AT&T Long lines
Microwave Relay Station – Kingsville
(Former FCC Call sign: KQD75)

Introduction:

Driving west on Plymouth Ridge Road near Kingsville, Ohio you come upon this intriguing structure. It's a remnant of the AT&T Long lines division that was responsible for the interstate transmission of telephone calls and television programs for a period of nearly fifty years beginning in 1955 and ending in the early 21st century. I had a unique opportunity to visit this site thanks to Jack Sabo, N8XUA, and look over the installation before the building and tower site were converted for use as a "clubhouse" and base station for the "Ohio-Pennsylvania Emergency Radio And Tactical Information and Operations Network" (hereafter referred to simply as the OPERATIONS Team.) Beyond the immediate and natural technical curiosity about the site, I was also fascinated by the history of the site and the greater history of the network of microwave relay stations, coaxial cable, and (eventually) fiber-optic cables that supported long-distance communication in the second half of the 20th century.

First Impressions:

Although the tower and building have been stripped of most of the communications equipment that the site was built to support, an impressive number of relics remain to tell its story of 50 years of service in providing interstate long-distance communications.

The tower itself is impressive: 70 meters (229.66 feet) tall, it sits on the crest of a ridge that is already 277.1 meters (909 feet) above mean sea level. This allows a clear line-of-site to both Painesville, Ohio (west) and Waterford, Pennsylvania (east) the adjacent relay stations on this part of the network. The tower is a self-supporting type that was engineered to support the original complement of eight microwave horns and associated wave-guide, the substantial lateral wind loads associated with its location near Lake Erie, and the snow and ice loads that are inevitable in northeastern Ohio.

The main building is built "like a Turkish battleship" and designed to withstand all but a direct hit during a nuclear attack. The walls are more than a foot thick and built from reinforced concrete. The roof is similarly constructed, with integral pre-tensioned concrete beams and a thick slab of concrete covered by an impermeable rubber membrane ballasted by 2" "patio blocks" that provide a protective outer layer. The interior walls are shielded against radio-frequency interference (and the electromagnetic pulse effects of a nuclear explosion) by a fine copper mesh that creates a Faraday cage.

The electrical system found in the building is equally impressive. The building was wired for three-phase service, as is typical of industrial installations. A diesel backup generator provided at least 15-20 kilowatts of standby power. The building transfer switch allowed for operation from the commercial power-grid, the backup generator, or a portable generator that could be brought to the site in the event that the backup generator failed. Sadly, the backup generator has been removed, but most of the wiring and switch gear remains in place.

A prominent feature found inside the building is the extensive infrastructure of cable trays, grounding bus-bar, and power distribution equipment that supported the TD-2 microwave repeaters, frequency and time-division multiplexers, and switching gear that served the Long lines network. This was a broadband microwave installation that not only handled telephone calls, but also relayed television programming, Telex / TWX traffic, and internal network communications.

Although most of the operations here were automated from the beginning, the building also provided support for the AT&T employees who maintained and operated the equipment. A septic system provides for basic sanitation and on-site water well provides running water. A vintage note taped to the wall of the restroom indicates that the water was not suitable for drinking, and certainly not pure enough for use in the lead-acid batteries that provided DC power at the site.

There is some evidence that a boiler was once installed to provide central heating for the building. That boiler was removed some time ago and electrical space heaters were installed in its place. In its original role as a microwave relay station, there was probably little need for heat, as the tube-type electronics of the immediate post World War II era generated plenty of heat as a consequence of their operation. In later years, as transistorized circuitry replaced tubes and integrated circuits replaced discrete transistors, waste heat from the electronics was no longer sufficient to heat the building.

Large air-handlers in the building and associated air conditioning units mounted on the roof indicate that cooling the building was a serious business. I was unable to determine the total cooling capacity of the three existing air conditioners, but based on size alone I suspect that the building interior would serve well as a cold-storage warehouse.

Adjacent to the main building is a two-car garage and attached workshop built using conventional cement-block construction. Interesting artifacts in the garage include a suite of fiber-optic test equipment, fiber-optic splicing and encapsulation kits, part of a Burroughs mainframe computer rack, and a collection of vintage warning signs that indicate proximity to a buried intercontinental coaxial cable. Some of these signs predate modern telephone switching, as they indicate the emergency phone number using the name of the telephone exchange followed by a five-digit telephone number (as in Pennsylvania 6-5000.)

AT&T Long Lines:

The American Telephone & Telegraph Long Lines wire, cable, and microwave radio relay network provided long-distance transport services to AT&T and its customers from the late 1940s to the early 1980s. Formal opening of the coast to coast connection was on August 17, 1951. A sophisticated achievement, Long Lines provided computerized reconfiguration of microwave circuits coast-to-coast via AT&T's network control center in New York City, NY. By the 1970s, Long Lines carried 95 percent of all long-haul television traffic, and 70 percent of intercity telephone calls in the United States.

Before utilizing microwave relay, AT&T used heavy-duty open-wire lines for Long distance service. The introduction of vacuum tube amplifiers allowed such connections to reach across North America. In the 1930s the company experimented with long-distance coaxial (coax) cable. The first long-distance coaxial link in 1936 connected Philadelphia and New York. After World War II it was quickly determined that microwave relay networks were less expensive and easier to build, especially over mountainous regions and rough terrain, and Long Lines evolved into a hybrid network. L-4 and L-5 coaxial systems connected all major US cities, and a digital millimeter waveguide system connected New York to Philadelphia, but the primary medium was microwave air links.

Early in the 20th century the telephone companies organized a "Separations and Settlements" process by which Long Lines and the local companies, Bell and Independent, divided the revenues of long distance calls according to their respective costs. The mid-century advent of microwave and other high capacity systems dramatically cut the cost of long-haul operations, but pricing did not decline proportionally. Rather, the local fraction of revenue sharing rose to subsidize local service. This system became obsolete with the rise of competitive long distance and the later abolition of the Bell System.

By the 1980s, alternatives (including fiber optics and satellites) were replacing microwave as the preferred network transport, but the remnants of the Long Lines microwave network can still be seen across the country-side today.

Microwave Relay -- Theory of Operation:

Microwave radio relay is a technology for transmitting digital and analog signals, such as long-distance telephone calls and the relay of television programs to transmitters, between two locations on a line of sight radio path. In microwave radio relay, radio waves are transmitted between the two locations with directional antennas, forming a fixed radio connection between the two points. Long daisy-chained series of such links form transcontinental telephone and/or television communication systems.

Because a line of sight radio link is made, the radio frequencies used occupy only a narrow path between stations (with the exception of a certain radius of each station). Antennas used must have a high directive effect; these antennas are installed in elevated locations such as large radio towers in order to be able to transmit across long distances. Typical types of antenna used in radio relay link installations are parabolic reflectors, shell antennas and horn radiators, which have a diameter of up to 4 meters. Highly directive antennas permit an economical use of the available frequency spectrum, despite long transmission distances.

Because of the high frequencies used, a quasi-optical line of sight between the stations is generally required. Additionally, in order to form the line of sight connection between the two stations, the first Fresnel zone must be free from obstacles so the radio waves can propagate across a nearly uninterrupted path. Obstacles in the signal field cause unwanted attenuation, and are as a result only acceptable in exceptional cases.

Obstacles, the curvature of the Earth, the geography of the area and reception issues arising from the use of nearby land (such as in manufacturing and forestry) are important issues to consider when planning radio links. In the planning process, it is essential that "path profiles" are produced, which provide information about the terrain and Fresnel zones affecting the transmission path. The presence of a water surface, such as a lake or river, in the mid-path region also must be taken into consideration as it can result in a near-perfect reflection (even modulated by wave or tide motions), creating multi-path distortion as the two received signals ("wanted" and "unwanted") swing in and out of phase. Multi-path fades are usually deep only in a small spot and a narrow frequency band, so space and frequency diversity schemes were usually applied in the third quarter of the 20th century.

The effects of atmospheric stratification cause the radio path to bend downward in a typical situation so a major distance is possible as the earth equivalent curvature increases from 6370 km to about 8500 km (a 4/3 equivalent radius effect). Rare events of temperature, humidity and pressure profile versus height, may produce large deviations and distortion of the propagation and affect transmission quality. High intensity rain and snow must also be considered as an impairment factor, especially at frequencies above 10 GHz. All previous factors make it necessary to compute suitable power margins, in order to maintain the link operative for a high percentage of time, like the standard 99.99% or 99.999% used in 'carrier class' services of most telecommunication operators.

In over-horizon, or tropospheric scatter, microwave radio relay, unlike a standard microwave radio relay link, the sending and receiving antennas do not use a line of sight transmission path. Instead, the stray signal transmission, known as "tropo-scatter" or simply "scatter," from the sent signal is picked up by the receiving station. Signal clarity obtained by this method depends on the weather and other factors, and as a result a high level of technical difficulty is involved in the creation of a reliable over horizon radio relay link. Over horizon radio relay links are therefore only used where standard radio relay links are unsuitable (for example, in providing a microwave link to an island).

During the 1950s the AT&T Communications system of TD radio grew to carry the majority of US Long Distance telephone traffic, as well as intercontinental television network signals. Similar systems were soon built in many countries, until the 1980s when the technology lost its share of fixed operation to newer technologies such as fiber-optic cable and optical radio relay links (of which offer larger data capacities at lower cost per bit). Communication satellites, which are also microwave radio relays, better retained its market share.