By David A. Rosenthal, N6TST

Satellite DXing "To Go"

It was a dark and stormy night. Well, it ***was***... Despite the driving snowstorm blanketing our lonely campsite, the rich assortment of satellite signals filling my transceiver's speaker represented the exciting culmination of an Amateur Radio adventure.

As an inveterate mobile operator and equipment builder, I'd always dreamed of being able to somehow engineer a full-featured station into an easily transportable package that could travel almost anywhere—especially via a commercial airline. But then, who hasn't?

Taking it a step further, though—designing, building, transporting and operating a completely portable but full-sized mobile satellite antenna array—presented a fascinating challenge. The notion first triggered my innovative inclinations when my wife, Donna, KF6ZVE, a professional travel writer, announced she'd landed a two-week assignment to Alaska. We could both go, plus have the use of a rental RV there. Because we'd camp in some fairly remote spots, I thought about how I might put together a station with as much flexibility as possible to work from a few obscure grids for "lower-48" hams.

About that time, a friend showed me how easy it was to monitor amateur satellite traffic from a high-angle pass by UO-14 using only a credit card-sized 70 cm HT. "Satellites? Hmm…," I thought. At first, it seemed too wild to consider but, given some of the amazingly versatile compact transceivers now available, I also wondered how practical it might be to combine functionality with feasibility to also enjoy "working the birds" from an exotic locale. Before I knew it, the idea had become irresistible.

The Project

The engineering goal was simple: create an airline baggage-checkable station assembled from basic materials to mount in and on a conventional RV without damaging it. Another objective was to choose components judiciously to allow 2-meter SSB and HF operation to broaden the bandwidth and increase the fun. A third was to modularize the design, i.e., be able to select only those ingredients I could use for subsequent, simpler trips and still have everything work together.

For the antenna, I decided on a tilt-over, vertical, rotatable mast with a horizontal cross boom. VHF and UHF beams at either end would provide the satellite up- and downlinks. A mobile HF antenna would top the central mast.

Meanwhile, the beams had to be healthily sized for decent gain; moreover, I'd probably need a 2-meter "brick" power amp for terrestrial SSB and the satellite uplink. Between this and the rotator, I'd also need access to a small gas-powered generator since there's no way an RV camper battery could handle this kind of load for long. The RV we'd get didn't have a generator but I knew there would be rental units available in Alaska.

Operationally, I wanted to be able to arrive at a chosen camping site and get on the air fairly quickly. Having my preassembled antennas conveniently stored, the scheme would enable me to raise the mast, bolt on the antennas, and hook up everything with a custom-built "umbilical" cable. Inside the RV, the station equipment would already be in place. Theory indicated that, with careful design and a little practice, this could all unfold within about an hour. With our two-week travel time-frame selected for the end of the Alaskan tourist season in late September, we began making arrangements and I started work on the gear.

On the Mast

Portable operation via satellite is easier than it sounds. Despite the near-perfection attainable with circularly polarized, high-gain antennas, big power amps and az-el rotators, you can achieve remarkable results with simple but well-chosen components at a fraction of the cost. For my RV-mounted 2-meter uplink, I used Cushcraft's 10-element beam (A148-10S) and their 11-element 430 MHz model (A430-11S) for the 70 cm downlink. These devices turned out to be reasonably priced, particularly robust, lightweight and easy (read that "foolproof") to put up and take down quickly. Plus, once tuned, they're excellent performers: the gain they provide serves well to compensate for polarization-related signal losses.

Instead of an elevation rotator, I'd simply angle both beams upward about 15-20 degrees; the combination of this and the antennas' more than 30-degree 3 dB beamwidth would enable me to exchange sufficient energy with the satellites at almost any angle. The trade-off here emerges during near-overhead passes when the bird moves above the main lobe. Statistically, however, the greatest number of passes generally occurs below about 50 degrees for a given location and the lightning pace of a near-overhead pass minimizes bird-time outside the beam.

Mounting the 2-meter beam with horizontal polarization would enable me to level it for terrestrial SSB while a quick trip back to the roof and an easy tug on its boom could angle it skyward again. The 430 MHz beam I'd mount with its elements vertical to mitigate any potential interference between the antennas and as a "poor man's" polarization compensator.

For HF, I chose my trusty and reliable 12-year-old Spider mobile antenna, fitting it with four resonators, pre-tuning with an MFJ-259 analyzer, and letting the HF rig's autotuner clean up the rough edges.

The system's heaviest component turned out to be the rugged medium-duty rotator, the Yaesu G-800S, whose abilities my antennas' light weight and comparatively low surface area could never challenge. Finally, I'd attach my venerable SSB SP-2 2 meter low-noise mast preamp and the scheme would be complete.

Inside the Mobile Shack

To keep everything compact and simple, my choice for the transceiver at the heart of this system was the desktop-footprint-friendly ICOM IC-706 MkIIG. Its all-mode capability on both 2 meters and 70 cm as well as its reputation for great HF performance qualified it well. But also important is its proven ability to deliver a high-quality signal, even when battery voltages dip just below 12.0 V (its specs quote an operating voltage of 13.8±15%). This can be critical when leaving the generator at home.

For 13.8 V dc, the best device seemed to be one of a family of new, lightweight, compact dc switching power supplies recently reviewed in *QST* (January and September 2000 issues). I picked MFJ's 40-A (MFJ-4245) model because it is quiet and can deliver a hefty amount of current to transmit with the '706 and the VHF brick simultaneously. Another new MFJ product, the Model 1117 compact dc distribution block (8×2×3 inches), made those high-current connections safe and neat.

A tiny-but-precious package was the Rigblaster Nomic. One of several low-cost rig-computer interfaces popping onto the market lately, it's a self-contained miracle for a sound card-equipped laptop. Powered by the computer's serial port and driven by software included with the Nomic (or what's easily available free on the Internet), it not only enables HF communication using dramatically bandwidth-efficient schemes like PSK31, but also provides keyboard access to a whole new world of operation via previously equipment-intensive modes like RTTY and SSTV. I used it for all three.

The heaviest component on the bench turned out to be the Yaesu rotator controller (about 5 pounds) but there was no way to get around it. At the other end of the weight spectrum was my ICOM speaker—long, light and rectangular, it added good bass to the received audio and made a great monitor to plug into the Nomic's audio output. Besides, it made an excellent base on which to stack the "brick" amplifier.

From the '706's VHF/UHF antenna port, I ran a coax pigtail to a Larsen (AD 2/70) mobile duplexer where the VHF output connected through another pigtail to a Mirage Model 83016 30 W in/160 W out 2-meter "brick" power amp.

The Umbilical

Critical to everything was the cabling needed to connect it all together. I'd been in touch with Alaska RV, the outfit providing the vehicle, and identified a model very close to the one we'd get. Using the manufacturer's Web site, I tracked down relatively nearby RV dealers who carried it, and then went to their lots to make measurements and take pictures.

Using specs from the RV's brochure, measurements from the RVs I'd seen, and even scaling photos I'd shot, I came up with a design to build and route my nearly three-inch-diameter cable bundle from the interior, through an overhead vent, to the roof. Once finished, the umbilical cord contained runs of RG-213 and the new flexible 9913 cable ranging in length from 25 to 40 feet, along with the multiconductor rotator cable, a power cable for the mast amp, and a ground strap. Altogether, it weighed 19 pounds.

Finding a Spot

Throughout the whole process, I'd been thinking about the finished mast, mount and antenna assembly and how I'd non-destructively install this approximately 60-pound package onto a rental RV. To anyone experienced with materials used in constructing contemporary RVs, the concept of "structural paint" makes painful sense. If you've ever wondered what other uses "kite sticks" and staples might have, peek beneath the lightweight outer membrane of just about any RV.

But practically speaking, often the only real "hard-point" on a modern RV is the roof-access ladder mounted to its rear plane. Other spots include the vehicle's side-mirror mounts but many models encase these sturdy metal supports in a cosmetic plastic sheath or the entire mirror assembly sits inaccessible beneath a cabover sleeper unit—or both.

Plasticized, hidden mirrors were indeed the situation on the unit we'd get. Meanwhile, our ladder would be in the open, quite strong, and, believe it or not, fairly standard in design with rungs spaced a foot apart. This made the ladder my choice for a strong anchor point.

Gap Antenna's Quick-Tilt ladder mount (often used for HF "screwdrivers") appeared ideal but, with my array's chunky 60-pound design weight and possible wind loads (both sitting statically and driving with the mast and rotator tilted over and anchored to the roof), the best approach looked to be Gap's ground-mounted Quick-Tilt model, whose longer legs enabled greater mechanical strength by attaching to twice as many rungs (see Figure 1). Fortunately, both units sell for the same price.

Figure 1—Gap's "Quick Tilt" ground mount was a better bet for the 60-pound antenna and rotator array since its longer legs enabled me to spread the load over four steps of my camper's ladder.

As far as overall mast-element length, most commercial airlines impose a 72-inch limit on checked baggage so my design needed to ensure no component exceeded about 70 inches (to allow for a little inside-the-box padding). I fabricated my primary mast from a cut-down standard 19-foot RadioShack telescoping mast (#15-506), cutting the inner section a bit longer than the outer to anchor 2-meter mast-mounted preamp and serve as the base for the rotator. The finished product, once mounted, raised and guyed, would extend more than 10 feet above the already 10-foot-high RV.

A trip to the building supply warehouse provided my length of 1¼ inch diameter electrical conduit for the 70 inch horizontal antenna mounting bar and I fabricated the cross plate from some scrap ¼ inch aluminum sheet stock with holes drilled for U-bolts. By May, I was ready to put it all together.

Testing...Testing

The finished product looked pretty good and my first all-up test consisted of putting a concrete beach umbrella base outside the home shack and standing the mast on it. Using parachute cord (550 cord) as guys, I oriented the rotator and spent about a week giving myself some on the job training in tracking and working satellites.

It was a little tricky at first, operating the '706 in "split" frequency mode and adjusting the rotator while manually compensating the downlinked 70 cm frequency for Doppler shifts but I got quite proficient. I had lots of contacts and even more fun!

On Field Day 2001, Donna and I headed for a remote mountaintop where we could not only practice setting up and tearing down (that turned out to be very important), but also check out the 2-meter beam's SSB performance. There, we used my truck as an anchor and, shaded from the sun by my old military poncho, I easily worked stations up to 500 miles away on 144.200 MHz while giving them valuable points and an unusual grid. Meanwhile, the satellites continued coming over and we got another dozen contacts there.

Back at home, I assembled the ladder mount and tested it by setting up the whole enchilada a final time, this time on my own camper as it sat on blocks behind the garage. By now, I'd become quite proficient at manually working bird passes and also quite addicted. Once we tore down, we were ready to pack for Alaska.

I'd already contacted Alaskan hams in Anchorage and Fairbanks and they'd been extremely helpful. Jim, KL7CC, President of the South Central Amateur Radio Club, had offered me the loan of his small electric generator and we were looking forward to dropping by the Anchorage Hamfest with the RV to show off the installed system, once we got there.

Ready, But...

All the gear—radios, antennas, mast, cables and piece parts—fit into two cardboard boxes and a suitcase. The long carton I used for the mast and antennas came from a moving company (Mayflower, in this case). Called "lamp boxes," these $7 cartons measure 12×12×40 inches and are designed for one to be inverted and slid over the top of another to adjust the finished box to the necessary height. Altogether and totally sealed, everything weighed about 140 pounds. It all went into the spare bedroom to wait for our departure on September 13.

But September 11 came first.

We canceled and didn't really think about recreational travel for more than two months. Finally, we stirred and Donna suggested we try an expedition with our own camper. I looked around and discovered an attractively remote spot on the Grand Canyon's North Rim, accessible only by a four-wheel-drive road.

It was therapy and instantly energized us. Within days, we were ready to go. We had to move quickly since winter snows would close the four-wheel-drive road any time now. With everything loaded, we headed out for Kanab Point, located about 4000 feet vertically above the confluence of Kanab Creek and the Colorado River. It was only about an eight-hour drive from our home QTH in the northwestern corner of the Mojave Desert. Figure 2 gives an idea of the view from Kanab Point.

Finding out from the Ranger in Toroweep (he's got a satellite phone) that the road was still in good shape, we proceeded. But the last several miles turned out to be extremely rough and wound through an incredibly dense piñon pine forest. Despite my best efforts, the trees damaged the camper significantly and, with a snowstorm only about two days off, we decided to spend just one night and not set up the array so we could be sure to get out the following morning.

Nevertheless, with just the HF rig run-

Figure 2—A 22-degree morning in December at Kanab Point on the Grand Canyon's North Rim. Sixty miles of rugged dirt and rock from the nearest paved road, there's no electrical noise here. It was some of the quietest mobile DXing I've ever done!

Satellites Oversimplified

Including amateur equipment on the International Space Station, the AMSAT Web site's (**www.amsat.org/**) weekly status page currently shows 27 satellites of utility to radio amateurs with 19 of them listed as "operational" or "semi-operational." Many of these are genuinely in that latter category with onboard equipment problems or malfunctions preventing their full usability. Others operate with totally digital applications, e.g., store-and-forward packet, digipeating, or simply put out data via telemetry.

For straightforward voice operation, only about four or so are easily and reliably available for use with conventional gear found in many ham shacks: JAS-1 (FO-20), JAS-2 (FO-29), UoSat 14 (also known as UO-14 or OSCAR 14) and AO-27 (AMRAD OSCAR). Nevertheless, for the vast majority of operators, these four make several good passes each day and working them is surprisingly easy.

JAS-1 and 2 are Japanese (Fuji-OSCAR 20 and 29, respectively) and act as SSB translators in space, currently working in their "analog" configuration (Mode JA). As their antennas' footprint sweeps over the ground, an operator beams up a 2-meter LSB voice signal (typically about 145.850 MHz) and the satellite translates it to a 70 cm USB signal (about 435.850 MHz) to be sent back down. Using directive or even efficient omnidirectional antennas plus all-mode transceivers, essentially any station within the footprint (often the size of an entire continent) is within reach of anyone else there.

Very similar are UO-14 and AO-27, which also use a 2 meters up/430 MHz down scheme, but these birds operate exclusively in the FM mode. They are essentially "crossband FM repeaters in the sky."

Admittedly, this description vastly understates the undeniable art form that is satellite operation but it also provides a feel for how straightforward communicating with them can be. If you're prepared to put together the necessary gear and do a little how-to-operate homework, an amazing radio adventure awaits. This is something my wife discovered and it delighted her no end.

Figure 3—It was such a tight fit on the four-wheel-drive road through the piñon pine forest to Kanab Point that the trees would rip away anything that wasn't taped against the camper body. Covered up here is the coax feed for the VHF/UHF antenna mount. Even with all the tape and just creeping along, we lost half the railing on the roof.

ning on the camper batteries and my Spider mobile antenna, I worked some amazing DX far into the night as well as sending out near-real-time SSTV photos. Great contacts continued the following morning.

Slowly and carefully, we worked our way out, having not only removed all our antennas, but even taping down any exposed cables and projections, lest they get ripped away by the road-encroaching trees. See Figure 3. It took us two hours to cover just four miles but we made it with minimal additional damage.

Finally, An Opportunity!

The next afternoon found us setting up at Coral Pink Sand Dunes State Park near Kanab, Utah. With my GPS coordinates loaded into the satellite tracking software and the first flakes of snow beginning to fall, we dove into the installation.

It took nearly two hours—largely because the snow was building on the camper roof and, working up there, I had to move very carefully. But all our practice assembling and disassembling the array paid off and we were ready to go.

Within 10 minutes, I had the generator purring and ran inside to bring up the system for the first satellite pass. I checked the laptop's satellite screen, slewed the beams, looked at my watch and keyed the mike with a CQ. Jerry, WØSAT, in Dubuque, Iowa came right back after the very first transmission! Amazing!

Figure 4—No, those aren't stars. By the time we got the satellite array up and running, the snow was coming down at a rate of about an inch an hour. Note how the camper's right rear corner has been ripped back and away from the body by our passage through the piñon pine forest near the Grand Canyon's North Rim.

We had a great QSO, virtually alone on the bird (FO-29) and, when the footprint left him, I snagged him a few minutes later on the pass of FO-20. Despite the heavy snowstorm now howling outside, this promised to be a wonderful night (see Figure 4).

And it was. I had 100% success working pass after pass, then working HF in between. With the laptop, I used the Rigblaster Nomic to send out JPEGs from the Grand Canyon and our setup via SSTV, then made a couple of RTTY contacts with stations in the East. 14.070 was a mountain range of PSK31 signals and I took time saying hello to at least half a dozen stations. Meanwhile, the DX window was open to the Pacific and South Africa and I made a couple of contacts there.

After midnight, we collapsed and I set the alarm for an early morning satellite pass.

As I worked on making predawn coffee, Donna switched on the system and asked me if she might try to work one of the upcoming passes. That was more than fine with me and I went out into the snow to crank the generator.

When OSCAR 14 broke the horizon, she was ready (see Figure 5). Jumping right in, she managed about half a dozen quick contacts in the crowded, fast-moving, tobacco auction-like grid exchange that is a UO-14 pass. When the bird's

Figure 5—KF6ZVE dives into the hectic world of UO-14 operation during an early morning pass.

footprint finally left us, she fell back, breathless. "There's no comparison between watching someone else doing it and doing it yourself," she told me. "It's like the difference between eating Godiva chocolate and watching an ad for it on TV."

Reflecting

Back at home, the camper is patched and on its behind-the-garage blocks. The now-neatly stacked, packed and stored components confirm we certainly accomplished our goal of creating a modularized, commercially air-transportable, full-featured station while reducing the total effort to very manageable proportions. We also accumulated lots of excellent practice with every step from packing to setup to operation and back again.

But probably the greatest benefit from this yearlong undertaking has been the intriguing new operating dimensions it's opened for both of us—not to mention yet another Amateur Radio activity we enjoy together. We're currently putting together a home satellite station while keeping careful track of AMSAT's progress with AO-40.

Donna continues getting travel assignments, now footnoting teamwork-driven radio operating possibilities as part of the destination selection process. Regardless of whether working satellites is practical, we can quickly configure our modularized equipment scheme for the next adventure.

Meanwhile, Alaska still beckons and we plan to try again—this time with the equipment already in-hand and proven. The only thing about which we have no doubt is that there *will* be a "next adventure."

David Rosenthal, N6TST, has been a ham since 1989 and holds an Extra Class license. He's an Electronics Engineer and a physicist actively working in the area of RF engineering and HF radio propagation. You can contact him at **n6tst@ridgenet.net**.

Photos by N6TST and KF6ZVE