The Story Behind Finnish Telecommunications Industry: Military Radio Systems and Electronic Warfare in Finland during World War II (1939-1945)

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ABSTRACT

The growth of the Finnish telecommunications industry is not only based on the common Nordic need of talking to each other nor is it only dependent on the generally superior technical skills achieved through education but also has its tradition, which dates back to the years of WW II, when Finland was alone at the most critical moments of the nation's history and had to develop procedures and technologies to survive. From post-war documents, a connecting link can be found between key persons and organizations, which were once designing military electronics, but later adopted their know-how to the needs of public communications.

INTRODUCTION

Finland already had, before the second World War, one of the most advanced public telecommunication networks (PSTN). Perhaps due to the inherited characteristics of the individual citizens, some 160,000 phones were in use for roughly 4 million people. The network was fairly dense, and many towns had automated exchanges, which is noteworthy, as Finland covers more than 300,000 square kilometers, and the vertical distances exceed 1,000 km. The Finnish broadcasting company had been operating for over a decade and a number of radio amateurs were active.

Despite this, the Finnish Army was caught in the Pan-European turbulences with minimal communication resources, as the Soviet troops attacked Finland the last of November, 1939. To be honest, the situation was all over; the military preparations were roughly the same. Many of the recruits were given only a leather belt as a "sign" of belonging to the troops, because nothing else was available in needed volumes. The separate branch of telecom forces had existed only for a couple of months [1], having been previously a part of the common engineering division and the official pre-war documents mention signaling flags, birds and dogs as suitable battlefield communication methods [2]. The only technical device, which was theoretically usable in required quantities was the field phone, but as it turned out, the Soviet artillery broke the lines quickly and much too often.

During the next five years, Finland experienced a rapid growth in military strength, partly because of huge financial efforts, which gave the army some 70% of the yearly state budget [3] and partly because of both home-made and foreign,

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mainly German, technology which became available in 1941. Radio equipment and associated procedures came to military use. All of this was necessary, because, at that time, the nation was forced into a game of survival against a 100-fold bigger opponent.

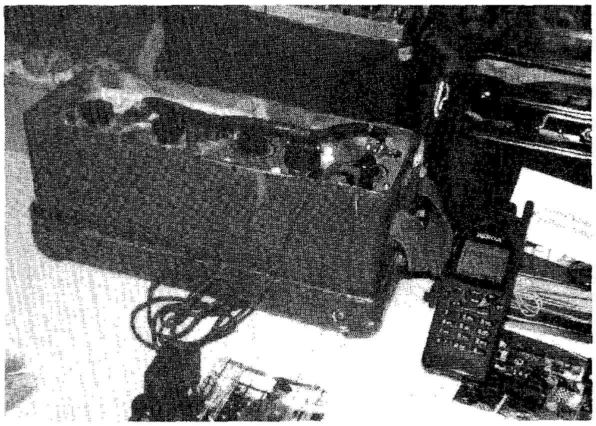

Fig. 1. The Grandfather and the Grandson: A Wartime "Mobile Phone," The "Kyynel"-Transceiver for Finnish Guerilla Troops Together With a Present-Day Nokia GSM-Portable Photographed at the Signal Museum, Riihimaki, Finland

RADIO EQUIPMENT FOR GUERILLA TROOPS

One of the most advanced local war-time electronic developments in Finland was the small portable transmitter called "Kyynel" ("Tear") and the later-added receiver "Topo" ("Stub") [4]. They were solely designed and manufactured for the use of guerilla troops, which were sent behind Soviet lines to gather information and destroy military targets and transportation infrastructure. Naturally, a base station network was created to support the communications.

The "Kyynel" transmitter was constructed in an aluminum alloy box. One of the most demanding tasks was the attempt to make the unit watertight, because the operator must have access to the switches and tuning knobs inside the cover. The tubes, which were from the DII-series and other electronic components were mounted side-by-side — no circuit boards were available at that time — and this proved to be advantageous both because of short interconnections and, thus, minimal stray capacitance or series inductance, but also because the whole unit was very stable and could sustain a drop from several meters — also with a parachute. Depending on version, the weight of the transmitter was 5.6-7.4 kg, with batteries. One of the "Kyynel" versions is shown photographed at the Signal Museum (Riihimaki Garrison, Finland) in Figure 1; together with its grandson, the Nokia GSM-Portable.

A V-dipole was chosen as the wire antenna, but later so models also had a ladder-feed system in order to stabilize th impedance. The antenna tuner in the transmitter had a bulb which was automatically connected to the circuit, if one of tl dipole leads was pulled slightly out. The brightness of the lig told the operator about the tuning status. Also, the key and headphones were constructed locally. The anode voltage wa supplied from a 120 V Hellesens dry-cell, which, particularly wintertime, had capacity problems.

The transmitting frequency was originally, up to model adjusted by a small tuning capacitor between 3 and 5 MHz (free-running oscillator!). A variometer was tested, but founc too unstable. Finally, crystal oscillators were installed in models 10X, 10 XB and 11, but the availability of quartz uni was a problem as, in the whole country, only one person was qualified for this job.

The name of the transmitter has two explanations. A typical operating position of the unit was somewhere in the

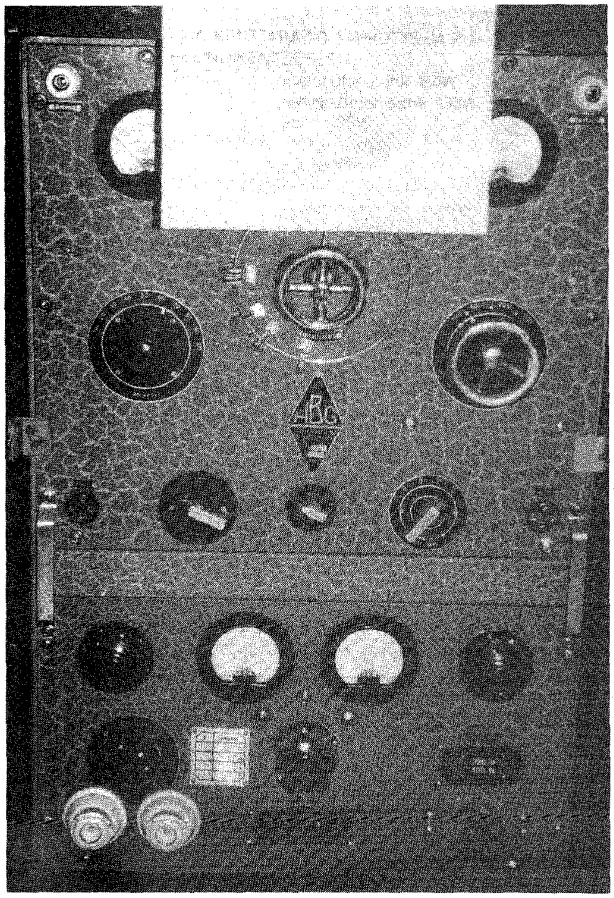

Fig. 2. The Base Station Network for "Kyynel"-Transceivers was made of Fairly Powerful Units like this, Manufactured by Helvar, Finland. The Output Power was about 300 W, but the Equipment was Really Heavy and Needed Frequent Maintenance.

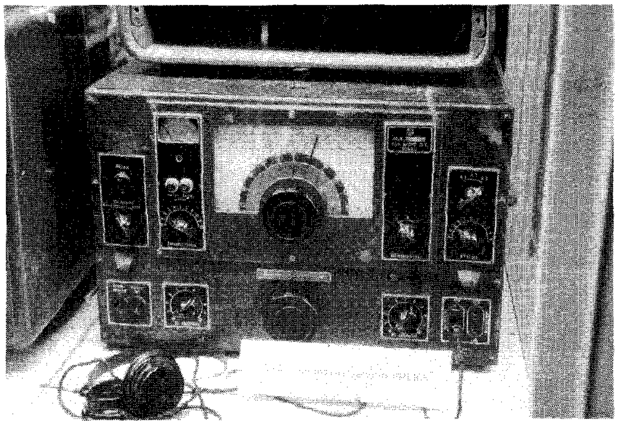

Fig. 3. Separate Receivers with a Code Name V407, Locally Manufactured by ASA Radio, were used throughout the Armed Forces up to the 1970's. The sensitivity was satisfactory, but frequency stability only moderate to poor.

deep forest under big trees — which, in peace-time Finland, would have been an ideal place for an illegal brandy factory (in Finnish: "korpikuusen kyynel"). Another, perhaps more technical translation, comes from the received audio of the unit, which to some ears sounded like a crying child — and was highly annoying to the chief designer, Eng. Lautkari.

The "Topo" receiver operated at the frequency of the Lahti broadcasting station, 166 kHz. It was constructed in a small cardboard tube, 180 mm long. Same battery types were used so that they could be changed to the transmitter, if necessary. Later, from code number 10 onward, the receiver and transmitter were integrated.

All the equipment was packed in a green cardboard box, where more technically-oriented operators also had a soldering iron (fireplace model) and some components for field repairs!

The base station network used 300 W transmitters with both ground and sky wave. A typical unit, manufactured by Helvar, Finland, is shown in Figure 2 (see on previous page) installed in a shock-absorbing rack. As the numerical methods for predicting sky wave propagation were too time-consuming at that time, but generally the attenuation was acceptable, several stations were also established in central Finland. The receivers were originally type National NC100XA from the USA, but later a replica, which can be seen in Figure 3, was constructed locally by ASA Radio. This type, under the code name V407, was still in use in the 1970's, when the author served as a young engineer at Riihimaki Base.

AIR FORCE SYSTEMS

One of the very first military radio systems in Finland was constructed for the Air Force by the Electric Workshop of the Army [5]. Initially, a home-made project was started around 1930, which, unfortunately, was not very promising. Vibration was an obvious problem in an aircraft and also the use of conventional microphones was impossible due to the loud noise. An improved model, P-12-15, had more power and was designed to be mechanically more stable, but the reconfigured throat-type microphone became so hot during flight, that it burned the pilot's skin. The following prototype, later manufactured by Fenno Radio, had even more power — up to 30 W. It was actually too powerful and not only caught fire, but also caused a number of complete fighters to go up in flames.

The frequency range was selected, for some unknown reason, between 3-5 MHz and new units were ordered from the local workshop in 1934. The transceiver worked quite well, but only occasionally. Vibration was, again, a major cause of faults; especially the operating frequency drift before take-off. The pilot had no possibility to change the channel but it was adjusted by screwdriver before the mission. The inverter unit had a relay box on the floor, and needed a sharp kick every now and then.

For British-made Bristol Blenheim Bombers, a new radio type, P-12-14, was designed. It had direction-finding capabilities, but operated on a different frequency band from all of our other transceivers. This caused severe problems during the 1939-1940 period. Besides, original ideas did not include complete transceivers for each fighter plane, but the suggested relative percentage was 4 TX/17RX within a squadron.

During the stable period of 1940-1941, several new types of fighter planes entered service from all over the world, including the US Air Cobra, Mustang, Italian Fiat G50 and British Hurricane. Most of them had unique radio equipment. More than 11 different radio types were flying simultaneously. German types FuG7, FuG10 and FuG16 (20W, 40 MHz) were the most popular.

The latest of these, the FuG16ZE was a fairly modern design. It included an extendible antenna, which was necessary due to the tail-dragger design of the Me109G-fighter. For prolonged operations in high altitudes, the transceiver electronics had an electric heating system. The airborne system had the possibility for active homing together with suitable ground installations [6].

The lack of spare units, frequent mechanical problems and equipment destruction during less successful missions, required immediate and thorough servicing of the radios. This servicing was performed outside in the field under inhuman conditions; as the temperature stayed below -40° C for weeks. The more severe troubles were solved at the Army Electronic Workshop.

RADAR

Radar came to Finland in the Spring of 1943 from Germany, in the form of two Freya surveillance systems and four Wurzburg-D tracking radars for AA-batteries. The first two towns effectively protected by these were Helsinki and

Kotka. Later on, some fighter and night fighter units and a couple of IFF equipments were received, but these were not used for real missions. The key technical person connected to war-time radar in Finland was Eng. Lieutenant J. Pohjanpalo, who after the war, became a professor and the Director General of the State Telecommunications Laboratory for several decades. During the war, he was responsible for the applications and redevelopment of the German units at the State Electrical Workshop.

The air defense system of Helsinki utilized four automatic AA-batteries equipped with radar and 88 mm guns. The rest of the guns were operated manually. Two Freya radars searched for incoming Soviet bombers and the situation was displayed on a mapboard, where metal pointers turned through telemetry signals directly received from radars showing the present directions of attack.

Originally, the Freya-radar was developed for the German Navy in 1938. The operating frequency was about 125 MHz. Two separate antenna assemblies, each consisting of 12 dipoles in two rows were used. The output power was 8 kW and the PRF was approximately 1,000 Hz. Individual bombers, flying at an altitude of 5,000 m were detectable at up to a distance of 70 km, the figure going down to 40 km at 2,000 meters, and for bigger formations (the type Soviets generally used) to 130 km. The distance uncertainty was 150 meters and the angular resolution 5 degrees [7].

The Wurzburg radar was introduced in 1939 and volume production started in Germany in 1940. The system was installed on a four-wheel trailer and used a 3 meter paraboloid antenna. The operating frequency was originally 565 MHz and the pulse power 8 kW with a PRF of 3,750 Hz. The theoretical distance limit was thus 40 km, but receiver sensitivity of 250 kT_0 lowered this limit. The angular resolution was 0.5 degrees and error in distance 25 meters. The improvement of angle measuring performance was achieved with a rotating feed dipole in front of the paraboloid. However, the rotary joint added to the complexity of the system.

JAMMING

The Soviet forces had the capability to jam many of the Finnish military radio networks. Either normal transmitters operating at the required frequency or special high power units were utilized. The use of voice modulation was notably high, which obviously gave an alert immediately. However, due to the modest use of radio systems on the Finnish side and the high qualifications of staff, 16% of which were women, the effects of Soviet jamming were not severe [8].

A special occasion, originally described in [9] happened in 1942 on the shore of Lake Ozero, when the Finnish railway radio network was interfered by — as it was initially thought — our own AM broadcasts. Later on, it turned out that Soviet COMINT units on the opposite shore of the same lake received the Finnish public AM transmission, demodulated it and further retransmitted the original baseband signal at the railway frequency. Quite soon, the Air Force attacked the jammer; the position of which was found with recently installed German DF-devices with terminating results.

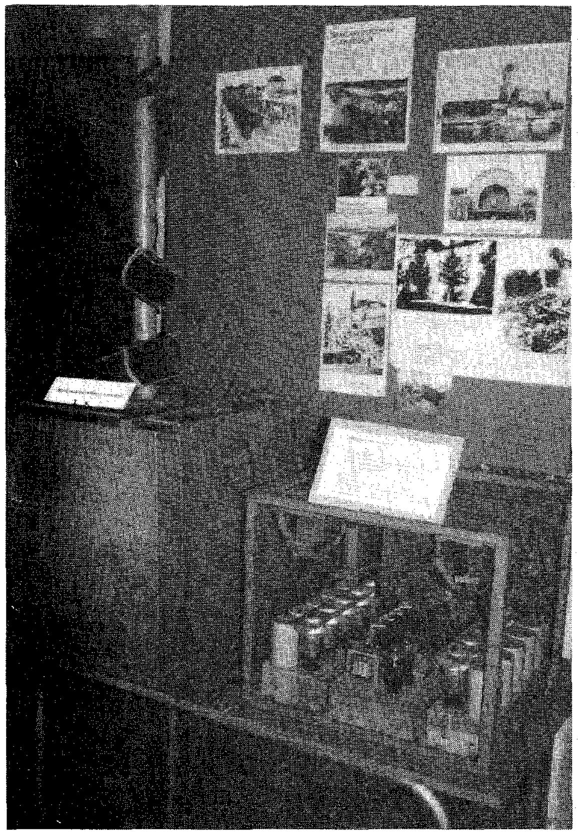

Fig. 4. The Soviet Forces Tried to Destroy the City of Viipuri in 1941 with Radio-Controlled Mines, the RF and Code Units which are shown here. A Couple Weeks of "Sakkijarven Polkka" at the Operating Frequency Prevented the Explosions and Probably Saved the Castle and the City.

The lack of suitable equipment and manpower prevented a widespread intentional jamming of Soviet telecom systems. Occasionally, however, remarkable results could be obtained. Late summer 1941, when the Finnish forces had already done a re-entry to the city of Viipuri, which was lost to Russia in March 1940, a couple of radio-controlled mines, see Figure 4, were found beside a bridge. Also, sudden explosions were heard in areas which should have been under Finnish control.

Rapidly, it turned out, that the whole city seemed to be covered with such radio mines and Finnish specialists suggested a jamming action to be carried out on a frequency, which could be defined from the previously found mine. A popular Finnish folk song "Sakkijarven polkka" was played day after day through a powerful conventional AM transmitter [10]. The choice of the record was not based on its popularity, but this particular piece of music (actually not a very nice one) happens to be practically continuous with no silent spots. Several triggering attempts by an audio triad could be heard on the band, but the music covered it until the batteries of the mines were exhausted. The action probably not only minimized the destruction of the city but also saved the castle of Viipuri for the coming generations.

RADIO MONITORING SERVICES

The Finnish radio monitoring service, or COMINT, as we call it now, was established by A. Paasonen and R. Hallamaa in 1927. In 1939, at the beginning of WW II, a total of 75 persons were involved, including secretaries and guards. Naturally, the force grew through the years. After the war, many specialists decided to move to the USA or other western countries, but numerous engineers adopted their knowledge for the local civilian telecom operator's and industry's needs.

Generally, the Soviet wireless military communications were fairly easy to follow, because of frequent Soviet operator mistakes and simple encryption algorithms. Tuning of aircraft transmitters connected to the antenna was a common practice, which, particularly in February 1944, gave the Finnish COMINT services the possibility to track Soviet Bombers straight from their start, define their total number and final destination. The massive Soviet bombings, which were planned to destroy Helsinki, had no success as the Finns knew when, where, and how many aircraft were coming and could, thus, focus the AA-activities accordingly. Only 5% of the bombs dropped could hit the built-up areas [11].

Sometimes the Finnish monitoring people had good luck, as was the case in late summer 1942, when a distant and weak signal was received, in a small village called Sortavala, and later decrypted, giving the exact plans of the Allied Convoy PQ18 to Murmansk [12]. This information was handed over to German forces, who succeeded in causing heavy losses to the convoy.

CONCLUSION

As such, the past wars generally promoted technical development — think about the jet engine, rockets and radar. In Finland, the scenery was in a smaller scale, but World War II definitely started the development of the Finnish telecommunications industry. There exists a direct, though long relationship between the Radio Workshop of the Armed Forces, which produced the transmitters for Finnish guerilla troops; the State Electrical Workshop, which was responsible for many Air Force radios; and the present Nokia Telecommunications, the well-known supplier of both microwave equipment, cellular radio systems and — not too astonishingly — modern military communication infrastructure [1]. Also, the huge growth in the number of qualified engineers and technicians with practical skills during wartime has been of major importance.

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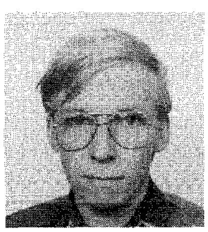

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