BASIC RELATIONS IN DETECTION OF AMMUNITION

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Abstract:

The delectability of buried objects is based on the recognition of indicators belonging to certain particular object. Without the option to visualize objects of our interest, we must use detectors. The success depends on the proper adjustment of the measuring tool, which can suppress effects of the surrounding material and enhances effect of the buried object. That substitutes the ideal situation, when visible indicators are available, i.e. impact craters, tail fins etc. Until now, the limited number of detecting methods have been implemented in the field.
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1. Explanatory Note

This article will use the expression „Ammunition“ regardless of its nature. It comprises unexploded, left behind or booby trapped ordnance and mines. From the detection point of view the nature of ammunition is not a decisive factor. The following text will explain it.

2. Restricting Factors

The first restricting factor is the quantity of artificial or natural objects in the soil. They possess properties similar to ammunition, causing false alarms of the detector, generally

called noise. In the field conditions the signal/noise ratio approaches a value 5:1000.

The second restricting factor is based of the reality that many objects of interest (e.g. plastic mines) possess similar features like the surrounding soil. The practical result is the mine remains camouflaged, not detected and still threatening.

The both restricting factors contributed to the acceleration of research/development of the new detection technologies. This process proceeds for decades but namely in the nineties, when even Europe was affected by mines again (in the former Yugoslavia). There are two basically approaches how to encounter this challenge: Either to use the current methods, where the prodder is a basic tool or to trust in the repeated promises of the substantial progress in the near future. The both approaches have their supporters. Let us try to gain an basic orientation in this discussion.

3. Review of Natural Fields

The detection is based on the knowledge of the fields, acting throughout all Nature. Basically, two natural fields act generally, gravitation and electromagnetic fields. All objects interact each other by gravity force. This force acts from the Universe up to atomic scale. Its suitability for the detections is

severely restricted by complicated elimination of all affecting objects (first of them is the Earth), and excludes this method from our interest.

Electromagnetic field is the second one taken into account. Its scale of validity is similar to gravity field. Because of the metal in ammunition construction the contrast between metal objects and surrounding soil is high and all detecting methods based on it are very promising.

The direct current produces a static magnetic field ***B*** assigned by the Ampere's rule:

$$B = \mu \cdot \frac{I}{2\pi r}$$

In the case of timing changes of the magnetic field the electromotor force is induced (Faraday's rule):

$$rotB \approx \frac{\partial E}{\partial t} \quad rotE \approx \frac{\partial B}{\partial t}$$

The both formulas (simplified Maxwell's formulas) describe the unity and indivisibility of electric and magnetic parts of the electromagnetic field. Oscillation produces electromagnetic waves being released from its transmitter. The spreading speed of electromagnetic waves is:

$$c = \sqrt{\frac{1}{\varepsilon \cdot \mu}}$$

where ε is an electric permittivity and μ is a magnetic permeability. The electromagnetic waves are transversal and the vectors ***B*** and ***E*** oscillate perpendicularly to each other and to the movement direction. The maximal speed of electromagnetic waves is in vacuum – light speed. The wavelength λ depends on the frequency f by the relation:

$$\lambda = \frac{c}{f}$$

The electromagnetic waves take a part of energy from their transmitter. The energy of oscillation depends according to the Planck's rule on the frequency:

$$E = h \cdot f \quad h = 4 \cdot 10^{-15} \left[\frac{eV}{Hz} \right]$$

The electromagnetic waves have a dual character:

Wavy: reflection, refraction, bending, interferential, polarization.

Quantified: Photo effect.

The review of the spectrum of the electromagnetic field shows the Figure No. 1 (on the next whole page). The first two left columns indicate relation between a frequency and wavelength. The electromagnetic spectrum is arranged according to the frequency from the stationary field until the highest frequencies of Gamma rays.

The static electromagnetic field is caused by the direct current. The source may be represented by DC cell, battery. For detection is used Earth magnetic field, affecting the whole World. Its source is explained as a movement of charged particles in the Earth core due to the thermal gradient.

The low frequency electromagnetic field is caused by alternating current. The source is represented by alternator. The detection makes use of different frequencies and is based on the Faraday's rule on electromagnetic induction.

The radio frequency waves are used mainly for geophysics. The microwaves are spreading directly, analogically with waves in the visible bandwidth (740-380nm). The detection tool is represented by the ground penetrating radar (GPR).

Infrared waves are caused by any object of the temperature bigger than 0^0 K (Kelvin scale). The detectors make use of either remote area of bandwidth, when intrinsic radiation of the object is detected or close area, when rays from the hot objects (sun, stars, etc) are reflected from objects of interest. The same principle functions in the bandwidth of the visible radiation. Ultraviolet radiation is caused by electrons emitting energy when they return from the excited

into original status. Those electrons keep the outer spheres of the atom. [1]

X-rays and characteristic radiation[2] are emitted from the inner electron spheres. The atomic nucleus could be excited by the impact of neutron. The de-excitation is accompanied by the energy emission in the form of gamma radiation. The energy of all described effects grows proportionally to frequency of electromagnetic field. If we look through the position of detection methods in the spectre of electromagnetic field, we could come to conclusion, the higher frequency of the electromagnetic field, the more sophisticated detection methods have to be applied, the more affected by surrounded materials. This statement can be justified by detailed analysis of each detection method only. But it is outside of this article.

[1] Those electron spheres are involved in the chemical reactions, so chemical detectors, as well as biological sensors could be described by approaching the same electromagnetic field.

[2] Photoeffect

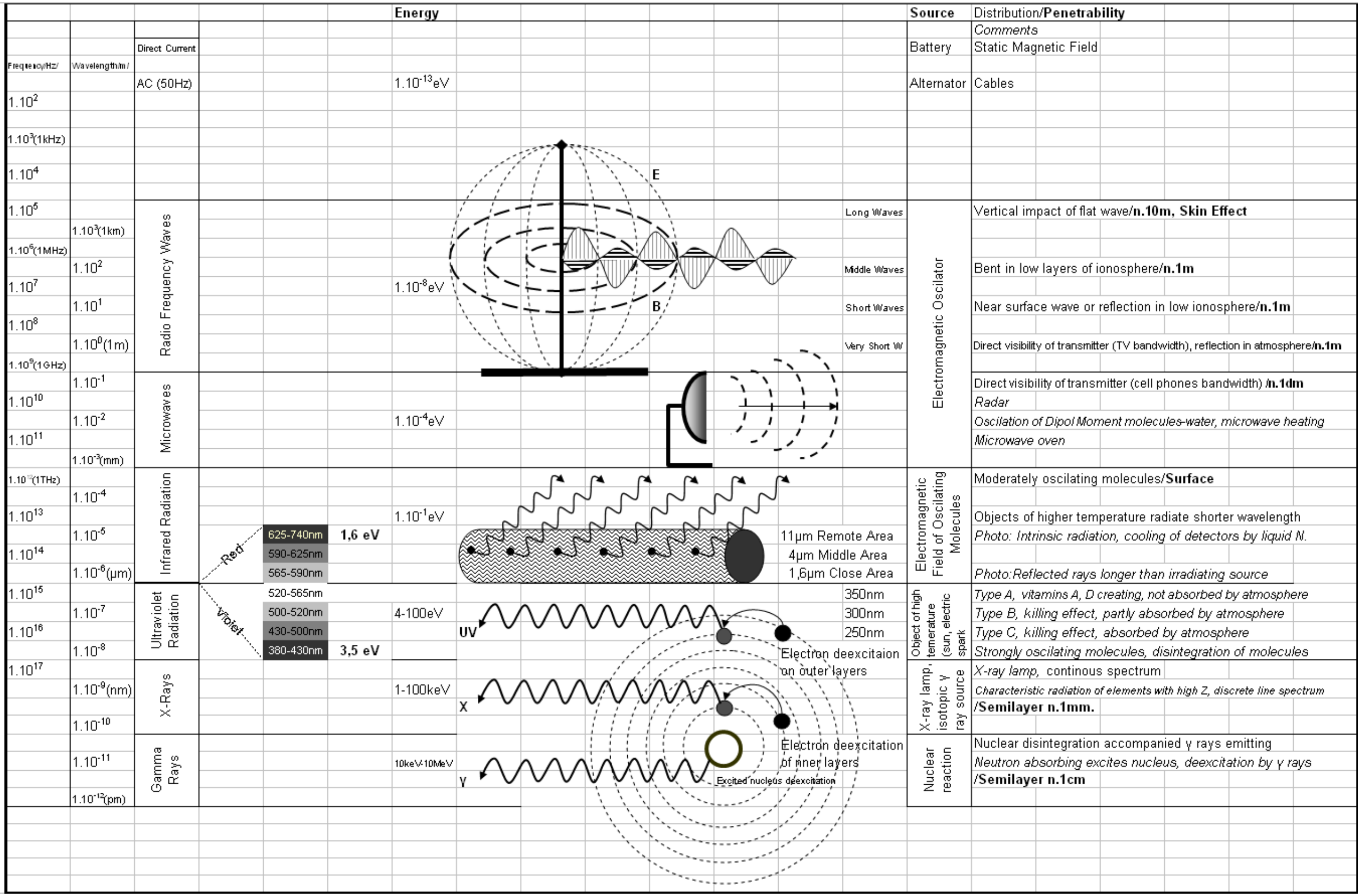

Fig. 1 Review of Electromagnetic Spectrum

4. Review of Detection Methods

The first step is to conduct review of the detection methods. There is a large amount of publications from scientific, commercial or political environment. It is almost impossible for any individuals to follow the flow of publications issued permanently. For us is better to take an official review published by NATO, the instruction NIAG/SG 84, Countering IED. This publication contains 378 pages, analyzes 55 technologies, 5 out of them based on biosensors, 2 on chemistry, 7 on mechanic effects and the rest, 41 based on electromagnetic field. Chemical methods have been used mainly in criminology, mechanical in breaching minefields. For detection of the ammunition concealed in ground the electromagnetic field has to be considered decisive. The research results in conjunction with the results from praxis lead to certain imagination, which detection methods represent a basis for ammunition disposal. This is depicted in the Figure 2.

Antipersonnel mines are placed just under surface. They contain a neglect able quantity of metal. As a rule, the case of plastic stuff covers explosive. Metallic parts, if any, compose a fuse. Metal detector is not very suitable for detection. Ground penetrating radar (GPR) is supposed to be the best

solution for their detection. The drawing indicates the GPR array of transmitting and receiving antenna and the imaginative trajectory of the radar beam.

The ammunition expressed by the artillery shell is to detect by the metal detector working on the basis of electromagnetic induction. Their mass varies from the first to tens of kilograms. The depth of shells in the ground depends on their kinetic energy in the moment of the impact, angle of incidence and disintegrability of soil. Uncovered shells are found at a depth up to 0,5 m frequently. The picture shows the searching coil which is typical for metal detectors.

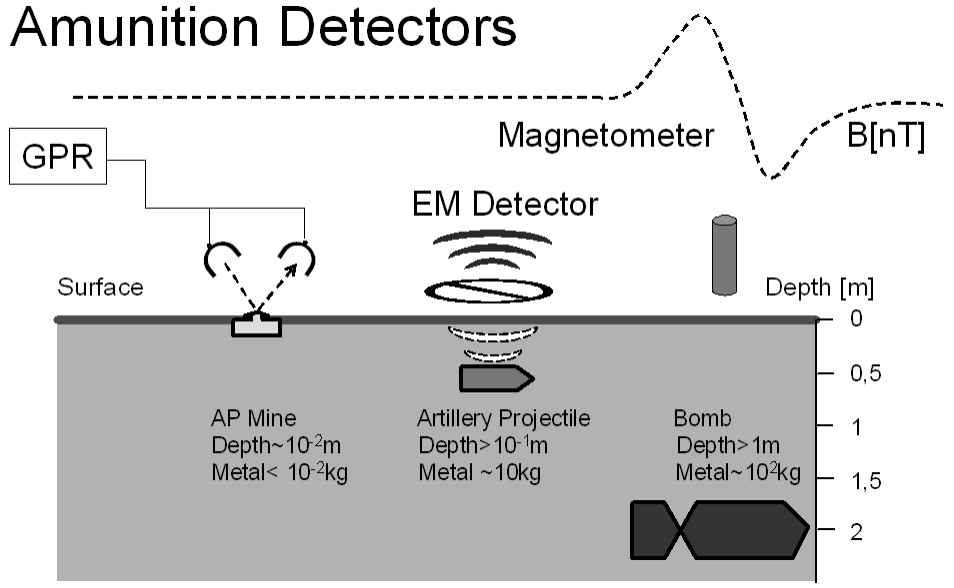

Fig. 2 Representatives of Detection Methods

The air dropped bombs penetrate the ground up to depth of some metres. The metal detector working on the electromagnetic induction is not efficient for those depths. Air dropped bomb thanks to its mass and a metal content induces a significant magnetic anomaly. The picture indicates a course of the magnetic induction anomaly over the buried bomb.

Nevertheless, the current research covers all electromagnetic spectrum of frequencies/wavelengths. This is described in the diagram on the Figure 3. It shows the representatives of the whole scale of ammunition, its features and a method which is believed the most effective in detection.

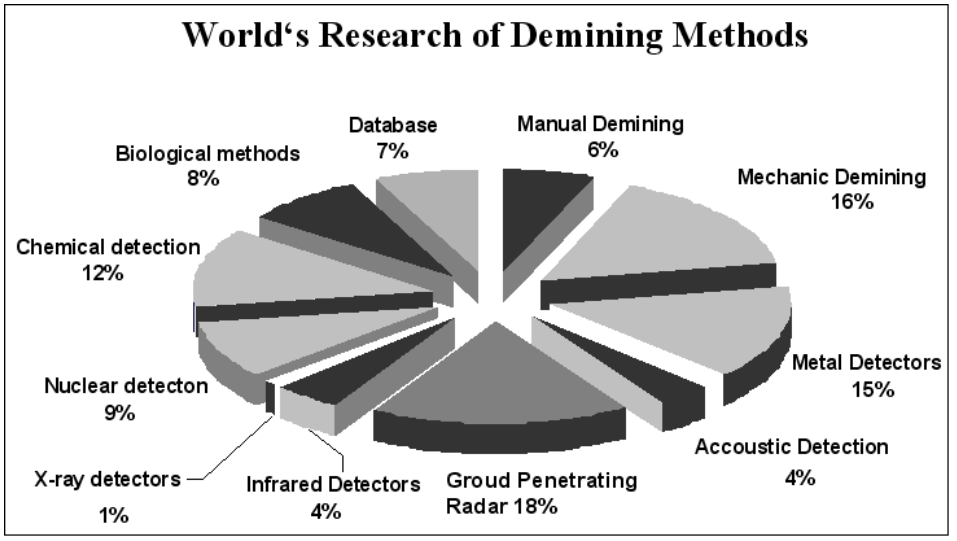

Fig. 3 Share of the Detection Methods in the Research of the World

The most popular parts of the electromagnetic spectrum for the research are low frequencies, microwaves and gamma rays.

In comparison with the extent of the electromagnetic spectrum, quantity of detection methods under research and the scarcely three applicable field methods concludes to apparent discrepancy. We have to face towards a serious fact: All methods were theoretically developed in the early 20th century, when nuclear physics science accelerated forward. Laboratory applications have appeared since a middle of 20 century, when military support of nuclear program culminated. The field application became common in early 70th, when the World encountered the first energy crisis and a survey of natural deposits enjoyed a boom consequently. The applicability for ammunition detection has been in the international focus from the end of eighties, when minefields occurred in Europe. But despite of the international support, the last two decades did not bring any significant progress.

There are many countries, societies, companies and institutes supporting research in demining technologies. United Nations, Department of Humanitarian Affairs, publishes annually a contribution of particular governmental and non-governmental donors. The Figure 4 shows the review

of activities, which are donated. Regardless of the fact, this review is from 1998 year, the portions of support remain approximately unchanged since.

One third of the whole sum of money is spent for campaigning. The political influence of campaign representatives is significant. On the other hand they are severely criticised. The reason is, funds, originally assigned for demining, are averted from minefields to their offices. And they make use of those funds for bigger publicity and more money for campaigns. Mine victims assistance is an implication of the fact that demining forges too slowly. The absence of mines in field would make those funds automatically redundant. Mine awareness comprises education of people, maintenance of fencing or recognition of areas of risk. Money spent for demining represent barely more than ten percent of all funds. This is the reason for campaign criticism. Research/Development exceeds slightly one third of all annual funds. The question is, how much the R/D contributed to the demining effectivity in the course of the last decade.

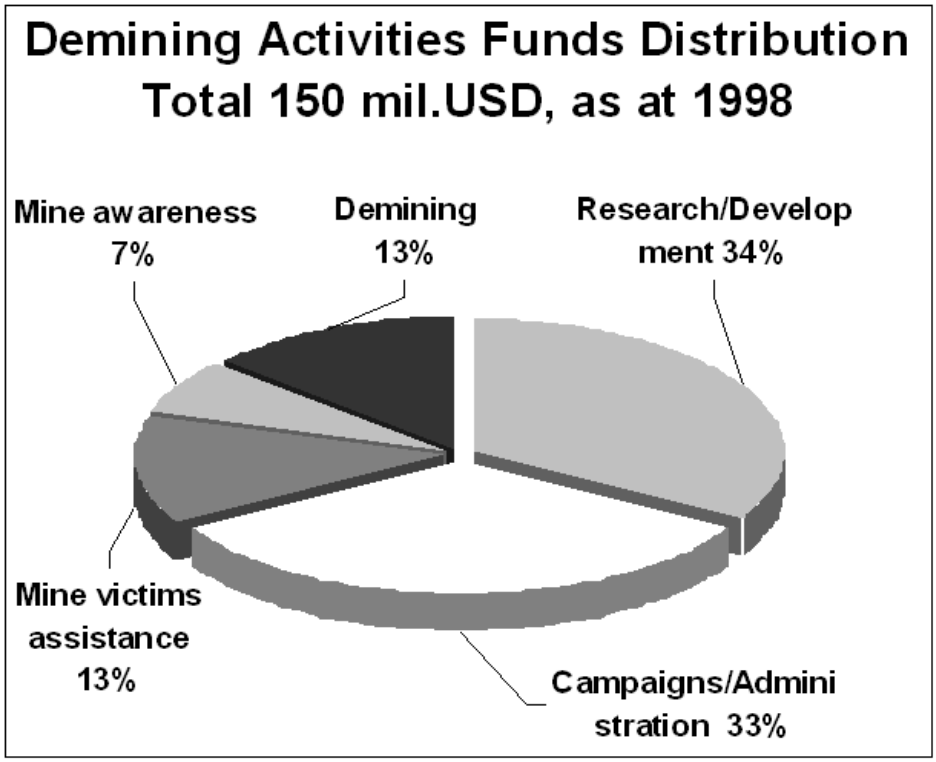

Fig. 4, Funds Distribution

5. Conclusion

This leads to the pessimistic conclusion stating, it is impossible expect any progress in detection methods development, regardless of the money and the time spent. If we want to notice whether it is correct or not, we have to recognize theoretical principles of detection methods in their location inside of the electromagnetic spectrum and their restricting factors. And it has to be a subject of the next

contribution to the publications specified on the particular detection methods.

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