Ham Video

A DATV transmitter on Columbus

1. The Columbus project

As far back as the year 2000, a proposal for an ATV system on the International Space Station was submitted to the ARISS Project Selection and Use Committee by Graham Shirville G3VZV.

November 2002, a request for amateur radio facilities on the then under construction Columbus module was submitted by Gaston Bertels, ON4WF to Mr Jörg Feustel-Büechl, Director of Manned Spaceflight and Microgravity Directorate of the European Space Agency (ESA).

The request was to install wideband amateur radio antennas on the nadir of Columbus, facing the earth. With such antennas, the on board amateur radio facilities could be extended to amateur TV.

In 2003 the request was examined in detail and finally accepted. ARISS would pay for the development, manufacturing and qualification of the antennas. ESA would support the installation cost.

ARISS-Europe started a funding campaign, all donations being published on the website.

In 2004 coaxial feed throughs were installed on the port cone of Columbus. This was needed for accessing the antennas with feedlines from inside the module.

In 2005, the Royal Belgian Amateur Radio Society (UBA) signed a contract with the Wroclaw University of Technology, Poland for the development and manufacturing of the antennas. Whereas initial plans were for UHF, L-band and S-band antennas, only L- and S-band antennas could be ordered by lack of funding. The cost of the project was 47.000 Euro.

Early 2006 the antennas were delivered to ESA. Meanwhile main Columbus contractor EADS and subcontractor Alenia Spazio had reviewed mechanical and thermal constraints. Wroclaw University proceeded to qualifications tests (cost 3.000 Euro) and the antennas failed.

In 2007 an additional contract was signed with the Wroclaw University for the development of modified antennas. This amounted to 36.000 Euro. These antennas were accepted and installed on Columbus, October 2007.

The cost of the antennas finally amounted to 86.000 Euro and was covered by a wordwide funding campaign.

ESA supported the total installation cost of the antennas, including feed throughs and coaxial cables.

After the successful launch of Columbus and its integration into the International Space Station complex, an ARISS-Europe working group started a study for the development of an amateur television transmitter on Columbus, using one of the the S-band antennas. A debate started between the supporters of analog television (ATV) and the proponents of digital television (DATV). The working group, which met monthly per teleconference, made progress, but was stuck by the lack of funding.

Meanwhile a possibility opened for the installation of VHF/UHF antennas on Columbus. The European Space Agency wanted a VHF antenna for a specific payload and was interested in the manner ARISS antennas had been attached to handrails on the Russian service module. A similar system was adopted for Columbus and, in the same time, ESA accepted the installation of a dual band VHF/UHF antenna for ARISS. This antenna project was funded entirely by AMSAT-NA and volunteers who built the antennas for both the ESA experiment and for ARISS. The installation was done per EVA, 21 November 2009. Soon an Ericsson UHF transceiver, which had served in the early ARISS days, migrated from the Russian to the American segment of the Space Station and started Packet Radio operation.

As time went by, the debate on ATV versus DATV evolved at the advantage of the latter, but no funding was in sight… Then, suddenly, supported by the enthusiasm of Italian astronaut Paolo Nespoli IZ0PA, who had performed many ARISS school contacts during his 2010-2011 expedition aboard the Space Station, at the initiative of AMSAT Italia, an Italian manufacturer, Kayser Italia, presented a project for an amateur radio DATV transmitter to ESA's educational services. In 2012,

this proposal was accepted and ESA signed a contract with Kayser Italia for the development and the manufacturing of a DATV transmitter on S-band. This transmitter, dubbed “Ham Video”, is presently slated for launch on HTV-4, August 4, 2013.

2. Ham Video

The Ham Video DATV transmitter, developed for installation in the Columbus module, features the following characteristics:

- Downlink frequencies:
  - 2.422 GHz
  - 2.437 GHz
- DVB-S standard (QPSK modulation)
- Symbol rates: 1.3 Ms/s and 2.0 Ms/s
- FEC : ½
- SIF: 352x240 or D1:720x480
- RF radiated power : approximately 10 W EIRP

Ham Video will operate with a Canon XF-305 camera, provided by NASA.

Power will be provided by a portable power supply, also known as KuPS, another Kayser Italia product. The KuPS is a standard equipment on Columbus, used for several experiments. It converts the 120VDC, which is the standard main voltage in the American segment, to 28VDC.

Ham Video is downlink only. No DATV receiver is presently considered on board Columbus.

From a technical perspective, Ham Video is a standalone payload.

ESA puts Ham Video at the disposal of ARISS for educational outreach.

When video enhanced ARISS school contacts will be performed, the downlink audio and video signals will be produced by **Ham Video** and the uplink audio signals will be received with the Ericsson transceiver. In this two way setup, the global system is dubbed **Ham TV**.

3. Ham TV

An important element of the Ham TV system is the ground segment.

Receiving DATV signals from Columbus will be far more demanding than receiving VHF or UHF. A careful study of the link budget, conducted by Piero Tognolatti I0KPT, shows that DATV decoding should be possible, for a ground station equipped with a 1.2m dish, when the ISS is within a range of about 800 - 1000km. This limits the time of DATV reception to about 3 – 4 minutes during a favourable pass.

A 1.2m dish has a beam width of about 4 degrees (between -1 dB points). ISS tracking will be far more demanding than it is for receiving VHF signals.

ARISS will establish a chain of 5 volunteering amateur ground stations, located at carefully chosen places along a typical ISS pass over Europe. These stations will receive and decode the DATV signals and stream the audio and the video over the Internet to the BATC server in UK. The school will connect to the BATC server which offers the possibility to visualise up to 6 images simultaneously. With this setup, Ham Video reception is expected to reach the 15 minutes goal ESA has fixed.

ARISS’ expectation is, that similar chains of ground stations will be established in other continents, allowing more flexibility for Ham Video enhanced ARISS school contacts.

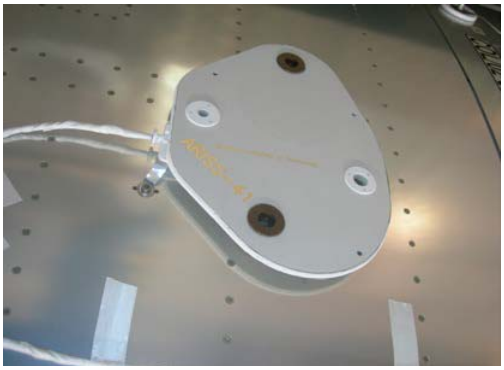
Ham Video transmissions will not be limited to school contacts. Automated transmission of recorded video can also be envisaged. Several amateur radio experiments can be developed, within the limits proper to the International Space Station.

A new era opens for amateur radio on the International Space Station.

Gaston Bertels, ON4WF
ARISS-Europe chairman

Ham Video DATV transmitter

Canon XF-305 camera

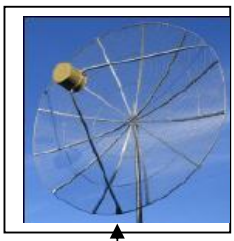


ARISS L/S-band patch antenna

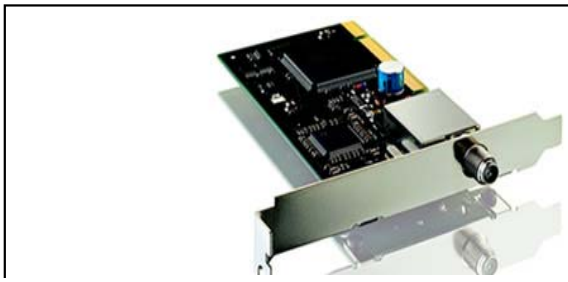
Ground Station for Ham Video reception

Main Specifications

- Parabolic antenna
  - polarisation : RHCP
  - gain about 26 dB
- AZ-EL rotor
  - accuracy : +/- 2 degrees (1.2 m dish)
  - slew rate : 5° per second
  - range : 0-180 elevation & 0-360 azimuth
- LNB (Low Noise Block downconverter)
  - input frequency : S-band
  - output frequency : L-band
  - gain : at least 40 dB
  - frequency stability : +/- 20 kHz
  - noise figure : about 0.7 dB
- Tracking software
  - allowing flip mode
- DVB-S receiver



LNB
Mast mounted



AZ-EL motors
+
Tracking software

PCI Satellite Receiver (DVB-S)

Measurement and Display software

Ground station components

Comments – References - Sources

1. Parabolic antenna with AZ-EL pointing

The dish shall be mounted for azimuth and elevation pointing and moved by precision motors. with a total system pointing accuracy of 2° or less (including motor precision, antenna alignment, and pointing control software).

The elevation movement shall cover 180 degrees (flip mode capability).
The azimuth movement shall cover 360 degrees or more.

A possible alternative to the flip mode for the elevation movement is the capability of azimuth movement up to 540 degrees to allow for reception of ISS passes over north.

Azimuth angular speed greater than 5°/sec allows for reception of ISS passes up to 90° elevation. Less angular speed will allow reception of passes with lower elevation.

The AZ-EL motors for the main European ground stations are made by Prosistel (http://www.prosistel.it).

The driver is WISP DDE by CX6DD (http://www.mederoscnc.com/CX6DD/wispdde/wispdde.htm) modified by AMSAT Italia in order to interface Prosistel rotors in the Azimuth extended-range mode. This modified version of WISP DDE also allows automatic sweeping of the antenna around the Sun direction, in order both to check correct Az/El alignment and to measure G/T of receiving system.

2. Tracking software

A number of shareware, freeware, cardware and commercial tracking softwares are available on the web.

Selection of the software shall take care of the capability to drive the AZ-EL motors, flip mode included.

The tracking software used for the on-going tests is Orbitron (http://www.stoff.pl/).

3. LHCP dish feed

ARISS antennas on Columbus are right circularly polarised. Hence, for single reflector antennas, the feed shall be left hand circularly polarised, since each dish reflection reverses the polarisation.

The dish feed can be a patch type or a helix type, positioned in the focus of the parabola.

The dish feed used for ARISS-Europe ground stations is a product of

RF HamDesign (http://www.rfhamdesign.com)

Type LH-13XL 2.1 - 2.7GHz Connector N-Female 50 ohm

4. LNB

ARISS-Europe ground stations are equipped with an LNB downconverter produced by Kuhne Electronic. The LNB is designed for mast mounting near the parabola.

Two options are suitable :

Option 1 :
KU LNC 25 TM (centered 2450 MHz)

Frequency range : 2350 – 2550 MHz
IF : 1433.5 – 1633.5 MHz
Amplification : 40 dB
http://www.kuhne-electronic.de/en/products/down-converters/ku-lnc-25-tm.html

Option 2 :
KU LNC 23 TM (centered 2385 MHz) – specific DATV
Frequency range: 2320 – 2450 MHz
IF : 1404 – 1534 MHz
Amplification : 40 dB
http://www.kuhne-electronic.de/en/products/down-converters/mku-lnc-23-tm.html

The KU LNC 23 TM has a notch filter on 1.3 GHz for duplex operation : 1.3 GHz (transmit) and 2.3 GHz (receive). This could be useful from the perspective of a planned cross band voice transponder on Columbus.

5. DVB-S satellite receiver

A suitable DVB-S satellite receiver PCI tuner card is produced by Techno Trend
http://www.technotrend.eu/2920/TT-budget__S2-1600.html

The Techno Trend card fits in a PCI computer slot and supports HD TV (MPEG2 and MPEG4/ H.264) :

- Computer OS : Windows XP, Vista, Windows 7, Windows 8
- CPU for SDTV: at least 800 MHz
- CPU for HDTV: at least P4 3,4 GHz or comparable AMD Athlon (Dual Core recommended) - not needed for Ham TV
- 512MB main storage (1024MB recommended) at least 1GB free hard disc storage
- Graphics card with at least 64MB and DirectX 9 support
- Sound card with DirectX 9 support

Besides the TT-budget S2-1600 card, TechnoTrend produces the TT-S2-3200 card, also suitable.

In addition to the PCI card ground station solution described, it is understood that some specific DVB-S “set top” boxes are able to operate correctly at the symbol rates that will be used by the Ham TV system.

6. Measurement and Display software

Jean Pierre Courjaud F6DZP has developed a free software utility providing radio amateurs and DVB technicians a tool that allows Digital ATV (DVB-S) to be measured precisely. Please see :
http://www.vivadatv.org/page.php?p=tutioune-en

This software comes in two versions :

- Tutioune V2.0 for use with the TT S2-3200 card
http://www.vivadatv.org/viewtopic.php?f=60&t=205

- Tutioune 1600 V0.1 for use with the TT S2-1600 card
http://www.vivadatv.org/viewtopic.php?f=60&t=214

With the above mentioned setup, Ham Video from Columbus can be received, decoded and visioned on a computer screen. Audio is also available.

7. Noise Power Measurement for antenna alignment

As suggested by Piero Tognolatti I0KPT and with his collaboration, Jean Pierre F6DZP developed a special software for Noise Power Measurement.

With this software, a TT-S2-3200 or a TT-S2-1600 PCI card can be used for Dish alignment by measuring the Sun noise on S-band.

http://www.vivadatv.org/viewtopic.php?f=67&t=212

8. Streaming video on the Internet

For H264 encoding and streaming video on the Internet, several software solutions exist:

- Adobe Flash Media Live Encoder (FMLE) – free – Win XP, Win7, Win8
- FFsplit – free – Win7, Win8
- Open Broadcaster (OBS) – free – Win7n Win8
- Xsplit – only basic functions are free – Win XP, Win7, Win8

Under Windows XP, the best solution is FMLE.

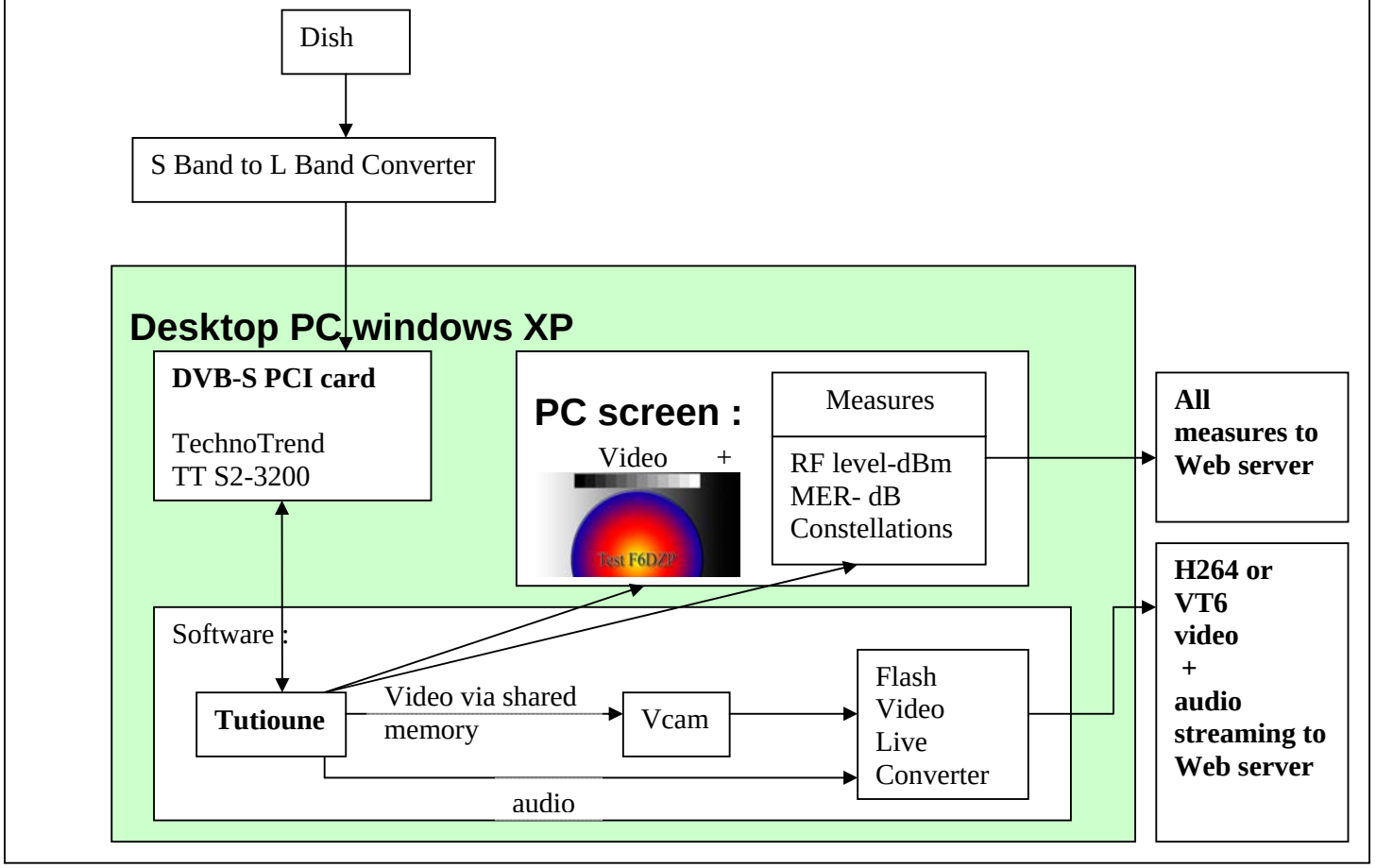
For H264 encoding and streaming, a good Dual Core or a Quad Core CPU is needed.

Sending the video stream, produced by the DVB-S receiving software, to the Internet encoder/streamer software (FMLE, OBS…) needs additional software such as Vcam.

The general ground station setup is shown in the two appended charts :

- Solution 1 : based on a DVB-S PCI card
- Solution 2 : based on Set Top Box with Ethernet output

Solution 1



Solution 2