by Richard E. Hogue

The US Army's currently fielded combat net radio, the AN/VRC-12 family, was built around the RT-524 and RT-246 receiver-transmitters. These RTs are large, heavy, and hard to handle. They operate on one frequency (single channel) and have difficulty operating with some encryption devices, TACFIRE, and other digital data devices. Designed in the early 50's and fielded in the 60's, they became obsolete in 1970.

This obsolescence was the result of technological changes and logistic difficulties. The RT units are difficult to repair and repair parts are expensive. The high failure rate combined with a long maintenance time kept the AN/VRC-12 radio below an acceptable level of combat availability. (See "FM Radio Maintenance—A Challenge," Jan-Feb issue of *Logistician* 1981.) The other principal cause of obsolescence of the RT-524 is the vulnerability to the Soviet Electronic Warfare threat.

To overcome this obsolescence, the US Army did a study in early 1970 to analyze single channel ground and air radio requirements, and, in 1974, the requirements for a new jam-resistant radio were announced. Industry responded to these requirements and, in 1983, the Army selected ITT's radio design for production. This radio is commonly referred to as SINCGARS, for single channel ground and air radio system, and is equipped with the latest in digital circuitry. The RT for the SINCGARS radio is the RT-1439. For a comparison of the RT-524/246 and the RT-1439, see Table 1.

The three major threats that the AN/VRC-12 is most susceptible to are interference, interception, and jamming. Definitions of these threats, as they relate to radio communications, follow.

Interference, man-made or natural, degrades received signals. Natural electrical or electromagnetic disturbances are lightning, static and other such phenomena. Man-made interference is caused by motors, fluorescent lights, rotating electronic machines, and radios operating on the same frequency.

The space age radio

Table 1. Comparison of RT-524/246 and the RT-1439

Characteristic	RT-524/246	RT-1439
Type of RT	FM	FM
Frequency Range	30-75.95 mHz	30-87.975
Interval	50 kHz	25 kHz
Stability	3 kHz	5 PPM
Sensitivity	1 uV minimum	0.35 uV minimum
Channels	920	2,320
Type of Tuning	manual	automatic
HI Power	35-65 watts	4 watts
Med Power	—	160 miliwatt
LO power	.5-10 watts	32 microwatt
Power Amplifier	—	50 watts
Squelch Tone	150 Hz	150 Hz
Jam-resistant	no	yes
Built-in-test	no	yes
Scanner mode	no	yes
Whisper Mode	no	yes
Weight*	51 pounds	13 pounds

**Weight comparisons are misleading, unless comparing two weapon systems with similar characteristics. What is meaningful is that the RT-1439 is easier to carry to direct support maintenance, or is the two man lift required to install any component of the RT-1439 series radio. Total weight in vehicle is roughly the same for either radio.*

Interception of radio signals can be particularly damaging to military units. Anyone with a similar receiver can pick up a radiated signal. To provide security for critical radio nets and to deny information to unauthorized listeners, digital message encryption has been developed and has reached a level of deployment over the past few years. Pseudo-random techniques of voice encryption by COMSEC devices are now common.

Jamming is the third threat. Because gaining information from the signal is more valuable to an enemy, jamming is the last threat to be employed in electronic warfare. (See Table 2 for types of jamming.) Unsecured radio nets are monitored, and sometimes an "enemy" operator will enter the net and transmit erroneous information. Encryption, then, is one answer to denying the interceptor any information; however, if he can't decrypt, he will probably resort to jamming.

The answer to defending against jamming is threefold. The basis of one defense is to evade the jammer. By moving the receiver so that a hill or some other obstruction is between it and the jammer, the interfering signal is attenuated. The steerable null antenna processor (SNAP) is an attempt to electronically attenuate jamming signals. A second method is to increase the power transmitted to the desired receiver. This is particularly effective against FM jamming; the receiver, because of the FM capture effect, will respond to the stronger signal. However, there is an upper limit to the power output of any transmitter. This increased power method then becomes a game of "Who has the most power?" The enemy generally wins the game because his jammer is close to the receiver. A third method to defend against jamming is to change the operating frequency of the radios being jammed.

Of the three defenses, frequency changing is the most effective. Tactical situations generally preclude moving radios from unfavorable sites. Good tactical positions are almost always poor radio sites. For example, forests help to conceal troops, but they absorb RF radiation. Transmitter output power limitations and the possibility of high power interference with other radios decrease the overall value of boosting transmitter power to overcome jamming. Therefore, the question now concerns which frequency should be used and when it should be used.

Several characteristics of jamming must be considered before this question can be answered. Efficiency in jamming a band of frequencies is inversely related to the bandwidth being jammed. Therefore, single channels are easier to jam. When single channels are to be jammed, all the jammer's transmitter power can be concentrated on one frequency. The jammer can reach deeper into the "enemy" side's rear area and jam

Table 2. Types of jamming

Waveforms	Type
Voice Modulation: AM FM	All types
Noise Bursts: Narrowband Wideband	Spot jamming Barrage jamming
Swept Frequency: FM	Bagpipes
Phase-shift-keyed (PSK)	Spot jamming
Frequency-shift-keyed (FSK)	Spot jamming
CW tones	Spot and swept

Table 3. SINCGARS configurations

	Description	Replaces
AN/PRC-119	RT-1439 mounted on the ALICE backpack. Short range only.	AN/PRC-25 AN/PRC-77
AN/VRC-87	One RT-1439 in vehicular mount used for short range.	AN/VRC-53 AN/VRC-64
AN/VRC-88	One RT-1439 in vehicular mount with ALICE backpack. Short range only.	AN/GRC-125 AN/GRC-160
AN/VRC-89	Two RT-1439s. Short and long range capabilities. Vehicular mounted.	AN/VRC-12 AN/VRC-47
AN/VRC-90	One RT-1439 and one RF Power Amplifier. Vehicular mounted, long range set.	AN/VRC-43 AN/VRC-46
AN/VRC-91	Two RT-1439s and one RF Power Amplifier. Short and long range capabilities. Vehicular mounted with ALICE backpack.	AN/GRC-160 AN/GRC-125 AN/VRC-46
AN/VRC-92	Two RT-1439s and two power amplifiers. Dual long range capabilities.	AN/VRC-45 AN/VRC-49

more radios. On the other hand, jamming of a broad band of frequencies requires spreading the transmitter power over a number of frequencies. This reduces the range and effectiveness of a rear-area jam. However, broad-band jamming is more effective because a larger number of single frequencies are jammed.

ITT recognizes that the key defense to jamming is to change frequency often enough to avoid the effects of a jammer. This is accomplished by coupling a digital frequency synthesizer to a microprocessor. A software program tells the central processor unit (CPU) what frequencies to use and the CPU tells the synthesizer the frequency to develop. By repeating this sequence very rapidly, the SINCGARS RT-1439 hops (changes) frequency greater than 100 times a second.

However, some countries are developing jammers that can monitor the FM band and can also rapidly change frequencies. In fact, some smart jammers can even predict the frequency to be used and can get there first. To thwart this possibility, the change of frequencies must be random. Total randomness is chaotic and unpredictable. Such selection of operating frequencies cannot be predicted by a jammer, and only by chance can a station be jammed for 1/100 of a second or less.

Randomness would be ideal to avoid jamming. However, frequency selection must be predictable to keep transmitter and receiver together. Otherwise, the receiver would receive only brief, random sections of the transmitted message. Therefore, ITT developed a pseudo-random process for frequency selection.

The process of Frequency Hopping involves three main parameters which are stored in each radio in a net. The first is a Hopset, a "menu", or listing of all the frequencies that can be used, which must be common to all communicating RT's. The second is a TRANSEC, a code word, or key variable, which determines the selection process of the frequencies on the menu. The third is time. Unless the frequencies selected from the menu are used at the same time, communication will be impossible. The SINCGARS radios are very tolerant of time differences between transmitting and receiving radios, but it is mandatory that the identical Hopset and TRANSEC be in all communicating radios.

In summary, the new SINCGARS radios are the most sophisticated and reliable radios ever produced; they effectively counter the three threats to radio communication: interference, interception, and jamming. SINCGARS is easier to operate and maintain than earlier model radios, it has incorporated the most up-to-date technology today, and it will eventually make the US Army's communication system one of the finest in the world. Table 3 shows the many SINCGARS configurations available today.

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