SSTV from Space

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Another page in the history of Amateur Radio was written when Tony England W0ORE and John-David Bartoe W4NYZ, on board the space Shuttle *Challenger*, transmitted television pictures to the world's amateurs on their recent flight. The pictures were transmitted in the slow scan television mode which allowed the use of conventional 144MHz (2m) v.h.f. f.m. equipment—a portable hand-held transceiver in the space-craft and standard f.m. receivers to be found in most v.h.f. operators' shacks.

What is SSTV?

Slow-scan TV, SSTV for short, is a method of sending and receiving pictures within the bandwidth of an ordinary telephony channel. There are various standards and formats in use throughout the world but, nowadays, they all operate on the same principle.

The picture to be sent is "snatched" and stored in a digital memory, exactly like the freeze frame that some TV programmes use, then the stored picture is read out slowly into a tone generator, the output of which replaces the microphone in the microphone socket of the transmitter. At the receiving end, the audio tone is decoded and digitised and, in the authors' case, the picture is displayed on the monitor screen of a BBC micro.

The digital memory in the SSTV transmit converter holds the picture as a number of picture cells (pixels) each of which may represent one of a number of shades of grey. By far the most popular is the format using 128 pixels to a line and 128 lines to a frame. The picture is usually converted to 16 levels of grey, the lightest being white and the darkest being black—the other 14 filling in the shades in between. This format takes around 8 seconds to transmit a single frame, so you can see that moving pictures are not really possible. However, the results are not far off the quality of photographs that appear in the newspapers—see the accompanying figures and also the excellent *Television* regular feature by Ron Ham.

Part of the space-lab instrumentation, the tail-fin of *Challenger* and the Earth beyond

Weightlessness makes a neat group pose rather difficult

In the quest for better definition, further "high resolution" formats have been developed. Since the bandwidth of the SSTV signal was designed to occupy no more spectrum than a 'phone transmission, it becomes apparent that to put more information into the picture it will take a longer period of time to send it. Consider the case of the format having 256 pixels on 256 lines. This has twice as many pixels to a line and twice as many lines to a frame as the 8 seconds format and, consequently, takes 4 times as long to send. It should be mentioned that this format usually has 64 grey shades as well and, as a result, requires 16 times more memory in the transmit converter than the 8-second format!

Colour

The next logical development was colour SSTV. Once again there are several methods of transmitting colour pictures over radio. The earliest and probably the most popular is the 8-second frame sequential format. Here the original picture is snatched into memory like its black and white counterpart, but this time the memory is in three sections. There is a section for each of the red, green and blue signals that comprise the colour picture and each section of the memory is the same size as the black and white equivalent. So we now have the picture stored in pixels in three memory sections each section representing the red, green and blue content of the original scene.

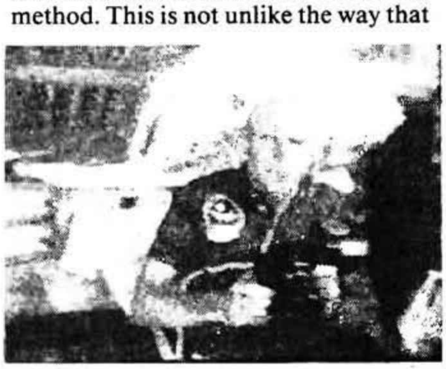
The sections are transmitted as a complete frame of one colour followed by complete frames of the other two. It is usual to send the red frame first and sometimes to send it twice, using the first to check the picture quality, and then to send the green frame and finally the blue frame. Careful attention to the operator on 'phone will reveal what he intends to do—he may say "two, one and one", which means that the red frame will be sent twice and then the green and blue frames will follow once each. The main problem with frame sequential colour is that of QRM and QSB which will spoil parts of each of the three frames and, according to Murphy's Law, will leave the picture with no part unaffected on one of the three colours.

To help offset this problem, line-sequential colour systems were developed. Here a line of the red picture is sent, followed by a line of green, followed by a line of blue and repeated until the whole picture has been sent. Each of the red, green and blue lines refer to the same scan-line of the picture so that if QRM or QSB spoil the reception they will affect the same area of the picture in each of the three colours leaving, hopefully, the majority of the frame unaffected. Colour reception is a little more difficult to obtain because the picture takes three times longer to transmit than if it were in black and white. At least that used to be the case!

Robot 1200c

The Robot 1200c, as used by W0ORE, uses an entirely new system to send colour pictures and it does so in less time than both the sequential methods outlined above.

The system is based on the fact that the optimum use of transmission time is best used to produce high-resolution black and white images and these may then be coloured in a lower resolution method. This is not unlike the way that



Watch the birdie!

standard broadcast TV works, where the maximum bandwidth is used to create fine monochrome detail and the chrominance information is transmitted at much reduced bandwidth to provide the colour in the picture. The result of all this is that a picture at a given resolution takes only two thirds of the time to send in the new Robot format.

The transmissions made by W0ORE on board *Challenger* with the Robot equipment were generally an automatic cycle of:

(a) frame-sequential 8-second colour
(b) Robot format 12-second colour
(c) Robot format 24-second colour.

Receiving the Space Pictures

Despite problems arising shortly after lift-off, the *Challenger* was put into orbit only slightly lower than that intended for the flight. In general, the orbits of the shuttle series are not very high and may be directly compared with the "low" orbiting satellites such as UOSAT/OSCARS 9 and 11. These orbits at best offer approximately a 10 minute period when the satellite is in view from a fixed point on the ground. With such a limited time, it is important that the station be well organised to make the best use of the time available.

Preparations

At G3VPC, the receiver audio is routed through to a "magic box". It isn't magic really, but it does handle the routing of audio signals to and from the radio equipment, the cassette recorder, the computer, the RTTY terminal unit and the SSTV interface. Thus any chosen audio signal source is available to the remaining pieces of equipment and, as everything is permanently connected, there is no longer any problem finding the right sort of plugs and leads to put things together on the spur of the moment. Such an arrangement is highly recommended for any shack as it permits instant recording of the signals from the radio and direct playback into the TX mic socket. It has proved invaluable to other operators when some particular characteristic of their transmission can be recorded and played back to them so they can hear exactly what it sounds like!

The only preparation required here was to make sure that all the plugs were firmly engaged (one wasn't) and that the tape-head was clean.

In order to find out the status of the operations on board the space-craft, the special News Bulletins from RSGB HQ were invaluable since the orbital predictions for scheduled operations for London, Leeds and Glasgow were given together with the Keplerian Elements of the *Challenger's* orbit. Since the workload on the astronauts varies on an almost hourly basis and there was no guarantee that transmissions would be made on the scheduled orbits, the orbital elements were installed in the OSCAR-10 program from AMSAT and a list of all likely orbits in range was generated. This proved very useful since the first sked did not take place and a transmission was made on the following non-scheduled orbit.

A low-resolution picture of Dr. Tony England W0ORE

Equipment Used

The 144MHz station at G3VPC comprises:

Antennas	Vertical Colinear UR67M feeder 20-element horizontal beam H-100 feeder
Transceiver	FT-221RD Modified front end
Recorder	ITT SL58—mains powered
SSTV	Home-brew interface and software
Micro	BBC-B with disks and monochrome and colour monitors.

Whilst the station is quite reasonably equipped for terrestrial operation, the very directional long Yagi is a severe disadvantage for space communications since it does not have an elevation motor. This means that a signal emanating from the sky above 20 degrees elevation was severely attenuated. In fact the best signals were obtained from the *Challenger* when it was some 1500km distant and, consequently, fairly low in the sky. However, switching between the vertical and horizontal antennas ensured that the best signal was obtained.

The *Challenger* downlink on 145·550MHz (S22) was recorded on tape whenever the signal showed promise of coming up out of the noise. Being an f.m. transmission, the signal needs to be a little stronger to handle SSTV than if it were an s.s.b. 'phone transmission. Nevertheless, when the beam was swung for best signal, the results were very good as long as the space craft was not too high in the sky.

The Pictures

During the passes of the *Challenger*, the main attention of the operator was given to steering the antenna and correcting the receiver tuning for Doppler shift, leaving the tape recorder to capture the audio signals for later decoding.

When the tape was played back and the decoded pictures were studied, it was noticed that there were some lines on each of the different formats that were always corrupted. It is presumed that there was some internal QRM on the space craft that upset the snatching of the video frame from the cameras. Since the pictures were of otherwise high quality, it was decided to perform some computer processing on the received images and the results are shown in the accompanying figures.

The BBC micro is not able to resolve the pictures in colour because the colours are used to represent the brightness of the scene: the different colours giving a different brightness level on a black and white monitor. Thus a picture can be resolved in eight shades using mode 2. Also the display format does not exactly agree with the standard, being 160 pixels on 128 lines for the low-resolution format and 160 pixels on 256 lines for the high-resolution format. Nonetheless, the computer images are a very good representation of the original scene and, being on a micro, offer the ability to enhance them which is not at all possible on dedicated SSTV converters.

Conclusion

The whole exercise was an unqualified success despite the limitations of uncertain operating periods and terrestrial antennas. It is to be hoped that future Shuttle flights will carry amateur radio of this very interesting nature which helps offset the other problems experienced by NASA with this project. Certainly, the best use of the limited time that the space-craft was within range was made by continuously cycling through the various formats.

There also seemed to be much less QRM on the downlink channel than there was on the earlier Shuttle mission and most of the passes were received with no QRM at all.

The authors would like to convey their thanks to the RSGB for their news bulletins, and their apologies to experienced SSTV operators for ignoring the intimate differences between US and European standards, so as not to confuse the novice.

Finally, a plea to all operators. Please give the SSTV bandplan frequencies a little room when working on 'phone. Many a picture on 20m is totally lost due to s.s.b. operators working on or very close to 14·230MHz. Other bandplan frequencies on which SSTV may be found are: 3·730, 7·040, 21·340, 28·680 and 144·500MHz. ***PW***