# Get Ready for ARISSat-1

*From space to classroom with the first Software Defined Amateur Radio transponder in orbit.*

**David Jordan, AA4KN, for the ARISSat-1 Team**

Several years ago, an idea surfaced out of the Russian space program of turning a retired Russian Orlan spacesuit stored on board the International Space Station (ISS) into an Amateur Radio satellite. The suit would be filled with Amateur Radio equipment, connected to a battery and an antenna mounted on the helmet, and then released into orbit during an extra-vehicular activity (EVA). Sergey Samburov, RV3DR, of RSC-Energia introduced the idea at the 2004 AMSAT Symposium in Washington, DC. At this meeting, Lou McFadin, W5DID, of AMSAT-NA introduced the name *SuitSat* for the project and the name stuck.

This idea came to fruition when, on February 3, 2006, cosmonaut Valery Tokarey quite literally shoved the spacesuit into orbit from the ISS with the parting words, “Goodbye…Mr Smith.” And with that, SuitSat-1 began its journey, sailing on a slow descent as it orbited Earth. For a couple of weeks it transmitted a collection of stored messages and other data until its final transmission was heard on February 18, 2006.

Unfortunately, due to a still unexplained problem, SuitSat-1 was extremely hard to hear on the ground for all but the most sophisticated stations. But, nevertheless, the “successful failure” of SuitSat-1 piqued the interest of millions, not to mention energizing its innovative experimenters into building a follow-on project they tentatively called *SuitSat-II*.

In November 2006, discussions began with the idea of creating a new and improved SuitSat. Again, the plan was to use a retired Orlan suit, but with some significant improvements. For example, SuitSat-1 contained only a battery for supplying power. This new “satellite in uniform” would have solar panels attached to its legs for recharging its onboard battery along with modular subsystems that, once designed, could be easily replicated for future SuitSats. And to really push the envelope, the spacesuit turned satellite would also contain a software defined transponder (SDX), a first for any ham satellite up to that time.

Things were going well and excitement was building until July 2009 when, out of necessity to make room on the ISS for some new orbital occupants, the Orlan suit tagged for SuitSat-II had to be discarded. The good news was that the Amateur Radio on the International Space Station (ARISS) team would still be given the opportunity to fly the radio gear up to the ISS and have it deployed during an EVA. But there was the lingering problem of what would house all the radio gear, solar panels and batteries.

For many years, AMSAT had been toying with the idea of building a small satellite that could be tossed overboard from the space shuttle. The idea took on many forms, most of which were later discarded. One “half-baked” idea even included mounting some Amateur Radio gear and batteries inside a pizza box, sticking a few antennas on the outside and tossing it overboard…an idea that, for obvious reasons, came to be unceremoniously dubbed “pizza sat.”


So, once again the ARISS team drew on a similar concept and came to the conclusion that, since they no longer had a spacesuit available for the project, how about using a space frame instead? And, sure enough, almost, immediately after the announcement that an Orlan suit was unavailable, work began in earnest to reconfigure SuitSat-II’s components to both fit and operate inside a new housing. But, there was another issue to resolve. Since there would no longer be a spacesuit involved, the name needed to change. ARISS-International later decided that the craft would now be called *ARISSat-1* with its full official name being *ARISSat-1/Radioskaf V*.

By the time you read this, ARISSat-1 will have been shipped to Russia for integration of the Kursk Student Experiment as well as testing with the Russian battery installed. It was to have then been shipped to Kazakhstan in December where it was due to be loaded onto the Russian Progress supply vehicle 41P and launched to the ISS in January 2011. Deployment of this Amateur Radio experiment to the ISS is scheduled for February 2011 during EVA #28 and, if all goes as planned the craft will be in full operation 15 minutes after its release.

## So…What’s in the ARISSat-1 Space Frame?

*Well*…quite a lot! ARISSat-1 is basically an aluminum frame with modules inside (Figure 1). The overall size of the unit was determined by the solar panels that measure 19 × 10.5 inches and are mounted on all four sides and the top and bottom plates of the craft. The modules contain the various subsystem circuits. The circuits interconnect allowing the satellite to carry out its on-orbit functions. Let's take a look at the subsystems on board.

First of all, there are a total of six solar panels — one on each of the four sides plus on the top and bottom. Each panel can generate 50 V and more than 19 W of power. The output of each panel connects to its own circuit in the Maximum Power Point Tracker module (or MPPT) where the power from each panel is optimized. Power from the solar panels is used to run the satellite and recharge its battery. Having a charged battery is especially important for supplying power to the spacecraft when it's in darkness ("eclipse"). The battery is the same type used on the Russian Orlan spacesuits and was donated by RSC-Energia. There is an RF module containing a 2 meter communications transmitter that connects to a whip antenna mounted on the satellite's top panel and a 70 cm receiver with a whip on the bottom panel. The module also houses an SSB/CW transponder that will (hopefully) be easily accessible in orbit by users running less than 5 W.

All Earth-orbiting satellites must have a means of being controlled from Earth as necessary. So, a 70 cm command receiver, always listening for commands from hams serving as ground control stations is also contained within the RF module.

As a safety precaution, it is important that ARISSat-1's transmitter and solar panel power system remain inactive until after its deployment. The control panel made up of three toggle switches is mounted on the top plate of the satellite. Just before ARISSat-1 is released into space, a space-walking crewmember will turn on all three switches. This starts a timing sequence that delays activation of the transmitter and generation of power by the spacecraft for 15 minutes to insure there will be no RF interference with the crew member's spacesuit electronics until ARISSat-1 is well on its way.

In addition to the radio gear carried aboard, the satellite also has a total of four cameras mounted on the top and bottom of the spacecraft. These cameras will receive power just prior to release and are designed to capture images of the deployment for later transmission. They will also continue to operate while in orbit, supplying views of the Earth and space via slow scan television (SSTV) to those stations so equipped.

Protruding from the top plate and resembling a silver colored "top hat" is the Kursk science experiment. This is an experiment developed by students at the Kursk State Technical University in Russia. Its purpose is to take periodic measurements of vacuum as ARISSat-1 continues its gradual descent into the Earth's atmosphere.

The Internal Housekeeping Unit (or IHU) is the processing center for the satellite. It is here where all analog and digital signals from the modules are routed and converted to a usable form to do particular tasks. The main "brains" of this unit is a PIC32MX processor that provides the overall control of the satellite's systems and generates telemetry to report the health of the spacecraft. A second PIC32MX is the first software-defined transponder (SDX) ever to fly on a ham satellite.

## What Happens after ARISSat-1 is Switched On?

Just prior to ARISSat-1's EVA, clear Lexan solar panel covers will be carefully removed from all sides of the satellite frame and replaced by protective soft covers. These soft covers will be removed before deployment. One of the EVA crewmembers will slowly guide the craft through the open hatch and then engage the three control panel switches beginning from left to right. Flashing yellow LEDs on the panel will begin their slow cadence indicating that the 15 minute "countdown to power up" sequence has begun. The crewmember will then grasp the space frame's large corner handles, carefully angle the craft and push ARISSat-1 into a gradual rearward separation from the ISS.

ARISSat-1 is initially expected to orbit at a height around 350 km while exhibiting a very gradual decline in altitude over time. Hopefully, it will remain functional and in orbit for two to six months. The "best estimate" is approximately 3.5 months based upon an analysis conducted by NASA's ISS and Trajectory Planning Team as part of their review of how ARISSat-1 should be deployed by the International Space Station.

## How Do I "Work" the New Bird?

ARISSat-1 is a unique Amateur Radio experiment and offers many new and exciting features. Among them, the on-board SDX system allows hams to speak with one another via satellite using CW and SSB. And unlike FM repeater satellites that can only support one conversation at a time, the

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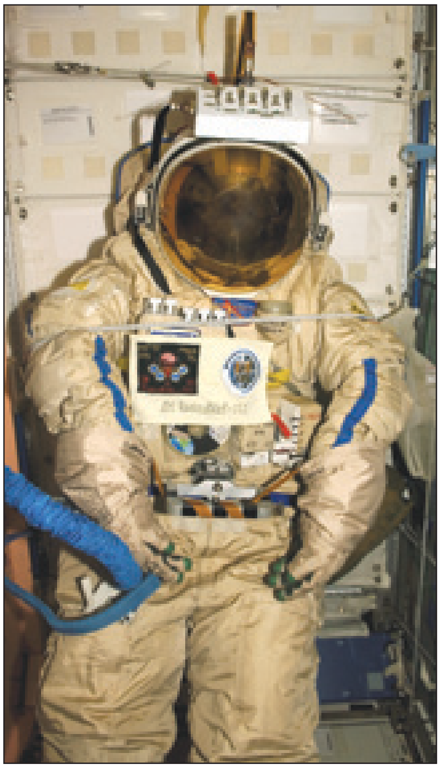

**SuitSat-1 all dressed up for its flight into space.**

TONY MONTEIRO, AA2TX

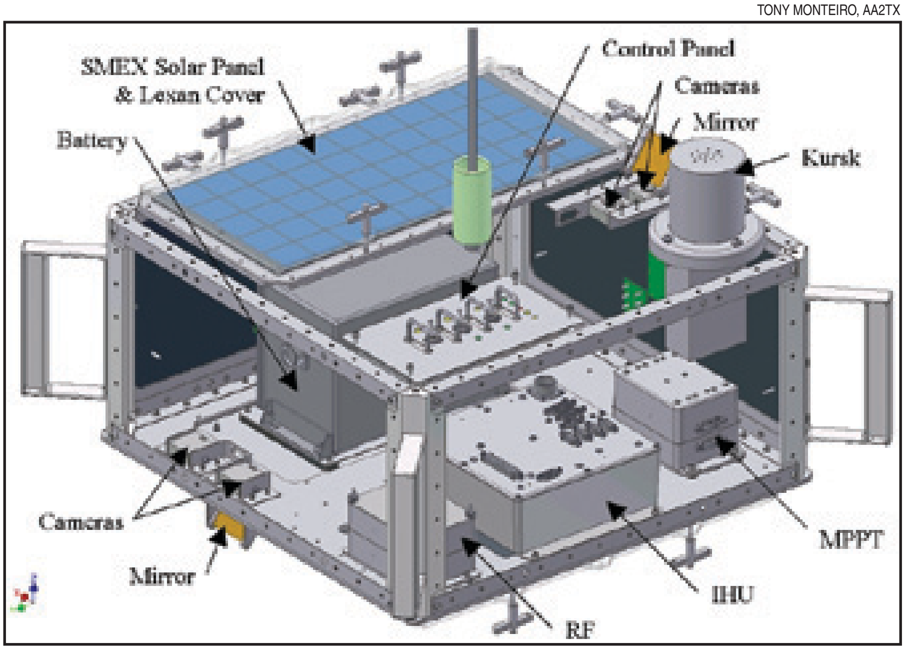


**Figure 1 — An internal view of the ARISSat-1 modules housed in a space frame.**

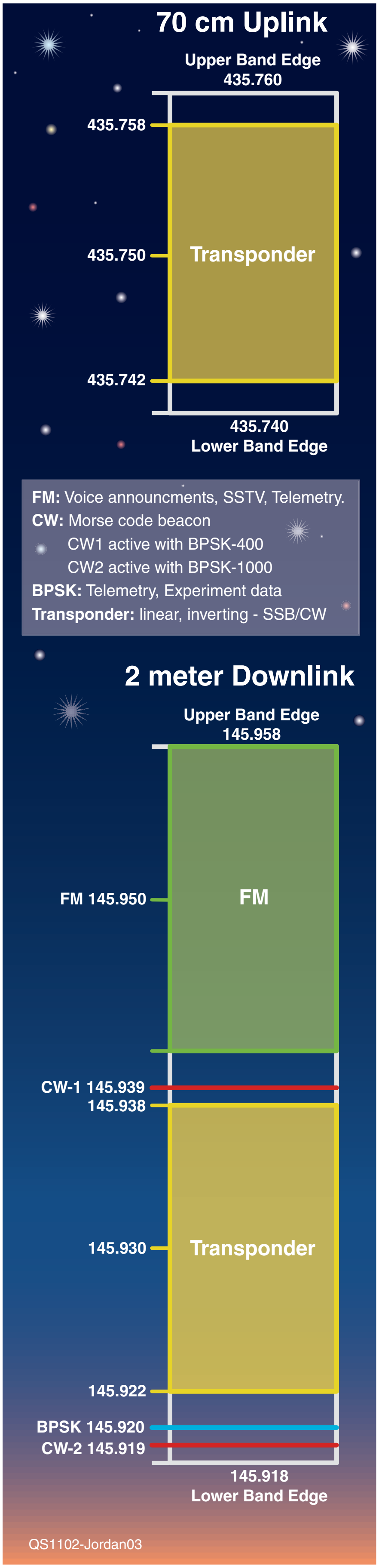


**Figure 2 — The ARISSat-1 uplink and downlink bandplan.**

## Classroom Applications for ARISSat-1

Innovative teachers can find many ways to integrate communication with ARISSat into their Science, Technology, Engineering and Mathematics (STEM) curriculum. Topics might include the satellite's characteristics, capabilities and transmitted information. Whether it's constructing a classroom ground station to receive and track ARISSat-1, demonstrating RF frequency shift due to the Doppler effect, creating a project to track the daily changes in the health of the satellite by recording and decoding telemetry, or the opportunity to introduce students to Morse code through collecting call signs in the CW contest, the only limit is the teacher's imagination.

ARISSat-1 transponder can relay several conversations *simultaneously*.

Digital enthusiasts will enjoy the challenge of receiving BPSK-1000 telemetry. This will be an exciting application of a digital mode that is entirely new to Amateur Radio.

All transmissions from ARISSat-1 will be sent within the 2 meter satellite band using various modes of operation (see Figure 2). All stored voice transmissions will use FM at 145.950 MHz. This includes a female voice ID, female voice telemetry (subset) and 24 greeting messages in 15 different languages from students and other individuals from around the world. Many of these messages end with a "secret word." If listeners successfully collect and identify all the secret words, they can submit them and receive a special certificate. Details for the contest will be announced via the AMSAT and ARISSat-1 Web pages as well as the AMSAT News Service before deployment. To add even more variety, SSTV ID images and images acquired by the on-board cameras are slated to be part of the transmission sequence. The SSTV signals will be sent in Robot 36 protocol and can be displayed in real time on a computer using free downloadable software from the Internet. The freely available *MMSSTV* program was used during testing and works well.

Satellite telemetry will also be available on 2 meters on 145.920 MHz using a new BPSK transmission mode (BPSK-1000) specifically developed for ARISSat-1 by Phil Karn, KA9Q. There is a Phase 3, 400 bps BPSK telemetry downlink on board for use only as a backup system. Only the BPSK-1000 system is slated for activation. Even though the satellite will *not* be spin stabilized, the BPSK-1000 mode should provide an error-free signal allowing the use of simple antennas on the ground even during deep fades. Free decoding software for BPSK-1000 will also be made available before deployment. In addition, a downlink telemetry subset will be transmitted using CW (Morse code). If CW is transmitting on 145.919 MHz, then BPSK-1000 is active on 145.920 MHz. If CW is transmitting on 145.939 MHz, the BPSK-400 backup mode is active on 145.920 MHz.

To encourage an interest in using Morse code, the CW beacons will also host a CW contest, transmitting the call signs of hams that have contributed to Amateur Radio in space. Received call signs may be submitted for a special CW certificate. Again, specific details for the contest will be announced before deployment.

As noted earlier, for those so equipped, ARISSat-1 will feature the first software defined transponder (SDX) to fly on board an Amateur Radio satellite. A software-defined transponder creates the modulation schemes (FM, CW, USB, LSB) used by the uplink and downlinks in software through digital signal

## Funding for ARISSat-1 — You Can Help!

Even though the spacecraft was built by volunteers, the ARISSat project has cost AMSAT about $180,000. That money has come from AMSAT's financial reserves that now must be replenished. AMSAT also needs funding to provide seed money for work on future space projects.

You can support AMSAT by going online and making a donation at **www.amsat-na.com/store/donation.php**. You can also send donations by mail to AMSAT Headquarters, 850 Sligo Ave, Ste 600, Silver Spring, MD 20910. Donations can also be accepted via telephone with a credit card from the USA and Canada at 888-322-6728 or 301-589-6062 from all other locations.

ARISSat-1 is the result of hard work from a large group of talented individuals from around the world. These people have freely volunteered their time and talents with the goal of creating an Amateur Radio satellite that demonstrates the latest technology while at the same time acting as an educational tool for teachers to inspire students considering careers in science, technology, math and engineering. We hope you enjoy it!

## What Do I Need to Work or Hear ARISSat-1?

The only radio you need to receive the voice ID, voice telemetry, SSTV and voice messages is a 2 meter FM transceiver (even a handheld radio), or a scanner that covers 2 meters.

If you are fortunate enough to own a multiband or multimode 2 meter/70 cm rig such as the Yaesu FT-817, Kenwood TS-2000, ICOM IC-910 or an older Yaesu FT-847 or FT-736R, you already have what you need to monitor and/or access ARISSat-1. If this isn't the case, here are some options to consider.

Since ARISSat-1 is a multimode satellite, it would be best to have a single radio that covers 2 meters and can receive SSB, CW and FM modes. The Yaesu FT-817 is a good choice since it also features digital and packet modes and has positions for narrower CW filters to improve reception. This rig, while being a good performer, can be expensive if purchased new, however.

Another approach is to use one of several multiband/multimode scanners available that cover the 2 meter band. Pricing for these units starts at around $300 to $500. Hamfests (or online auction sites such as eBay) are also good sources for used radios such as the ICOM R-10 and Yaesu VR-500. With a little searching, these radios can often be found in good condition and at bargain prices.

If you only plan to listen to the FM audio, a common "scanner" should be adequate provided it covers the 2 meter band and you have a decent outside antenna. By that, I'm suggesting that you at least use a ¼ wave vertical or circularly polarized antenna. This is discussed in more detail in the section on antennas. Of course, you'll only be able to tap into the downlinked voice and SSTV signals with these rigs.

The RF output of ARISSat-1 varies according to the mode in use…

**250 mW: FM audio (including SSTV)**
**100 mW: BPSK-1000 beacon**
**25 mW: CW beacon**
**125 mW: SDX transponder**

This may not seem like much power, but consider the height of the antenna!

The multimode receivers I've discussed will also allow you to receive downlink signals from the SSB/CW SDX transponder. If you want to uplink to the transponder, however, you will need a 70 cm SSB transmitter.

*Antennas*

When it comes to antennas, a ¼ wave vertical antenna should work well even without a preamp as long as you minimize your coax cable loss by keeping its length less than 25 feet. If a longer cable run is necessary, you might want to move up to the lower loss, LMR-400 solid center conductor coax. A ⅝ wave or larger "gain" vertical will be worse since all the gain is toward the horizon. Because the orbiting satellite will be in a slow, random tumble, the listener will probably experience some fading caused by *spin modulation*.

To minimize this problem, you may want to consider building a simple circularly polarized antenna such as the K5OE "Texas Potato Masher." You'll find instructions on the Web at **victrolla.homeip.net/wo5s/junkpile/432/tpm2.pdf**. Another approach is to purchase and install the 2 meter Eggbeater, model EB144, from $M^2$ Antenna Systems (**www.m2inc.com**). The popular handheld Arrow beam antennas (**www.arrowantennas.com**) should also work well. Note that the 70 cm versions of all of the antennas I've mentioned here will also allow you to uplink to the SDX transponder. I recommend the 70 cm antenna be separated from the receive antenna by at least 8 feet to avoid crosstalk.

*Computers and Software*

As I've said, free software for demodulating and decoding the BPSK-1000 via a computer sound card will be made available before ARISSat-1's deployment. You'll also need software to receive and display the SSTV images from ARISSat-1. *MMSSTV* performed well for this purpose during the craft's development. *MMSSTV* can be downloaded free of charge at **mmhamsoft.amateur-radio.ca/pages/mmsstv.php**. Mac users have several options to decode SSTV signals. The Mac SSTV program *Multiscan* is available free at **web.me.com/kd6cji/MacSSTV/MultiScan.html**. Another option is to download *Coca Modem*, which is also a free at **homepage.mac.com/chen/w7ay/cocoaModem/index.html**.

To know when ARISSat-1 passes over your location, you'll need to track it. You'll find tracking software such as *SATPC32* available from AMSAT at **www.amsat.org** (all proceeds from the sales are donated to AMSAT). The AMSAT Web site also hosts a satellite pass prediction program for your convenience (**www.amsat.org/amsat-new/tools/predict/**). Mac users can purchase the *MacDoppler* tracking program at **www.dogparksoftware.com/Macintosh_Amateur_Radio_Pr.html**.

processing rather than analog circuits. Using a linear, inverting SSB/CW transponder in U/V mode (UHF uplink/VHF downlink) sporting a 16 kHz bandwidth, hams will be able to chat with each other whenever the satellite is within range. The uplink window is from 435.742 MHz to 435.758 MHz with a downlink window of 145.922 MHz to 145.938 MHz.

Another exciting aspect of the ARISSat-1 mission is called "Fly a File." The ARISS team has accepted digitized submissions of space and science related images as well as information about various science projects from students worldwide. These have all been loaded onto a memory chip that was attached to the inside of the spacecraft prior to shipment and will now be flown as part of the mission. The submissions will not be accessible from space, but rather, are posted for viewing at the ARISS Europe Web site at **www.ariss-eu.org/arissat-1.htm**.

As you can see, ARISSat-1 is a satellite that offers something for everyone. It will offer various modes of operation for individual hams as well as providing many "hands-on" opportunities for educational applications.

DAVID JORDAN, AA4KN

**A simple handheld setup like this will be more than sufficient to receive ARISSat-1.**

*David Jordan, AA4KN, is an Amateur Extra Class operator and has been a licensed ham for 37 years. He attended the University of Central Florida where he earned a BS in Engineering Technology and worked as a design engineer for a local Orlando firm. David spends much of his time promoting Amateur Radio in local schools and is heavily involved in both AMSAT and the ARISS program. Most recently, David served as a member of the ARISSat-1 Project Team playing a role in its development and integration. He also serves as Education Chair for the Lake Monroe Amateur Radio Society (LMARS). You can contact David at 825 Hickory Hill Ct, Orlando, FL 32828 or by e-mail at* **aa4kn@amsat.org**.