Jamming:

Will It Be Tactically Effective?

Ed. Note: This article does not reflect the philosophy or doctrine of the US Army Signal Center.

by Mr. Lawrence E. Follis

There appears to be a generally held assumption that jamming Army tactical communications (friendly or enemy) will be highly effective and will cause widespread disruption and delays and have significant effects on combat outcome. The purpose of this article is to challenge this assumption and to suggest that, as a practical matter, jamming will seldom have significant tactical effects.

There are several factors that cast doubt on the tactical effectiveness of jamming:

If jamming does occur, frequency can be changed or an alternate means of communication can be used.

Jammers will generally be on for two minutes or more in their efforts. This is sufficient time to locate them; appropriate actions can then be taken to put them under artillery fire. Hence, jammers will be prime targets for artillery and must therefore change position frequently.

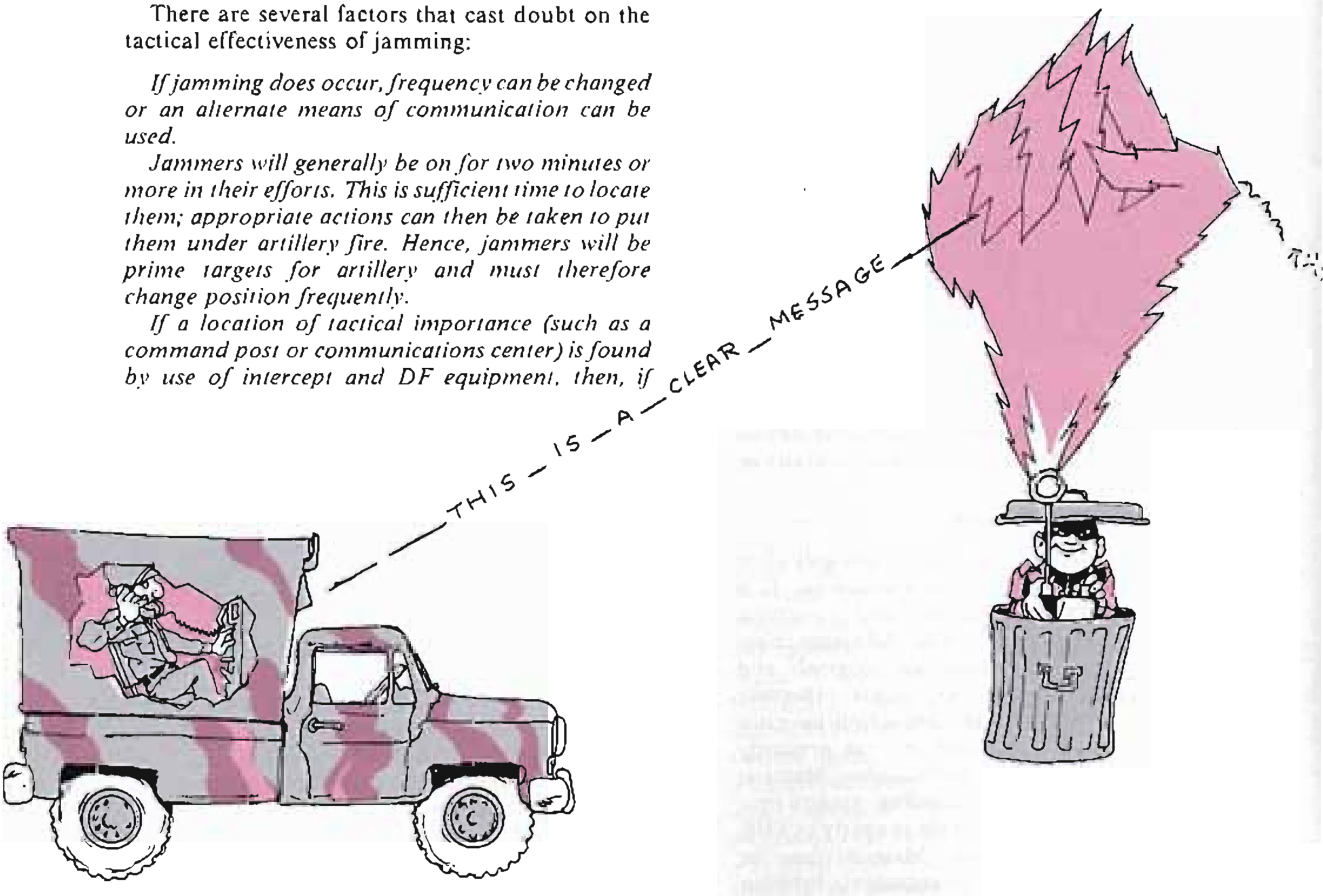
If a location of tactical importance (such as a command post or communications center) is found by use of intercept and DF equipment, then, if possible, destruction would generally be preferable to jamming.

Jamming by US forces would in all probability involve some unintentional jamming of US forces because of the well-known crowded frequency spectrum.

Rough (hilly or mountainous) terrain serves to reduce the communications range; other things being equal, the range of effective jamming will likewise be reduced in rough terrain conditions.

The use of a Steerable Null Antenna Processor (SNAP) device at a friendly receiver would eliminate interference caused by an enemy jammer. This device should be provided only to critical receivers (for example, field artillery and command control nets) and would cost the friendly force less than it would cost the enemy to equip his forces with a sufficient number of jammers to be tactically effective.

The number of receivers in a US division operating in the 30-76 MHz region is around 2,500. This greatly exceeds the number of jammers which might be used against them. Any practical number of jammers a friendly force might have will always



be far less than the number of enemy nets or receivers.

Experience in field training exercises has shown that trained operators can frequently continue to communicate in spite of the attempted jamming.

The success of an attempted jamming operation will not be obvious because the distance for successful jamming (and for successful communications without any jamming) depends on several factors, including antenna heights above the ground, antenna gain, receiver sensitivity, terrain roughness and soil condition, operating frequencies, band width, polarization, and the transmitter and jammer power levels. These are just too many factors to grasp intuitively, and one must resort to calculations and tests to determine their effects.

First, in order to get a feel for communications range (the maximum range at which a friendly communications signal can be detected), it is necessary to determine the path loss of the transmitted signal. Path loss (expressed in decibels (dB) is a measure of the reduction in signal strength between transmitter and receiver. The jammer signal will likewise have a path loss associated with it since the signal travels from jammer to receiver.

By using some simple equations involving transmitter and jammer output power levels and antenna gains, one can readily determine the Signal-to-Noise (S/N) ratio at the receiver (and thus determine the communications range when there is no jamming), and also the Jamming-to-Signal (J/S) ratio when there is jamming. For Army tactical VHF/FM, communications will be satisfactory when S/N is about 12.0 dB or more, and the communications link can be successfully jammed when the J/S is around 1.0 dB or greater.

One can use these calculations to make some interesting points. Take as a base case the following situation (tactical VHF/FM communications), in which a friendly transmitter and enemy ground jammer are both emitting signals that are being picked up by a friendly receiver.

h_T = transmitter antenna height = 5 m

h_R = receiver antenna height = 5 m

h_J = jammer antenna height = 10 m

f = operating frequency = 50 MHz

d_{tr} = transmitter to receiver range = 5 km

d_{jr} = jammer to receiver range = 8 km

P_T = transmitter output power = 35 watts

P_J = jammer output power = 1000 watts

Terrain type - average

All antenna gain values = 2.15 dB (whip antennas)

Using the values for the base case and finding path losses by the calculation procedure above, it can be determined that when

S/N $\geqslant$ 12.0 dB, good communications exist when there is no jamming.

J/S $\geqslant$ 0 dB, the attempted jamming is successful.

The first point of interest is that by reducing the transmitter-to-receiver range from 5.0 km to 1.0 km, one would have to move the 1,000-watt jammer to within about 3.0 km of the receiver in order to jam successfully—a step which is not tactically practical. The effective jamming range cannot be determined without defining the transmitter-receiver range first.

By tripling jammer power, one might think that the range at which one could jam successfully would be tripled, but this is not the case at all. For the base case, a 1,000-watt jammer will successfully jam to a range of 14 km, a 3,000-watt jammer will jam only to a range of 19 km. (An attempt to barrage jam by spreading the power of a 3,000-watt jammer over 20 channels (150 watts per channel) would reduce the maximum jamming range to 9 km.)

Another way to increase jammer range is to increase the height above the ground of the jamming antenna. Increasing this height from 10 m to 20 m will increase the maximum jamming range by only 4 km (from 14 km to 18 km).

The use of a directional antenna at the jammer will increase jammer antenna gain from 2.15 dB (standard value for a whip antenna) to around 7 dB. This again will increase maximum jammer effective range only from 14 km to 18 km.

Jamming at a frequency of 80 MHz (rather than 50 MHz) will increase maximum jammer effective range from 14 km to 14.5 km—a rather small effect.

Except for the barrage jamming case, the above discussion assumes that all of the transmitter output power is being put into a single tactical communications radio channel and that the jammer output power is being put into the same channel. It is evident that there is no single step which will cause

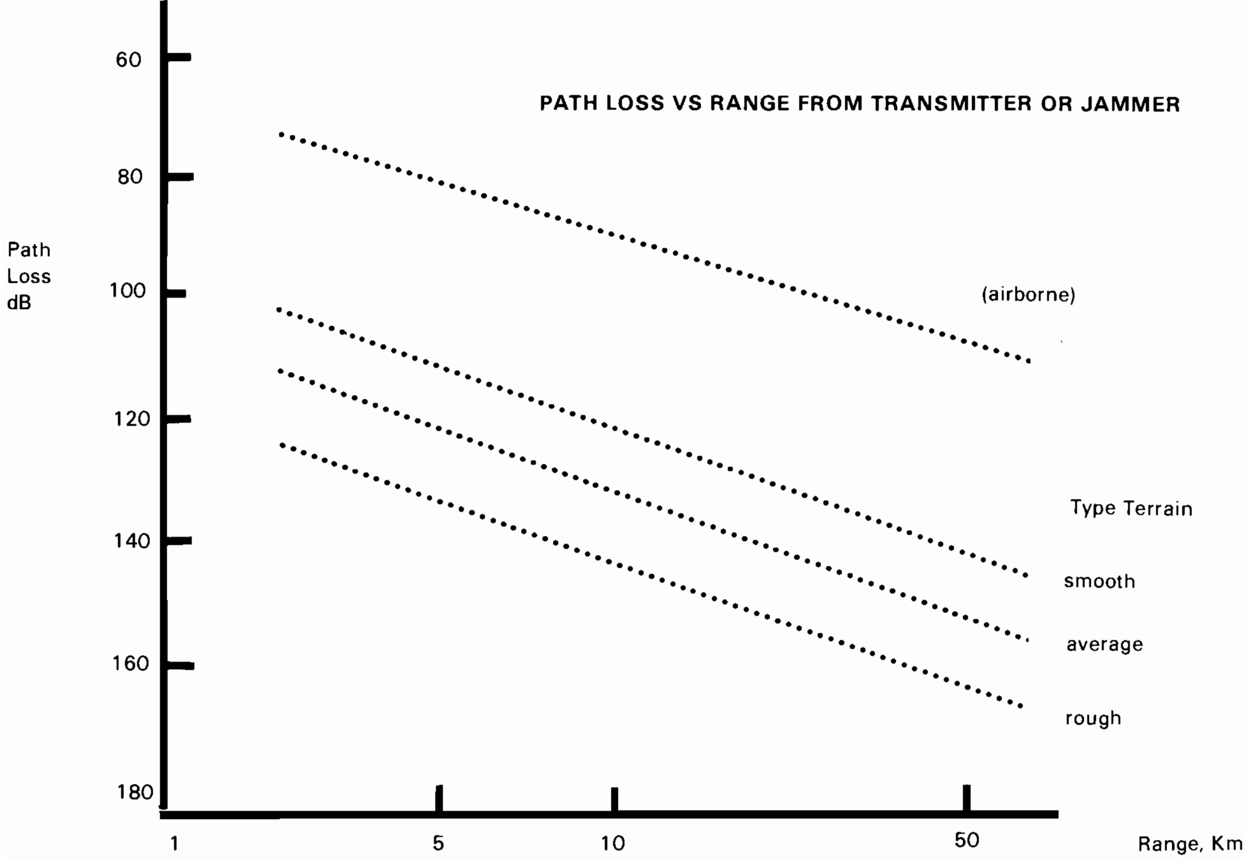


Figure 1.

really dramatic improvements in ranges and effectiveness of ground jammers.

The numbers calculated above are approximate and make use of one specific technique of calculating path loss. Other techniques would yield somewhat different numbers, but the trends would still be the same. One would still conclude that being able to achieve ground jammer effectiveness at ranges of tactical interest is not something that can be relied upon.

It has been suggested that a remotely piloted vehicle (RPV) would make a good platform for jammers. RPVs would, admittedly, have two distinct advantages: the jammer (RPV)-to-victim receiver range would be short and, since the jamming is being conducted from an airborne platform, the path loss would be small, as indicated in figure 1. Unfortunately, the jamming power currently available on an RPV would be so severely limited (on the order of perhaps 20 watts) that all the power might have to be put on one receiver channel; as a consequence, one RPV would be lucky to jam one receiver. This would not appear to be an acceptable use of RPV resources.

It has also been suggested that the use of a large number of small unattended/expendable jammers scattered on the ground in the vicinity of enemy receivers might provide a means of jamming effectively. Unfortunately, expendables are limited with respect to power output (and therefore jamming range); they would have to be battery powered and thus have a limited operational lifetime, and, if deployed by artillery, they would impose a further burden on artillery logistics.

Although this article has, for the most part, addressed considerations of the effectiveness of ground jammers against FM/VHF communications, many of the same considerations, may be applicable to multichannel and radar jamming.

In conclusion, to get a reliable estimate of jammer tactical effectiveness, one would have to take the following actions based on a study of the deployment of a large number of receivers and jammers in realistic tactical situations: first, determine how frequently the jammers are effective in delaying transfer of significant information, and, second, find (possibly using computer models) the results of this delayed transfer of information in terms of effects on the outcome of combat.

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