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AMSAT-OSCAR 7 TECHNICAL OPERATIONS PLAN AND EXPERIMENTER'S GUIDE

PREFACE

This document has been prepared to outline for the telecommand stations and user experimenters, the expected conditions under which the several experiments onboard AMSAT-OSCAR 7 are to be used. (NOTE: For all purposes of publication or correspondence, please be sure to refer to the satellite as "AMSAT-OSCAR 7.")

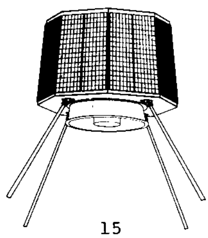
1.0 MISSION OBJECTIVES

The principal objective of the AMSAT-OSCAR 7 mission is to provide a means for its use as an educational tool in schools. Other objectives include the demonstration, by means of stations in the amateur service, of the feasibility of using satellites with small user terminals for "bush" communication, emergency communication, communication between medical centers and isolated areas, aeronautical, maritime and land mobile communications, direct satellite-to-home voice broadcasting to simple amateur receivers and other similar applications. Further objectives are to demonstrate special operating techniques that enhance the usefulness of low orbits for these satellite applications, and to test new communications repeaters and telemetry systems for operation with small terminal users.

1.1 OSCAR Education Program

A fundamental objective of the AMSAT-OSCAR 7 mission is to permit continuation of the education program begun with OSCAR 5 and 6 over a longer-term basis consistent with its longer three-year anticipated lifetime. OSCAR satellites are beginning to play an important role in a new approach to science education. Used as remote laboratory tools, these satellites represent a pioneering utilization of an active space system in the classroom. Since the launch of the first satellites seventeen years ago, satellites have had a very dramatic impact on American education. With inexpensive ground terminals for OSCAR satellites in schools, students can gain first-hand experience in space science. This type of direct, active involvement has relevance to the study of communications, astronomy, physics, mathematics and meteorology. The OSCAR ground terminal puts at the disposal of the instructor and student, an active satellite system, for demonstration and experimentation.

With the assistance of the American Radio Relay League, the organization responsible for OSCAR satellite educational activities, OSCAR curriculum material has been prepared under a contract with the Talcott Mountain Science Center, Avon, Connecticut, and is being distributed to schools throughout the country. Technical and educational consultation services are also being provided at no cost to encourage teachers to establish OSCAR ground terminals in their classrooms.



1.2 Small-terminal "Bush" Communication Tests

"Bush" or "out-back" communication of a non-amateur variety such as might be found in Alaska, northern Canada, Australia, Antarctica or the developing countries is analogous in many respects to amateur communication anywhere in the world. Many amateurs regularly use small portable HF and VHF transmitters and receivers, equipment installed in automobiles, and hand-held equipment. AMSAT-OSCAR 7 is designed to provide long-distance VHF communication, especially needed during night-time periods or during other times when long-distance ionospheric communication at HF is difficult. Amateurs equipped in various localities, including particularly Alaska and Antarctica will be called upon to participate in these tests.

1.3 Emergency Communication

Radio amateurs have, on numerous occasions, provided the only source of communication in time of emergency. The 1970 earthquake in Peru and 1972 earthquake in Managua are but two recent examples. Indeed, in setting forth the basis and purpose of the amateur service, the U. S. Federal Communications Commission cites ". . . the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications." It is expected that AMSAT-OSCAR 7 will be used in support of such communications during any such emergencies, as a backup for HF radio, which is highly dependent upon favorable ionospheric conditions.

1.4 Medical Data Communications

Many cases have been documented in which amateur communication was used to locate needed drugs, diagnose a rare disease or give medical instructions during surgery. AMSAT-OSCAR 7 will be capable of relaying such communication and, in addition, tests will be arranged between medical centers and hospitals in isolated areas to exchange medical data using the satellite to relay this information. The National Institutes of Health Amateur Radio Club in Bethesda, Maryland, an AMSAT affiliated organization, has been involved in this aspect of the amateur satellite program.

1.5 Mobile Terminal Communication

AMSAT-OSCAR 7 is the first amateur satellite to employ circularly polarized antennas so that the spacecraft can potentially provide further useful data on satellite signal propagation to mobile terminals, supplementing the multipath and ionospheric scintillation data already obtained at VHF from NASA's ATS-1 and ATS-3 Applications Technology Satellites, which used linearly polarized antennas. Aircraft, ship and automobile amateur terminals will be installed to provide further information on the feasibility of using VHF satellite mobile terminals over all possible satellite elevation angles and with several types of modulation.

1.6 Direct Satellite-to-Home Voice Broadcasts

The transmitter power output of AMSAT-OSCAR 7 is expected to be sufficient to permit useful reception with ordinary amateur receivers using low-gain receiving antennas. Transmissions using the satellite repeaters will demonstrate the potential of using satellites for satellite-to-home voice broadcasting directly to conventional, inexpensive receivers. In addition, it is anticipated that satellite experience will lead to the development by amateurs of increasingly simple ground equipment for these applications. Amateurs have a history for devising innovative methods of producing simple equipment at low cost.

1.7 Low-Orbit Operational Feasibility

AMSAT-OSCAR 7 is intended for operation in a 1460 Km orbit, considerably below synchronous altitude. AMSAT expects to be able to demonstrate the operational potential of such low, non-synchronous polar orbits for the small terminal user applications outlined above.

1.8 Communication Repeater and Telemetry Experiments

Two types of experimental communication repeater systems, two experimental telemetry systems and a store-and-forward message storage unit are flying on this mission. These include experiments designed and constructed in Australia, Canada, Germany and the United States. The unique characteristics of these experiments are described in Section 2.

2.0 SPACECRAFT DESCRIPTION

AMSAT-OSCAR 7 is a small communications satellite designed to operate with small stations in the amateur service on a non-commercial basis. The spacecraft contains two basic experimental repeater packages, redundant command systems, two experimental telemetry systems, and a store-and-forward message storage unit. The spacecraft is solar powered, weighs 65 pounds, and has a three-year anticipated lifetime. It contains beacons on 29.50, 145.98, 435.10 and 2304.1 MHz.

2.1 Communications Repeaters

Two types of communications repeaters are aboard the spacecraft, only one of which operates at a time. The first repeater is a higher power, two-watt version of the one-watt two-to-ten meter linear repeater that flew on the OSCAR 6 mission. This unit receives uplink signals between 145.85 and 145.95 MHz, and retransmits them between 29.4 and 29.5 MHz on the downlink. A 200 milliwatt telemetry beacon provides telemetry data on 29.502 MHz.* Approximately -100 dBm is required at the repeater input terminals for an output of 1 watt. This corresponds to an eirp from the ground of 80 watts for a distance to the satellite of 2,000 miles and a polarization mismatch of 3 dB.

The second repeater, constructed by AMSAT Deutschland e.V., AMSAT's affiliate in Marbach, West Germany, is a 40-kHz* bandwidth linear repeater. It employs an 8 -watt* PEP power amplifier using the envelope elimination and restoration technique to maintain linear operation over a wide dynamic range with high efficiency. This repeater has an uplink from 432.125 to 432.175 MHz, and a downlink from 145.925 to 145.975 MHz. Since the uplink band is shared with the radiolocation service, an experimental pulse suppression circuit is incorporated in the repeater to reduce the effects of wideband pulsed radar interference in the uplink. Developmental versions of this repeater have flown in high-altitude balloon experiments in Germany, and aircraft flight tests of the repeater prototype unit. A 200 milliwatt telemetry beacon on 145.975* provides telemetry data. Approximately 80 W.*eirp is required to produce 3 watts of repeater output at a range of 2,000 miles assuming a polarization mismatch of 3 dB.

The two repeaters are operated alternately by means of a timer arrangement, but repeater selection and output power control can also be accomplished by ground command. Each of the repeaters includes a keyed telemetry beacon at the upper edge of the downlink passband to provide housekeeping data and to provide a frequency and amplitude reference marker to assist the amateur in antenna pointing, Doppler frequency compensation, and setting uplink power level. The cross-band (146-to-29.5 and 432-to-146 MHz) design of the two repeaters will permit the amateur to monitor his own downlink signal easily, and consequently, he can adjust his power and frequency to continually compensate for changing path loss, repeater loading and Doppler shift. It is anticipated that such a method of self-monitoring and control can eventually be made automatic through closed-loop frequency and power control circuitry that can be developed for the ground terminal equipment. Both repeaters are designed for use by as many as one to two dozen single-sideband amateur stations, all transmitting simultaneously, where downlink self-monitoring will minimize interference between users and will also permit duplex operation as well as self-control of power balance.

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*This number represents a more precise actual measurement which differs from previously reported values.

2.2 Command System

Redundant command decoders of a design similar to the unit proven highly successful in OSCAR 6 will be flown. The decoder has provisions for 35 separate functions, and is designed to provide a reliable means of controlling the emissions of the repeaters, beacons and other experiments aboard the spacecraft.

2.3 Telemetry and Message Storage Systems

AMSAT-OSCAR 7 contains two experimental telemetry systems designed for use with simple ground terminal equipment. The first system, developed by the WIA-Project Australis group in Australia, telemeters 60 parameters in 850-Hz shift, 60 WPM five-level Baudot teletype code to permit printout on standard teletype equipment in a format readily convertible for direct processing by small digital computer. The second system telemeters 24 parameters as numbers in standard Morse code and can be received with pencil and paper. This system was used on OSCAR 6 and proved highly successful as a reliable means of obtaining real-time telemetry data.

An experimental Morse code message storage unit, Codestore, capable of storing and repeatedly retransmitting 18-word Morse code messages loaded by ground stations is also aboard AMSAT-OSCAR 7. This unit was first flown on OSCAR 6.

The teletype telemetry encoder amplitude-modulates telemetry beacons on 29.50 MHz (200 mw), 145.98 MHz (200 mw) and frequency-shift keys the beacon on 435.10 MHz (300-400 mw), as selected by ground command. The Morse code telemetry encoder and Codestore message storage unit directly key these beacons as selected by ground command.

3.0 LAUNCH INTERFACE AND ORBIT

The AMSAT-OSCAR 7 spacecraft is being launched from the NASA Western Test Range as a secondary "piggyback" payload with the ITOS-G meteorological satellite and the Spanish INTASAT spacecraft. The spacecraft will be ejected from the second stage of the two-stage Thor-Delta launch vehicle 4,653 seconds after lift-off, at a position of 38.4°N. latitude, 23.5°E. longitude. Orbital parameters are expected to be very similar to those of AMSAT-OSCAR 6: 1,460 km altitude circular orbit, 102° inclination (retrograde, sun-synchronous orbit).

Four seconds after ejection from the launch vehicle, two sets of pyrotechnic nylon line cutters will fire, deploying the ten-meter dipole antenna, and one to two seconds later the spacecraft will initialize in Mode D*, the recharge mode, with all transmitters OFF except the 435.1 MHz telemetry beacon.

4.0 SPACECRAFT INITIALIZATION PROCEDURE

AMSAT-OSCAR 7 will automatically be powered up upon ejection from the Thor-Delta launch vehicle in the vicinity of Italy and Greece, and is designed to initialize itself in Mode D with the 435.1 MHz beacon ON, keyed with Morse code telemetry at 20 or 10 WPM. Unless overridden by ground command, after 24 hours the spacecraft clock will switch the satellite to Mode B*. It was found during thermal-vacuum tests that the 70 cm-to-2 m repeater can develop corona discharge in the RF power stages during the pressure transition to vacuum. Therefore, to prevent possible damage to this repeater, the satellite should be commanded to Mode A 24 hours after initialization to give an additional 24 hours for the 70 cm-to-2 m repeater to outgas to the pressure of hard vacuum where corona will no longer be present.

On the second day, after A-O 7 is in orbit, each telecommand station should verify that it is able to command successfully by switching the code speed on the 435 MHz beacon, first using command decoder "A" and then "B", and using command receiver channel A (which operates in Mode D as well as in Mode A).

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* See Section 5 for a description of the operating modes.

The spacecraft 24-hour clock should be reset as close to 0000 GMT as possible on the day of launch, and again on the day following launch (before the spacecraft has a chance to go into Mode B). As soon as possible after launch, the teletype telemetry encoder should be commanded by the Australian command station alternately between the "dwell" and "run" modes several times. This will initialize the teletype telemetry system, and with it, its clock (which is read out in octal form as part of the teletype telemetry status information). The teletype encoder will not operate until it is initialized, so its operation is a ready means of identifying that the unit has been initialized properly.

On the first orbit following the reference orbit during the initial days when the satellite is still in Mode D, teletype telemetry should be commanded onto the 435 MHz beacon so that data can be collected from this system and its proper operation can be verified. On other orbits, the 435 MHz beacon should be keyed with Morse code telemetry until the satellite is declared operational and is put into its regular daily Mode A - Mode B operating cycle.

Once operationally in Mode A, the two-to-ten meter repeater should automatically have been initialized to operate at full sensitivity and with the 29.50 MHz beacon keyed with 20 WPM Morse code telemetry. If any of these conditions are not found to be the case, the spacecraft should be manually commanded to these modes. The 435 MHz beacon should be commanded over to teletype telemetry and left ON, the normal operational conditions for Mode A (as described in Section 5.1).

When the spacecraft first goes operationally into Mode B, each telecommand station should verify that it is able to command successfully by commanding the Morse code telemetry to key the 145.98 MHz beacon (if not already initialized in this condition), and switching the code speed, using command receiver channel B (which operates in Mode C as well as in Mode B).

The Morse code telemetry should be carefully recorded in the initial orbits. First the voltages should be verified (channels 3A, 3B, 3C), as well as the charging currents in sunlight (1A = 1B + 1C + 1D + 2A, although spacecraft spin may affect this result). 2D should be greater than 50 counts when the spacecraft is in sunlight. Verify that calibration channel 6D = 50 ± 1 counts; if it is not, all other data telemetered by the Morse code telemetry encoder may be invalid. Proper operation of the 24-hour clock can be checked by observing channel 2C, and this is the normal means of telling when the clock is about to switch from Mode A to Mode B or vice versa. (When channel 2C = 92 counts, switching of modes can be expected within 14.4 minutes.) Successful resetting of the clock on ground command can be verified by observing if 2C = 0. 2C should begin at 0 and increment one or two counts each 14.4 minutes.

As the several beacons and two repeaters become powered up for the first time, their respective RF power outputs should be verified (channels 6B, 6C, 6A and 2B), and their power consumption should be verified from channels 5B and 2D. Channel 2D should provide a useful means of measuring instantaneous power consumption of the systems in operation at any given time, but these measurements should be made while the satellite is in darkness so that charging current will be absent.

The temperature channels 3D, 4A, 4B, 4C, 4D, 5A and 5C should all read around room temperature (50 counts), although 5A and 5C will generally display higher temperatures (a lower number of counts) when the Mode B repeater is ON, and 4B will show higher temperatures when the Mode A repeater is ON.

5.0 SPACECRAFT OPERATING MODES AND FAILURE CONDITIONS

5.1 Mode A -- Two-to-ten Meter Repeater ON, 435 and 2304 MHz Beacons Operable

The two-to-ten meter repeater is always ON in Mode A, and only in Mode A. The 435.1 MHz beacon can be ON or OFF in this mode (by ground command), and normally will be ON and transmitting 850-Hz FSK teletype telemetry. The

2304.1 MHz beacon will normally be OFF except for specially scheduled experiments,* when it can be operated for 14 minutes at a time, after which it will be shut OFF by an internal timer. Keying of the 2304 MHz beacon is 170 Hz shift (F-1) Morse code.

The 29.50 MHz beacon is also always ON in Mode A, and normally will be sending Morse code telemetry at 20 WPM, except during orbits when Codestore contains a message to be read out periodically.

Mode A will be the normal operating mode on alternate days (GMT days) for 24 hours at a time, after which the OSCAR 7 onboard 24-hour clock will reset the spacecraft (at 0000 GMT)** to Mode B.

5.1.1 Mode A Failure Conditions

i) If there is a failure of the two-to-ten meter repeater, the satellite is to be commanded into Mode B and the spacecraft 24-hour clock should be reset by ground command every 24 hours (or less) to keep the spacecraft in Mode B. Remember that if there is a loss of the two-to-ten meter repeater receiver or of command channel A, all commanding must be done while the spacecraft is in Mode B or C (using command channel B). If the clock should put the spacecraft in Mode A before it is reset from the ground, command capability will be lost for 24 hours until the clock again switches the satellite back from Mode A to Mode B. Remember also that if the spacecraft should go into Mode D (either on command or due to a low-battery voltage condition sensed by the experiment control logic), again command capability will be lost until the clock switches the spacecraft from Mode D into Mode B 24 hours later.

ii) In the event of loss of the 435 MHz beacon, this beacon should be kept OFF except for periodic tests to see if the unit has recovered. The teletype telemetry is then to be switched to the 145.98 MHz beacon (in AFSK mode) between 1200 and 2400 GMT on Mode B or C days, and Morse code telemetry on the 145.98 MHz beacon at other times. On Mode A days, the 29.50 MHz beacon should be commanded back to Morse code telemetry at approximately 0000 GMT.

iii) The 2304.1 MHz beacon should normally be kept OFF until such time as Government authorization is received to conduct experiments in this band. When authorization is approved, the beacon will generally be operated in the "internal" (long carrier) mode, unless there is a failure of the 435.1 or 29.50 MHz beacon, in which case it is to be switched to the Morse code telemetry mode and activated more frequently. If the 2304.1 MHz beacon should fail, this beacon should not be turned ON except for periodic tests to see if the unit has recovered.

5.2 Mode B -- 70 cm-to-2 m Repeater ON in High-power Mode, 2304 MHz Beacon Operable

The seventy centimeter-to-two meter repeater is always ON in Mode B in the full-power (10 watt) mode, and the 145.98 MHz beacon always operates in this mode. The 2304.1 MHz beacon can be operated upon ground command in this mode.

Mode B will be the normal operating mode on alternate days (GMT days) for 24 hours at a time, after which the onboard 24-hour clock will reset the spacecraft (at 0000 GMT) to Mode A.

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*The U. S. Federal Communications Commission has notified AMSAT that the 2304 MHz beacon should be "prevented from transmitting" until further notice.

**The telecommand stations are asked to reset the spacecraft clock at 0000 GMT if the clock is more than five minutes off. If the clock is running slow, be sure to command also to the proper new mode.

5.2.1 Mode B Failure Conditions

i) If the 70 cm-to-2 m repeater receiver should fail, command capability in Mode B will be lost. When the 24-hour clock switches the spacecraft into Mode A, it should be reset by ground command every 24 hours (or less) to keep the spacecraft in Mode A. Remember that any commanding or clock-switching into Mode B will result in loss of command capability for 24 hours, when the satellite will again be switched by the clock into Mode A.

ii) If the 70 cm-to-2 m repeater transmitter should fail, command capability will still be possible in Mode B, but the satellite should be kept in Mode A and the clock reset every 24 hours (or less).

iii) If the 2304.1 MHz beacon should fail it should be kept OFF.

5.3 Mode C -- 70 cm-to-2 m Repeater ON in Quarter-power Mode, 2304 MHz Beacon Operable

In Mode B, the seventy centimeter-to-two meter repeater is always ON, but in the quarter-power (2.5 watt) mode. The 145.98 MHz beacon will be ON in this mode and the 2304 MHz beacon can be operated upon ground command. Normally, the spacecraft should be commanded to Mode C only if there is low battery voltage (between 12.1 and 12.4 volts, generally indicating a low battery charge condition). In this case the 2304 MHz beacon should not be turned ON so that it will not add to the battery drain.

5.3.1 Mode C Failure Conditions

i) Generally, Mode C is to be used if the battery is not charging sufficiently. Mode C can only be switched into by ground command, and should be selected if the battery voltage goes below a preset cutoff level of 12.4 volts. If there is a failure of one or more of the cells in the ten-cell battery, or if there are heavy current surges, this cutoff level may be reached while the overall battery is at a good level of charge.

ii) If any of the other failure conditions described in Section 5.2.1 should occur, the same command procedures outlined in that section should be followed.

5.4 Mode D -- Recharge Mode, Both Repeaters OFF, 435 and 2304 MHz Beacons Operable

In Mode D, both repeaters are OFF and telemetry can be obtained by commanding ON either the 435.1 or 2304.1 MHz beacon(s). Mode D should normally be used if recharging of the battery should become necessary and also on days reserved for experiments when no experiments are planned.

5.4.1 Mode D Failure Conditions

i) Normally, Mode D is used if the battery is in a poor state of charge and in need of rapid recharging at the expense of not operating the repeater experiments. The experiment control logic will automatically place the spacecraft in Mode D (regardless of the existing Mode) if the battery voltage continues to drop to a second preset cutoff level of 12.1 volts. As in the failure mode discussed for Mode C above, if one or more of the cells in the battery should fail, or if a heavy current surge is experienced, the Mode D cutoff level may be reached even though the battery is not in need of recharge. In this case it will be necessary to command the satellite to Mode A or B manually (depending upon the scheduled day) in order to override the voltage cutoff circuit. (This resetting may have to be done frequently.)

ii) In Mode D, all commands must be accomplished through command channel A. The 435.1 MHz beacon should be left ON to obtain telemetry data, unless the battery is in a critical state of discharge (below 12.0 volts). If the battery should drop any further than this level, the telemetry systems will cease to function due to loss of negative voltage output from the instrumentation switching regulator power supplies. If the spacecraft is commanded to Mode D, the 435.1 MHz beacon should be operated continuously, to provide telemetry data, unless the battery voltage is very low (approaching 12.1 volts), in which case it should only be turned ON for ten minutes during each reference orbit (the first orbit of each Greenwich day) to permit the gathering of telemetry data.

iii) If the two-to-ten meter receiver or command channel A is not functioning, the spacecraft should be kept out of Mode D and placed in Mode C (if recharging of the battery is needed) or Mode B (if the battery is charged to above the Mode C cutoff point of 12.4 volts). It should always be kept in one of these two modes; otherwise, if the battery stays below the Mode D cutoff voltage (12.1 volts), the experiment control logic may continually keep the satellite in Mode D where it won't be possible to override it by command.

5.5 Morse Code Telemetry

Normally, Morse code telemetry will be available on the 29.50 MHz beacon when the spacecraft is in Mode A, and the 145.98 MHz beacon when the spacecraft is in Mode B or C. The speed should be kept at 20 WPM, unless there is a need to use the 10 WPM speed temporarily. If for some reason 10 WPM is commanded, the encoder should be commanded back to 20 WPM before the end of the pass. Changing of the code speed should be used mainly as a means of checking the satellite's response to ground command (especially to verify that a particular ground telecommand station is working properly). The encoder may be used at 10 WPM during educational demonstrations (normally conducted during local morning passes).

5.5.1 Morse Code Telemetry System Failure Conditions

i) In the event of failure of the Morse code telemetry encoder, the teletype telemetry encoder should be commanded to the 145.98 MHz beacon (in the AFSK mode) and the 29.50 and 435.1 MHz beacon (in the FSK mode), the latter being the normal beacon for the teletype telemetry. If the battery voltage should drop below 12.0 volts, the Morse code telemetry system may begin to generate meaningless numbers because of loss of negative bias from the instrumentation switching regulator. In this event, the spacecraft should be commanded into Mode D (if not in this mode already via the undervoltage sensors), and the 435.1 MHz beacon should be turned OFF to permit recharging at a maximum rate. The 435.1 MHz beacon should be turned ON on each reference orbit to see if telemetry has recovered.

ii) If we should encounter a failure of the 29.50 MHz beacon (but not of the two-to-ten meter repeater itself), Morse code telemetry should be switched to the 435.1 MHz beacon between approximately 1200 and 2400 GMT, and FSK teletype to this beacon at all other times. When in Mode A, Morse code telemetry should be put on the 2304 MHz beacon and the beacon should be turned on immediately upon AOS on the reference orbit (the first orbit in Mode A of the Greenwich day).*

iii) In case of failure of the 145.98 MHz beacon (but not of the 70 cm-to-2 m repeater), Morse code telemetry should be put on the 2304 MHz beacon and the beacon should be turned on immediately upon AOS on the reference orbits (the first orbit in Mode B of the Greenwich day).*

5.6 Teletype Telemetry

Teletype telemetry will normally be on the 435.1 MHz beacon (as 850-Hz FSK), and so can only be heard in Mode A or D. The status channels of the teletype telemetry can be used to verify receipt of commands (including a reading of the last received command), and should be used as a means of verifying that the ground telecommand station is working properly. The transmitted command carrier should be left ON during this verification procedure to prevent noise bursts from entering the status channels and affecting the resultant data. If the command status bits appear to be changing at random with the command carrier ON, this is an indication that the link is not "locked up."

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*The U. S. Federal Communications Commission has notified AMSAT that the 2304 MHz beacon should be "prevented from transmitting" until further notice.

5.6.1 Teletype Telemetry System Failure Conditions

i) If the teletype telemetry encoder ceases to function, Morse code telemetry should be switched to the 435.1 MHz beacon, and Codestore switched to the 29.50 MHz beacon on Mode A days (unless Codestore is not loaded, in which case Morse code telemetry should be sent on the 29.50 MHz beacon also). On Mode B days Morse code telemetry should be sent on the 145.98 MHz beacon as this will be the only source of telemetry in this mode.

ii) If the 435.1 MHz beacon should fail, follow the procedure for this failure condition described in Section 5.1.1(ii).

5.7 Codestore Message Storage Unit

If possible, Codestore should contain a message at all times. During initial weeks, a reference orbit, the orbital period, longitude increment, and Mode A/ Mode B operating schedule as well as the HI identifier should be loaded and updated regularly because of the critical need to disseminate this information as quickly as possible. Codestore has a capacity of 896 bits (about 18 five-letter words), as with OSCAR 6, but there is no "autoload" capability. This means that the spacecraft must be commanded into the Codestore "load" mode before it is loaded and back to the "run" mode before the message is retrieved. If, when listening for Codestore, nothing is heard, it should be commanded to the "run" mode and left there. Remember also to listen for the message on the beacon downlink while it is being loaded; this is a good means of verifying that the spacecraft is accepting the load. Codestore should be loaded at least once a week, and switched onto the 29.50 or 145.98 MHz beacon at least once a day, preferably on the reference orbit.

5.7.1 Codestore Failure Conditions

i) If Codestore fails to retain its message more than a few hours, it should be left off the beacons except for special experiments.

ii) If Codestore retains its message for only a few days, it should be reloaded as often as necessary to keep the message readable and accurate, as well as up-to-date.

iii) If the Codestore unit fails to load, it should be left off the beacons, but should be checked periodically to see if it has recovered. Be certain that the problem is not at the ground loading station, as the unit must be loaded correctly with careful attention to procedure.

5.8 Command Decoders

Command decoder "A" is the primary command decoder system to be used. Decoder "B" serves as a backup and is not normally used. Command status verification (by means of the teletype telemetry status channels) is possible only for decoder "A" and not for decoder "B" (see Section 9.2).

5.8.1 Command Decoder Failure Conditions

i) In the event of a failure of decoder "A", use decoder "B". If decoder "A" fails to work only for some functions, use the backup commands for that decoder, or if this fails, use decoder "B" for all functions.

ii) If there is a failure of command receiver channel A, the satellite should not be commanded into Mode A or D, or else command capability will be lost for 24 hours until the onboard clock resets the spacecraft into Mode B.

iii) If there is a failure of the command receiver channel B, the satellite should not be commanded into Mode B or C or else command capability will be lost for 24 hours until the onboard clock resets the spacecraft into Mode A.

5.9 Power System

At beginning of life, the OSCAR 7 solar panels should be capable of providing as much as 16 watts in sunlight (about 10 watts orbit average, assuming an 80% sunlit orbit). The solar cells and six ampere-hour rechargeable nickel-cadmium battery should be adequate to power the spacecraft with a positive power budget even if there is a degradation below the original power (which might occur over the course of several years due to radiation damage to the solar cells). Normally, the battery will not be discharged below about 5 to 10% of its full-charge level.

5.9.1 Power System Failure Conditions

i) The ground telecommand stations should be prepared to switch the satellite into Mode C if a 60% battery discharge level (3.6 AH discharge) is reached (this occurs if the battery voltage drops below 12.4 volts), and to Mode D if the battery discharge level drops further to 70% (4.2 AH discharge) depth of discharge (this occurs if the battery voltage drops below 12.1 volts). In case of improper operation of these cutoff sensors, they should be overridden by commanding to the proper mode (Mode A or B). This may be necessary, for example, if there is a loss of one or more cells of the ten-cell battery which might cause the battery voltage to drop to the cutoff point even though the remaining cells might be in a good state of charge (see also the procedures outlined for this condition in Sections 5.3.1 and 5.4.1). Heavy current surges may also cause the spacecraft to switch into Mode D. In any case, the battery must not be allowed to drop below 12.0 volts. Below this level there is a loss of negative voltage output from the instrumentation switching regulator power supplies, and this will cause a loss of both the teletype and Morse code telemetry systems (all channels will read zero or else meaningless numbers.)

ii) If there is a loss of one or more of the solar panels, or excessive degradation in their power output, or loss in capacity or charge efficiency of the nickel-cadmium battery, or battery drain from one or more of the experiments becomes excessive, it may be necessary to operate in Mode C on alternate days instead of Mode B to permit additional battery charging. If additional action is needed, the 435 MHz beacon should be operated less frequently. If these measures are insufficient, it may be necessary to reduce average power consumption still further by going to Mode D during a portion of each day, but still maintaining the 48-hour cycle between the two repeaters.

iii) The spacecraft contains two battery charge regulators. Normally, regulator #1 will be in operation. If it should fail, it should automatically switch over to regulator #2. If for some reason switchover does not occur, the battery will be discharging continuously and therefore it is imperative that the #2 regulator be commanded on as soon as possible. If the #2 regulator fails, be sure to command to the #1 regulator; if neither regulator is working, this is an emergency condition and the spacecraft should be kept in Mode D with the 435 and 2304 MHz beacons OFF (this will require daily commands to Mode D unless the battery voltage has dropped sufficiently for the undervoltage sensor to keep it in this mode). Once a day during the reference orbit, the 435 MHz beacon should then be turned ON for several frames of teletype telemetry and then for several frames of Morse code telemetry, and the battery charge regulator should be commanded from #1 to #2 (or vice versa) while the spacecraft is in sunlight, to see if one of the regulators has recovered. Spacecraft lifetime will only be 100-200 hours in this condition before the battery becomes fully discharged.

5.10 Experiment Control Logic

The experiment control logic (ECL) controls nearly all functions of the repeaters and beacons, including switching them ON and OFF and selecting the telemetry modulation sources. It also contains the undervoltage sensors and 24-hour spacecraft clock which switches between the operating modes.

5.10.1 Experiment Control Logic Failure Conditions

i) If for some reason there should be a temporary loss of power in the spacecraft (defined as when the bus voltage goes below 12.0 volts), the spacecraft should be commanded to the proper operating conditions after power has been restored. This includes putting the spacecraft in Mode A or B, turning ON the 435 MHz beacon, keeping the 2304 MHz beacon OFF, resetting the clock at 0000 GMT, and selecting the proper telemetry system for the proper beacons. The two-to-ten meter repeater should be kept in the full-sensitivity mode, and Morse code telemetry should be kept at 20 WPM.

ii) If the ECL is unable to select the proper telemetry encoder or modulation source or beacon, the backup procedures outlined for the Mode A and B Morse code and teletype telemetry system failure conditions should be followed.

iii) If the 24-hour clock should fail, the spacecraft should be commanded to the correct mode (A or B) daily ten minutes after the reference orbit equatorial crossing.

iv) If the battery voltage appears to be approaching 12.0 volts and the undervoltage sensor fails to switch into Mode D, this switching should be done manually.

6.0 SUGGESTED EXPERIMENTS

Generally, one day a week will be reserved for special experiments, although experiments can be scheduled at other times as well if they will not interfere with the normal operation of the two repeaters. In the event that no experiments are planned, the spacecraft should be left in Mode D, with the 435 MHz beacon commanded ON in the teletype telemetry mode. The two repeaters will not be available for general use unless a specially planned experiment has been arranged with AMSAT. All users are invited and encouraged to originate experiments, which can be of a technical, operations, application, or demonstration nature. Listed below are suggested experiments as a guide to what can be done with the experimental subsystems onboard AMSAT-OSCAR 7.

6.1 Two-to-ten Meter and 70 cm-to-2 m Repeater Experiments

A. Educational demonstrations in schools.

B. Ranging (distance measurement) experiments to determine satellite or user position.

C. Small-terminal user experiments using hand-held equipment, or equipment operated from an automobile, airplane, boat, bicycle or motorcycle.

D. Emergency communications demonstrations with portable equipment.

E. Medical data exchange experiments, including possibly the transmission of analog or digital physiological data (see 4X4MH's proposal in the September 1973 issue of the "AMSAT Newsletter," pages 13-14).

F. Data collection from remote, unattended ground terminals.

G. Slow-scan and medium-scan television experiments.

H. Remote control experiments.

I. Repeater interlinking experiments (this will require approval by the government licensing authority).

J. Multiple-access experiments, particularly quantitative experiments to determine reduction in S/N due to power sharing, for different modulation techniques.

K. Ground station automation experiments (closed-loop monitoring of downlink and adjustment of uplink power and frequency automatically).

L. "Broadcast" demonstrations using the repeater in a single-access mode, and measuring downlink S/N for different modulation modes.

M. Extended range communications experiments to attempt transmission or reception beyond the normal maximum communications range.

N. Minimum power user experiments, to determine the minimum power needed to establish communications under controlled, single-access conditions.

O. Traffic nets scheduled on the satellite.

P. Automatic tracking of ground station antennas (either on an open-loop or closed-loop basis).

6.2 435.1 MHz Beacon Experiments

A. Inverted and Arrested Doppler propagation experiments (see the report by WØLER and WØMJS in the June 1973 issue of the *AMSAT Newsletter*, pages 10-14).

B. Aurora propagation experiments.

C. Scintillation effect quantitative measurements.

D. Doppler measurements (used for orbit determination).

E. Frequency splitting or "twinning" propagation experiments.

F. Utilizing Codestore with beacon as a single channel repeater.

6.3 2304.1 MHz Beacon Experiments

A. Propagation experiments.

B. Doppler measurements (used for orbit determination).

C. Downlink interference measurements (with radar).

6.4 Codestore Experiments

A. Teletype message storage experiments (Mark only, at quarter-speed).

B. Real-time message retransmission (Codestore in the "repeater" mode, in which the unit transmits its message while it is being loaded).

C. Delayed, stored-QSO demonstrations.

D. Bulletin transmission demonstrations.

E. Message loading or retrieval from remote, unattended terminals.

F. Interrogation of remote terminals using preassigned addresses.

6.5 Teletype and Morse Code Telemetry Experiments

A. Unattended, automatic telemetry data collection (using tape recorders, or "autostart" terminal units with phaselock detectors).

B. Online (or offline) computer processing of received telemetry data, with printout of parameter values and units.

C. Automatic computer processing of teletype status bits to provide printout of spacecraft operating conditions.

D. Use of teletype status bits for real-time verification of commands.

E. Experiments involving physical parameters, e.g., determination of spacecraft orientation and spin characteristics from solar panel currents and Z axis sensor information. (Note that the teletype telemetry encoder can be put in a "dwell" mode on any particular channel as needed for these experiments.)

6.6 Command System Experiments

A. Automatic transmission of commands at preprogrammed times.

B. Automatic verification of command acceptance.

C. Programming the list of commands to be sent to the satellite, with the capability of changing the commands from orbit to orbit (so that Codestore can be turned ON during particular passes, for example).

D. Automatic printout of commands transmitted, listing the actual commands sent, with dates, times and orbit numbers, for command station logging purposes.

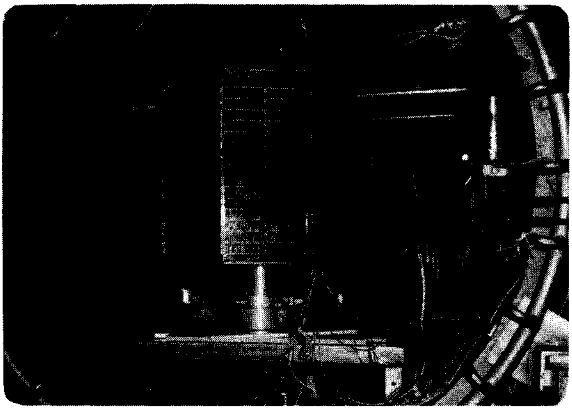
E. Automatic logging of spacecraft states (including mode), with dates, times and orbit numbers, for space station logging purposes. For example, determine and log which repeater and/or beacon(s) are in operation.

F. Automatic closed-loop control of command sequence according to observed spacecraft state. For example, if the Morse code telemetry system is found to be at 10 WPM instead of 20 WPM, the speed could be switched automatically to 20 WPM.

G. Turning ON and OFF the command transmitter automatically, and automatically tracking the command transmitter antennas.

6.6.1 Important Note to All Telecommand Stations

It is extremely important that all AMSAT-OSCAR 7 telecommand stations keep detailed logs of all command transmissions for collection and retention by AMSAT as licensee of the space station. Special command log forms have been prepared by AMSAT for this purpose, and should be submitted by each telecommand station monthly. It is imperative that all spacecraft commands be traceable back to the telecommand station who sent them.



THE AMSAT-OSCAR-7 SPACECRAFT IN THE THERMAL-VACUUM TEST CHAMBER

7.0 CALIBRATION EQUATIONS FOR THE AMSAT-OSCAR 7 MORSE CODE TELEMETRY SYSTEM

Line No. X12 N

Channel	Measured Parameter	Measurement Range	Preliminary Calibration Equation
1A	Total Solar Array Current	0 to 3000 ma.	$I_T = 29.5\ N$ (ma.)
1B	+X Solar Panel Current	0 to 2000 ma.	$I_{+x} = 1970 - 20\ N$ (ma.)
1C	-X Solar Panel Current	0 to 2000 ma.	$I_{-x} = 1970 - 20\ N$ (ma.)
1D	+Y Solar Panel Current	0 to 2000 ma.	$I_{+y} = 1970 - 20\ N$ (ma.)
2A	-Y Solar Panel Current	0 to 2000 ma.	$I_{-y} = 1970 - 20\ N$ (ma.)
2B	RF Pwr. Out-70/2 Rptr.	0 to 8 watts	$P_{70/2} = 8\ (1 - 0.01\ N)^2$ (watts)
2C	24-hour Clock Time	0 to 1440 minutes	$t = 14.4\ N$ (min.) or $0.24\ N$ (hrs.)
2D	Bat. Charge-Discharge Current	-2000 to +2000 ma.	$I_B = 40\ (N - 50)$ (ma.)
3A	Battery Voltage	6.4 to 16.4 volts	$V_B = 0.1\ N + 6.4$ (volts)
3B	Half-Battery Voltage	0 to 10 volts	$V_{\frac{1}{2}B} = 0.10\ N$ (volts)
3C	Bat. Charge Reg. #1 Vtge.	0 to 15 volts	$V_{cr1} = 0.15\ N$ (volts)
3D	Battery Temperature	-30° to +50° C.	$T_{Bat} = 95.8 - 1.48\ N$ (°C.)
4A	Baseplate Temperature	-30° to +50° C.	$T_{bp} = 95.8 - 1.48\ N$ (°C.)
4B	PA Temp. - 2/10 Rptr.	-30° to +50° C.	$T_{10} = 95.8 - 1.48\ N$ (°C.)
4C	+X Facet Temperature	-30° to +50° C.	$T_{+x} = 95.8 - 1.48\ N$ (°C.)
4D	+Z Facet Temperature	-30° to +50° C.	$T_{+z} = 95.8 - 1.48\ N$ (°C.)
5A	PA Temp. - 70/2 Rptr.	-30° to +50° C.	$T_2 = 95.8 - 1.48\ N$ (°C.)
5B	PA Emit. Curr. - 2/10 Rptr.	0 to 1167 ma.	$I_{10} = 11.67\ N$ (ma.)
5C	Modulator Temp. - 70/2 Rptr.	-30° to +50° C.	$T_m = 95.8 - 1.48\ N$ (°C.)
5D	Instr. Sw. Reg. Input Curr. (@ 14.3V)	0 to 93 ma.	$I_{isr} = 11 + 0.82\ N$ (ma.)
6A	RF Power Out - 2/10 Rptr.	0 to 10,000 mw.	$P_{2/10} = N^2$ (milliwatts)
6B	RF Power Out - 435 Beacon	0 to 1,000 mw.	$P_{435} = 0.1\ N^2$ (milliwatts)
6C	RF Power Out - 2304 Beacon	0 to 100 mw.	$P_{2304} = 0.01\ N^2$ (milliwatts)
6D	Midrange Telemetry Calibration	0.500 volts	$N = 50 \pm 1$ counts

8.0 CALIBRATION EQUATIONS FOR THE AMSAT-OSCAR 7 TELETYPE TELEMETRY SYSTEM

Channel No. → XX123 ← N

Channel	Measured Parameter	Measurement Range	Calibration Equation (at 25°C.)
00	PA Temp. - 70/2 Rptr.	-30° to +50°C.	$T_2 = 95.79 - 0.1480\ N$ (°C.)
01	+X Solar Panel Current	0 to 2000 ma.	$I_{+x} = 1995 - 2.191\ N$ (ma.)
02	+Y Solar Panel Current	0 to 2000 ma.	$I_{+y} = 1968 - 2.175\ N$ (ma.)
03	-X Solar Panel Current	0 to 2000 ma.	$I_{-x} = 1953 - 2.150\ N$ (ma.)
04	-Y Solar Panel Current	0 to 2000 ma.	$I_{-y} = 1954 - 2.150\ N$ (ma.)
05	+Z Axis Orientation	0 to 90°	$\theta_z = \arccos (N/N_{max})$ (deg. from Z axis)
06	+X Solar Panel Current	0 to 2000 ma.	$I_{+x} = 1995 - 2.191\ N$ (ma.)
07	+Y Solar Panel Current	0 to 2000 ma.	$I_{+y} = 1968 - 2.175\ N$ (ma.)
08	-X Solar Panel Current	0 to 2000 ma.	$I_{-x} = 1953 - 2.150\ N$ (ma.)
09	-Y Solar Panel Current	0 to 2000 ma.	$I_{-y} = 1954 - 2.150\ N$ (ma.)
10	-Z Axis Orientation	0 to 90°	$\theta_{-z} = \arccos (N/N_{max})$ (deg. from Z axis)
11	Battery Voltage	6.4 to 16.4 V.	$V_B = 0.01\ N + 6.40$ (volts)
12	Half-Battery Voltage	0 to 10 V.	$V_{\frac{1}{2}B} = 0.01045\ N$ (volts)
13	28V. Regulator Voltage	0 to 34 V.	$V_{28} = 0.034\ N$ (volts)
14	10V. Regulator Voltage	0 to 15 V.	$V_{10} = 0.01558\ N$ (volts)
15	9V. Regulator Voltage	0 to 10 V.	$V_9 = 0.01\ N$ (volts)
16	Battery Charge Reg. #1 Voltage	0 to 15 V.	$V_{cr1} = 0.015\ N$ (volts)
17	Battery Charge Reg. #2 Voltage	0 to 15 V.	$V_{cr2} = 0.015\ N$ (volts)
18	Ground-Zero Telemetry Cal.	0 V.	$V_o = 0.00$ (volts); $N = 000 \pm 1$ count
19	RF Power Out - 2304 Beacon	0 to 100 mw.	$P_{2304} = (N/100)^2$ (mw.)
20	Battery Charge-Discharge Curr.	-1500 to +1500 ma.	$I_B = 3.08\ N - 1474$ (ma.)
21	+X Solar Panel Current	0 to 2000 ma.	$I_{+x} = 1995 - 2.191\ N$ (ma.)
22	+Y Solar Panel Current	0 to 2000 ma.	$I_{+y} = 1968 - 2.175\ N$ (ma.)
23	-X Solar Panel Current	0 to 2000 ma.	$I_{-x} = 1953 - 2.150\ N$ (ma.)
24	-Y Solar Panel Current	0 to 2000 ma.	$I_{-y} = 1954 - 2.150\ N$ (ma.)
25	+Z Axis Orientation	0 to 90°	$\theta_{+z} = \arccos (N/N_{max})$ (deg. from Z axis)
26	+X Solar Panel Current	0 to 2000 ma.	$I_{+x} = 1995 - 2.191\ N$ (ma.)
27	+Y Solar Panel Current	0 to 2000 ma.	$I_{+y} = 1968 - 2.175\ N$ (ma.)
28	-X Solar Panel Current	0 to 2000 ma.	$I_{-x} = 1953 - 2.150\ N$ (ma.)
29	-Y Solar Panel Current	0 to 2000 ma.	$I_{-y} = 1954 - 2.150\ N$ (ma.)

8.0 CALIBRATION EQUATIONS FOR THE AMSAT-OSCAR 7 TELETYPE TELEMETRY SYSTEM (cont'd.)

Channel	Measured Parameter	Measurement Range	Calibration Equation (at 25°C.)
30	-Z Axis Orientation	0 to 90°	$\theta_{-z} = \arccos (N/N_{max})$ (deg. from Z axis)
31	RF Power Out - 2/10 Repeater	0 to 10,000 mw.	$P_{2/10} = (N/10)^2$ (milliwatts)
32	RF Power Out - 70/2 Repeater	0 to 8 watts	$P_{70/2} = 8\ (1 - 0.001\ N)^2$ (watts)
33	RF Power Out - 435 Beacon	0 to 1000 mw.	$P_{435} = 0.001\ N^2$ (milliwatts)
34	Total Solar Panel Current	0 to 3000 ma.	$I_T = 3.115\ (N - 7)$ (ma.)
35	Battery Temperature	-30° to +50° C.	$T_{Bat} = 95.79 - 0.1480\ N$ (°C.)
36	Baseplate Temperature	-30° to +50° C.	$T_{bp} = 95.79 - 0.1480\ N$ (°C.)
37	+X Facet Temperature	-30° to +50° C.	$T_{+x} = 95.79 - 0.1480\ N$ (°C.)
38	+Z Facet Temperature	-30° to +50° C.	$T_{+z} = 95.79 - 0.1480\ N$ (°C.)
39	2304 Beacon Temperature	-30° to +50° C.	$T_{2304} = 95.79 - 0.1480\ N$ (°C.)
40	Midrange Telemetry Calibration	0.500 ± 0.005 V.	$V = 0.001\ N$ (volts) ($N = 500 \pm 5$)
41	+X Solar Panel Current	0 to 2000 ma.	$I_{+x} = 1995 - 2.191\ N$ (ma.)
42	+Y Solar Panel Current	0 to 2000 ma.	$I_{+y} = 1968 - 2.175\ N$ (ma.)
43	-X Solar Panel Current	0 to 2000 ma.	$I_{-x} = 1953 - 2.150\ N$ (ma.)
44	-Y Solar Panel Current	0 to 2000 ma.	$I_{-y} = 1954 - 2.150\ N$ (ma.)
45	+Z Axis Orientation	0 to 90°	$\theta_{+z} = \arccos (N/N_{max})$ (deg. from Z axis)
46	+X Solar Panel Current	0 to 2000 ma.	$I_{+x} = 1995 - 2.191\ N$ (ma.)
47	+Y Solar Panel Current	0 to 2000 ma.	$I_{+y} = 1968 - 2.175\ N$ (ma.)
48	-X Solar Panel Current	0 to 2000 ma.	$I_{-x} = 1953 - 2.150\ N$ (ma.)
49	-Y Solar Panel Current	0 to 2000 ma.	$I_{-y} = 1954 - 2.150\ N$ (ma.)
50	-Z Axis Orientation	0 to 90°	$\theta_{-z} = \arccos (N/N_{max})$ (deg. from Z axis)
51	Battery Voltage	6.4 to 16.4 V.	$V_B = 0.01\ N + 6.45$ (volts)
52	Half-Battery Voltage	0 to 10 V.	$V_{\frac{1}{2}B} = 0.01052\ N$ (volts)
53	AGC Level - 70/2 Rptr.	0 to 29 dB	$AGC = 20 \log_{10} (1093 - N) - 60$ (dB)
54	TX Osc. Test Pt. - 70/2 Repeater	0 to 100%	N(TX OSC) = 977 (typical)
55	RX Osc. Test Pt. - 70/2 Repeater	0 to 100%	N(RX OSC) = 316 (typical)
56	Modulator Out. - 70/2 Repeater	0 to 1 V.	$MOD = 0.00128\ N$ (volts)
57	Envelope Level - 70/2 Repeater	0 to 1 V.	$ENV = 0.00128\ N$ (volts)
58	AGC Level - 2/10 Rptr.	0 to 27 dB	$AGC = 10 \log_{10} (N-500)$ (dB)
59	CONV Osc. Test Pt. - 70/2 Repeater	0 to 10 V.	$CONV = 0.01\ N$ (volts)

9.0 INTERPRETATION OF THE STATUS WORDS IN TELETYPE TELEMETRY CHANNELS 60 - 79

The seventh and eighth lines of telemetry data from the teletype telemetry encoder are spacecraft status words, coded in octal (base 8) form. Two status words are sent alternately, "satellite clock time" (sent in teletype telemetry channels 60, 62, 64, 66, 68, 70, 72, 74, 76, and 78), and spacecraft state/mode (sent in channels 61, 63, 65, 67, 69, 71, 73, 75, 77, and 79).

Each status word consists of five octal numbers. The first (left-most) digit is not used and should be disregarded. The second, third, fourth and fifth digits are octal numbers containing the status information.

9.1 Satellite Clock Time (Teletype Telemetry Channels 60, 62, 64, 66, 68, 70, 72, 74, 76, and 78)

Satellite clock time is telemetered in AMSAT-OSCAR 7 to permit identification of the approximate time that a frame of telemetry was recorded. The clock increments every 96 minutes and repeats again from zero every 273 days. The clock reading is telemetered as a five-digit word in octal form. For example, the word X3746 represents a clock count of $(3 \times 8^3) + (7 \times 8^2) + (4 \times 8^1) + (2 \times 8^0) =$

$$1536 + 448 + 32 + 6 = 2022$$

(The left-most digit, represented above as "X" is not used and should be disregarded. It will generally be zero.) At 96-minute intervals, the word would increment to X3747, then X3750, then X3751, and so forth.

9.2 Spacecraft State/Mode (Teletype Telemetry Channels 61, 63, 65, 67, 69, 71, 73, 75, 77, and 79)

The state/mode of the spacecraft is transmitted in octal form in five digit words. The first digit is not used and will usually be zero. The second, third and fourth digits are command status words corresponding to the last command received by the spacecraft command system. This information can be interpreted by means of the command status word table given on the following page.

The fourth and fifth digits provide information on the Mode (i.e., whether the satellite is in Mode A, B, C, or D), and whether the 435 MHz and 2304 MHz beacons are ON or OFF in accordance with the table on the next page.

KARIN MEINZER (DJ4ZC's XYL), MARIE MARR, DICK DANIELS WA4DGU, DR. KARL MEINZER DJ4ZC, AND JAN KING W3GEY PREPARE AMSAT-OSCAR 7 TO GO INTO THE THERMAL-VACUUM TEST CHAMBER (SEEN IN THE BACKGROUND).

TABLE OF COMMAND STATUS WORDS IN TELETYPE TELEMETRY CHANNELS
61, 63, 65, 67, 69, 71, 73, 75, 77 and 79

CMND #	digit: 1	2	3	4	5	CMND #	digit: 1	2	3	4	5
01	Ø	7	Ø	ev	X	19	Ø	6	Ø	od	X
02	Ø	3	1	ev	X	20	Ø	2	3	ev	X
03	Ø	3	2	ev	X	21	Ø	2	5	ev	X
04	Ø	3	4	ev	X	22	Ø	2	1	od	X
05	Ø	3	Ø	od	X	23	Ø	2	6	ev	X
06	Ø	5	1	ev	X	24	Ø	2	2	od	X
07	Ø	5	2	ev	X	25	Ø	2	4	od	X
08	Ø	5	4	ev	X	26	Ø	4	3	ev	X
09	Ø	5	Ø	od	X	27	Ø	4	5	ev	X
10	Ø	1	3	ev	X	28	Ø	4	1	od	X
11	Ø	1	5	ev	X	29	Ø	4	6	ev	X
12	Ø	1	1	od	X	30	Ø	4	2	od	X
13	Ø	1	6	ev	X	31	Ø	4	4	od	X
14	Ø	1	2	od	X	32	Ø	Ø	7	ev	X
15	Ø	1	4	od	X	33	Ø	Ø	3	od	X
16	Ø	6	1	ev	X	34	Ø	Ø	5	od	X
17	Ø	6	2	ev	X	35	Ø	Ø	6	od	X
18	Ø	6	4	ev	X						

(digits 1–5 are the status word)

Note: "X" can be any number and can be disregarded.
"od" represents an odd number (1, 3, 5, or 7).
"ev" represents an even number (0, 2, 4, or 6).

The fourth digit of the status word is an indication whether the spacecraft is in Mode A, B, C, or D as follows:

	Fourth status bit
Mode A	4 or 5
Mode B	6 or 7
Mode C	2 or 3
Mode D	0 or 1

CMND #

10.0 AMSAT-OSCAR-7 OPERATING MODES

1 - MODE A SELECT - 2/10 RPTR ON AND/OR 435 BEACON ON, 70/2 RPTR OFF.

2 - MODE B SELECT - 70/2 RPTR ON AT FULL-POWER, 2/10 RPTR OFF, 435 BEACON OFF.

3 - 435 BEACON ON (DURING MODE A OR MODE D ONLY).

4 - 435 BEACON OFF.

5 - CODESTORE - RUN MODE.

6 - CODESTORE - LOAD MODE.

7 - MORSE CODE TELEMETRY - 20 WPM.

8 - MORSE CODE TELEMETRY - 10 WPM.

9 - 2/10 RPTR - FULL SENSITIVITY.

10 - 2/10 RPTR - REDUCED SENSITIVITY (-14 DB).

11 - 435 BEACON - CODESTORE KEYING.

12 - 435 BEACON - MORSE CODE TELEMETRY KEYING.

13 - 435 BEACON - TELETYPE TELEMETRY KEYING.

14 - 29.50 OR 145.98 BEACON - MORSE CODE TELEMETRY KEYING.

15 - 29.50 OR 145.98 BEACON - CODESTORE KEYING.

16 - 29.50 OR 145.98 BEACON - TELETYPE TELEMETRY KEYING.

17 - RESET 24-HOUR SATELLITE CLOCK.

18 - MODE C SELECT - 70/2 RPTR ON AT QUARTER-POWER, 2/10 RPTR OFF, 435 BEACON OFF.

19 - MODE D SELECT - RECHARGE MODE; 70/2 RPTR OFF, 2/10 RPTR OFF. NOTE - 435 BEACON CAN BE OPERATED IN THIS MODE.

20 - CHARGE REGULATOR NO. 1 SELECT.

21 - CHARGE REGULATOR NO. 2 SELECT.

22 - TELETYPE TELEMETRY - DWELL MODE.

23 - TELETYPE TELEMETRY - RUN MODE.

24 - 2304 BEACON ON (FOR 14 MINUTES ONLY). NOTE - THIS BEACON IS OPERABLE IN ALL MODES.

25 - 2304 BEACON OFF.

26 - 2304 BEACON - INTERNAL KEYING.

27 - 2304 BEACON - MORSE CODE TELEMETRY KEYING.

28 - TELETYPE TELEMETRY - FSK MODE.

29 - TELETYPE TELEMETRY - AFSK MODE.

30 - MODE A SELECT (REDUNDANT TO #1).

31 - MODE B SELECT (REDUNDANT TO #2).

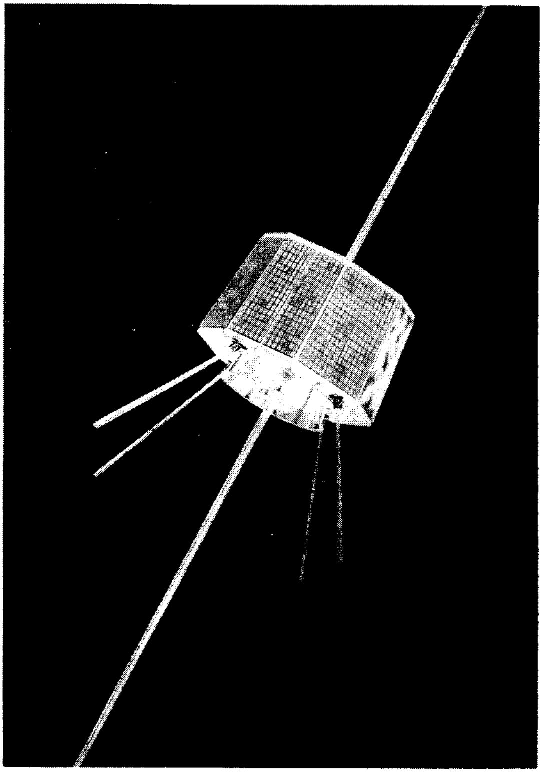
32 - 435 BEACON ON (REDUNDANT TO #3).

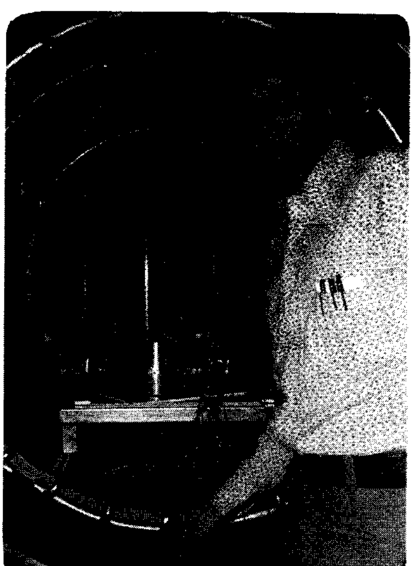
33 - 435 BEACON OFF (REDUNDANT TO #4).

34 - MODE C SELECT (REDUNDANT TO #18).

35 - MODE D SELECT (REDUNDANT TO #19).

AN ARTIST'S RENDITION OF THE AMSAT-OSCAR 7 SATELLITE IN ORBIT





JAN KING W3GEY, AMSAT-OSCAR 7 PROJECT MANAGER, INSPECTS THE SPACECRAFT IN THE THERMAL-VACUUM TEST CHAMBER.

BUCK MOORE W3ZKI, POTTING THE AMSAT-OSCAR 7 TWO-TO-TEN METER REPEATER WITH ECCOFOAM FPH.