Meteor Burst Communications:

An Ignored Phenomenon? (U)

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I. INTRODUCTION

(U) The idea of bouncing radio signals off meteor trails and back to earth to the intended receiver is not new. Since the early 1940s various communicators have wrestled with the possibility. From these early studies, workable systems have evolved until today it is not uncommon for amateur radio operators (hams) to use this method of communicating. How is it possible to use a meteor the size of a grain of sand to reflect a radio signal to its intended receiver? Let us begin with the meteor.

II. THE METEOR

(U) The meteors we will concern ourselves with orbit around the sun in a path that coincides with the earth's. These meteors occur at a rate of two to eight billion daily or roughly 50,000 per second. As these meteors catch up with the earth or are overtaken by it, they enter the atmosphere at a speed of 10 to 75 kilometers per second. The friction caused by the meteor colliding with the atmosphere results in the vaporization of the meteor. The vaporized trails are further restricted by the atmosphere, stripping electrons from the vaporized atoms, causing a trail of positive-charged ions and free electrons to form behind the meteor. This phenomenon occurs at about 115 kilometers altitude and by 85 kilometers has completely burned out. The ionized trails last anywhere from a few seconds to only a few hundredths of a second, and it is these upon which Meteor Burst Communications (MBC) depend.

(U) There are two ways a meteor trail redirects the radio wave, depending upon the density of the trail. The first, called an overdense trail, occurs during a meteor shower and has a free electron density great enough to prevent the radio wave from penetrating. The wave reflects back to earth much like a beam of light reflects from a mirror. Overdense trails have a long life, sometimes lasting up to two seconds. These meteor showers, however, play only a small part in MBC operations because they seldom occur and are only a small fraction of the total number of meteors that fall upon the earth each day.

(U) The second category of meteor trail, the one best suited for Meteor Burst Communications, is the underdense trail. This trail, caused by the steady drizzle of meteors that fall upon the earth each day, is less dense and allows the radio wave to penetrate. This penetration causes excitement among the electrons, which act as small dipole antennas, redirecting the wave back to earth in a scattering fashion. These trails last only a fraction of a second, but because of their regularity they are more dependable than meteor showers.

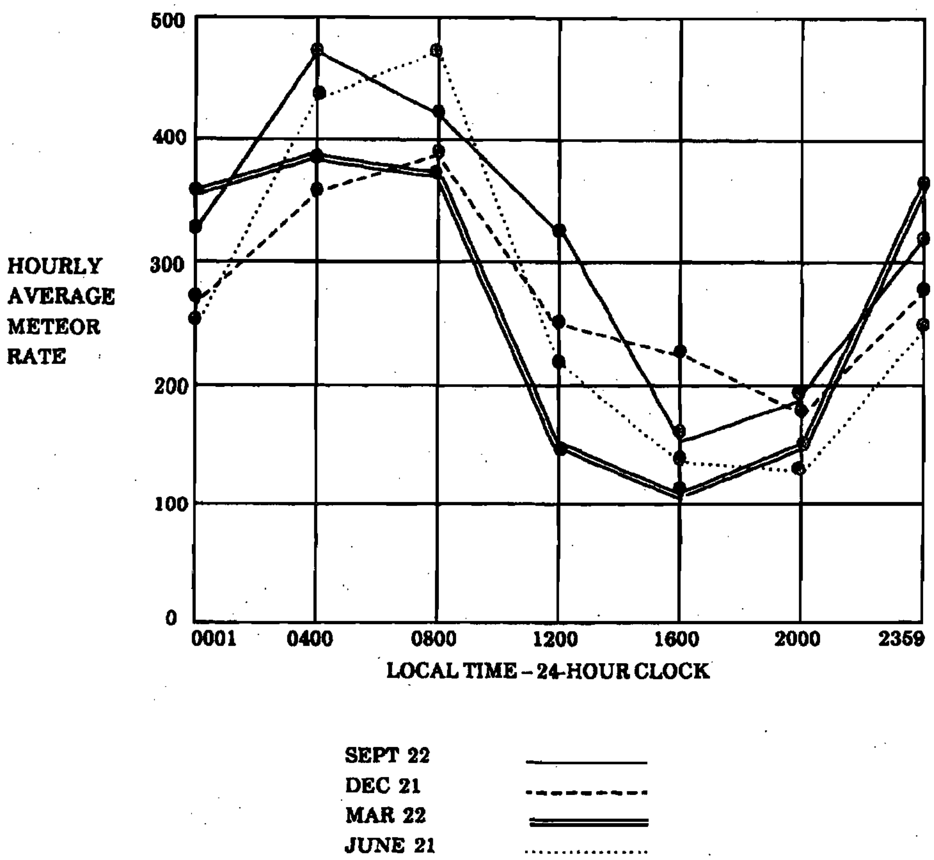
(U) The total number of usable meteor trails depends on the time of day and month of year. Daily, the largest number of meteors occurs during the early morning and dissipates in the evening, around sunset. During the morning the earth is rotating toward the sun, while most meteors move away from the sun. This results in the earth sweeping up and overtaking meteors. In the evening the earth rotates away from the sun, and only those meteors that overtake earth create usable trails. This process is known as the diurnal variation,[1] which results in about four times as many meteor trails in the morning as in the evening.

(U) Nearly three times as many meteors occur in August as in February. This seasonal variation occurs because the earth is tilted more toward the sun in August. MBC appear to be most effective from July through September from the hours of 0400 through 0800. Table 1 illustrates the variations in the total number of meteors available at various times and dates.

(U) Most meteors are very small, the average meteor being near 1 milligram in weight. The resulting trail is anywhere from 10 to 20 miles long with a radius of approximately one meter at the head of the trail.

1. Ronald D. Elliott. "Meteor Burst Communications in Tactical Intelligence Support," *SIGNAL*, November 1986, p. 84.

Table 1
Daily Meteor Trail Availability



CURVES ARE HOURLY AVERAGE RATES FOR THREE-MONTH PERIODS, CENTERED ON THE DATES INDICATED.

III. PROCEDURE

(U) All MBC systems consist of a master station and one or more remote stations or sensors. Hardware at both the master and remote station usually consists of a small laptop computer terminal with storage for message buffering, a transmitter, receiver, and antenna. Frequency usage can range between 20 and 120 MHz. Most systems operate in the 40 to 50 MHz range, which allows the use of smaller antennas. Transmissions can be either simplex, half-duplex or full-duplex.

(U) The master station is responsible for locating a meteor trail that will permit the two stations to communicate. To accomplish this, the master station transmits a probe that may consist of a simple, continuous tone on a fixed frequency with the remote station's receiver tuned to the same frequency. The probe continues to bounce against various meteor trails until a suitable path exists between master station and remote. The angle of incidence and the angle of reflection determine the path.[2] Appendix A illustrates how a usable trail is determined. When the remote station receives the probe, it replies with one of its own, and at that time transmission of data between the two stations takes place. When the usable meteor trail burns out, the master station retransmits its probe until another suitable path is located.

(U) The period of searching between usable trails is known as the wait time. During the wait time, the communications are buffered into storage until the next usable meteor appears. Wait times vary in proportion to the usable time of the trail. Table 2 shows various times for usable trails.

Table 2
Wait Times Required for Various Burst Durations

BURST DURATION	WAIT TIME REQUIRED
.1 SECONDS	17 SECONDS
.2 SECONDS	35 SECONDS
.4 SECONDS	143 SECONDS
1.6 SECONDS	2 DAYS *

* A BURST OF 1.6 SECONDS IS THE RESULT OF AN OVERDENSE METEOR TRAIL.

(U) If the system contains more than one remote station, the probe transmitted by the master may consist of more than just a solid tone. The probe may consist of an address code that will trigger the remote station's response. If, by chance, a remote station should receive a probe intended for another remote, it will remain idle until it receives the proper address.

2. P. S. Cannon and A. P. C. Reed. "The Evolution of Meteor Burst Communication Systems," *Journal of the Institution of Electronic and Radio Engineers*, Vol. 57, No. 3, May/June 1987, pp. 101–12.

(U) The use of Forward Error Correction (FEC) and Automatic Repeat reQuest (ARQ) equipment is responsible for preventing the transmission of data when no suitable path exists. If either the master station or any of the remote stations are receiving garbled traffic, indicating a usable path is burned out, they transmit an ARQ, resulting in retransmission of the data. The FEC equipment is responsible for locating the exact location within a message where the path became unusable. This produces relatively error-free transmissions.

(U) Data rates for a typical Meteor Burst system range from 75 to 100 words per minute, if unencrypted, to 15 words per minute encrypted. The error rate hovers around one error in 50,000 characters. For low-volume users who depend on accurate data, this system seems ideal.

IV. ADVANTAGES

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(U) Another advantage of Meteor Burst Communications is their independence. Satellites are normally controlled by a third party interested in a profit and are not necessarily adaptable to the user's needs. This is not the case with MBC; the system belongs to and is controlled by the user. Since the user owns the system, it is also less likely to be compromised.

(U) MBC systems have several advantages over High Frequency (HF) systems. HF systems usually require multiple frequencies, e.g., day and night frequencies; MBC systems operate fulltime on one frequency only. MBC equipment is light and durable, and the manpack is deployable.

(U) Finally, MBC have the ability to survive a nuclear war. Following a nuclear explosion, the nuclear fallout present in the D-Layer of the atmosphere would thwart HF communications. It is also likely that satellites and their ground terminals would be high-priority targets. MBC, on the other hand, would fare much better. Meteors would continue to bombard the earth's atmosphere, creating trails required by MBC. MBC do not require large, fixed ground stations; therefore, they would be difficult to target. A nuclear detonation would, however, require an increase of operating power to penetrate the fallout present in the atmosphere's D-Layer.[5]

V. DISADVANTAGES

(U) The most obvious disadvantage of using Meteor Burst Communications is the very low data rate. The keying speed of the burst is actually quite fast, 2.0 to 4.8 kilobits per second, but because of the wait time involved in finding a usable meteor trail, most systems average only about 100 words per minute of actual data. If a user needs to transmit large volumes of data, MBC are probably not the right choice. MBC would, however, make an excellent back-up system for high volume users.

(U) Meteor Burst Communications are also limited by distance. This form of communication is effective only up to a range of 1,200 miles. Any user wishing to transmit farther than 1,200 miles could not use MBC. It is possible, however, to link several MBC sites together and relay the traffic, which would increase the effective operating distance indefinitely.

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5. Ronald D. Elliott. "Meteor Burst Communications in Tactical Intelligence Support," *SIGNAL*, November 1986, p. 86.

(U) A third disadvantage of Meteor Burst Communications is their incompatibility with certain types of signals, mainly voice. Because of the wait time required between meteor trails, voice communications would be broken into segments. A user might hear 15 words, then have to wait 30 seconds for another burst.

VI. EARLY SYSTEMS

(U) The first usable Meteor Burst Communications system was the JANET, a Canadian system developed in 1954. This system was crude by today's standards, but it stimulated interest in Meteor Burst. It was a simple system in that neither station used ARQ equipment. Communications began when both stations received a 650 Hz tone and concluded when the signal-to-noise ratio fell below a predetermined level. The average data rate for this system was approximately 30 words per minute with an error rate from .1 percent to 4 percent.

(U) In 1965, NATO developed the first Meteor Burst system to employ ARQ equipment. The system was known as COMET (COmmunications by MEteor Trails) and was used successfully for point-to-point telecommunications between the Netherlands and France. With the advent of ARQ equipment, the error rates fell dramatically.

(U) SNOTEL (SNOw pack TELemetry), developed in the 1970s, is still in use throughout the western United States. This system contains 2 master stations and more than 500 remote data acquisition sites in 11 western states. The system monitors snowfall and other meteorological data. The 500 unmanned, remote stations are divided into selectively addressed groups of approximately 60 remote stations in each group. Polling a group of 60 stations takes an average of 5 minutes.

(U) AMBCS (Alaskan Meteor Burst Communications System) was deployed in the late 1970s and is owned jointly by several government agencies. The system collects aeronautical and environmental data from remote sensors and also serves as a source of teletype communications between remote manned sites. This system is especially useful in Alaska because Meteor Burst Communications do not experience the auroral interference common to High Frequency communications.

VII. WORLDWIDE DEVELOPMENTS IN MBC

(U) Although the United States is the leader in MBC technology, it is not alone in the effort to exploit its usefulness. Several countries, including friendly, hostile, and third world nations, are either developing their own systems or attempting to import them from the United States. Following is a brief summary of worldwide developments in MBC.

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7. Ibid., p. 14.

8. Ibid., p. 18.

9. Ibid., p. 22.

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United States [redacted]

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10. Ibid.
11. Ibid., p. 26.
12. Ibid., p. 28.
13. Ibid., p. 29.

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VIII. LATEST TECHNOLOGICAL BREAKTHROUGHS

VHF Convertors

(U) Developed by an American company, IA Research Corporation, the VHF convertor allows the conversion of any VHF radio to an MBC terminal. The time required for conversion is minimal and completely reversible, allowing a terminal to go back and forth from VHF to MBC in a matter of minutes. The conversion is possible on any VHF radio, including manpack-deployable units. This development has the potential of opening the field to thousands of new MBC users. At a recent convention in Washington, D.C., several thousand dollars' worth of these convertors was stolen in an overnight theft.[15] The convertors would be very beneficial to anyone wishing to secretly convert to Meteor Burst Communications.

Adaptive Signaling Rates

(U) The Meteor Communications Corporation of Seattle, Washington, has developed equipment that allows adaptive signaling rates. The equipment senses the signal-to-noise ratio and sets the signal rate accordingly. If a strong signal-to-noise ratio is present, the signal rate is greater, allowing the transmission of larger volumes of data. Many potential users, currently not employing MBC because of MBC's inability to pass large volumes of traffic, may be very interested in this development.

IX. CONCLUSIONS

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14. Ibid., p. 24.

15. Bobby J. Mitchell. "New Meteor Burst Communications Technology Displayed at AFCEA Annual Convention and Trade Show," New Meteor Burst Communications Technology – Information Memorandum, July 1987, p. 3.

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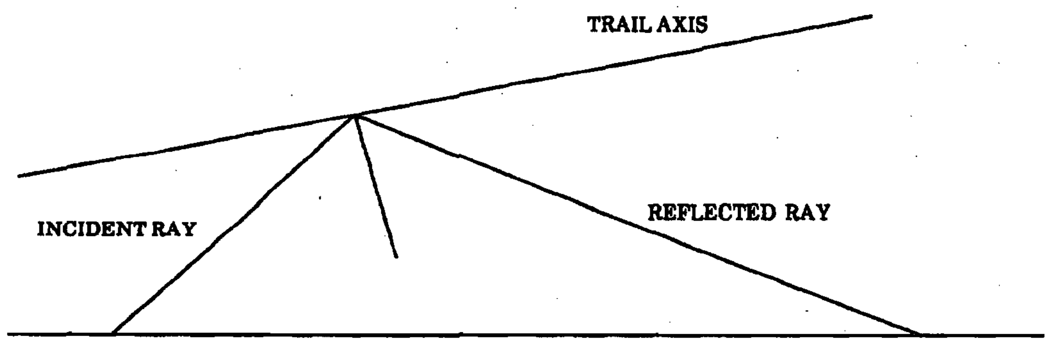
Appendix A

Meteor Burst Communications Propagation



The angle formed by the incident ray striking the meteor trail is equal to the angle formed by the ray being reflected from the meteor trail. This determines the signal path. In the above example, communications would occur. Had either station been positioned anywhere else along the line, communications would not have occurred. Likewise, the signal would not have been intercepted unless the interceptor was within the footprint of the receiver or the ground wave of the transmitter.

Appendix B

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Appendix C

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