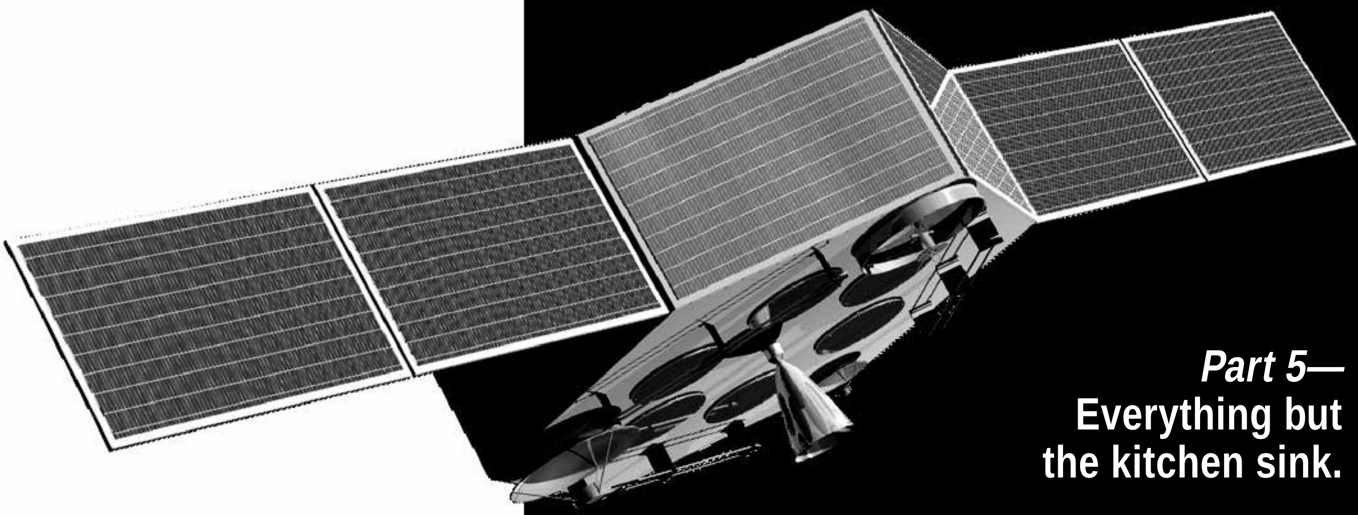
By Steve Ford, WB8IMY, and Zack Lau, W1VT

Get Ready for Phase 3D!



Part 5— Everything but the kitchen sink.

When conversation turns to the subject of Phase 3D, most hams speculate on the joys of operating SSB and CW through its many transponders. But Phase 3D is more than a collection of receivers and transmitters. There are several fascinating aspects of this satellite that may have escaped your attention—until now.

Swapping Bytes with RUDAK

Phase 3D will have a powerful digital "voice" in the form of the *RUDAK* experiment. RUDAK is a German acronym: Regenerativer Umsetzer fuer Digitale Amateurfunk Kommunikation (Regenerative Transponder for Digital Amateur Radio Communication). At an AMSAT forum a few years ago, someone asked, "What is RUDAK?" A Phase 3D engineer replied, "Anything we want it to be!" That isn't an exaggeration. RUDAK is a flexible digital transponder that can be programmed to do—or "be"—many things.

Do you remember OSCAR 21? It was a satellite that functioned as an FM repeater, listening on 70 cm and relaying on 2 meters. Until its demise in 1994, OSCAR 21 was a favorite among new satellite operators. Few hams, however, realized that its repeater was entirely *digital*. OSCAR 21's RUDAK digitized and processed the 70-cm signals and then retransmitted them as FM on 2 meters. It behaved like an FM repeater because that's what it was programmed to do.

The RUDAK scheduled to fly on Phase 3D represents the next generation. It includes modems based on DSP (digital signal processing) technology. There will be two processors. Each processor will have 16 Mbytes of memory, 10 serial ports, and 16 DMA channels. RUDAK's arsenal of modems will include two 9600-baud hardware modems and four DSP modems.

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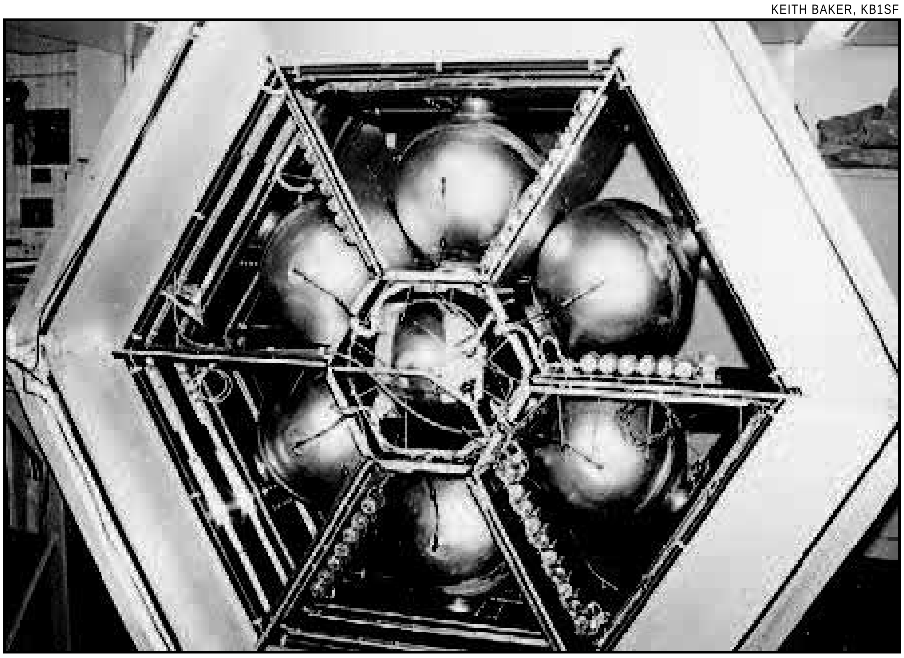


By late last year, Phase 3D's battery mounting and integration efforts were nearing completion. After a series of tests, the satellite will be ready for its July flight aboard an Ariane 5 rocket.

At minimum, Phase 3D's RUDAK can function as a 9600-baud digital repeater or a store-and-forward file system similar to the current PACSATs. However, RUDAK is capable of much higher data rates, up to

56 kbaud. Imagine a high-speed data network accessible by hams throughout an entire *hemisphere* for hours at a time!

If you're presently active on the 9600-baud PACSATs, and have a station equipped with beam antennas, preamps and RF power amps, you should be able to use the same gear to access the Phase 3D digital transponders. If your PACSAT station uses omnidirectional antennas, you may be able to access Phase 3D during perigee when the satellite is closest to the Earth.

But will it ever be possible to work Phase 3D digitally with small, omnidirectional antennas—regardless of where the satellite is located? Believe it or not, the answer is a qualified…*maybe*.

There is some discussion of a NASA-standard rate-$^1/_2$ convolutional forward error correction (FEC) code that may be available on the RUDAK high-speed modem. This coding scheme drops the data rate by 50%, but provides enough "gain" from the FEC that should make it possible to receive data with a compact, omnidirectional antenna—even at a distance of 30,000 miles. Aside from the antenna, you'd only need a basic receiver and a Pentium computer running the convolutional decoding software.

Digital "miracles" like these only await hams with sufficient knowledge and dedication to make them happen. RUDAK will be their proving ground.

GPS Aboard Phase 3D

To use any satellite, you must be able to predict where it will be at a particular date and time. Most satellite enthusiasts rely on tracking software to tell them when their favorite birds will appear above their local horizons. The software also describes how the satellites will move through the sky. For example, will the bird travel from northwest to southeast, or from southwest to northeast? How high will the satellite rise above the horizon? Is this evening's pass a "skimmer" that barely gets above the backyard trees, or will the satellite be whizzing directly overhead?

If you expect your software to crank out these delightful predictions, it must have some means of determining the nature of satellite orbits. You need to provide sets of numbers known as *orbital elements* or *Keplerian elements*, which mathematically describe these orbits. The ARRL distributes orbital elements (provided by NASA) via its W1AW bulletins, and you can also pick them up from a number of sites on the World Wide Web.

But what if a satellite could generate its *own* orbital elements? And what if you could update your software *directly from the satellite*, without waiting for NASA, W1AW or whomever? This is exactly what the AMSAT engineers have in mind for Phase 3D!

Phase 3D will determine its position in space through the use of two Trimble GPS receivers. It will be one of the few satellites—amateur or otherwise—to have this feature, and it will be the *first* satellite to carry GPS receivers in a high, elliptical orbit.

Whenever Phase 3D is traveling below the orbits of the GPS satellites, the Trimble receivers should have little difficulty acquiring signals. After processing through the RUDAK, the orbital data will be available to hams on the ground. In addition to orbital data, hams will be able to calibrate their station clocks to the highly accurate time provided by the GPS receivers.

But why do we need two GPS receivers? When Phase 3D is below the GPS constellation of satellites, it will receive signals at "normal" levels. When the satellite shoots out beyond the orbits of the GPS satellites, however, it may only receive signals from birds on the far side of the Earth—as much as 52,000 miles away. So we're talking about two very different antenna and preamplifier requirements, depending on the position of the satellite. The designers determined that it was easier to use two Trimble units than to install one unit and attempt to switch antennas and preamps. Besides, having two GPS receivers adds a comfortable margin of redundancy.

Peering through the SCOPE

Video imaging from amateur satellites is not new. PACSATs such as OSCARs 18, 22, 23 and 25 have been giving us fascinating views of the Earth for several years. For Phase 3D, however, we'll be going a step further—a *big* step further.

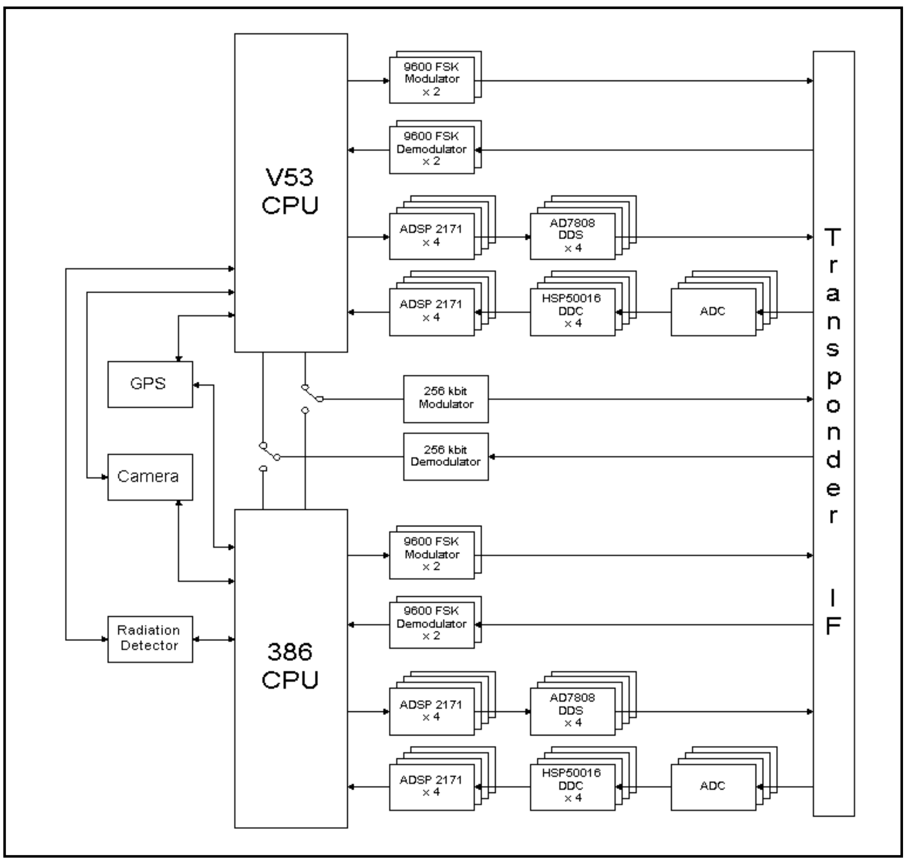
JAMSAT—the Japanese affiliate of AMSAT—has developed a dual-camera video system for Phase 3D known as

AMSAT Still Needs *Your* Help

Delay is part and parcel of the launch business. When you have millions of dollars of hardware riding into space aboard a flying bomb, "hurry up" is not part of your vocabulary. According to the original timetable, Phase 3D would have been in orbit by now. But the European Space Agency delayed the launch of Ariane 502—Phase 3D's express train to space—until September.

Delays are not only frustrating, they're costly. In the case of Phase 3D, this delay is going to ring up a hefty bill. The AMSAT organizations are doing everything possible to fill the gap, but they still need your assistance.

If you haven't yet donated to the Phase 3D project, now is the time! And if you have donated, please consider doing so again. Send your tax-deductible contributions to AMSAT, PO Box 27, Washington, DC 20044.



Block diagram of the Phase 3D RUDAK experiment.

SCOPE: *S*pacecraft *C*amera experiment for *O*bservation of *P*lanets and the *E*arth. SCOPE is composed of two commercial camcorder CCD units that have been modified for spaceflight. One camera will take wide-angle shots, while the other captures narrow-angle views. Both cameras are high-resolution *color* units. Translation: You're going to see some spectacular pictures from Phase 3D!

Images from the SCOPE cameras will be processed by the RUDAK and transmitted to Earth. After you capture the image data, all you'll need is the software to display the picture on your computer monitor. This software will be available through AMSAT and other sources.

Experiments at 24 GHz

In addition to Phase 3D's array of high-power transponders, there is an interesting experimental module designed and built by a group of Belgian amateurs. This is the *K*-band transponder generating a single watt of RF in the 24-GHz band. Two downlink passbands will be available: *Digital*, from 24,048.450 to 24,048.750 MHz; and *Analog*, from 24,048.025 to 24,048.275 MHz.

When you're this high in microwave territory, you're well beyond off-the-shelf, plug-and-play experience. For example, you won't find 24-GHz transverters at your favorite Amateur Radio dealer, but they are available if you're willing to shop around. Several sources include the following:

Kuhne Electronic
Birkenweg 15
D-95119 Naila/Holle
Germany
tel 011-49-9288-8232
fax 011-49-9288-1768

SSB Electronic USA
124 Cherrywood Dr
Mountaintop, PA 18707
tel 717-868-5643
WWW **http://www.ssbusa.com**

If 24 GHz is the downlink, what is the uplink? That has yet to be decided. With Phase 3D's versatile matrix, there are a number of good candidates. A 435-MHz uplink would create mode U/K; a 1.2-GHz uplink would be mode L/K.

The transponder is tentatively scheduled to be active during the highest portion of Phase 3D's orbit. Combine the vast distance with the low output power and you have a challenging situation. That's the point, though. The 24-GHz transponder functions much like a cape in the hand of a bullfighter, tempting us to action. Will we dare leave the cozy world of appliance operating and venture into—shudder—microwave homebrewing?

Interesting Times

"May you live in interesting times" is an ancient curse. Think about it. From our twentieth-century perspective, aren't the charred ruins of Pompeii interesting? If Vesuvius had never blown its top and incinerated an entire population, Pompeii would be little more than a footnote in history.

Well, Phase 3D's orbit is going to take the satellite through some very interesting regions of space. At perigee, when the satellite is closest to the Earth, it will cross the inner Van Allen radiation belt. This region has a large population of high-energy protons, which are the bane of satellite designers. When Phase 3D cruises into deep space at apogee, it will be outside the sheltering influence of the Earth's magnetosphere. Here it will be blasted by cosmic rays and solar radiation.

Of course, Phase 3D will be shielded against the effects of proton and cosmic ray bombardment. But as long as the bird is flying through these areas, why not take some measurements? That's the purpose of CEDEX, the Cosmic Ray Energy Deposition Experiment.

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An engineering prototype of JAMSAT's SCOPE camera. The camera is above, and to the right, of the monitor. Phase 3D will carry two SCOPE cameras—wide angle and narrow angle. Both will provide spectacular color images.

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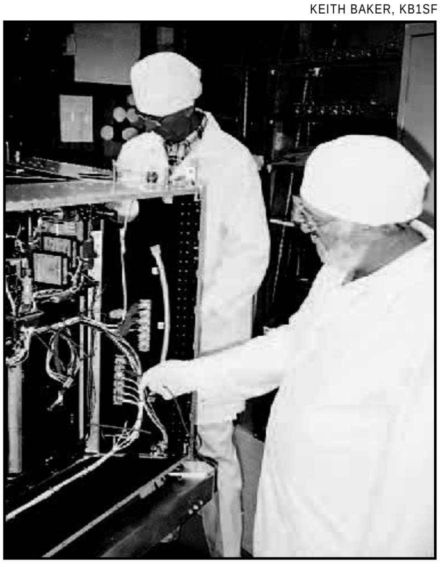

AMSAT Phase 3D Integration Laboratory Manager Lou McFadin, W5DID (r), and Assistant VP, Engineering Stan Wood, WA4NFY, AMSAT-NA (l), perform continuity tests on the satellite's wiring harness.

CEDEX is really two experiments in one. The Total Dose Experiment (TDE) measures the accumulated ionizing radiation dose inside Phase 3D. It does this with a series of solid-state RADFET dosimeters (modified power MOSFETs) that have a thick (0.1-micron) gate-oxide to make them especially sensitive to ionizing radiation. Exposure to radiation causes the formation of trapped holes (positive charges) in the gate oxide, which in turn causes a gradual shift in the threshold voltage with the accumulated dose.

The Cosmic Particle Experiment (CPE) is a highly sensitive particle detector in a special housing. It is designed to count the "hits" as high-energy particles strike the satellite. The CEDEX designers are particularly eager to see how the CPE performs during solar flares.

Data from CEDEX will be provided to the RUDAK and available to you for downloading. The idea of monitoring radiation in space appeals to the scientist in all of us. It also has potential for use in classrooms.

Countdown

And so now we wait. If everything proceeds as planned, we'll see Phase 3D in orbit in about 6 months. Once it has reached its permanent orbit and passed all its systems tests, the satellite will be open for general use—probably 60 to 90 days after launch. That means we may be enjoying the thrill of global satellite operating by the end of the year.

Throughout this series we've made general recommendations for station equipment and we've pointed you toward some sources. Does this mean it's time to start building your Phase 3D station? The answer depends on what you hope to achieve, and how much you're willing to gamble.

If you put together a Phase 3D station for mode V/U (2 meters up, 70 cm down), you'll be able to use a wide range of current analog and digital satellites from OSCAR 16 to OSCAR 29. And if you're developing a taste for terrestrial VHF or UHF operating, a Phase 3D station will serve you well.

But if all you care about is working Phase 3D, the best advice is to wait. Space is deep in the domain of Murphy—where anything can go wrong. Rockets explode in flight. Satellite systems fail catastrophically. Are you willing to put money on the table right now and roll the dice?

Nail-biting skittishness aside, we're looking forward to the sound of popping champagne corks as Phase 3D takes its place among the stars. It will be an achievement that every ham can point to with pride. After all, Phase 3D is more than a satellite, it is another milestone for the greatest hobby and service on Earth—and beyond!