TETRA SYSTEM - OPEN PLATFORM - INTEROPERABILITY AND APPLICATIONS

Claudiu Dan Bârcă [1*]

ABSTRACT

Digital Terrestrial Trunked Radio System - (TETRA) is a professional system standardized by the European Telecommunications Standards Institute (ETSI). In this paper, TETRA technology – an open and inter-operable platform intended in particular to ensure the communications needs of the public safety services in order to ensure order and public safety (Public Saftey Sector-PSS) and prompt response to disasters (Public Protection and Disaster Relief -PPDR). Also the telecommunications industry worldwide has recognized the opportunity and perspectives which standard Tetra offers as a high quality solution for unified communications to different entities.

KEYWORDS: *Tetra, Interoperability, Wireless Communication, Public Safety, Emergency*

INTRODUCTION

Any emergency situation management is generally a common and continue process involving persons or communities, in order to avoid or diminish the effects of an eventual disaster impact [1].

The public security which complies with a series of tasks implies with a higher need of telecommunication services, especially during the move condition [2].

Some of these services challenges are:

- in case of disaster – providing the communication over a wide area along with the unitary communications between the different entities (police, fire, rescue) it is necessary;

- car crash in highways/tunnels – in which, because of the large number of traffic communication applications, the public mobile phone services are overstretched, thus relaying/blocking a rapid response from the various emergency crews;

- the intervention for restoring the public order – inquires special operations undergoing the necessity of protected and encrypted communications from the security forces.

Over the world, regarding the majority of public safety and security structures, the communication is vital. So, in the last years, the communications between these structures have demanded services well above the conventional radio network capacity used.

[1]* corresponding author, Assistant PhD, Faculty of Computer Science for Business Management, Romanian - American University, Bucharest, barca_dan@yahoo.com

Thereupon, removing the conventional, analogic systems in favour of digital radio networks demands a complex process, throw technical and commercial aspects.

Although each country is characterised by its specific situation, some dispositions are general:

- the solutions must have an open standard above the specific, individual solutions - one of the standardization results is the equipment's interoperability from different manufacturers, thus being vital for the network users and operators.
- the use of trunked digital radio systems (Terapol, Tetra): by comparison with the parallel systems, the trunked digital systems offers a series of advantages (a better signal propagation and use of frequency spectrum, an increased resistance at the interface, its suitable for the integrating of various type of information, with the possibility of being efficient encrypted.
- the achievement of national professional radio networks, in which the network infrastructure (the commutation centres, official stations) is available for a large number of users. Each user works normally in his own virtual network and connects with other ones, along with other entities, if it is necessary.

TRUNKED DIGITAL NETWORK

Two technologies for the emergency situations communication systems are available in the EU: TETRAPOL and TETRA

TETRAPOL communication system

Born in France from the agreement between the French Gendarmerie and The National Guard Company Matra Communications [3]. This technology is responsible for the national public safety communication network in France.

The Tetrapol wasn't adopted by ETSI (The European Institute for the Telecommunication Standards), but different companies reunited and gave born to a forum for the technology development, where specification according to the ETSI standards were elaborated, in order to disseminate technic information [3].

The Tetrapol system is worldwide known and represents one of the digital radio options for the military or public security. In according with the Tetrapol forum, 83 Tetrapol network are available worldwide, that means 850000 radio equipment's are serving 460 million people in an area of 11000000 km^2 [3].

Technical specifications

The Tetrapol system uses the Frequency Division Multiple Access technology (FMDA), with a narrow band channel, of 12.5 kHz AND Gaussian minimum shift keying modulation (GMSK), in the frequency range 70 – 520 MHz [1]. In Europe, Tetrapol is present in the 380 – 400 MHz band for the channels of the public safety and military services for national security. Thus, the Ultra High Frequency band (UHF), with a 10 kHz or 12.5 kHz and a distance of 5 MHz in the duplex module is used. The Tetrapol base stations are connected to the fixe public network, the mobile one or the IP one.

The scheme of a Tetrapol network is presented in figure 1.

It can be noticed the interoperability of the Tetrapol network with the IP interfaces available for each network unit. So, by integrating a Tetrapol network, it must be adopted the mechanism for sharing the logic channels into the IP platform and between the network units.

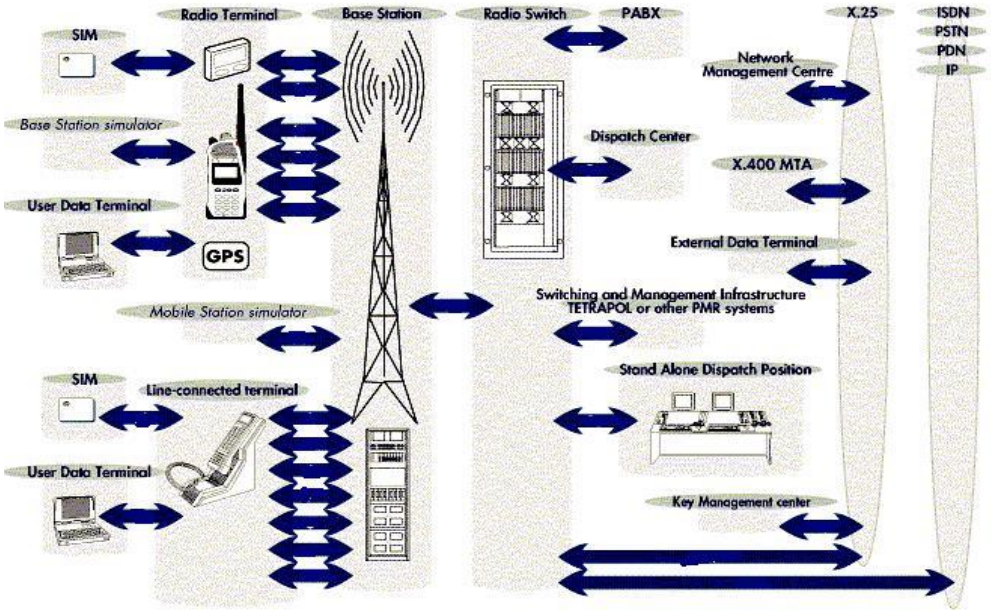

Figure 1 The generic scheme of a Tetrapol network [3]

The Tetrapol system complies with the PMR (Professional Mobile Radio) requirements and ensures an efficient radio coverage among the costs for the large networks, extended in densely populated or inaccessible areas. It offers an infrastructure capable of interconnecting national in cross border multinationals.

Conceived as a national technology, TETRAPOL offers the possibility of a multi-source acquisition using the TETRAPOL forum, which allows free access to patents for the worldwide scientists, ensuring full interoperability of products from different sources.

The TETRA communication system

One of the most spread digital radio system is TETRA (Terrestrial Trunked Radio). This standard was approved and defined by The European Telecommunication Standards Institute (ETSI), as being the only European official standard for professional radio communication (PMR).

It is a global standard for radio communication in the same manner that GSM is the standard for the mobile phones. It provides regular and professional cells services: group communications, field workers management services (dispatching) and efficient data

services. It is a unique combination of group vocal communication services, mobile phone and data services, but special conceived for the authorities use.

In a TETRA trunked radiophone system, the radio channels are centralised and the system automatically assigns channels available to users, at the beginning of each call. The assigns from a common synoptic table are called trunking and the systems providing this assign method are therefore trunked. TETRA uses the TMDA digital technology (Time Division Multiple Access).

A TETRA channel width of 25 kHz takes four temporal slots or communication channels figure 2.

The analogic systems are based on the frequency modulation and a channel takes a 12.5 kHz or 25 kHz width band. Consequently, TETRA is two to four times more efficient than the analogic classical systems.

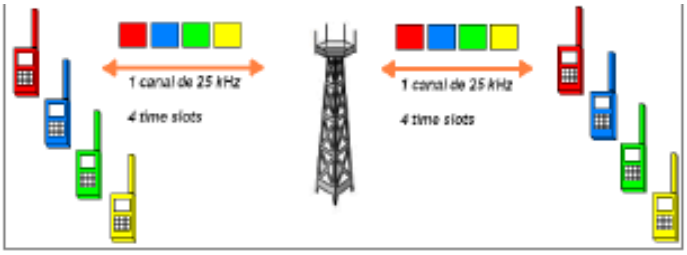

Figure 2 The TMDA communication for TETRA [4]

TETRA acknowledge three frequency bands. In Europe, the 380-400 kHz band is only for the security problems and public safety, the 410-430 MHZ band for the professional radio communication systems. Outside Europe, the 800 MHz band id the chosen one for the TETRA system [5].

The TETRA standard (first version) was the first standard known as open-system for the professional radio communication. It was developed by the European Telecommunication Standard Institute (ETSI) along with the user organizations, in order to establish their well functionality and rapidly adopted by the national administrations. The efforts for the standardization are continued by achieving new characteristics, like the interconnecting possibility with mobile communication standards, like GSM, GPRS and UMTS. Beside standards for the network elements, another TETRA services and facilities are standardized .Among these, the most important are:

- Advanced and fast dialling services - unencrypted and encrypted
- Individual calls - unencrypted and encrypted
- Fast service data - unencrypted and encrypted
- Packet data services - unencrypted and encrypted

The first version of the TETRA system (voice + data) provides a comprehensive portfolio of services and facilities, but the increased demands of the users lead to the technology evolution. Important events from the telecommunication industry among changes of the

market needs allowed a large number of services and facilities to be standardized, thus being included into the second version of the TETRA system.

The new services permitted:

- The TMO coverage expansion (Trunked Mode Operation)
- The AMR vocal codec (Adaptive Multiple Rate)
- The MELPe advanced vocal codec (Mixed Excitation Liner Predictive)
- The TEDS advanced data services (TETRA Enhanced Data Service)

The TETRA radio networks can allow IP-over-TETRA and it is realized by the IP gateway, available in most TETRA systems. This gateway allows the data and status messages exchange between a TETRA terminal and a gadget app connected to the IP network. Also, data packets are available on some TETRA systems, which allows the IP data exchange between a gadget app connected to the TETRA terminal and a ruling app on a server from Intranet [6,7,8.]. An IP-over-TETRA alternative is using WAP (wireless Application Protocol) on TETRA terminals. A TETRA-over-IP system network topology is very flexible. Basically, any topology is supported, including star-type topology, mesh topology, ring topology and a combination thereof. It's just a matter of setting links and routers in order to achieve the required topology. In most cases, a combination of these topologies is the best choice.

TETRA-over-IP offers several advantages. One of the most important advantages is that IP is used to connect all elements in a TETRA network. TETRA-over-IP thus provides a single architecture for multiple purposes figure 3.

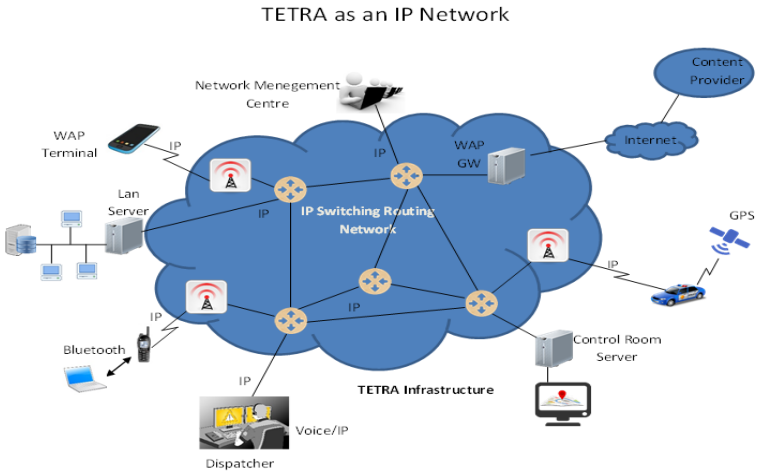

Figure 3 Tetra over IP (source - Mobile Broadband Communications for Public Safety-© 2015 John Wiley & Sons, Ltd)

INTEROPERABILITY FOR TETRA OPEN MARKET

TETRA is an open standard for digital PMR who created the foundations for markets with several providers and introduces TETRA products of several manufacturers.

The aim is to ensure interoperability can use TETRA products - mainly of TETRA terminals - on any network from any vendor and to facilitate the flow of critical information. This will improve the timeliness and accuracy by reducing circuit necessary duration of communication possible causes of interruption, and reducing the number of people who may commit errors.

In Europe, standardization is the key word for almost all international activities closely related to public safety communications. Internationally and technically there are three main initiatives used to address communication:

- Police: police cooperation Schengen
- Standardization institutions: European Telecommunications Standards Institute (ESTI)
- Institutions supporting European standard (TETRA MoU)

Interoperability between different networks and terminals traders is of great importance in building large shared network. This allows increased flexibility and price products user companies. To ensure interoperability, a neutral party interoperability tests and certificates are awarded according interoperability profiles, as defined by Tetra MoU.

The technological development of the Tetra system contain: standardization,

interoperability tests Tetra MoU, manufacturing, final testing interoperability figure 4.

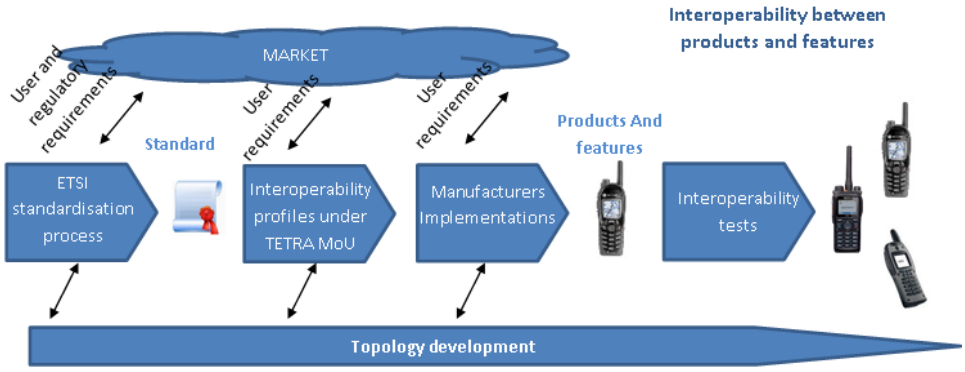

Figure 4 Tetra system technological developments [9]

TETRA SYSTEM - IMPLEMENTATION

TETRA is the only European standard for radio, and with this system, public safety agencies have a wide range of communications and new operational opportunities. TETRA provides secure voice and data transmission, communications allow coalition all public safety agencies in a single system and also connects to telecommunication

networksIn addition to the transfer of voice data can be transmitted simultaneously. Also, TETRA can transmit fingerprints and photographs of wanted persons by mobile terminals.

Tetra system is implemented not only in Europe but in the United States, Canada, Australia, New Zealand and in many countries in Asia and Africa. [10,11,12]

In Europe figure 5 Tetra networks are implemented: Italy, Ireland, Poland, Greece, Bulgaria, Portugal, Slovenia, Romania, Lithuania, Vatican State, Island (reteua IRJA), Finland (VIVRE), Hungary (Pro-M), Sweden (Rakel), Norway (Nodnett), Belgium (AATRID), Denmark(TetraNet), Austria (Digitalfunk), Netherlands(C2000) Germany (Bos Digitalfunk).

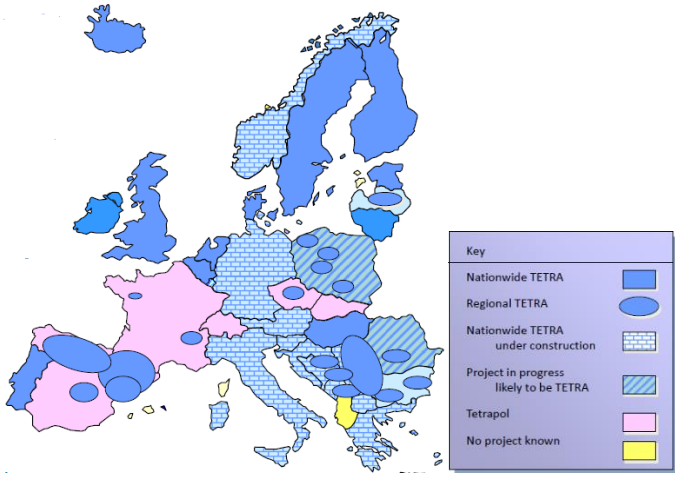

Figure 5 Tetra networks in Europe [10]

Tetra applications in Romania

In Romania, mobile radio communications infrastructure is managed by the Special Telecommunications Service [www.sts.ro] and consists mainly in digital radio communication systems professional TETRA, TETRAPOL and local networks conventional infrastructure which provide voice and data mobility for state authorities.

Romania network coverage Tetra (red) is shown in figure 6.

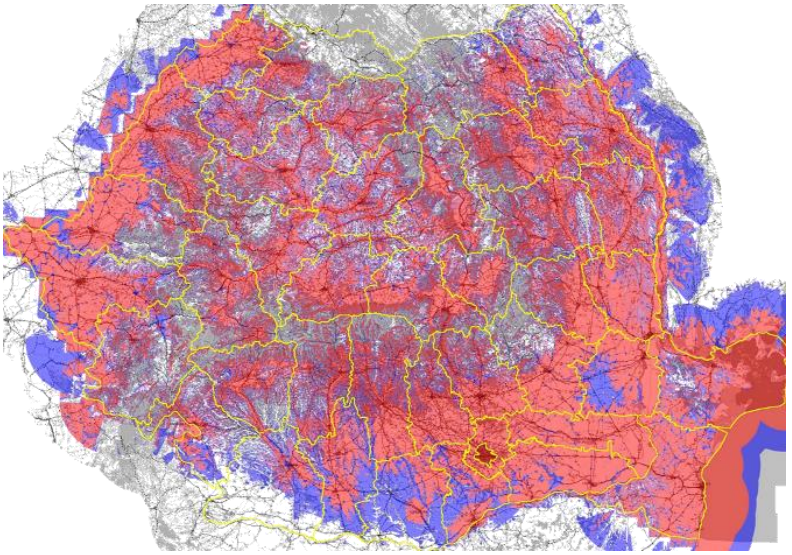

Figure 6 Romania network coverage Tetra [13]

Main applications are developed on this infrastructure:

- *Intelligent management and control of urban traffic in Bucharest [14]*

Components "Intelligent Transportation System" are:

-subsystem Urban Traffic Control(UTC)
-subsystem Public Transport management (PTM)
-subsystem Closed-Circuit television (CCTV)

They are complemented by the Control Center, which get information from all three subsystems and managed to obtain data on traffic and prioritize its needs.

- *Operating System in emergency management*

This system was implemented as a result of the need to ensure radio voice services and data to the emergencies. Its primary objective is to develop comprehensive services for state authorities in charge of managing events and emergencies like 112 and eCall [15,16,17], including in areas where there is currently no telecommunications services offered by other operators.

- *Radio system operable to public authorities*

Common platform TETRA belongs to the following authorities: Ministry of Interior (Police Romanian, Border Police, General Inspectorate for Emergency Situations, SMURD, Romanian Gendarmerie), Romanian Intelligence Service, Ministry of Health (Ambulance), Ministry of Finance (National Agency for Tax Administration, Ministry of Defense, Service Protection and Guard and other authorities under the supervision or control of the Government;

- *Integrated System for Border Security of Romania*

TETRA technology has been adopted in the Schengen Convention as the standard for communication systems for law enforcement authorities, including police, in all European countries. Since this technology is planned in border security, it was made a national consensus on the development of common platforms. It will also provide mobile radio communications requirements of all institutions of defense systems and authorities with responsibilities in citizen safety.

TETRA common platform provide services required by the authorities. This is service support secure voice and data services database query national and Schengen Information System.

Romania has complied with commitments made in the negotiations with the European Union. Border security project involved the purchase, installation and integration of modern surveillance systems in order to obtain modern command and control centers for the provision of over 180 operating locations of the border police. It made such an efficient and systematic control and continuous surveillance of the border, especially in sectors that will be the European Union's external borders. The project provides and expand and develop IT and communication infrastructure necessary for cooperation between all institutions and competent authorities at the border and with neighboring countries (Hungary, Bulgaria, Moldova) principle figure 7.

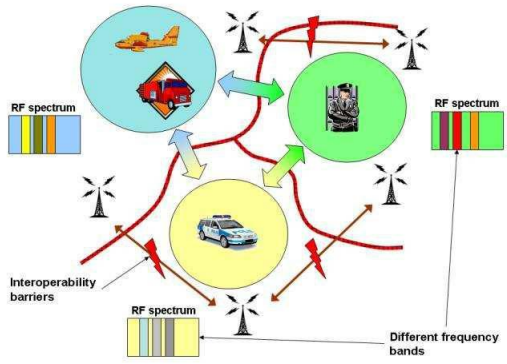

Figure 7 Model of Cross Border Cooperation [2]

This scenario involves various nations or regions border geo-political and national authoritiesThey are usually equipped with communication systems based on different standards or operating in different frequencies. In this scenario, interoperability issues is the main challenge, while traffic capacity is well planned.

Figure 8 present counties covered by the Phare or Integrated Border Security System (IBSS) who have made investments in the development of Tetra. The system is completed today.

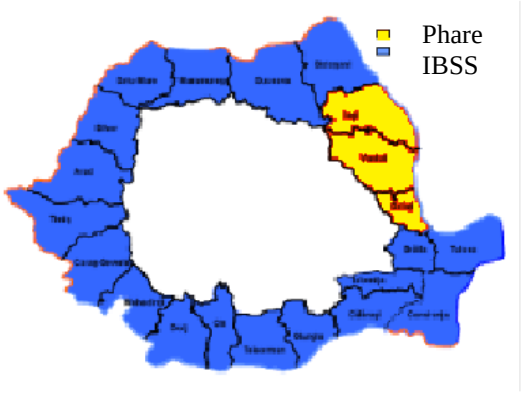

Figure 8 - Counties covered by the Phare or Integrated Border Security System

❑ *Alert system in case of earthquake*

Earthquakes are a major natural disaster. An early warning system was developed in Romania to launch a warning in advance of 25-35 seconds (Bucharest city), in case of earthquakes with magnitude above 6.5 (Figure 9). To reduce the losses caused by earthquakes is very important to use advanced technologies. Earthquake Early Warning System will enable natural and avoid economic losses in emergencies caused by earthquakes. Information is the key point in the management of disasters and the Internet is one of the most commonly used tools, and with reduced costs [18]. To send warning signals to local authorities and civil protection units uses TETRA system.

Compared with GSM, DECT system has the shortest transmission information figure 10.

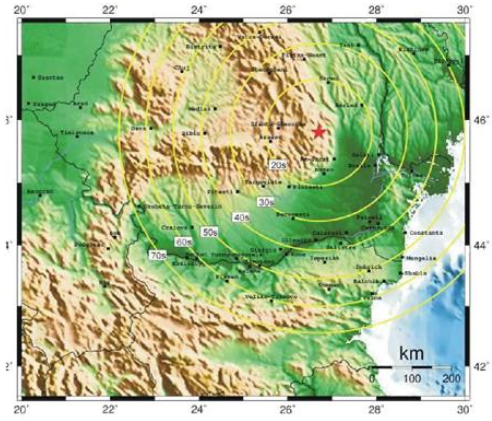

Figure 9 Wave propagation time [19]

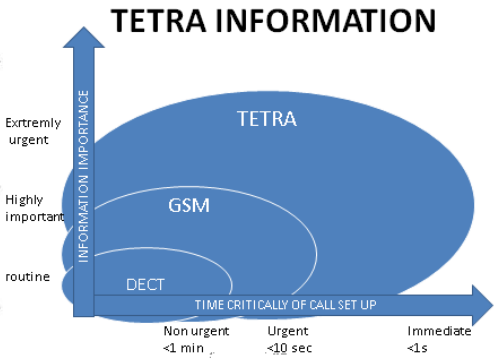

Figure10 Shortest transmission information

Such alarm systems are used before the arrival of the secondary wave, which leads to improved reaction in case of an earthquake. All this information to alert transmitted using secure systems between systems and users earthquake evaluation.

CONCLUSIONS

Digital Terrestrial Trunked Radio System - (TETRA) was introduced as the first open standard for professional mobile radio equipment. Tetra was adopted in the European area as a cross-border system and consequently, some states have used this technology in the European Union - accession to Schengen chapter. Tetra is an inter-operable coverage system with a fast response speed and a high degree of availability and security of communications. Studies from the National Institute of Research and Development for Earth's Physics showed that Tetra platform can be used also as an early warning system in case of earthquakes.

REFERENCES

[1] Ramon Ferrús and Oriol Sallent- *Mobile Broadband Communications for Public Safety: The Road Ahead Through LTE Technology*-2015 John Wiley & Sons, Ltd

[2] Baldini, G., Karanasios, S., Allen, D., & Vergari, F. *Survey of Wireless Communication Technologies for Public Safety*. Communications Surveys & Tutorials, IEEE, 16(2), 2013, 619-941.

[3] www.tetrapol.org

[4] TETRA Association, "*PS and commercial services*", work document presented at CEPT ECC FM49 meeting, November 2011.

[5] ETSI EN 300 392-1 V1.4.1 (2009-01), *Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D)*; Part 1: General network design.

[6] Claudiu Pirnau, Mihai Alexandru Botezatu, Iuliu Stefan Grigorescu, "*Databases Role Correlated With Knowledge Transfer Between Entities Of A Cluster*", "Mircea cel Batran" Naval Academy Scientific Bulletin, Volume XIX – 2016 – Issue 1, Editura "Mircea cel Batran" Naval Academy Press, pg 476-483, Constanta, Romania

[7] Barca Cristian, Barca Claudiu, Cucu Cristian, Gavriloaia Mariuca-Roxana, Vizireanu Radu, Fratu Octavian , Halunga Simona - *A Virtual Cloud Computing Provider for Mobile Devices*. Proceedings of the International Conference on Electronics, Computers And Artificial Intelligence - ECAI-2013

[8] Claudiu Pirnau, Mihai Alexandru Botezatu -*Service-Oriented Architecture (SOA) and Web Services* -Database Systems Journal vol. VII, no. 4/2016

[9] http://www.telekomunikacije.rs

[10] Phil Kidner-*An introduction to Tetra in Europe* –ENNA Conference2013

[11] Phil Kidner -*Tetra-today-in-Europe* : Tetra today issue 36, 2017

[12] http://www.tetratoday.com

[13] Vasilca, I.-S. (2012) "*The STS National Network*", EU Emergency Services Workshop,http://www.eena.org/ressource/static/files/_sts-national-network.pps

[14] www.uti.eu.com

[15] George Căruțașu, Cezar Botezatu, Mihai Botezatu, *Expanding eCall from cars to other means of transport*, Journal of Information Systems & Operations Management, Vol. 10 No.2 / December, pag. 354-363, 2016, ISSN 1843-4711,

[16] Botezatu Cezar, Botezatu Cornelia Paulina, Carutasu George, Barcă Claudiu Dan - *eCall safety transportation management systems –features and capabilities*, Annals of the Oradea University, CD -ROM Edition, Volume VIII (XVIII) 1583-0691

[17] www.sts.ro

[18] Cristina Coculescu, Mironela Pirnau, Mihai Alexandru Botezatu, *Processing and interpretation of statistical data regarding the occurrence of earthquakes*, Journal of Information Systems & Operations Management, Vol. 10 No.2 / December, pag. 364-372, 2016, ISSN 1843-4711

[19] Constantin Ionescu- *Earthquake early warning system and disaster management concept for Romania-Bulgaria Cross-Border area*-prezentare DACEA - "Sistem de alerta in caz de cutremure pentru regiunea transfrontaliera Romania – Bulgaria" (Giurgiu, 13 octombrie 2011)

[20] 123seminarsonly.com