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Paper Session III-C - AMSAT's Phase 3-D Satellite New opportunities for Space Education

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AMSAT's Phase 3-D satellite
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Teachers and amateur radio operators have been using satellites for education since the first OSCAR launch in 1961. The recent high power OSCAR satellites are in use every day in classrooms around the world by teachers with amateur radio licenses. Central Florida hams are assembling Phase 3-D, the next generation amateur radio satellite. Phase 3-D will offer many new opportunities for education due to an earth-viewing camera experiment, and higher power which will permit schools to use the satellite with much less hardware. Locally the Phase 3-D integration team is looking for educational groups to participate in the assembly and testing of the spacecraft. We are hoping to offer students from the middle-school to university level hands-on experience with spacecraft manufacturing and testing.

This paper will introduce the OSCAR satellites, their current educational applications, the Phase 3-D project, and how educational organizations can get involved.

The first amateur radio transmitter in space was launched in December 1961 - at the beginning of the space age. OSCAR-1 (Orbiting Satellite Carrying Amateur Radio) was a primitive battery operated Morse code transmitter, but it did prove that amateur radio operators could design, develop, and build equipment for use in space, and ushered in a new age for amateur radio. AMSAT, the Radio Amateur Satellite corporation was founded as a non-profit 501 (c) (3) corporation in 1969 for the purpose of obtaining funding and launch opportunities for amateur radio satellites. One of the key points in AMSAT's charter is education. To date almost 30 OSCAR satellites have been successfully placed in orbit.

All of the OSCAR spacecraft have been used for educational purposes. Many of the satellites are used as relay stations, permitting amateur radio operators on different continents to communicate with each other. Other amateur radio satellites have computer bulletin boards onboard and can be used to distribute computer data around the world. One particular satellite built by Brazilian and U.S. hams, DOVE, was designed specifically for educational demonstrations involving young children. DOVE - Digital Orbiting Voice Encoder - speaks in plain English (or Portuguese) with messages of peace and friendship. Its orbit is fairly low and its transmitter is powerful enough to enable it to be received with an inexpensive VHF scanner.

Many schools have fully equipped OSCAR ground stations capable of two way communications with a variety of spacecraft. Unfortunately the limited power available on current satellites and their orbits increase the difficulties in making reliable contacts. Relatively high power equipment is needed with fairly sophisticated hardware. These disadvantages result in a large amount of skill and funds, often beyond the budget of a typical school.

The Phase 3-D satellite, currently under construction in the Foreign Trade Zone at Orlando International Airport, promises to make amateur radio from space available to a much larger audience by reducing the amount of necessary hardware.

Phase 3-D builds on the heritage of the three previous Phase 3 satellites. The Phase 3 program was started by Dr. Karl Meinzer of AMSAT-DL, the German amateur satellite organization. The Phase 3 satellites use elliptical Molniya orbits. Molniya, Russian for "Lightning" is named after the Russian communications satellites which first used this unique orbit. A Molniya orbit has a fairly low perigee in the Southern hemisphere with a high apogee in the Northern hemisphere. The orbit's inclination and period are chosen to produce an orbit with a period which is some multiple of 8 or 12 hours. The result is a spacecraft which appears to hang in the sky for long periods, much like how a baseball tossed up vertically will appear to stand still for a couple of seconds before it starts to descend. This type of orbit is extremely useful for users at high latitudes where geosynchronous satellites are less usable. From AMSAT's point of view another advantage is a single satellite can serve most of the world, as opposed to a geosynchronous satellite which would be able to be accessed by less than half of the world.

Phase 3-A was lost in an early Ariane launch failure. The Phase 3-B satellite was successfully launched in 1983 and renamed OSCAR-10 upon entering operation. For such an old spacecraft it is in surprisingly good shape. Spacecraft batteries have limited lifetimes and OSCAR-10's batteries and computer both exceeded the planned lifetimes. Nevertheless when its solar cells face the sun OSCAR-10 can still be used.

Phase 3-C, renamed OSCAR-13 in orbit, is in continuous use every day by hams around the world. It was launched on an Ariane 44LP booster on June 15, 1988 and used its onboard liquid engine to reach its operational orbit. Unfortunately that orbit has proven to be unstable, and OSCAR-13 is expected to reenter the Earth's atmosphere some time in late 1996.

The Phase 3-D spacecraft is manifested for the second Ariane 5 test flight, currently scheduled for April 1996. Its principles are similar to Phase 3-C, but with many incremental improvements. At launch Phase 3-D will weigh over 800 lbs., making it the largest amateur radio satellite. As a comparison this is similar to the mass of the early Ranger lunar probes, first generation Navstar spacecraft, Clementine lunar probe, or Ulysses solar probe. The earlier Phase 3 spacecraft were spin-stabilized, with their antennas only pointing at Earth during a portion of each orbit. Phase 3-D is three axis stabilized and will have its antenna farm aimed directly at the Earth. Besides 3-D's propellant system to put it into our Molniya-style orbit we will also include a station-keeping system with an ammonia arc-jet thruster. This will keep our orbit stable, preventing the premature reentry anticipated for 3-C. The Molniya orbit has been optimized to coincide with a typical ham's schedule. Our 16 hour orbit will result in the spacecraft remaining high in the sky, with little apparent motion, for several hours each day. On one day North America will have many hours to talk to Europe. On the next day North American hams will talk to Asian hams. On the third day Asian and European hams will communicate, and on the fourth day the cycle repeats. If you live in the Northern hemisphere this will be the satellite of choice. Phase 3-D will also be the first amateur satellite with deployable solar arrays, permitting a much higher power budget for the transponders.

Phase 3-D will set several space records. We are using a GPS receiver for positional and velocity information, and for attitude determination. Most of the time we will be well above the orbits of the GPS constellation, setting the altitude record for a satellite with a GPS receiver. All together 3-D will have transmitters for six different bands, every frequency band authorized for amateur radio communications in space from 10 MHz to 24 GHz. We will transmit on more bands than any other satellite ever launched.

The telemetry streams on all of the OSCAR satellites are unencoded and easily interpreted. Inexpensive data manipulation programs are available for a variety of personal computers and many schools use this telemetry within technical courses.

Schools without amateur radio stations have used AMSAT's satellite tracking programs to understand Newtonian mechanics and how satellite orbits work.

The Phase 3-D improvements will result in a much higher link budget for the ground stations. This works out to much less complicated hardware. It's anticipated that a handheld receiver will be able to receive Phase 3-D's transmissions, and a fairly simple ground station will be adequate for almost any application.

Phase 3-D is an international project with hams around the world participating in the design, assembly, and testing. The German AMSAT-DL organization is the leader for the effort, providing the program management and many of the components. The U.S. hams are responsible for the spacecraft frame, antennas, GPS system, and one of the onboard computers. More importantly we are responsible for one third of the fund raising. Other countries participating in the project include Finland, the Czech republic, Russia, Japan, Canada, Hungary, the United Kingdom, Belgium, South Africa, Slovenia, and Canada.

The spacecraft's aluminum frame was built by undergraduate students at Weber State University in Utah. The same team at Weber State had previously built WeberSat, which is in operation as OSCAR-18. The spaceframe arrived in July 1994 and was assembled with its heat pipes. The six propellant tanks, built in Russia, have been installed and we are waiting for the various payload modules to arrive.

Locally the spacecraft integration team consists of approximately a dozen amateur radio operators. We do our tasks during our spare time whenever we can get away from our jobs and family responsibilities. Our team is responsible for the spacecraft's integration and testing. In addition we will be building the various antennas, the wiring harness, and the Liquid Ignition Unit which will control the bipropellant orbit-changing engine.

Last summer we had a co-op student provided by the University of Central Florida, and we would like to get more local Central Florida educational groups involved in Phase 3-D's integration effort.

As an example, a middle-school group could participate with stringing the wiring for the harnesses. High School students could help test the antennas and help perform some of the analysis. College students would be able to gain useful experience in their respective fields. Electrical Engineering students could help assemble the harnesses and with the spacecraft testing. Chemical engineers could perform contamination analysis of the spacecraft's surfaces, and so on.

Phase 3-D has an anticipated lifetime of at least 15 years, which will bring AMSAT well into the next century. It will offer many new opportunities for education, both in space when it's in operation, and now as it's being assembled.