VOA Radiogram: Text and Images via Shortwave Broadcasting

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Abstract: The Internet has largely replaced shortwave radio for the broadcast of news and information across international boundaries. A growing number of countries, however, are blocking Internet content from abroad. As a possible workaround, digital text modes familiar to the amateur radio community can be used to broadcast news via existing shortwave transmitters and can be received on any shortwave radio, but software is required to decode the text. VOA Radiogram is a weekly Voice of America program experimenting with text and images through a shortwave broadcast transmitter

Keywords: broadcasting, HF, shortwave, MFSK

Introduction

International broadcasting services such as the Voice of America and BBC World Service traditionally employed shortwave radio to transmit news and information across national boundaries. In recent years, international broadcast content has shifted to the Internet as more audiences have access to this new medium. The Internet enables not only audio, but also text, images, and video to be conveyed over long distances, and it provides the audience with more control over the choice of content, as well as an immediate means of feedback.

Unlike shortwave radio, Internet content is usually brought into a country via landlines, and is routed through Internet providers in the "target" country. These factors provide a national government the opportunity to block Internet content it deems undesirable. Circumvention technologies, e.g. Psiphon and Tor, afford audiences in the target country some opportunity to overcome this interdiction, but an even larger industry (much of it based in the United States) help governments step up their counter-circumvention efforts.

Internet content can be disrupted not only by dictators, but also by disasters, both natural and caused by humans.

Digital modes via analog broadcast

In the past decades, while pondering solutions to Internet interdiction, I also became active in the amateur radio digital modes. I was most impressed by the ability of the digital modes to transmit text successfully even in the worst reception conditions. This led me to wonder if the digital text modes from amateur radio could be used on a shortwave broadcast transmitter.

Educated by my engineering colleagues at the International Broadcasting Bureau (parent agency of the Voice of America), I learned that this could be done, at least in theory. In fact, the modes could even be transmitted in the AM mode of the IBB's shortwave broadcast transmitters, and received on typical low-cost shortwave radios lacking single sideband capability. Early tests used amateur radio transceivers with a dummy load "antenna" to nearby shortwave radios. By the spring of 2012, brief transmissions via private shortwave broadcast stations in the United States resulted in successful decodes hundreds of kilometers from the transmitter.

In March 2013, VOA Radiogram went on the air. This half-hour program is transmitted four times per weekend through a 50-year-old GE transmitter, operating at 80 kilowatts, at the Edward R. Murrow transmitting station near Greenville, North Carolina. Two of the transmissions are via a curtain antenna directed to Europe, and two are via a dipole to the Caribbean. The broadcasts are typically heard both in and outside their nominal target areas.

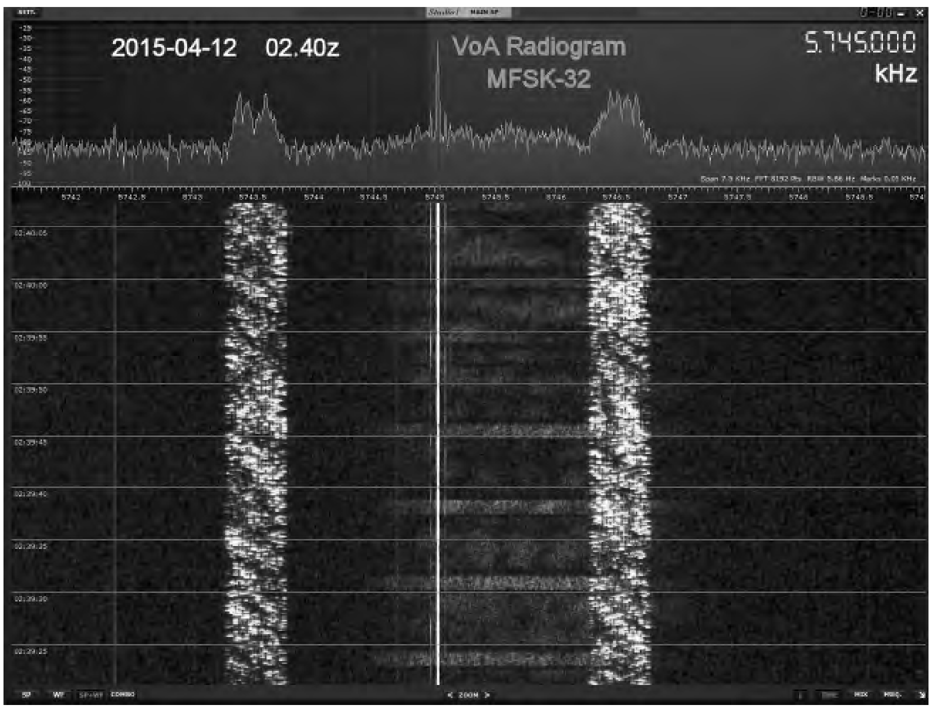

Figure1: MFSK32 data, about 500 Hz wide, 1500 Hz above and below the 5745 kHz carrier, as received by VOA Radiogram listener Roger in Germany. An interfering signal is in the upper sideband.1

Most of the content on VOA radiogram consists of science news from the Voice of America website, voanews.com. Text from the website is pasted to the transmit pane of Fldigi, the well-known digital encoding/decoding software from authored by David Freese, W1HKJ. Fldigi transforms the text to the tones which are inserted into a digital audio file for broadcast. Most listeners use Fldigi to decode, but some decode with other software, such as MultiPSK and DM780.

Thousands of reports have been received from shortwave listeners and radio amateurs throughout Europe and North America, as well as some in Latin America, and, beyond the nominal coverage area of the North Carolina transmitter, in Asia and the Pacific. Listeners use a variety of equipment to receive VOA Radiogram, including amateur transceivers, shortwave portables, antique radios with shortwave bands, and SDR black boxes and dongles. Reception on inexpensive radios is

Figure 2: Typical equipment needed to receive and decode VOA adiogram broadcasts is a portable shortwave radio and a notebook PC, with a patch cord feeding audio from the former to the latter. Appropriate software is also necessary.

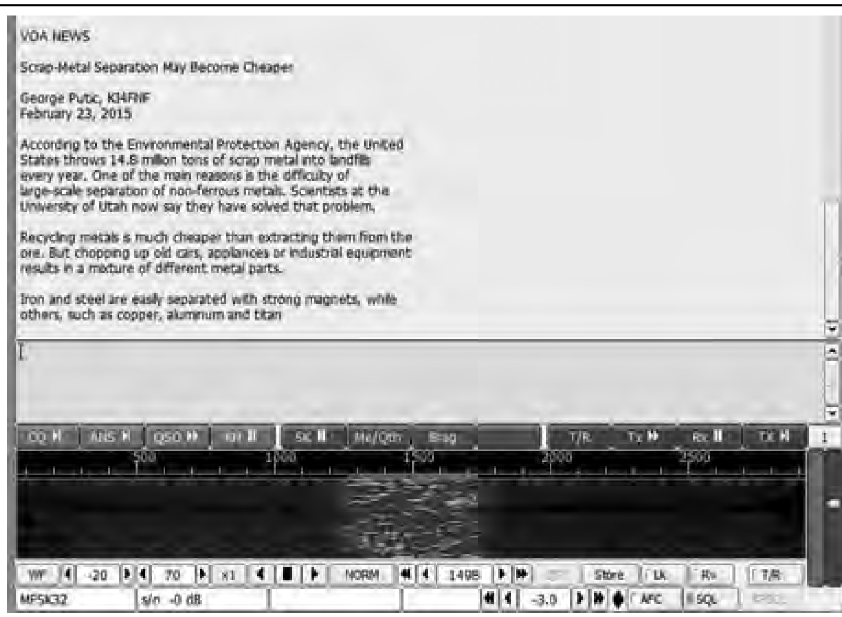

Figure 3: MFSK32 centered on 1500 Hz decoded in Germany, March 1, 2015, 0230-0300 UTC on 5745 kHz.

especially encouraged. Audio is typically fed to a computer using a patch cord, or through an interface such as SignaLink. “Acoustic coupling,” in which the built-in microphone of a laptop computer is placed near the radio’s speaker, is not uncommon.

MFSK and challengers

During the early weeks of VOA Radiogram, modes of similar speeds were transmitted to compare the number of errors. The MFSK modes performed well early on, so, in the manner of boxing, “champion” MFSK took on challengers one at a time. One week the 110 word per minute PSKR125 would be followed by the 120-wpm MFSK32, and the 220-wpm PSKR250 would be followed by the 240-word MFSK64. In the subsequent weeks, MFSK modes would be compared to similar mode speeds of MT-63, DominoEX, and THOR. Throughout this process, the MFSK exhibited fewer, and at least no more, errors than the competing mode.

With MFSK established as the most promising mode, VOA News content was transmitted in different speeds of MFSK to determine which provide ideal performance in shortwave broadcast conditions. Based on hundreds of reports, it was determined that MFSK32, at 120 wpm, provides the best combination of performance and speed in the conditions experienced by most VOA Radiogram listeners.

The MFSK16 mode is slower but can be useful in difficult reception conditions. For reliable transmissions paths, such as the typical distance between an IBB shortwave relay site and most VOA target countries, MFSK64 will usually succeed and allows twice the content during the time period than does MFSK32. General guidelines for the use of MFSK modes under different conditions are summarized in Table 1.

Table 1: Guidelines for the use of MFSK modes in different shortwave reception conditions

Mode	Speed (WPM)	Expected Conditions
MFSK16	60	Poor
MFSK32	120	Fair
MFSK64	240	Good
MFSK128	480	Excellent

During the first year of VOA Radiogram, it was also discovered that text via analog transmitter provided more reliable reception than voice via analog transmitter, i.e. the original purpose of these transmitters. In reception conditions where voice content may be difficult to comprehend, text often provides a 100% decode. Text via shortwave extends the useful range of a shortwave broadcast transmitter.

Another advantage of text via analog radio is the opportunity for “unattended reception.” Text content can be received during the overnight hours and read after waking in the morning. Or the text can be receiving during the day, to be read when returning home from work.

If the Fldigi software is configured for the UTF-8 character set, and the user’s operating supports the language, alphabets with diacritics and even non-Latin characters can be accommodated. VOA Radiogram has successful transmitted content in Russian, Chinese, Tibetan, and even the right-to-left Persian language. This is obviously a vital feature in international broadcasting.

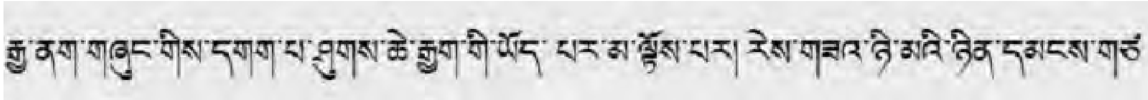

Figure 4: Tibetan text decided by Merkouris in Greece, August 31, 2015, 1930-2000 UTC on 15670 kHz, using Fldigi.

Images via shortwave broadcast

A bonus of the MFSK mode is its ability to transmit images. Images can add to the meaning of a VOA News story, or enhance its credibility.

SSTV modes have been tested on VOA Radiogram. MFSK has proven more satisfactory in part because, unlike with SSTV, the size and shape of the image can be adjusted. In general, images are limited to 200x300 or 300x200 pixels so that their transmission does no occupy too much time. Images of the same size in MFSK16, 32, 64, and 128 require the same amount of time to transmit, but resolution sharpens as the baud rate increases. The higher baud rates, however, also increase the chances for interference, usually exhibited as lines in the decoded image. As with text, MFSK32 has shown itself to be the best compromise, in this case between resolution and resistance from interference.

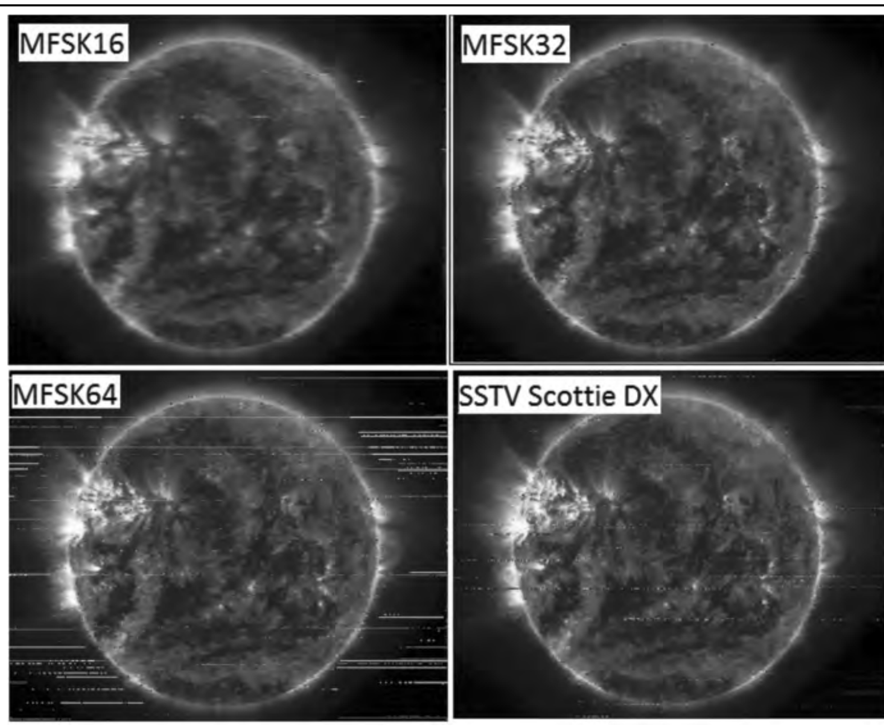

Figure 5: Four modes of images as received by Frank in the Netherlands, August 2, 2015, 1930-2000 UTC, on 15670 kHz.

Images are often fuzzy or noisy, the more important text content is usually received 100% thanks to the error correction built in to the MFSK modes.

Images in EasyPal, which uses DRM (Digital Radio Mondiale) encoding, have also been tested on VOA Radiogram. This is the all-radio version of EasyPal, not the hybrid version that refers the user to a server for download. As is typical of digital communication, the results were either perfect (and dazzling) or completely absent. As impressive as the successes were, the failures were too frequent to encourage continuation of the Easypal experiments. The seven-minute transmission time for the most robust version of EasyPal images was another impediment.

Figure 6: This EasyPal (DRM) image was decoded by Lorenzo in Italy, June 22, 2015, during the 1600-1630 UTC broadcast on 17860 kHz.

Jamming

If a regime blocks Internet content from other countries, there is a good chance it will also jam shortwave broadcasts from abroad. China vigorously jams shortwave broadcasts from the United States and other Western countries. Usually this is done by placing Chinese domestic radio programming, usually from more than one transmitting site, on the same frequency as a VOA or Radio Free Asia broadcast in Mandarin, Cantonese, Tibetan, or Uighur. Chinese operatic music or just noise is also used.

To determine if the text modes via analog shortwave broadcast can penetrate jamming, brief text transmissions were inserted in the shortwave broadcasts of the VOA Mandarin and RFA Cantonese services. The transmitters were the usual IBB relay facilities in Asia. MFSK16 and Olivia modes were used during these tests. Monitoring on receivers in Hong Kong and Japan demonstrated that these modes often, but not always, resulted in successful decodes of the Chinese text, despite conditions that prevented the comprehension of the accompanying VOA and RFA voice content.

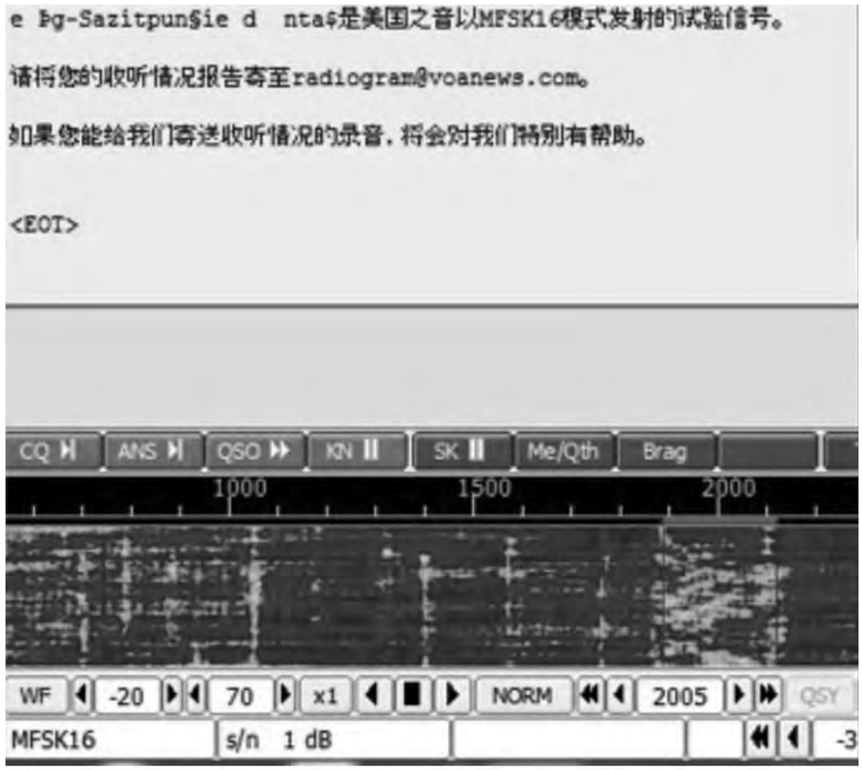

Figure 7: Chinese text in MFSK16, centered on 2000 Hz, penetrated Chinese jamming, August 7, 2014, 2258 UTC on 9845 kHz, as received and decoded by TW in Japan.

Similar successful tests were conducted with Radio Martí shortwave broadcasts, which are heavily jammed by Cuba.

A future for text via shortwave broadcast?

The Fldigi software has remarkable capabilities, but it may be intimidating to non-technical users. Furthermore, audiences for international broadcasting do not need the encoding capabilities of this software. Wider accessibility to text and images via analog shortwave broadcast will require the development of software applications to simplify the decoding process and to enable decoding to be possible on mobile devices. (An Android version of Fldigi, AndFlmsg, is already available in beta version.)

It would also be very helpful for some shortwave receivers to include the ability to decode text modes. Such a development would be assisted by the adoption of one or a small number of modes to be used in shortwave broadcasting, and encouraged by the transmission of text by more shortwave broadcasters. (Text and images via analog radio can also be employed on the AM [medium wave] and FM radio bands.)

The development of easier-to-use software and hardware will probably not transform text via shortwave into a popular mass medium. If this technology can reach a few thousand users in a country or area cut off from external Internet traffic, those users can then relay the information through what would become the country’s intranet, or through non-electronic means in a disaster zone.

The future of shortwave broadcasting, voice or text, is certainly in question. As audiences have migrated to television and the Internet, many major shortwave broadcast transmitting facilities have been dismantled. Most developing countries have eliminated or largely curtailed their use of shortwave for domestic broadcasting now that their territories are covered by networks of FM and television transmitters. Fewer shortwave radios are available for sale; Sony, for example, is down to one model.

There is some interest in adopting DRM (Digital Radio Mondiale) to increase the fidelity of shortwave broadcasts. DRM is, however, less forgiving than analogue shortwave, with the audio dropping out completely in reception conditions, e.g. diminished signal strength and co-channel interference, that are not unusual on the shortwave bands. In similar difficult conditions, text via shortwave is *more* forgiving than analogue voice via shortwave. The availability of this technology to work around Internet interdiction may not be available if analogue shortwave transmitters and receivers are no longer available.

For more information about VOA Radiogram, including the transmission schedule, visit voaradiogram.net.

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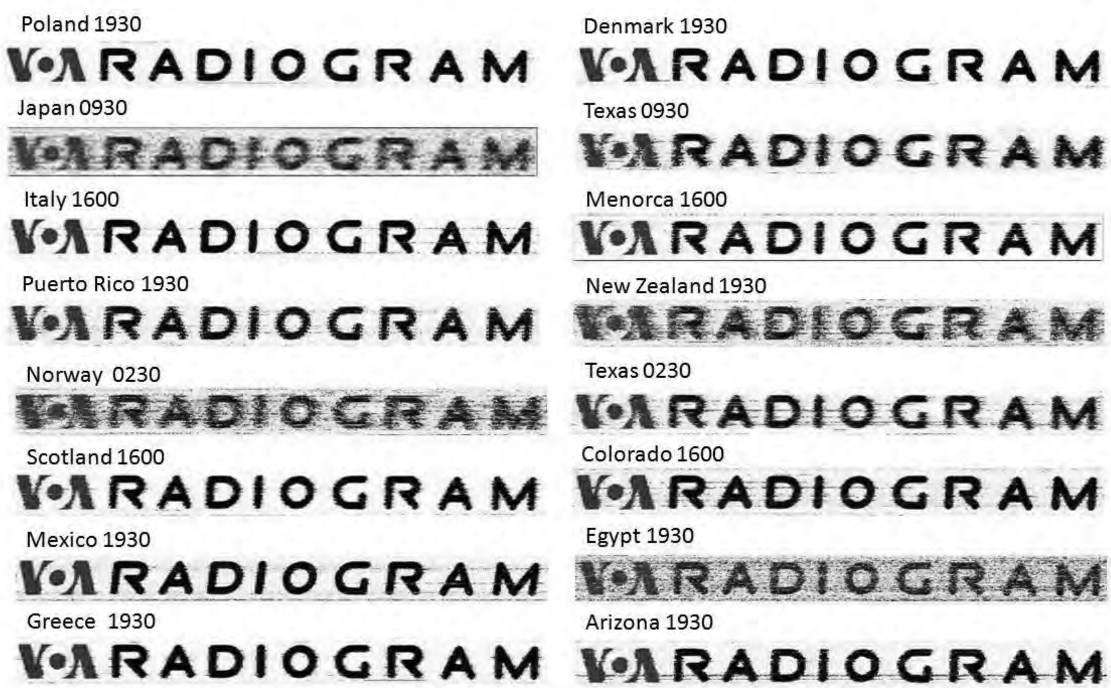
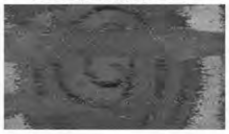
Figure 8: This $25 radio in Germany provided audio for a successful decode of VOA Radiogram text.

Images received from VOA Radiogram, program 51, 22-23 March 2014



UTC: 0930 Sat 5745 kHz. 1600 Sat 17860 kHz. 0230 Sub 5745 kHz. 1930 Sun 5745 kHz. voaradiogram.net

New Zealand 0930



Ontario 0930

Michigan 0930

Texas 0930

Lithuania 1600

Serbia 1600

Greece 1600

Scotland 1600

Germany 1600

VOA RADIOGRAM

MFSK32 images received 15-16 March 2014

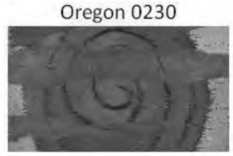
UTC: 0930 Sat 5745 kHz. 1600 Sat 17860 kHz.
0230 Sun 5745 kHz. 1930 Sun 1570 kHz.

France 1600

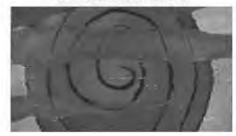
Colorado 1600

Norway 0230

Oregon 0230



Denmark 1930



England 1930

Wales 1930

Cuba 1930

Italy Radio Centro FM

New Zealand, Saturday 0930 UTC, 5745 kHz

Denmark, Saturday 1600 UTC, 17860 kHz

MFSK32 images received from VOA Radiogram, program 74, 30-31 August 2014, all via North Carolina

Virginia, Sunday 0230 UTC, 5745 kHz

Poland, Sunday 1930 UTC, 15670 kHz

voaradiogram.net