FROM FLARES TO SATELLITES

A Brief History of Air Force Communications

Larry R. Morrison
Air Force Communications Agency
Office of History

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The Early Years

"What hath God wrought?" questioned Samuel F. B. Morse in May 1844 in the first long-distance message transmitted over his invention, the telegraph. Over 30 years later, in March 1876, Alexander Graham Bell's more prosaic first message, "Mr. Watson, come here. I want you." ushered in the age of the telephone. Unlike these two inventions, no single scientist or inventor can be credited with bringing the idea of radio to fruition. Instead, there is a long list of people who contributed to the development of the medium. They include such men as James Clerk Maxwell and his theory of electromagnetic radiation, Jacques and Pierre Curie and their work with crystal oscillations to control frequency, Amos E. Dolbear and his early wireless communications apparatus, Heinrich Hertz and his pioneering work with high frequency waves, and Guglielmo Marconi and his experiments with "wireless" (i.e., radio) communications.

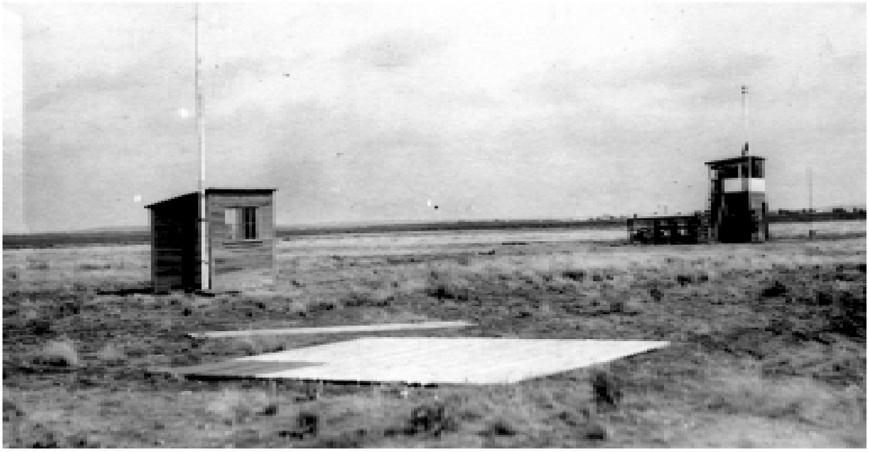
Aviators in open cockpit bi-plane demonstrate the latest in aviation radio equipment, ca. 1917.

Combined, what these three inventions had wrought was a communications miracle that diminished time and distance in the transmission of information. All would also have a profound effect upon what would become Air Force communications.

Communications, or the art of transmitting information, is as old as man himself. But the communications we know today are, by necessity, more complicated and more pervasive than earlier methods. Today, communications constitute the pulse of the world and, within the military establishments, are the means by which commanders execute command and control of globally dispersed forces.

From the earliest days of manned flight, farsighted individuals had predicted that the destinies of aircraft and communications would be closely linked. In many ways, the airplane and radio came of age together. In 1909, the American military acquired its first aircraft. One year later, the first message was sent by radio-telegraph from a plane to a receiver on the ground. In 1911, a group of planes was directed in formation by radio-telegraph, and by 1917 radio-telephones for aircraft were in production. By the end of the decade, the Aviation Section of the Army Signal Corps was actively experimenting with two-way air-to-air and ground-to-air communications.

By World War I most nations had experimented with the very noisy radio, or wireless, in airplanes, but throughout the war messages by such means were difficult to hear. Indeed, a hand-written note dropped in a tube or pouch, attached to a parachute or simple streamer to attract attention, had proven during the war to be more reliable than a radio for sending a message from an airplane to the ground. Airmen working with ground forces gave prearranged signals with flares or aerial maneuvers. For communicating in the other direction, ground troops displayed panels in sundry patterns or resorted to flares, smoke, and lights to convey prearranged messages to airplanes. All of these primitive methods of communication persisted through the first half of the 1920s.



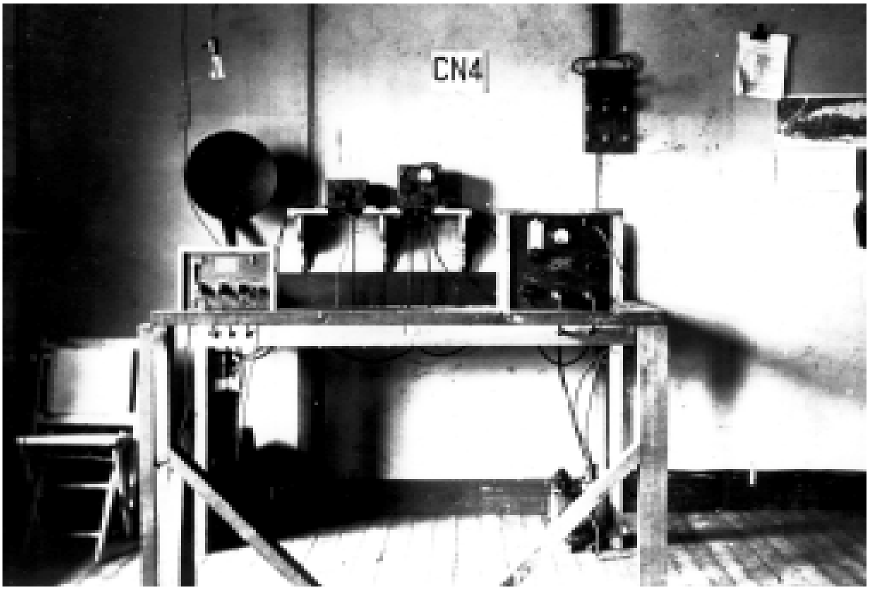
Radio stage at Kelly Field, Texas. Observation stand on right, receiving station on left, antenna strung between poles, and ground signalling strips in foreground, 12 November 1918.

Interwar Period

Some progress in Air Service communications was made after the war. Early in 1920, the War Department shifted to the Air Service responsibility for installing, maintaining, and operating the radio apparatus of its units and stations. The Air Service was not allowed to take over equipment development, but the Signal Corps established an Aircraft Radio Laboratory at McCook Field, Ohio, for closer coordination between the two services.

The first Air Service aircraft to use radios on a regular basis were the bombers of the 1st Provisional Air Brigade which carried voice sets to talk among planes in formation. In addition, each formation's control plane also carried a spark set of longer range to communicate with the station at Langley Field, and the naval base at Norfolk, Virginia, or U. S. naval ships along the line of flight. Gradually, observation units adapted two-way radios for adjusting artillery fire.

Experience with radios, together with modifications of apparatus and procedures, steadily enhanced communications.



Radio station of the 1st Observation Squadron, Mitchell Field, New York, 1923.

During the 1920s the Signal Corps developed a family of radios, the SCR-130 series, for pursuit, observation, and bombardment. Each set of radios was slightly different and carried its own enumeration. For example, SCR [Signal Corps Radio]-133 was the pursuit set which assured voice communications between aircraft to a distance of five miles.

Many problems remained with this SCR-130 series of radios. Electrical interference caused reception trouble. Ignition systems needed shielding, amounting in some cases to the complete rewiring of the aircraft; however, such complex rewiring for receivers and transmitters often caused fires in the aircraft. Wooden planes had to be metalized by adding wire and metal strips to wings and fuselage for adequate grounding. All metal required bonding to prevent absorption of radiated energy, eliminate the danger of sparks between metal parts, and reduce receiver noise. Early radio sets also weighed so much that the payload and fuel load had to be reduced when radios were carried on the aircraft.

Despite static and interference from the electrical systems of airplanes, the pilots usually could read telegraph signals. On the other hand, microphones picked up so much noise from the engine and from the rush of air in an open cockpit that flyers usually could not understand spoken transmissions. Not surprisingly, because of these problems, some pilots developed such an antagonism towards radios that they tossed the sets overboard and reported them as lost due to accident. Correcting these problems demanded extensive experimentation and development.

The search for suitable aircraft antennas was among the more critical technical problems that had to be solved. The masts and other fixed antennas sometimes used provided only short-range communications. More often the antenna consisted of a wire from 100 to 200 feet long, weighted at the end, and let out from the plane to trail

Installing radio equipment, ignition shielding, bonding, and metalizing on a Douglas O-2 at Chanute Field, Illinois, June 1925.

behind. A trailing wire antenna gave greater range than a mast, but presented a hazard to other planes and prevented flying in close formation. If the pilot maneuvered suddenly, the antenna snapped off. If he flew too close to the ground, the wire caught on a tree or other object and pulled off. So unpopular were these trailing antennas with many of the pilots that "accidental" destruction was not that uncommon.

In 1928, a board of Air Corps and Signal Corps officers, headed by Major (later Lieutenant Colonel) Horace M. Hickam, concluded that two types of radio communications were required. The first type needed was "command" communications within a pursuit, bombardment, or attack unit in the air, or between units in combined operations. The second type the board labeled "liaison" communications, or those between aircraft in the air and Air Corps or other units on the ground. Unfortunately, the equipment on hand did not meet either of these requirements, but the board's recognition of the types of equipment needed would point the way for future developments.

Increasingly, the Air Corps came to realize that accurate and current weather information and good communications were essential for the movement of aircraft and units for both peace-time training and war-time operations. Federal airways, though useful, did not always furnish service when and where the Air Corps needed it. The Army's communications systems, run by the Signal Corps, gave priority to administrative messages and did not function fast enough for aircraft movement and operations. An aircraft sometimes reached its destination before the message announcing its arrival.

One individual who recognized the need for an efficient airways communications system was Lieutenant Colonel (later General of the Army) Henry H. (Hap) Arnold. In July 1934, Arnold led a flight of ten Martin B-10 bombers on a record-setting, long-distance flight from Bolling Field, Washington D.C., to Fairbanks, Alaska, and back. Careful advanced preparations had been made along the route, and the communications essential to navigation and the transmission of weather data were provided. As a result, the flight was never out of contact with communications stations on the ground. Information

Air Corps field radio equipment, ca. 1933.

on weather and local conditions thus eliminated one of the main reasons for errors in navigating across the northwest wilderness.

In contrast, a later training mission flight led by Arnold encountered a series of difficulties due to bad weather and unreliable communications. These experiences convinced Arnold and a dedicated cadre of men around him, such as Captain (later Major General) Harold M. McClelland and 1st Lieutenant (later Brigadier General) Ivan L. Farman, of the need to establish an effective, integrated, centrally-managed military airways communications system. Eventually, these efforts culminated in the establishment, in November 1938, of the Army Airways Communications System.

As part of this effort, the Army Air Corps embarked upon a program of spanning the continental United States with military airways connecting Air Corps fields and installing, in cooperation with the Civil Aeronautics Board, the required radio ranges and ground communications facilities required both for the exchange of information on aircraft movements and for air-to-ground communications. Such navigational aids and communications facilities reduced the pilot's dependence on the "iron compass" (railroads), and heralded the beginning of marking off airspace into definite traffic lanes.

The establishment of the Signal Corps Aircraft Laboratory at Wright Field, Ohio, led to the joint development with the Air Corps of radio communications and navigational equipment designed specifically for military aircraft operations. Under the leadership of Air Corps officers, pioneer work was done at the Aircraft Laboratory in radio direction finding and instrument landing systems.

By the late 1930s, political leaders in the United States finally accepted what military members had been saying for years: the major portion of American radio equipment was rapidly approaching obsolescence. Funds were finally forthcoming to initiate a new program for tactical radio development. Coming out of this effort were the wholesale use of crystal control and the adaptation of frequency modulation.

World War II

Such developments, however, came too late to be of much benefit when American forces entered World War II, and they had to rely heavily on the communications systems of Great Britain. American aircraft, for example, were equipped initially with British-supplied Very High Frequency (VHF) radio equipment to meet the requirements for operations in a common ground environment. Such equipment was later manufactured in the United States. These initial adaptations had an impact on American world-wide forces to the extent that at the end of World War II all allied combat aircraft and associated ground units had been converted to VHF for air-to-air and air-to-ground communications in order to provide compatibility in air operations.

The two most significant features of World War II which dictated the scope and complexity of the communications systems required were the global nature of the conflict, and the advent of air power as a decisive influence on the conduct of the war. The operation of American forces in all corners of the world required the immediate establishment by the Army and Navy of world-wide communications, centering upon Washington D.C., for strategic direction, intelligence, administration, and logistics support.

In the early days of the war, much of the needed long-distance communications was provided by high frequency (HF) radio systems which provided an economical means of long-haul, point-to-point communications, even though the usefulness of HF was limited by several factors. In the first place, HF, as it was then configured, had

Radio station of the 2d Army Airways Communications Service Wing, Tehran, Iran, 1943.

limited capacity. It provided only four voice channels, or an equivalent combination of voice, teletype, data, or facsimile on each circuit. Moreover, because of the effects of atmospheric propagation, HF sometimes had problems with reliability.

The advent of air power resulted in a struggle by both sets of belligerents to achieve air superiority. The inevitable outgrowth of this struggle was the perfection of radar as a basic tool of air defense. The disposition of radars in the combat area required the operation of combat centers, in the ground forces and aboard ship, to direct the defensive operations of fighter aircraft and anti-aircraft weapons. Adequate, accurate, and timely information and direction dictated the pattern, quantity, reliability, and types of communications installed. Communications for transmission of weather data and aircraft movements in the area had to be provided. Similarly, communications terminals equipped for a complex of point-to-point and air-to-ground operations and message centers had to be created. Additional facilities were also required for the coordinated direction of air operations. Thus, the communications systems and facilities provided attained an order of accuracy and speed in the handling, assimilation, and use of combat data never previously experienced.

During the war years, state-of-the-art communications made great leaps forward as military planners and engineers reacted to the conditions and needs imposed by war. For example, the Army Air Forces' frustrating efforts to achieve precision bombing lead to renewed American efforts to plot accurate courses which, in turn, prompted the development of improved navigational aids.

One product that came out of this development effort was ground controlled approach (GCA) radar. First fielded in 1944, GCA used both radar and the radio-telephone to pick up the airplane miles from the airfield and instruct the pilot in the proper speed, altitude, and direction needed to stay on the correct glide path to the runway for a safe landing when either darkness or weather conditions prevented the pilot from seeing the runway.

The use of this system was quickly adopted because it saved lives and aircraft, and also because the aircraft required no special equipment and the pilot needed no special training. Dr. Luis W. Alvarez, the inventor of the system, was presented the coveted Collier Trophy in 1946 for this achievement. Proven during the war, GCA was quickly adopted by civilian aviation.

During the war, radio and wire systems were also improved. For example, the Army's Fort Monmouth, New Jersey, laboratories perfected the development of FM radio relay, producing a communications break-through which integrated radio into wire systems with equal transmission quality and dependability. By the final campaigns in Europe in 1945, Western Electric had fielded a time division, multiplexed, microwave radio relay system.

The communications lessons learned during the war were major. In addition to the primary realization that equipment rapidly became obsolete, it was recognized that as the mobility, firepower, and complexity of modern war increased, the quantity and quality of communications support must also increase.

Post-War Period

In 1947, the Army Air Corps became the United States Air Force. In addition to adapting to a new service and new procedures, people also had to adjust to a personnel strength that had dropped significantly from the levels attained during the war. Initially, however, Air Force communications changed little from the war period. In point-to-point communications, the Army Command and Administrative Network (ACAN) formed the pattern of operations. The equipment installed was Signal Corps single-channel voice, telegraph, and torn tape relay, operated over low and high frequency radio and wire carriers.

One of the lessons coming out of World War II was the need for integrated communications systems. The first such integrated system for the Air Force was the Military Flight Service Communications System, installed in 1947. It handled flight plans and aided in the control of aircraft for all Air Force bases within the continental United States. The system's nine centers forwarded to their respec-

A C-54 flies past ground controlled approach (GCA) units on departure from Rhein-Main Air Force Base, Germany, during the Berlin Airlift.

tive destinations departure times and routes for every Air Force originating flight. Rescue operations were automatically initiated when an aircraft was overdue, based on this information.

At the same time, navigational aids were set up along established air routes to enable aircraft to reach their destinations safely. Aircraft warnings, weather changes, and alterations in flight plans were instantaneously relayed to aircraft by high, and very high, frequency radio. The airfields themselves were connected to one another by interphone and teletype.

In the area of air defense, human operators on the ground watched radar scopes, then verbally guided subsonic manned interceptors towards suspect aircraft, and manually passed control to the next sector as the aircraft moved beyond the limited range of their radars. Air Defense Control Centers (ADCCs) received verbal data from these operators, and the information was displayed manually by grease pencil on transparent plotting boards for use by commanders. Command and control functions between the ADCCs and the aircraft were by low and high frequency telegraphy and by high frequency or very high frequency voice.

The aircraft itself was equipped with detection, navigational, and bombing radars of limited range and accuracy. Navigational aids included the Adcock four-course radio range and triangulation by Long Range Aid to Navigation (LORAN) and Short Range Aid to Navigation (SHORAN). Point-to-point communications equipment was single-channel voice, telegraph, and tape relay, operated under low and high frequency radio and wire carriers.

During this period, the demands for information handling capacity and versatility increased beyond the capability of the techniques available. To satisfy those demands, the U. S. Air Force embarked on a program of installing ionospheric and tropospheric circuits. The Air Force actually pioneered the development of tropospheric scatter communications, more commonly called "tropo." Using the lowest area of the atmosphere as its environment, tropospheric scatter employed the distinctive layers of temperature and moisture content to reflect and refract radio waves. Tropo was a medium-capacity system that could support up to 120 voice channels at a single time. Unfortunately, this system also had drawbacks, because for all practical purposes each link was limited to about 300 miles and at that distance would not support the full 120 channels. Obviously, this range limitation meant that tropo could not be used on transoceanic paths. However, the utility and trustworthiness of the system was confirmed with the installation of circuits connecting the radar stations in the rugged terrain of Labrador and Newfoundland. Under Arctic conditions where other means of radio communications could not be depended on, tropospheric scatter provided a system reliability of better than 99 percent.

During this same period of time, the Air Force also began to experiment with microwave systems to provide high-capacity, high-quality communications over "line-of-sight" distances. These systems were used extensively for intersite communications and for multi-relay, long-haul systems in those parts of the Pacific and Europe where military installations were relatively close together.

By 1950, despite the increased size and scope of Air Force activities, technological advances enabled personnel to provide more services at more bases with fewer people than had been possible previously with the older, more manual-type equipment. In air traffic services, for example, control tower construction was constantly and radically changing during the post-war years, both to improve effectiveness and to incorporate the improvements in electronics. A variety of improved consoles, power units, and recorders were developed and steadily improved, relieving the tower personnel from dependency upon their eyes and reactions alone.

Standardized equipment and procedures came into the inventory. Radio and radar beacons, radio and radar ranges, and air-to-ground communications were installed, maintained, and operated so that regulated "highways in the skies" began to take shape. Aircraft used standard radio compasses to take bearing on radio beacons, although special receivers were needed to use the radar beacons and ranges. Air-to-ground stations along the routes provided a system of exchanging information with the aircraft through high frequency voice or radio telegraph transmissions. Pilots were kept informed of changing weather conditions, other aircraft in the area, and any necessary alterations in flight plans.

Beginning in 1951, all Air Force air/ground radio stations were converted from continuous wave Morse Code to radio telephone. The smaller crew sizes on the new jet bombers did not allow for a radio operator, prompting the conversion to voice communications. The demands of both military and civilian agencies for use of the radio spectrum led to the adoption of the ultra high frequency (UHF) band. It was used for short-range communications with aircraft as well as radio relay. Newly developed equipment permitted the rapid selection of a large number of channels. The use of this frequency band was extended to all countries in the North Atlantic Treaty Organization (NATO), enabling allied military aircraft to communicate with one another and with each nation's ground stations.

Ground controlled approach radar became the primary means of bringing aircraft in for safe landings when the weather prevented visual approaches. It was often used in conjunction with the Instrument Landing System (ILS) which sent out a beam that aligned the aircraft with the runway and allowed for the correct angle of descent.

During this same period, improvements were also made in the avionics which interacted with the equipment and facilities on the ground. By the end of the 1950s, air-to-ground communications used the electronic spectrum from low to ultra high frequencies. Modulation techniques included AM, FM, single sideband, data link, and digitalized command. Navigation aids used operational radio, radar, stellar and inertial guidance systems. LORAN-C eliminated time-consuming manual operations by automatically computing an airplane's position. Not only were position reports obtained quickly, a requirement in operating supersonic aircraft, but they were also more accurate.

The very high frequency omni-directional range (VOR) was one of the early improved navigational aids. This omni-directional radio range system gave pilots continuous headings to the station from any point on the compass by transmitting timed pulses at very high frequency. These signals, however, traveled in a straight line and did not follow the curvature of the earth, thus were limited to line-of-sight distances.

Another kind of navigation aid that came in during this period was the Tactical Air Navigation (TACAN) system. This system employed a ground radio beacon which produced a steady stream of ultra high frequency pulses that were received by a transponder in the airplane. This transponder, in turn, translated the signal into the distance of the aircraft from the beacon whose location was known. Some of these systems were later combined with VOR to create VORTAC. These systems eventually replaced most radio ranges, beacons, and direction finders.

In the early 1950s, the changing global political climate and continued scientific developments combined to produce a critical impact on the United States Air Force. The Soviet Union had the atomic bomb by 1949 and detonated its first thermonuclear weapon in 1953. Jet aircraft rapidly replaced piston-driven aircraft. Air defense systems needed earlier detection, faster analysis, and more rapid and accurate communications to defend North America from possible Soviet nuclear attacks. No longer a local affair, air defense now covered the entire northern hemisphere and was dependent upon reliable long-distance communications.

Designed to be used with jet aircraft, the Base Air Defense Ground Environment (BADGE) was the cognitive system of the Air Defense Command. Combat Operation Centers (COCs) exercised control of defensive tactics over larger sectors. Information in the COCs was projected on the plotting board by rear projection systems which were controlled manually by operators viewing radar screens directly. Air-to-ground communications were mostly voice, using low, high, very high, and ultra high frequencies. Navigational radars were being improved, and automatic bombing radars became operational.

This system was soon outdated when the launching of Sputnik I by the Soviets in 1957 demonstrated that they had the potential to develop an intercontinental ballistic missile with a nuclear warhead. When this weapon system became a reality, the warning time needed to defend against an enemy attack was now drastically reduced to minutes. This Soviet missile threat lead to the construction of the Ballistic Missile Early Warning System, known as BMEWS, which was able to survey the air space over the Soviet Union itself.

Each progressive extension of these air defense capabilities was accompanied by increasingly demanding requirements for communications. These requirements were changing so rapidly and drastically that the basic systems and techniques which had once proved satisfactory were soon outdated. Adaptations and extensions of existing systems were no longer adequate; new capabilities had to be provided. Weapons, radar, and communications could no longer be operated as separate systems joined together by human operating links. The need to reduce the time lapse by the greatest amount possible, while attaining the highest reliability and accuracy, called for meeting stringent new requirements.

Such new capabilities became possible with the advent of the electronic computer and the development of associated data processing, conversion, and transmission equipment. The electron tube, the transistor, and a common-language system of digital data gradually reduced the human functions to maintenance and decision-making. The first attempt to incorporate these new elements into a single system was the Semi-Automatic Ground Environment (SAGE) system, which first became operational in 1957.

As the name indicates, SAGE was, indeed, a semi-automatic ground environment system, a network of control centers and radars surrounding the United States. The system constantly received and reviewed huge masses of information concerning the air space at the nation's borders. With human assistance, non-essential information was discarded, and all air traffic was plotted. As aircraft were identified, they were "tagged." Upon command, the computers, which were non-decision making, routine work-handling "brains" of the system, would simultaneously predict the individual future courses of large numbers of aircraft, monitor their actual courses, and sound an alarm upon any deviation from the predicted paths. The final result of this enormous complex of radars, communications, and computers was in the form of a display on the screen of an operating console. Aircraft within a given sector were shown in their relative positions and courses, with heights and velocities indicated. Attention of the operator was called to any unexpected change of flight path by a suspect aircraft.

Knowledge of the situation was useless unless corrective action could be initiated. To assist in this, SAGE computers were fed information on the location and capabilities of interceptors. Upon request, the computers could calculate intercept courses for any suspect aircraft.

Concomitant to these changes in air defense, point-to-point communications also changed drastically during the 1950s. The Air Force approach to missions and operations, particularly after the Korean War, shifted away from the "theater commander" concept, where joint operations and functions were centralized under a single commander, to a concept of "functional" commands which exercised vertical control. One result of this approach was that each of the major commands, such as the Strategic Air Command, had their own communications networks tying their command headquarters in the United States to their activities around the world. This allowed them complete and instantaneous control of their components in a precise time frame, whether scheduling in-flight refueling, providing weather information, or conducting airlift operations. This concept would change somewhat with the establishment of the Global Communications System (GLOBECOM), which eventually became the common-user system for worldwide communications.

Construction of GLOBECOM began in 1951, but it would be several years before the system was completed. Basically a radio system, GLOBECOM was the first integrated communications system to span the world. It was an extension of the Air Force Communications Network which was primarily a continental United States wire system. Larger than any commercial system in the world at that time, its cost of almost a quarter of a billion dollars by 1953 made it worth slightly more than Western Union. Eventually, about one-third of the Air Force's entire communications manpower resources would be associated with this network.

GLOBECOM was an integrated system of interconnected Air Force radio stations, together with leased commercial or allocated Army and Navy long-haul wire and radio channels, the necessary terminal equipment, relay facilities, communications centers, and cryptographic facilities. However, the internal, tactical, and special purpose communications systems of the various commands, used for specific missions within their organizations, were not a part of GLOBECOM.

Each GLOBECOM station had four distinct facilities: a relay or message center, a technical control facility, and remotely located transmitter and receiver plants to service the technical control facility. The last two were placed far apart to avoid being affected by local noise or transmitters. Microwave connected them all because cable was expensive and difficult to protect in overseas locations. The central nervous system of the network consisted of seven main stations which were interconnected by high-power, multi-channel radio cir-


GLOBECOM torn-tape relay center, 1950s.

cuits. Each station had spare multi-channel transmitting equipment to ensure reliability. Voice, teletype, and facsimile circuits, along with torn tape relay and off-line encryption, were used on four-channel low and high frequency radio and landline circuits. These beltline stations served 36 other stations.

In 1952, air-to-ground capability was added to the system, allowing commanders to talk to aircraft up to 3,000 miles away. In 1955, the system was renamed AIRCOM, which stood for the Air Force Communications Complex. Under this system, both 16-channel single sideband facilities and 36-channel ionospheric and tropospheric scatter systems were added. Four-channel multiplex circuits for high frequency radio and landlines became standard. Microwave relay systems with 24-voice channels, each channel capable of carrying 16 teletype channels, became common.

In 1957, the first fully automatic switching equipment was added. Called Plan 55 and operated by Western Union, this equipment served 4,400 stations throughout the world through 10 switching centers, handling 2.5 billion words per year. The automatic features of this system enabled one person to do the work of eight under the old manual system, thus saving millions of dollars annually in personnel costs.

The 1960s

The decade of the 60s marked both a challenge and a revolution in Air Force communications. There were rapid advancements in electronic communications technology and dramatic changes in the world political situation which, combined, had an impact on Air Force communications. The most visible organizational manifestation of this impact was the creation, in July 1961, of the Air Force Communications Service as a major command. Communications had always been an integral part of the various air commands, with each commander owning and operating most of the facilities needed to support his mission. Increasingly, however, the evolving character of military operations dictated centralized control over widely dispersed forces. At the same time, the mounting costs of communications equipment made individual command ownership and support increasingly prohibitive. Thus, by the early 60s, most Air Force leaders accepted the idea that command, control, and communications were inseparable, and the Air Force needed to find a way to achieve a new management concept for its growing global networks, which already transcended geographic, political, and military boundaries.

Gradually, over the next few years, Air Force communications responsibilities were consolidated under AFCS, except for those belonging to Air Defense Command and Strategic Air Command. The commanders of those two organizations contended that the tremendous importance of the air defense and strategic bombing missions of their commands demanded that they own, control, and operate their own communications. The Air Staff agreed that the participation of those two organizations in the consolidation of Air Force communications should be studied further. The issue remained unresolved until the late 1970s when these systems, too, were placed under AFCS.

In terms of communications themselves, two of the major developments in the 1960s were the increasing use of computers and the introduction of miniaturized electronic components using integrated and high-speed data circuits. The former permitted large-scale data recording and analysis; the latter opened new avenues in the communications field. In many ways, the development of high-speed, inter-base record communications systems provided the most dramatic accomplishment in Air Force communications during the early 60s.

These changes effected the entire range of Air Force communications. For example, Air Force communicators had long recognized the need to modernize and expand weather networks so they could satisfy present and future requirements. Accordingly, in 1962, the Weather Communications Center at Tinker Air Force Base, Oklahoma, was converted from manual to semi-automatic operations and commissioned to receive and transmit weather data from 143 strategically located stations. Establishment of this system made Tinker the central military weather data collection and relay point within the United States. As the Department of Defense expanded its efforts to provide more weather transmission services, the Automatic Weather Network was established in July 1965. Using three dispersed automated digital weather centers, in Japan, the United Kingdom, and the United States, this worldwide computer system collected and edited weather information, then distributed this data to military forecasting centers.

During the same period, planning began for the Air Force Data Communications (AFDATACOM) system, an automatic system for the transmission of digital data information. Originally, this network was conceived as a logistics network, called the Combat Logistics Network, or COMLOGNET. As initially envisioned, COMLOGNET would be an automatic, fully electronic, transistorized, high-speed data communications network, intended primarily for Air Force use. This system, however, soon moved beyond that limited scope and became the prime record communications network for the Department of Defense. AFDATACOM became the first high-speed, digital communications system to use advanced techniques of information handling in the Air Force. It enabled subscribers to send messages originating from teletypewriters, punched cards, accounting machines, paper tapes, or magnetic tape devices. The system used automatic electronic switching centers to convert the differences in codes, formats, speeds, and control, as well as to forward priority messages. Becoming fully operational on 4 February 1963, the network provided five automatic electronic switching centers with a total of 550 switching terminations in the continental United States.

Eventually, AFDATACOM became part of the Defense Communications System and was redesignated the Automatic Digital Network (AUTODIN). Broadened in scope far beyond its original concept, AUTODIN provided a vehicle for the efficient, global control and transmission of all forms of command and control, operational, logistics, statistical, and administrative information. Fully operational by February 1963, the primary objective behind AUTODIN was to integrate the advancements in automatic switching into a single long-haul system that would make use of all circuitry available at any given time to fulfill the priority needs of the user.

As originally constituted, AUTODIN could handle 7 million punched cards daily, the equivalent of 100 million words, and could exchange data freely among a variety of information forms. Initially, five automatic switching centers, located around the United States, were set up to handle the traffic. By the end of the first year's operation, however, the system was already saturated, and the Secretary of Defense approved 14 additional switching centers to enhance the network's capacity.

Another major development in long-haul communications in the early 1960s was the Automatic Voice Network, commonly called AUTOVON. Activated in December 1963, AUTOVON, derived from the Army's Switched Circuit Automatic Network, was designed to provide the Department of Defense with an internal telephone capability to replace toll and Wide Area Telephone Service (WATS) calls, while also allowing precedence preemption for high priority users. Development of the AUTOVON system represented one of the most significant and comprehensive telecommunications programs ever undertaken by the DOD. While the dedicated circuits used in earlier networks provided good response time, weaknesses in survivability and reliability were significant problems. The loss of a single circuit between two points disrupted communications between subscribers, and each termination placed on the dedicated circuit required a separate instrument. AUTOVON did much to correct these deficiencies.

AUTOVON became the principal long-haul, nonsecure voice communications network within the Defense Communications System. The network served the entire Department of Defense and handled essential communications concerning command, operations, and administration. It was a global network comprised of interconnected automatic switching centers and thousands of subscriber terminals throughout the world. Over the next 25 years, the network would be continually modernized and expanded to provide more service and capabilities to the users. Finally, it became a part of the new Defense Switched Network (DSN), the replacement system activated in 1990 to provide long-distance telephone service to the military.

As data processing and managing techniques became more sophisticated and demanding, communications requirements had to keep pace. To meet the increased demands, microwave and tropospheric scatter systems played a dominant role, serving as both a primary and back-up means of reliable transmission. As a consequence, it was imperative that these new techniques and equipment possess the sophistication and capabilities required to support high-density digital data networks.

To meet these needs, in the 1960s tropospheric scatter technology for long-distance communications was refined to increase the economy, accuracy, and efficiency of that method of communications. The introduction of powerful new transmitters and sensitive receivers permitted the transmission of many separate telephone conversations and telegraph messages over a single radio signal that was relatively free of atmospheric interference.

One of the most significant technological innovations to enter the Air Force's communications inventory in the 1960s was the communications satellite. The desire to use satellites for communications purposes had a long history. As early as January 1946, the Army Signal Corps had experimented with using the earth's only natural satellite, the moon, as a reflector for radio signals. In November 1959, voice transmissions actually were sent from New Jersey to California by bouncing signals off the moon. At other times during the 1950s, the moon had been used to relay radio transmissions between stations in the continental United States and Hawaii when atmospheric disturbances disrupted normal radio communications.

The first American use of an artificial satellite for communications purposes was Project SCORE. Launched in December 1958, the Signal Communications by Orbiting Relay Equipment (SCORE) broadcast the first message from outer space—a taped Christmas message from President Dwight D. Eisenhower. The satellite was then used to transmit messages between Arizona, Texas, and Georgia. SCORE was neither a passive set, nor was it a "true repeater" set. Rather, it was a "store and forward" system: upon receiving a message from a ground station, the satellite's equipment stored it on a tape recorder, and then transmitted that message when a signal from a ground station triggered the system.

The first American experiments using a satellite for true communications were begun with the launching of Echo 1 in August 1960. Echo was a passive satellite, consisting of a 100-foot diameter mylar plastic balloon, which circled the earth in an elliptical orbit varying between 945 and 1,049 miles. Experiments were conducted in which both radio and television signals were reflected off the mylar surface. An improved version of this satellite, Echo 2, was launched in 1964. In a demonstration of its practicality, signals between the United States and the Soviet Union were relayed over this new satellite.

Even while these experiments were going on, the Department of Defense, American Telephone and Telegraph (AT&T), and the National Aeronautics and Space Administration (NASA) worked together to develop active satellites. As a result of this joint effort, on 10 July 1962, Telestar 1 was launched. The same day it was launched, Telestar successfully relayed live television pictures from the United States to France. In May 1963, Telestar 2 was launched, and numerous experiments were conducted using this satellite until it went off the air two years later.

During this same period, NASA and the Radio Corporation of America (RCA) worked to develop another type of satellite known as Relay, which had two transmitters to provide more reliability. Launched in December 1962, experiments conducted with Relay 1 demonstrated the feasibility of using satellite transmissions for everything from typesetting to sending human medical charts from one location to another.

There was also a political side to communications satellite developments. In August 1962, Congress passed the Communications Satellite Act which provided for the establishment of a privately owned corporation to act as the United States' agent in international satellite agreements. Under this act, the Communications Satellite Corporation (COMSAT) was incorporated in early 1963. A year later, a consortium of nine nations established the International Telecommunications Satellite Consortium (INTELSAT). It was this group, then, that designed and developed the first global satellite communications system.

The ideal altitude for a communications satellite is 22,300 miles above the equator. From this position, the satellite appears to be stationary because it is in a geosynchronous orbit. The Echo and Relay satellites had not been placed in such an orbit because none of the rocket boosters then available were powerful enough to reach that height. The first American satellite to reach geosynchronous orbit was SYNCOM III, in August 1964. The Synchronous Communications (SYNCOM) satellites were a joint project of the DOD and NASA and were used to demonstrate the practicality of continuous, 24-hour communications, and the economic potential of the new technology.

While these experiments were going on, the international consortium launched its first satellite. INTELSAT 1, known as Early Bird, was launched on 6 April 1965. Early Bird had 240 two-way voice circuits and was put into orbit for trans-Atlantic use. Over the next six years, INTELSAT launched a series of communications satellites for both the Atlantic and Pacific. Each set was more powerful and capable than the preceding one. In setting up its overlapping coverage, INTELSAT, by 1969, rightfully could claim that it had provided the first truly worldwide satellite communications system.

While commercial satellite communications systems were making tremendous strides, so, too, were military systems. While drawing upon the technology developed for commercial satellites, the military was also anxious about meeting certain requirements that were unique to military situations. The most critical, of course, was security. If the enemy could jam or monitor the transmissions, the satellites would be essentially useless for most military purposes. The military was also concerned about the ability to expand service in a specific area, on short notice, to meet operational needs. As part of that requirement, military ground terminals had to be mobile and operate with an extremely high degree of reliability in all types of environments.

By 1967, military use of satellites became a reality. Under a project labeled the Initial Defense Communications Satellite Program, the first satellite terminal, an AN/MSC-46, was placed in operation at Clark Air Base, Philippines, on 1 July 1967. Improvements in satellite communications systems proceeded, and by November 1968, tests performed by the 3d Mobile Communications Group had proven the feasibility of a mobile ground satellite communications terminal, the AN/TSC-54. The increasing demand for satellite communications prompted the Air Staff to direct the establishment of an Air Force planning office for the testing and development of new systems; thus, in April 1969, the Satellite Test Control Terminal was activated at the Belleville, Illinois, Communications Annex of Scott Air Force Base.

In terms of control, there are essentially two categories of military satellites: those under the direct operational control of the

Joint Chiefs of Staff (JCS), such as the Defense Satellite Communications System (DSCS); and those systems managed by a specific military service, such as the Air Force Satellite Communications (AFSATCOM) system. AFSATCOM was designed specifically to meet the needs of the Air Force to communicate with its worldwide operational forces. The Air Force system had no satellites of its own, but utilized host satellite systems, such as the Navy's Fleet Satellite Communications System. The AFSATCOM system achieved initial operational capability on 19 May 1979.

Services provided by other types of satellites have also played an important role in Air Force communications since the 1960s. For example, the Defense Meteorological Satellite Program (DMSP), operational since July 1965, was designed to furnish the high resolution, near-real-time global meteorological information necessary to conduct worldwide military operations. The data gathered through this program were also furnished to the civilian community through the National Oceanic and Atmospheric Administration (NOAA). The weather information collected by these satellites helps identify, locate, and determine the intensity of severe weather. The satellites supply meteorological data to the military services' ground stations. The information collected by the satellites is stored and sent to any of the four ground stations and is then forwarded to the Air Force Global Weather Central, now located at Offutt Air Force Base, Nebraska. The information received is used to prepare comprehensive weather reports around the world.

The evolution of United States defense policy in the 1960s, from a primary orientation towards massive retaliation to one that emphasized controlled response, was the result of both gradual developments and situations that required immediate and selective responses. A series of events in this decade, highlighted by the American involvement in Southeast Asia, dramatically increased efforts to improve the responsive capability of the Air Force.

It was during this period that the continuing Cold War climate and the emergence of contingencies in "third world" countries like Lebanon and the Congo forced the Air Force to place increased emphasis on developing quick reaction capabilities. In addition, numerous events during the decade demonstrated the need for communications personnel and equipment to meet the demands of national defense in any emergency.

From the earliest days of World War II, there had been combat or mobile communications units in the Army Air Corps to support locations that lacked established communications facilities, or to ensure continued operations in the event of a national disaster or combat situation. By 1960, this capability was best manifested in the Air Force Communications Service's "Talking Bird" quick reaction communications system. In August of that year, HQ USAF directed that a prototype flyable communications "facility" be developed to conduct operational tests and evaluations as a model command and control aircraft to serve as an initial, on-site communications facility for contingencies. Ultimately, the result of this directive was "Talking Bird," an air-transportable communications package designed to be loaded in a C-130 and operated from within that aircraft after landing in a contingency area.

The complete "Talking Bird" package included 18,000 pounds of communications equipment and a 21-person team. Designed to be a self-sufficient mobile communications plant, "Talking Bird" was capable of long-range communications with any fixed station in the USAF AIRCOM system, the worldwide communications complex of air/ground, point-to-point, weather, logistics, and radio teletype relay networks. The entire facility could be loaded and airborne in four hours from first notice and operational within two hours of landing.

In its deployed configuration, "Talking Bird" provided both long-haul and short-range communications. The electronic nucleus of a "Talking Bird" communications package was a radio transmitter/receiver system operating in the high frequency band. The package contained equipment for both local area and ground/air communications. When placed in full operation, the system provided for long-haul, duplex communications, via one radio voice channel and one clear or encrypted radio teletype channel. In addition, it provided simultaneous reception of radio teletype weather data as well as

Interior of “Talking Bird” flyable communications station.

ground/air, very high frequency and ultra high frequency voice communications. The total package also included all the necessary antennas, tools, test equipment, and spare parts to keep the communications functioning.

“Talking Bird” was first used in a real contingency in September 1962 to support airlift disaster relief in Iran after a major earthquake devastated parts of that country. More significantly, when political turmoil disrupted the Dominican Republic in 1965, President Lyndon B. Johnson quickly sent in United States troops to protect the refugees and Americans living in the area. One of the first contingents to arrive was a “Talking Bird” communications package which provided services within 55 minutes of its arrival, and for 3 days served as the initial command post for the U. S. operation.

In addition to supporting disaster relief and military contingencies, Air Force communicators, throughout much of the 1960s, were used to support the United States space program. Although primarily non-military in nature, the space program did use DOD communications facilities and services whenever practical to support its missions. In May 1962, for example, numerous single sideband radio teams and equipment deployed to several worldwide locations to support Project Mercury's "Man in Space" program. In 1965, Air Force communications technicians were posted around the globe to provide communications service for the Gemini space efforts. Again, in 1968, Air Force communicators furnished support to various Apollo missions by deploying mobile communications units to strategic positions around the world.

The War in Southeast Asia

In the 1960s and early 70s, Air Force communications played a critical role in Southeast Asia. Communication support to the massive operations in Southeast Asia involved a host of specialists performing every then-known communications-electronics function and devising new ones as situations dictated. The war in Vietnam dramatically tested the responsiveness of communications operators to the various demands of tactical combat as well as counter-insurgency operations.

In the early 1960s, mainland Southeast Asia was virtually devoid of modern communications systems. The situation in South Vietnam presented American forces with unprecedented problems. For the communicators, there were no existing well-developed communications systems serving either government or military needs. Furthermore, unpredictable guerrilla insurgent activity prohibited the use of cable or wire outside protected areas, compounding the problems for communicators. The available air fields and communications facilities were outdated, largely of French design, and difficult to maintain. Consequently, American forces had to provide virtually all their own communications needs.

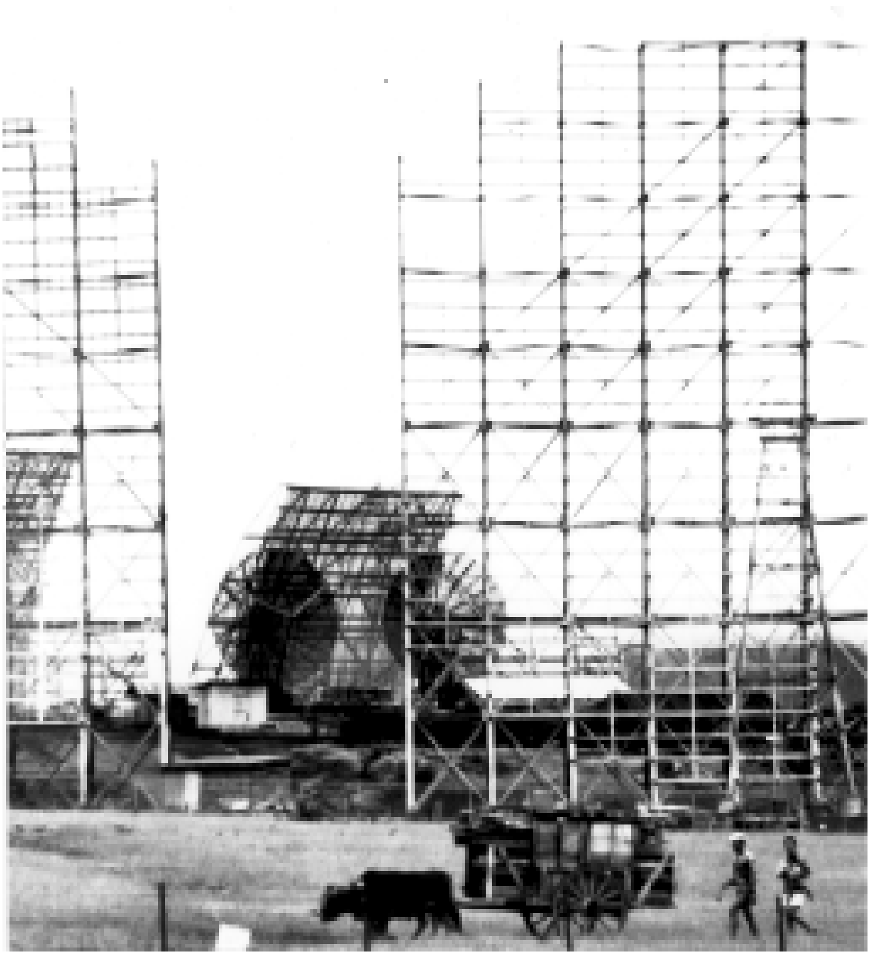
One of the most important functions performed by the early American advisors was that of air traffic control. The first USAF team deployed to Southeast Asia for this support was a detachment of the 1st Mobile Communications Group, which arrived in Thailand in February 1961. Subsequently, other teams were deployed to the area to support American and other allied forces. At the end of 1961, because of the rising tensions in the area, the Pacific Air Forces directed that a tactical air control system be installed and operational in South Vietnam within two weeks. The result of this request was that the 1st Mobile Communications Group was directed to provide voice and teletype service to South Vietnam at Tan Son Nhut, Pleiku, Da Nang, and Nha Trang. These actions represented the beginning of a lengthy and heavy involvement in Vietnam for Air Force communicators.

As American involvement in the conflict increased, so too did the demands for communications systems, such as the Tactical Air Control System (TACS). Communications to support the original TACS, implemented during 1961, was provided by high frequency radio. This equipment, however, furnished neither the capacity nor the reliability deemed necessary to support the increasing tempo of tactical air operations. Consequently, during 1962, a program was implemented to provide a point-to-point communications system within Southeast Asia. This effort, labeled "Backporch," was initially managed by the Air Force under the Office of the Secretary of Defense (OSD) direction, and resulted in the installation of tactical tropospheric scatter relay facilities in an initial Southeast Asia "backbone" configuration. This system was intended to provide the primary long-distance communications medium for the TACS, with the tactical high frequency radio equipment retained as a backup, alternate path. This initial system was later augmented by additional tropo equipment and tactical microwave and became the main part of the Southeast Asia Wideband System (SEAWBS), managed by the Defense Communications Agency.

The Backporch system had been designed originally to support a relatively modest Vietnamese requirement. As the conflict expanded, the increasing communications requirements overloaded the capacity of SEAWBS. System quality and reliability were degraded. Frequently, essential circuits were out of service for hours, if not days.

Furthermore, unlike the original intent, SEAWBS had become a common-user system, carrying administrative and logistic information, as well as command and control, so its inadequacies reverberated throughout the Air Force's Southeast Asia activities.

One response to the increasing need for more reliable, capable, and available communications was the proliferation of high frequency radio networks dedicated to a specific purpose, such as the



Tropospheric scatter communications antennas at Pleiku Air Base, South Vietnam, 1966.

Seventh Air Force's Air Base Emergency Net. A second response generated by the growing awareness of the communications inadequacy was the formal initiation, in mid-1964, of an improved backbone system, the Integrated Wideband Communications System (IWCS). As envisioned at the time, the IWCS would provide a high quality, reliable backbone system of sufficient capacity to handle the Southeast Asia communications requirements. The problem was, however, that this capacity was tied to the requirements as seen in 1964, prior to the decision to commit large numbers of U.S. combat ground and air forces to Southeast Asia. Consequently, the initial system concept later had to be expanded considerably.

Physically, the IWCS backbone communications system consisted of a chain of fixed ground tropospheric scatter, more commonly known as "troposcatter," and microwave relay nodes, the first links of which became operational in both Thailand and South Vietnam in late 1966. In June 1967, this system was supplemented by a coastal submarine cable system, the 493L program, which provided a high quality and reliable adjunct to the land-based equipment. Ironically, this submarine cable system was installed, maintained, and operated by the USAF. In June 1968, the entire IWCS system was redesignated the Integrated Communications System - Southeast Asia (ICS-SEA). It contained approximately 80 nodes, about evenly divided between South Vietnam and Thailand.

As indicated by the term "backbone," this system provided the basic framework for point-to-point communications within Southeast Asia. Its circuits were used for voice, record, and data transmissions. Some circuits were devoted to common-user voice and record services, while others were dedicated to command and control communications requirements.

A major problem with the system, however, was that it was engineered to be a high quality system, based on fixed requirements and installed permanently in specified locations. In addition to requiring long lead times for engineering and installation, such an approach meant that the adaptability to rapidly changing requirements in a tactical theater of operations was lost to a considerable degree.

As a result, still more stop-gap facilities were installed. For example, at the request of Pacific Air Forces, between May and December 1965 ten mobile tropospheric scatter relay systems were deployed to Southeast Asia to augment the backbone configuration then operational.

The limitations of this backbone system in terms of reliability and capacity also led to the proliferation of high frequency single sideband (HF SSB) networks dedicated to the support of a functional community or special interest. Initially, these networks constituted the primary means of communications for the community which they supported, but with the maturation of ICS-SEA, these radio facilities supporting the ground-based elements were used as an alternate means of communications. Among some of the more significant of these networks were the Direct Air Request Network, which relayed requests for immediate close air support for ground forces; the Tiger Hound/Tally Ho network, which supported interdiction operations in areas outside South Vietnam; and the Search and Rescue Network, which functioned as the primary means of monitoring, coordinating, and directing the efforts required to locate and rescue downed personnel.

Point-to-point voice telephone circuits were also derived from the basic backbone system. Tactical control units and mobile communications units provided intra-TACS telephone service which was controlled by a central switchboard. This switchboard also had trunk circuits which were terminated at a backbone entry node through transmission facilities provided by the tactical control unit or mobile communications unit.

There were three major command and control point-to-point networks set up in Southeast Asia. Essentially, they were the primary voice communications channels, with each one bearing primary responsibility for a particular function: in-country, out-country, and airlift operations. The common user voice facilities were initially provided by mobile communications units which furnished tactical switchboards for intrabase telephone service. At locations which became permanent bases, the mobile communications facilities were replaced eventually by fixed installations which were operated and maintained by Air Force Communications Service personnel. Trunk service was still derived from the backbone system; thus general administrative telephone service between bases had to compete with command and control needs for those backbone circuits.

By the mid-60s, this system did not meet the needs for telephone service adequately, and a tandem switch telephone system was developed. This system reduced the number of point-to-point voice trunks and provided automatic long-distance within Southeast Asia. Under this solution, trunk circuits from the local telephone switches of the various services were routed through the backbone system to one of nine interconnected tandem switches. No longer did a base need a large number of direct circuits to other locations, but it could get by with a few circuits to one or more of the tandem switches, essentially dialing direct to virtually any other subscriber in Southeast Asia. Another feature was that a preemption feature automatically disconnected calls in progress in favor of those authorized higher precedence. At the same time, access from Southeast Asia to the worldwide AUTOVON system was obtained through tandem switches at Nha Trang, South Vietnam, and Korat, Thailand, where AUTOVON trunk equipment had been installed.

There was a similar evolution in message transmission systems in Southeast Asia. Initially, old manual teletype networks were brought into the area. Manual teletypewriter equipment terminals were connected through backbone circuits to the relay nodes. A message prepared by a user and delivered to the communications center to be processed for transmission had to be rekeyed onto punched paper tape which was then transmitted by teletype to a relay station. At the relay station was another teletype machine which received the message in punched tape medium. An operator looked at the tape, determined its destination, and physically carried the tape to still another teletype machine linked to the destination station. The message was then retransmitted to the designated end terminal where it was received as punched tape, which again had to be "translated."

It did not take long for developments in Southeast Asia to overtax the capacity of this manual system. In order to speed the message handling process, automated terminals and relay equipment were introduced into the theater. In July 1967, the Pacific Interim Automated Command and Control System was approved for implementation. Key elements of this system were two computer switches used in lieu of manual relay centers. One switch, installed at Headquarters Pacific Air Forces, was connected directly to the other switch at Headquarters Seventh Air Force in Saigon. Furthermore, both switches were collocated with the USAF command and control computer systems at those locations and tied directly to them. Punched card terminals replaced the teletype equipment. The punched card messages were introduced directly into the computer systems, eliminating the various manual manipulations needed earlier.

In terms of communications to and from Southeast Asia, several means were employed to route voice and record traffic, including satellite transmission, high frequency radio transmission, and submarine cable. The primary medium for transmission of command and control information was the Wetwash Alpha submarine cable, laid between San Miguel in the Philippines and Nha Trang, South Vietnam. Becoming operational in January 1965, both the 60-channel cable and the land cable heads were installed, maintained, and operated by the USAF. The Wetwash Tropospheric Scatter System between Nha Trang and Saigon was installed as part of the SEAWBS to allow access to the cable from the Saigon area. Becoming operational in March 1965, it provided reliable out-of-theater service, having an operational efficiency exceeding 99 percent.

Another area of critical communications support was air traffic services. Ten air bases in South Vietnam provided such services. Six were manned essentially by Vietnamese with USAF personnel supplementing tower operations and fully managing the air traffic control radars. Handling high density air traffic was no easy task under the best circumstances, and circumstances were far from "the best" in South Vietnam where controllers operated some of the busiest bases in the world. For example, combined monthly control tower and radar operations at Da Nang and Bien Hoa Air Bases averaged more than 71,000 and 67,000 respectively throughout 1967. Furthermore, about 75 percent of the traffic into Da Nang was unannounced, with notification of intent to land seldom made before the aircraft was directly in the control area. In 1968, air traffic controllers at three bases in South Vietnam routinely handled traffic exceeding that at America's busiest airport, Chicago's O'Hare. In May 1968, air traffic operations at Da Nang averaged nearly 2,600 operations daily. This count was the highest for any airport in the world at that time. At the busiest bases in Southeast Asia, there were times when 60 aircraft were waiting to take off, while several aircraft circled overhead waiting their turn to land. These operations were often further complicated by enemy attacks on bases involved with launching and recovering aircraft.

Southeast Asia also proved to be a theater where new communications techniques and equipment were tested. In South Vietnam, satellite transmission from a tactical theater of operations was employed for the first time. The first satellite communications terminal in South Vietnam was installed near Ton Son Nhut in June 1966. It used the Synchronous Communications (SYNCOM) Satellite to provide a very limited one voice and one record circuit between Saigon and Hawaii. This capability lasted only to December 1967 when service was disrupted due to satellite drift.

A more capable satellite transmission system resulted from the installation of two ground terminals, one at Nha Trang, the other at Saigon, as part of the Initial Defense Communications Satellite System. At the initial operational date in July 1967, the capability of each terminal was 5 circuits, but this expanded to 11 in January 1968. In addition to the military satellite systems, some use was made of commercial satellite circuits. For example, ten circuits to Hawaii were leased from the Commercial Satellite Corporation facilities in Bangkok, Thailand.

As to be expected, the very nature of the conflict itself had an impact on the communications systems employed in Southeast Asia. Unlike World War II, the war in Vietnam did not have a moving front but had a relatively stable ground environment and established patterns of conflict. Consequently, the military effort settled into a theater-wide continued presence where communications facilities became, more or less, permanent. Within the Air Force, providing such permanent facilities meant going through established programming procedures which required relatively long lead times for implementation. This process caused significant delays in fielding permanent facilities to support command and control, logistics, and administrative communications needs. In the meantime, mobile communications equipment was used to fill the gap, to the detriment of those assets. Equipment designed for limited deployments remained in place for months, even years. Not only did this long usage contribute to equipment deterioration, it also meant that those communications assets were not available for other uses. The "front," however, was not completely static. Units did move and missions did change. Thus, communications plans were frequently changed to reflect new demands, or, worse, could not be changed because of long lead time requirements. Such conditions, obviously, exacerbated the already existing communications problems.

The 1970s

Throughout the 1970s, technological advances and the associated communications systems modernization meant continual changes in the standard way of doing things. New programs kept Air Force communicators busy setting up new or updated communications systems and learning how to operate them. The Air Force faced an insatiable demand for new and better systems which, through technological advances, made weapons and management systems not only more productive, but also less costly.

This demand was felt across the entire gamut of Air Force communications. For example, during the 1970s, Air Force communicators worked diligently to update air traffic services in all categories: equipment, facilities, and procedures. These modernization efforts affected all of the standard facilities such as control towers, mobile equipment, radios, radar and landing aids, and navigational aids. Experiences gained in Southeast Asia graphically illustrated the need for a variety of new mobile air traffic services equipment and procedures. The requirements for increased radar coverage control and ruggedness, along with decreased weight for transportability, prompted the creation of new mobile tower and radar approach equipment. By the end of the decade, both new mobile control towers and transportable radar approach control systems were part of the Air Force inventory. The latter actually could be broken down into three separate component units: an airport surveillance radar, a precision approach radar, and an operational center. Such a system permitted Air Force communicators to provide different equipment configurations in response to the needs of any given situation. Moreover, this equipment was lightweight, had good capacity, and could operate in foul weather.

As part of this development effort, in 1973 the Air Force started a master program to correct problems with the precision approach equipment. In conjunction with efforts to install solid state instrument landing systems, the Air Force worked to develop a microwave landing system and started a program to replace obsolescent airport search radars and precision approach radars with solid state, relocatable facilities. The installation of such facilities, beginning in 1979, was intended to fill the gap between radar systems that were highly mobile but had limited capability, and heavy fixed-base radars that provided full capability but could not be moved easily.

One of the critical areas of Air Force communications centered around long-distance communications. In the 1970s, U.S. public utilities, particularly Bell Telephone and Western Union, possessed such good systems that, in the United States, the Air Force could lease much of its long-distance communications from these commercial carriers. Overseas, in contrast, the Air Force operated and maintained most of its own switches and communications networks comprised of cable, microwave, tropospheric scatter, and satellite systems. Unfortunately, many of the long-distance communications systems operated by the Air Force were wearing out and requiring extensive maintenance. These problems, combined with technological changes and pressures to consolidate, compelled the Air Force to put increasing emphasis on the common-user long-distance systems such as AUTODIN and AUTOVON.

By 1970, the Defense Communication Agency's common-user, worldwide record communications system, AUTODIN, was essentially completed when the last of the old electro-mechanical switches was closed. However, continued pressure for greater speed and error-free service, along with the increased quantity of traffic, meant that the Air Force and other Department of Defense users continually would work to modify and improve the system.

For example, the AUTODIN enhancement program that began in 1973 provided new equipment for some of the automatic switching centers. A system command terminal, consisting of a cathode ray display with teletypewriter keyboard and a medium-speed printer, provided a record copy of all important computer control actions; a disk memory unit provided backup information storage; and a systems autoload module provided a fast means of reloading disk memory after a stoppage.

In mid-decade, the Air Force also began to provide a solid-state, uninterruptable power supply for overseas switching centers. This new backup equipment was needed to provide uninterrupted power as well as a smoother flow of power to keep the solid state data processors running efficiently. Another modification updated the memory capacity at the switches. The Expanded Memory Storage System, with additional computers and special software, represented a quantum leap in the accession of large quantities of stored data, and eliminated the delays associated with the retrieval of stored information from magnetic tapes.

The Automatic Voice Network (AUTOVON), by the early 70s, had reached its mature development with a global network of 87 switches. From the beginning of the system, however, AUTOVON had been criticized for not providing traffic handling capacity commensurate with that of the commercial direct dialing systems. The major problem was that AUTOVON had been envisioned primarily as a command and control network, with the handling of administrative and general requirements a secondary concern. With the growth in all three types of traffic, the system was unable to handle any of them efficiently or effectively. The Defense Communications Agency, working with all the military services, continued throughout the decade to make improvements, such as installing additional trans-oceanic trunks, employing dual homing techniques, and modernizing the system by providing new state-of-the-art equipment.

Unfortunately, despite all the efforts to improve AUTOVON, two distinct factors continued to play havoc with this service. Budgetary constraints plagued the system with limits that prevented the acquisition of enough additional trunking and circuits necessary to meet minimum official service requirements, and the tendency of some users to saturate the network suggested that AUTOVON would have trouble satisfying circuit needs.

Another system reaching saturation was the Automatic Secure Voice Communications (AUTOSEVOCOM) system. At installation in the 1960s, in order to get the system up and working, Air Force engineers accepted certain limitations, such as insufficient capacity, poor voice quality, and needed continuous maintenance. By the mid-70s, these problems were too serious to ignore any longer. When revamping the maintenance and operations procedures failed to maintain system reliability, the Air Staff proposed a replacement program. However, struggles over the technical definition of the new system and high costs, common with sophisticated technology, delayed the program's implementation for over a decade.

With Air Force communications operations circling the globe, and political and technological forces calling for continued alterations and modernizations of cable, microwave, and tropospheric transmission systems, Air Force communicators worked on hundreds of communications projects during this decade. Obviously some projects were more significant and generated special consideration. Other projects, although important, could be categorized as "business as usual" and received less recognition. The following brief description of several of the more significant projects illustrates the variety of efforts Air Force communicators were involved with during the 1970s.

In Asia, Air Force communicators continued their involvement with submarine cable when they assumed responsibility for procuring a cable to accommodate new high speed data transmission between Okinawa, Taiwan, and the Philippines. In 1972, the growing importance of Korea also found Air Force personnel managing the update of a Japan-Korea microwave link.

In Europe, Air Force engineers were engaged in another microwave modernization effort, this one for Lajes Field, Azores. They were also involved on the continent in several projects to modernize the heavily used microwave and troposcatter transmission system. During the decade, Air Force people updated equipment throughout the Mediterranean, Germany, the Low Countries, and the United Kingdom in an attempt to keep pace with the technological needs of the forces in Europe.

During the 1970s, Air Force communications engineers were also involved in transmitter and receiver modernization efforts. They worked particularly in directing channel-packing projects in overseas locations to develop systems comparable to American commercial systems. Channel-packing combined several parallel-routed circuits into a single channel, saving money by reducing the number of leased channels needed. In simplified terms, the bits of one data stream traveled in the empty spaces between the bits of other data streams. The channel-packing equipment allowed up to four times the usual amount of data on one channel.

In addition to the common-user, long-haul communications systems, Air Force communicators worked to modernize a number of specialized communications systems dedicated to specific Air Force users for singular purposes. Two of the more critical systems receiving special emphasis in the 1970s were the air-to-ground and point-to-point high frequency systems, which gave commanders the ability to communicate with aircraft throughout the world and also provided constant contact with aircraft carrying the President, cabinet members, and other government officials; and a series of satellite communications programs that gave increased communications capability for strategic and tactical commanders, provided a global positioning system, and increased redundancy for other central communications systems.

As aircraft traveled over long distances, they were often beyond the communications range of air traffic control tower radios. To provide the necessary flight communications, the Air Force employed 16 aeronautical stations along major world air routes. These high frequency, high powered radio stations helped relay air traffic control, weather, and other vital information to enroute aircraft. Part of this aeronautical radio system was dedicated solely to supporting the President and high-ranking civilian and military officials. These officials had instant and virtually 100 percent reliable communications capability with the White House from any location in the world.

Several significant programs in the 1970s kept these aeronautical stations operating efficiently. Between 1970 and 1976, the Scope Pattern program brought new transmitters, receivers, antennas, consoles, and associated equipment to selected stations. In the mid-70s the Air Force began an expensive, multi-faceted program, called Scope Signal, to upgrade, reconfigure, and consolidate all high powered, high frequency stations. Because of funding problems, however, this effort would continue into the 1990s.

One part of the general Scope Signal program was the specific project to modernize the Strategic Air Command's "Giant Talk" facilities. Since the 1950s, these facilities had provided the backbone of SAC's airborne communications. By the 70s, aging equipment, combined with changing requirements, necessitated improving this equipment; however, it would be several years before this process was completed.

In the late 1970s, the earlier promise to find reliable long-distance communications via the use of satellites was fulfilled as various Air Force satellite programs reached, or neared, completion. The first program to reach actual capability was the Tactical Satellite Communications System, an interim program which became operational in 1970. The basic purpose of this program was military research and development, testing the feasibility of providing tactical communications via satellites. Once operational, the system also provided satellite communications for the National Military Command System and other high priority customers between 1970 and 1976. After 1976, a revised program, called Scope Dawn, used commercially leased satellites combined with Tactical Satellite Communications System ground terminals to continue providing interim high priority communications links.

Simultaneously, developmental efforts for the Air Force Satellite Communications System began in the early 70s. This program was designed to give the Strategic Air Command and other high priority users a reliable and secure communications system between the ground and airborne terminal links. This system came into partial operation in 1979. The 1970s also saw the initial development of other satellite systems which would have increasing utility, indeed become essential, as the century progressed. Among the more critical of these were the Defense Satellite Communications System, the Defense Meteorological Satellite Systems, and the Navigation System using Time And Ranging (NAVSTAR) Global Positioning System.

The NAVSTAR Global Positioning System (GPS), for example, quickly became of critical importance. The first satellite of this system was launched in 1978, and currently 16 of the projected 18 satellites of this system are in operation. They provide 24-hour, all weather, precise positioning and navigation information. The GPS could be used for a multitude of activities, ranging from precision weapons delivery, to aerial rendezvous, to search and rescue operations. Using GPS receivers, users could determine their positions within 60 feet. The development of small, lightweight atomic clocks capable of being orbited was the key to NAVSTAR's ability to transmit precise time data accurate to plus or minus one second in 300,000 years.

Throughout the 1970s Air Force communicators also spent considerable time and energy dealing with on-base communications, such as telephones, telecommunications centers, and weather equipment. Much of this effort was devoted to two interlocking processes: the problems caused by aging equipment and the attempts to solve those problems and provide better service through technological advancements.

The pilot of a UH-1N Huey helicopter keys data into the onboard Global Positioning System receiver

For many years, Air Force planners had labored over solutions to the problems of base telephone systems, developing various plans to provide an efficient and economical system. Most Air Force base telephone systems in the early 70s still used outdated, pre-World War II, electro-mechanical telephone exchange equipment. Much of the equipment had not been manufactured for years, making it difficult to maintain. The situation was further complicated by fragmented equipment procurement practices and a variety of training, logistics, and maintenance support problems. Furthermore, electro-mechanical switches would not satisfy consistently the growing need to expand telephone capacity, data transmission, and the message processing centers.

By the late 70s, the increased awareness of the problems with the telephone systems combined with a presidential policy to decrease civilian personnel compelled the Air Force to move ahead with a rational replacement modernization program. In 1979, Air Force Headquarters approved a replacement strategy known as "Scope Dial." This multimillion dollar program was designed to replace nearly 30 government-owned dial central offices worldwide. The new electronic equipment required fewer operators and maintenance people, and provided better service with cheaper spare parts. Compact, desktop consoles replaced bulky switchboards; troubles in the equipment would be signaled and isolated automatically; and the equipment was also able to record all accounting information on toll calls to simplify record keeping. This equipment, however, would not enter the Air Force inventory until the 1980s.

Telecommunications centers had a history of continual change as the Air Force adopted consolidation schemes, introduced technologically advanced equipment, and employed new techniques and procedures to provide greater service at lower costs. This process had started in the 60s with the early attempts to modernize the telecommunications centers using computer-aided teleprocessing. The process continued in the early 70s with the introduction of more capable automatic systems. A variety of automated processors used throughout the 70s had the capability of automatically collecting and distributing messages within an Air Force installation and interconnecting with the AUTODIN system for inter-base communications. These systems also connected computers both on base and between bases to transfer computer data. The data processing systems were usually commercially procured and maintained, reducing the reliance on military maintenance personnel and associated costs.

As part of these continuing efforts, in 1975 Headquarters Air Force Communications Service (AFCS) and the Communications Computer Programming Center at Tinker Air Force Base, Oklahoma, originated a new automation concept called the Automated Telecommunication Program, which replaced the expensive computer-aided processing system then in use with mini-computers. These new computers, which AFCS began to install in 1979 under the new Automated Message Processing Exchange (AMPE) program would satisfy expanded communications needs. The computers enabled store and forward processing to use transmission circuits more efficiently. They also allowed the centralization of local telecommunications processing and administrative functions.

Base weather office systems were another of the communications areas modernized in the 1970s. Throughout the decade, Air Force engineers planned and installed new weather terminal equipment and a digital transmission network in the United States replacing the old manually-operated information service and teletype network, which had provided weather data to base flight operations through the Automated Weather Network switch at Carswell Air Force Base, Texas. The new system, the Continental United States Meteorological Data System, featured high speed data transmission accessed through terminals located at base weather stations. The terminals consisted of page copy printers, keyboards, and electronic visual display screens. The advantages of this system included improved pilot weather briefings, better control of weather status documents, and quick call up of stored information, all requiring less time and manpower.

Technological innovations, however, made this system obsolescent even before installation was completed. As early as 1975, Air Force planners began working on an automated weather distribution system. This system was a streamlined modular arrangement that replaced the clipboard storage of weather messages and bulletins and the wall display of facsimile charts previously employed in base weather stations. At the same time, the system alleviated many menial, labor-intensive tasks, but, most important, it kept pace with the critical requirements for more accurate and timely reporting of airfield weather observations and forecasts.

The 1980s

The full impact of technology is often felt only when separate but complementary threads of invention are drawn together to create new and powerful capabilities. In the 1980s this was exemplified by the merging technologies in communications and data automation. State-of-the-art technology in both disciplines evolved at an unprecedented rate, and simultaneously, the price of small personal computers dropped tremendously. The resultant rapid proliferation of microcomputers and the widespread introduction of computers into American schools and businesses were a reflection of the changes being made in American society as the two technologies converged. The lines of demarcation between computers that communicated, communications devices with an innate computing function, and office automation equipment became blurred. The term coined to describe this merged technology was "information systems."

An Air Staff study conducted in early 1982 looked at the growth of information technology and concluded that the Air Force was no longer a leader in this area. As a result of that study, General Charles A. Gabriel, USAF Chief of Staff, directed the integration of communications and automation in the Air Force and established the leadership structure to do this on 1 June 1983 by reorganizing HQ USAF to form an Assistant Chief of Staff for Information Systems.

Caught up in this same process was the question of integrating the two disciplines in the field. In the fall of 1983, at the direction of the Air Staff, the Air Force Communications Command[1] initiated a test at Peterson Air Force Base, Colorado, and Malmstrom Air Force Base, Montana, of the feasibility of consolidating on-base data processing installations and telecommunications centers. Initially scheduled to run for a year, these tests were concluded early at both locations because of very favorable results. After 1984, the data processing installation-telecommunications center collocation effort became simply one aspect of the broader communications and automated data processing integration effort.

Growing out of this integration was the issue of merging career fields for Air Force personnel. On the enlisted side, the merger involved combining Air Force Specialty Code (AFSC) 291X0, telecommunications center operator; AFSC 295X0, automatic digital

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[1] On 15 November 1979 the Air Force Communications Service was redesignated Air Force Communications Command.

switch operator; and AFSC 511X0, computer operator into one skill. In late 1983, tests at Peterson and Scott Air Force Bases to evaluate a possible merger, convinced Headquarters USAF and the major commands to create a single career field, AFSC 491XX, called information systems operations. The actual merger, involving nearly 10,000 people, took place on 30 April 1985. At the same time, the communications officer (AFSC 30XX) and data automation officer (AFSC 51XX) career fields were merged into the information officers career field (AFSC 49XX). Air Force planners were convinced these mergers would produce several benefits. Most importantly, the mergers would make the people in the career fields more versatile and better able to remain current with state-of-the-art equipment and technology. The single skills would also be needed to operate consolidated data processing and telecommunications facilities. The combined career fields also created a larger manpower pool and improved manning for the telecommunications centers and the rotational balance for overseas tours.

In terms of data automation itself, one of the Air Force's major modernization efforts during this period was the program known as Phase IV. This effort, begun in 1976, replaced the old supply and base level computers with a single system, composed of state-of-the-art data processing equipment. Beyond modernization, the underlying purpose of this effort was to provide all Air Force installations a standardized base computer system which would support such base functions as operations, supply, maintenance, personnel, and accounting and finance. Functional policies, operating procedures, and computer systems were integrated into a total systems approach, ensuring that each functional transaction was processed the same way regardless of mission location.

In January 1983, the Air Force announced that Sperry-Univac had been selected as the contractor to replace the base-level computers worldwide. As implemented, this replacement program was divided into three segments: the first replaced the old Univac base online systems, the second replaced the old Burroughs systems, and the third combined the first two into an integrated system. After a year of perfecting the design and implementation of the system, the first conversion began in May 1983. It took 3 years to complete this largest data automation acquisition effort in Air Force history, but at completion, 121 Air Force bases and regional centers around the world had converted to the new system.

Throughout the early 1980s, the Air Force Communications Command (AFCC) was often in the forefront of developing and demonstrating the utilization of various data automation applications for the Air Force. For example, to demonstrate one of the possibilities of data automation, AFCC created an office information system for the command's headquarters. In September 1981, AFCC embarked upon this long-range project which eventually would revolutionize the way the Air Force conducted day-to-day business by automating many routine office functions. In April 1982, Major General Robert F. McCarthy, the AFCC commander, directed the start of a pilot Office Information System (OIS) project in one portion of the command's headquarters, the Operations, Plans and Readiness Directorate. In October 1983, after the successful implementation and operation of this pilot project, General McCarthy directed the expansion of the system to his entire headquarters.

The purpose of this system was to increase overall staff productivity by processing information more rapidly and improving information resource sharing throughout the headquarters. Furthermore, the productivity improvements that it was projected the full-scale OIS would provide were needed immediately to compensate for the increased workload and decreased manning at the headquarters. In addition, General McCarthy believed this pilot OIS would serve as an example for other commands on the possibilities of office information systems.

In early December 1984, this office information system was implemented officially throughout the AFCC headquarters. Over 600 personal computers were linked together via an electronic network, allowing the headquarters' staff to exchange information and data rapidly, send and receive electronic mail over the Defense Data Network, and utilize automated office aids such as a calendar and suspense control system. Although crude and not very "user friendly" by later standards, this system did showcase the possibilities of office information systems and pointed the way for future Air Force efforts.

Along similar lines, one of the most promising communications technologies devised in the early 1980s was the creation of Local Area Networks. In general terms, a Local Area Network (LAN) was a base-wide or headquarters-wide communications network, such as the one for the Air Force Academy, designed to interconnect numerous pieces of data processing and communications equipment with a high degree of connectivity and/or interoperability. These LANs helped alleviate some of the Air Force's communications requirements and problems because properly implemented networks were operationally flexible enough to allow easy addition or deletion of user equipment, or even the reconfiguration of equipment. While LAN technology was promising, the proliferation and control of the systems rapidly became problems in themselves.

As indicated by the development of LANs and office information systems, the 80s marked the period when the "user" became the "communicator." No longer did the user need to go to the data or communications center; such capabilities were now sitting on everyone's desk.

Another aspect of the Air Force's data automation effort included a modernization program to replace antiquated and logistically unsupportable punched card and paper tape devices with new technologies which meant, in the 80s, floppy disks. The means to this end was SARAH, the acronym for Standard Automated Remote to AUTODIN Host, a user friendly software package that allowed messages to be prepared and stored on computer floppy disks rather than paper. Developed in the mid-80s, there were actually two versions of the system: one for administration, the other for communications. The former allowed users to create messages for storage on a disk or

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[2]TEMPEST was an Air Force program for the control of compromising emanations from all equipment and systems that processed classified information.

for printing on paper, such as a message form. The latter was used on TEMPEST[2] versions of the Zenith 248 computer and gave message preparers on-line access to the AUTODIN system. Initially installed at Langley and Tinker Air Force Bases, by the end of the decade the conversion to SARAH had been made at every Air Force communications center.

During the 1980s and continuing into the 90s, Air Force communicators also were involved in negotiating the contracts known popularly as Desktop III and Desktop IV. These were a series of desktop computer contracts for the purchase of micro-computers, associated peripheral devices, and a core suite of software for the Air Force and other DOD agencies.

Another of the major activities that occupied Air Force communicators in the early 80s was defining the role of communications in space. In November 1982, the Air Force Vice Chief of Staff, General Jerome F. O'Malley, requested a review of long-term Air Force goals in the context of an overall Air Force space strategy. A number of panels, consisting of representatives from various major commands and separate operating agencies, began assessing the Air Force's role in space. In terms of communications, the goal was to develop an affordable space force structure that would ensure survivable communications.

One step towards that goal was the Air Force Satellite Communications (AFSATCOM) program, a dedicated, ultra high frequency, worldwide satellite communications system intended to provide the Air Force secure, reliable, and survivable satellite communications for the 1980s and early 90s. This satellite communications program was designed specifically to send emergency messages, direct forces, and provide a network for Commanders in Chief (CINCs). The first segment of the system became operational in May 1979, and on 15 June 1984, the Air Staff declared the entire system fully operational. It was a major accomplishment. The AFSATCOM installations had taken three and a half years to complete, and represented the first new command and control system for the Strategic Air Command since 1967.

Another technological communications innovation the Air Force developed in the 1980s was meteor burst communications. Under this methodology, a 40 to 50 Mhz signal was bounced off the trail of ionized electrons left by meteors as they burned up in the earth's atmosphere. Data messages were stored for a given period of time and then released at a rate of 10 to 100 or more times the normal speed. Fortunately, enough meteors came hurtling into the atmosphere each hour that their trails were continuously accessible. The effective range of these transmissions was up to 1,200 miles, limited primarily by the earth's curvature and the angle at which the signal hit the meteor trail.

The system was tested first by the Alaskan Air Command as a way of providing more secure and reliable communications. The test, concluded in September 1983, was entirely satisfactory. The implications of such a system were far reaching because they represented, at a modest cost, new, very reliable and highly jam-resistant operational capabilities for the Air Force.

More mundane, but critically important, by 1980 Air Force communicators were responsible for the operation and maintenance of approximately 200 telephone systems at nearly every Air Force installation in the world. However, most of the telephone equipment employed was technologically outdated and logistically unsupportable. This situation, combined with the lack of a standardized telephone switch throughout the Air Force, caused unacceptably high costs for training, technical data, and supply support. Consequently, the majority of Air Force telephone offices could not meet customer needs, let alone future requirements. New equipment, using current technology, was desperately needed.

To satisfy this need, the Air Force developed several programs. One of the most significant of these was Scope Dial, the concept for which was approved in 1979, but the program did not become operational until the early 80s. Under this program, the Air Force eliminated the practice of contracting separately for each base's requirements. Instead, the program consolidated the base telephone requirements for government-owned switches worldwide. Rather than spend-

The telephone switching systems supervisor programs Scope Dial features into the DMS-100 telephone switch.

ing money on research and development, Air Force financial personnel decided to use commercially available equipment. Accordingly, in March 1981, the Air Force awarded a five-year contract to Northern Telecom, Inc. to use its digital multiplex switching system in the new dial central offices. The first Scope Dial installation became operational at Vandenberg Air Force Base, California, in July 1982. By the end of the five-year contract, a total of 40 digital telephone switches, totaling more than 138,000 lines, had been installed worldwide.

Closely allied to the Scope Dial telephone modernization effort was the program known as Scope Exchange. The latter was a continental United States only initiative to acquire, by competitive contracting, state-of-the-art telephone systems for Air Force locations that leased services from private companies. Under this program, contractors, rather than the Air Force, provided total on-site telephone service to include engineering, design, installation, system management, operations, maintenance, and logistics support. Eventually, nearly 30 bases acquired new telephone systems using the Scope Exchange program.

During this same period, the Air Force was also involved with several other communications modernization efforts. Fiber optics, Mission Effective Information Transfer System, and T-carrier programs were explored to exploit new technological advances to transmit voice and data. Simultaneously, network control improvements in the Dial Central Office Management Information System and the Base Central Test Facility concepts were examined.

As effective as these programs were, they remained a piecemeal approach to satisfying Air Force base level information switching and transmission systems requirements. Consequently, Air Force communicators developed a new program to tie all these disparate elements together: the Base Information Digital Distribution System (BIDDS). The intent of this approach was to modernize base communications as a system by acquiring, installing and providing operations and maintenance support for digital transmission and switching systems and customer premise equipment at Air Force bases worldwide. This new equipment would provide increased transmission capacity and reliable, low-noise circuits to satisfy both voice and data requirements. Eventually, 170 bases worldwide received new telephone systems of one type or another through this program.

One of the important sub-elements of the BIDDS program was its management subsystem which was a combination automated administrative and crisis management tool. It gave Air Force communicators the capability to make cable assignments automatically and provide reliable switch and circuit configuration information. It also automated such functions as operator assistance, telephone directories, management reports, billing, and records of cable, telephone, and circuit numbers.

By the late 1980s, Air Force personnel were also working on the first Integrated Services Digital Network (ISDN) switch. This network was the technology the Air Force and Department of Defense were counting on to tie commercial telephones, the Defense

Switched Network, and the Defense Data Network into one integrated service package, an integrated standard for digitized voice, data, and video communications. The ISDN system was developed by digitally enhancing current telephone networks to combine voice and data circuits into one transmission and switching infrastructure. Once fully developed, ISDN would allow the simultaneous transmission and reception of voice and digital data over existing communications networks. It would also permit the real-time exchange of data between distant locations. The Air Force began testing the first ISDN switch at Mather Air Force Base, California, in July 1988.

One other significant development in the telecommunications field in the 1980s was the divestiture and deregulation of the telephone industry which had a tremendous impact on Air Force communications. While often viewed synonymously, divestiture and deregulation were not the same. The deregulation of the telecommunications service industry had been ongoing for several years. Various decisions by the Federal Communications Commission had opened certain types of services to increased competition. The most significant of these decisions was the Computer Inquiry II decision of 1 April 1980, which removed all restrictions on merging communications and computer technology by individual service providers, effective 1 January 1983. Previously, providers had been restricted to offering services or systems that utilized either of these technologies, but not both. Besides requiring the industry to develop new business methods and relationships, deregulation also caused unprecedented cost growth for service.

Prior to deregulation, the government had enjoyed a favorable rate structure under the TELPAK tariff, which was generally unavailable to the public. This tariff was abolished in May 1981, and followed one month later by a 34 percent rate increase. In 1981 and 1982 other rates were raised to level out the costs to American Telephone and Telegraph (AT&T) of long-distance communications that previously had been shared among its other subdivisions. This leveling of costs and the attendant cost increases passed to users was unparalleled in the telecommunications industry and exerted an adverse financial impact upon the Air Force. At that time, Air Force financial personnel projected that from 1980 to 1984 the Air Force would have to pay 80 percent more for the same level of service. There was a funding shortfall of $26 million for leased communications in fiscal year 1982 alone. Ultimately, in late 1983, Congress approved a reprogramming request that included money to cover the Air Force's deficit.

While these unanticipated conditions were creating all sorts of problems for Air Force communicators, the whole issue of divestiture hit center stage as well. Historically, AT&T had been viewed as a legal monopoly. However, during the 1960s, the question as to whether AT&T should be permitted to retain that status was raised with increasing frequency and intensity. In November 1974, the Department of Justice finally entered an antitrust suit against AT&T. After years of legal maneuverings, on 24 August 1982, the Department of Justice and AT&T reached an agreement. This agreement, commonly referred to as the Modified Final Judgment, established the procedures by which the 22 Bell Telephone operating companies became independent from the AT&T organization.

This judgment "freed" the local Bell operating companies from their AT&T parent company, but in the process they also lost the previous subsidies they had been receiving from that parent. Previously, the Bell System had maintained local telephone costs at an artificially low level by providing subsidies from its more profitable long-distance business. In 1981, for example, this subsidy totaled over $7 billion, which meant that roughly 37 cents of every dollar spent on long-distance costs had gone to subsidize local telephone companies. This loss of revenue, beginning 1 January 1984, could only be made up by increased costs to the consumers, one of whom was the Air Force.

Base communications bore the brunt of the new rates. Air Force financial planners estimated that the new access charges would cost the service approximately $5.3 million. In addition, costs for tariff increases would also be high. The uncertainty about costs was compounded by the fact that the rate increases were unpredictable — varying between 20 to 186 percent for similar services in different states.

To help meet these challenges, HQ AFCC, under Air Staff direction, established a special Tariff Regulator Law Office within the command's Staff Judge Advocate's staff. Created 1 July 1983, this office acted as the Air Force's legal counsel on telephone rates and liaison with other federal agencies contesting rate increases. It also used its legal expertise to protect the Air Force from disproportionate or discriminatory rates.

At the same time, Air Force personnel began to use the new environment to the service's advantage. In September 1982, the Air Staff commissioned AFCC to study and test the feasibility of obtaining telecommunications services at cheaper rates by using a competitive procurement process. After tests at Tinker and Kelly Air Force Bases showed how substantial savings could be gained by using common carrier services, competitive procedures were expanded throughout the Air Force.

Weather communications obviously continued to be of critical importance to the Air Force. In the 1980s, the Automated Weather Distribution System (AWDS) was the Air Force's primary capital improvement program for modernizing the base weather stations. This research and development effort emphasized the modernization of all Air Force weather dissemination capabilities at base level. The major goal of the program was to improve Air Force meteorological support by increasing the timeliness, quality, and reliability of the weather data provided to base customers. Once completed, the system would collect, store, distribute, and display automatically local and worldwide weather conditions to base weather personnel, air traffic control facilities, and operational units. In specific terms, this system would enable weather forecasters to display forecasts and maps at computerized work stations, replacing the cumbersome, grainy maps used previously to illustrate changing weather conditions. The system would also streamline weather operations by allowing people to plot weather conditions automatically in five to ten minutes, instead of the hour required under the old manual system.

A second major weather communications development effort in the 1980s was Next Generation Weather Radar (NEXRAD). The basic weather radar system for the continental United States needed to be replaced because of equipment obsolescence and performance limitations. By the early 1980s, managers from three government agencies (Departments of Defense, Commerce, and Transportation) were working together to shape a joint use weather surveillance radar (WSR) replacement program. With enhanced Doppler (1988-D) technology, this new radar would provide significantly improved capability to detect, acquire, process, and distribute weather data to aid in reducing injuries, loss of life, and damage to property. Air Force personnel had high expectations for the new system. They expected the new WSR-88D system to give an average tornado warning time of at least 20 minutes (compared to the 1-2 minutes of older sys-

Solid-state electronic weather equipment allows weather forecasters to calculate the intensity and precise location of a storm.

tems); to improve the detection of damaging winds and hail; to improve the detection and measurement of wind shear and thunderstorm turbulence; to reduce the size of warning areas through more precise weather determination; and to lower the number of false hazardous weather warnings. By the end of the decade, a contractor had been selected and a limited production run of the units initiated.

In the 1960s there had been a gradual move away from high frequency radio as alternative high capacity, reliable transmission systems were developed. Later, however, the ability of signal processing technology to mitigate nuclear and electronic jamming effects stirred new interest in the military application of high frequency radio. Thus, by the 1980s, the Air Force had several new high frequency radio acquisition and modernization programs in operation.

One such modernization program was labeled Scope Signal, a five phase Air Force effort to consolidate, collocate, and upgrade Air Force high frequency radio facilities around the world. Many of the existing stations had been built and equipped in the 1960s and could not be supported logistically much after 1990. Phase I of the Scope Signal program was completed in 1976, integrating the Tactical Air Command's command and control functions with the Air Force Communications Service's aeronautical stations. On 1 October 1983 this combined system was redesignated the Global Command Control System.

Planning for Phases II, IV, and V, begun in 1979, would consolidate, collocate, and modernize the facilities in the Pacific, Europe, and the Western Hemisphere respectively. These programs were originally an initiative to replace and standardize the high frequency equipment, but the Air Staff, in April 1983, directed a regionalization and consolidation initiative to accompany the modernization effort. Two years later, however, severe funding cuts rendered the programs unexecutable. To replace these efforts, a new program, Scope Command, was created. Eventually, this program would become part of a broader Department of Defense-wide effort to consolidate and "right size" high frequency facilities across all the services.

Scope Signal III was slightly different from the other Scope Signal projects. It provided modernized high frequency single sideband equipment, with automatic switching, for the Strategic Air Command's (SAC) "Giant Talk" system. By consolidating SAC's high frequency radio stations and the aeronautical stations, Scope Signal III provided improvements in the Giant Talk system while simultaneously reducing the number of locations utilizing high frequency single sideband radios. In early March 1983, the United States portion of the new system was operational, with most of the overseas' stations completed by the end of 1985.

As with Scope Signal I, most of the Scope Signal III stations were collocated with the Air Force Communications Command's Global Command Control System (GCCS) stations. In the 1980s there were 14 GCCS stations located strategically around the world. The stations' mission was to provide reliable, rapid, two-way command and control, and operational communications between Department of Defense aircraft on transoceanic flights and military ground agencies, regardless of the geographic location or type of aircraft. The GCCS air-to-ground communications complex, through its high frequency voice and data circuits, ensured that major commands could maintain continuous, real-time communications with their aircraft. If needed, the GCCS stations could also support special purpose and contingency air-to-ground-to-air missions.

In addition to the Scope Signal efforts, Air Force personnel were working concurrently to replace all low-powered high frequency equipment. Under this program, known as Pacer Bounce, the numerous models of 1960s vintage radios were replaced with a new, standard model featuring solid state electronics and remote digital tuning. This replacement effort was part of the Air Force's increasing emphasis on standardization and commonality.

During the 1980s the Air Force was also increasingly involved in joint service programs such as Mystic Star. Mystic Star was the name given to a worldwide, joint service, high frequency communications network that supported the President, Vice President, members of Congress, foreign heads of state, and other government and military officials by providing rapid, high quality, two-way, air-ground-air voice and data communications while aboard Special Air Mission (SAM) aircraft anywhere in the world.

Initially established in 1967, by the early 80s the existing Mystic Star equipment could no longer support its mission tasking adequately. Consequently, HQ USAF directed the modernization of both the Special Air Mission aircraft communications and the ground communications network supporting that aircraft. The first part of this modernization effort began in 1985 as a program to upgrade the quality and speed of the data and voice communications provided to Special Air Mission aircraft. To handle this increased communications requirement, the system's Network Control Station at Andrews Air Force Base, Maryland, had to be upgraded. The new system dramatically expanded the old one, going from a 100-line crossbar switch to a digital switch that could handle up to 5,000 lines. In the old station, there were only three operator positions providing five data circuits. The new station, in contrast, had 12 consoles handling 72 of the same type circuits. In addition, the new system included four new satellite stations covering the globe. While the old network had only 6 manually controlled satellite terminals, the new one had 18 terminals worldwide, remotely controlled by the operators at Andrews. New cryptographic equipment was also added to the system.

Another Air Force radio communications system that reached initial operational capability in the 1980s was the Ground Wave Emergency Network (GWEN). As conceptualized, GWEN would provide high confidence connectivity throughout the continental United States for critical command, control, and communications before, during, and after a nuclear attack. As envisioned, this continual connectivity would be achieved by using a highly redundant network of unmanned, electromagnetic-pulse-hardened communications nodes connected by low frequency radio groundwave signals.

The first part of this network, deployed in 1984, validated the concept through an initial connectivity capability, which provided connectivity between Headquarters, Strategic Air Command, the North American Air Defense Command, and Buckley Air National Guard

Base, Colorado, while simultaneously providing a receive-only capability at 11 SAC bases. The second phase of the network, declared operational in December 1987, demonstrated the full-scale development of the system by testing a thin line connectivity capability across the United States. This thin line connected 8 input-output terminals, 30 receive-only terminals, and 56 tower relay nodes, the minimum number of relay nodes needed to make the GWEN system operational.

One of the biggest, continuing, communications needs in the 1980s was providing rapid, but secure, communications. Several incidents, especially a nuclear weapons accident exercise conducted in April 1979, and an explosion at an Arkansas Titan Missile site in September 1980, revealed a lack of timely and secure communications for dealing with nuclear weapon accidents. To correct this communications shortcoming, the Air Force Communications Command's commander, Major General (later General) Robert T. Herres, organized a small, elite, and highly flexible unit, called Hammer Ace, to provide secure voice communications between response teams and command posts during emergencies, contingencies, and special operations.

As initially instituted, Hammer Ace consisted of 19 of the command's most highly skilled officers, noncommissioned officers, and airmen. A team could deploy within three hours of notification and provide long-range communications from virtually any place on earth. A Hammer Ace team deployed for the first time during a Strategic Air Command exercise in July 1982. Since then, the concept and the team's value have been validated through continuous use.

Between 1982 and 1989, for example, Hammer Ace teams deployed to numerous aircraft accident sites, provided secure communications for high level Air Force conferences, and participated in several actual contingencies. In 1983 Hammer Ace teams participated in two critical operations: one was to Grenada during operation Urgent Fury, the rescue of Americans trapped on the island; the second was to Sudan as part of operation Arid Farmer, the United States' reaction to Libyan aggression in Chad. In 1986, Hammer Ace teams were particularly active, deploying 23 times in support of numerous aircraft accident investigations and/or recovery efforts, exer-

A technician checks the performance of a Hammer Ace deployable communications system.

cises, and demonstrations. Among the more important deployments in 1989 were those supporting the Military Airlift Command's mission at Howard Air Force Base, Panama, during operation Just Cause; aiding the *Exxon Valdez* oil spill recovery efforts in Alaska in April; and the relief efforts for Hurricane Hugo in September and October in the Caribbean and southeastern United States. Throughout the 1990s, Hammer Ace continued to fulfill this role of providing rapid and secure communications support.

The 1990s

By the early 1990s the world situation had changed dramatically. The most obvious manifestation of this change was the end of the Cold War, the guiding principle of American foreign policy for over 40 years. In 1989, the Berlin Wall, perhaps the most visible symbol of that struggle, was demolished. That same year, the Warsaw Pact alliance of the Soviet Union and its Eastern European allies, which had endured since the 1950s, collapsed. Subsequently, most of those Eastern European countries overthrew their Communist governments without interference from Moscow, and usually without bloodshed. The Soviet Union itself was increasingly beset by economic problems, internal ethnic and nationalistic unrest, and agitation for democratic reforms. In late December 1991, the Soviet Union passed into history as its constituent states became independent entities.

In the United States, certain groups began to agitate for a "peace dividend" and a reduction in military expenditures now that the Cold War had been won. About the same time, there were new disclosures that the Department of Defense was paying outrageous sums of money for some procurement items. Because of these various developments, Secretary of Defense Richard B. Cheney directed the military services to review their operations and focus on improving the acquisition process by finding more efficient, cost effective management methods. Eventually, this review was expanded to include all aspects of the military and its business processes. Secretary Cheney set a target of $39 billion in savings during fiscal years 1991-95. As projected, these savings would be achieved by cutting management layers, streamlining procurement and logistics, eliminating less essential functions, and consolidating related jobs.

Clearly, changes of such massive proportions ultimately would have an impact on Air Force communications business. One of the most obvious changes was the restructure in the way Air Force communications had been organized for the past 30 years. Instead of a centralized, functionally-oriented communications command, the Air Force Communications Command (AFCC), a new decentralized structure was adopted. On 1 October 1990, the communications operation and maintenance units were transferred from AFCC to the host units they had been serving. In other words, each host base gained command responsibility for the local communications unit formerly commanded by AFCC. At the same time, the old AFCC divisions as well as other direct reporting units were transferred to the major commands. For example, those units engaged primarily in acquisition or installation and engineering were transferred to Air Force Materiel Command. The remaining corporate portions of AFCC became an Air Force field operating agency assigned to HQ USAF/SC.

At the same time the Air Force was reorganizing its communications structures, communicators themselves faced one of their biggest challenges with Desert Shield/Desert Storm, the American-led operation to protect Saudi Arabia and force Iraq to remove its troops from Kuwait. During that effort, highly effective communications were often supplied in the face of almost overwhelming obstacles. The study of Air Force tactical communications during Desert Shield/Desert Storm, done by the U.S. Central Command Air Forces, graphically emphasized this point. Air Force communicators provided various communications services such as satellite terminals, terrestrial links, automatic telephone switches, and message switches to U.S. and coalition forces stationed in nine countries scattered across four continents. From September 1990 to March 1991 nearly 30 million telephone calls and 1 1/2 million messages, an unprecedented traffic load for tactical systems, were processed. At the same time, Air Force communicators also furnished air traffic services on a large scale. Approximately 350 USAF air traffic controllers were dispersed at 24 locations in 6 countries. At the height of Desert Storm these people handled over 3,000 sorties daily.

On more than one occasion, experience has demonstrated that to fight a war successfully accurate, timely, and precise communications are a prerequisite. One of the points that Alan Campen makes in the preface to his *The First Information War* is that in Desert Storm "the outcome turned as much on superior management of *knowledge* as it did upon performances of people or weapons. . ."[3] In other words, communications played a key role in victory in the Gulf War.

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[3]Emphasis original. Alan D. Campen, "Preface," in Alan D. Campen (ed.), *The First Information War* (Fairfax, VA: AFCEA International Press, 1992), vii.

This same commentator even claimed that this information warfare was a “radically new form of warfare.” He went on to explain his point: “By exploiting *knowledge*, it devastated Iraq’s formidable military machine, astonished the world, confounded defense critics, surprised itself and quite possibly ‘changed the standards for performance of U.S. forces in armed conflict.’” He continued: “By leveraging information, U.S. and allied forces brought to warfare a degree of flexibility, synchronization, speed and precision heretofore unknown.”[4]

Operations other than war became increasingly common occurrences in the 1990s. All of these efforts, from Provide Comfort for the Iraqi Kurds to peacekeeping actions in Somalia, Haiti, and Bosnia, involved joint, and often combined, operations. Obviously, communications played a critical role in these endeavors. By the mid-90s, as never before, communications capabilities had reached the point where the commander could have virtual control of his forces without necessarily being on the front lines. In many ways, especially when dealing with coalition operations, it thus became more of a political decision as to where the commander was located. At the same time, however, because of modern communications the “on scene” commander was increasingly subject to “sharing” the control of his resources and decisions with others who were also in instantaneous communication. During combined operations, it was also ironic, as one Air Force communicator noted, that the “interoperability” of communications equipment was not so much the problem as was the issue of “releasability,” i.e., what American equipment and/or technical solutions and information could be released to the other coalition partners.[5]

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[4]Emphasis original. Alan D. Campen, "Introduction," in Campen (ed.), *First Information War,* ix.

[5]Electronic message, Col Dale Meyerrose, USAFE/SC, to Mr Bill James, USAF/SCT, "ASD/C3I Request for Lessons Learned," 7 June 1996.

One of the most significant military developments in the 1990s was the push towards interoperability. In the communications arena, this concept was given its voice in the publication *C4I for the Warrior* produced by the C4 Systems Directorate (J-6) of the Joint Chiefs of Staff. In looking at command, control, communications, and intelligence (C4I), this pamphlet pointed out: "The Joint Force can no longer be viewed as the simple sum of Service and Defense agency-derived capabilities; rather the Joint Force must be the point of departure from which Service and Defense agencies derive those capabilities. The C4I for the Warrior concept recognizes and embraces this reality." According to this publication, the "essence of the C4I concept" was to give the warrior "the capability to respond and coordinate horizontally and vertically to prosecute effectively and successfully any mission in the Battlespace." By its authors, *C4I for the Warrior* was thus seen as a "much needed vision for which to strive and ... a roadmap of how to get there."[6]

Planners for the nation's military strategy extended this concept and declared: "Consistent with the 'C4I for the Warrior' plan, all Service- and Agency-programmed systems must be compatible and interoperable to support joint and combined operations across the entire spectrum of conflict."[7] Air Force communications planners showed how all these ideas fit into their own concepts in two publications, *HORIZON* and *HORIZON '95*, distributed in the mid-90s.

General Ronald R. Fogleman, the new Air Force Chief of Staff, in 1995 remarked in his introduction to the second of these pamphlets that warfare in the past had been seen as four-dimensional: air, land, sea, and space. He contended, however, that "Now, *information* is recognized as the *fifth* opera-

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[6]*C4I for the Warrior* (Washington D.C.: C4 Architecture and Integration Division, J-6, Joint Chiefs of Staff, [1993]), [1],2,4.

[7]National Military Strategy Document, FY 1994-1999, Annex C, as quoted in *C4I for the Warrior,* 18.

tional environment, and information dominance across the spectrum of conflict is crucial to military success."[8]

HORIZON, written in 1993, focused on information architectures by formulating a vision of an integrated and responsive global "infosphere" which would support the Air Force's worldwide objectives. It defined a path to an Air Force-wide architecture for C4I systems. Updated two years later, *HORIZON '95* expanded upon the original version by establishing Air Force information infrastructure objectives for the 21st century, and by planning for the rapid integration of evolving technology into the current and anticipated infrastructure.

In order to maintain American communications superiority, during the 1990s there were a number of modernization programs, many of them focusing on interoperabililty needs. One of the most critical of these was the Global Command and Control System (GCCS). Replacing the old World-Wide Military Command and Control System, GCCS was the principal migration path for defense-wide command and control systems. As envisioned by its developers, GCCS ultimately would provide command and control of American forces across the full range of military operations and through each phase of force projection. The system would give the warfighter a highly flexible system capable of collecting, processing, disseminating, and protecting information to support critical decision-making and to achieve unity of effort and command dominance.

A concomitant system for support was the Global Combat Support System (GCSS). What GCCS did for command and control programs, GCSS will do for combat support. The latter was designed to establish a common foundation for combat support automated information systems. The GCSS emphasized using tested and widely employed commercial or government off-the-shelf products and practices. The intent of GCSS was to provide the common technical solutions required to satisfy combat support operational needs.

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[8]Emphasis original. *HORIZON '95*, (Washington D.C.: Deputy Chief of Staff for Command, Control, Communications and Computers, USAF, [1995]), 1.

Another of the modernization efforts was the Defense Message System (DMS), the replacement for the old AUTODIN system. The DMS was designed to be one, seamless, end-to-end global electronic messaging service within the Department of Defense. Once completed, DMS would provide a fully integrated, supportable, secure, accountable, and completely commercial off-the-shelf capability for electronic mail and organizational/official messages for the DOD. The DMS was not a network; it was an application system. The transport of messages between elements of the DMS was done via existing (or planned) communications networks and media, primarily the Defense Information Systems Network.

The 1990s also witnessed what many Air Force communicators saw as the wave of the future—the increasing use of such tools as local area networks, the Internet, the world wide web, and networks like SIPRNET (Secret Internet Protocol Router Network) and NIPRNET (Non-secure Internet Protocol Router Network). The common building block of most of these military systems, and indeed for the whole concept of interoperability, was the Defense Information Systems Agency's evolving Defense Information Infrastructure specifications for a Common Operating Environment. The Defense Information Infrastructure (DII) Common Operating Environment (COE) provided a standard environment, "off-the shelf" software, and a set of programming standards that described in detail how mission applications would operate in that environment. The COE contained common support applications and platform services required by mission applications. Each application that migrated to the common environment had to comply with published guidance described in the Integration and Runtime Specification.

During the 1990s, as part of the continuing evolution of the way Air Force communications was defined and organized, there was a merger of the communications-computer and information management functions. In October 1994, the Chief of Staff of the Air Force, General Merrill A. McPeak, directed a study be conducted to assess the advantages to be gained by integrating these two functional areas. After extensive discussions, in early 1996 the Secretary of the Air

Force, Sheila E. Widnall, agreed to this merger. Nearly 1,500 officers in the IM (AFSC 37AX) or Visual Information (AFSC 33VX) career fields converted to the SC career field (AFSC 33SX). The AFSCs for enlisted personnel did not change but their training and education will be modified, over time, to emphasize performing the IM mission in any media. On the surface, this merger would seem to have a minimal impact; however, when all those affected are considered, nearly 20 percent of all Air Force personnel were involved.

At the ceremony celebrating the combining of these functions, it was pointed out that the merger integrated "planning, policy and procedures; architectures and standards; and printing and visual information." More importantly, however, the integration meant the leadership of the Air Force recognized "the inseparable relationship between effective information management and communications and computer technology. The combination of these disciplines into a single functional area will guarantee that the vision the Air Force has for Information Dominance will be met."[9]

There was one other major organizational change in the communications functional area in the 1990s, the creation of the Chief Information Officer of the Air Force. On 8 August 1996 Congress passed the Information Technology Management Reform Act (ITMRA), sometimes referred to as the Clinger-Cohen Act, after its sponsors Senator William S. Cohen of Maine and Representative William F. Clinger, Jr. of Pennsylvania. This act was passed in response to the perceived problem of the government's spending billions of dollars on automated data processing systems that failed to produce the anticipated results.

Under this act, the Air Force was given the full, independent acquisition authority for its information technology investments. The act also required the appointment of an Air Force Chief Information Officer (CIO), who was given a broad mandate to improve the acqui-

[9]Memorandum, USAF/AA, "Ceremony Marking Integration of SAF/AAI with AF/SC," 12 March 1996.

sition and use of information and information technology to support directly the service's strategic mission performance. Secretary Widnall appointed the Assistant Secretary of the Air Force for Acquisition (SAF/AQ), Mr. Arthur L. Money, as the Air Force CIO, and the Deputy Chief of Staff for Communications and Information (AF/SC) as the Deputy CIO.

Mr. Money viewed the new arrangement as a "continuation of the re-engineering of the Air Force information management and command, control, communications and computers (C4) functions into a single functional area, designated as communications and information, at all levels of command." He maintained that the management reforms mandated by this act provided "the opportunity to significantly improve the way the Air Force acquires and manages information technology. By centralizing our focus on capital planning, investment concepts and evaluation of information technology through outcome-based performance measures will provide greater accountability concerning our information technology investments."[10]

During the 1990s, the concept of information dominance surfaced as a recurring theme in Air Force planning. In *Joint Vision 2010* the Chairman of the Joint Chiefs of Staff called for the U.S. military to have "the capability to dominate an opponent across the range of military operations." Air Force leaders believed that to do this required "Information Superiority, the capability to collect, process, analyze and disseminate information while denying an adversary's ability to do the same." It was clear that both Secretary Widnall and General Fogleman were determined to pursue this concept of information dominance. In their 1996 published statement, *Global Engagement: A Vision for the 21st Century Air Force*, they listed "information superiority" as one of the "core competencies" of the Air Force. As *Global Engagement* noted, "In no other area is the pace and extent of technological change as great as in the realm of infor-

[10]Memorandum, SAF/AQ, "Chief Information Officer of the Air Forcce," 11 September 1996.

mation." *Global Engagement* continued, "Information Operations, and Information Warfare (IW) in particular, will grow in importance during the 21st Century. The Air Force will aggressively expand its efforts in defensive IW as it continues to develop its offensive IW capabilities. The top IW priority is to defend our own increasingly information-intensive capabilities."[11]

As part of this same effort to envision where the Air Force should be heading, the USAF Scientific Advisory Board (SAB) in the mid-1990s examined communications and present conditions, then tried to project future developments, in a series of publications entitled *New World Vistas: Air and Space for the 21st Century*. The SAB believed that "The crucial importance of detailed and timely knowledge and rapid communications to the successful pursuit of our new missions will demand creative use of commercial and military applications to an extent not yet encountered. This intertwining will blur the distinction between threat and asset, offense and defense, and, even, friend and foe." The SAB emphasized the critical role communications would play. The Board's succinct conclusion was that "knowledge and control of information is necessary for all missions, whether in peace or war, logistics or combat."[12]

One of the SAB studies listed six goals for 21st century aerospace power. Almost all of them dealt with some aspect of communications, including the more pointed:

> Get the right *knowledge*, to the right place, at the right time for all aerospace missions.

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[11]*Global Engagement: A Vision for the 21st Century Air Force* [Washington D.C.: United States Air Force, 1996], 5, 14.

[12]USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century - Summary Volume* [Washington, D.C., 1996], iii, 4.

> Achieve global *communication* between the air, ground, and space assets of the Air Force, as well as those with whom we operate.
>
> *Dominate* the information battlespace.[13]

The "futurist" John Peterson, in looking towards the early years of the 21st century, also gave communications a critical role. Among some of the most significant factors he saw effecting the future were those dealing with communications. He contended that "Information is the capital commodity of the future." Furthermore, he maintained that "Information technology is making it more advantageous—in almost every situation—to move information rather than people." He also had a warning for communicators when he pointed out that "The more complex a system becomes, the more likely the chance of system failure."[14]

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[13]Emphasis original. USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century - Information Applications Volume* [Washington, D.C., 1996], iii.

[14]John Peterson, *The Road to 2015* as quoted in USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century - Information Technology Volume* [Washington, D.C., 1996], 112.

5th Combat Communications Group personnel deploy a lightweight, multi-band satellite communications unit.

Epilogue

Communications today are of the types that only science fiction writers dreamed of 50 years ago—wireless cellular telephones, laptop mini-computers, electronic mail, satellite communications. All of these were dreamed of, developed, and brought to fruition over the past 50 years. The challenge confronting today's Air Force communicators is to build on those developments and support the CSAF's long-range vision of keeping the USAF as the world's leader in Information Superiority.

In facing this challenge, Lieutenant General William J. Donahue, the Air Force Deputy Chief of Staff, Communications and Information, and Commander of the Air Force Communications and Information Center,[15] has his own insights and a vision of where Air

Force communications should be heading. In an interview in early 1997, he shared his ideas about the future for Air Force communicators. He said that "Historically, we communicators, with few exceptions, have not seen ourselves as part of the operational community. That is changing. Over the course of the next few years, we will become more integral to the fight than previously imagined. We are now engaged in the process of becoming so infused throughout the Air Force's operational community, that one day our now distinctive roles will be barely distinguishable."

The general emphasized that "We are in the midst of a computer and communications technological revolution. . . . We continue to move toward smaller, faster, more portable, bandwidth scaleable systems that will provide information dominance for the warfighter. We are finding newer ways to exploit technology." He challenged Air Force communicators to continue this process: "We have to find a way to make sure we don't let the power of our old process and ideas hold us back. We in the comm and info business need to be the best there is at applying technology to make sure things are done better, faster, cheaper."

As part of his vision for the future, General Donahue contended that the Air Force communications community needed "to become the agents of major change." He saw the establishment of the Air Force Communications and Information Center (AFCIC), on 1 April 1997, as central to that change. "The Air Force Communications and Information Center will be the primary vehicle I use to meet my overall objectives of an Air Force that works better and costs less." He maintained that "Any high-performing organization that's globally engaged in a high technology area has to continue to examine its organizational structures and processes. They have to continue to find ways to do their jobs better." He explained, "One thing we will not do is put our old processes on this new structure. We're

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[15]The Air Force Communications and Information Center (AFCIC) was established 1 April 1997.

trying to reinvent a whole new set of structures, a whole new set of processes, so we can be fully prepared to take the Air Force into the next century."

In looking towards the future, the general said "We need to be viewed as Air and Space operators whose contribution is communications and information. We do that by saddling up with the operators and our customers. We have to understand our operational customers' jobs and their missions—know their business as good as they do. We need to bring our communications and information expertise to the mission and job that they have, to the point that we can be the enabler of change and improvements. We exist for no other reason than to let other people do their jobs better, faster, cheaper. And if we do it right, with smart use of technology, we've been successful."

General Donahue also stated that Air Force communicators need to "Think in terms of 'just in time information.' We must learn to acquire, process, fuse, disseminate, and display information so that exactly the right information, in the right quantity and form, gets to the right place, at the right time. Whether it's beans, bullets, or information, we've got to ensure we have enough, but not too much, exactly when we need it. Too much will eat up scarce resources, like airlift, storage, and bandwidth; and overload our ability to use it efficiently and effectively. Too little and we will starve, or be overrun. Striking the right balance between perfect information and too much, too soon, too little, or too late is a daunting task. The smart application of information technology offers the most promise for success."

General Donahue also emphasized the criticality of the role communicators would have to play: "'Dominant battlefield awareness' will be realized in our lifetime and we must do whatever it takes to assure that the information, and the systems that support it, is fully protected. Nothing short of success is acceptable—the alternative spells disaster."[16]

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[16]All quotations from Interview, TSgt Ed Ferguson and SSgt Gerald Sonnenberg, AFCA Public Affairs, with Lt Gen William J. Donahue, 13 Feb 1997, forthcoming in *intercom*.

Appendix 1

Air Service/Air Corps/Air Force Chief Communications Officers

Air Communications Officer *

Maj (later Col) Clarence C. Culver	1918 - 1921
Capt Burdette S. Wright	1921 - 1925
Maj (later Maj Gen) St. Clair Streett	1925 - 1927
Unknown	1927 - 1930
Maj (later Brig Gen) Jacob H. Rudolph	1930 - 1933
Col William B. Souza	1934 - 1936
Maj (later Brig Gen) Alfred W. Marriner	1936 - 1938
Maj (later Brig Gen) Wallace G. Smith	1938 - 1941
Brig Gen Alfred W. Marriner	1941 - 1943
Brig Gen (later Maj Gen) Harold M. McClelland	1943 - 1946
Maj Gen Francis L. Ankenbrandt	1946 - 1947

Director of Communications

Maj Gen Francis L. Ankenbrandt	1947 - 1952
Maj Gen Raymond C. Maude	1952 - 1953
Maj Gen (later Lt Gen) Gordon A. Blake	1953 - 1955

Director of Communications-Electronics

Maj Gen (later Lt Gen) Gordon A. Blake	1955 - 1956
Maj Gen Alvin L. Paschynski	1956 - 1959
Maj Gen (later Lt Gen) Harold W. Grant	1959 - 1960

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* Post World War I demobilization made it impossible for the Air Service Headquarters to attain organizational stability. Changes in functional and staff alignments were the normal order. Furthermore, the communications function did not receive high priority, so extant records make it impossible to trace the position or person of the chief communications officer with any high degree of confidence.

Director of Telecommunications

Maj Gen (later Lt Gen) Harold W. Grant	1960 - 1961
Maj Gen John B. Bestic	1961 - 1962

Director of Command, Control, and Communications

Maj Gen J. Francis Taylor, Jr.	1962 - 1965
Maj Gen (later Lt Gen) Gordon T. Gould, Jr.	1965 - 1971
Maj Gen (later Lt Gen) Lee M. Paschall	1971 - 1974
Brig Gen (later Maj Gen) Robert L. Edge	1974 - 1975

Assistant Chief of Staff, Communications and Computer Resources

Maj Gen Robert L. Edge	1975 - 1977
Maj Gen (later Gen) Robert T. Herres	1977 - 1978

Director of Command, Control, and Communications

Maj Gen (later Gen) Robert T. Herres	1978 - 1979

Director of Command and Control and Telecommunications

Brig Gen (later Maj Gen) William G. Mac Laren, Jr.	1979 - 1981
Brig Gen (later Maj Gen) Gerald L. Prather	1981 - 1983

Assistant Chief of Staff, Information Systems

Maj Gen Gerald L. Prather	1983 - 1984
Brig Gen (later Maj Gen) John T. Stihl	1984 - 1986

Assistant Chief of Staff, Systems for Command, Control, Communications and Computers

Maj Gen John T. Stihl	1986 - 1986
Maj Gen (later Lt Gen) Robert H. Ludwig	1986 - 1989

Assistant Chief of Staff, Command, Control, Communications, and Computers

Maj Gen (later Lt Gen) Albert J. Edmonds	1989 - 1990

Deputy Chief of Staff, Command, Control, Communications, and Computers

Lt Gen Robert H. Ludwig	1990 - 1992
Lt Gen Carl G. O'Berry	1992 - 1995
Lt Gen John S. Fairfield	1995 - 1996

Deputy Chief of Staff, Communications and Information

Lt Gen John S. Fairfield	1996 - 1996
Lt Gen William J. Donahue	1996 - 1997

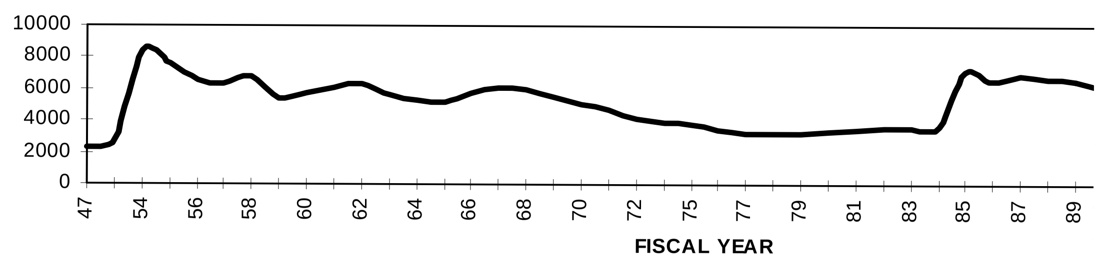
Director, Communications and Information

Lt Gen William J. Donahue	1997 -

Appendix 2
Chart 1

USAF ACTIVE DUTY COMMUNICATIONS-COMPUTER SYSTEMS OFFICERS, FY47-99*
Sources: *USAF Statistical Digest, FY98 Manpower Profile*

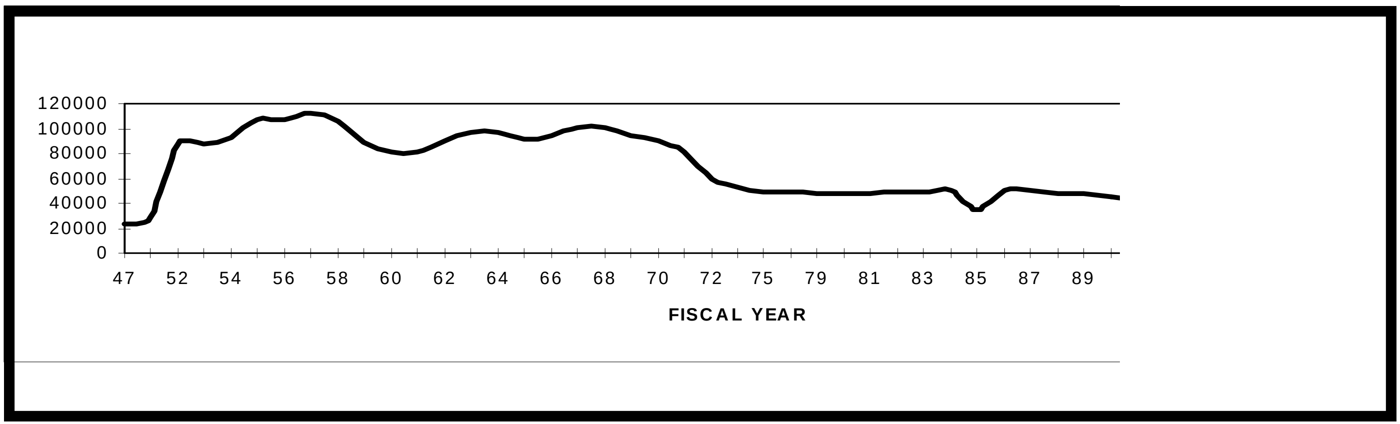
* Communications-Electronics and Computer Technology AFSCs merged and renamed Information Systems in FY85. Information Systems renamed Communications-Computer Systems in FY87. Information Management AFSC merged into Communications-Computer Systems in FY97. FY97-99 data as projected on 31 Sept 1996.



Appendix 2
Chart 2

USAF ACTIVE DUTY COMMUNICATIONS-COMPUTER
AND COMMUNICATIONS-ELECTRONICS SYSTEMS ENLISTED, FY47-99*
Sources: *USAF Statistical Digest, FY98 Manpower Profile*

* Communications Operations and Computer Systems AFSCs merged and renamed Information Systems in FY85. Information Systems renamed Communications-Computer Systems in FY87. Radio-Radar Systems merged/renamed Communications-Electronics Systems circa FY63. Wire Communications Systems Maintenance merged with Communications-Electronics Systems in FY94. FY97-99 data as projected on 31 Sept 1996.



Glossary

AACS	Army Airways Communications System
ABEN	Air Base Emergency Net
ACAN	Army Command and Administrative Network
ADC	Air Defense Command
ADCC	Air Defense Control Center
AFB	Air Force Base
AFCC	Air Force Communications Command
AFCIC	Air Force Communications and Information Center
AFCS	Air Force Communications Service
AFDATACOM	Air Force Data Communications
AFSATCOM	Air Force Satellite Communications
AFSC	Air Force Specialty Code
AIRCOM	Air Force Communications Complex
AM	Amplitude Modulation
AMPE	Automated Message Processing Exchange
AT&T	American Telephone and Telegraph
AUTODIN	Automatic Digital Network
AUTOSEVOCOM	Automatic Secure Voice Network
AUTOVON	Automatic Voice Network
AWDS	Automated Weather Distribution System
AWN	Automated Weather Network
BADGE	Base Air Defense Ground Environment
BIDDS	Base Information Digital Distribution System
BMEWS	Ballistic Missile Early Warning System
C2	Command and Control
C4	Command, Control, Communications and Computers
C4I	Command, Control, Communications, Computers and Intelligence
CINC	Commander in Chief
CIO	Chief Information Officer
COC	Combat Operation Center
COE	Common Operating Environment
COMEDS	Continental [US] Meteorological Data System
COMLOGNET	Combat Logistics Network
COMSAT	Communications Satellite Corporation

CSAF	Chief of Staff, Air Force
DARN	Direct Air Request Network
DCS	Defense Communications System
DCSP	Defense Communications Satellite Program
DDN	Defense Data Network
DII	Defense Information Infrastructure
DMSP	Defense Meteorological Satellite Program
DOD	Department of Defense
DSCS	Defense Satellite Communications System
DSN	Defense Switched Network
FM	Frequency Modulation
GCA	Ground Controlled Approach
GCCS	Global Command Control System
GCSS	Global Combat Support System
GLOBECOM	Global Communications System
GPS	Global Positioning System
GWEN	Ground Wave Emergency Network
HF	High Frequency
HQ	Headquarters
ICS-SEA	Integrated Communications System-Southeast Asia
ILS	Instrument Landing System
INTELSAT	International Telecommunications Satellite Consortium
ISDN	Integrated Services Digital Network
ITMRA	Information Technology Management Reform Act
IW	Information Warfare
IWCS	Integrated Wideband Communications System
JCS	Joint Chiefs of Staff
LAN	Local Area Network
LORAN	Long Range Aid to Navigation
MEITS	Mission Effective Information Transfer System
MFSCS	Military Flight Service Communications System
Mhz	Mega Hertz
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVSTAR	Navigation System using Time And Ranging
NCS	Network Control Center

NEXRAD	Next Generation Weather Radar
NIPRNET	Non-secure Internet Protocol Router Network
NMCS	National Military Command System
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Air Defense Command
OIS	Office Information System
OSD	Office of the Secretary of Defense
PIACCS	Pacific Interim Automated Command and Control System
RCA	Radio Corporation of America
SAB	Scientific Advisory Board
SAC	Strategic Air Command
SAGE	Semi-Automatic Ground Environment
SAM	Special Air Mission
SARAH	Standard Automated Remote to AUTODIN Host
SCAN	Switched Circuit Automatic Network
SCORE	Signal Communications by Orbiting Relay Equipment
SCR	Signal Corps Radio
SEAWBS	Southeast Asia Wideband System
SHF	Super High Frequency
SHORAN	Short Range Aid to Navigation
SIPRNET	Secret Internet Protocol Router Network
SSB	Single Sideband
STCT	Satellite Test Control Terminal
SYNCOM	Synchronous Communications
TAC	Tactical Air Command
TACAN	Tactical Air Navigation
TACS	Tactical Air Control System
TSCS	Tactical Satellite Communications System
UHF	Ultra High Frequency
USAF	United States Air Force
VHF	Very High Frequency
VOR	VHF Omni-Directional Range
VORTAC	VHF Omni Range Tactical Air Navigation
WATS	Wide Area Telephone Service
WSR	Weather Surveillance Radar

Bibliography

Brown, H. McD. "A Signal Corps Space Odyssey: Part II - SCORE and beyond," *Army Communicator*, Vol 7, No 1, Winter 1982, pp. 12-22.

C4I for the Warrior. Washington, D.C.: C4 Architecture and Integration Division (J6I), J-6, The Joint Chiefs of Staff, [1993].

Campen, Alan D. "Communications, Air Power Ride Data Age Roller Coaster," *Signal*, Vol 46, No 1, September 1991, pp. 43-45.

Campen, Alan D. (ed.) *The First Information War*. Fairfax, VA: AFCEA International Press, 1992.

Corbett, Wayne. "Ludwig talks about his Air Force career" [Interview with Lt Gen Robert H. Ludwig], *intercom*, May 1992.

Cossaboom, Robert T. and Morrison, Larry R. *Joint Communications in the Desert*. Scott Air Force Base, IL: AFCA Office of History, forthcoming.

Global Engagement: A Vision for the 21st Century Air Force. [Washington D.C.: United States Air Force, 1996.]

HORIZON. Washington D.C.: Deputy Chief of Staff Command, Control, Communications and Computers, USAF, [1993].

HORIZON '95. Washington D.C.: Deputy Chief of Staff Command, Control, Communications and Computers, USAF, [1995].

Lane, John J. Jr. *Command and Control and Communications Structures in Southeast Asia.* Maxwell AFB, AL: Air University, 1981.

Macksey, Kenneth. *For Want of a Nail*. London: Brassey's Ltd., 1989.

Maurer, Maurer. *Aviation in the U.S. Army 1919-1939*. Washington, D.C.: Office of Air Force History, 1987.

McKenzie, Dave. "US AIR FORCE DESERT STORM COMMUNICATIONS...PROVIDING THE COMBAT REINS OF COMMAND," in Witt, Randy (ed.). *Air Force Tactical Communications in War: The DESERT SHIELD/DESERT STORM Comm Story*. Riyadh, Saudi Arabia: Headquarters United States Central Command Air Forces, 1991.

Mucklow, Timothy J. *HAMMER ACE*. Scott Air Force Base, IL: AFCC Office of History, 1988.

O'Connell, J.D., Pachynski, A. L., and Howeth, L.S. "A Summary of Military Communication in the United States-1860 to 1962," in *Prodeedings of the IRE*, 1962.

Snyder, Thomas S. (General Editor) et al. *Air Force Communications Command: 1938-1991 An Illustrated History*. Scott Air Force Base, IL: AFCC Office of History, 1991.

Sonnenberg, Gerald P. "SC defines C4I roles of the future" [Interview with Lt Gen John S. Fairfield], *intercom*, November 1995.

Trapp, Melinda Wigginton. *Deregulation and Divestiture*. Scott Air Force Base, IL: AFCC Office of History, 1989.

USAF Scientific Advisory Board. *New World Vistas: Air and Space Power for the 21st Century - Information Applications Volume*. [Washington, D.C., 1996].

USAF Scientific Advisory Board. *New World Vistas: Air and Space Power for the 21st Century - Information Technology Volume*. [Washington, D.C., 1996].

USAF Scientific Advisory Board. *New World Vistas: Air and Space Power for the 21st Century - Summary Volume*. [Washington, D.C., 1996].

Witt, Randy (ed.). *Air Force Tactical Communications in War: The DESERT SHIELD/DESERT STORM Comm Story*. Riyadh, Saudi Arabia: Headquarters United States Central Command Air Forces, 1991.

Young, Tommy R. II, "Communications," in Jessup, J. E. and Ketz, L. B. (eds.), *Encyclopedia of the American Military*. Volume III, pp. 1471-94. New York: Charles Scriber's Sons, 1994.

Ziegler, Hans K. "A Signal Corps Space Odyssey: Part I - Prelude to SCORE," *Army Communicator*, Vol 6, No 4, Fall 1981, pp. 17-24.