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AUTHORIZED RADIO SYSTEMS TEST IN URBAN AREA

Absztrakt

Because of hybrid warfare and migration there are emerging new requirements for communication networks. Nowadays many military activities are carried out in urban areas, where the interference and shielding bring difficulties in radio networks. In this paper, there will be presented three different radio systems test to install network centric communication to support commanders' military decision making

A hibrid hadviselés és a migráció új követelményeket támaszt a kommunikációs hálózatokkal szemben. A városi körülmények között végrehajtott katonai műveletek számára nehézséget jelent a rádió hálózatokat érő interferencia és visszaverődés. Az alábbiakban három rádiórendszer kerül bemutatásra, amelyek a parancsnoki döntéshozatalt hivatottak elősegíteni a hálózatközpontú kommunikáció során.

Keywords: *very high frequency radio; cellular radio system; ultra-wideband radio; network centric communication system; decision making process; situational awareness ~ magas frekvenciájú rádió, cellás rádió rendszer, ultra szélessávú rádió, hálózatközpontú kommunikációs rendszer, döntéshozatal, helyzetismeret*

INTRODUCTION

After analyzing the ongoing military operations all over the world we can argue, that the military environment has been changed in the 21st century. Based on these there is one theory, which deals with generations of warfare. Some experts are expressing that nowadays we are in the era of the so called Fourth Generation Warfare (4GW). In parallel with this there are described the so called "hybrid warfare" activities too. "Hybrid threats are – any adversary that simultaneously employs a tailored mix of conventional weapons, irregular tactics, terrorism, and criminal behavior in the same time and battle space to obtain their political objectives" [1]. In the main military hotspot areas (Afghanistan, Iraq) these hybrid warfare activities are the most specific operations. Usually the countering military missions are carried out in urban environment, which can cause huge difficulties for our communication systems, and the internet and mobile networks are influenced also by hybrid challenges. [2]

In our days, the other important security issue, which is needed to be mentioned, is the migration. There are strong governmental and social expectations in Hungary that we must control our borders and especially to recon terrorists aiming to enter to the European Union. Of course, when migrants entering our territories they find cities, villages and other objects, which can influence our communication networks.

The above mentioned threats and challenges are influencing the military application too. Dedicated experts are arguing, that next generation of commanders should be ready for them and it is expected that they must lead their units in a very proper way. [3]

In May 2016, the Faculty of Military Sciences and Officer Training (National University of Public Service, Budapest, Hungary) conducted an exercise focusing on urban combat. The signal soldiers have had to provide a network centric communication system to support the commander with almost real life information. It means that after the soldiers get the information, they have had to transmit and process it to build up the best situational awareness. [4] At the lowest level (company, platoon) there were just radios available to establish the subnetworks.

This paper presents the problems and the solutions of the radio communication with different devices in urban district.

THE RADIO SYSTEMS OF THE EXERCISE

In the beginning of the exercise we had to realize which our possibilities are. For this we had to know our capabilities such as:

- tasks to be carried out;
- system of activity and deployment;
- number and nature of partakers,
- organizations;
- info-communication capabilities of professional control;
- tasks of the subordinate staff, system of activity;
- environment of the execution;
- available tools and infrastructure at hand [5].

We used three different types of radios on the exercise. First of all, we tried to communicate via our VHF military radios, then we used a civil cellular radio system, and the last version was the ultra-wideband radios.

Military VHF Radio

The military radios were multi-role radios with modern transmission techniques provides long reach- and noise resistant communication. The system is developed to meet the demands in modern tactical communication, and have a wide range of roles: combat net radio (CNR), combat net radio relay, data transmission, text message terminal, single channel radio access. The technical data of the radios:

– Frequency band:	30,000–87,975 Hz
– Channel bandwith:	45 kHz
– RF modulation type:	GMSK (Gaussian minimum shift keying)
– Modulation data:	Orthogonal M-ary
– Channel spacing:	25 kHz
– Output power:	10 mW; 500 mW; 5 W or 50 W
– Interfaces	Eurocom J (multiwire – modified RS-232) compatible with V.24/V.28
	Eurocom K and K+ (2-wire)
	2 audio interfaces (also for parameter loading

During the exercise we used the frequency hopping mode to avoid enemy jamming and interception. The audio and data signal was encrypted, and the signal was encoded with spread spectrum technique and modulated with Gaussian Filtered Minimum Shift Keying (GMSK) modulation. The radios used frequency hopping by constantly changing the carrier frequency. In this case the transmitter and receiver had to follow the same hopping pattern. Our main problam was with the hopping network, that for the communication it was required very exact time synchronization (among the radios $\Delta t<300$ ms in the same network). We used the radio for voice and data networks in combat net radio and Autonomous Packet Radio (APR) mode. Both communications had an issue with the reflection and the shielding. When we had direct line of sight (LOS) the network worked fine, but it was just among few of the soldiers, not among all of them. For that the better solution was the APR, where the operators have the possibility to do direct adressed calls to other radio operators. In this case the radios, which have LOS, forward the call to the next radio till the signal reaches the receiver. The communication channel is this signalway among the radios.

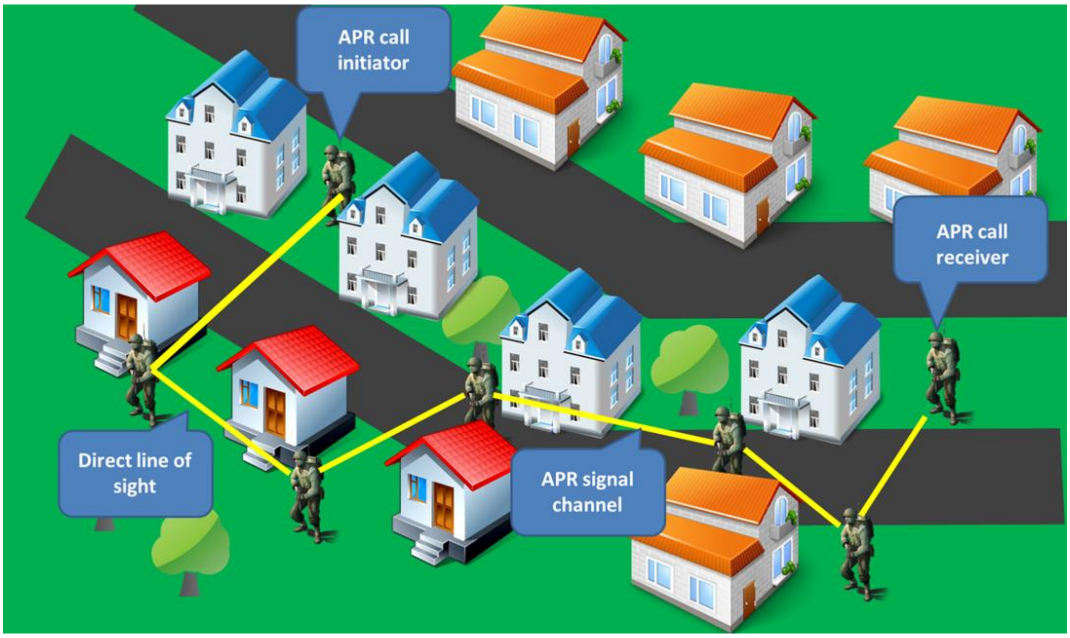

Fig. 1. The autonomous packet radio (APR) mode in urban area.

We were able to provide voice, data and message terminal functions for the soldiers. The voice and message terminals worked well in these solutions but the datarange was too low, so we could not send real life pictures for the commanders. In data transmission services the maximum data rate was in asynchronous transfer mode 19,200 bit/s. Because of this, and the long distance among the troops and headquarters the situational awareness was not granted so we had to use other services. Another disadvantage of the radio that it is not a Ground-Air-Ground (GAG) radio, so we did not have the possibility to communicate to the aircrafts during the exercise.

The Civil Cellular Radio System

We tried to use a civilian system, so called unified digital radio system, with which we are able to make direct push-to-talk (PTT) communication to groups and with priority setting; centralized call control, for priority and queuing; direct mode, portable to portable without central radio coverage; relay mode, one portable can use another mobile device to link to the central radio; and data networks. A huge advantage of the system is, that we can coopeerate with police, disaster management, fire departments, ambulance and other services, which use the same devices. The network based on terrestrial trunked radio (TETRA) technology. It provides secure speech and data transfer, and on the management side we can follow our troops via the built GPS in the devices. If we have no GPS in our radio the system can also show our near position with triangulation from the base stations. We are able to send pictures and videos on the system, because the available data rate can manage it continously. [6] The data rate can reach the 700 kbit/s with 64-QAM and the bandwidths of 150 kHz with direct LOS, so we could help the commander's decision making with real information.

Table 1. The Most Important System Parameters for TETRA [7];

Parameter	Value
Frequency	380-385 MHz (mobile station) / 390-395 MHz (base station)
Carrier Spacing	25 kHz
Access Method	TDMA, 4 Timeslots / Carrier
Uplink / Downlink Spacing	10 MHz
Modulation	$\pi/4$ DQPSK
Carrier Data Rate	36 kbit/s
Voice Coder Rate	7.2 kbit/s gross

The problem is with the system, that at least one base station is needed for the communication. At the exercise area, we had one of it, where the companies and platoons acted. They could communicate directly with this station, or reached it with relay mode. Someone, who can not connect to the base station directly, can use another mobile device to get connected to the radio network. Because we had just one node at the area sometimes it happened, that some of the soldiers were dropped off the network, because it was overloaded, when many of the wanted to communicate at the same time. The battalion headquarters was about 20 km far away from them, and there we had our own base station. The commander and the members of the staff had their own private mobile radio, and at the communication and information section we had a public access mobile radio. It was a huge advantage, because with it we were able to connect the radio system to the local area network (to share data with the subunits) and to the Private Automated Branch Exchange (PABX) and the Public

Switched Telephone Network (PSTN). This povided for us the possibility to make calls from the radios to the telephone system and we could reach from the desks of the staff the troops on the exercise field. It helped to make a faster communication and better information sharing from the lowest levels. The system can be connected to the GSM network as well, and we are able to make direct call to mobile phones if it is necessary.

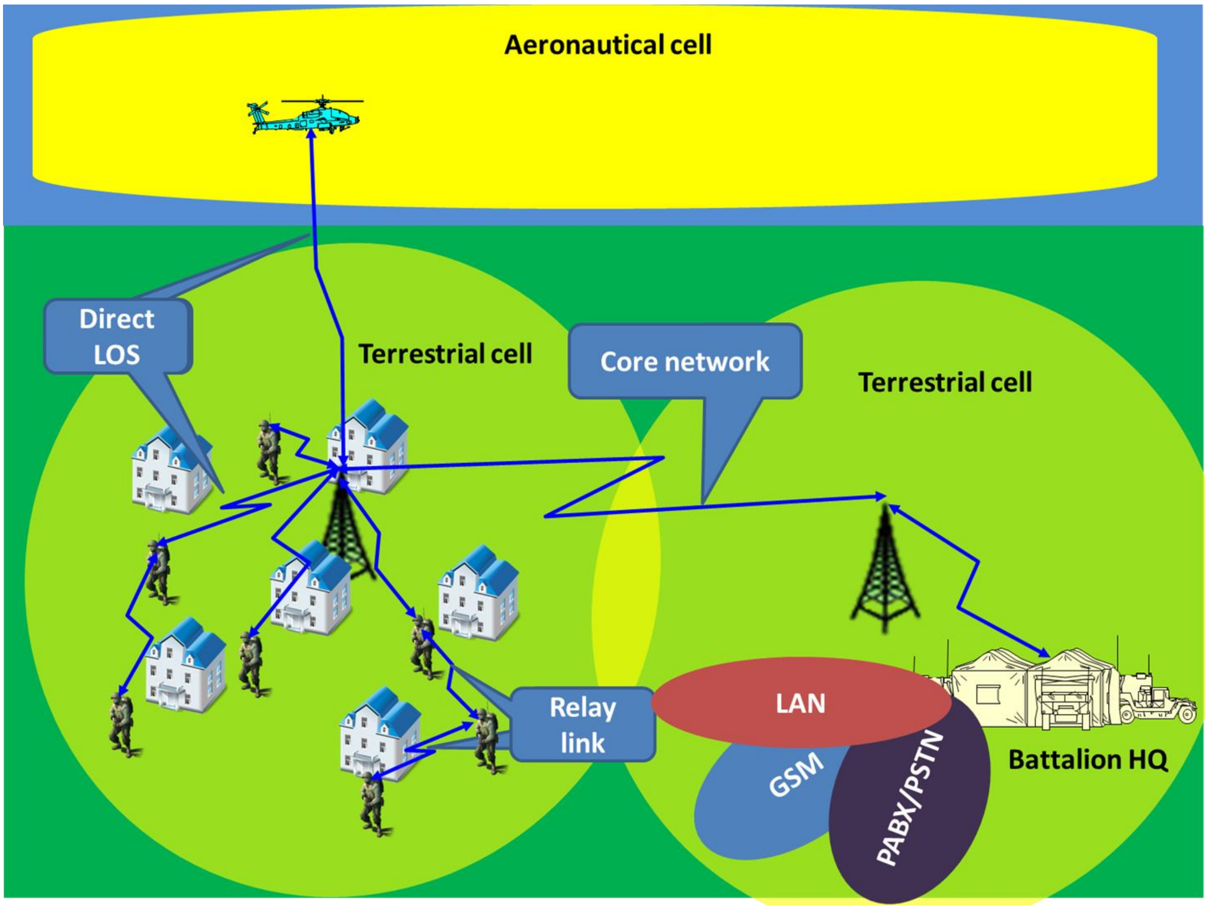

Fig. 2. Terrestrial and Air-Ground-Air network of unified digital radio system [8].

Another advanatge of the system is that it has Air-Ground-Air (AGA) capability, so we had the possibility to communicate with aircrafts like helicopters and airplanes. It helped to ask close air support (CAS) and medical evacuation (MEDEVAC), or just to keep the contact with the aircrafts during the missions.

Due to the cellular technology, the long distance among the troops and headquarters was not an issue, because we could send our data on the established core network between the two base stations. The voice, the data and the video signals were separeted from each other with virtual private network, and the management helped to reach the best quality of service.

Our communication networks operated very well with this solution, we could provide real life information (data, picture and video) for the commander and the subunits to support situational awareness. The problem with it is that most of the services do not work without base station. Because of this reason we can use this system inside the country, where the core network is built, but this solution can not operate for instance in peacekeeping missions.

Ultra-Wideband Radios

We tried on the exercise an ultra-wideband (UWB) radio as well to build a network centric operational area. It was a high-speed, short-range wireless communication network to share information on situational awareness and tactical instructions for the commanders. It was a wireless mobile network to forward high-speed communication (voice and data) within a cluttered urban warfare environment. The ultra-wideband systems have some benefits such as:

- provide high data rates;
- have very good time domain resolution allowing for ranging and communication at the same time;
- have immunity to multipath and interference [9].

The UWB is an air interface technology that provides adequate bandwidth, and with it we can establish an optimal operational environment, which is effectively maintain a low probability of detection and intercept.

We used devices with standard IEEE 802.15.3 and we reached the maximum data rates of 50 Mbps in short range (about 10 meters). We had several short distance wireless personal area networks (WPANs), and the information sharing was acted on them. The data rates decreased exponentially; above 30 meters the signal loss was so high, that we used the devices just on the maximum range of 25-30 meters. The platoon commanders could follow their troops among the buildings very well from there command posts; they had real life pictures from the activities. Due to the reflections and the short distance of the soldiers everybody was reachable, and there was just a very few point of the shielded territories.

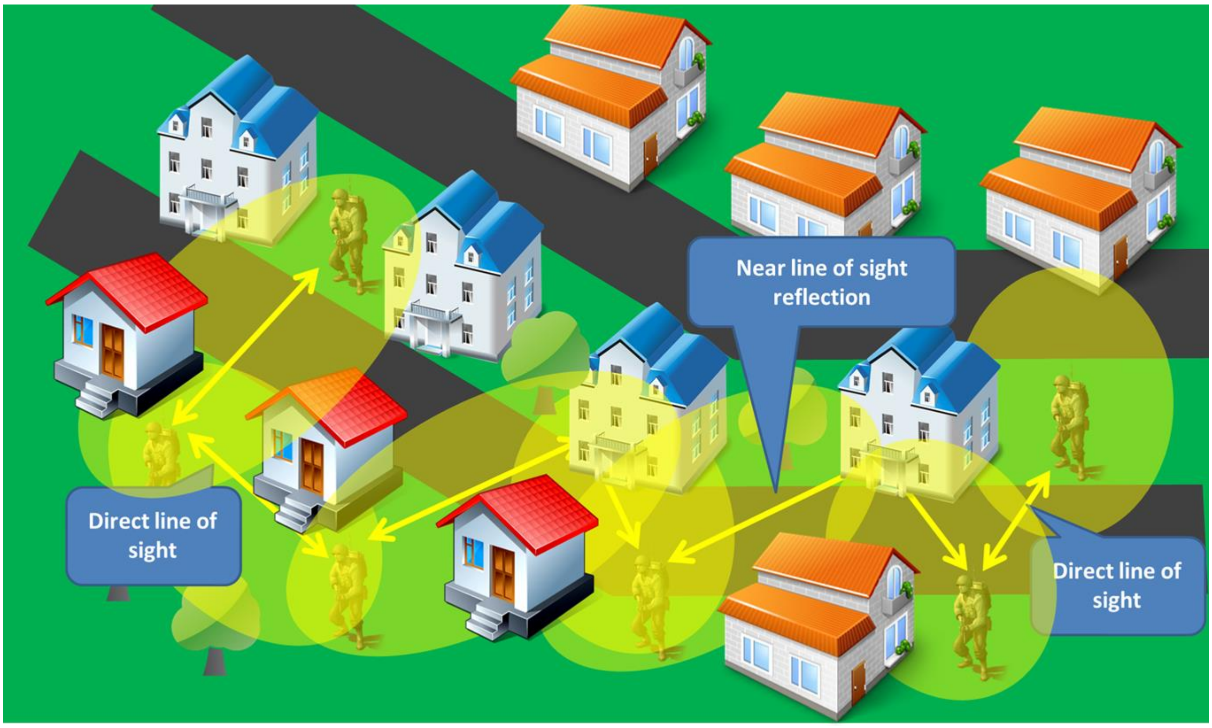

Fig. 3. The ultra-wideband radio usage on urban warfare environment.

According to our experiences the UWB radios could work very well in urban area on short range communication, but the problem was, that we could not send the information to the higher headquarters. We had to establish a node close to the command posts of the executors. There was a mobile microwave link to be installed between the node and the battalion headquarters. The radio was a flexible software defined radio microwave radio with the frequency band 7-8 GHz, and the interface was configured to transmit four 2 Mbit/s channels. Another disadvantage of the system, that we had no connection with aircrafts, commanders had to use also the devices of the node to communicate with helicopters and close air support airplanes.

CONCLUSIONS

On the exercise we used three different systems to support commanders' military decision making in urban area. Nowadays the main activities of military and non-military (peacekeeping, humanitarian, and boarder guard) operations are executed in villages, cities or populated areas. As signal soldiers we have to provide the best communication links for the commander and units to get in touch and to share information to make situational awareness.

The first system was an authorized military VHF system in the Hungarian Defence Forces. We realized that these radios are not able to provide the necessary capability for a network centric communication system. In urban areas the radios can not communicate among each others because of the interference and shielding. In open areas the systems provided reliable voice communication in over 20 kilometers range, but the data rate was so slow that we could not provide real life information. The only one possibility was, to send data via this system, the short text message, but it was not enough to share all the necessary information. Other disadvantage was that the soldiers could not get in touch with aircraft, because these radios are not interoperable with our airforce radios.

The second system was a civilian cellular radio network, which worked very well on the exercise area; we could share information in near-real life (voice, data, video etc.). The main conclusion was that we can use this network at our boarders, because it is needed base stations for the system. With mobile base station we could install this complex in abroad as well, and then it can support for instance the peacekkeping missions too. It is able to work together with aircrafts and cooperate with other services such as police, fire departments, ambulance. According to the system's management methods we can carry out multinational networks, and it provides secure communication links among allied troops, and helps the information sharing for the commanders via data transfer links.

The third system was an ultra-wideband radio network, which was able to provide high-speed communication links in a short-range territory. In small units it was the best solution to share information inmediatelly, but a huge issue of the system was that we could not send data from the units to the headquarters with it. It was needed to install an other communication link to share information with the commanders on the exercise area.

To summarize the three systems have separeted capabilities and possibilities. They can be integrated in one system and with this solution we are able to build a network centric communication system, where the commanders can share information among each others. The VHF and UWB devices can be used by the subunits, and the cellular network can support the communication links with the higher headquarters.

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