AUSTRALIS-OSCAR 5 SUMMARY REPORT*

1. INTRODUCTION

Australis-Oscar 5 (AO-5) was launched on January 23, 1970, as a secondary (piggyback) payload on the NASA TIROS-M/ITOS-1 launch mission, from the Western Test Range, Lompoc, California. This satellite, built by Australian radio amateurs and prepared for launch by members of the Radio Amateur Satellite Corporation (AMSAT) in the Washington, D. C. area, carried amplitude-modulated telemetry beacons transmitting on 144.05 and 29.450 MHz in the two- and ten-meter bands.

With the exception of a loss, after the second orbit, of the modulation on the ten-meter beacon, the mission was entirely successful. The correct orbit was achieved, the stabilization system performed outstandingly, accurate telemetry data was received, and the command system operated reliably. The two-meter beacon lasted until February 14 (23 days), and the ten-meter beacon lasted until around March 9 (46 days), when the spacecraft reached end-of-life with the depletion of its chemical batteries, as expected.

2. TECHNOLOGICAL HIGHLIGHTS

The AO-5 mission was technologically significant in several respects. Although it carried beacons rather than communications repeaters, AO-5 provided an excellent opportunity to test several important concepts new to satellites in the amateur service.

Probably most significant was the command system. A command receiver and decoder were included in the satellite. The purpose of this system was to switch on and off the power-consuming 180-milliwatt ten-meter transmitter. This was done by stations both in the United States and in Australia on a regular, prearranged schedule. Each Friday morning the ten-meter beacon was turned on, and each Monday morning it was switched off again, thus confining operation to the weekends when the greatest number of amateurs would be available to make observations. This was the first time that successful operation of a command system has been demonstrated in a satellite in the amateur service. Successful commands required a properly modulated and encoded sequence of signals transmitted in a particular frequency combination. Thus, the probability of spurious responses of the command system and unauthorized commands was negligible, and indeed, no false commands were experienced.

A passive Magnetic Attitude Stabilization System was employed on AO-5. This system used a bar magnet and eddy-current damper to bring one axis of the satellite into eventual alignment along the magnetic field lines of the earth, just as a compass aligns itself with the earth's poles. This simple, reliable and lightweight single-axis stabilization system proved excellent for this low-orbit satellite in polar orbit. The initial spin rate of the spacecraft, as determined by telemetry data obtained from AO-5's three horizon sensors, was approximately 4 rpm. By Orbit 74, about six days later, the spin rate had decreased to around 0.13 rpm. This rapidity of stabilization was indicative of the effectiveness of this method of stabilization.

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AO-5 was the first satellite in the amateur service to transmit in an HF amateur band. Many reception reports of the 29.45 MHz ten-meter beacon were received from amateurs using simple long-wire or dipole antennas. This would suggest that further communications satellite experiments would be highly desirable at these frequencies, especially during the minima of the sunspot cycle or during the night, when the maximum usable frequencies are relatively low and the ionosphere does not support long-distance communication. It was interesting to find that several amateurs reported receiving the AO-5 ten-meter signal with indoor antennas or on mobile receivers, an indication of the ease of reception of satellite signals at these frequencies.

The seven-channel telemetry system carried on AO-5 was far more elaborate than the systems contained in the previous four satellites of the OSCAR series. In spite of its sophistication, the analog audio tone encoding scheme employed was designed for simple decoding without requiring expensive equipment, and the system proved very useful, even at low signal-to-noise ratios. Many amateurs were able to decode the telemetry data successfully, and a few used simply a piano to determine the telemetry tone frequencies and thus decode the signals. The telemetry system encoded, in a time-multiplexed tone format, engineering data (voltage and current), spacecraft attitude and spin rate data from three orthogonal optical horizon sensors, and internal and external spacecraft temperature values. The telemetered voltage data was useful in determining the satellite's remaining lifetime, and the telemetered current proved to be an excellent method of determining whether the ten-meter transmitter had been switched on or off. The temperature data was of particular interest in verifying the assumptions used for the spacecraft's thermal design. The information obtained is expected to be very useful for the design of thermal control systems in future satellites of the OSCAR series.

To summarize, AO-5 provided experimental verification of a reliable command system, passive magnetic attitude stabilization, the use of HF frequencies, simplified multiple-parameter telemetry, and the method of thermal control.

3. SCIENTIFIC HIGHLIGHTS

Temperature and light-sensor data are expected to have scientific value once the telemetry reports have been fully processed and analyzed. The temperature sensors detected satellite entry into the earth's shadow. The optical sensors proved to be more responsive than anticipated, responding apparently to diffused light at the edge of the earth's disc as well as to light intensity variations apparently produced by cloud cover.

Among the most valuable scientific benefits, however, were those in the propagation area[1]. Reports of over-the-horizon, antipodal and "north polar anomaly" propagation were received, particularly from amateurs observing the ten-meter beacon, and AMSAT's propagation analyses were concentrated on these phenomena. Over-the-horizon pro-

[1]Raphael Soifer, "Ionospheric Propagation from Australis-OSCAR 5," a survey report prepared for delivery at the 1970 American Radio Relay League National Convention, Boston, Massachusetts; May 30, 1970.

pagation was observed by several amateurs with high-gain antennas, and the most outstanding examples of this effect were reported by an Australian, VK3ATN, who was using a rhombic antenna and who reported receiving nine passes with durations of 28 minutes, some six to eight minutes longer than the line-of-sight time. At least 34 reports were received from ten stations reporting antipodal propagation, in which signals were received when the satellite was located on the opposite side of the earth, far from the observing station. It appears from the data that the effects observed may have been the result of normal ionospheric skip propagation, rather than scattering or ducting. The north polar anomaly was reported, in which signals were observed arriving more often from the north than the south even though the band was open to both regions. It appears that this phenomenon may be due to geographical variations in critical frequency and virtual height.

4. OPERATIONAL HIGHLIGHTS

A major success of the AO-5 mission was the interest and enthusiasm it generated within the amateur and short-wave listener community throughout the world. Reports were received from several hundred stations in at least 27 countries, including Australia, Belgium, Brazil, Canada, Denmark, England, Estonia (SSR), Finland, France, Germany, Greece, Hungary, India, Ireland, Italy, Japan, Laos, Luxembourg, Netherlands, New Zealand, Norway, Rhodesia, Scotland, Spain, Sweden, Switzerland, and the United States. All telemetry reports were forwarded to the University of Melbourne in Australia for computer analysis of the telemetry data, which is still in progress.

Some amateurs showed unusual interest and dedication. For example, one U.S. amateur, John Fox, WØLER, tracked virtually all the passes and submitted a 43-page report giving his interpretations of his observations. Several amateur clubs, including the Nassau Amateur Satellite Tracking Astronomy and Radio Society (NASTAR) and the Goddard Amateur Radio Club performed extensive tracking and telemetry data recording. At the Talcott Mountain Science Center in Avon, Connecticut, over two hundred students were introduced to the methods of tracking satellites using real-time passes of AO-5. The results of this community-oriented project suggest that an expanded program of this type could be of benefit both domestically and in the emerging nations.

Of very great importance was the enthusiastic international cooperation achieved among the amateurs involved in the AO-5 program. The Australian builders and U.S. amateurs of Project OSCAR and AMSAT worked together as a well-coordinated team, and a great deal of favorable publicity and goodwill were generated, especially in Australia. As a consequence, it now appears that groups in Australia, England and Germany are interested in joining with AMSAT in the construction of hardware for AMSAT-OSCAR-B, the next planned amateur spacecraft. The AO-5 program also resulted in an informal third-party agreement between Australia and the United States, permitting the exchange of information concerning AO-5. Steps are now being taken to extend this agreement to the AMSAT-OSCAR-B satellite project.

It is quite apparent that the inclusion of the ten-meter beacon in AO-5 encouraged more widespread interest and participation than a VHF-only OSCAR satellite would have, particularly among amateurs in the developing countries where VHF receiving equipment is not as readily available.

5. PROSPECTS FOR THE FUTURE

AO-5 contributed significantly to plans for future satellites in the amateur service. It was the first OSCAR satellite to be launched by NASA; this is an important milestone since secondary payload space is expected to be available on future Thor-Delta launches as the payload capability of that rocket continues to be upgraded. Thus, the next OSCAR satellites under development by AMSAT are being designed specifically to interface with Delta launch vehicles.

The precedent of the command capability proven in the AO-5 mission is very significant, particularly in planning for long-life, solar-powered satellites in the amateur service, and in preparation for the 1971 ITU World Administrative Radio Conference on Space. The use of command systems should prove a feasible alternative to the adoption of absolute power flux density limitations, so that satellites in the amateur service can be turned off upon command in the event of interference to other services operating in the shared amateur bands.

The success of the Magnetic Attitude Stabilization System demonstrated that this technique is a most attractive one for future satellites.

The precedents established in international group cooperation among amateurs, and the training and educational benefits derived from the design, construction, testing and flight of AO-5 will also be of great usefulness in future radio amateur satellite projects.

6. SUMMARY

A summary of the general characteristics of the Australis-OSCAR 5 amateur satellite is given below.

Launch:	23 Jan. 1970 at 1131 GMT on a Thor-Delta
Orbit:	910 mi. apogee, 880 mi. perigee; 102° inclination
VHF beacon transmitter:	50 mW at 144.05 MHz, amplitude-modulated
HF beacon transmitter:	180 mW at 29.450 MHz, operated on command
Antennas:	quarter-wave monopoles for VHF; dipole for HF
Stabilization:	Magnetic Attitude Stabilization System
Power source:	28 type G manganese-alkaline battery cells
Operating life of batteries:	23 days for VHF, 46 days for HF operation
No. of orbits during operation:	281 for VHF, 562 for HF
Size:	17 x 12 x 6 inches, rectangular box
Weight:	39 pounds
Telemetry system:	7 channels, AM tones, decoded by measuring freq. of each tone. Encoded voltage, current, internal and external temperature, and three horizon sensors.