Development of a Sound Card Mode for MARS

Progress Report - 4 November 2002

Background

Sound card modems have become popular recently in amateur radio communications. New modes such as PSK31, MFSK16, Throb, and MT63 have become commonplace on amateur frequencies. Previous modes such as RTTY, AMTOR, PACTOR and Packet are also frequently heard, as well as less-common modes such as PACTOR-II and Clover.

The new sound card modes have become popular for several reasons:

- Economics - a single interface between the sound card and the radio will support several different modes, and the interfaces are generally small and inexpensive.
- Bandwidth - most of the sound-card modes consume very little bandwidth; with the crowded conditions on many of the HF amateur bands, modes requiring on the order of 100 Hz can accommodate many users in limited spectrum.
- Flexibility - as new modes are developed, and new programs released, it is a simple matter for users to try out new modes and features.
- Efficiency - the sound card modes were developed to work in a weak-signal and/or high noise environment with low transmitter power.
- Reliability - some of the new modes support high-quality error correction algorithms which are not available with older hardware modes, and are available only at considerable cost using the newer hardware modes.

The MARS services have only implemented sound cards modes on an experimental or very limited basis. When considering why adoption has not been widespread, the needs of the MARS programs and the capabilities of the existing modes were compared. While economics, flexibility, reliability and efficiency are excellent characteristics and map well into the MARS goals (reliability, security, and speed) and MARS resources (primarily volunteer), one inconsistency was noted.

The MARS goal of "speed" does not match well with the sound card mode feature of low bandwidth. Of the common sound card modes, only MT63 provides speed and reliability comparable to PACTOR Mode B (FEC).

Because of this mismatch, the question was raised at the Region Four Navy - Marine Corps MARS conference (October 12, 2002) as to whether new modes not being used on amateur frequencies could be developed and tested on MARS frequencies. An affirmative reply from Chief, Navy - Marine Corps MARS (as long as the mode will fit in our 3 kHz channel) was the driver for this experimentation.

Initial Experimentation

In selecting a starting point, two protocols were considered - MT63 and MFSK16. Both provide excellent weak-signal performance, but MFSK16's 16-tone FSK scheme was chosen over MT63's 64-tone parallel BPSK scheme. This choice was based on the following criteria:

- MFSK16 has throughput of about 4-5 characters/second using a bandwidth of about 250 Hz. MT63 has a throughput of about 5 characters/second at a bandwidth of about 500 Hz. As implemented, MFSK16 can provide about twice the throughput as MT63 in the same bandwidth.
- MFSK16 uses variable-length character encoding, while MT63 is fixed. Future enhancements could easily include some long super-characters, for example, "NNN0", "MARS", and other abbreviations and acronyms frequently seen in message traffic.
- MT63 is much more CPU-intensive than MFSK16; Indiana NAVMARCORMARS has several low-end Pentium laptops for ART use; the CPU power available on them is insufficient to run MT63 at 2 kHz bandwidth.

The Linux operating system was used for initial testing because of the availability of source code for sound card modem packages. gMFSK, written by Tomi Manninen, OH2BNS in Finland, was used as a starting point for initial experimentation. Two other members in Indiana, Larry Perkinson, NNN0YLX, and Dean Langley, NNN0AGW, consented to install Red Hat 8.0 Linux on systems at their locations in order to do over-the-air proof-of-concept tests.

The software for gMFSK was modified to add three new variants of MFSK16 -- tentatively labeled as MFSK16x2, MFSK16x4 and MFSK16x8. These modes are simply MFSK16 with the symbol rate and frequency spacing increased from the normal 15.625 symbols/ per second /15.625 Hz tone spacing to twice, four times, and eight times the standard values (note - doing this is a clear violation of the MFSK specification, and according to that specification, these modes are not to be called MFSK)

Initial testing was done using two computers acoustically coupled (microphone - to - speaker), followed by on - the - air testing with NNN0AGW and NNN0YLX after the 4B1B net closed from 27 October to 4 November. The 8x mode produced promising results:

- Once a few bugs (audio levels, etc.) were worked out, near-perfect to perfect copy was obtained in 2-way over-the-air tests.
- CHNAVMARCORMARS INFO BCST 47-02 (1,010 characters) was transmitted in just under 30 seconds with no reception errors. (An off-air test of the file converted to all-lower-case completed in about 23 seconds.)
- Tuning of the signal becomes much easier than for standard MFSK16 -- with the tone spacing increased to 125 Hz, AFC locks in easily as long as the starting

point is within about 50 Hz or so. (The criticality of tuning is one of the major drawbacks of both MT63 and MFSK16).

- Fairly good performance on the 90 MHz Pentium laptop was obtained even at 8x, but the CPU was fully loaded. By turning off the waterfall display, loading was reduced to under 70% and error-free copy was achieved. Loading during transmission is not an issue (unlike MT63).

Drawbacks noted - the waterfall display is not very informative at the higher data rate; a different tuning mechanism may be in order for future use.

Future Work

First, development of software to work on the Windows platform is needed; while Linux is an excellent environment for this application, virtually all MARS members are running Windows systems.

Second, additional experimentation into modulating schemes needs to be done. In particular, a 3-of-7 tone scheme looks interesting on paper (on - the - air tests will determine if IMD products and such would make this unworkable). By reducing the number of tones required by half, the tone spacing and the symbol rate doubled from the current parameters. In addition, a 3-of-7 scheme would yield 35 possible states per symbol, allowing 5 bits per symbol rather than 4 -- giving an overall raw throughput of 2.5 times the MFSK16-based approach (which would be about 100 characters/second).

Third, optimizing the symbol set for MARS message traffic (giving upper-case letters preference, etc.), and adding symbols for common multiple-character sequences would provide additional efficiency with no loss of reliability.

Updates will be provided to chain of command as progress occurs.

Respectfully submitted, November 4, 2002 by Paul L Schmidt, NNN0BOK IN