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the *Lenkurt* Demodulator

Worldwide Defense Communications...

In the last five years the Department of Defense and its Defense Communications Agency have been implementing two worldwide communications networks, known as AUTOVON *and* AUTODIN. *As the needs of the world change, so do the responsibilities of the communications industry. Close cooperation between the Federal Government and private enterprise has been necessary to successfully carry out such a project.*

This article briefly reviews the needs for such a communications system, and gives an overall view of its functions and capabilities.

At a time when the United States military and diplomatic forces are spread around the globe in proportions greater than at any time in history, communication is decidedly *the* most important factor in establishing and maintaining centralized control. The military tactic of selective response — retaliation in proportion to the enemy's action — has placed a tremendous burden on national communications agencies. They must gather and assimilate pertinent information, transmit it reliably to centralized locations, and disseminate directives instantly to field forces, all in time limits measured in minutes. Actions, diplomatic and military, must share a high degree of worldwide coordination, with decisions in one corner of the world in concert with those in every other part of the world.

Traditionally, communications have been centralized within each branch of the Armed Forces. The Army, Navy, and Air Force have maintained their own individual global networks serving their own needs. Policy coordination existed at higher levels of command, with directives filtering down to field commands through separate military channels.

Post-war years saw the growth of numerous civil and Government communications channels criss-crossing the nation and the world. For example, the National Aeronautics and Space Administration (NASA) operates a specialized and complex worldwide network for continuous contact with astronauts in flight. Additionally, the State Department, the Federal Aviation Agency (FAA), the Interior Department, the Immigration Service and others find need for their own communications systems linking centralized control with numerous locations.

Then came another compounding factor — the need to transmit high speed data between many of these points. In a very few years computer technology grew to giant proportions, and telephone circuits were no longer simply paths for human conversation, but carriers of a new machine language made up of high speed, coded pulses. Equipment sophistication was forced to meet this new demand.

New Technology

Miniaturization, largely the result of intensified aerospace research for smaller and more reliable on-board electronics in spacecraft, added to the communication engineer's ability to create extremely small broadband components and fast switching methods. Transistors, diodes and others in the solid state family were added tools for building high capacity communications systems in small packages, with fewer heat problems and power needs.

At the same time, the communications industry attempted to keep up with the increasing demands for service and reliability by establishing more and more routes across the country, and laying thousands of miles of ocean cable to match the needs of around-the-world message delivery.

Soon it became increasingly obvious that the duplication of effort being made by the many agencies serving national needs were not only inefficient because of incompatibility and needless duplication, but were making it more and more difficult to maintain centralized control.

DCA Established

In May 1960, the Defense Communications Agency (DCA) was formed to coordinate military communications. At about the same time, concepts involving all Government agency communications were formulated into a plan known as the National Communi-

Figure 1. The Defense Communications Agency coordinates worldwide military communications through the AUTOVON *and* AUTODIN *networks.*

cations System. Under this plan, duplication was reduced in all communications systems under government control. As one system developed, no others were to be authorized for the same purpose. Supplementing this concept, the DCA's precise mission was to form a single, integrated Defense Communications Systems (DCS) from existing military networks.

To meet the long-haul, point-to-point telecommunications requirements of the Department of Defense, the DCS has been faced with problems of technological and geographic enormity. The system must be capable of providing instantaneous service almost any place in the world, withstanding both natural and man-made failures, moving large volumes of traffic, and satisfying the need for highly secure (classified) communications.

To accomplish this, two major networks are being implemented: AUTOVON (Automatic Voice Network) and AUTODIN (Automatic Digital Network). Where possible, such as in the Continental United States (CONUS), telephone and telegraph communications facilities are being leased from the common carriers. Overseas, the Government is building and operating most of its own facilities.

Existing military networks became the skeletons for the two DCS networks. AUTOVON, primarily a voice network, is built on portions of the Strategic Army Communications System (STARCOM), the Army's Switched Circuit Automatic Network (SCAN) and a switched network developed for the North American Air Defense Command (NORAD). Similarly, AUTODIN has used for its backbone the Air Force Data Communications Network (AFDATACOM). Both AUTOVON and AUTODIN will eventually provide a multitude of fast, computer-controlled automatic switching centers all over the world. Many of them are already in use.

AUTOVON

AUTOVON in the Continental United States was initiated with seven important switching centers — soon to become nine — and will continue to grow until there are 74 stateside locations (including as many as nine in Canada) and 23 overseas centers. Of those overseas, seven will be in the Pacific, one each in Alaska and Panama, and fourteen in the Europe-Mediterranean area (Figure 3). For the most part, the automatic switching centers will be located outside heavy industrial areas or other potential prime targets. Interlacing the switches will be numerous alternate routes for back-up and computer-controlled rerouting in case of failure or overload conditions.

The automatic switching centers for AUTOVON serve much the same function as the telephone company central office, providing circuit connections for all users, and interconnecting with a large number of trunks to other switching centers. The automatic centers offer many advantages over manual or semiautomatic techniques, including less restoral time in case of breakdown, and reducing the quantity of full-time allocated (or dedicated) circuits necessary. Automatic switching provides approximately 20 percent more capacity than previous methods, and survivability is three to four times greater.

AUTOVON Services

Four types of users will be connected to the AUTOVON switching system (Figure 2). General purpose subscribers will include most military installations, who will have service through their local PABX. Selected personnel will have direct access to the network through push button, touch tone telephone sets. Off-hook hot line service will be installed for certain command and control operations, and special grade service will permit use of some circuits for data and facsimile. In addition to these basic users, there will also be the capability of organizing special networks within AUTOVON for specific purposes. The automatic switches will be able to handle either the new tone dial signal from push button instruments, or conventional dial pulse signaling through the PABX.

A directly dialed connection through AUTOVON will be provided in about four seconds; difficult conditions may

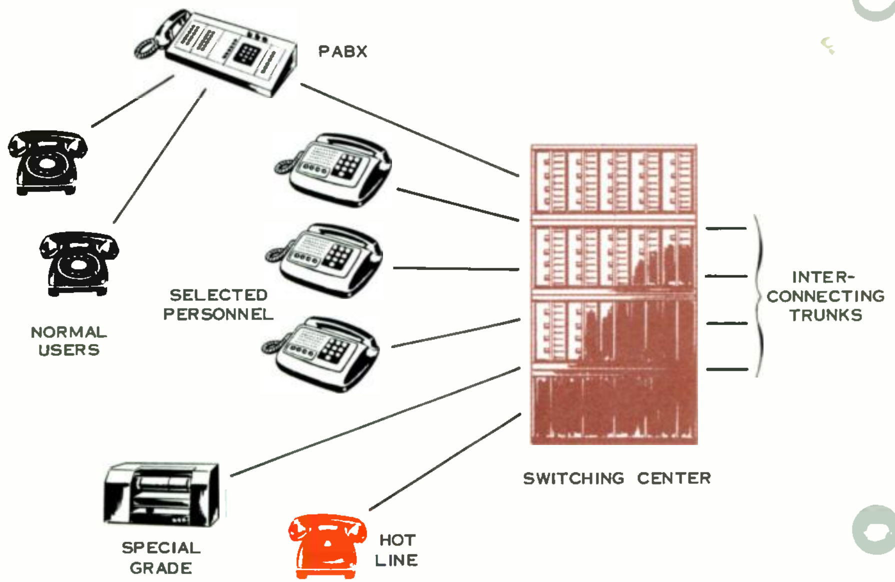


Figure 2. AUTOVON *switching centers will accept a variety of subscribers, providing direct connections to the network for priority and hot line telephones, normal phone use through* PABX, *and limited data and facsimile.*

lengthen this to a maximum of 10 seconds. Hot line service will be completed in less than two seconds. In addition, sophisticated memory and logic circuits will provide a four-level priority service, cued by push buttons on the touch tone telephone instrument. High priority calls will be routed through otherwise tied-up channels by seizing the circuits necessary to complete the call.

Priority 1 authorization will be held by the Secretary of Defense, Secretaries of Military Departments, Joint Chiefs of Staff, commanders of unified and special commands, and officers of four-star rank. Priority 2 will be shared by the operation deputies of the military services; the Director of the Joint Staff, Joint Chiefs of Staff; the Director of Operations, Joint Staff; and the Joint War Room operational communications.

Priority 3 is used for operational communications by other general or flag officers, by tactical commanders, and by the unified and specified command war rooms and service war rooms. Priority 4 applies to other urgent official communications of an operational nature. All other official communications are categorized as Priority 5.

Other services available to AUTOVON subscribers include conference call flexibility, allowing callers all over the world to be joined in conversation — as many as 30 or more at one time. Callers have at their disposal broadcast facilities, needed to disseminate information to large numbers of persons in remote areas, and recorded announcements which may be stored in the network for future release. Dial assistance switchboards will be available at various locations in each country to meet requirements for information, directory, intercepting, recording, or conference call connections. Abbreviated dialing will be provided for often-dialed numbers, and computer memory banks controlling switching and routing will also be open for reprogramming should the need arise.

AUTODIN

The AUTODIN network is the data equivalent of AUTOVON, and will process digital traffic for all commands of the Armed Forces. The initial increment of AUTODIN in the United States includes five AFDATACOM major relay centers currently operated by the Air Force. Added to this will be four more switching centers in the U.S. and 10 overseas: three in Europe, one each in Alaska and the Caribbean, and five in the Pacific (Figure 3).

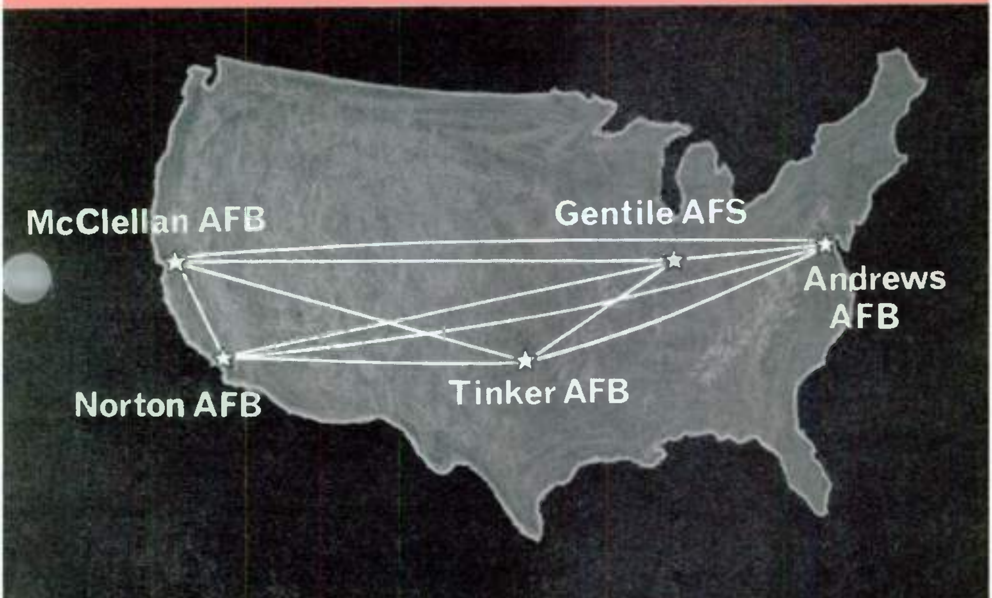
AUTODIN is designed for use with punch cards, perforated or magnetic tape, teletype, digitalized graphic signals such as facsimile, and computer-to-computer language (Figure 4). Digital coding techniques also will provide for secure communication of classified information over the network. With full duplex, two-way connections between centers, sending stations will receive immediate confirmation of message delivery. Automatic equipment will hold a circuit until an acknowledge signal is received from the other end.

AUTODIN wideband switching and transmission circuits will allow processing large volumes of digital data. One common teletype coding technique requires 7½ binary digit pulses, or *bits*, to identify a single letter. This includes start and stop pulses. Assuming an average of 6 letters per word, a 100 word-per-minute teletype system must have a speed of 75 bits per second. In this reference, it is interesting to note that a man can talk at approximately 16 bits per second, or absorb about 60 bits per second when listening. Computers and other digital devices will transmit

AUTOVON

Figure 3. Automatic switching centers are being built around the wor

AUTODIN



own in the United States are the initial installations now in operation.

over AUTODIN at rates anywhere from 75 bits per second to as high as 4800 bits per second. The system will have the equivalent capacity of more than 160,000,000 words daily, and may be expanded above this.

AUTODIN Switching

To provide a smooth and efficient flow of information through the network, AUTODIN centers utilize both circuit and message switching. Circuit switching is the common practice of connecting the calling party directly to the person (or machine) being called. However, to improve handling of large volumes of digital traffic, message switching allows storage of incoming messages until they can be forwarded to the next switching center, or to their ultimate destination. In this way, as soon as a switching center has relayed a message to another center, it is free for a new incoming call. The technique avoids long delays under "busy conditions", and prevents worldwide circuits from being tied up while one message is being completed.

The AUTODIN switching center is similar to that of AUTOVON, although its needs and functions are specialized for handling data-type digital signals rather than voice. Overall control of the center is maintained by the communication data processor units. In addition, the circuit and message switching units are interconnected for versatility.

Four types of services can work into AUTODIN through the switching centers. They are identified as compound, magnetic tape, high speed teletype, and

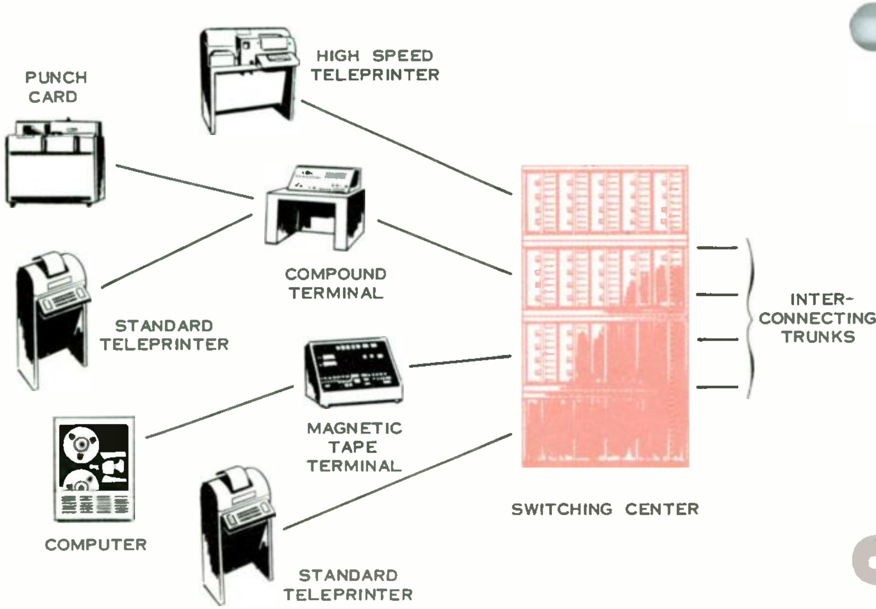


Figure 4. AUTODIN *switching centers work with four types of data terminals. Computer-controlled circuit and message switching give the network the equivalent capacity of over 160,000,000 words daily.*

standard teleprinter terminals. The compound terminal transmits and receives teletype and punch card messages. Magnetic tape terminals serve to connect computers to the system. High speed teletype terminals operate similarly to the compound terminal except that their rate of transmission is higher. These three terminal types require elaborate circuit control methods to insure acknowledgement of messages received. The fourth input to the network is the standard teleprinter terminal.

Leased Facilities

In the United States and wherever else possible, facilities for AUTOVON and AUTODIN are being leased by the Government from existing telephone and telegraph companies. In the total National Communications System, of which DCS is a part, over 30 million channel-miles are devoted to AUTOVON and AUTODIN. Facilities outside the Continental United States are in 96 different countries and are mostly owned by the U.S. Government.

A total of 182 major and minor relay stations will serve the networks, with about 2200 tributary stations connected to them. One of the prime reasons for this large number of stations is survivability through decentralization — a most important factor to the military. Switching centers will be built mostly underground in what are called "hardened" facilities. Trunks in and out of these centers also will be heavily protected. In addition, a multiplicity of transmission means and paths will increase the survivability. Key components along the transmission system will be provided with mobile replacements — in fact, many switching centers will be capable of being airlifted to more secure locations.

Wherever possible, the same trunks will be used by both networks. On a dial-up basis, AUTOVON callers may actually be using AUTODIN trunks to avoid unneeded duplication. However, this in no way affects the justifiable need for redundant circuits in all military networks. It merely eliminates building two facilities over parallel paths in virtually the same locations. Also, it is thought that the increased desirability of secure voice communications will force more and more AUTOVON conversations to the easily coded digital transmission methods of AUTODIN.

Both networks will rely on most every means of transmission available, including telephone cable, microwave, high frequency radio, troposcatter, and undersea cable. The Defense Communications Satellite Progam, established by DCA, is studying the feasibility of satellites in the systems, and has planned for a series of synchronous or near-synchronous satellites to be launched in 1966. In addition to adding more paths to increase survivability, satellites could provide communications to remote areas as quickly as ground stations could be set up.

Conclusion

AUTOVON and AUTODIN have grown from the widespread military and diplomatic forces' need for reliable contact with each other, and their responsibility to centralized command. Technological advances in recent years have made possible the sophisticated machinery to carry out such a task. Indeed, while it will be a number of years before the entire Defense Communications System is ultimately completed, it is surely the most advanced telecommunications network in the world today. The telephone industry, by playing a valuable role in the construction and operation of AUTOVON and AUTODIN, will undoubtedly profit greatly through association with such a project.

GLOSSARY

Listed are a number of terms often encountered in literature about AUTOVON and AUTODIN and are a supplement to those terms used and explained in the accompanying article.

ADPE—Automatic Data Processing Equipment. As a system, communications and data equipment linked together to process and transmit data.

ANALOG—Literally, resembling something else; the voltages on a telephone line are the *analog* of the original speech. In computers, the principle of performing calculations by measuring voltages, resistances, etc., as opposed to the counting processes in a digital system.

AUTOMATIC ELECTRONIC SWITCHING—High-speed electronics techniques used to control small mechanical switches in completing connections between users. Computer controlled, automatic switching in AUTOVON/AUTODIN permits priority routing, quick restoral in case of failure, dial-up conference calls, and many other services without an operator.

BAUD—The unit of speed in the transmission of binary information, corresponding to one bit-per-second. Standard 100 word-per-minute teletype transmission operates at 75 bauds, or 75 bits-per-second.

BINARY DIGIT—A unit of information in a two-element binary code. Commonly referred to in the contracted form, *bit*.

CIRCUIT SWITCHING—Common central office switching where two telephone lines are connected in order to complete a call.

CONUS—Continental United States.

DIGITAL DATA—Information expressed in numerical values based on some particular base numbering system. The binary system, for example, uses a base of two digits.

EDPE—Electronic Data Processing Equipment.

FULL DUPLEX—A communications system allowing simultaneous transmission in both directions. A telephone system is full duplex.

MESSAGE SWITCHING—A "store-and-forward" capability used in AUTODIN switching centers allowing messages to be recorded, then forwarded at a more appropriate time.

OFF-HOOK—A *hot line* service providing instantaneous and automatic ringing at a distant phone when the receiver is lifted at the local subscriber's set. Also known as *automatic ringdown.*

PABX—Private Automatic Branch Exchange. An automatic version of the PBX switchboard.

SECURE COMMUNICATIONS—Transmission methods employed to prohibit unauthorized persons from gaining access to classified messages. May include cryptographic coding. AUTODIN, using digital coding techniques, can easily be made a *secure* network.

SWITCHING CENTER—The centralized location of automatic switches, where calls are routed, or stored and forwarded as in AUTODIN message switching. Includes switching units and computer processing units.

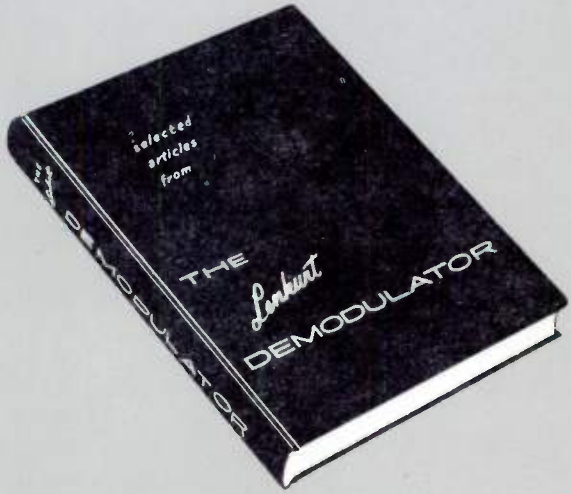
TOUCH TONE DIALING—Multiple-tone dialing technique replacing the common dial pulse system. The telephone instrument has push buttons instead of a dial, and sends various tones corresponding to address numbers.

NOTICE

The present *Demodulator Reprint Book*, published in 1959, is OUT OF PRINT and copies are no longer available.

A NEW *Demodulator Reprint Book* is now being prepared. This larger revised edition will contain selected *Demodulator* articles from issues published through December 1965. The new cloth-bound book will be a valuable source of reference for subjects relating to telecommunications. An announcement will be made in *The Demodulator* when the new book is available.

THE EDITOR
THE LENKURT DEMODULATOR



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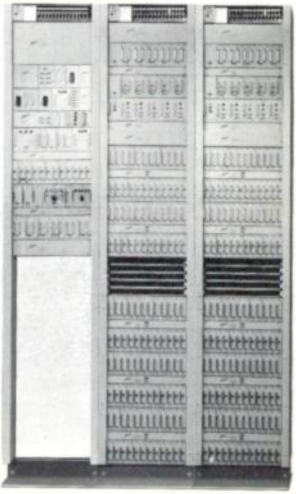

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