow, creating a 100,000-mile (160,000-kilometer) long cavity, or wake. Based on measurements, the internal conductivity of the Moon was estimated. This measurement indicated that the Moon's internal temperature was less than 1,800 degrees Fahrenheit (1,000 degrees Celsius). EXPLORER 35 would continue to perform beyond its one year design life and even return information in conjunction with experiments carried by the APOLLO missions well into the early 1970s.

LUNAR ORBITER 5

On August 1, the United States launched its third lunar probe in two and one-half weeks. The last of its series, LUNAR ORBITER 5, was successfully placed on a trajectory to Earth's natural satellite by its ATLAS-AGENA D launch vehicle. The mission was for the probe to assume a low polar orbit and photograph 36 selected sites of scientific interest as well as virtually complete coverage of the Moon's far side.

At first LUNAR ORBITER had some trouble locating its celestial reference, Canopus, but finally did so 18 hours, 34 minutes after launch. The following day a 26-second mid-course correction burn was performed, followed by another 508-second burn 89 hours after launch. Shedding 1,440 miles per hour (644 meters per second), LUNAR ORBITER 5 settled into a 122 by 3,754-mile (196 by 6,040-kilometer) orbit inclined 85 degrees to the lunar equator.

Imaging began on August 6. An orbital trim maneuver the following day changed the orbit to 62 by 3,760 miles (100 by 6,050 kilometers) and decreased the inclination by 0.4 degrees. During the balance of the month, LUNAR ORBITER 5 exposed a total of 213 frames of film and completed their transmission by August 27. In total, all five spacecraft of the series imaged 99 percent of the lunar surface, far surpassing the expectations of their designers and controllers.

With its photographic mission completed, LUNAR ORBITER 5 set about gathering data on the Moon's irregular gravitational field, proton radiation levels, and micrometeoroids. The probe was also observed by APOLLO tracking stations in preparation for the day APOLLO would orbit the Moon. A 41-second burn of the velocity control engine on October 10 changed the orbit to 124 by 1,234 miles (200 by 1,986 kilometers) inclined 85.15 degrees to the equator. This orbit would reduce the period of lunar eclipses that would start in eight days.

By the end of 1967, LUNAR ORBITER 5 was nearing the end of its usefulness but still had plenty of attitude control gas left. As a result, a unique experiment was approved. The underside of the orbiter was cover by 514 small quartz mirrors for thermal control which, when

combined with the solar panels, was the equivalent of a fully reflecting mirror with an area of nine square feet (0.8 square meters). If all these surfaces were perfectly aligned and the spacecraft oriented properly, LUNAR ORBITER 5 would appear as a sixth magnitude star up to nine arc minutes from the bright limb of the Moon as seen from Earth. Even making allowances for the fact that these surfaces were not optically flat, the little spacecraft would be visible in a large telescope. Optical tracking combined with standard radio tracking would allow scientists to better determine the position of the Moon's center of mass relative to its limb.

Major observatories were advised of this opportunity: Seven would observe the first attempt on January 18, 1968. After one hour of maneuvering, LUNAR ORBITER 5 was not detected. A second attempt on January 21 was much more successful. The spacecraft was rolled 96 degrees from Canopus then changed its yaw angle by 37 degrees. The cone of light reflecting off of the probe's underside was about 19,000 miles (31,000 kilometers) across by the time it reached Earth. Through a series of six small yaw and pitch maneuvers, the orbiter was slowly rocked, allowing this cone to scan across Earth.

The freshly cleaned and modified 61-inch (1.5-meter) Catalina reflector, operated by the University of Arizona's Lunar and Planetary Laboratory, had perfect conditions that evening and actually detected the spacecraft. A total of eighty five-and-ten-second exposures were made over the course of almost two hours. Of these, 52 plates actually showed the orbiter, which was tracked for a total of one hour, eight minutes, and twenty seconds. At times it appeared as bright at a twelfth magnitude star, while other times fading below fifteenth magnitude and into virtual invisibility.

Unfortunately, a third attempt of this experiment was never made. On January 31, an 18.9-second burn of the velocity control engine allowed LUNAR ORBITER 5 to crash into the Moon on the equator at seventy degrees west longitude near the rim of the crater Hevelius. With an unprecedented five straight successes, the LUNAR ORBITER program was over.

SURVEYOR 5

All eyes now turned to the SURVEYOR project and its last three missions. SURVEYOR 5 was lofted towards the Moon on September 8, 1967 by ATLAS-CENTAUR

Comet Comments

by Don Machholz

(916) 346-8963 December 7, 1993

Four comets remain visible in our skies, while one was recovered.

Periodic Comet Mueller (1993s): Jean Mueller discovered this comet on Nov. 20 during the course of the Second Palomar Survey. An early orbit indicated it may brighten to magnitude 14 in more than a year, it has a distant (2.3 AU) perihelion distance.

Comet	Mueller				(1993a)
Date	RA-2000	Dec	Elong	Sky	Mag
12–24	21h12.8m	+27°04′	67°	E	9.0
12–29	21h19.5m	+24°13′	63°	E	9.1
01–03	21h25.9m	+21°40′	58°	E	9.2
01–08	21h32.0m	+19°23′	53°	E	9.2
01–13	21h37.9m	+17°19′	49°	E	9.3
01–18	21h43.7m	+15°29′	44°	E	9.4
01–23	21h49.2m	+13°49′	40°	E	9.4
01–28	21h54.6m	+12°19′	36°	E	9.5
02–02	21h59.8m	+10°57′	31°	E	9.6
02–07	22h04.9m	+09°42′	27°	E	9.7

Comet	Mueller				(1993p)
Date	RA-2000	Dec	Elong	Sky	Mag
12–24	22h52.8m	−02°50′	71°	E	10.4
12–29	22h54.7m	−05°00′	66°	E	10.2
01–03	22h57.1m	−07°02′	60°	E	10.1
01–08	23h00.1m	−08°55′	55°	E	10.0
01–13	23h03.5m	−10°42′	50°	E	9.9
01–18	23h07.4m	−12°24′	46°	E	9.7
01–23	23h11.7m	−14°01′	41°	E	9.6
01–28	23h16.3m	−15°36′	37°	E	9.4
02–02	23h21.4m	−17°09′	33°	E	9.2
02–07	23h26.8m	−18°42′	30°	E	9.0

Periodic	Comet				Encke
Date	RA-2000	Dec	Elong	Sky	Mag
12–24	22h29.6m	+04°08′	69°	E	9.9
12–29	22h29.5m	+03°40′	64°	E	9.6
01–03	22h29.4m	+03°12′	59°	E	9.3
01–08	22h29.0m	+02°38′	53°	E	8.9
01–13	22h27.5m	+01°54′	48°	E	8.4
01–18	22h24.1m	+00°46′	41°	E	7.8
01–23	22h16.8m	−01°04′	34°	E	7.2
01–28	22h02.9m	−04°08′	25°	E	6.4

Periodic Comet Schwassmann-Wachmann 2					
Date	RA-2000	Dec	Elong	Sky	Mag
12–24	08h43.0m	+16°35′	144°	M	11.2
12–29	08h42.4m	+16°48′	149°	M	11.1
01–03	08h41.1m	+17°05′	154°	M	11.1
01–08	08h39.1m	+17°26′	160°	M	11.0
01–13	08h36.5m	+17°49′	166°	M	11.0
01–18	08h33.5m	+18°15′	172°	M	11.0
01–23	08h30.2m	+18°42′	178°	M	10.9
01–28	08h26.8m	+19°09′	177°	M	10.9
02–02	08h23.5m	+19°35′	171°	M	11.0
02–07	08h20.5m	+20°00′	165°	M	11.0

Summary of Lunar Probe Launches — 1967 to First Half 1968

Name	Launch Date	Country	Weight lbs (kg)	Launch Vehicle	Comments
LUNAR ORBITER 3	Feb 5, 1967	US	848 (385)	ATLAS-AGENA D	Photographic lunar orbiter
KOSMOS 146	Mar 10, 1967	USSR	11047 (5017)	PROTON	Unsuccessful cislunar L-1 test
KOSMOS 154	Apr 8, 1967	USSR	11050 (5020)?	PROTON	Unsuccessful cislunar L-1 test
SURVEYOR 3	Apr 17, 1967	US	2279 (1035)	ATLAS-CENTAUR	Lunar landing
LUNAR ORBITER 4	May 4, 1967	US	859 (390)	ATLAS-AGENA D	Photographic lunar orbiter
KOSMOS 159	May 16, 1967	USSR	3500 (1600)?	MOLNIYA	Cislunar communication test with second generation LUNA bus
SURVEYOR 4	Jul 14, 1967	US	2283 (1037)	ATLAS-CENTAUR	Unsuccessful lunar landing attempt
EXPLORER 35	Jul 19, 1967	US	229 (104)	DELTA E	Lunar orbiter
LUNAR ORBITER 5	Aug 1, 1967	US	859 (390)	ATLAS-AGENA D	Photographic lunar orbiter
SURVEYOR 5	Sep 8, 1967	US	2215 (1006)	ATLAS-CENTAUR	Lunar landing
SURVEYOR 6	Nov 7, 1967	US	2220 (1008)	ATLAS-CENTAUR	Lunar landing
Unannounced	Nov 21, 1967	USSR	11300 (5140)?	PROTON	Launch failure of L-1 test
SURVEYOR 7	Jan 7, 1968	US	2290 (1040)	ATLAS-CENTAUR	Lunar landing
ZOND 4	Mar 2, 1968	USSR	11300 (5140)?	PROTON	Partially successful cislunar L-1 test
LUNA 14	Apr 7, 1968	USSR	3500 (1600)?	MOLNIYA	Lunar orbiter
Unannounced	Apr 22, 1968?	USSR	11300 (5140)?	PROTON	Possible launch failure of L-1 test

13 after a brief coast in Earth parking orbit. Its mission was to land at one degree north, 24 degrees east longitude in the southern part of Mare Tranquillitatis. This would be the most easterly landing site of the series and would require this lander to negotiate a landing approach 47 degrees from the vertical.

Unlike the previous two landers, which carried the SMSS, this spacecraft carried an alpha particle scattering experiment. A box-shaped sensor head, once lowered to the surface, used radioactive curium-242 to bombard a small patch of the lunar surface with alpha particles. By measuring the properties of the backscattered alpha particles and the induced proton emissions using two sensors, the relative amounts of elements from boron to potassium in the surface material could be determined. All together the sensor head, deployment mechanism, and the thermal compartment holding the support electronics weighed 28 pounds (13 kilograms).

After a mid-course correction burn, it was discovered that the helium pressurant for the vernier engines' propellant tanks was leaking into space. In the eighteen hours since launch, the pressure in the helium tank had dropped from 5,200 pounds per square inch (psi) (360 bars) to only 3,000 psi (200 bars). This gas was needed to force the propellants out of the tanks and into the verniers. If the pressure in the propellant tanks fell below 550 psi (38 bars),

SAC and SAC Meetings

Saguaro Astronomy Club (SAC) was formed in 1977 to promote fellowship and the exchange of scientific information among its members — amateur astronomers. SAC meets monthly for both general meetings and star parties, and regularly conducts and supports public programs on astronomy.

SAC meetings are usually held on the Friday nearest the full moon. This means that over the course of the year, meetings are not held on same week of the month. The same is true of the club's star parties. Star parties at Buckeye Hills are mostly held on the Saturday of the third quarter moon.

1994 SAC Meetings
Jan. 28
Feb. 25
Mar. 25
Apr. 22
May 27
Jun. 24
Jul. 22
Aug. 19
Sep. 16
Oct. 21
Nov. 18
Dec. 17 Party

1994 SAC Star Parties		
Date	Sunset	Moonrise
Jan. 8	5:38pm	5:22am
Feb. 5	6:05pm	4:11am
Mar. 5	6:29pm	2:58am
Apr. 9	6:55pm	5:42am
May 7	7:16pm	4:17am
Jun. 4	7:34pm	2:52am
Jul. 2	7:42pm	1:27am
Aug. 6	7:24pm	6:09am
Sep. 3	6:51pm	4:56am
Oct. 1	6:14pm	3:40am
Oct. 29	5:40pm	2:24am
Nov. 26	5:22pm	1:12am

the verniers would not work.

It was determined that a regulator valve had failed and the helium was leaking directly into the propellant tanks. These tanks' pressure relief valves would then bleed off excess gas once the pressure reached 830 psi (57 bars). The verniers were fired several times in an effort to close the faulty valve but to no avail. Had it not been for the quick thinking of ground controllers the mission would have failed.

One option which was quickly rejected was to fire the retrorocket, while the verniers still worked, to place SURVEYOR 5 into a highly elliptical orbit around Earth in order to gather at least some engineering data from the mission. Instead, calculations and tests performed on Earth with SURVEYOR F (which would be the sixth spacecraft in the series) had shown that a lunar landing was still possible with an altered fast descent profile. If the retrorocket was fired 12.5 seconds later than normal, just enough helium would be left to quickly reach the surface, which would now be 5.82 miles (9.36 kilometers) closer than at a normal burnout.

Split second timing was needed. A one-second delay in retrorocket burnout, which was possible given the state of solid rocket technology in 1967, would result in a crash. One final course correction was made to negate the effects of the previous burns made to jar the regulator valve closed. A final burn the day before landing left the optimum amount of propellant and pressurant in the tanks.

With the new landing sequence loaded on a tape recorder to be transmitted to SURVEYOR 5 in real time, the probe approached the lunar surface on September 11. As the lander passed the 60-mile (97-kilometer) mark two minutes before landing, the tape was started. The normal retrorocket ignition altitude of 51.9 miles (83.5 kilometers) was passed. At 28.4 miles (45.7 kilometers), the retrorocket and the three verniers were finally ignited. Two seconds before burnout, the explosive bolts holding the retrorocket in place were blown. This also activated the landing radar and allowed it to lock onto the approaching surface a precious few seconds early. The retrorocket was then held in place by its own thrust for the remainder of the burn.

Burnout occurred nearly on schedule at an altitude of 4,400 feet (1,340 meters) at a speed of sixty miles per hour (27 meters per second). SURVEYOR 5 finally landed at a speed of nine miles per hour (four meters per second) at 1.5 degrees north, 23.19 degrees east only eighteen miles (29 kilometers) off course. Upon touchdown the tank pressure was 556 psi (38.3 bars) — only six psi (0.4 bars) above the safe operation limit.

The first images returned showed that SURVEYOR 5 had come to rest after a brief slide on the inner twenty-degree slope of a thirty by forty-foot (nine by twelve-meter) crater. The alpha particle scattering experiment was then begun. First a sample of known composition on the lander was examined. The sensor head was then partially lowered on its nylon line to gather background radiation data. The sensor was then lowered the remaining distance onto the surface and the analysis began.

The final results, after 93.5 hours of operation, indicated that the soil was similar to terrestrial basalt in composition, a conclusion verified two years later with the return of the first lunar samples taken by APOLLO 11, which landed only 15.5 miles (29 kilometers) to the southeast. Images of a pair of bars — one magnetic the other not — similar to those carried on SURVEYOR 4, indicated that free iron was also present in the soil.

In another test, the verniers were fired for 0.2 seconds to see what effect it had on the lunar surface. No dust cloud was observed and only three or four out of five observed clods of soil near the lander's engines had moved. By sunset on September 24, SURVEYOR 5 had returned 18,006 television images and was placed into hibernation. The spacecraft responded immediately to commands at sunrise on October 15. During its second lunar day of surface operations, the robot returned another 1,048 images.

No images were recorded during the third lunar day, but the last 64 200-line images were returned during the fourth. Attempts were made during this fourth day to simultaneously track SURVEYOR 5 and 6 in order to determine the amount of lunar wobble. This investigation failed as transmissions from both landers weakened. SURVEYOR 5 finally fell silent on December 17.

SURVEYOR 6

SURVEYOR 6 had been launched towards the Moon the previous month on November 7. This lander was headed for the same region as the failed SURVEYOR 4. Except for a modified television camera hood to block stray light and the replacement of the color filters with polarizing filters, this lander was identical to SURVEYOR 5. After a brief coast in Earth parking orbit, the CENTAUR ignited a second time and shot SURVEYOR 6 to within 55 miles (90 kilometers) of its target. A short burn of the verniers 18 hours, 41 minutes after launch fine tuned the aim further. Sixty-five hours, 22 minutes after launch the latest American lunar lander came to rest on the lunar surface at 0.53 degrees north, 1.4 degrees west longitude only four miles (six kilometers) from its post mid-course correction target.

The analysis of the new landing site showed that it was similar in character to the previous three. Analysis of the soil by the alpha scattering experiment based on 43 hours of operation showed that the composition was nearly identical to that found at the previous landing site.

An experiment performed on November 17 helped put to rest any doubts that the physical laws of the planet Earth also apply to the Moon. The three verniers were fired for 2.5 seconds, consuming 1.5 pounds (0.7 kilograms) of propellant. This lifted SURVEYOR 6 about ten feet (three meters) off the surface. It came down eight feet (2.3 meters) to the west, thus confirming that a rocket can lift off the lunar surface. The new position allowed

the lander to perform stereoscopic imaging of the landing area. Unfortunately the alpha scattering experiment sensor head came to rest upside down, ending its usefulness.

By sunset on November 24, SURVEYOR 6 had taken 29,952 images and was placed into hibernation. Attempts at communication starting on November 26 remained unanswered until December 14. The lander did not come through the lunar night in good shape and fell silent permanently after only a brief communication session. With the conclusion of this mission, all of the SURVEYOR program's objective were met, freeing the last lander for more scientifically interesting lunar sites.

The Final Missions

SURVEYOR 7 was to be the last of America's unmanned lunar missions before the arrival of APOLLO. Indeed, it would prove to be the last such American mission dedicated solely to the study of the Moon for 26 years. This lander was targeted to land just outside of the prominent lunar crater Tycho. It would carry both the SMSS and alpha particle scattering experiment, allowing a full characterization of this lunar highland site to be made. Additional magnets were attached to the SMSS bucket in search of ferrous materials. A pair of flat mirrors were mounted on the lander's frame to obtain stereo images of small portions of the landing site. Because of the dangerous nature of the landing site, two course correction burns were scheduled to bring the lander to within twelve miles (twenty kilometers) of the aiming point, one-third of that in the previous missions.

On January 7, 1968, ATLAS-CENTAUR 15 launched the last SURVEYOR towards its rendezvous with Tycho. The first course correction burn the following day proved to be so accurate that the second was not needed. SURVEYOR 7 came to rest at 40.86 degrees south, 11.47 degrees west longitude, eighteen miles north of the rim of Tycho after a flight of 66 hours, 35 minutes. This was only 1.5 miles (2.5 kilometers) from its intended landing point. The first images returned showed that the lander had come down among rolling hills covered with blocks of various sizes. Despite the much rougher appearance of the terrain, even a site such as this would be accessible to a manned lander.

After almost 21 hours on the surface, a pyrotechnic squib was fired to release the alpha scattering experiment, but the next day it was discovered that it had stayed put. Apparently the nylon line had jammed on its reel due to the lunar dust. The SMSS was able to reach over and nudge the sensor head twice, but this failed to free it. The following day the arm applied one pound (4.5 newtons) of force, finally unjamming it and allowing analysis to begin. Later the arm picked up the sensor and moved it to a small rock to determine its composition.

In addition to its repair duties, the SMSS also performed sixteen bearing tests, dug seven trenches up to sixteen inches (forty centimeters) long and six inches (fifteen centimeters) deep. The arm even picked up a small rock and weighed it by recording the amount of current needed to lift the object. The measurement indicated that the stone was 2.4 to 3.1 times more dense than water. Another rock was broken using the scoop.

On January 20, the camera turned towards Earth and was just able to detect two one-watt laser beams aimed towards it from observatories in California and Arizona. This demonstrated the feasibility of using lasers to communicate with spacecraft and was a prelude to the laser ranging experiments carried by future American and Soviet lunar missions.

As the Sun appeared to set at the end of the first lunar day of operations, SURVEYOR 7 took images of Earth's yellow star, detecting its corona out to fifty solar radii. This brought its image total to over 21,000. The lander finally responded to commands from Earth after lunar sunrise on February 12. Unfortunately the lander did not handle the long lunar night well and finally fell silent on February 21 after returning only 45 more 200-line images during this last lunar day. The SURVEYOR program was now finished.

LUNA 14

To round out a history of this phase of human exploration of our only natural satellite, one must include the Soviets last known second generation lunar mission, LUNA 14. Launched on April 7, 1968 on a MOLNIYA launch vehicle, the Soviets simply stated that the mission of this spacecraft was to more accurately determine the relative masses of the Moon and Earth, study the stability of radio signal from the Moon to Earth, investigate the orbital motions of the Moon, and measure the solar charged particle environment and cosmic rays. Years later, the Soviets also disclosed that this mission carried a set of electric motors similar to those that were to be used on future third generation LUNA rover missions. This mission now seems to be similar to that of KOSMOS 159.

LUNA 14 made a course correction the day after launch. On April 10, the retrorocket fired, cutting the spacecraft's approach velocity from 4,900 miles per hour (2,190 kilometers per second) to 2,862 miles per hour (1,279 kilometers per second), placing the Moon's newest satellite into a 99 by 541-mile (160 by 870-kilometer) orbit inclined 42 degrees to the lunar equator.

For many years, Western analysts have thought that this mission was much more than what was officially stated by Soviet authorities. It was thought that this mission was similar to LUNA 12, which carried a phototelevision package that failed on this flight. In light of recent Soviet revelations, it would seem that this mission was nothing more than as originally stated back in 1968.

The information that LUNA 14 was supposed to have gathered would be needed to accurately plan the trajectories used by the ZOND spacecraft, especially given the irregular nature of the Moon's gravitational field. It was not until after the mission of LUNA 14 was completed sometime in the early fall of 1968 that the first L-1 circumlunar flight, ZOND 5, was attempted.

Finally, with recent revelations on the state of the Soviet manned lunar programs, there was little near term need for further photographic studies, since the earliest realistic launch date for a manned lunar landing was 1971, by which time the third generation LUNA spacecraft would be operational. These new advanced spacecraft could supply much more information on potential landing sites than could the more primitive second generation LUNA.

Thus, by the end of 1968, the Soviet Union and United States had completed their first series of unmanned missions to the Moon. The Americans would go on to win the race to the Moon with the successful mission of APOLLO 11 in July of 1969. After the last APOLLO mission at the end of 1972, the Americans would almost completely abandon the Moon. Over the next twenty years, American spacecraft would only occasionally view the barren lunar surface or use it as a gravitational slingshot as they made their way to more exciting targets throughout the solar system.

The Soviet Union's manned lunar program would falter and ultimately be abandoned with the success of the American program. The third generation LUNA program would, at least at first, be hailed as the preferred means of lunar exploration. In the end, however, this program would also fall victim to apathy as resources were shifted to more scientifically and politically interesting targets such as the planets Venus and Mars. But that is another story.

Bibliography

Clark, Phillip S., "Obscure Unmanned Soviet Satellite Missions", **Journal of the British Interplanetary Society**, October 1993

Clark, Phillip S., **The Soviet Manned Space Program**, 1988

Gatland, Kenneth, **Illustrated Encyclopedia of Space Technology**, 1988

Gatland, Kenneth, **Robot Explorers**, 1972

Johnson, Nicholas, **Handbook of Soviet Lunar and Planetary Exploration**, 1979

LePage, Andrew J., "The Great Moon Race: The Soviet Story (Parts 1 and 2)", **Electronic Journal of the Astronomical Society of the Atlantic (EJASA)**, December 1990 and January 1991

Levinson, A. A. (Ed.), **Proceedings of the Second Lunar Science Conference Volume 3: Physical Properties/Surveyor 3**, 1971

Scott, Ronald F., "The Feel of the Moon", **Scientific American**, December 1967

Watts, Raymond M., "SURVEYOR 3 on the Moon", **Sky & Telescope**, June 1967

Watts, Raymond M., "New Circumlunar Probe", **Sky & Telescope**, September 1967

Watts, Raymond M., "LUNAR ORBITER 5 Takes Unusual Pictures", **Sky & Telescope**, October 1967

Watts, Raymond M., "How SURVEYOR 5 Was Saved", **Sky & Telescope**, November 1967

Watts, Raymond M., "NASA Lunar Reconnaissance Continues", **Sky & Telescope**, February 1968

Watts, Raymond M., "SURVEYOR 7 on the Moon", **Sky & Telescope**, April 1968

Watts, Raymond M., "Some SURVEYOR 6 Results", **Sky & Telescope**, August 1968

Wilson, Andrew, **(Jane's) Solar System Log**, 1987

"First Photographs from Earth of a Lunar Satellite", **Sky & Telescope**, April 1968

JPL Press Release #429, January 9, 1967

JPL Press Release #454, August 28, 1967

"Photographs by LUNAR ORBITER 4", **Sky & Telescope**, July 1967

"Spacecraft Details", **TRW Space Log**, Winter 1967-1968

"SURVEYOR VII to Combine Digging, Chemical Testing of Surface of Moon's Highlands", JPL Press Release #464, December 21 1967

Vectors, Volume X: SURVEYOR Commemorative Issue, 1968

About the Author

Andrew J. LePage is a scientist at a small R&D company in the Boston, Massachusetts area involved in space science image and data analysis. He has written many articles on the history of spaceflight and astronomy over the past few years that have been published in many magazines throughout North America and Europe. Andrew has been a serious observer of the Soviet/CIS space program for over one dozen years. Andrew's Internet address is: `lepage@bur.visidyne.com`.

Newsletter Deadline

Mail items at least two weeks before the end of the month. Items arriving too late for an issue will be included in the next newsletter.

Bits and Pieces

Coming Events

There are a lot of events to look forward to this year. There is the Messier Marathon, Sentinel Star Gaze, Grand Canyon Star Party, and the All-Arizona Star Party as well as a couple of Public Star Parties.

Jerry Belcher has positions available for a week-long raft trip down the Grand Canyon in June. Anyone interested in going should contact him soon at 938–2932.

As of publishing time, the date of the Spin-Cast Party at Stewart Observatory Mirror Lab is still not known. Those who are on the list will be notified as soon as we are told of a definite date.

Deep Sky Meeting

The Deep Sky Group is made up of people that like to observe celestial bodies out past the far reaches of our Solar System. These bodies include stars, nebula and galaxies. If you are interested in sharing your observations, or

knowing what they look like in telescopes — then by all means come join us at the next meeting. We will discuss Deep Sky objects in Gemini and Lupus. The meeting will be held at John McGrath's house; directions are here in the newsletter.

You don't need to RSVP, we don't extend special invitations to anyone — ourselves included. If you are interested show up, we'd love to have you.

The Deep Sky meeting will take place on Thursday, February 3 at 7:30pm.

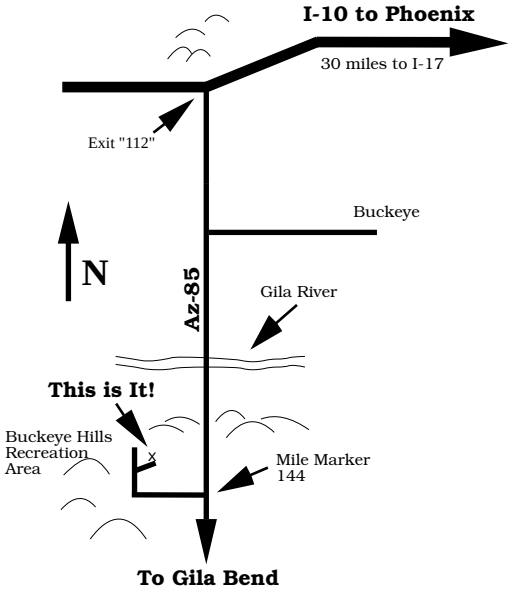
Newsletter Delay

Due to computer problems, now resolved, the publication of this newsletter was delayed until the first week of January.

Directions to SAC Events

SAC General Meetings 7:30 PM at Grand Canyon University, Fleming Building, Room 105 — 1 mile west of Interstate 17 on Camelback Rd., north on 33rd Ave., second building on the right.

SAC Star Parties at Buckeye Hills Recreation Area



Interstate 10 west to Exit 112 (30 miles west of Interstate 17), then south for 10.5 miles, right at entrance to recreation area, one-half mile, on the right. No water and only pit toilets. Please arrive before sunset; allow one hour from central Phoenix.

SAC Deep Sky Subgroup Meeting at John & Tom McGrath's, 11239 N. 75th St., Scottsdale, 998–4661 — Scottsdale Rd. north, Cholla St. east to 75th St., southeast corner.

Looking Back...

by Harold Moorin

Some of the original members will remember a charming young couple, still in their teens, and dedicated to astronomy. I refer to George and Lisa Balazs.

At the same time, George majored in engineering at A.S.U. where he eventually got his degree. He also found time to serve as Vice President of SAC. He was active in our club's activities and often conducted some of the meetings. I temporarily lost track of them, and when they reemerged, he was a pilot in the U.S. Air Force. They also have four lovely children.

His hobby is inventing and experimenting with various shapes of large kites. Thus he studies the effect of dynamics and relates the results to the motion of bodies in space.

At present, he is being transferred from Sawyer A.F.B, in Michigan. When I get their new address, some of our members may wish to contact them and their four children. They would enjoy hearing from you and receiving our newsletter.

E-Mail Roster

Here is another update to the e-mail addresses of SAC members and friends.

Bob Bryant	Bob_Bryant@ poncho.phx.sectel.mot.com
Steve Coe	74040.2071@compuserve.com
A J Crayon	a.crayon@az05.bull.com
Paul Dickson	p.dickson@az05.bull.com
	paul.dickson@asu.edu
	pdickson@bix.com
Michael Janes	mjanes@delphi.com
Dean Ketelsen	ketelsen@as.arizona.edu
Tim Lee	71361.3541@compuserve.com
David Levy	dhlevy@lpl.arizona.edu
Paul Lind	plind@sedona.intel.com
Pete Manly	petemanly@bix.com
Paul Maxson	maxson@gc.maricopa.edu
	72117.1372@compuserve.com
Tom McGrath	mcgrath@phyast.la.asu.edu
Tom Polakis	70413.1543@compuserve.com
Chris Schur	72070.2612@compuserve.com
Brian Skiff	bas@lowell.edu
Steve Strazdus	sstrazdu@sedona.intel.com
Alex Vrenios	alex@acm.org
Diane Vrenios	71024.3024@compuserve.com
Dan Ward	72040.3357@compuserve.com
Mike Willmoth	mwillmoth@bix.com
	76170.1037@compuserve.com
	m.willmoth@genie.geis.com

January 1994

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
All Times are Mountain Standard Time						Earth at Perihelion 11:00 P.M. 1
2	Quandrantid meteor shower 3	Last Quarter Moon 5:00 A.M. 4	5	Jupiter 3°N of Moon 3 P.M. 6	7	**SAC Star Party** Buckeye Hills (members & guests) 8
9	10	New Moon 4:10 A.M. 11	12	**PAS Meeting** 13	14	Saturn 7°S of Moon 15
16	17	18	First Quarter Moon 1:27 P.M. 19	20	21	22
23/30	24/31	25	**EVAC Meeting** 26	Full Moon 6:23 A.M. 27	**SAC Meeting** 28	29

Magazines & Discounts

Club members may subscribe to astronomical magazines at reduced rates through the club Treasurer. See the Member Services Form on the back page of this newsletter. Furthermore, club members are encouraged to align their subscriptions with the Jan.–Dec. calendar year. This eases the burden both on the Treasurer and the Publisher by permitting a single Group Renewal to be placed in the autumn for the upcoming calendar year.

Those members who experience problems with their subscriptions to *Astronomy* magazine may call Kalmbach Publishing Customer Service at (800) 446–5489.

Those members who experience problems with their subscriptions to *Sky & Telescope* magazine may call Sky Publishing at (800) 253–0245.

Besides the club discount on *Sky & Telescope* magazine, Sky Publishing offers club members a 10% discount on all other Sky publications. This means books, star atlases, observing aids, Spotlight prints, videos, globes, computer software, and more.

Club members who subscribe to *Sky & Telescope* through the Club Discount Plan may order Sky publications directly, at the above toll-free number, without going through the club Treasurer. Simply mention the Club Discount Plan and give the Saguaro Astronomy Club name to receive the discount. Sky Publishing will check their records to verify that you are eligible to receive the discount.

Saguaro Astronomy Club Member Services Form

Membership

Memberships are for the calendar year and are pro-rated as follows: Jan - Mar 100%, Apr - Jun 75%, Jul - Sep 50%, Oct - Dec 25%.

- ❑ $20.....Individual Membership
- ❑ $30.....Family Membership (one newsletter)
- ❑ $100.....Business Membership (includes advertising)
- ❑ $4.....Nametag for members
- ❑ $10.....Newsletter Only

Subscriptions

The following magazines are available to members. Subscribe or renew by paying the club treasurer. You will receive the discounted club rate only by allowing the treasurer to renew your subscription.

Sky & Telescope.....$20.00 for one year ❑

Astronomy.....$18.00 for one year ❑

Write your name, address, and phone number in the space below.

Make checks payable to SAC. Mail the completed form to:

Carol Lee
SAC Treasurer
3314 N 68th Street, #205-W
Scottsdale AZ 85251

SACNEWS

c/o Paul Dickson
7714 N 36th Avenue
Phoenix AZ 85051

Stamp

First Class Mail