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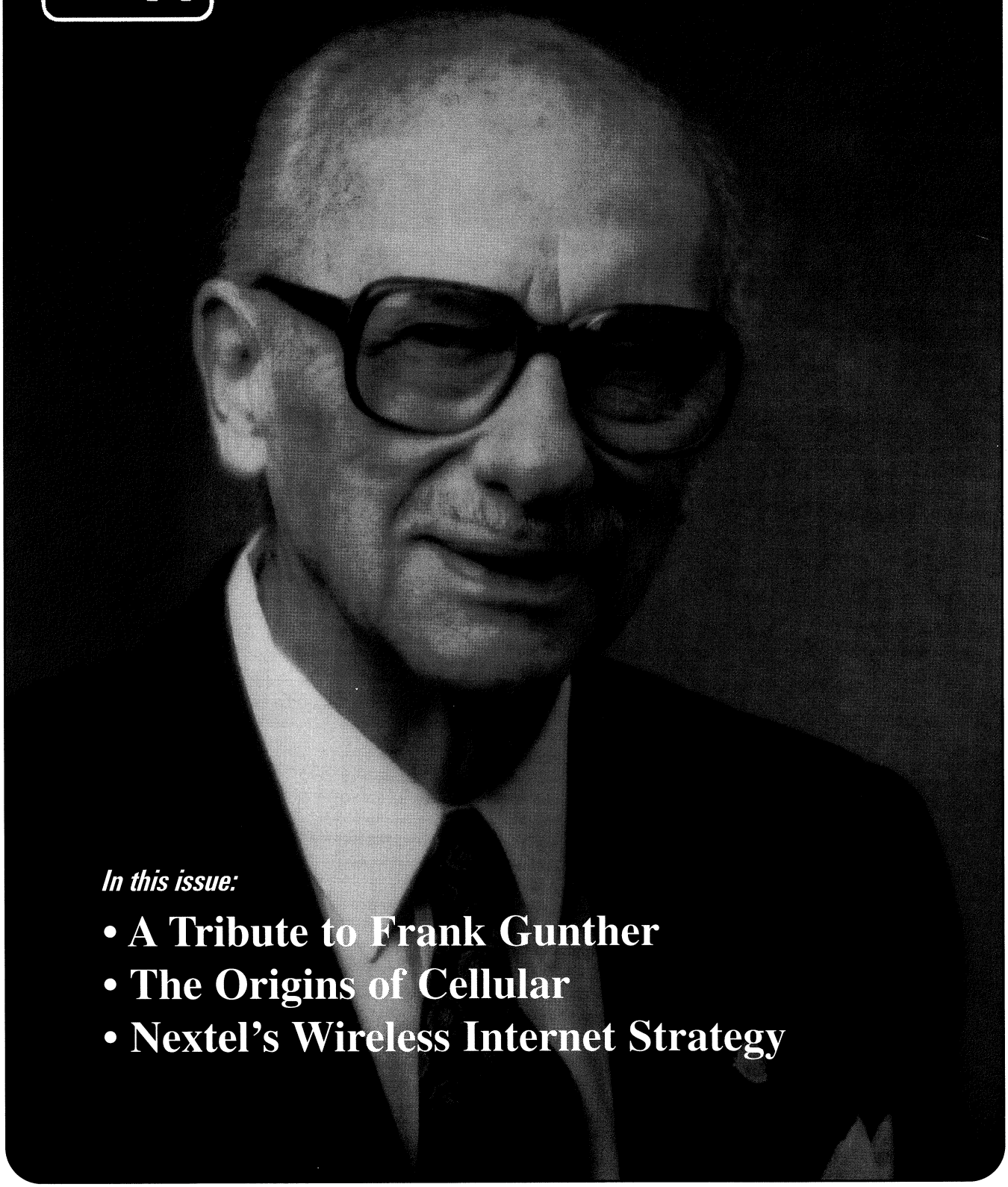

*In this issue:*

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- **The Origins of Cellular**
- **Nextel's Wireless Internet Strategy**

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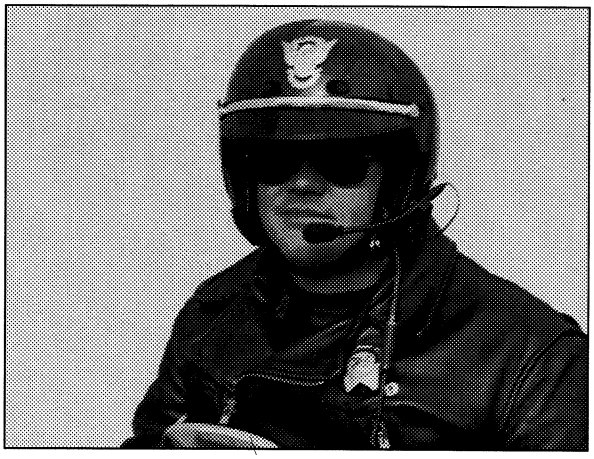

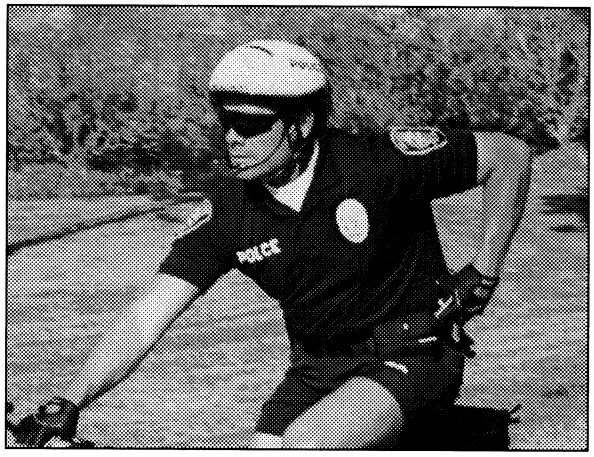

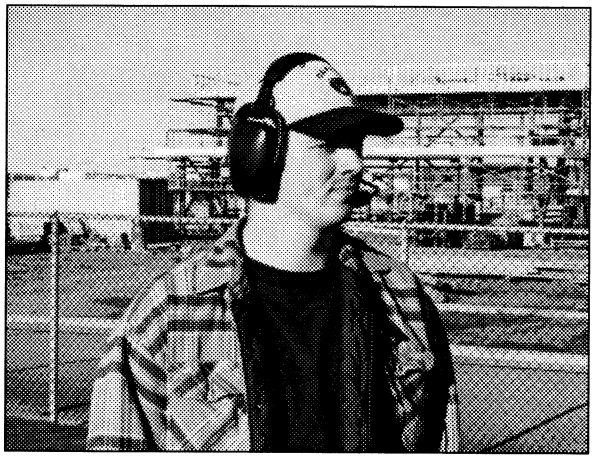

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# Frank A. Gunther, Radio Legend

Frank A.Gunther, 91, one of America's radio transmission pioneers and the original developer of short-wave radio equipment that was the genesis of today's wireless transmission industry, died on May 24, 1999 in Venice, FL. A native New Yorker, Frank maintained homes in Staten Island, NY and Nokomis, FL. A Fellow in the Institute of Electrical & Electronic Engineers (IEEE), Frank's extraordinary 72-year career in radio transmission ranged from installing the 600 meter transmitter-receiver in the sea plane used by Amelia Earhart in 1928, to touring Vietnam, as a three-star Lieutenant General, at the request of the U.S. Army Signal Corp. to inspect various communications installations in that country.

Known to military, police, fire and community leaders around the world, Frank designed, installed and proved the viability of wireless communications during an age and time when few envisioned, and even fewer understood, the enormous potential and impact wireless communications would have on the way we live. He also was aware of the lives that could be saved using wireless communications in emergency alert systems.

## Pioneering Radio

In October 1935, Frank worked with Edwin H. Armstrong and operated the receiving equipment for Armstrong's first public demonstration of frequency modulation (FM) transmission at the Institute of Radio Engineers auditorium in New York City. The following year, Frank designed and manufactured the early transmitter components for Armstrong's wide band frequency modulation system and thus began a 25-year collaboration between the two radio pioneers.

Educated at Stuyvesant High School, Columbia University and Wagner College in New York City, Frank joined the Radio Engineering Laboratories (REL) based in Long Island City in 1925. He immediately became involved in the construction and operation of experimental station 2SV, pioneer short wave broadcasting system. In 1926, Frank equipped the first U.S. Coast Guard cutter on ice patrol in the Davis Strait, Canada, with a HF radio, 500 watt C.W. equipment that transmitted directly, via a connection to existing land lines, to the Coast Guard's Washington, D.C. headquarters.

In that same year, Frank extended wireless transmission internationally, installing for the All American Cable Co. of Manhattan Beach, a high-frequency circuit with Buenos Aires, Argentina. This was the beginning of a series of international assignments that was highlighted by the first demonstration and installation of two-way mobile radio transmission outside of the United States, for the Rio de Janeiro, Brazil, Police Department. The antenna for this installation was placed atop the famed Corcovado Mountain.

At home, Frank became well known among police and fire officials nationally as he designed, proved the viability of and installed two-way mobile radio systems for major cities such as New Orleans, LA; Bethlehem, PA; Brookline, MA; Long Beach, CA; and Atlantic City, NJ; in more than 12 states. These installations grew out of the fact that Frank was the first person to secure a Federal Radio Commission license for the world's first two-way mobile radio system for the city of Bayonne, NJ.

In the world of radio broadcasting between 1939 and 1942, Frank was responsible for designing, manufacturing and installing the transmission equipment for more than 25 FM stations nationwide.

In the aviation arena, not only did Frank find fellow visionaries who saw the potential of wireless transmission for their aircraft, but he found an avocation as well. This interest began early in his career when in 1929 he participated in the first voice broadcast to the public from an aircraft in flight via WABC, NY. He also supplied the radio communication (WOR) for the only attempt to attach an airship to the Empire State Building. In 1932, he successfully achieved the first aircraft VHF two-way radio installation for the NYC Department of Conservation. On the personal side, he obtained his first private pilot's license in 1940, flew the first airplane on a solo flight from the old Staten Island airport and within one year, upgraded his rating to a commercial pilot's license.

### Military Contributions

It was in the 1940s that Frank's expertise in wireless communications truly came to the attention of military leaders as the dark clouds of World War II gathered and then exploded on the horizons. In 1939, he demonstrated the first FM mobile transmitter to the U.S. Armed Forces and two years later, demonstrated the first two-way radio system to the U.S. Army Air Corps in Mitchell Field, LI and Staten Island.

But it was the U.S. Coast Guard that saw the first visionary application of this technology when in 1941, Frank traveled to the radiation laboratories of MIT to listen to Melvill Eastham describe and present highly classified drawings and details on what was to become known as the LORAN guidance systems. Frank's company, REL then designed and manufactured for the Coast Guard, the first 176 LORAN transmitters constituting the entire LORAN system used during WWII.

He went on to work with virtually all branches of the armed services. An early member and past president of the Radio Club of America (RCA), he was honored by the establishment of the Frank A. Gunther Award by the club in 1996. This award is given annually to recipients who make major contributions to the advancement of wireless military electronic communications systems.

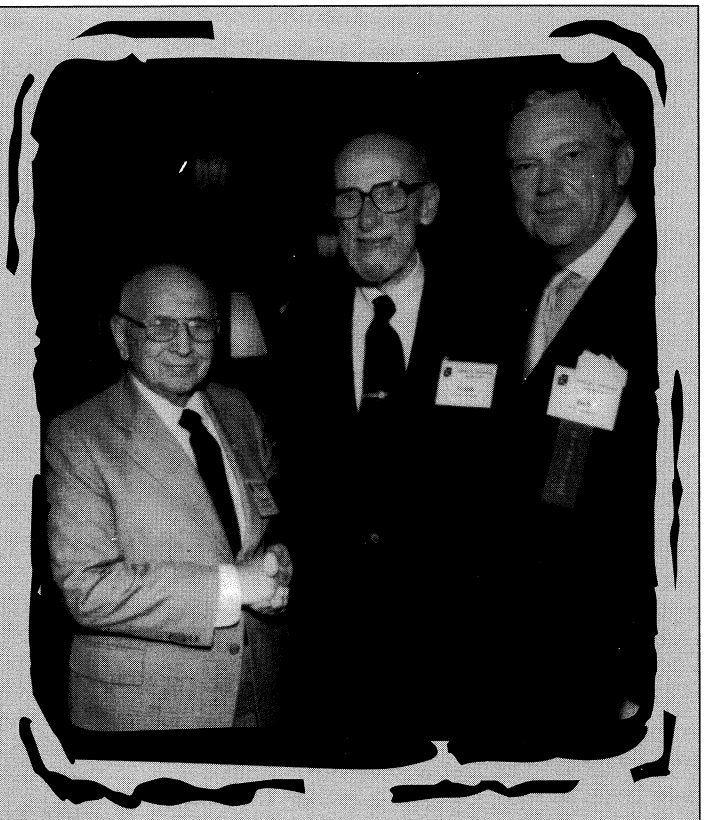
August 6, 1947 marked one of the milestones of the Gunther-Armstrong collaboration. It was on that day that Frank installed a 1KW FM broadcast transmitter associated relay receiver and operated the system during demonstrations wherein Maj. Armstrong introduced frequency modulation capabilities before the International Frequency Allocations Conference in Atlantic City, NJ. This demonstration tied in stations, for the first time, from Mount Washington, NH to Atlantic City without the use of telephone interconnects and so the seed was planted for the growth of America's wireless telephone communications network.

## Prestigious Award

Rarely does an award recipient get to meet the honoree for whom the award has been named but Seymour Krevsky, P.E. was able to shake hands with 91-year-old Frank A. Gunther at the RCA annual dinner in New York city last fall. Robert C. Gunther, Frank's son, and president of High Point Management Co., Inc. presented RCA's Frank A. Gunther Award to Krevsky for his advances in high-frequency ionospheric radio propagation theory and techniques. Krevsky's work was instrumental to the development of forward-over-the-horizon radio transmission techniques used extensively in Vietnam by the U.S. military.

Krevsky has more than 40 years of experience in the wireless communications industry. He has worked for a variety of well-known firms and served as Deputy Director of Engineering and Chief Engineer at the U.S. Army Communications Systems Agency. He now works as a consultant. A member of a host of professional organizations, Krevsky is a Fellow in the American Association for the Advancement of Science and a Life Senior Member of the Institute of Electrical & Electronics Engineers.

The RCA, established in 1909, today numbers 1,200 members and has grown from its social/fellowship origins to become a scientific organization of recognized standing. Among its better known awards are the Sarnoff Citation and the Armstrong Medal. The Frank A. Gunther Award was established in 1996 and is given to recipients who make major contributions to the advancement of wireless military electronic communications systems.



Seymour Krevsky, P.E. [left] shaking hands with 91-year-old Frank A. Gunther [center] at the annual RCA dinner last year. Robert C. Gunther [right] is Frank's son.

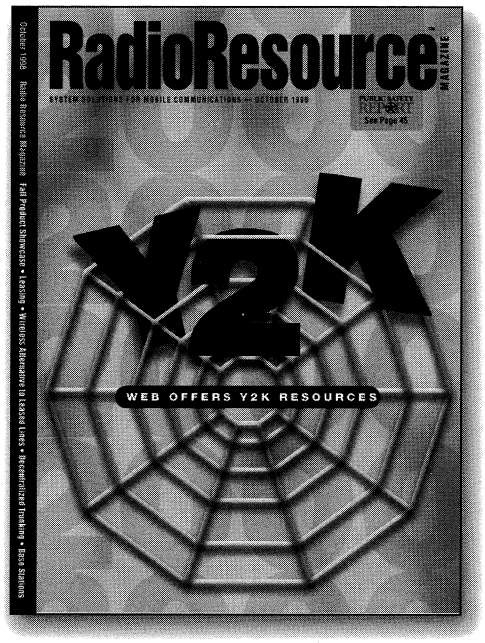
Frank Gunther was a pioneer in the development of the first FM wireless radio transmission made in 1929. His work was the genesis of the High Point Management Co., now headed by his son, Robert.

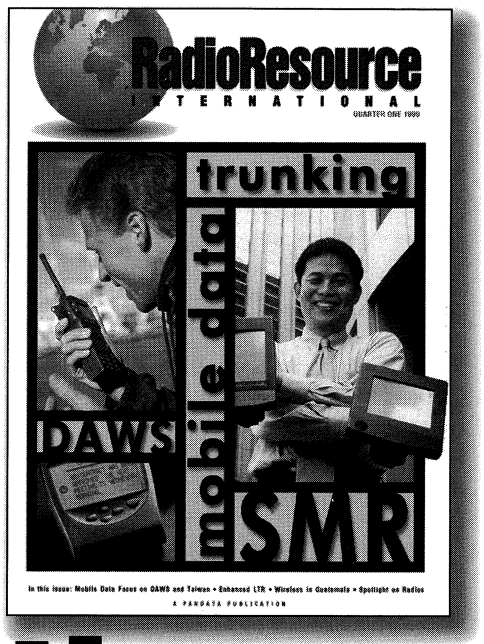
### Professional Recognition

Professionally, Frank was named president of REL in 1960. He was also elected to the Board of Directors of Dynamics Corporation of America in 1966. He received the DeForest Award for being the "Original Developer of Short Wave Radio Equipment" in 1977. In 1992, he was featured in a PBS television program entitled "Empire of the Air: The Men who Made Radio," a documentary about the birth of radio. He also served as a consultant for the documentary.

Most recently, Frank worked as a consultant with his son, Robert, president of Highpoint Development Ltd. of Staten Island. Highpoint Development is one of the wireless industry's leading communications tower developers, constructors and site managers.

Frank married the former Lillian Madden in 1930. His wife died in 1997. Two sons, Frank M. and Robert C. Gunther; five grandchildren, six great-grandchildren and five step-grandchildren survive him. He was buried in Moravian Cemetery in Staten Island.

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*By Michael Katzdorn*

# The History of Radio at Purdue University

Purdue University was one of 68 land-grant colleges and universities that emerged from the Morrill Act signed by President Lincoln on July 2, 1862. Seven years later, the Indiana General Assembly accepted $150,000 and 150 acres of land from John Purdue giving birth to Purdue University. Although the Physics Department taught electricity as early as 1884, the Electrical Engineering Department didn't begin until 1892.

Reginald Aubrey Fessenden was the third head professor and the first professor of Electrical Engineering (EE) at Purdue University from 1892 to 1893. Despite his many professorial obligations, as head of the EE School and creating the first Purdue courses in electrical machinery, Fessenden found time to begin experiments that led directly to the wireless transmission of music and the human voice. Although he remained at Purdue for only one year, his talent as a teacher and experimenter and his later success as an inventor established him as a major figure in EE history. Fessenden considered himself indebted to the University that launched his career. In gratitude, his estate provides fellowships for EE students at Purdue.

Fessenden was enticed to Purdue by President Smart's statement, "You have a free hand at purchasing equipment." Purdue provided Fessenden the opportunity he sought—a teaching position, a well-equipped laboratory and the freedom to develop his idea of transmitting the human voice without wires.

Fessenden was a gifted teacher who made the complex seem simple. Students worked with him in the EE Building transmitting wireless messages from one end of the laboratory to the other. He integrated the results of these experiments into the design of sending-end and receiving-end apparatus (transmitter and receiver). Fessenden, trained as a mathematics teacher in Ontario, Canada, and had previously taught in Bermuda. He learned about electricity from Edison, his former employer, and successfully combined mathematics and electricity at Purdue in an engaging way.

Unfortunately for Purdue, George Westinghouse enticed Fessenden to the University of Pittsburgh, where the chair of electrical engineering was vacant. At Pittsburgh, Fessenden developed his designs for a detector (coherer) for Hertzian (radio) waves. One model was a cylinder of iron filings and the other was a platinum needle dipping into sulfuric acid. The former was a solid state rectifier—the latter an electrolytic rectifier which, surprisingly enough, was better; so he patented it, as he did some 300 other inventions.

**Figure 1.** ***Retirement photographs of Helen May Trott Fessenden and Reginald Aubrey Fessenden, head of the School of Electrical Engineering and first professor of Electrical Engineering (1892-1893).***

## The Beginning of Wireless

More than a decade later, wireless communication was initiated at Purdue. In 1910, senior EE students began building a telegraphic station. R. V. Achatz, a member of the EE faculty from 1916 to 1923 and an originator of radiotelegraphy at Purdue, wrote about the project in the Indiana News in 1920:

The first attempt to install a radio station at Purdue University was made in connection with the senior thesis of R. A. Garrett and 0. W. Melndoo of the 1910 class. These two erected an aerial from the top of the stack to the north wing of the Electrical Engineering Building on the campus, and installed an apparatus. No communication at that time was established with other stations, and the experimenters turned their attention to tests of various types of crystal detectors then used exclusively for receiving signals. A small indoor antenna was used to send the signals.

A. E. Hague and J. R. Pigman commenced the next installation in 1912. R. E. Cleveland continued the work in 1918. In 1915, G. M. Wilson and E. H. Bulls undertook the improvement of the station. A new oscillation transformer and a new high-tension condenser were constructed for the transmitting outfit. The design of the condenser was unique, as it consisted of a group of milk bottles, which were placed in a metal tank filled with salt water to about two-thirds the height of the bottles. The bottles were filled to about the same height with salt water. The tank and the salt water outside the bottles formed one plate and rods reaching down to the salt water inside the bottles formed the other plate. A new receiving set also was constructed.

In 1918 the university entered actively into the work of instruction along radio lines in conjunction with the Signal Corps of the United States Army. The university undertook the instruction of 150 radio operators for the Army. This number was later increased to 400. In 1919 a temporary permit was granted the university for the operation of a radio station, and immediate steps were taken to install a permanent station. During 1919-20 much construction work was done, and the sending set installed in the present radio room of the university. The call letters 9YB were assigned, and the transmitting wavelengths 200 and 375 meters were permitted.

Further information about the teaching of wireless is presented in the Purdue Trustees Report of 1917-18:

*This line of work is administered under the direction of the Signal Corps of the U.S. Army. It is open to students in engineering schools who have had adequate preparation in electric theory. All students electing this course are required to pass physical examination for entrance into the U.S. Army and to take an oath before a Notary Public to regard the material as strictly confidential. Enlistment in the U.S. service is not a prerequisite but those taking the course are expected to be available for the Signal Corps later. Seniors in EE may take this course as a substitute for other second semester electives as well as for EE Lab or Thesis. (It seems that this was the only year this course was offered. It was not until 1920-21 that another radio course, Radio Communication, was offered, carrying the description: "This course covers the fundamental principles of radiotelegraphy and radiotelephony, together with a study of the construction and operation of radio apparatus.")*

*The Purdue station has talked with all states along the Atlantic seaboard and as far west as Texas and the Black Hills in South Dakota. It has been heard in almost every state from Colorado east to the Atlantic. Radio work is given, besides that in the electric school, to certain sections of the ROTC and is used in the military maneuvers by the motorized unit of ROTC. A number of men in the Signal Corp sections take this work and get actual field experience in handling wireless outfits for the artillery units.*

*Purdue was instrumental in starting the Western Conference radio service. This radio service between Big Ten schools is every Monday night. Student operators take turnabout each night at the Purdue station, two being on duty Monday to Friday nights.*

*Purdue co-operated with the Bureau of Standards in making fading of wave tests last year.*

*Last year results of the regional basketball tourney were broadcasted after each game, practically all schools in northern Indiana which had receiving outfits reporting receipt of the score a few minutes after each game was over.*

## Purdue's First Radio Station

In 1912 a receiver built by a senior student obtained the returns of the presidential election in which Woodrow Wilson defeated Theodore Roosevelt and William Howard Taft. Even at that early date, the local hams (radio amateurs) were

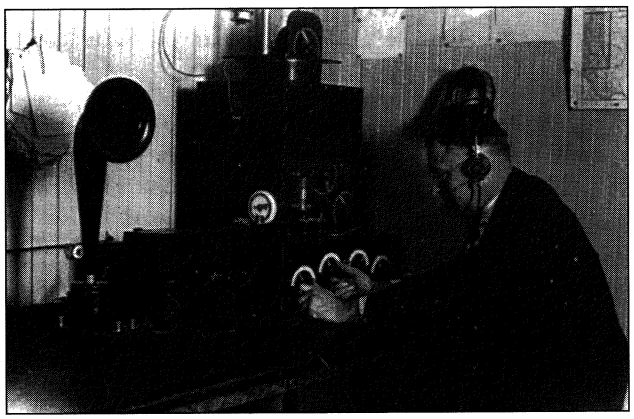


**Figure 2.** *Prof. R. V. Achatz (EE Faculty member from 1916-1923) at the controls of Purdue's first radio station, W9YB.*

flourishing. By 1913 there were six ham radio transmitters in Lafayette, with a federal inspector arriving to check them.

One of the amateur radio stations was owned by a young man, John Fetzer, who later became famous as a Midwestern broadcaster and the reorganizer of telecommunications in Germany after World War II. Between 1914 and 1917, Fetzer built a spark-gap transmitter. He placed a carbon-button microphone in series with the battery energizing it and transmitted the human voice a distance of three miles. This was the first voice broadcast in Indiana.

In 1916, with the entry of the United States in World War I, all radio broadcasting was halted. Local amateurs, however, including those at Purdue, went on broadcasting to each other. According to Fetzer, they used bedfalls as antennas, rather than outdoor antennas that could easily be spotted by inspectors.

While he was living on Lutz Street in West Lafayette, Fetzer built a 500-watt amateur radiotelephone station, which was licensed as W9FD—all the while maintaining contact with the EE faculty.

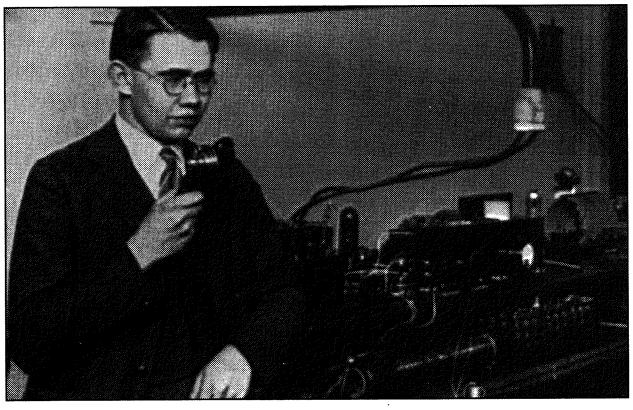


**Figure 3.** *Glenn W. Earnhat (BS 1925), student who helped build WBAA.*

Fetzer later became manager of the radio receiver manufacturing department of the Wolever Electric Company of Lafayette and attended Purdue as a part-time EE student in courses taught by Achatz. Figure 2 shows Achaz operating W9YB. Although he did not complete his degree, an event that was not uncommon in those days, Fetzer made genuine contributions to the faculty who were developing WBAA and was one of the pioneer designers and producers of vacuum-tube radio receivers.

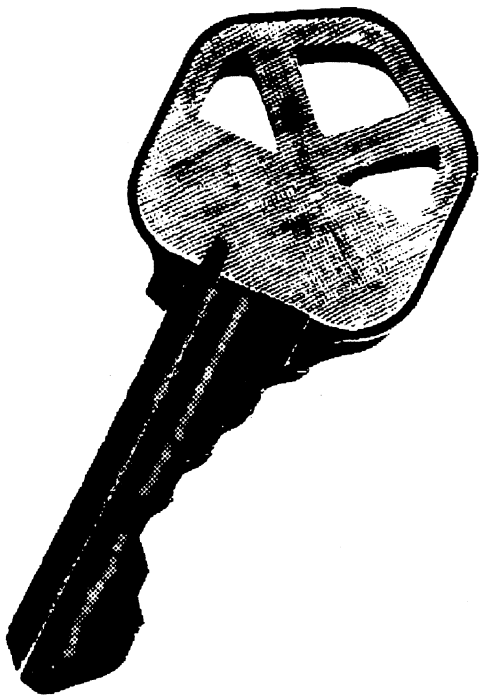
Fetzer acknowledged his indebtedness to Purdue in his memoirs. "In collaboration with the Electrical Engineering department at Purdue University, I continued my interest in furthering my knowledge of the communication field. I well remember the communication courses given by Dr. R. V. Achatz, professor of Telephone Engineering at Purdue. To him I owe a debt of great gratitude."

And, on May 18,1986, Purdue recognized Fetzer's contributions to broadcasting by awarding him a Doctorate of Humane Letters, "for outstanding accomplishments in electronic communications, both as a wireless pioneer at Purdue and as a broadcast industry leader."

World War I demonstrated the importance of wireless communication. Although Marconi broadcast the first wireless signal across the Atlantic in 1901, with a message in Morse Code consisting of the letter S (three dots), it was Fessenden, who first broadcast the human voice and music on December 24, 1906.

Commercial radio broadcasting was launched in the United States on November 2, 1920, by the experimental station 8XK, later licensed as KDKA (Westinghouse), Pittsburgh. This station still is operating with the same call letters. At Purdue, meanwhile, Achatz and D. L. Curtner, who taught courses in wireless telegraphy and telephony, were constructing Indiana's first broadcast radio station. Without funds, but with incredible scrounging and the help of EE student volunteers, they built their station in a 12' x 14' basement room of the first Electrical Engineering Building (erected in 1889 on the site of the present Chemistry Building).

# LOCKARD & WHITE



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## WBAA is Born

On April 4, 1922, the Achatz and Curtner station was licensed by the Federal Radio Commission (FRC) to broadcast on 360 meters (833 kHz) with the call letters WBAA and a power of 200 watts. The first program was presented two weeks later at 9:00 p.m. on April 21, 1922. The schedule called for programming on Mondays and Fridays from 3:00 to 5:00 p.m. and 7:00 to 9:00 p.m.

Figure 3 is a photograph of the WBAA studio in its early days. The student is Glenn Williams Earnhart, who helped build WBAA. Earnhart received his BS in physics in 1925, writing his thesis on *Design and Improvement of the Radio Station of Purdue University.* He also received an EE degree in 1936. The work Fessenden started in EE three decades earlier had finally blossomed at Purdue. In 1922 the Indiana News reported the current interest in radio at Purdue as follows:

*When the members of the 1922 graduating class of Purdue University receive their degrees in June among the number will be several who have specialized in radio engineering, having completed the regular course in that subject conducted by Professor R. V. Achatz, who has charge of all radio work at the university and is operator of 9YB, Purdue University's wireless transmitting station. Seven seniors are taking the radio course and eight students are enrolled in an advanced course, which amounts to post-graduate work. Lectures are given each Wednesday evening which are attended by more than fifty students. The men who are studying radio as a specialty are planning to take up work as radio engineers or to use the information gained in connection with electrical work in connection with phone or telegraph.*

About three weeks after broadcasting began, deliberations from the Lafayette meeting of the League of Women Voters were broadcast by WBAA. Most of the first programs, however, consisted of agricultural information and recordings. Mainly EE students operated the station. Figure 4 shows the studio during a student program. Faculty wives sang and everyone within reach (including professors) was commandeered to fill the airtime. Programming was described as "spontaneous planning." The official 1929 Purdue Report stated that "lectures and other educational matters are broadcast in radiotelephone under the call letters WBAA."

Not long after WBAA started broadcasting, the

**Figure 4.** *J. C. Baily (BSEE 1933) and W. M. McCandless (BSEE 1934) entertaining in WBAA studio in the EE Building.*

wavelength was changed to 373 meters (804 kHz) and plans were made for rebuilding the equipment to increase its power to 500 watts. This new transmitter also was located in the first EE Building until 1927. In 1923, construction had begun on the EE Building on Northwestern Avenue where WBAA was to be located. A rare glimpse of its birth comes from George F. Metcalf, who, after four months as a wireless operator on ships, came to Purdue for his EE degree. Metcalf wrote:

*By the summer of 1926 space was made available on the third floor and the towers were erected on the roof. Walter Lanterman (BSEE 1928) and I were given the job to work full time that summer to build and get a 500-watt radio broadcast station into operation.*

*When I say build, I mean build and make all the parts (except tubes, etc.) and we finally worked for one to two weeks hand chiseling a hole through the six-inch concrete roof for the antenna lead. This work was finished in time to broadcast that fall.*

*I also remember that the new equipment was in operation in September of that year and that we broadcast the first football game of the season. We used an open telephone circuit in the stadium and the telephone in an adjoining lab to relay the broadcast.*

*As to the programs, I broadcast agricultural market reports every week day at 10 a.m. which sometimes interfered a little with my classes as I had to warm up the transmitter and check the frequency, etc., then announce market reports and hope that the transmitter was operating as I was there all alone. I kept this job until graduation in 1928. The State of Indiana paid 75 cents per broadcast that was a lot of money for me.*

*On Friday and Saturday nights we broadcast*

*popular records until the telephone calls with requests stopped coming in, usually about two to three a.m. Calls came regularly from Fort Wayne, Chicago and Indianapolis and occasionally from remote points when conditions were just right. A hundred or more calls were usually received during an evening.*

Such was the beginning of WBAA. After graduation in 1928, Metcalf joined the General Electric Company and became regional vice-president of Defense Activities. He later joined the Martin-Marietta Company as vice-president of engineering and in 1966, he was awarded an honorary doctorate by Purdue.

In the new EE Building the WBAA transmitter and studio were on the third floor, in the area now occupied by Rooms 330 and 332. (Figure 5).

## Challenges

Two towers to support the vertical antenna were erected on the roof, which had been designed to accept this load. The attic was designed to contain and support the weight of the motor-generator sets needed to provide dc plate and filament voltage for the transmitting tubes-for mercury-vapor and copper-oxide (solid-state) rectifiers had not yet made their appearance.

Comfortably installed in the new EE Building the station was headed for a bright future. In 1929, however, it was almost completely destroyed by fire. C. Francis Harding, then head of EE, attributed the fire to "a short circuit between a cigarette and the waste-paper basket." Despite this disaster, faculty, staff and students began rebuilding the station, which they did in record time. The scars of the fire can still be seen in the attic of the EE Building.

Volunteer faculty and students, notably Professor Glenn E. West and John Hammond (BSEE 1932), continued to keep the station on the air, which was no small task since on-the spot maintenance and improvisation was continually required. For example, there were numerous bugs (entomological) in the equipment. On warm summer evenings, when the transmitter-room windows were open, insects found their way between the plates of tuning capacitors and caused some rather spectacular arcing. Evidently no one recognized that this was an excellent way of killing bugs, for electrostatic bug killers did not appear until decades later.

In spite of these difficulties, WBAA was maturing. Programming became more sophisticated and radio plays (Figure 6) were popular. The players read their lines from scripts, a practice that has largely ended because of television. A full-time engineer, James Ebel, was appointed and was succeeded by Ralph Townsley in 1934, one of the early student volunteers, who remained with the station until his retirement in 1982. Ebel went on to the University of Illinois, after which he joined John Fetzer's organization where he later became president of the Cornhusker Television Corporation, a Fetzer company.

G. D. Williams of the Speech Department became the first program director, and the hours of programming were increased. In 1935, C. B. Aiken of the Speech and Communication department became program director. WBAA was clearly coming of age, with programming being the province of a new type of specialist. Nonetheless, assistance from EE still was required to keep the station on the air.

An interesting sidebar on these early days of radio was the sharing of the same frequency by two

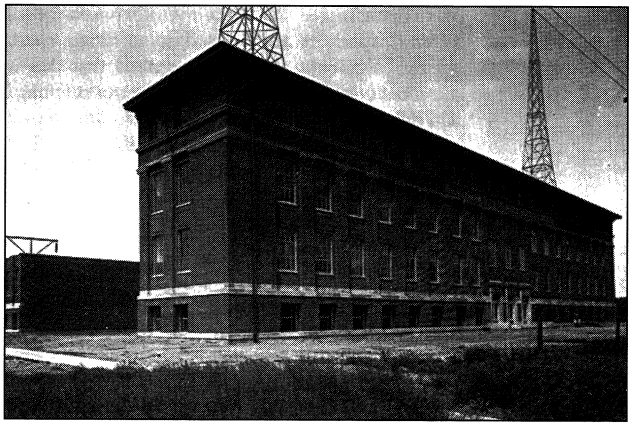

**Figure 5.** ***The EE Building with its Marconi Towers. In the background is the high-voltage lab and the high-voltage transmission line entering it.***

**Figure 6.** ***1940 Radio Play on WBAA.***

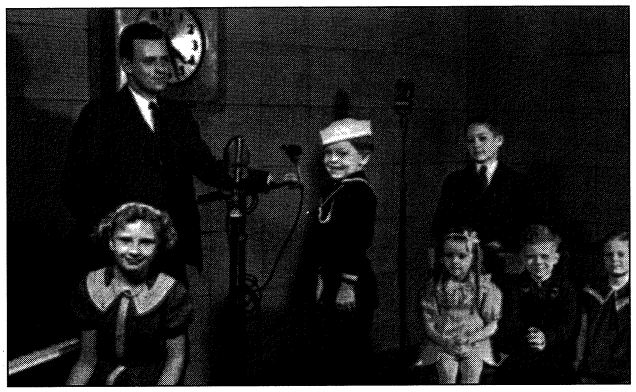

Figure 7. *Al Stewart and his Saturday morning children's show.*

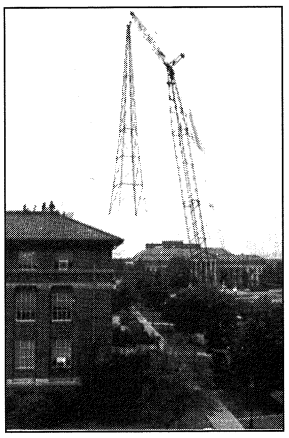

**Figure 8.** *Removal of WBAA towers from the EE Building.*

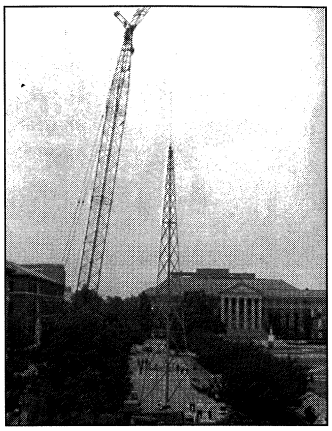

**Figure 9.** *One of the two Marconi towers is safely on the ground.*

stations. Both WBAA and WKBF (now WIRE) at Indianapolis shared broadcast hours. Early in the fall of 1933, the FRC changed WBAA's frequency to 890 kHz and authorized a power of 1,000 watts, but WBAA was to share time with WILL (University of Illinois, Urbana) and operate during the daytime only.

With this change WBAA was able to extend its broadcast schedule from 10:00 a.m. to 2:00 p.m. and from 6:00 p.m. until local sunset. With the increased time, the programming included sports, homemaking, musical performances, agricultural information and a half-hour Saturday morning children's program entitled Just Kids and hosted by Al Stewart. Later television stations were to copy this concept. Figure 7 is a photograph of participants of a Saturday morning program taken on January 27, 1936.

## A Change of Address

In 1941 the WBAA studio moved to the Elliott Hall of Music, but the transmitter remained in EE for another year. A new 5,000-watt transmitter was located in Wea Plains, South 9th Street, in Lafayette. Radio had matured and no longer needed the EE staff, faculty and students to keep the transmitter on the air. The official Purdue Report for 1939 to 1940 lists WBAA as broadcasting on 890 kHz. In 1941, while the transmitter was still in EE, the operating frequency was moved to 920 kHz, its present frequency.

Purdue recognized the 25th anniversary of WBAA in March 1947. A committee of EE professors and representatives from other schools operated the station; the chairman was T. B. Johnson and the late Jim Miles was the station manager with 34 student announcers.

## The Tower Controversy

From 1927 to 1982, the EE Building had a distinctive appearance with its two huge Marconi towers that made it easy to identify. The fate of the towers was uncertain, however. Despite not having been used since 1942, the towers had to be painted regularly. At EE faculty meetings there were frequent heated discussions between the pro-tower and anti-tower advocates. The cost of painting every few years was about $1,800. Removal of the towers was estimated to cost about $7,000. It was difficult, therefore, to make the decision that soon forced itself on EE.

The towers were 88 feet high and, with the antenna, constituted an excellent collector of static electricity. During thunderstorms, the discharges brought short-duration, high-voltage pulses into the building that now contained computers. After two lightning strikes damaged a dozen terminals and the main computer, it was decided that even if they were attractive and part of a tradition, the towers had to go. On May 24 and 25,1982, the Marconi towers were removed (Figures 8 and 9), leaving the EE Building bereft except for a radar antenna. In 1988 the upper halves of both towers were cut up and made into Centennial trophies.

One might well ask, "What good did wireless and radio do for EE at Purdue?" But the answer is clear — it was the force that brought electronics into the EE curriculum.

*Extracted, by permission, from the book: "A Century of Progress: The History of Electrical Engineering at Purdue (1888-1988)" by Radio Club Member Professor L. A. Geddes.*

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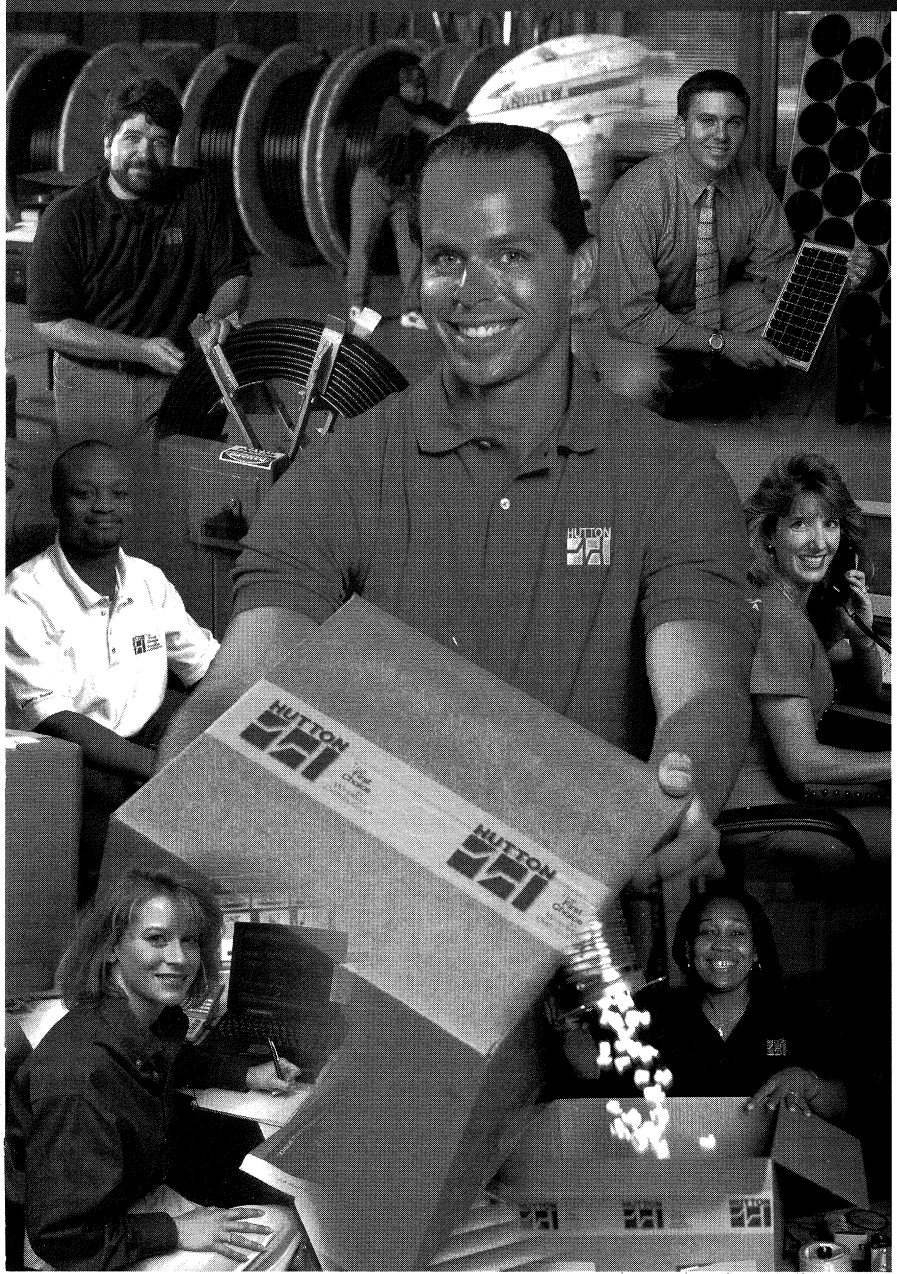

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*By Jane Bryant*

# The Origins of the Cellular Portable Phone

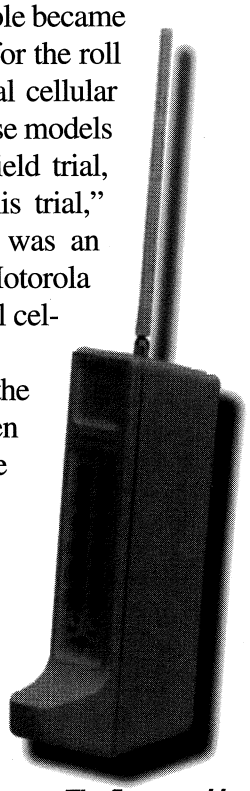
Known now as the "brick," the first portable cellular telephone was introduced in 1973 under the guidance of Martin Cooper, then vice president and general manager of Motorola's Communications Systems. Together, Schaumburg, IL-based Motorola and Cooper rolled out the innovation that changed the way people communicate for business and personal needs. Today, more than 25 years later and as we are approaching the new millennium, there are nearly 80 million wireless subscribers.

How this happened is owed in part to competition and tenacity. At the time, AT&T was a monopoly and the word was out that the FCC was considering allocating spectrum for cellular. "We knew AT&T asked for 75 MHz of dedicated spectrum from the FCC for cellular and other services, and we wanted to demonstrate to the FCC that there were others who had the capability to provide cellular service," says Martin Cooper, now chairman and CEO of ArrayComm based in San Jose, CA, and a Radio Club member.

So began development of the first portable cellular phone. "In a matter of two months, my research team put together a portable. Motorola's Industrial Design Group held a design contest, and we ended up with a dozen great designs from which we selected what came to be the DynaTAC portable. In April of 1973, we demonstrated the first cellular portable telephone," recalls Cooper.

Motorola engineers set up a terminal in a New York City building and made phone calls while walking the city streets. They conducted similar demonstrations in Washington, DC.

Developing this phone into a commercial model did not come easily. Five models evolved between 1973 and 1983 before the portable became a commercial product, in time for the roll out of the first U.S. commercial cellular system in Chicago. "One of these models was used in the Washington field trial, and we built about 100 for this trial," says Cooper, adding that this was an expensive endeavor. In 1978, Motorola supplied 1,000 phones for a trial cellular system in Chicago.



***The first portable cellular phone***

"Our real contribution was the vision," Cooper states. "When cellular was first discussed in the 1960s, AT&T believed it would be a vehicular service; Motorola did not," he says.

Vision. Competence. Technology. Commitment. These four criteria are attributed to the successful rollout of Motorola's portable, according to Jim Caile, vice president of marketing for Motorola. "There are people who have vision, competence and technology, but they do not have the commitment to bring products to the marketplace—and this takes pain," he says.

"Marty played a tremendous role in the design of portables at the time—he drove it. He was the most visionary and committed to developing personal portable telephony of anyone in the world," Caile says.

## Complex Design

The mechanical complexity of the first portable cellular phone was incredible. It was made with

thousands of parts. During development, each time engineers captured the technology and functionality of the portable in a package, they moved on to the next generation, Caile says.

Due to advances in technology and processing power, today's portables are smaller, lighter and packed with functionality. Industry analyst Herschel Shosteck correctly predicted that the processing power on chips would double, and the commensurate decline in the costs of the chips would spur the cellular market.

> *"Today, almost all of those thousands of parts on the DynaTAC fit on a couple of chips in a portable cellular phone."*
>
> – Martin Cooper, ArrayComm

"Today, almost all of those thousands of parts on the DynaTAC fit on a couple of chips in a portable cellular phone," notes Cooper. "Modern phones have more capability, but it is concentrated in the large-scale integrated circuits."

Cooper is proud of promoting competition in the wireless market. "We made a substantial contribution in getting the FCC rule changes so cellular could be an open market," he says.

No one questions the impact of the first cellular portable on today's wireless growth, although no one fully realized the vision behind the product at the time.

"It was so far away from people's imaginations that they could not understand it. I don't think anyone appreciated the portables when they came out, but the impact that they would have 15 years later...the importance of bandwidth is fading and what is becoming important is the processing power and memory power in order to deliver packets of data," says Shosteck, president and CEO of Herschel Shosteck Associates, Wheaton, MD.

### Here Comes Competition

One of the dramatic changes since the debut of the first cellular portable is the introduction of competition into the market. "For the first dozen years, there were two carriers per market...now in cities like Boston, there are seven carriers," emphasizes Cooper.

"Now carriers are going to get creative in distinguishing themselves from others. The real change will be new services, a variety of services, targeted services such as the SOS phone that focuses on elderly and teenagers in the United States, and the PHS phone in Japan that focuses on young professionals," he says.

All wireless will merge, Shosteck predicts. "This goes back to the processing power of the chips," he says. "It makes no sense to build out different networks.

"Tri-mode phones in three, four, five years will be common. Everything will go to multimode and multiband with roaming made easier. It will become a commodity business where everything needs to be done at a low cost. There might be three or four major wireless carriers in the United States, just as there are three to four major long-distance carriers," Shosteck says.

Besides the competition on the carrier side of the wireless business, competition has its hold on the manufacturing end, as well. Caile says, "Because companies choose to focus on individual products, it's difficult to be a simultaneous leader in all segments."

### Future Stars

In terms of future portable models, Shosteck believes wristwatch devices will be realistic as the industry develops background noise cancellation in the microphone in the terminal. "A lot of telemetry-type applications will exist that will be invisible to most people. Carriers will make their money on volume," he says.

"We will see lots of voice-activated products," Shosteck says. "We will see kids phones soon. Consumers will buy a snowsuit with a cell phone pocket."

Cooper envisions data being a key driver of the future. "Data will take off, and the stimulus for that

will be the Internet," he adds.

Caile agrees. "In general, there is certainly a greater emphasis on data and messaging and even imaging and full motion video in the future and the promise of 3G," he says. "Many of those same attributes will be incorporated in this generation as it evolves. In addition, the Internet is already becoming a significant market enabler."

*"The fundamental competition in wireless today is wireless vs. copper. We are going to see an integration of wireless networks with wireline."*

–Herschel Shosteck

cellular carrier to put wireless in the entire campus," he explains. "And with smart phones, students can communicate via voice and e-mail, and not have wireline phones—and have a flat rate similar to landline."

Cooper adds, "The industry is still in its infancy. The real growth will be in wireless local loop. A few years from now, there will not be any more wireline systems built for voice and low-rate data."

### Still More To Come

There is no question that cellular has made great strides since commercial service debuted in the early 1980s, but the industry still has a long way to go. "The performance of cellular is not as good as wireline. There's lots of room for technical improvements," Cooper says. "One of the technology's problems is the inherent inefficiency of broadcasting radio signals in all directions when we are only interested in talking with one person. The solution to this is smart antennas. Within the next five to 10 years, most personal communications base stations will incorporate some form of smart antenna technology," he predicts.

"The vision is that when cellular service is as reliable as wireline and with the same quality as wireline, then people will carry their phones with them and no longer use a phone that is tied to a wall or desk," Cooper adds.

Shosteck agrees. "If you look at the history of the last 15 or so years and push it forward, the costs of wireless networks will drop, along with that of the handsets, and the functionality of both will increase," Shosteck says. "You will see PCS drop to 10 to 12 cents a minute for airtime. Average use of minutes increased with PCS because as tariffs are lower with PCS—they are picking up landline usage."

"The fundamental competition in wireless today is wireless vs. copper. We are going to see an integration of wireless networks with wireline. We see campus applications with universities inviting a

### The Visionaries

The wireless industry is built on visionaries like Cooper, known as the father of cellular, who think long-term and transform their visions into products, services and solutions. Cooper had the vision in 1973 to see that cellular portable phones were the way of the future and would enable multiple carriers to provide cellular service in a spectrum-finite era. Now, more than 25 years later, portable sales in the United States outnumber vehicular sales. In the new millennium, vision from radio pioneers will continue to enhance the way we communicate such as wireless-Internet integration and innovative offerings.


*Jane Bryant is a Fellow in the Radio Club of America and serves on the board of directors. She is general manager and editorial director of McQUERTERGROUP, which specializes in high-tech public relations.*

By Al Gross

# World War II Clandestine Radio Communications

At the onset of World War II, the President of the United States, Franklin Roosevelt, desperately needed vital information on what was occurring in occupied countries. The British who were already engaged in warfare with Germany were using intelligence gathering, by espionage. Winston Churchill had clandestine spy organizations giving him daily communiqués on what was going on, and Roosevelt did not.

To overcome this handicap, on July 11, 1941, Roosevelt appointed William J. Donovan as "Coordinator of Information." Donovan was a prominent New York lawyer, who won the Congressional Medal of Honor as an Army Colonel in World War I. Donovan as "Coordinator," had some difficulty working with the various military commands to gain intelligence from their respective organizations. To overcome this situation Roosevelt signed a military order on June 13, 1942, establishing the Office of Strategic Services (OSS) and named Donovan as its Director.

Donovan remained a civilian until March 24, 1943 when he was appointed brigadier general. He advanced to the rank of major general on November 10, 1944. Donovan had strict orders from Roosevelt to gain daily intelligence and send the reports directly to the president.

Within this organization a branch was established for operators that had been recruited and staffed in various wireless positions. One important communications project required wireless communications within occupied territory.

An essential component of successful espionage is good communications. As the final battle against Germany began in the fall of 1944, the German Reich presented problems, which largely nullified all previous radio communications and techniques by other agents.

### The J-E Project

In a review of the situation, by members of the communications branch, it was suggested the use of a small hand-held transceiver to communicate with aircraft might provide the solution. This led to the "Joan-Eleanor" (J-E) project. Excellent results were achieved in France with wireless telegraphy (W/T) sets operated from safe houses and shifted to others as necessary.

*One important communications project required wireless communications within occupied territory.*

It was impossible to follow this procedure in Germany. A hostile population and tighter security controls made W/T sets dangerously conspicuous to carry around and extremely difficult to hide. The need for codebooks, antennas and power supplies entailed further security risks. The most serious handicap was the more efficient direction-finding activities, which was

feared in the Reich itself. W/T signals were easy to pick up and although this danger was minimized in France (where W/T sets could be moved from place to place), in Germany, the absence of sympathetic contacts made precautions more difficult.

Finally, breakage often rendered the parachuted W/T sets worthless. This made less difference in France where the short flying distance and partisans on the zone made drops of additional sets or parts easy. But such compensating details were not present in Germany and the smashing of seven out of twenty-two W/T sets dropped into the Reich by intelligence groups meant the teams were useless.

*J-E was a two-way communications device that enabled an agent on the ground to talk directly with an appropriately equipped OSS agent flying in a plane.*

These difficulties were overcome with the development and use of the J-E project during the fall of 1944. J-E was a two-way communications device that enabled an agent on the ground to talk directly with an appropriately equipped OSS agent flying in a plane. A plane flying at 30,000 feet could be in constant contact with little danger to the agent of interception. The high frequency and vertical cone-shaped directivity virtually nullified enemy direction-finding (D/Fing).

J-E operation offered other operational advantages. Having the agent in direct communications with the operator in the plane who could get repeats or clarifications on confusing points minimized mistakes. As a double check, all conversations were recorded.

The direct two-way voice communication also meant elimination of the delays and danger of code garbling. It further enabled spot briefing to be given to the agent, with the additional advantage of an immediate reply. Most important of all, it meant as much data could be exchanged in a twenty-minute contact as could be carried out in days of W/T communications.

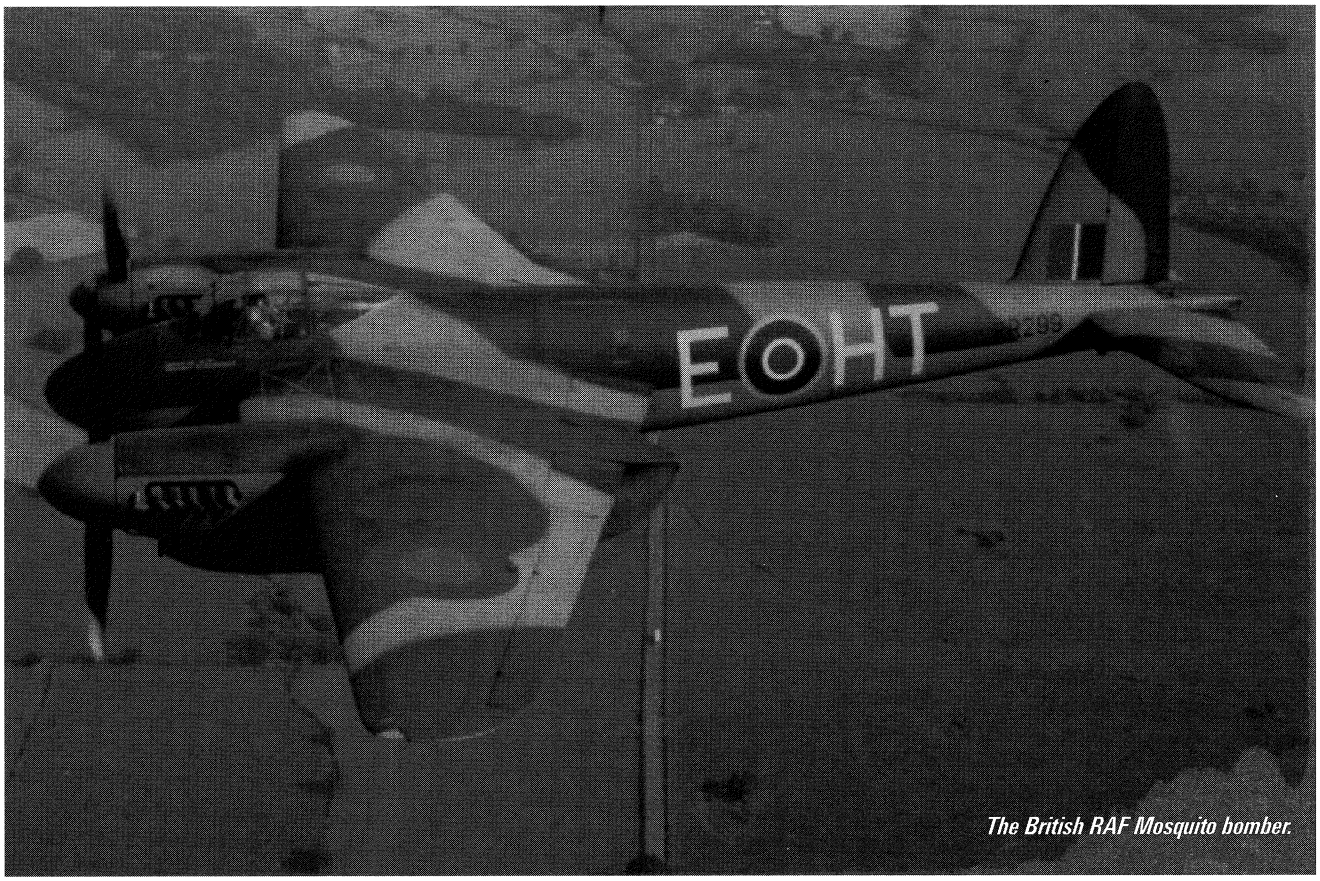
**The Mosquito Bomber**

To fly J-E missions, the British RAF provided the "Mosquito" bomber during the fall of 1944. The tail-sections were remodeled to include complete oxygen systems, inter-com, direction indicators and emergency lights and to provide space for the J-E operator and his equipment. Special training was given to the crews to perfect them in the precision techniques required for the operations. The first J-E mission was started in November 1944 landing an OSS agent in Ulrum, Holland. From this time until VE-Day in August 1945, a total of 14 J-E OSS teams landed in Stuttgart, Berlin, Munster, Regensburg, Munich, Landshut Leipzig, Plauen, Straubing and Bregenz.

Successful J-E communications were established with four OSS groups located at Ulrum, Regensburg, Berlin and Munich. Thirty-eight wireless contacts were made with four teams. Sixteen were with the mission dropped to Ulrum. Only one two-way wireless contact was made with the Berlin OSS agents.

The percentage of successful wireless contacts increased greatly with experience. Results received from the few missions contacted were valuable and promising, compared to those from W/T equipped teams. Finally the "know-how" acquired revealed that the J-E project made a successful contribution to the science of long-range clandestine intelligence gathering.

One J-E operation with a plane in accordance with a prearranged schedule made first contact with an OSS agent on November 2, 1944 and regular wireless communications continued until March



*The British RAF Mosquito bomber.*

30, 1945. The agent's early contacts revealed such items as information on German preparations to flood the Polder River, enemy troop movements at Arnhem, erection of water barriers between Ens and Winschoter Diep and results of allied air raids on the Gaarkeuken docks in the Netherlands.

### Captured Agent

On February 10, 1945, the Germans began "playing back" an OSS agent who got caught, but fortunately escaped later. He immediately flashed his prearranged control signal-frequent use of profanity in the course of his message. He stressed the fact that he did not want any additional agents, reporting that he thought that the Germans might have one "other" OSS agent (there was no such situation). The OSS agent mollified the suspicions of the Gestapo unit by pointing out that the Americans would be less likely to believe that he himself was under control if he flavored his broadcasts with cautions.

The OSS had caught the agents control signal and Secret Intelligence (SI) in London cooperating with British Intelligence (X-2) in the standard operation for keeping captured agents alive by feeding misleading material to the enemy. Finally, in mid-April, 1945 the Germans used the captured OSS agent to carry a message back through the lines to open negotiations with the OSS for a joint OSS-Gestapo operation to be directed at penetrating Russia and Japan.

During the entire period of this OSS agent's captivity, he maintained the appearance of cooperation, but at the same time, he never gave any important operational information of the OSS organization or techniques, which the Germans could not be expected to already, know. Other J-E successful operations were conducted in Italy, Austria and the Far East.

*By Pat West*

# The String Pullers

One of the least known electronic systems of World War II was the SCR-575 Radio Set. Herein, the equipment and its use is discussed as well as the dedication and effort of John N. Elwood to assemble one of the sets for posterity.

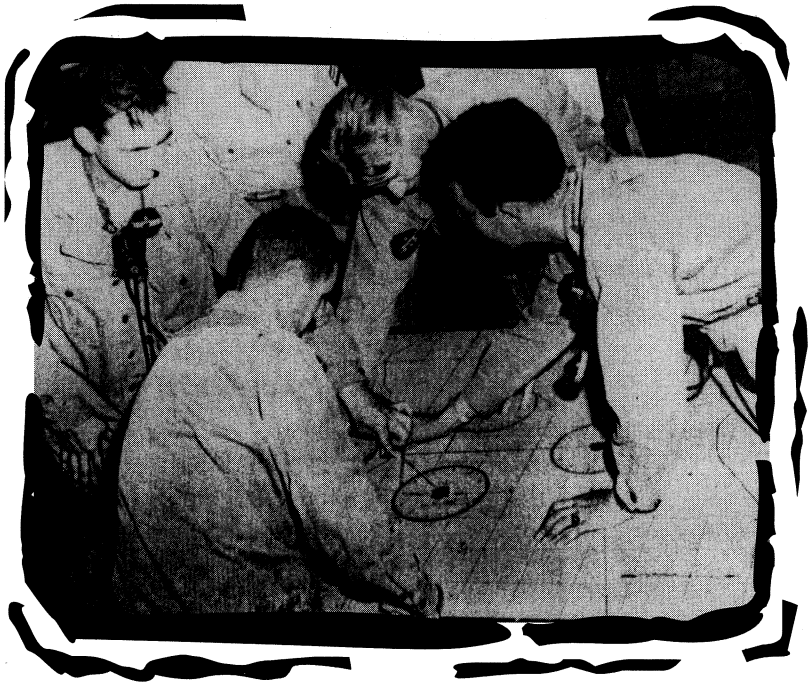
During World War II, thousands of aircraft and pilots were saved through the use of the SCR-575 equipment. The direction finding equipment in this set supplemented the use of RADAR in the location of aircraft. Just ask any fighter pilot who flew combat missions. At one time or another they had to depend on a fix and heading either to complete a mission or to return to a home air base.

## Locating Fighter Pilots

The SCR-575 was a direction finder (DF) and homer, with communications capability. At least two or more stations at different locations were required to pin point the location or fix of an aircraft. An aircraft would provide a transmission so that each station could obtain a bearing on that aircraft. Once a bearing was obtained, each station would report it to their operations center via telephone or radio.

At the operations center, a large card-size table, was covered with a map of the operational area. Around the table were two or more plotters depending on the number of SCR-575 DF stations deployed. Each plotter had direct communications with his DF station.

The location of each DF station was shown on a map with a string extending from that location. A



***A fix is plotted on the Operations Center plotting board so the controller can give a bearing.***

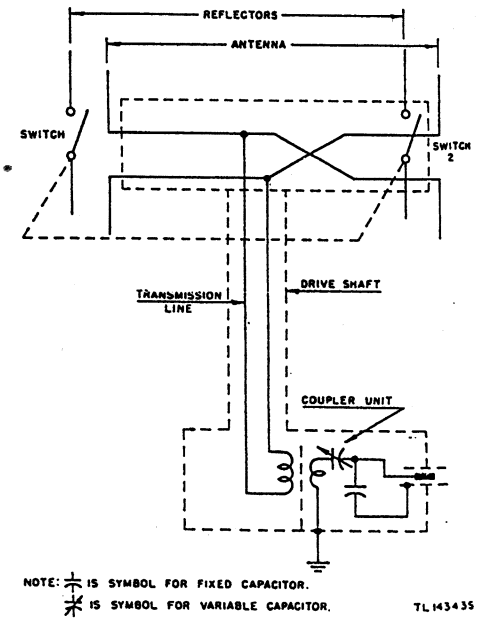



***Figure 1. H-Adcock antenna functional schematic***

compass rose encircled each station's location on the map. Operators at each DF site would call in the bearing or azimuth of the aircraft to the operations center. Each plotter at the center would stretch his string out to the reported azimuth from his DF station. The point where the strings crossed would be the location of the aircraft requesting a fix. This location would be conveyed to the operations center filter officer, who would identify the position of the aircraft on the plotting table.

### Tricking the Enemy

A controller would then communicate with the aircraft and give him a bearing and range either to a target or to his home base. The aircraft pilot would sometimes use an authentication chart to verify the authenticity of the controller. This would ensure that an enemy controller was not giving him instructions. During World War II, the writer witnessed the capture of two German fighter aircraft that followed our own controllers to one of our fields where they were apprehended. We had an intelligence service referred to as "Y" Service, manned by German speaking personnel. They used captured German radios to communicate with the enemy's aircraft, giving them wrong directions.

The following represents a typical radio conversation between a lost aircraft pilot and an operations center controller. In this example, FLIGHT LEADER is the radio call sign of an aircraft leading a flight of P47 aircraft, and BOXCAR is the radio call sign of the operations center.

"BOXCAR, this is FLIGHT LEADER, request a steer."

"FLIGHT LEADER, this is BOXCAR, count for a fix."

"BOXCAR, this is FLIGHT LEADER, one, two, three, four, five, six, seven, eight, nine, zero, over."

"FLIGHT LEADER, this is BOXCAR, stand by, out."

"FLIGHT LEADER, this is BOXCAR, we have you located, what is your pleasure?"

"BOXCAR, this is FLIGHT LEADER, request heading and distance to base, authentication code is alpha, bravo, over."

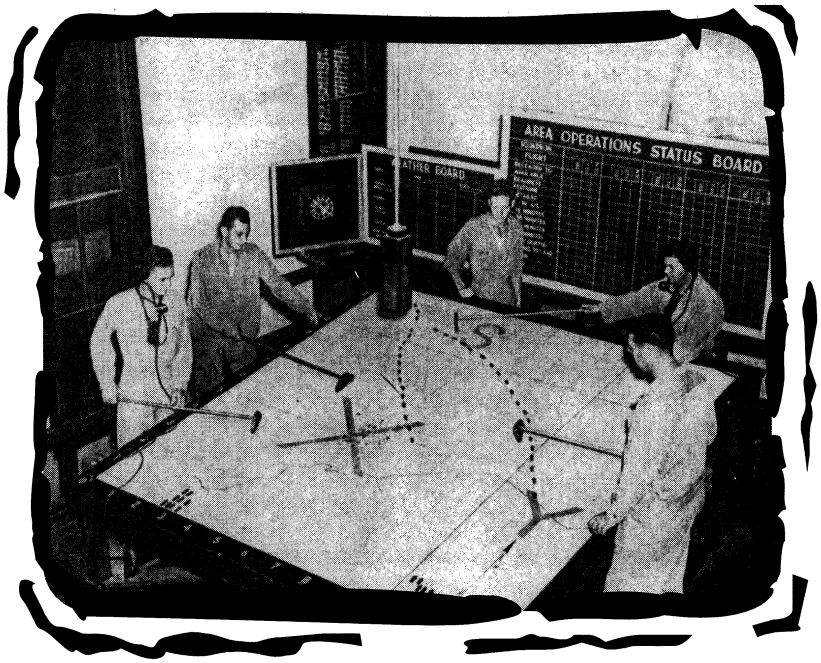
"FLIGHT LEADER, this is BOXCAR, authentication code is figures two six. Proceed on heading two five seven for five zero miles, over."

"BOXCAR, this is FLIGHT LEADER, roger, wilco, thank you, out."

### How Bearings are Determined

The following as derived from Signal Corps manual describes some of the features of the SCR-575 as well as how bearings are obtained.

The set was a mobile, very high frequency (VHF)




*A fix is made on an aircraft flight. The process is called triangulation.*

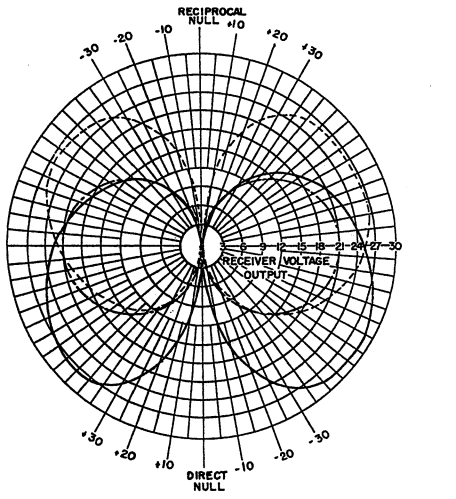



*Figure 2. H-Adcock antenna polar diagram.*

***SCR-575 radio set with Adcock antenna deployed.***

direction finder (DF), and homer, with a voice communications capability. The direction finder operated in the frequency range from 100 to 156 MHz and was used to determine the bearing of aircraft equipped with compatible transmitters. For communications the DF set was equipped with an SCR-522, crystal controlled, voice transceiver. The DF set could therefore be used on its own to guide an aircraft to a safe landing place, but was ordinarily used in conjunction with other sets to spot the position of an aircraft to a control center.

The DF portion consisted of an aural-null type direction finder utilizing a specialized type of manually rotatable H-Frame Adcock antenna system. This system consisted of an Adcock antenna with reflectors, mounted on a horizontal H-frame attached to a drive shaft, supported by a tripod mounted to the roof of the transport vehicle.

The H-frame, as illustrated in the Figure 1 schematic, was 1/4 wavelength long at 125 MHz, the approximated center frequency range of the system. The supports for the reflector dipoles were 0.15 wavelength behind the Adcock dipole support. The antenna driven element was connected through a low impedance transmission line to the antenna coupling system.

The search reflector dipoles were normally connected or disconnected by a "SENSE" switch. When disconnected, they become four independent quarter-wave rods and ceased to act as reflectors.

Electrical characteristics of the antenna can be explained by referring to Figures 1 and 2. The DF portion of the SCR-575 is normally operated as a true aural-null direction finder, that is, the nulls are detected by a decreased in audible output of the receiver. In addition to this aural means of detection, an output type-bearing indicator is connected across the receiver output circuit. Minimum output of the receiver, and therefore bearing position as indicated on a compass rose is denoted by a minimum reading of the meter. In most cases, an operator's hearing rather than the meter reading would determine the bearing to a target.

The antenna pattern of a normal Adcock antenna without reflectors is the customary figure eight, and is shown as the dot and dash pattern on Figure 2. When the reflector rods are added, but not connected together, the pattern becomes slightly distorted with the lobes pulled toward the reflectors as shown by the dashed lines in Figure 2.

When the reflector elements are connected together to form half-wave reflectors, the antenna pattern becomes more distorted, but the lobes are now pulled away from the reflectors. This pattern is shown as the solid line curve in Figure 2.

The null position defines the target bearing or azimuth, but with a dipole antenna, two nulls are obtained. The following procedure is used to determine the correct null and actual direction to a transmitted signal.

Bearings are obtained with the dipole reflectors shorted, giving rise to the solid line pattern of Figure 2. Sense or the correct bearing is determined by the operator turning the antenna 20 degrees from the null point, and opening the dipole reflector switch by depressing the sense mechanism. If the

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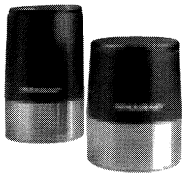

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# The Ballad of Boxcar Control

*Oh, the Ops Room crew is a rugged crew,*
*A bunch of bleary sots;*
*They fight the war behind closed doors*
*With telephones and plots.*

*They plot the woe of our hated foe*
*And plan his timely end,*
*But alert they stand to lend a hand*
*To any airborne friend.*

*They search the skies with secret eyes,*
*They search it night and day;*
*Where each plane goes, their witchcraft knows,*
*But how they will not say.*

*Now "Somewhere in France" by war's grim chance,*
*The Boxcar crew stood by*
*At that bloody time when we stormed the Rhine*
*'Neath France's dreary sky.*

*'Twas a day when the rain beat hard on the pane*
*And the sleet formed a dull murky screen*
*And the fog was so thick that a plotter named Dick*
*Was lost going to the latrine.*

*In the Ops all those bums just twiddled their thumbs,*
*The controller just stared at his shoe;*
*They thought of their gals with their war worker pals,*
*As soldiers are wont to do.*

*When out of the fog and the rain and the sleet*
*When out of the storm and the snow*
*When out of the box of the Victor How Fox*
*Came a voice that they all did know.*

*"Hello, Boxcar Control" came the voice like a soul*
*That speaks from the other world,*
*"Jampan One calling here, will you give me a steer?"*
*And the ends of their whiskers curled.*

*For Jampan, you see, was a V.V.I.P.,*
*At least to the boys at the board;*
*'Twas their valiant C.O. who now flew through the snow,*
*If they failed, it would not be ignored.*

*The plotters popped to, the controller did too:*
*These men had all what it takes,*
*And the deputy sang to his string-pulling gang,*
*"For God's sakes, let's make no mistakes!"*

*The controller was calm as he reached out his arm*
*And lifted the mike to his face,*
*And he said, "Please transmit," but he knew this was it,*
*It was home him or suffer disgrace.*

*Now ten stanzas here told how that crew brave and bold*
*Brought Jampan One safe to the field,*
*But the homing he got is "Secret, Top Bigot!"*
*Equals British "Cannot be revealed."*

*Now these lusty old sports, as they wrote their reports*
*Of the homing of Jampan One,*
*Said, "It's nothing at all for an Ops on the ball,*
*Why, its' simply a job to be done."*

*But the pilots all know, when you're lost in the snow*
*And the midst of the trackless air,*
*What the feeling is like, just reach for the mike*
*And know that old Boxcar is there.*

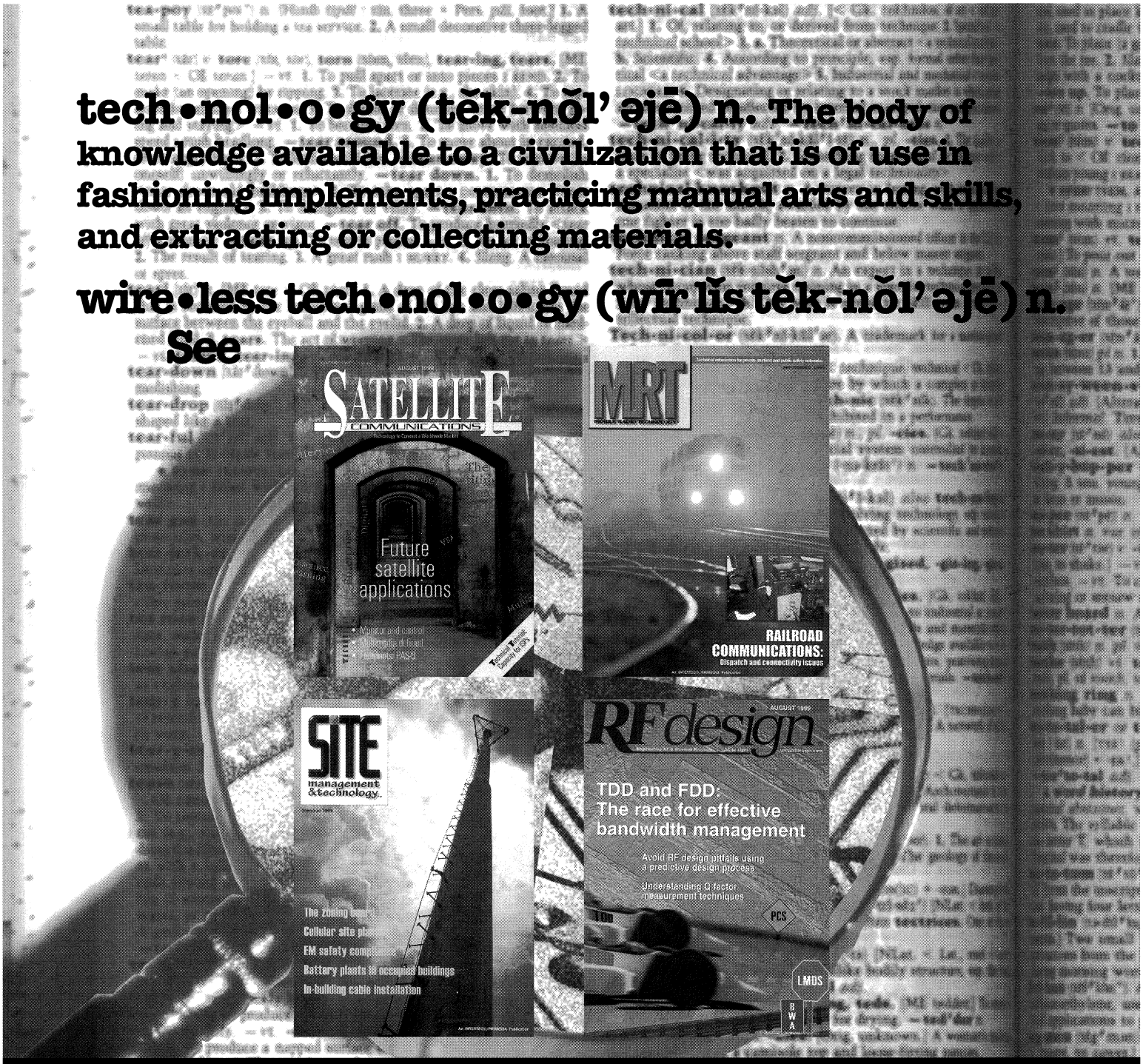
*Oh, the Ops Room crew is a rugged crew,*
*A bunch of bleary sots;*
*They fight the war behind closed doors*
*With telephones and plots.*

*They plot the woe of our hated foe*
*And plan his timely end,*
*But alert they stand to lend a hand*
*To any airborne friend.*

***By Capt. Lawrence D. Cavanagh***

**tech•nol•o•gy (tĕk-nŏl' əjē) n. The body of knowledge available to a civilization that is of use in fashioning implements, practicing manual arts and skills, and extracting or collecting materials.**

**wire•less tech•nol•o•gy (wīr lĭs tĕk-nŏl' əjē) n. See**

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Adcock antenna is facing the source of the signal, the output of the receiver will decrease, and the bearing obtained is the correct one. If the Adcock antenna is facing away from the transmitted signal, the receiver output will increase, and the bearing is the reciprocal of the bearing indication.

The radio receiver associated with the direction finder was a standard superheterodyne receiver with an intermediate frequency (IF) of 12 MHz. The local oscillator frequency was doubled before beating with an incoming signal to produce the IF frequency. Operation of the local oscillator at a lower frequency assured the stability required in DF receivers.

### Preserving the Station

Technical Sergeant Edward Bennett was crew chief, in charge of an SCR-575 station during the war. He fell in love with his "six wheeler" DF station vehicle, much the same way a cowboy falls in love with a horse. He drove it during the European campaign. He kept the radio equipment on the inside of the truck spotlessly clean and shiny, and even had pin-up photos of Rita Hayworth and others on the walls.

He advises that communications to the operations center from his station was mostly by high frequency (HF) radio, as telephone lines were seldom available. Because the very high frequency (VHF) signals received by DF stations were "line of sight," the stations were mostly located on the highest accessible mountains, with no intervening mountains to interfere with the area of coverage. In Italy, Sargeant Bennett remembers the torturous and steep roads his unit had to travel, hauling the radio equipment, electric power units, kitchen equipment, food, gasoline, camouflage tarps, etc. He wonders how they did it, but when you are young, the difficult appears to be easy.

Sergeant John Elwood was a member of the 328th Fighter Control Squadron during World War II. The squadron was an element of the 64th Fighter Wing. In Europe, he was with an SCR-575 DF site with the call sign identification "BUNKER." He was a DF operator and mechanic. His respect for the station prompted him to construct a complete station after the war except for the transport vehicle. All the sets used during the war had disappeared.

He picked up parts from all over the states, from army surplus stores and from electronic stores. There were even some donations from friends. Some parts had to be fabricated, including the Adcock H-frame antenna. The equipment, except the antenna was installed in two equipment racks. The equipment except transport and antenna was donated to the Pima Air and Space Museum in Tucson, Arizona. The museum is planning to exhibit this equipment with mannequins in the near future to illustrate an operating position.

John advised that during operations in Europe, several hundred bearings were taken each day and the operators were quite busy rotating the antenna to obtain bearings, and then transmitting bearing information to the control center to augment radar-positioning reports. He reported that some of the pilots used some unusual language when requesting a steer such as:

*"I like whiskey,*
*I like beer,*
*Come on BOXCAR*
*Give me a steer."*

John believed that the technique for determining bearings was developed by the British, but they never used VHF. They used high frequency (HF) equipment, possibly LORAN to obtain aircraft locations. Bendix Radio manufactured most of the VHF DF equipment used by our forces.

John Elwood should receive many accolades for his efforts to preserve an SCR-575 for posterity. In addition to being an avid amateur radio enthusiast with the call sign WW7P, he is a collector of continuous wave (CW) keys, and is a known authority in this activity.

Captain Lawrence D. Cavanagh was a senior controller in the 328th Fighter Control Squadron. He wrote a poem, dedicated to the operation room personnel, including the DF string pullers. Note that one of the verses refers to the string pullers in the operations center.

---

*Charles P. (Pat) West, P.E., W7EA, (F) is a retired Boeing Engineer. During World War II he commanded radar stations in Africa and Sicily; served as Communications Officer in Italy; and was a Signal Officer in France.*

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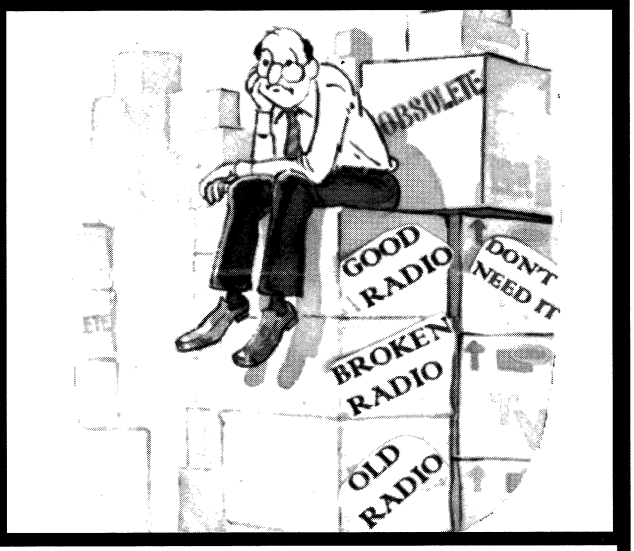


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By Cindy Loffler Stevens

# Nextel's Wireless Internet Strategy

Nextel obviously is a company driven by a vision. It has made great progress from its humble beginnings as a wireless dispatch operator burdened with technological difficulties and confronted with tough cellular and PCS competitors who gave the company little respect. Fast forward to November 1999, when Nextel has become regarded as an innovative wireless service provider with an enviable Internet strategy that has other companies taking notes.

How did Nextel become a leader offering nationwide wireless digital service? The company entered new territory in June 1999 when it launched Motorola's i1000plus phone one month ahead of schedule reaching beyond traditional voice boundaries to access the Internet. And then again, in August 1999, Nextel released the i500plus model also capable of pulling information off the Web. Nextel has emerged as an Internet company.

But the key point to remember, says Mike Ozburn, vice president and general manager of Nextel Online, is the core Nextel business subscriber. "We are fundamentally looking at the Web as a business tool for our customers," he says.

## The Beginning

Nextel has come a long way since being founded by Morgan O'Brien as Fleet Call Inc. in 1987. The company went public in 1992, trading at $15 a share, then changed its name to Nextel in 1993. The company's stock soared to a high of $56. In 1995, cellular pioneer Craig McCaw invested $ 1.1 billion in Nextel, the struggling wireless company that few had heard of. The company had virtually no spectrum—and, because it was comprised of three merged companies, employees were spread across the country, with no center of control.

In addition, the cellular phone manufactured by Motorola was large, awkward and it barely functioned. Despite the criticism, Motorola and Nextel worked together to improve the product and revamp Nextel's strategy. It began marketing its technology to business user groups, no longer touting itself as the third cellular carrier in each market.

McCaw's cash infusion set off a chain of events that led to the hire of Timothy Donahue as the company's president and chief operating officer. Nextel recruited Daniel Akerson as its chairman and chief executive officer in March 1996. On Sept. 15, 1996, Nextel rolled out its new iDEN technology in Chicago, the first carrier to combine digital cellular, a pager and two-way radio in one phone. Under Akerson's leadership, Nextel made great strides.

## Record Financial Growth

Although it has yet to make a profit, Nextel's revenues have been rising steadily. Nextel's financial results for the second quarter of 1999 included approximately 440,000 new subscribers, a new quarterly record. In addition, the average monthly revenue per subscriber was approximately $74 and consolidated operating cash flow was $108.9 million, a 204 percent increase from $35.8 million in the first quarter.

"During the quarter, Nextel teamed with Microsoft, launched the innovative i1000plus Internet-ready handset, secured significant additional funding, and dramatically improved our spectrum acquisition potential with the proposed settlement reached with the Department of Justice

that would loosen restrictions in an outdated consent decree," said Dan Akerson, Nextel's chairman at the time.

In June 1999, McCaw announced that his family and Wendy McCaw would invest approximately $315 million in Nextel by exercising their options to purchase 17 million shares of the company. Then this past July, Akerson joined McCaw as Co-Chairman of Eagle River and on September 22, announced he was taking the helm of NEXTLINK Communications as Chairman and CEO. But his legacy endures. Finally Nextel had captured the grudging respect of its competitors in the PCS and cellular arenas.

*Internet portals offer wireless carriers a lucrative opportunity.*

**Competition**

But the bigger Nextel gets, the greater the threat from larger competitors, such as AT&T and Sprint PCS. These rivals are beginning to court the same business customers that Nextel has so successfully targeted. Nextel's most original feature, the direct connect button on its handset which is similar to a sophisticated walkie-talkie, allows members of the Nextel Business Networks to instantly communicate with one another for a fraction of the cost of cellular.

With the touch of a button, the feature extends the workspace of any company to communicate with companies in the same or related industries. There are nearly 400 Nextel Business Networks nationwide in the construction, banking, real estate, government, health care and transportation industries. Nextel exceeded one million digital subscribers on Nextel Business Networks in the second quarter.

However, AT&T recently announced that it would offer a service similar to Nextel's direct connect feature presenting Nextel with a daunting challenge. Nextel needs money to keep pace with these telecom giants. One possible merger with MCI WorldCom, which was seeking a wireless network presence, fell through earlier this year. Now some speculate that MCI Worldcom's recent acquisition of Sprint could lead Nextel to partner with BellSouth.

It remains to be seen if Nextel will team up with one of the titans, but it is clear that the carrier is dreaming large. The vision of using a hand-held device on the beach to access Web content and services you usually receive only at your desk is getting closer to reality. Nextel first announced its plans for a wireless Internet portal at the Cellular Telecommunications Industry Association's (CTIA) annual convention in New Orleans.

Because portals provide carriers with a pipeline to their customers, they offer branding potential and new revenue sources such as advertising and e-commerce. Therefore, portals offer wireless carriers with a lucrative opportunity. Several companies have forged relationships including Sprint PCS with Yahoo! and Nextel with Microsoft to develop mobile Internet portal sites. The Yahoo! Mobile Web site is designed to bring the portal to wireless devices, hand-helds, kiosks, cars and other access devices. Yahoo! however, will face some stiff competition with Microsoft now aligning with Nextel.

**Microsoft Raises the Ante**

In May, Microsoft committed to invest $600 million in Nextel common stock to enable Nextel's subscribers to access a customized set of Internet services offered through a co-branded version of the Microsoft Network (MSN) portal. This investment is expected to be used by Nextel to advance the deployment of additional digital services, expand the Nextel National Network and fund system development in other countries. The price of the stock was fixed at $36. On a fully diluted basis, Microsoft's common stock ownership represents a 4.25 percent interest in Nextel.

The Internet-based services called Nextel Online are designed to leverage the power of the Internet with Nextel's network to integrate voice, data and messaging while extending Web-based applications to customers. Nextel's wireless Internet and intranet service is enabled by upgraded networks and browser-equipped handsets from Motorola, the

Wireless Application Protocol (WAP) conversion platform from Phone.com and Internet connectivity and content from MSN.

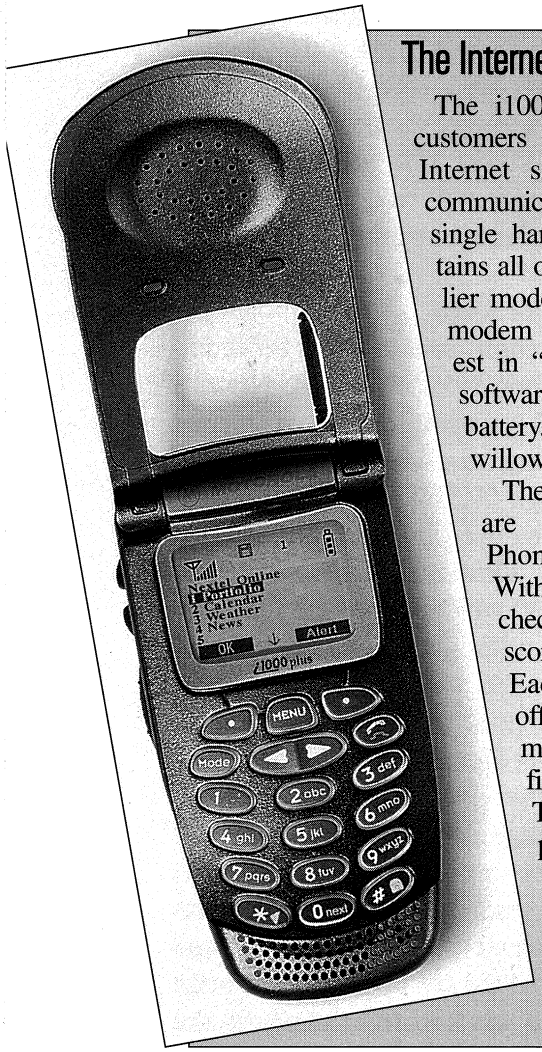
Mobile offerings will include Microsoft-specific content, such as news from MSNBC, but will also extend to other Web-based information and e-commerce offerings. Both Yahoo! and Microsoft plan to offer speech technologies for use with mobile devices and portals, though details are not yet available. However, Ozburn says, "Nextel has a critical mass of business users with needs. Generic portals like Yahoo can't do what we can do."

### Nextel Online

The customers Nextel Online is targeting are its core business enterprise subscribers consisting of workgroups and large field service organizations. The goal is to offer data across the entire network. But Nextel is not only connecting mobile customers to the Internet. A growing group of business application developers are being tapped to customize their services to be carried over Nextel's network. Ozburn says, "Our belief is that our customers see value in being able to use the Nextel Web site as a primary jumping off point for business while they give up nothing in consumer services."

Nextel Online will include three fundamental types of services to keep customers in touch with critical information while mobile. First, it will give customers an efficient way to interact with the company.

In the near future, Nextel says customers will be able to see account summaries, pay their bill online, add features to their service plan, change account information and get business headlines, stock quotes and other information. Behind the scenes, Microsoft applications will provide the foundation for Nextel's new Internet-based services, including




## The Internet Phones

The i1000 will provide Nextel customers with the integration of Internet services with wireless communications capabilities—in a single handset. The phone contains all of the features from earlier models, as well as wireless modem technology and the latest in "Internet microbrowser" software. With a slim lithium battery, the il000 weighs in at a willowy 5.4 ounces.

The phone's data services are provided by the Phone.com microbrowser. With the service, you can check stock quotes, sports scores and news headlines. Each of these services offers menu-driven information custom-tailored to fit the four-line display. Tegic Communications' predictive T9 text input helps to simplify typing on the keypad. The phone allows users to keep their calendars, contacts and other data outside the phone on a Web site, eliminating the need for manually updating information between phone and office.

Nextel's strategy is to provide a national mobile dial-up solution using the Nextel phone as a wireless modem combined with a standard laptop or hand-held computer such as 3Com's PalmPilot or Windows CE devices.

This remote capability permits users to access the network to send or receive time-critical information such as a sales proposal document or a field service report without using a separate fixed modem or a wireline remote connection. The i1000 also includes camera links to allow applications such as insurance appraisers using the phones to shoot photos in the field and send them over the phone lines back to the office. In the not-too-distant future, it will be possible to speak to your customized wireless Internet portal.

Motorola's i500plus is Nextel's second Internet-ready phone that combines digital cellular, text-numeric paging and Nextel's direct connect feature as well as a Web browser for access to Nextel Online services. When they are operational, the phones will enable users to send and remotely access e-mail, address book contacts and Web-based content and corporate Intranet information. The i500plus is smaller, lighter and is targeted to the business segment. ❐

an online store, billing and order fulfillment and the Nextel Business Network member directory. In addition, Nextel customers will be able to take advantage of the Nextel Online Messaging Center to send short message service (SMS) messages to other Nextel users.

The second set of services will include a variety of applications, content and services that can be customized to a customer's PC as well as to their Nextel phone via the co-branded MSN portal. The final element of the strategy is to encourage software developers to write Web-based applications specifically for business users. More than 90 organizations have joined Nextel's Developers Program. These various applications will be accessible from Nextel's Internet-ready phones over the Web.

*"In the business world, there are existing applications that customers want to be able to take advantage of from their wireless phones."*

Ozburn, says, "We launched a developers program in February to arm third-party developers with tools so that they can write applications that sit on the Web that are beneficial to our customers. We have been contacted by hundreds of developers, working to make applications available on WindowsCE and Java."

Nextel is taking applications that frequently are used in businesses and transferring them to wireless use. "In the business world, there are existing applications that customers want to be able to take advantage of from their wireless phones," says Ozburn. "We're selecting applications that are work tools — things people use at their desks — and making them available to people wherever they go."

When fully operational, the services are expected to include e-mail, calendar functionality, address book contacts, and access to Web-based information as well as a company's Intranet data. Customers will access these services with a range of devices, including personal digital assistants (PDAs), palmtop computers, PCs and Windows CE operating system-based devices. Nextel also will work with Microsoft to help define the requirements for Microsoft's microbrowser technology for wireless devices. "Migration to Web-based services is still in its infancy," says Ozburn. "First we have to get our customers comfortable."

Later this year, Nextel will deploy the Nextel Online wireless services in Washington, New York, Chicago, Atlanta, Philadelphia and the Carolinas. Thanks to the fact that Nextel's network was a packet-based IP platform initially, the transition will be easier. "Commercial service will be available early to mid 2000," says Ozburn. "We believe roll out will happen relatively quickly because it is a relatively minor build for us."

The company also announced the availability of Nextel Online Dial-Up Services (a wireless modem dial-up functionality) to customers in the transportation segment. This remote capability will permit customers to access their corporate network to send or receive time-critical information such as a sales proposal, e-mail or a field service report giving users access to more in-depth information in real-time without using a separate fixed modem or a landline connection.

### A Company to Watch

With the summer introductions of its Internet-ready phones behind it, Nextel is rapidly evolving into an Internet company, no easy task, since Nextel is promising to work with businesses to develop customized software applications. However, Nextel has already proven that it is an innovative leader by being the first to eliminate roaming fees and billing calls by rounding to the second rather than the minute. And it remains the only carrier with a national footprint to offer both a dispatch function and a conventional digital wireless voice service. With a solid Internet blueprint in hand, it will be interesting to watch this extraordinary company as its plans turn to reality.

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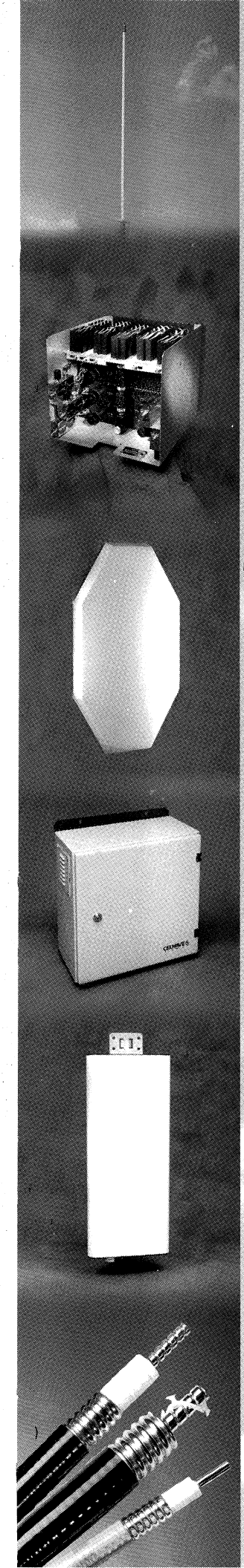

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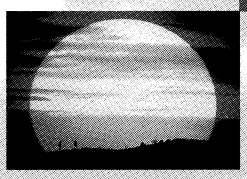

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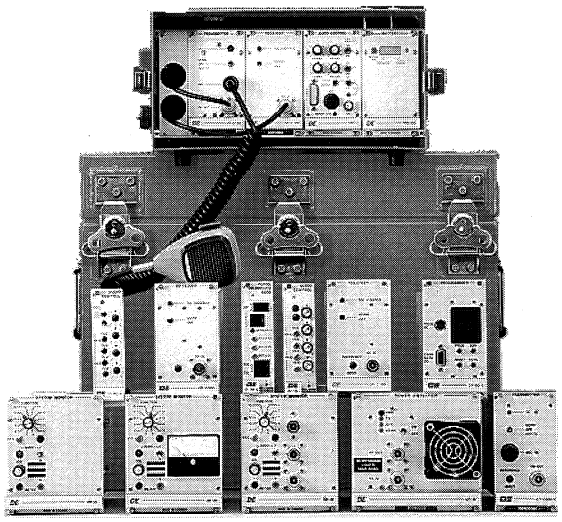

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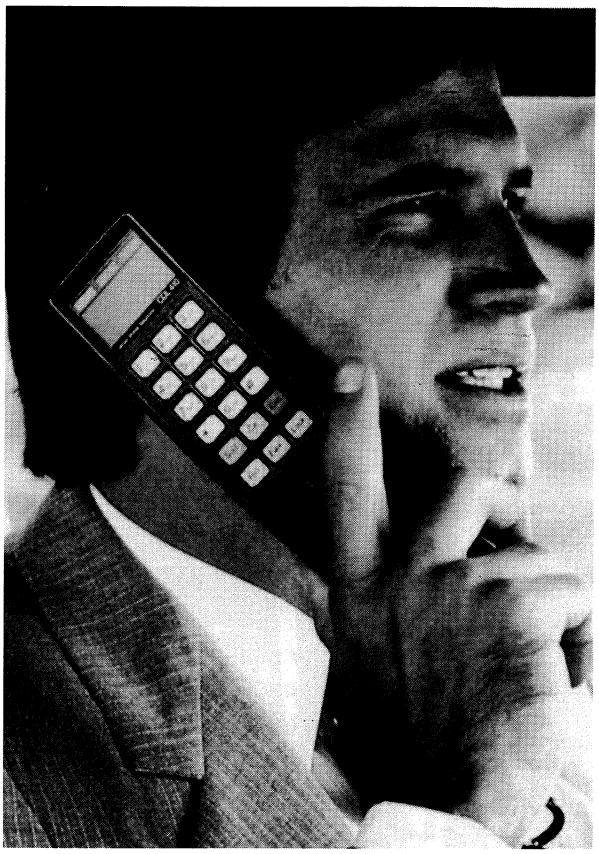

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