SuitSat – A Unique Satellite

by Gould Smith, WA4SXM, and Steve Bible, N7HPR

During an International Space Station (ISS) Extra Vehicular Activity (EVA), probably in early December 2005, a unique satellite will begin to orbit the Earth. The SuitSat satellite will be an end-of-service Russian Orlan spacesuit with an Amateur Radio transmitter inside. Messages in several languages, a slow scan TV (SSTV) image and telemetry data will be transmitted. The spacesuit batteries are expected to power the project for about one week. The satellite will orbit for a few more weeks until it reenters the Earth's atmosphere and burns up.

History

During the International ARISS Meeting in Washington, D.C. in October 2004, Sergey Samburov, RV3DR, proposed to convert a Russian Orlan spacesuit onboard the ISS that reached its end-of-service into an amateur satellite by placing an Amateur Radio transmitter inside and deploying it from the ISS. This idea was instantly dubbed "SuitSat".

SuitSat celebrates the 175th anniversary of Bauman Moscow State Technical University, the alma mater of many of the cosmonauts and engineers in the Russian space program. The project is called RadioSkaf, or Radio Sputnik in Russian, and is managed by RSC Energia (en-er-GEE-a) Project Manager A. P. Alexandrov in Moscow.

Figure 1 - SuitSat is a Russian Orlan spacesuit fitted with an antenna and activation switches on the helmet. The radio and batteries are inside the suit. (Photo courtesy RSC Energia)

Plan

With less than one year to complete, SuitSat would have to be a fast track project. On May 10, 2005, the okay was given to fly. ARISS Hardware Manager Lou McFadin, W5DID, led the hardware team of Stan Wood, WA4NFY, Steve Bible, N7HPR, Joe Julicher, N9WXU, and Rawin Rojvanit that designed, built and tested the controller, radio and activation switch boxes in four short weeks. On June 10, 2005 the hardware was sent from the Johnson Space Center in Houston to Russia for final testing, certification and integration. The SuitSat hardware was transported from Russia to the ISS via Progress 19P on September 8, 2005.

Since there was such a short time frame in which to accomplish this mission, the KISS principle of "Keep It Simple" was employed. The Orlan space suit will provide the 28 volt battery power. There are no solar cells, therefore the expected lifetime of SuitSat is estimated to be about one week. An off-the-shelf 2-meter Amateur Radio handheld transceiver was selected, a Kenwood TH-K2. The attached antenna is the same type presently used on the ISS Amateur Radio station. A controller unit was designed and built to play the pre-recorded voices, SSTV picture, and telemetry. A switch box was constructed so that SuitSat could be safely activated. At RSC Energia, engineers designed a bracket to hold the antenna and switch box on the helmet and control handle so that the cosmonaut can hold and deploy SuitSat.

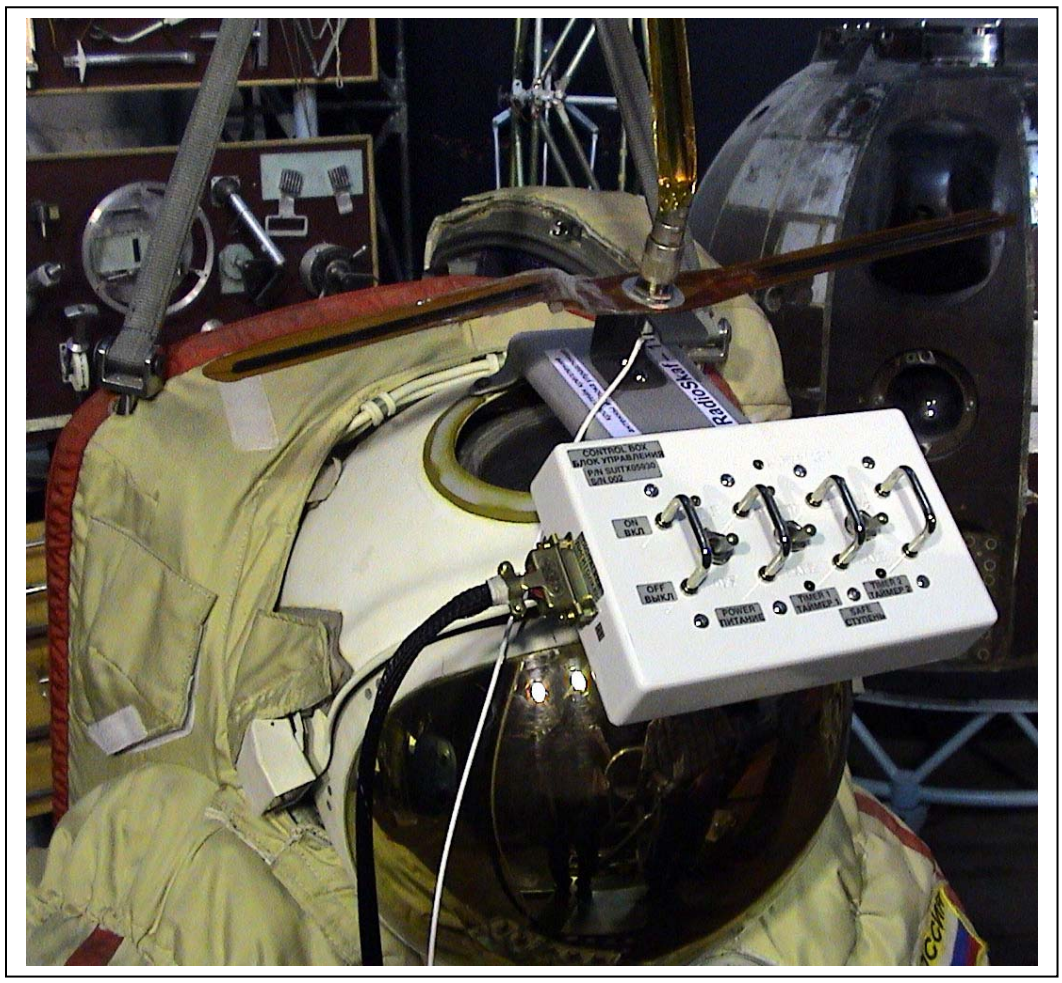

Figure 2 – SuitSat-1 Helmet Mounting Bracket (photo courtesy RSC Energia)

CD-ROM

In early June 2005, ARISS International Chairman Frank Bauer, KA3HDO, initiated a two-week program for school children from around the world to send in drawings, messages and poems to fly in space on a CD-ROM. Submissions from nearly 200 schools were received, digitized and stored on a CDROM. Two CDs were sent to the ISS, one will be deployed inside SuitSat and the second will be retained on the ISS to be viewed by the crew.

Deployment
The SuitSat hardware that was delivered to the ISS will be integrated with the Orlan spacesuit aboard the ISS. Deployment will be during an EVA which is anticipated in early December 2005.

Transmissions
SuitSat will transmit a 500 mW FM signal on 145.990 MHz. The station ID will say "This is SuitSat 1 – Amateur Radio station RS∅RS." Special voice greetings made by young people around the world will be transmitted in English, French, German, Spanish, Russian and Japanese to the youth and people of the world. Each greeting will last about 20 seconds followed by a 30-second period of no transmission. A single SSTV (Slow Scan Television) image in Robot 36 format will be transmitted. Telemetry will be spoken in an English voice and will consist of mission elapsed time (MET, in minutes), temperature (in degrees Celsius), and battery voltage. It will take approximately eight minutes to transmit the entire sequence.

Hardware
The radio box houses an off-the-shelf 2-meter Amateur Radio transceiver. The radio box was designed by Lou McFadin, W5DID, and Stan Wood, WA4NFY. The 2-meter TH-K2 was donated by Kenwood USA Corporation. The TH-K2 battery pack was removed and the radio was mounted to a milled block of aluminum to dissipate heat generated during transmission.

Figure 3 - SuitSat 1 Radio Box.

The transmit power was set to low-power mode (500 mW) and a transmit cycle of about 20 seconds on and 30 seconds off was chosen to minimize heat dispassion and extend battery life. Before close-out of the radio box, the radio settings were locked.

The controller box holds the EMI filter, DC-DC converter and controller PCB. The DC-DC converter converts the 28 volt battery voltage to 12 volts to power the radio and the controller PCB (printed circuit board). The controller PCB was designed by Steve Bible, N7HPR. The controller PCB contains a Microchip Technology PIC18F8722 micro-controller unit (MCU), MCP9800 temperature sensor, and one megabyte of serial memory.

Figure 4 - SuitSat 1 Controller Box. The controller PCB is on the lid. The EMI filter and DC-DC converter are inside the box.

The voice greetings and SSTV picture were recorded and encoded in adaptive pulse code modulation (ADPCM) format and stored in the one-Megabyte serial memory. The PICmicro® MCU selects which voice recording to play back and performs the ADPCM decoding. Numbers and units of measure (minutes, Celsius and Volts) were individually recorded so they can be spoken to form complete sentences during the telemetry speech segment.

The switch box houses the toggle switches that activate the safety timing sequences when SuitSat-1 is deployed. For the safety of the cosmonaut, SuitSat will be inhibited from transmitting for several minutes after the switches are thrown.

The switch box was designed by Joe Julicher, N9WXU.

Figure 5 - SuitSat 1 Switch Box

Notice on the switch box in Figure 5 that everything is labeled in both English and Russian.

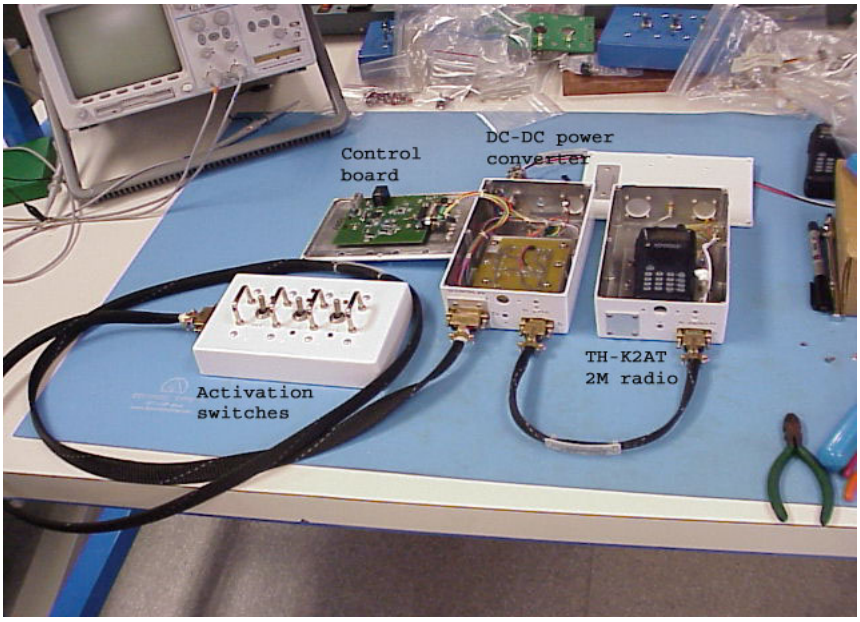

Figure 6 - SuitSat 1 US hardware at integration
(Photo courtesy of Lou McFadin)

To connect all these pieces together requires a power and control cable to the radio, power and control from the switch box to the controller box, as well as the coax cable from the radio box to the antenna. These cables are routed from the helmet, down the suit and into the right sleeve opening. Look for these in Figure 1.

Figure 7 - SuitSat 1 hardware (Photo courtesy RSC Energia)

Receiving Signals from SuitSat 1

A standard two-meter FM receiver or a scanner radio and a small directional antenna such as an Arrow Antennas model 146-3 or model 146/437-10 antenna should be sufficient to receive the signal well.

It will be necessary to point the antenna at SuitSat while it orbits overhead. A tracking program will be necessary to predict the "pass times" and "look angles" for your area. Tracking programs need daily Keplerian element updates for SuitSat. The AMSAT-NA web site will allow those without tracking programs to look up the pass times and where to look in the sky for one's location; see http://www.amsat.org. The current orbit of the ISS shows it making afternoon and evening passes over North America in December, although the orbit and pass times might change depending on the date SuitSat is deployed.

To decode the Robot 36 SSTV picture, a slow scan computer program such as MMSSTV can be used. The audio from the receiver is played into the computer sound card input. This can be done one of two ways. Directly connect a wire cable from the receiver speaker output into the computer sound card input for best results. Perhaps the easiest way is to play the receiver audio into a computer microphone. Since the transmitted SSTV picture is made up of audio tones, it could be recorded on a tape recorder and later played back into the SSTV computer program.

A Unique Satellite, A Unique Opportunity

SuitSat 1 can provide many unique opportunities to demonstrate amateur satellites and space science to young and old. Prepare now for this unique satellite. There is only a brief time to listen to SuitSat's special messages. The expected lifetime is only one week. Try your best to listen for all the messages, decode the SSTV picture, and listen to the voice telemetry. Share the excitement. And most of all -- have fun!

Additional Information

Amateur Radio on the International Space Station:
http://www.rac.ca/ariss

ISS Fan Club:
http://www.issfanclub.com

The Radio Amateur Satellite Corporation:
http://www.amsat.org

Bauman Moscow Technical State University:
http://www.bmstu.ru/

RSC Energia:
http://www.energia.ru/english/

MMSSTV:
http://mmhamsoft.ham-radio.ch/mmsstv/

Arrow Antennas:
http://www.arrowantennas.com/

Orlan Space Suit Information:
http://en.wikipedia.org/wiki/Orlan_space_suits
and http://space.cweb.nl/article.html?id=407