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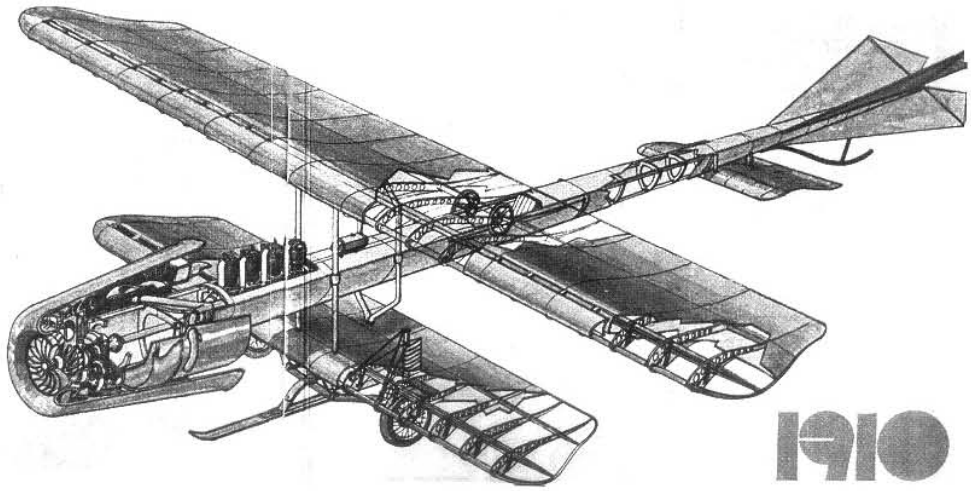

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C O N T E N T S

A NEW EMERGENCY LANDING CONCEPT FOR UNMANNED AERIAL VEHICLES

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Abstract: *Modern world is busy with newest UAV civil and military applications. Due to safety level provided by modern UAVs and UASs there are only few initiatives to apply UAV in habited areas to minimize damages and losses both in nature and environment, and in human beings, too. If the UAV must be landed in emergency situation fast and safe way, a human operator of the UAV having limited skills and abilities must be eliminated to ensure successful accomplishment of the emergency landing maneuver. The aim of the author is to establish a new concept of the emergency landing based upon multiple-criteria decision-making (MCDM) procedure.*

Keywords: *UAV, UAS, emergency landing, forced landing, multiple criteria decision making.*

1. INTRODUCTION

UAV applied in any mission can get in unsafe flight situation due to many reasons. If there is a human operator controlling the UAV he can make a decision about interrupting the flight mission. In the conventional fashion there are two common reasons that can lead to emergency landing of the UAV. First reason is loss of command signals. It is mainly handled with returning UAV to the place of take-off. This procedure is often known as RtH (Return-to-Home) mission.

Secondly, the loss of thrust provided by the propulsion system can lead to forced landing of the UAV. These two causes and their consequences have been exhaustively described in [6, 7, 10].

The main goal of the author is to identify and segment other reasons threatening flight safety of the UAV. Although there is a pre-flight inspection of the UAV to reach maximum of the flight safety, there are many reasons can lead to a critical flight situation.

It is needless to prove that UAV operator will plan the UAV flight mission with considerations of the all available initial data. The problem can arise here when external conditions (e.g. wind, deposit, temperature etc) are very changeable. Moreover, during simplest UAV applications at the operator's ground control station there is no information about flight conditions and processes turned into that of worse or extreme ones.

Regarding references of [4,6,7,10,11,12] dealing with UAV emergency landing many threats to flight safety of the UAV are still uninvestigated, and, only first steps are made in solution of problems related to UAV safe operations in emergency landing maneuver.

2. RELATED WORKS

The investigation of the emergency landing of the UAV in extreme flight situations is traced back almost a decade. It was, and still evident that onboard automatic flight control system must ensure flight safety minimums at any flight phase including emergency landing of the UAV.

The task of the safe execution of the emergency landing is very challengeable. Many early researches dealt with flight path planning ensuring landing on safe landing zones providing minimum losses and, minimized threat both to environment and to human being [4,6,7,10]. That problem often was combined with that of design of vision based automated landing of the UAV [6,11,12].

The emergency landing in many research works is originated back to engine failure leading to loss of the thrust and emergency landing is called for forced one [10].

3. CONDITIONS AFFECTING FLIGHT SAFETY OF THE UAV

Among those of possible hazardous conditions and events affecting UAV flight safety the followings are segmented by the author:

1. loss of the control signal;
2. engine(s) failure – partial or total loss of the thrust power;
3. weather conditions (atmospheric turbulences, wind gusts, deposits, icing, external temperature);
4. onboard hardware malfunction;
5. loss of orientation in general.

3.1 Loss of the Control Signal. The wireless control data link can interrupt data transmission between ground control station (GCS) and the UAV itself for a short, or, for a long period of time.

If control data transmission is interrupted due to any reason for a while, or, for a longer period of time the UAV must activate the 'Hold' regime of the automatic flight control system, if there is any applied. A 'Hold' function activates stabilization of the UAV at horizontal straight flight at constant speed and constant altitude with simultaneous stabilization of the Euler-angles.

If the duration of the signal loss of ΔT increases a predefined critical one of t_{crit}, i.e.

$$\Delta T \geq t_{crit}, \tag{1}$$

and the UAV has properly working thrust (power) system flight mission must be interrupted and, UAV flight control system must activate the RtH mission autonomously. The critical value of t_{crit} must be determined for the given class, and for the given type of the UAV.

3.2 Engine(s) Failure – Partial or Total Loss of the Thrust Power. The emergency situation when the autonomous landing of the UAV is highly needed is loss of thrust. Engine failure means that UAV losses the power needed to execute the given flight mission, or, the power of the UAV is drastically decreased and flight mission must be aborted. The 'Engine failure' can be identified evaluating following parameters:

– speed of rotation of the engine;
– current of the BLDC-motor(s).

If speed of the rotation (RPM) n is less than the predefined minimum of $n_{\min}$, i.e.

$$n \leq n_{\min}, \tag{2}$$

the procedure of the emergency landing must be activated finding best landing site ensuring minimization of the losses caused by the UAV.

When UAV rotor blade is driven by BLDC-motor, the status of the BLDC-motors can be monitored via its current required. If current required by BLDC motors is less or larger than its nominal value, i.e.

$$I_{\min} \le I \le I_{\max}, \tag{3}$$

and, if the UAV is a single-engined one, it must be abort flight mission and must enter a new maneuver of the unpowered forced landing.

If the UAV is the twin-engined, or multi-engined one, and there is a loss of a single BLDC-motor, the UAV must abort flight mission and, must enter the RtH maneuver.

The measurement of the current required by BLDC-motors is very important to predict flight time available and covered by electrical energy stored into batteries. The UAV on-board electronics can serve for measurement of the current required by the BLDC-motors. If there is any current values are far out of the current tolerance field, the BLDC-motor technical status can be evaluated, whether it is in normal mode or far out of that, and, it can be disconnected, for instance.

3.3. Weather Conditions. During UAV flights weather conditions can change very rapidly, and, bad weather conditions can threaten success of the flight mission, and can threaten the UAV itself. Although there is a thorough weather report available before flight planning, during UAV flight those weather conditions identified before may lead to a new set of weather minimums when flight mission must be interrupted.

Weather clearances are defined mostly in regulations and standards. For conventional aircraft there are famous standards of [2,3,5]. Besides those regulations many textbooks provide information about weather clearances, mainly the turbulent air modeling is in the focus of attention to derive mathematical models acceptable for preliminary computer simulations [1,9,13]. There are two ways to model atmospheric turbulences. First is the so-called deterministic model given in [1,2,3,5,9,13], which are represented in Figure 1, Figure 2 and Figure 3, respectively.

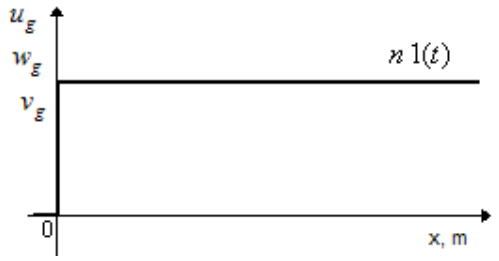

FIG. 1 Constant Air Speed.

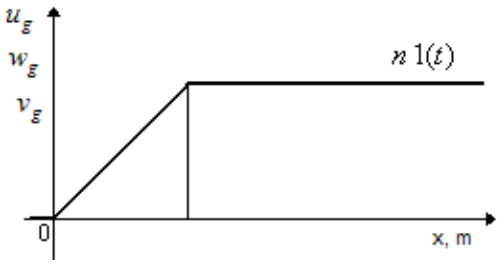

FIG. 2 Linear Gust Speed.

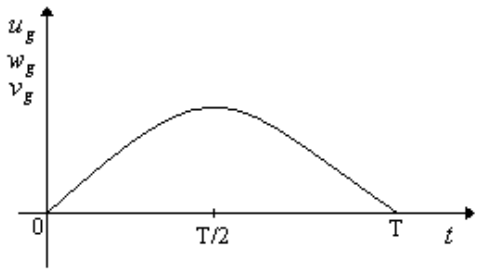

FIG. 3 (*1-COS*) GUST SPEED.

The second type of the atmospheric turbulence model is the random (stochastic) model of the turbulent air. Stochastic models of the turbulent air well-known and widely applied in aeronautical sciences, are the power spectral density (PSD) functions. Table 1 tabulates the most popular PSDs as defined in [1,2,3,5,8,9,13].

Table 1. PSD of the Air Turbulence Models

Model Name	PSD of the Air Turbulence Speed Components
Lumley–Panovsky Model	$\Phi_{vv}(\Omega) = \dfrac{1180\sigma_k^2}{c[(1+2950\Omega)^{2/3}]}$
Lappe–Model	$\Phi_{ii}(\Omega) = \delta_i^2 \dfrac{2\pi L}{(1+2\pi L\Omega)^2}$
The Model of the Royal Aeronautical Institute	$\Phi(\Omega) \approx K^{5/3} W_c$, *ha* $K > 0{,}5L$ $\Phi(\Omega) \approx K^{-1} W_c$, *ha* $K < 0{,}5L$
Lipman–Model	$\Phi_{vv}(\omega) = \dfrac{\sigma_\omega^2 L}{\pi U_o} \dfrac{2}{1+(\omega L/U_o)^2}$ $\Phi_{vv}(\omega) = \dfrac{\sigma_\omega^2 L}{\pi U_o} \dfrac{1+3(\omega L/U_o)^2}{1+\left[(\omega L/U_o)^2\right]^2}$
von Kármán–Model	$\Phi_{vv}(\Omega) = \dfrac{\sigma_\omega^2 L}{\pi} \dfrac{2}{\left\{1+(1{,}339L\Omega)^2\right\}^{3/5}}$ $\Phi(\Omega) = \dfrac{\sigma_w^2 L}{\pi} \dfrac{\left\{1+8/3(1{,}339L\Omega)^2\right\}}{\left\{1+(1{,}339L\Omega)^2\right\}^{11/6}}$
Dryden–Model	$\Phi_{uu}(\Omega) = \dfrac{2\sigma_u^2 L}{\pi} \dfrac{1}{1+(L\Omega)^2}$ $\Phi_{vv}(\Omega) = \dfrac{\sigma_v^2 L}{\pi} \dfrac{1+3(L\Omega)^2}{\left[1+(L\Omega)^2\right]^2}$ $\Phi_{ww}(\Omega) = \dfrac{\sigma_w^2 L}{\pi} \dfrac{1+3(L\Omega)^2}{\left[1+(L\Omega)^2\right]^2}$

The author published a paper dealing with atmospheric turbulences and generating time series of the wind speed components projected in the UAV body axis system using MATLAB [8].

If there are atmospheric turbulences and wind gusts having statistical parameters far out of that region of the weather clearances derived for the given class and given type of the UAV, an immediate emergency landing must be started and successfully executed ensuring safe UAV operations. The wind clearances are mostly defined for speed components of the atmospheric turbulences measured in the body-axis coordinate system of the UAV, and given by [1,2,3,5,9,13] as follows below:

$$u_g(t) \le u_g(t)_{crit};\ v_g(t) \le v_g(t)_{crit};\ w_g(t) \le w_g(t)_{crit}, \tag{4}$$

If there is any of those three inequalities defined by equation (4) is met, i.e.:

$$u_g(t) \ge u_g(t)_{crit}, \text{ or} \tag{5}$$

$$v_g(t) \ge v_g(t)_{crit}, \text{ or} \tag{6}$$

$$w_g(t) \ge w_g(t)_{crit}, \tag{7}$$

a safe UAV must start emergency landing maneuver. It is easy to understand that the above given problem is handled with the multiple criteria decision making (MCDM) able to handle simultaneous conditions formulated with inequalities defined by equations of (5)–(7).

3.4 Environmental Temperature. Temperature is an important weather condition for the given type of the UAV. Being designed to be robust one a UAV has the temperature range for normal flight scenarios such as:

$$T_{\min} \le T_{act} \le T_{\max}, \tag{8}$$

i.e. external temperature must lie between minimum and maximum values. UAV flights at lowest temperatures can threaten although with icing, or, with malfunctioning of the onboard electronics. UAV flights at highest temperatures can lead to worsening of the lift capabilities of the UAV. If there are temperatures out of the range allowed the UAV flight cannot be started, or, if there are so large changes during flights leading to extreme temperatures, the UAV must activate its emergency landing maneuver.

3.5 Onboard Computer and Sensor Hardware Malfunction. Onboard hardware serves for many purposes, and its functionality is no matter of question. To have reliable hardware system there are many methods, however, there is a unique one of building redundant systems.

It is easy to see that due to its complexity, due to increased sizes and weights, redundancy principle cannot be applied as the full-scale one for UAV onboard hardware of the micro-, mini or, for the small UAVs. For MALE and HALE UAV categories redundancy principle can be applied. Moreover, if UAV flies in non-segregated airspace, some UAV type worthiness and airworthiness requirements prescribe the redundancy principle as necessary design principle applied during conceptual design of the UAV.

Regarding general scheme of the UAV automatic flight control system described in [13] following crucial hardware elements are identified by the author:

1. onboard microcontroller (OMC);
2. INS unit;
3. GPS unit;
4. BLDC-controllers (BLDC-C);
5. sensorics (S).

The above listed hardware and their proper functioning is the crucial and key point of the safe UAV operations. The hardware must properly work simultaneously, in other words, if there is any of them is malfunctioning, the UAV is losing its airworthiness. The problem of the simultaneous functioning of the UAV hardware can be traced back to multiple criteria decision making problem (MCDM).

3.6 Losing Orientation (LO). The UAV flight executed in the environment with pure visibility, bad weather conditions, the busy airspace in which UAV flight happens can lead to the situation when UAV operator, in spite of being well-trained, well-prepared, disciplined and ready-to-flight can get in more complex flight situation leading to loose of coordinates and orientation of the UAV partially or totally. It is easy to understand that if it happens firstly the UAV must identify such conditions. If UAV identifies an LO, then the 'Hold' regime of the automatic flight control system of the UAV must be activated, if it is available onboard, i.e. the UAV must level itself at constant speed, and at constant altitude If the identified LO is a static one, in other words, the UAV remains in that uncontrolled flight operation for the time of $\Delta T \geq T_{crit}$, after the 'Hold' regime of the automatic flight control system of the UAV, the RtH mode must be activated after the no-return-point.

4. MULTIPLE CRITERIA DECISION MAKING APPLIED FOR UAV EMERGENCY LANDING SYSTEM

The scenarios described in the foregoing sections can be evaluated very effectively if to take into consideration that there are two types of the abnormal flight modes, namely, the Return-to-Home mode, and Emergency/forced landing modes are being examined after.

4.1 Activating 'RtH' Mode. Regarding segmented flight scenarios described above the activation of the RtH mode of the UAV is crucial via following logical rules for:

if $\Delta T \geq t_{crit}$, or (9)

$\Delta T \geq T_{crit}$, then activate 'RtH' mode. (10)

The RtH Mode means: finding direct heading angle to the landing zone with simultaneous stabilization of the altitude, and speed of the UAV.

4.2 Activating 'Forced Landing' (FL) Mode. Regarding segmented flight scenarios described above for the single-engined UAV the activation of the 'FL' mode must be activated if and only if: $n \leq n_{\min}$. The FL Mode means to land UAV in safe way with finding proper landing zone ensuring minimization of the losses caused by the UAV itself. The landing zone selection is mainly based upon onboard vision system.

4.3 Activating 'Emergency Landing' (EL) Mode. Regarding possible flight scenarios of the UAV activation of the 'EF' mode can be activated if and only if following set of logical conditions is met:

if $u_g(t) \geq u_g(t)_{crit}$, or, (11)

if $v_g(t) \geq v_g(t)_{crit}$, or, (12)

if $w_g(t) \geq w_g(t)_{crit}$, or, (13)

if $T_{\min} \leq T_{act} \leq T_{\max}$, or (14)

if OMC fails, or (15)

if INS fails, or (16)

if GPS fails, or (17)

if BLDC-C fails, or (18)

if S fails, (19)

then activate 'EL' Mode.

It is evident that if there is a single condition of the system of equation (11)–(19) met the automatic flight control system of the UAV, if there is any applied, must activate the 'EL' Mode to land UAV in the non-hazardous landing site selected via minimization of the possible losses caused by the UAV itself.

5. CONCLUSIONS AND FUTURE WORK

This paper addresses the UAV emergency landing concept. The existing solutions for UAV safe landing are very initial ones, dealing with the simplest flight scenarios, i.e. loss of thrust of the UAV, when forced landing of the UAV is activated. Besides of those failures of the engine(s) leading to the loss of thrust many threatening factors has been identified. There are three different modes of the automatic flight control system of the UAV are segmented. First one is the Return-to-Home Mode, and, logical conditions for activating RtH Mode were derived. A new principle is introduced here: the loss of orientation must be taken account when finding logical conditions for the RtH Mode.

Second mode fully and strongly connected to engine(s) failures leading loss of the thrust force. Failures can happen due to any reasons, i.e. due to failures in fuel system, in motor control system, or, due to icing of the rotor blades and leading edges of the wings.

The emergency landing is activated in case of any logical conditions met derived by equations (11)–(19).

The future work of the author in that field is devoted to application of the Fuzzy MCDM approach to take right decision in case of emergency situation, and ensure safe landing of the UAV with minimization of the losses caused by the UAV itself.

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THE ANALYSIS OF THE LAW MAKING PROCESS IN THE TRANSPORT OF DANGEROUS MATERIALS

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Abstract *The risks associated with the transport of dangerous goods by air have constituted a tremendous problem since the beginning of the activity connected with the transport of chemicals, radioactive substances and biological agents. In a situation of an increased mass of transported dangerous materials, it was necessary to develop international regulations in order to simplify the shipment of dangerous cargo between countries. International organizations responsible for air transport, as far as the middle of the previous century, introduced and updated provisions, whose aim was to organize safe carriage of dangerous substances and goods.The authors of this article attempt to make an analysis of the law-making process in the transport of dangerous goods and on its basis make an assessment of the undertaken actions.*

Key words: *Air transport, dangerous materials, ICAO, IATA, IAEA, CFR.*

1. INTRODUCTION

The transport of dangerous materials constitutes a specific segment of the undertakings related to the carriage of the whole range of cargo. This is due to an enormous risk for human health and life as well as the natural environment, which may arise as a result of an unfortunate incident during the transportation of chemicals, radioactive substances or biological infectious agents. The risks associated with the carriage of materials, posing such a huge threat, is the subject of ongoing analyses, research and legislative work aimed at the development of standards and recommended procedures for dealing with hazard substances and goods. The issue of threats posed by the transport of dangerous goods is dealt with by a large number of specialized national and international institutions. As a result of decades of work over the creation of possibly optimal arrangements with regard to the handling of dangerous substances and goods, new instructions, codes and regulations have successively been introduced. Very often revising the existing legislation was caused by tragic events that occurred during the carriage of dangerous materials.

Therefore, despite the fact that a number of procedures, published articles and books are legally binding, the process of making regulations for the transportation of hazard materials is not and will not be completed. Therefore, it is becoming extremely crucial to investigate the actions undertaken to improve transport safety of the materials endangering human life. The authors of this publication have attempted to demonstrate, on the basis of an analysis of implementing the legal regulations by international institutions engaged in the air transport of dangerous materials, its effectiveness and timeliness of the introduced solutions. The concept of timeliness shall be understood that the regulations have not been implemented too late in relation to the existing risks and measures adopted in other means of transport.

In the course of the analysis of the available literature and legal materials, particular emphasis has been on the issues of cooperation among particular institutions and results achieved in this way in the form of developed transportation regulations. An important asset of the conducted literature examinations is also a reference to the issue of the definition of dangerous materials. In the interpretation, on the one hand of varied approaches to the concept of "dangerous materials", and on the other hand of rendering the essence of the analyzed issue, has allowed a better understanding of the issues presented in this article.

2. THE ESSENCE OF DANGEROUS MATERIALS

The developed scientific publications and the binding legal norms contain a large number of phrases specifying the risks which arise from the air transport of dangerous goods. According to the authors, the created definitions were to facilitate a better understanding of the discussed problems, although quite often their contents tackles the expressions in a different way. In order to demonstrate the existing differences, the authors presented the definitions of dangerous materials, which particularly highlight the existing diversity in this matter.

The most common definition is the one that is included in the Technical Instructions for the Safe Transport of Dangerous Goods by Air (ICAO) that defines dangerous goods as: "*Articles or materials capable of posing significant risk to people, health, property, or environment, and which are listed in the dangerous goods in these Instructions or that have been classified in accordance with these instructions*" [13].

While characterizing the issue of clarifying the concept of dangerous materials, special attention should be drawn to the way it is interpreted by the US Department of Transportation (United States Department of Transportation - DOT) [15]. It is important to take this institution into consideration in the transport of dangerous materials for two reasons: Firstly, the market for the transport of dangerous materials in the USA is currently - in terms of size - the largest and thus the most developed one in the world. The second reason is associated with source materials, i.e. which regulations introduced by the DOT underlined the provisions created by the International Air Transport Association (IATA) and the International Civil Aviation Organisation (ICAO). In the definition developed by the US Department of Transportation and included in 49 Code of Federal Regulations (49 CFR), hazardous materials are: *"Substances or materials that may pose undue risk to health, safety or property during transport in commerce"* [15].

In the subject literature it is possible to find also other definitions of hazardous materials that are worth quoting, due to their slightly different approach to the issue at stake. For instance, W.G. Watters, in his publication „*Transportation of Hazard Goods and Materials, Handbook of Transport and the Environment*", presents dangerous materials in a very general way, specifying the core of the mentioned substances and goods. He claims that: "Hazardous materials are various types of materials and substances which may be marked as dangerous for several reasons" [10]. A more precise definition of hazardous materials, representing both the practical approach to the risks inherent in transport, was concluded in *Podręcznik Spedytora.*

Hazardous materials mentioned in this publication are referred to as [9]: *"Substances and goods which, because of their physical, chemical or biological properties, in case of improper handling during transport or cargo handling operations, may cause damage to the human body, health disorder, death, damage or destruction of tangible property, as well as contamination of the natural environment. From a legal point of view, dangerous goods are those materials and objects, whose carriage, in accordance with the binding regulations, is either prohibited or authorised only under the conditions specified in these regulations"* [16].

Despite the indication of existing differences in defining dangerous materials, there are also noticeable important similarities, which derive from the general characteristics of these substances. They mostly concern harmful effects on living organisms and the need for special conditions of their carriage. For this reason, the introduced legislation must cover all means of transport (land, water and air), which deal with the transport of cargo, and which constitute a threat to people and the natural environment. The safety of transport of dangerous materials must be based on the regulations that will become the basis of the activity of domestic and international carriers. In order to adapt the transport provisions to the needs of environmental transport (water, air, land) and at the same time, unify the existing regulations as much as possible, the international transport organisations have developed and implemented a number of provisions which take into account also the intermodal transport. The existing documents, depending on the modes of transport – include [2]:

a) Road Transport (ADR) - European agreement concerning the international carriage of dangerous goods by road.

b) Rail Transport (RID) - terms and conditions for the international carriage of dangerous goods by rail.

c) Maritime Transport (IMDG-Code) - international code for the carriage of dangerous goods in a packaged form.

d) Air Transport (IATA-DGR) - agreement specified by the International Association of Air Transport - the rules relating to hazardous goods.

Among the above-mentioned regulations, containing the norms and procedures for the safe transport of dangerous goods, the main principle is to attempt to develop common procedures for the carriage of dangerous goods for all modes of transport. The unification of norms and recommended practices, with regard to the existing capabilities, improves safety of carriage and allows the development of intermodal transport of hazardous materials carried by air, land, inland waterways and sea.

Among the mentioned means of transport, air services currently constitute one of the fastest growing capabilities of carrying people and goods. The constantly falling drop in the cost of air carriage, causes a rapid growth in weight and the range of goods carried by air. Air transport is constantly progressing although it is realized in conditions which are incomparably more difficult than those existing in land and water transport. Currently the largest existing restrictions on air transport are conditions connected with oversized loads and the ones which exceed the aircraft payload.

The primary factors hindering safe air transport are also pressure differences related to changes in altitude, big temperature differences between the inside of the aircraft and its surroundings, occurring mainly at high cruising altitudes. By analyzing the emerging hazards, one should also take into account weather conditions, which pose a significant threat, particularly during take-off and landing of aircraft [7].

The above-mentioned risks, related to the execution of flights in airspace, grow even further in the transport of hazardous materials. In case of the substances where physical, chemical or biological properties pose a threat to human life and health as well as the natural environment, it is possible to create favorable conditions for uncontrolled leaking into the environment. During the carriage of dangerous materials, there are circumstances posing a threat of unsealing of packaging used for the transport of chemical, biological or radioactive substances. Transportation errors (human factor), air incidents or terrorist activities may lead to unsealing transported single units or cargo containers.

Dangerous materials can be safely transported by air provided there are implemented and then enforced very strict transport procedures. The primary objective of creating procedures is to facilitate the transport of hazardous materials, while ensuring the level of security at which the risk of events, entailing a threat to the aircraft or its passengers, is reduced. However, in the event of unforeseen incidents involving dangerous materials, the existing procedures must prevent or minimize the size of possible disasters [13].

Therefore, dangerous materials or goods and substances that may pose risk to humans, animals, means of transport and any other components involved in the process of transport, that is, from the moment of their forwarding by the sender for delivery to the recipient, should have such conditions designed so as to safeguard their safe transport. The International Civil Aviation Convention, established in Chicago, December 5, 1944 [8], and in force as amended to date, does not contain any detailed formulations concerning the transportation of hazardous materials. However, it advises actions aimed at improving air safety [14]. On its basis, a number of documents that govern the carriage of substances dangerous for people and their environment were drawn, the most important one being Annex 18 to the Convention and the linked technical instructions for the Safe Transport of Dangerous Goods by Air. It should be noted that the carriage of dangerous goods is regulated by IATA Dangerous Goods Regulations, which are the interpretation of the provisions drawn up by the Committee of Experts of the ICAO (International Civil Aviation Organization) [3].

3. THE PROCESS OF CREATING THE REGULATORY FRAMEWORK IN THE TRANSPORT OF CHEMICAL AND BIOLOGICAL MATERIALS

Due to the constantly increasing air transport, resulting from the introduced international trade facilitations, after World War Two, there also increased air transport of hazardous materials. The growing number of chemical and biological substances, carried by air, with a simultaneous lack of regulations or the existence of inaccurate, complicated regulations, for instance in terms of the strength of the packaging, forced international organizations to take action to change the current status. The International Air Transport Association (IATA) [19], as early as in the 1950s took action aimed at establishing an international regulation with regard to the principles of transporting hazardous materials.

The research which was then conducted proved that only a few countries in the world had regulations regarding the carriage of dangerous substances, which could be used to develop international regulations. In considering the solutions that were possible to adapt, it was found that the United States had the most detailed provisions that had previously been developed for the carriage of dangerous goods by rail, and which later became adapted for the sake of American civil aviation [1].

The first regulations, resolving the issue of air transport of hazardous materials (Restricted Articles Regulations), were published in the year 1956. The solutions largely based on the transport regulations already in force in the USA, made by the United States Department of Transportation (DOT). It should be noted that the adopted provisions were restricted in numerous cases.

It involved the introduction of double or even triple packagings for chemical and biological materials in order to protect them from pressure changes and vibrations, occurring in air transport. Further changes to the existing legislation concerning the packaging of dangerous substances being transported, were already introduced in the 1960's. The International Air Transport Association also took steps to adopt the developed legislation (Restricted Articles Regulation) by the legislation of the IATA member states. The aim of internationalizing the developed provisions was to introduce them to the applicable national legislation, which in turn would create conditions for issuing permits for the carriage of dangerous substances by domestic and foreign carriers to or through the territory of particular countries [1].

A later increase in the mass of chemical and biological materials transported by air, involved the incorporation of the UN institution i.e. the International Civil Aviation Organization (ICAO) into the standardization of regulations [6]. The 1970s faced expectations as for the introduction of the regulations concerning the carriage of dangerous goods by air, which would cover all ICAO member states. The event which accelerated the inclusion of the International Civil Aviation Organization in the development of international arrangements, was the disaster of the Boeing 707-321C airline of the Pan American World Airways. It became apparent that there is a general lack of compliance procedures, normalizing the transport of hazardous materials. The occurred disaster resulted from the complexity of the existing legislation, on the other hand, however, it was caused by the general lack of knowledge of the applicable regulations and imperfections of supervision in their practical applications.

In order to enhance the provisions, in 1976 ICAO established a group of experts, which included the representatives of the International Air Transport Association (IATA) and the representatives of the IATA member states. The result of the five-year work of the Dangerous Goods Panel (DGP), was another 18 Annex to the Chicago Convention on the International Civil Aviation, bearing the name "*Safe transport of dangerous goods by air*". The encosed document to Annex 18 of the Convention, was "*Technical instructions for the safe transport of dangerous goods by air* (Doc 9284)". The Technical Instructions were developed as a legislation extending the basic provisions of Annex 18, and contained detailed solutions necessary to organize safe transport of dangerous goods by air [13].

The provisions included in Annex 18, in order to facilitate the achievement of the compatibility with the rules governing the transport of dangerous goods by other modes of transport (1), were based on the recommendations of the subcommittee - United Nations Committee of Experts on the Transport of Dangerous Goods as well as the provisions of the International Atomic Energy Agency (IAEA) relating to the Safe Transport of Radioactive Material [1].

The requirements governing the legal transportation of hazardous materials, of all ICAO member states, see Annex 18, and the linked Technical Instructions, were formally adopted by the Council of ICAO, at the beginning of the 1980s. The provisions of the ICAO Technical Instructions came into force in 1 January 1983, but their use was not mandatory. The first official release of the Technical Instructions for the safe transport of dangerous goods by air appeared in 1984 and since then it has been binding as legal regulations in the airline industry. The International Air Transport Association (IATA) consistently adjusted the binding regulations to the ones created by ICAO. In 1983 it changed the insofar used term - restricted articles - for dangerous goods. In the same year, IATA made significant changes in the regulations of its members, adapting them to the requirements of ICAO [1].

Adjusting the regulations of the International Air Transport Association (IATA) to the provisions in force in ICAO Technical Instructions does not mean the total abandonment of the provisions created by IATA. The binding IATA Dangerous Goods Regulations (DGR), which refer to air carriers, are called the "field manual" of the ICAO Technical Instructions. Despite the common regulatory basis, there are small differences between the rules applied by the International Air Transport Association and the International Civil Aviation Organization. It is written and revised by experts dealing with air transport of dangerous goods. It contains the requirements necessary for the shipment of dangerous goods by air in a way which is friendly to the user and easy to interpret. DGR also contains additional information that can help carriers in the preparation of consignments, in accordance with the requirements accepted by airlines. IATA-associated carriers have slightly more rigorous procedures set by the ICAO Technical Instructions [20].

The implementation of the ICAO Technical Instructions ICAO in use did not complete the process of procedural changes in the transport of dangerous materials. The increasing size of transport of chemical and biological substances, as well as the changing technological conditions, of both aircraft and goods, which serve to ensure safety during transport, enforce continuous updating of the existing legislation. The International Organization of Civil Aviation Transport has developed two-year periods of implementing changes in Annex 18 to the Civil Aviation Convention.

4. THE IMPLEMENTATION OF THE REGULATIONS ON THE SAFETY OF TRANSPORT OF RADIOACTIVE MATERIAL

Radioactive materials, similarly to the earlier discussed chemical substances and biological agents, are subject to the carriage by various modes of transport, around the world. Among the radioactive material carried by air, the majority of substances serve medical purposes. The use of aviation for a substantial part of the transport of radioactive medical materials is confirmed by Alicja Pieńkowska, an employee of the Office of Cargo and Mail in the Polish Airlines LOT S.A.

In the article entitled *Przewozy lotnicze ateriałów radioaktywnych (Air transport of radioactive material),* she claims that: "The majority of airlifted radioactive material serve medical purposes. *(...) Due to medical reasons, useful isotopes have quite a short life, which creates the need to arrange an efficient and fast transport over distances exceeding one thousand kilometers. Without air transport it is difficult to imagine the ability to carry, in a matter of several hours, an isotope from Warsaw to any Europe's capital." [4].*

The rise of the significance of radioactive material, used not only in medicine but also in industry, agriculture and science in the 1950s of the 20th century, resulted in the need to develop international procedures for the transport of these substances. The first provisions introduced by the International Air Transport Association, as in the case of transport rules for chemical and biological materials, were adapted from the regulations already in force in the United States Department of Transportation (DOT), which were used in rail transport, and then in the Civil Aviation of the United States [1].

The international regulations on the transport of radioactive material have been effective since June 1, 1958. They enabled transport of more radioactive sources with higher radioactivity in relation to the rules applicable in the United States. They also introduce new solutions for the packaging of radioactive shipments, whose structural strength to the risk of damage during a crash or a fire had to be certified. It is the certification of packages, particularly with regard to the transport of materials with heightened activity or radioactive concentration which allowed their automatic acceptance by individual members of the International Organization of Civil Aviation Transport.
At the beginning of the sixties, IATA jointly with the International Atomic Energy Agency (IAEA) conducted research aimed at the unification of norms and procedures for the safe transport of radioactive material in all modes of transport. This involved with the ever-increasing demand for radioactive material, and thus the growing transport. The rapid growth in the transport of these materials caused a large number of technical and organizational problems. The outcome of the research was the preparation and issuing, in 1961, for the first time, the Rules of Safe Transport of Radioactive Material [12].

Parallel to the development of the Rules on the Safe Transport of Radioactive Material, IATA, IAEA and the representatives of the main countries that manufacture or use radioactive material conducted research aimed at specifying uniform transport requirements in air transport. The final effect of the work over the IATA Regulations on Radioactive Material was the publication of the IATA Restricted Articles Regulations in October 1, 1967. The rules implemented by the International Air Transport Association (IATA), took into account the transportation regulations of the International Atomic Energy Agency (IAEA). The introduced provisions were periodically updated in order to implement the latest solutions in the area of safety, technology of applied packages and the rules for the transport of radioactive material [11].

Another achievement of the IAEA for improving the safety of transport of radioactive material was Regulations of the International Atomic Energy Agency on the safe transport of radioactive material (TS-R-1). The Regulations published in 1996 replaced the previously binding provisions Safety Series No. 6 (SS6) in 1985. However, the introduction of new regulations did not occur without obstacles. The greatest problems arose in the large changes introduced by TS-R-1. They concerned e.g. the definition of radioactive material, annual limits of absorbed doses, requirements concerning fissile materials, changes in UN shipment numbers and the rules for the transport of nuclear material by air [1].

The initially adopted date of 1 January 2001 for the introduction by member states of the International Atomic Energy Agency Regulations on the Safe Transport of radioactive material (TS-R-1) very quickly proved to be unrealistic. As a result of the emerging concerns, a new date of the implementation of the Regulations was set for 1 July 2001. Only the regulations for the International Civil Aviation Organisation (safety regulations for air transport) were introduced, despite an extended deadline. However, in road transport (ADR), rail transport (RID) and maritime transport (IMDG), a transitional period was fixed during which the TS-R-1 and Safety Series No.6 (SS6) remained in effect [2].

The success linked with an introduction of changes in air transport of radioactive material involved facilitations contained in the Regulations of the International Atomic Energy Agency on the Safe Transport of Radioactive Material (TS-R-1). In the autumn of 2000, IATA published a special edition of the *Technical Instructions for the Safe Transport of Dangerous Goods by Air 2001 (42nd DGR),* which contained both the existing rules SS6, remaining in force until 30 June 2001, and the new TS-R-1, which came in force on 1 July 2001. The double version of the Regulations informed of the extent of the new changes, such as: constructors of packages, the senders and recipients of radioactive cargo. It also simplified training, particularly of emergency services [1]. It should be noted that the current international regulations, relating to the safe transport of radioactive material TS-R-1, are implemented directly into national legislation (e.g. the Code of Federal Regulations - CFR in the United States). They also form the foundation for the created international rules (ICAO Technical Instructions, ADR, RID, ADN, IMDG Code), which relate to the transport of dangerous goods of class 7 [18].

The provisions concerning the transport of radioactive material by air, similar to the rules on the transport of chemical and biological substances - are periodically updated by a group of ICAO experts. They are made by periodical meetings within the works of the ICAO Dangerous Goods Panel. The result of the work carried out are the issues, made in two-year periods, of new versions of Technical Instructions. In the framework of the meetings, experts review the comments and proposals submitted by the ICAO member states as well as international organizations involved in the transport of dangerous materials. The updates of carriage rules do not concern - as proved earlier - only the carriage of radioactive material, but include transport of all hazardous materials. In addition, they assume the possibility of the best unification of the introduced regulations in all modes of transport. For this reason, the changes approved by the ICAO Dangerous Goods are recommended not only to the International Atomic Energy Agency (IAEA), but also to the United Nations Committee of Experts on the Transport of Dangerous Goods.

5. CONCLUSION

The conditionings, presented in this article, concerning the process of implementing the rules on dangerous goods transport, have been discussed according to the division into chemical and biological materials as well as radioactive substances. It is related to the specific properties of these materials and essential cooperation with the International Atomic Energy Agency (IAEA) in the creation of provisions for the transport of radioactive substances. It should be noted that despite the varied processes of developing and implementing the regulations for the transport of chemical and biological materials as well as radioactive substances, they have been included jointly in the Technical Instructions of the ICAO and are referred to under one common name of dangerous materials, in the publication.

Another issue that needs to be emphasized is the duration for the introduction of arrangements in the air transport of dangerous materials. The implementation of the current regulations, in particular types of means of transport, was made over a large time span. For example:

1. European Agreement concerning the International Carriage of Dangerous Goods by Road
2. European Agreement concerning the International Carriage of Dangerous Goods by Rail - implemented in 1980.
3. Technical Instruction of the International Civil Aviation Organization (ICAO) - implemented in 1984.
4. European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways - implemented in 2000.

It should be noted that the implementation of the regulations in the first half of the eighties should not be considered too late, at least in relation to other modes of transport. Although the European Agreement concerning the international carriage of dangerous goods by road (ADR) was introduced already in the year 1957, the first settlements in the transport of dangerous materials (e.g. Restricted Articles Regulations) appeared in a similar time. Another issue is the efficiency, timeliness and revision of the applied procedural solutions. The process of making constant changes in the binding procedures, points to the variable environment linked with the transport of dangerous goods, and not low efficiency of the existing regulations.
The examples presented in this article demonstrate that significant changes have frequently been made because of the occurring accidents. This does not prove, however, the late response of institutions involved in making law for the requests of carriers, and above all, intricacies of the existing regulations, as well as the low level of their enforcement.

An important conclusion therefore made based on the conducted analysis of the process of creating a regulatory framework in the transport of dangerous materials is the existing cooperation between users and institutions implementing their regulations. The development of e.g. common rules for the transport of dangerous materials, for all means of transport, resulted in a significant improvement in safety. Special attention needs to be drawn to the works over the creation of regulations in the transport of intermodal dangerous materials, i.e. those that combine carriage by air, land or sea. However, the development of uniform rules is not possible. In some cases, especially in air transport, it was necessary to introduce additional requirements and restrictions, directly related to the specific conditions prevailing in air transport.

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ASPECTS REGARDING ANTIAIRCRAFT FIRING EFFECTIVENESS

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Abstract: *The threat to state security world is a very topical subject which is in constant evolution . Of the many factors that directly influence this development. I believe that the most significant are the global security destabilizing threat related to emphasizing regional crises, the importance of tactical ballistic missile, air -to-surface missile, antiradar missile, cruise missiles, and unmanned aerial vehicles. Evolution launch procedures ammunition by modern means of air attack and the aerial threat against land targets, involves the Air Defence systems improvement.*

Keywords: *Integrated Air Defence system shoot kill probability decisive criteria*

1. INTRODUCTION

The Integrated Air Defence systems will be strong requested by the air density and timing enemy attacks. Air opponent will use massive and diverse means specific electronic warfare in order to neutralize in the first stage, radar and communication systems ground based.

In this context, the factors, requirements and operational concepts of an integrated Air Defense system are very complicated. The most important objective will be to achieve the "Near Zero Leak" level (any area uncovered) for objective protection. This level of protection is best guaranteed by a mixed Air Defence system composed of Surface - to-Air Missiles (SAM) and Antiaircraft Artillery (A.A.A.).

The SA -7 SAM system falls into the category of short-range infrared homing without cooling photosensitive element, intended to destroy the air targets that fly at small altitude, handled by one person. Thus, in the Land Forces, A- 94 missiles are launched by the CA- 94 complexes.

The SA -9 SAM system is also part of the short-range infrared homing. This self propelled type is designed for mobile Air Defence units of the Army. The system is intended for the destruction of planes and helicopters flying at low altitudes through direct sighting . CA-9 5 is the local version of the Soviet system STRELA -1. Instead armored car BRDM -2 has been used ABC-79M vehicle, manufactured by the local arms industry. Antiaircraft modernized variant of this system, currently in the Romanian Army is called CA - 95 M.

The SA - 6 SAM system „KUB", belongs to the SHORAD category, to defend troops and objectives against aerial threats that fly at low and medium altitudes with subsonic / supersonic speed.

The SAM medium-range HAWK (Homing All the Way Killer) is capable of destroying maneuvering aerial targets with high speed and helicopters that fly at low and medium altitudes. Originally the system has passed through three stages of modernization ending with HAWK XXI type . By adding external facility " tail chase " it has gained the capability to engage the Tactical Ballistic Missile (TBM).

Aerial vectors have a streamlined arrow aerodynamic configuration with delta wings and rudders, rectangular ailerons. Homing heads are equipped with phased array antennas networks conducted in numerical processing technologies. A primary objective is the integration of specific equipment HAWK PIP III with 3D cameras, SENTINEL type and distribution centers (control) fire (FDC).

The SA - 2 SAM system „VOLHOV" fall in the medium -range and is designed to combat aircraft, wings missile, automatic gas balloons drift, and other types of aerial targets in all weather conditions, time and season. In some cases, it may be used for the destruction of land or surface of water targets. The system entered the service in 1964 and underwent three successive modernizations, until the 80s . The system is equipped with own radar for searching airspace, conjugated to a radio altimeter and radar to guide the missile by radio commands . In the presence of jamming, the missile guidance to the target can be done visually, using a television system.

The Automatic Anti-aircraft gun S-60) is a road-transportable, short-range, single-barrel system. The gun is intended to destroy the different kind of targets that fly at low altitude (4800–6000 m) and land or surface of water targets up to a 2500 m distance.

The 30 and 35 mm size Anti-aircraft guns are weapons designed to attack aircraft. Such weapons commonly have a high rate of fire and are able to fire shells designed to damage aircraft. They also are capable of firing at high angles, but are also usually able to hit ground targets as well in a direct fire role.

2. DECISIVE CRITERIA OF AIR DEFENCE INTEGRATED SYSTEMS

For a decision to extend the resource, revitalization and modernization of air defense systems are commonly applicable to the following criteria :

- system performances;
- requirements for interoperability with NATO similar systems;
- the used technology;
- financial resource.

2.1 The performance criteria are a defining element to make the life extending decision of the Air Defense systems. The ability of these systems to carry out its mission successfully is determined by the following technical and tactical characteristics:

– single shoot kill probability;
– the rate of fire;
– the maximum and minimum altitude;
– the targets speed;
– the different kind of targets;
– the number of targets tackled simultaneously;
- the number of concentrated shooting against one target;
– the efficiency range;
– reaction time;
– the deployment.

Part of decisive performances are presented in table 1 for missiles systems and in table 2 for cannons.

Table 1 – The technical and operational performances of missile systems

System/measure units	VSHORAD		SHORAD	MRAD		
	SA-7	SA-9	SA- 8	SA- 6	HAWK	SA -2
Max altitude (Hm.)	23	23	50	140	≈ 25	300
Range (km.)	5	5	10	18	30	50
Missile weight (Kg.)	≈ 10	≈ 30	≈ 130	≈ 630	≈ 640	≈ 2400
Missile speed (mps)	500	500	550	950	800	759-800
Guidance	Self propelled IR		Radio command	Self propelled semi-active terminal homing		Radio command
Warhead weight (Kg.)	≈ 0,4	1	6,5	30	74	≈ 200
Single Shoot Kill Probability (SSKP)	≈ 0,3	≈ 0,4	≈ 0,8	≈ 0,8	≈ 0,6	≈ 0,7
Life cycle (years)	≈ 10	≈ 10	≈15	≈ 20	≈ 12	≈ 25

Table 2 – The technical and operational performances of artillery systems

System/measure units	VSHORAD		
	2 x 30 mm.	2 x 35 mm	S-60
Max altitude (Hm.)	30	35	50
Effective range (Km.)	≈ 3,5	≈ 4,2	≈ 6
Rate of fire (rounds/min.)	500 - 1000	1100	50 – 60
Velocity speed (mps)	1050	1175	1000
Single Shoot Kill Probability (SSKP)	≈ 0,0023	≈ 0,0023	0,0032

2.2 The requirements for interoperability with NATO similar systems. As a result Romania's accession to NATO, the ex-Soviet systems had some incompatibility with similar NATO ones (especially on the command and control area). Consequently the romanian modernization systems became priority to achieve interoperability with similar systems within the Alliance. Command and control outside the unique scope and will integrate in decision-making levels electronic assisted and complex expertised. These levels could be:

- political decision;
- military decision;
- the feed-back.
- execution;
- the operation leadership;
- the raising of defects rate.

2.3 Financial resources. Like any technical system the Air Defense ones have a limited technical resource (usually of the order of 10 to 30 years depending on the type of technique). With the passage of time the systems become older from physically and morally point of view. The end of systems operational life is usually accompanied by the following symptoms:

- the depreciation of special rocket fuels and powders in their shipments.
- depletion of stocks and accessories and the impossibility of renewing their (there is no equivalent on the market due to the age of technological parts).

2.4 The used technology. A more economical alternative than purchasing new systems is the upgrading the old ones, (by maintaining main equipment that were not affected by age system and replacing aging equipments). This process is performed mainly by replacing electronic components, communications/ IT, technologically obsolete. The up-grade decision is influenced heavily by a number of capabilities available to the recipient at a time, such as:

- the existence and functioning of a military group program management;
- the existence of a scientific panel of the policy areas;
- existence of industrial facilities for: machining; rockets engines loading / testing; load/ testing components of combat; assembly/ ground testing for missiles; antiaircraft firing range; electro-mechanical assemblies; replacement/ repair car equipment;
- availability of trained crews capable to signal some weaknesses;
- existence of tactics consultants to steer the program to the specific requirements of troops or imposed conditions on the ground.

3. SHOOT KILL PROBABILITY (SKP)

The possibilities of destruction are expressed by the number of destroyed or damaged air assets , from the total countered targets during an air attack carried out by the enemy (in a given period of time) and depend on:

- number of basic drawing subunits that compose fire system;
- the technical and tactical combat characteristics of equipment from the endowment subunits (rate of fire, effective shooting range, single shoot kill probability (SSKP);
- mission period of time;
- characteristics and vulnerability of air assets;
- action mode of aerial enemy;

For Antiaircraft Artillery the kill probability depend on the number of shooting projectiles against the target and SSKP. The SKP will be calculate tacking into account the formula:

$$P_{N(D)/A} = 1 - e^{-N \cdot P_1} \tag{1}$$

where:

$P_{N(D)/A}$ - probability of destruction of the aerial target using ,,n" projectiles (SKP);
P_1 - probability of annihilation (destruction) aerial target with one projectile (SSKP) ;
N - number of strokes executed ;
e - 2.71828.

It is considered that a target will be destroyed or damaged, if performed felling probability ($P_{N(D)/A}$) equal to 0,8 (done safety drawing).

For Surface - to- Air Missiles the kill probability depend on the number of launched missiles against the target and single shoot kill probability SSKP. The SKP will be calculate using the formula:

$$P_{N(D)/R} = 1 - \prod_{i=1}^{N} (1 - P_1) \tag{2}$$

where:

$P_{N(D}$ - probability of destruction of the target aerial using „n" missiles (SKP);

P_1 - probability of destruction with one missile (SSKP);

N - the number of antiaircraft missiles. [2]

Using integrated systems against aerial threats by distribution of fire SKP will be calculate using the formula :

$$P(R \bigcup T) = P(R) + P(T) - P(R \bigcap T) \tag{3}$$

For the same case but using concentrated fire against aerial threats SKP will be calculate using the formula:

$$P(R \bigcap T) = P(R) * P(T) \tag{4}$$

Increasing the number of projectiles the SKP will increase as followed:

Using the relation (1) for different number of projectiles SKP will have the values:

$P_{50} = 0,147$

$P_{100} = 0,273$

$P_{150} = 0,380$

$P_{550} = 0,827$

From theoretical point of view, using the S- 60 system the target will be destroyed by shooting 550 projectiles.

The kill probability of SAM system that launch two and three missiles against the target will be:

$P_2 = 0,91$

$P_3 = 0,97$

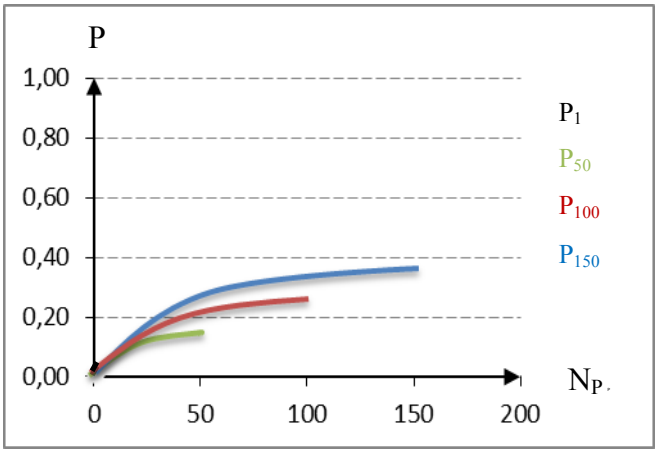
Using three missiles against the aerial threats, SKP will have the maximum value

Using integrated systems against aerial threats SKP will have the value between 0,78 and 0,98. The kill probability of integrated systems using 100 projectiles and one, two and three missile will be:

$P_{100/1} = 0,782$

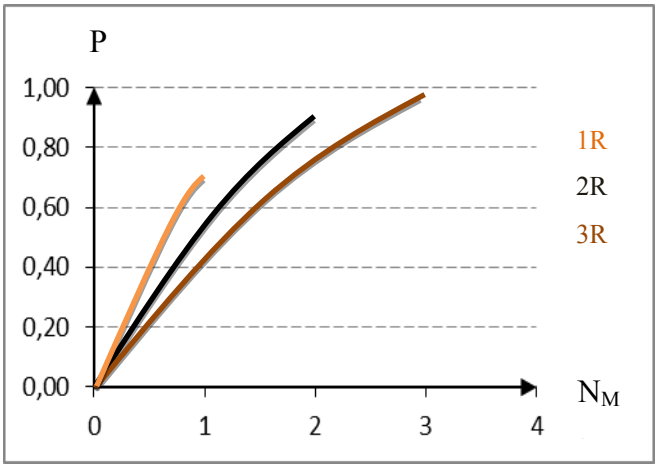
$P_{100/2} = 0,935$

$P_{100/3} = 0,978$



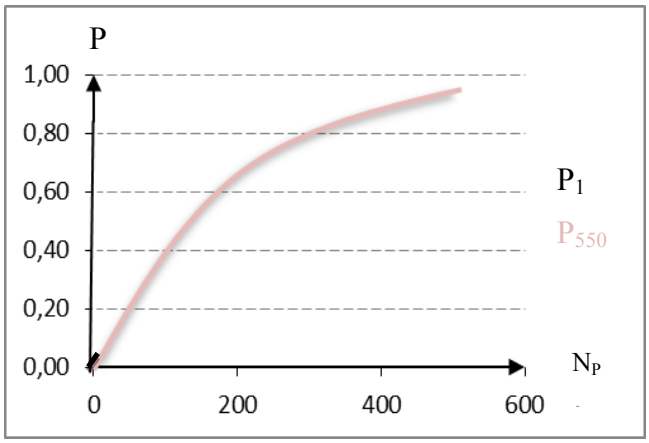
(a) (b)

FIG. 1. Comparative Gun shoot kill probability depending on number of projectiles case (a), using the S - 60 system (b)



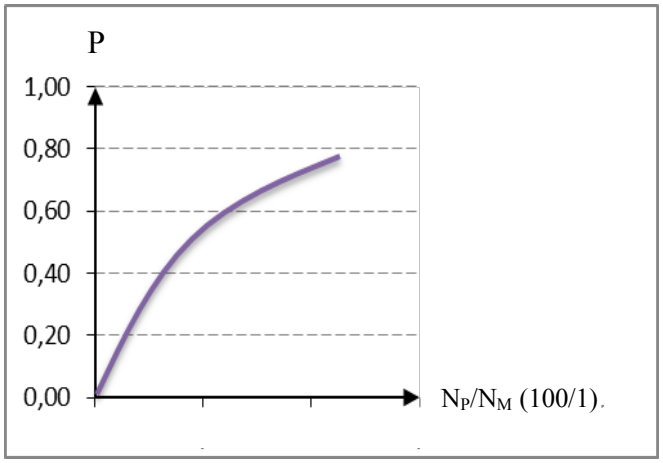
(a) (b)

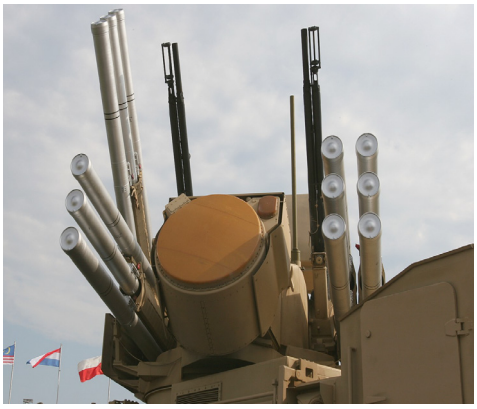
FIG. 2. Comparative missiles kill probability using one to three rockets case (a), with the SA - 6 system (b)



(a) (b)

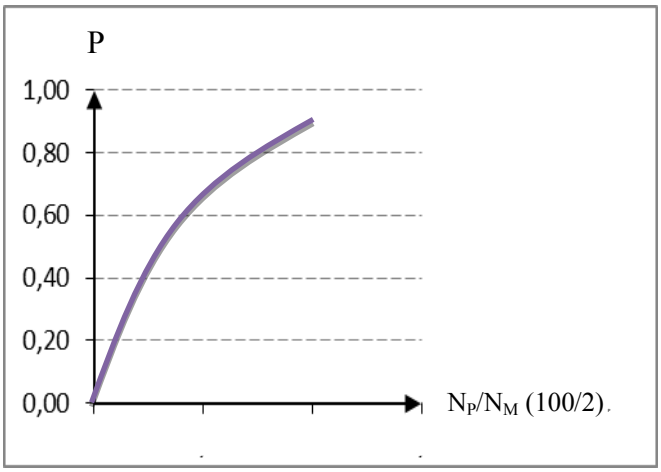
FIG. 3. Gun shoot kill probability using 550 projectiles case (a), with the 2x30 mm size system (b)





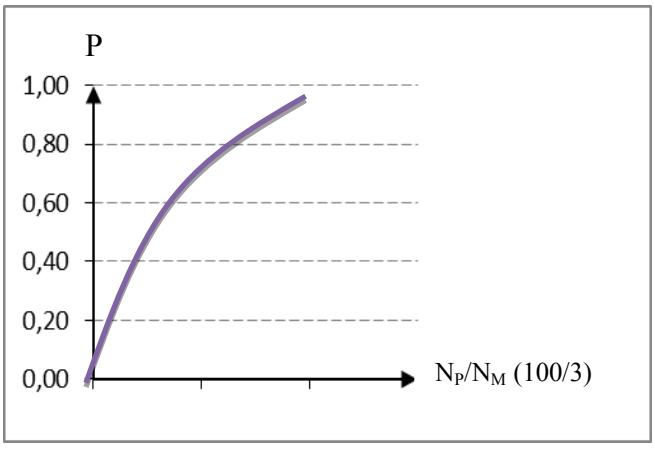
(a) (b)

FIG. 4. The shoot kill probability using 100 projectiles and one missile case (a), using integrated AD system SA 22 (b)



(a) (b)

FIG. 5. The shoot kill probability using 100 projectiles and two missile case (a), using integrated AD system (b)



(a) (b)

FIG. 6. The shoot kill probability using 100 projectiles and three missile case (a), using integrated AD system GHEPARD and SA 7 (b)

CONCLUSIONS

Tacking into account the issues analyzed in this paper it is clear that more data contribute to substantiate arguments for making a decision if need system up-grading. These take into consideration the following aspects:

- technical parameters and performance management imposed by the central structure (effective range, single shoot kill probability, system structure etc.);
- agility / versatility of main equipments (eg if the research radar can operate independently or integrated into ASOC - Air Sovereignty Operation Center);
- existence of industrial facilities domestic capacities;
- alliance policy;
- doctrine of armed forces regarding the unification of the equipment, tactics, and training for categories of forces;
- financial support available;
- strategic reasons that may require the deployment of some systems at a time.

In any case, an up-grading program for integrated Air Defense systems requires one to two years in the best logistical conditions. All these considerations are available in the case of a domestic system that lends itself to modernization (or previously acquired).

Reality of strategic environment shows that the armed that belong to relatively rich countries such as UK or United Arab Emirates as the powers that hold cutting-edge technologies in the field of Air Defense such as USA or Russian Federation not cast A.D. systems until their technical resource is consumed and up-gradation potential is fully exploited.

Finally the antiaircraft effectiveness increases with A.D. systems integration with reference to Surface-To-Air Missile and Antiaircraft Artillery arranged on the same chassis or different platforms. For both systems S.A.M. and A.A.A. the kill probability depend on the number of shooting /launching projectiles/missiles against the aerial targets and SSKP.

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EVALUATION SYSTEMS FOR ANTIAIRCRAFT ARTILLERY AND SURFACE-TO-AIR LIVE FIRING ACTIVITIES

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Abstract: *On September 19th, 1916, the first enemy airplane was shot down with 75 mm antiaircraft guns in Flămânda area. This is considered to be the birth of the Air Defense Artillery & Missile branch. In time, the branch has evolved from modified field artillery to specialized antiaircraft artillery and complex surface-to-air missile systems, the Air Defense Artillery & Missile branch thus becoming an essential component of Romania's air defense. The endowment and the development of the Romanian antiaircraft artillery after WWII imposed setting up a specialized firing range to allow training firings in safe battlefield-like conditions. Thus, on April 1st, 1950, "General de Brigadă Ion Bungescu" Training Camp and Surface-to-Air Firing Range (TIPTSA) was established, a permanent firing range, large, open and complex, the only structure in the Romanian Armed Forces to organize and host firing activities that include the third dimension – the air. TIPTSA's activity is complex and it includes mainly hosting the personnel and the equipment of the participants in the firing activities, providing the targets during the firing activities, observing and evaluating the firing activities. Evaluating the performances of the systems, as well as the personnel's training level through live firing activities during complex exercises is one of the most important links in evaluating the fighting capabilities of the units. This paper presents the evolution of the evaluation of the firing activities since the beginnings of TIPTSA, and tries to look into the future, with respect to the evaluation of the antiaircraft artillery and surface-to-air missile firings.*

Keywords: *antiaircraft artillery, antiaircraft missiles, surface-to-air missiles, antiaircraft firings, evaluation of firing activities*

1. INTRODUCTION

Antiaircraft artillery and antiaircraft / surface-to-air missiles are meant to destroy aircraft, which implies either the meeting between it and the projectile / missile, or detonating the missile in the proximity of the aircraft. Under the conditions provided by the firing range, solving the problem comes down to the meeting between the projectiles-missiles and the air targets be it target planes, flares, or airplane-towed targets.

Observing and evaluating antiaircraft firing activities demands the existence of some systems that are capable of assessing / measuring the error in range of the explosions of the projectile/missile to the air target, perpendicularly on the firing direction that contains the target. The evaluation systems have evolved in time, from the acoustic ones (AS-100, BT-23) to the radio (SRT-4) and the electro-optical ones (EOTS-F). Each of these systems has been used along the optical ones (optical observation telescope for angular difference – the TZK binoculars, the Bosch binoculars, POS-1 optical observation device de-phased firings).

Of all the evaluation systems used in the past the acoustic systems stand out, which came back to the attention of the designers along new and highly performing target plane systems. These show miss distances (zone) and miss angle (sector) of the antiaircraft firing activities.

The operating principle of the acoustic evaluation system uses the characteristics of the shock wave created around the supersonic projectile in order to determine the error of the projectile to the indicator (miss distance). The detection microphones of the indicator receive the amplitude of the shockwave. The electric signal from the microphones gives the error in range - miss distance. Each microphone has a preset code signal that indicates the sector. Both sets of impulses (zone and sector) are sent in space, received by the receiver, which after processing them indicates the zone, sector, and the number of observed firings [1].

The AS-100 and BT-23 acoustic systems used either the G.S.-RES-20604 ground station, which presents the results of the firing in 6 zone electronic counters and 4 sector electronic indicators, automatically recording them on tape, or the G.S.-REM–20300/B ground station – campaign receiving station, easy to transport and maintain, which showed the results of the firing on electronic indicators in 3 zones.

2. SYSTEMS CURRENTLY USED TO EVALUATE FIRING ACTIVITIES

2.1 Optical systems used to evaluate firing activities. For direct antiaircraft artillery firing *the TZK binoculars* are used, which are capable of:

- observing targets and the results of the firing activities;
- measuring miss distances between the burst trails and the target;
- measuring horizontal angles (within the n×360 º range) and vertical angles (within the -18º + 84º range);
- cueing the surface, air and water targets.

For off-phased firings, the *POS – 1 device* is used. It measures direction and elevation errors between explosions and targets, both for the mirror off-phasing method and the azimuth off-phasing method.

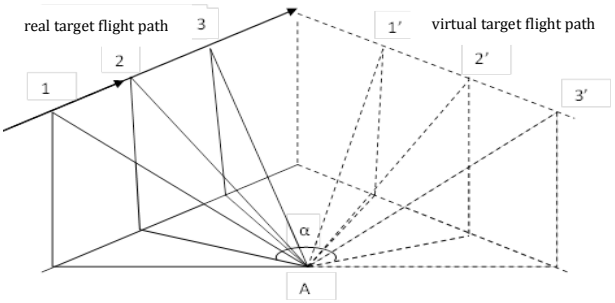

FIG.1. Firing scheme for azimuth off-phasing method by alfa angle (α)
1,2,3 – target positions, 1',2',3' –imaginary points positions, A - POS-1 station point, α –azimuth off-phasing angle

The basic working procedure for the POS-1 is the scale reading of the elements of the current position of the target and of the angular differences of the bursts on the cross lines of the commander's telescope.

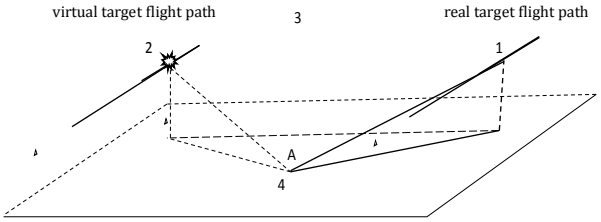

FIG. 2. Firing scheme for mirror off-phasing method
1- target, 2-imaginary point, 3- the surface of the mirror, 4 – artillery battery, A- POS-1 station point

Using two POS-1s set apart at a certain distance, we can also measure the errors in range between the bursts and the targets [2].

2.2 The electro-optical targeting system – EOTS-F. EOTS-F is meant to accurately determine the trajectories of the air targets, the errors between two air targets and between flares and an air target. Unlike the optical systems that are used, this is used for evaluating both antiaircraft artillery firing and antiaircraft/surface-to-air missile firing.

EOTS-F consists of:

- the Master Station – MS, which is mainly used to measure the trajectory and to evaluate the results of the firing activity. The other functions of the station are somehow related to this main task. The main components of the master station are MC32 front end (FE) computer, data interface of the FE computer (PDI), evaluation unit with TES and AFD sub-systems, micro-VAX (μVAX) computer, terminal operators (VT320) and the magnetic recording device.
- the cinetheodolite assemble: two bi-dimensional measuring instruments which have automated tracking devices in infrared (THIR1, THIR2), and two similar instruments which have automated tracking equipment in the visible specter (THTV1, THTV2) [2].

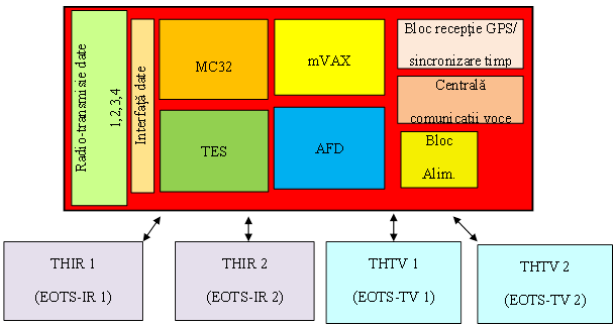

FIG. 3. EOTS-F components

The EOTS-F system is primarily based on determining the angular coordinates of a point in space using bi-dimensional measuring instruments that have a highly accurate measuring system for the azimuth and elevation angles ($2 \cdot 10^{-4}$ gons $\equiv 3.14$ mm/km), set in accurately determined positions [3]. Each cinetheodolite transmits a set of data, containing time, identification label, and position information comprising coded azimuth and elevation angles (t, no.th, α, λ). Using the implemented mathematical device the collected primary data is processed and synchronized and the spatial coordinates (x,y,z) of the tracked object are obtained for each tact of the generator related to time.

2.3 The numerical determination of the tri-dimensional coordinates with the EOTS-F. Numerically determining the position of the target, in relation to a reference position existing in the firing range, is based upon the triangulation method and allows obtaining the coordinates of the flying object through geometric calculus using the angles of the optical sighting /tracking axes of the target in azimuth and elevation of the theodolites.

The numerical method took into account several working hypothesis that refer to the existing situation in Capu-Midia firing range, and these are:

- the position of the cinetheodolites in Capu Midia firing range are accurately determined, the reference point having the coordinates [x = 0, y = 0, z = 14.093];
- the possible position to set the cinetheodolites are aligned and have an azimuth of 183°;
- the distances between the possible positions to set the cinetheodolites are accurately determined.

The geometric calculus, according to the situation corresponding to the working hypothesis in which the firing point PT is between the two cinetheodolites IR, is based on the representation depicted in Fig.4.

The case in which the firing point PT is situated south of the two cinetheodolites is similar.

Thus, we know:

- theodolite THIR1 in reference position→ P_1 (0,0);
- theodolite THIR2 in reference position P_2 on line183°;
- distance $P_1P_2 = D$;
- azimuth angles θ_1 and θ_2 of the THIR1 and THIR2 theodolites.

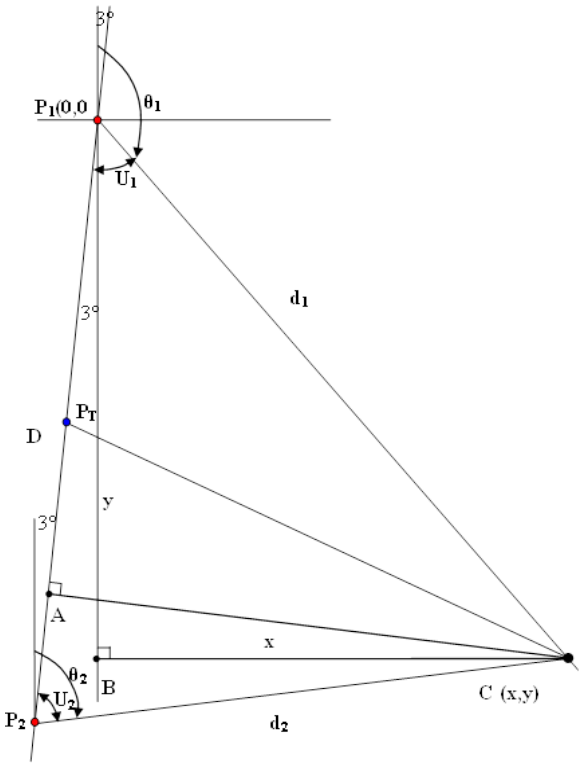

FIG.4 The firing point (PT) between the cinetheodolites

We must find the position of the traget: C (x, y).

We mark: $U_1 = 183 - \theta_1$ (1)

$U_2 = \theta_2 - 3$ (2)

The right-angled triangles P_1AC and P_2AC give us:

$$tg(U_1) = \frac{AC}{P_1A} \tag{3}$$

$$tg(U_2) = \frac{AC}{P_2A} \tag{4}$$

Replacing U_1 and U_2, we get:

$$P_1A = \frac{AC}{tg(183 - \theta_1)};\ P_2A = \frac{AC}{tg(\theta_2 - 3)} \tag{5}$$

$$D = P_1A + P_2A \tag{6}$$

Using equation (5) in (6) we get:

$$D = \left(\frac{AC}{tg(183 - \theta_1)}\right) + \left(\frac{AC}{tg(\theta_2 - 3)}\right) \tag{7}$$

(7) gives us:

$$AC = \frac{D \cdot tg(183 - \theta_1) \cdot tg(\theta_2 - 3)}{tg(183 - \theta_1) + tg(\theta_2 - 3)} \tag{8}$$

The right-angled triangle P_1AC gives us:

$$P_1C = \frac{AC}{\sin(183 - \theta_1)} \tag{9}$$

$$P_1C = \frac{D \cdot tg(183 - \theta_1) \cdot tg(\theta_2 - 3)}{\left(tg(183 - \theta_1) + tg(\theta_2 - 3)\right) \cdot \sin(183 - \theta_1)}$$

The right-angled triangle P_1BC gives us:

$$\sin(183 - \theta_1) = \frac{BC}{P_1C} \tag{10}$$

$$\cos(183 - \theta_1) = \frac{P_1B}{P_1C} \tag{11}$$

Replacing (9) in (10) and (11) and taking into account that x = BC and y = P_1B we get:

$$x = \frac{D \cdot tg(183 - \theta_1) \cdot tg(\theta_2 - 3) \cdot \sin(180 - \theta_1)}{\left(tg(183 - \theta_1) + tg(\theta_2 - 3)\right) \cdot \sin(183 - \theta_1)} \tag{12}$$

$$y = \frac{D \cdot tg(183 - \theta_1) \cdot tg(\theta_2 - 3) \cdot \cos(180 - \theta_1)}{\left(tg(183 - \theta_1) + tg(\theta_2 - 3)\right) \cdot \sin(183 - \theta_1)} \tag{13}$$

Taking into account Fig.4 and (9), (12) and (13), the horizontal distance (P_1C), between theodolite P_1 and the target can be expressed as:

$$P_1C = D \cdot \frac{\sin(183 - \theta_2)}{\sin(\theta_1 - \theta_2)} \tag{14}$$

And the coordinates of the target, related to the reference position, become:

$$x = x_1 + \frac{D \cdot \sin(183 - \theta_2) \cdot \sin\theta_1}{\sin(\theta_1 - \theta_2)};$$
$$y = y_1 + \frac{D \cdot \sin(183 - \theta_2) \cdot \cos\theta_1}{\sin(\theta_1 - \theta_2)}; \quad (15)$$
$$z = z_1 + \frac{D \cdot \sin(183 - \theta_2) \cdot tg\gamma_1}{\sin(\theta_1 - \theta_2)}$$

in which x_1=0, , y_1=0 and z_1=14.093 are the initial coordinates of the position of P_1 cinetheodolite, and γ_1 is the vertical angle of the sighting axis of P_1 cinetheodolite in relation to the horizontal plan.

2.4 Reports of objective evaluation of the firing activities. According to the category of firing activities that are being evaluated, the EOTS-F system uses different configurations and sets of dedicated programs. When evaluating surface-to-air missile firing activities, the sequences of spatial coordinates obtained by the TV cinetheodolites make up the trajectory of the target, the sequences of spatial coordinates obtained by the IR cinetheodolites make up the trajectory of the missile, and by using the set of TRAM (TRAjectory Measurement) programs, we get the relative distance between them.

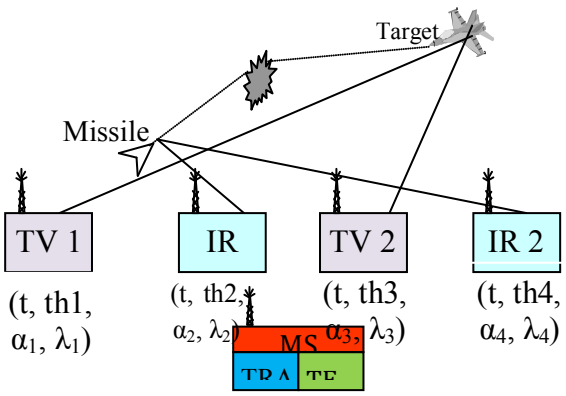

FIG.5 The standard configuration of the EOTS-F system in evaluating SAM firing activities

When evaluating artillery-firing activities, only the TV cinetheodolites are used and they determine the trajectory of the target. The input data in the evaluation process are the files containing position data and the images recorded on video tape in the same trigger as the moments of the data collection. By running the set of TES (Tracer Evaluation System) programs, a complete report with the images of all the projectile bursts in the plan of the target is obtained, with calculations of the average point of the firings and the marks according to the reckoners in the evaluation handbooks.

3. DEVELOPING EVALUATION SYSTEMS FOR FIRING ACTIVITIES

The main directions in the evolution of the equipment for the evaluation of the firing activities are:

- designing new scoring systems specific to the recently developed target planes;
- modernizing the EOTS-F system.

Given its general characteristics, the high precision and the possibilities to evaluate all categories of firing activities, it is quite appealing to refit the EOTS-F system with the latest equipment that will allow, besides accomplishing the initial functions at a high level of quality and configurability, the accomplishment of new functions, such as simultaneously tracking two targets and two missiles or tracking the air-to-air missiles of the Air Force.

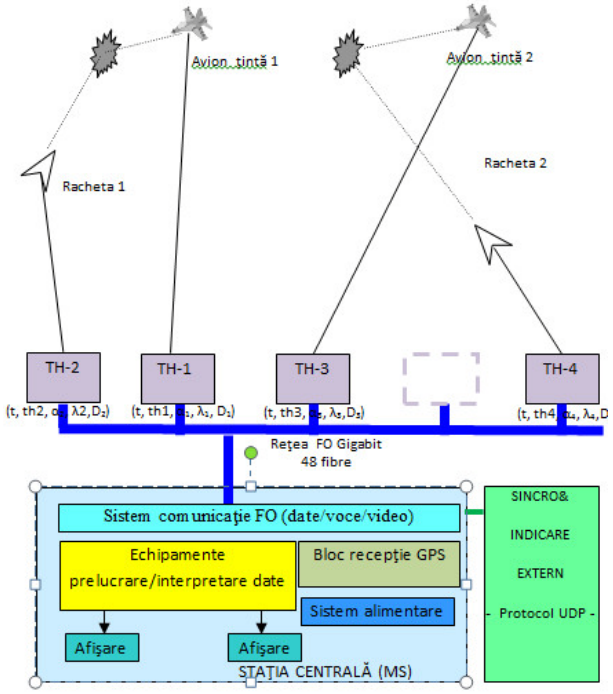

FIG.6 Evaluating firing activities on two targets in the modernized configuration

The refitting program has in view incorporating certain new pieces of equipment such as the total or partial replacement of some pieces of equipment, sensors, communication or computation blocks that are part of both the master station and the cinetheodolites. The possibilities of evaluation are enhanced by introducing some measuring devices for the *Laser Range Finder* distance and some high-speed video cameras fitted along the main sighting telescope principal of the cinetheodolites.

Operating at a higher frequency, the EOTS-F complex can collect a higher quantity of synchronized data and images at reduced intervals, which will increase the accuracy of the evaluation. The figure below shows the information leap of the measuring system after going through the modernization process.

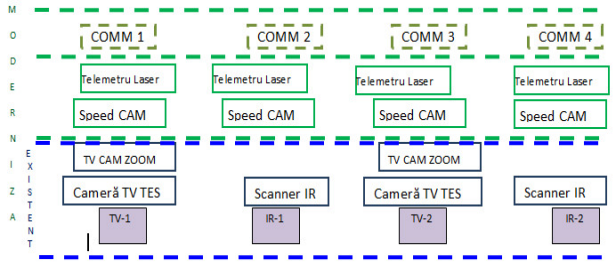

FIG.7 The modernization of the EOTS-F system at the level of the primary data sources

In this configuration, the system evaluates the firing activities and raises the complexity level of the firing scenarios.

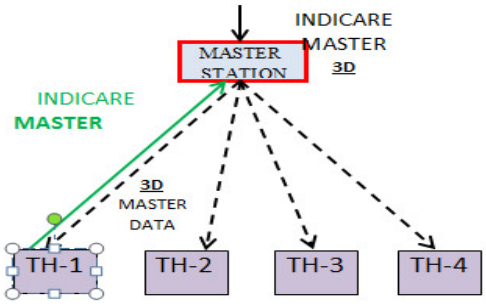

FIG.8 MASTER-SLAVE working levels for the EOTS-F system

In addition, the modernized system has the possibility to track a point within the area of the firing range after the external synchronized indication of its GPS coordinates. The indication is necessary in case the initial evolution of the target is outside the coverage of the EOT-S system, and there is subsequent entry in the combat area, where the evaluation of the firing activity takes place.

4. CONCLUSIONS & ACKNOWLEDGMENT

The existing evaluation systems constitute a good foundation on which further development of the future evaluation means can be built. All future improvements have the meaning to evaluate precisely actual and future SBAD systems. Optical and digital performances of the modernized evaluation system will be good enough to observe, analyze and evaluate live firings using even small missiles, like air-to-air missiles from distances up to 20 kilometers.

Training is a building block of any ground based air defense capability and, within it, the objective evaluation of the real firings constitutes the core tool that provides realistic view on the level of training, as well as the status of the equipment. Having this in mind, maintaining and enhancing the capabilities to evaluate the real firings should be a permanent concern for the decision-makers, in order to provide the fighters with the appropriate and unbiased feedback of their performance.

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RELIABILITY TESTING AND FAILURE ANALYSIS FOR SPAR STRUCTURE OF HELICOPTER ROTOR BLADE

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Abstract: *In the last years reliability tests represented a widely used method for different life cycle stages of the industrial products – design, manufacturing until service, because on their basis information regarding reliability, lifespan, failure rate etc. can be obtained in the shortest time. In this paper were determined the reliability indicators (reliability function, non-reliability function, failure rate, probability density, mean life) on the basis of the gathered data related to the blades' fatigue testing experiments. Moreover, was done technical expertise concerning a tested blade, with the help of microscopic analysis.*

Keywords: *reliability, fatigue test, blade helicopter, failure, mean life*

1. INTRODUCTION

The helicopter blades are characterised by the aerodynamic airfoil (or the profiles from which is made up), the plan shape, the twisting, the shape of its tip. From the profiles' point of view the blade has to fulfil certain requests [1]:

- high lift coefficient; critical Mach number as big as possible (to lower power loss due to compressibility), which is one of the limitations for the advancing blade;
- the torque coefficient at zero lift to be as low as possible or zero; the drag coefficient, at high lift coefficient and high Mach speeds;
- as reduced as possible variation of the chord's pressure centre.

Modern technology has imposed specific forms of the blade end of aerodynamic considerations, especially in terms of air flow characteristic of this area of the blade. Shaped of the blade tip has a very important role in terms of profile power value and of the rotor noise levels [2].

At helicopters, the loss of a blade immediately leads to the destruction of the rotor and therefore to the immediate loss of the helicopter. For this reason, the blade and the rotor components, and also the supple platinum fall into the vital parts category of helicopter, parts which damaged or lost cause inevitably the destruction the entire aircraft.

A vital piece must meet the following three conditions [3]:

- it is a piece that cannot be duplicated and the breaking of which determines or may determine a serious accident;
- it terms of helicopter operation, the part is subject to important alternating efforts (fatigue stress);
- current technical design of helicopters can not ensure high safety factors.

Some recent studies have been made on aerodynamic performance and mechanical characteristics of helicopters by finite element analysis of the various components [4] and CFD analyses [5,6] on the entire aircraft.

Gathering information on product reliability is typically achieved either watching the behaviour of the products in actual operation, or during the reliability tests. During observations in actual operation all the occurring phenomena are recorded in detail along the use of the product. A study based on this information is, however, a historical study, its value consisting only in the collection of experimental data or detection of factors leading to low reliability of the products.

Information from real operation often concerns obsolete products or equipment, so when arriving at conclusions, it might no longer be of importance to correct issues related to design and products' manufacture, as reliability desideratum. Without excluding tracking products in real operation it is appropriate to use the method of reliability tests. During these tests are sought, where possible, to simulate real service conditions, both through the reproduction of a range of internal stresses and environmental.

Due to the multitude of factors that influence the behaviour of products, reliability's theoretical foundation is the theory of probability and mathematical statistics and the experimental foundation are the reliability tests [7]. A direction intensely researched is the reliability [8] and failure mode analysis [9.10] for blades from the helicopters' structure.

Other studies look on improving flight performance through innovative methods and components deployed on helicopters' structure [11,12]. By implementing composite materials [13] and new blade manufacturing technologies [14] a significant weight reduction is achieved and much higher fatigue strength compared with metal blades. Due to more restrictive noise regulations for helicopters, several current studies have shown the importance of knowing the noise level for helicopter on the ground, during take-off and during manoeuvres [15,16].

2. MATERIALS

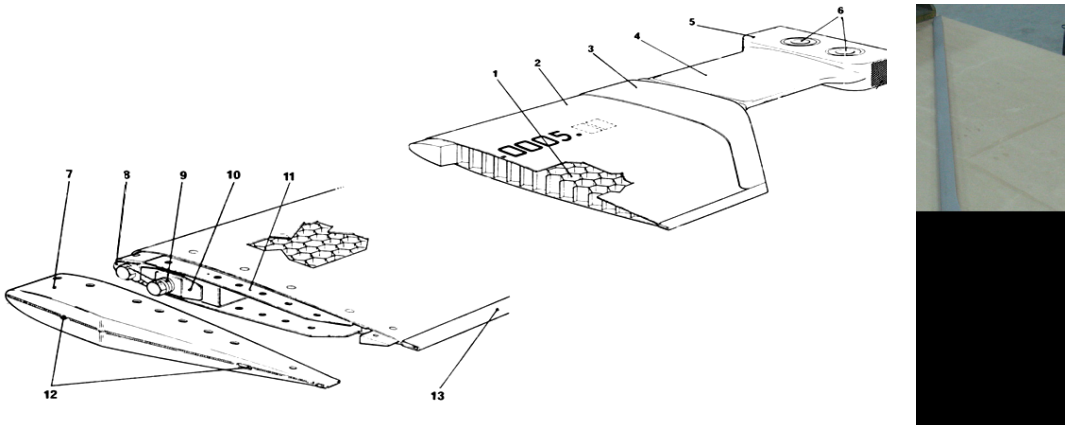
Reliability testing, in which the main degradation phenomenon is fatigue, are very important in industrial and especially aerospace industry with applications on components of airplanes and helicopters' structure. Between these components are included: the engines used on different aircraft, rotor blades and compressor blades, landing gear, various avionics equipment, main and anti-torque rotor blades, supple platinum [17].

In this paper it was conducted a constructive and functional study on the rotor blades of IAR 330 Puma helicopter. Anti-torque rotor compensates for the torque generated by the main rotor and serves to control the helicopter's yaw axis.

The tail rotor structure comprises of 5 blades. A blade structure shown in Figure 1.a. The main characteristics of tail rotor blade are: profile NACA 0012; chord 186.5 mm; length 1244.3 mm; mass 2.680 kg.

The components of the anti-torque rotor blade, with reference to Figure 1.a, are: NIDA core (1); shell (2); stiffener (3); spar (4); connection parts (5); fixing bushings (6); "salmon" (7); ballast weights (8); balancing rings (9); balancing counterweights (10); extremity rib (11); eyelets (12); trailing edge (13).

Fatigue tests from this paper were carried out on the metal spar (figure 1b), which is part of the tail rotor blade structure of IAR 330 Puma helicopter. The metal spar from the blade's structure is the reinforcing element most stressed and is subject to severe fatigue tests for determining its lifespan.



(a) (b)

FIG. 1. Anti-torque rotor blade of the helicopter IAR 330 Puma (a) the internal structure of the blade (b) 6061 T6 aluminium blade spar [18]

3. METHODS

In the case study (tail rotor blade) of this paper it will be applied a cyclic mechanical stress. For cyclical stress most commonly used are metal components and systems, and degrading phenomenon most common is fatigue. Fatigue degradation involves a variety of issues: the type of strain; the shape of the part; the surface quality of the worked part; the environment in which the part works. In general, fatigue can be considered as a process in which damage accumulates in a material following stresses with variable characteristic to which it is subjected. Fatigue is a local process, which manifests itself in various materials used in engineering practice such as: metal alloys, polymeric materials and composites, etc. [19,20].

The test bench allows the introduction of stresses according to blade specimen as follows: axial force via an axial cable; lagging dynamic bending moment changes by means of rods that connect to the tensioned blade; flapping dynamic bending moment in the form of an arrow controlled at the end of the blade by means of an eccentric.

To determine the corresponding bending moment of the lagging movement for the blade, use the relation 1:

$$M_{ib} = F_b \cdot b \tag{1}$$

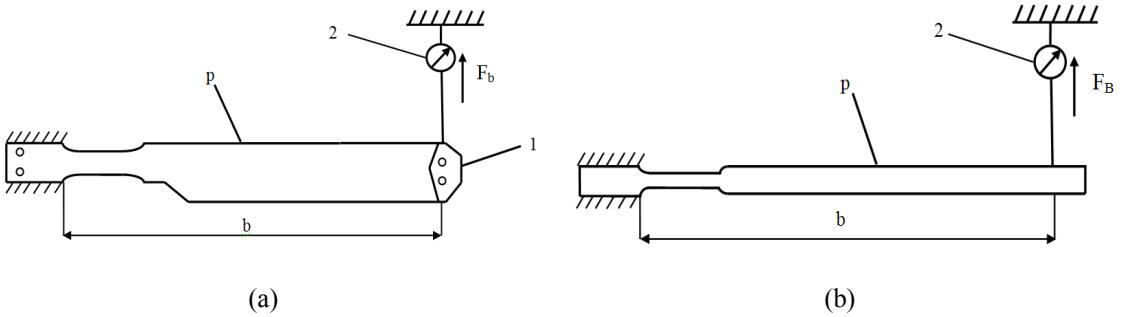
where: F_b - the force in the blade's lagging plan; b - blade's lever arm.

To determine the bending moment corresponding to the flapping movement of the blade is used the relation 2:

$$M_{iB} = F_B \cdot b \tag{2}$$

where: F_B - force in the blade's flapping plan; b - blade's lever arm.

Fig. 2.a and 2.b are the methodologies of blade calibration at lagging and flapping movements. For calibrating the lagging movement (p), the blade is embedded in the rotating frame of the test bed. It is installed a dynamometer (2) with the help of two hooks and joining cable (1). The application, at the blade tip, of the force in the lagging plane is achieved by tightening a screw to the set values for calibration. The values indicated by the dynamometer and the indicated specific strains values are read the strain gauge bridge. For calibrating the flapping movement the blade rotates 90° and the calibration procedure is similar to the sweep movement.



(a) (b)

FIG. 2. IAR 330 Puma helicopter blade calibration (a) lagging movement blade calibration (b) flapping movement blade calibration

The test bench for fatigue testing of the IAR 330 helicopter tail rotor blades must allow the blade stress at the following parameters: static force T = 32000 N; lagging dynamic bending moment Mz = ± 1000 Nm; flapping dynamic bending moment My = ± 200 Nm;

Fatigue helicopter blades testing involves subjecting them to oscillating stresses with a set frequency and amplitude, until cracks in the embedding plan appear. Fulfilling this request is done with the help of the test bed that allows the development in the investigated section – blade's spar neck – of the forces and moments imposed.

This paper is focused on achieving reliability testing techniques on tail rotor blades of the helicopter structure, with the main purpose of determining the reliability indicators and the failure modes.

4. RESULTS AND DISCUSSION

Data obtained from fatigue testing 10 blade-type samples has been introduced in Weibull ++ 7 to perform statistical analysis in order to determine and plot the reliability indicators. Weibull++7 is a software specific to the reliability domain which performs data analysis on the lifespan (operation) for thousands of companies worldwide. This software provides all the tools needed in the statistical analysis of experimental data, including working with all data types (complete, suspended, censored) and key statistical distributions [21].

For data of blades' fatigue tests the bi-parametric Weibull distribution is suitable because it is the most appropriate for calculation of the fatigue on mechanical components. Are calculated the two Weibull model parameters by the method of estimation for the maximum likelihood for data from Weibull++7 software. The results are the following values of parameters: shape parameter (β=4.3); scale parameter (η=2939101.24).

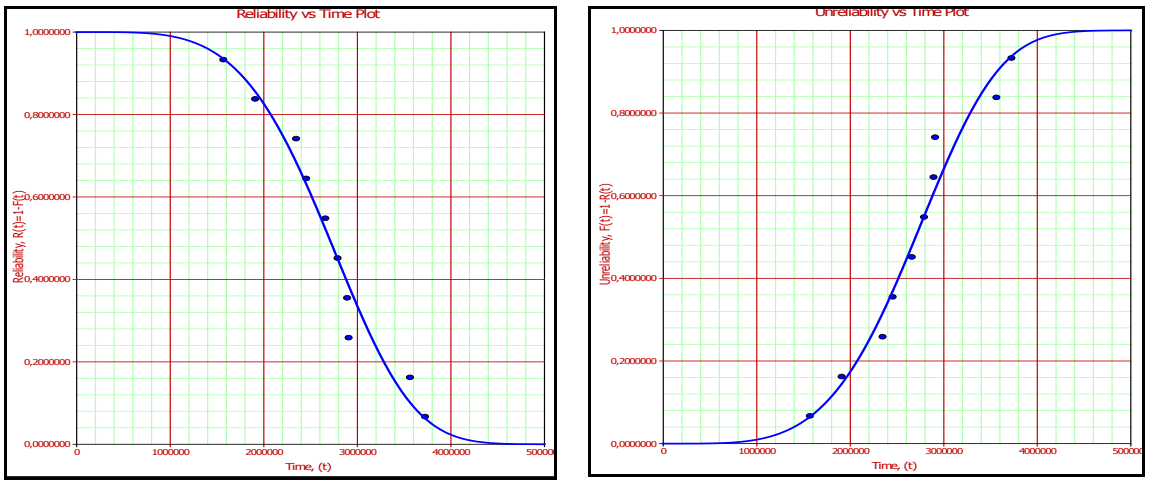
By reliability indicators is understood a measure by which reliability or one of its characteristics is expressed quantitatively. These reliability indicators were determined by relations (Table 1) specific to bi-parametric Weibull distribution. In Table 2 are determined and graphically represented (figure 3.a,b) the main reliability indicators, depending on the number of cycles to failure, resulting from reliability tests with the main degrading factor the fatigue of helicopter blades.

Table 1. Reliability indicators of the Weibull distribution

Reliability indicators	Relation
Reliability function	$R(t) = e^{-\left(\frac{t}{\eta}\right)^{\beta}}$
Unreliability function	$F(t) = 1 - e^{-\left(\frac{t}{\eta}\right)^{\beta}}$
Failure rate function	$\lambda(t) = \frac{f(t)}{R(t)} = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1}$
Probability density function	$f(t) = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1} \cdot e^{-\left(\frac{t}{\eta}\right)^{\beta}}$

Table 2. Dependence between the number of cycles to failure and blade's reliability indicators

Cycles to failure	Reliability R(t)	Unreliability F(t)	Failure rate $\lambda(t) \cdot 10^{-6}$	PDF $f(t) \cdot 10^{-6}$
1567825	0.933	0.067	0.488	0.172
1907658	0.837	0.163	0.715	0.301
2345129	0.741	0.259	1.200	0.476
2453217	0.644	0.356	1.381	0.509
2657892	0.548	0.452	1.827	0.549
2789056	0.451	0.549	2.199	0.554
2890756	0.355	0.645	2.542	0.546
2907543	0.258	0.742	2.603	0.544
3562728	0.162	0.838	6.441	0.280
3723620	0.066	0.934	7.932	0.201

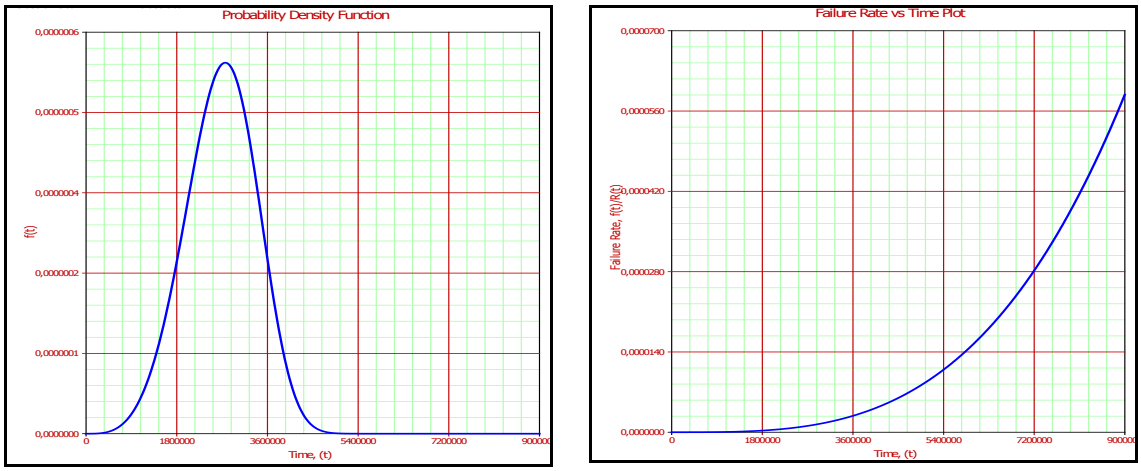


(a) (b)

FIG. 3. Blade's reliability indicators (a) reliability function (b) unreliability function

The probability density function represents the relative frequency of failure times as a function of time. The failure rate function enables the determination of the number of failures occurring per unit time.

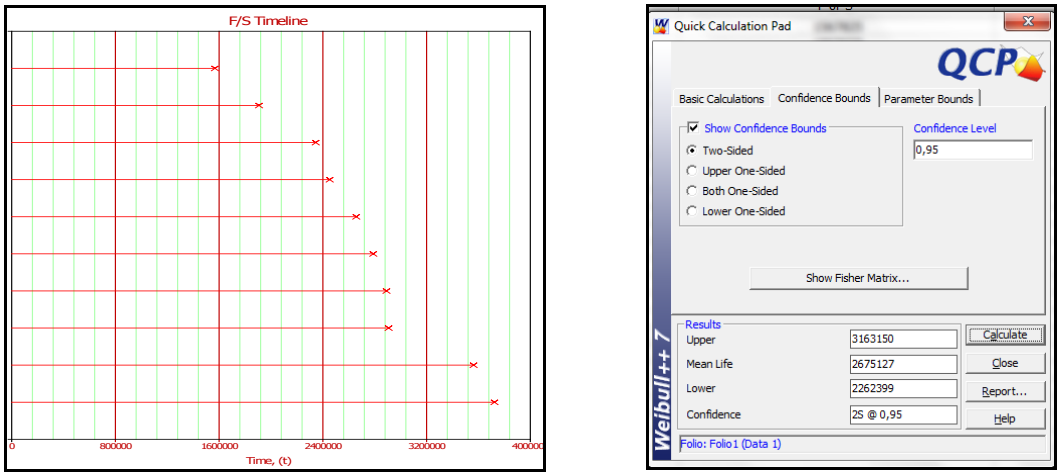
It is useful in characterizing the failure behavior of a component, determining maintenance crew allocation, planning for spares provisioning, etc [21]. The graphic representations of functions - probability density and failure rate are shown in Fig. 4.a, b.



(a) (b)

FIG. 4. Blade's reliability indicators (a) probability density function (b) failure rate

The failures/suspensions timeline diagram (figure 5.a) represents the values of the failures and suspensions are plotted on the y-axis and the time periods are on the x-axis [21]. The mean number of cycles to failure is determined by the mean relationship for Weibull distribution. Mean life is the most important reliability indicator and is determined using the Weibull software through a Quick Calculation Pad, and its value is 2675127 cycles at a confidence level of 0.95 (Fig. 5.b).



(a) (b)

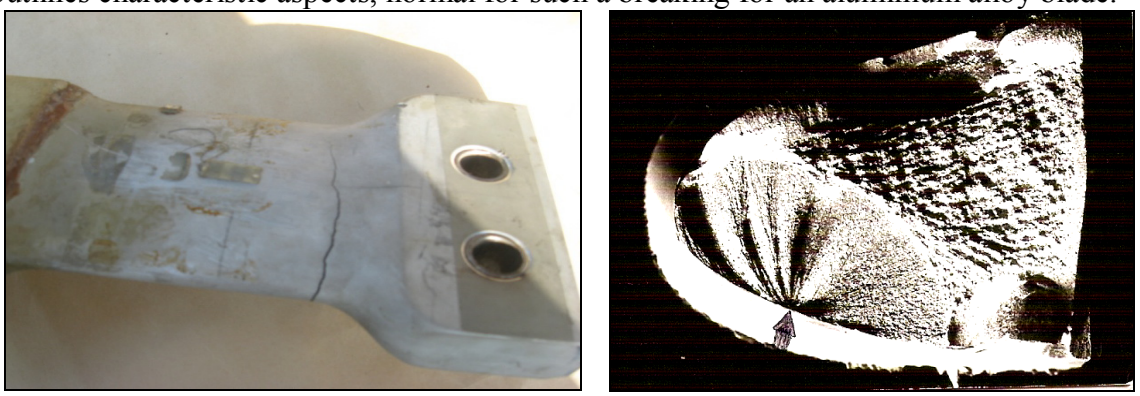
FIG. 5. Blade's reliability indicators (a) the failures/suspensions timeline diagram (b) mean life

5. FAILURE ANALYSIS OF A HELICOPTER ANTITORQUE ROTOR BLADE

The 10 blades fatigue tested have failed in the spar area (figure 6.a). For a helicopter blade there was a microscopic examination with optical stereo microscope IOR and with the electron microscope Philips SEM-515, with magnifications ranging between x10 - X3000. Microscopic appearance of the fracture surfaces is illustrated in Figure 6.b.

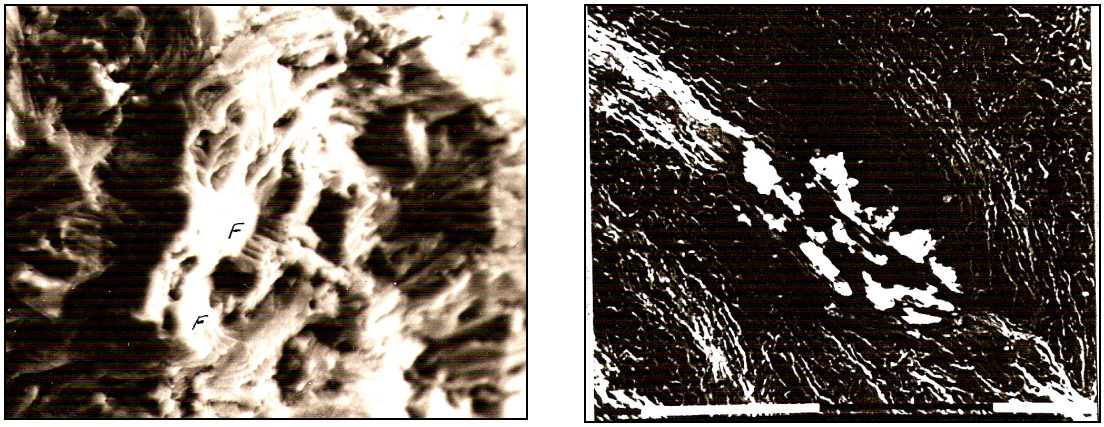
The arrow indicates the fatigue crack priming area that has propagated around the entire section of the blade near to the opposite edge, where the final tearing of the product when it reached the critical section took place.

In Fig. 7.a there is a fragile area (marked with the letter F), fatigue striations characteristic to the fatigue phenomenon occur within the broken surface. The material from which the helicopter blade was made contains oxide type inclusions, oxide film, mainly delivered in the breaking priming area. Some of these inclusions are visible to the naked eye breaking the surface in the form of dark spots of colour. Microscopy image of Fig.7.b shows such an inclusion that is contaminated in the electron beam. In the rupture of the surface more oxide inclusions can be seen, oxide film, indicating an impure material. Some of these inclusions are visible to the naked eye. Fatigue tear propagation outlines characteristic aspects, normal for such a breaking for an aluminium alloy blade.



(a) (b)

FIG. 6. (a) Defects shown in the blade's spar area (b) the microscopic appearance of the break surface



(a) (b)

FIG. 7. (a) Microscopic appearance of the fragile breaking area (b) oxide type inclusion highlighted in the breaking surface

CONCLUSIONS

Product and service quality is the basic indicator of an industry or economy. Reliability being a component along with other indicators of quality, it must stay in the attention of all the factors determining the smooth running of society. In this paper the main indicators of reliability (reliability function, non-reliability function, failure rate, probability density, and mean life) were determined and plotted using statistical analysis and processing of experimental data. Although the tests are in a complex reliability program the most expensive component, when well designed and properly deployed they determine the lasting economic effects at all negligible.

In conclusion, the helicopter tail rotor blade breaking was produced due to priming and propagation of a fatigue crack. The stress concentrator that favoured the priming was the oxide inclusion, oxide film, located at the outer edge, to one of the blade's edges.

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PERSONALITIES OF MILITARY THOUGHT IN ROMANIA GENERAL VIRGIL ECONOMU – AVIATION AS AN ELEMENT OF COVERAGE

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Abstract: *Aviation is one of the fundamental elements of an army. A century ago, in full World War, the Air Force gave a dangerous exam. As a weapon freestanding, it proved its viability. It was able to execute many various missions successfully.*

General Virgil Economu dedicated many pages to this weapon, and he described the ability of an army to raise his aviation and its power to adapt to the harsh conditions. In "România Militară" journal, the author described with memorable, but realistic words the aviation's role in defending the territory, based on numerous lessons learned. From these lessons learned, the army can learn more.

Keywords: *strategy, Balkan Wars, maneuver, aviation, military doctrine, Clausewitz*

1. INTRODUCTION

General Virgil Economu was the Editorial Director of the journal *„România Militară"*[1] in the period 1927-1935. He was one of the most important mentors of the Romanian military doctrine and art, alongside names like N. Alevra, C.N. Hîrjeu, Ion Jitianu, Ioan Sichitiu and Mircea Tomescu, the personalities of the Romanian military thought. His studies on the problematic of military life, by developing many materials, articles, they formed the basis of proposals or solutions adopted by policymakers and military leaders, in the interwar period especially.

The national independence and territorial integrity were two of the most significant and delicate topics on the agenda of politicians and military leaders of Romania, from the earliest times. Those were two main themes that represented the subject of debate for the formation of viable plans to strengthen defense and military power of our country. People like those up mentioned have delivered valuable ideas; they have come up with innovative solutions, which were materialized in a series of tactical studies or outstanding works.

[1] *„Romania Militară"* was founded in 1864, as a publication issued by Romanian Army Forces General Staff. In its 150 years, it had different names, like *„Cultura militară", „Probleme de artă militară"* and, since 1990, *„Gândirea militară românească"*, a military theory and science journal published by General Staff.

Thus, Romanian military doctrine was the result of long and prolific approaches in areas such as economic, political and military, given the geopolitical realities of the years. Based on analyzes prepared, the Romanian military theorists were those that sketched the concept of *„military thought"*, a phrase rather controversial today as they are some opinions according to which the military issue should be studied only by military analysts! In the 80s, this concept has been defined as *„all ideas, concepts, theories and doctrines that addresses the phenomenon in an era military"*. [2, p. 31] In 2013, in a study about military theory and concepts, Ross A. Miller, PhD., a former officer in the U.S. Navy, said that although *„Military strategy was long described as a theoretical - an art that could only be fully comprehended by military genius, this contention is no longer held, as military staffs, comprised of experts and specialists, are able to formulate strategy aided by mini-theories of strategy and a process that takes advantage of collective wisdom rather than singular genius"*. [4, p. 3]

Over the years, the concept was developed into military science, military history, military geography, military doctrine, social sciences with applications in military field, war philosophy [13, p.14]. In addition, there are authors who believe that military thought addresses the issue of armed struggle, the institution as such, factors underlying the preparation, command and outcome of armed conflict [3,p.10]. Beyond these assessments or, perhaps, on that source, I believe that the study of military thought is an important and necessary step for understanding both the personalities of military life Romanian and currents of opinions and ideas that built this edifice of science. In this regard, Liddell-Hart stressed that *„history is the universal experience, not the experience of one man, but several people who work in varying conditions.* [11, p.3]

2. JOURNEY THROUGH BIOGRAPHY

General Virgil Economu was born in 1875. After graduating from the Military School of Infantry and Cavalry Officers in Bucharest (1896-1898) and the complementary Staff Course (1909-1910), he promoted all military ranks, toward the general. It had an important role during the campaign of 1916, where he was an officer attached to A.3 Command and Defense Group „Danube". On the way to the 25th Infantry Division, where he was to be appointed chief of staff, he was wounded and taken prisoner by the Bulgarians (20/21 November 1916), where it will stay a year and a half in camp Sliven, Bulgaria [12, p. 154].

After the First World War, he had several functions, such as the Director of School's military regiment and commander of brigade. He taught military history at the Higher School of War (now, "Carol I" National Defense University, Bucharest) and was chair of the editorial board of the journal *"România Militară"* in the interwar period. According to specialists, it is considered one of the most active and prolific thinkers' Romanian officer for the reason of his great works and studies that it has developed and which has materialized in publications, especially in *"România Militară"*, between 1933 and 1934. Among his workings, include *„Study on maneuvers royal of 1910"* (1911), *„The discussions of a concept in the Russo-Japanese War"* (1912), *"Seven applications tactical map"* (1927), *„Discussions about the wars in the Balkans. 1912-1913"* (1926), *„Study on tactical operations of 2/5 November 1916"* (1932*), „How we reduce the*

military service" (1933), *„An historical impossibility"* (1933), *„The organization of the nation for war"* (1933*), „The war that is coming"* (1939).

He was member in the Joint Commission for delimiting the borders between Romania and Kingdom of Serbs, Croats and Slovenes (1921-1922) until the decision of the Paris Peace Conference [12, p.154].

Unfortunately, based on what I searched, I have not found data on the death of the General Economu.

3. STRATEGY'S APPLICABILITY

Almost a leitmotif, the profession of faith of General Virgil Economu was condensed into the following statement: *„The entire study military history to be dominated by a single didactic purpose: strategy' applicability"*. [6, p. 75] On this statement, he was convinced that each campaign to which the Romanian army took part gives one or more so-called *„lessons learned"*. This means that each campaign has its significance, because in *„all these campaigns, our army participated effectively"*. [6, p. 76] In this regard, General Economu argued that the main campaign in which Romania participated should be studied not only from the military perspective, but also from the geographical, political and economic one. Thus, about the Balkan wars, he said that the value of its headquarters and army on the battlefield is a reflection of the care and attention that the politics has given to it. His argument was because an army cannot be formed in a short period, quickly, but the feedback is at least several years of training and equipping. As an example, he used the defeat of Turkey in the first Balkan war, because, among other things, it was a lack of consistency in the army and an absence a fleet powerful to be able to guarantee supremacy in the Aegean Sea: *"The campaign of 1912 demonstrates that the fleet for a country whose territories are separated by sea is indispensable complement of the army (...). Turkish organizers did not understand that the reorganization of the fleet is a vital issue for empire"*. [6, p.28]

A major aspect that General Economu analyzed in her studies refers to the methodology of design and applications solving on tactical map and on the ground. The main feature of these applications was the spirit of coordination and connection between those participating. People were asked to think together for the same purpose. For example, he analyzed the activity of Division 2/5 (a combination between Division 2 and Division 5, at October 17, 1916), led by General Alexander Socec [1], and he drew up a study in three parts, detailed in journal *"România Militară"* [8, p.23]. It is about the Division's mission 2/5 in wide-ranging activities organized by the General Staff: Battle of the Neajlov-Argeş or the Fight to defense the capital Bucharest. The mission was to get out the Central Powers forces across the Danube and defending the city Bucharest in this way. In this battle, they used two divisions: 2/5 and 9/19.

The author made an extensive study, an objective analysis of the mode of action of division to reach Flămânda-Târnave, highlighting the negative aspects of the mission, too. Of these, General Economu thought being important: *„ignorance of the exact situation, lack insecurity and lack of judgment"* [8, p. 8]. Division was in a precarious location, without adequate safeguards, without freedom of action.

Also, commandant's portrait is grim, *„his decisions lacked conviction and firmness"* [8, p.9], an extremely serious problem not only in such crucial moments, but always. The value of a commander, wrote General Economu, depends on the value of the whole army!

During the three parts of his study in *"România Militară"* journal, General Economu approached relevant and potential solutions, based on the situation on the battlefield, from the known data, the Division's organization, but also about the order received by it. Division's mission was its entrance into Old Letca's region, in Giurgiu. Moreover, what was more important, namely, the element of *„surprise"*, could not be implemented, the surprise being "*a condition essential in the execution of maneuvers in flank and rearward"* [8, p.9].

One of the essential topics of General Economu in his writings was the maneuver used by divisions under cover. In this regard, he established some principles and stages of maneuver of major units arranged in coverage, which he detailed in *"Maneuver in retreating on troops from coverage"* [7, p.24].

In addition, in the study of *"România Militară"*, he concluded that large units operations arising principally from operations for the previous day:*"These operations previously performed contributed to the abnormal situation and to involuntary Group's maneuver, approaching the Neajlov during the day. If, on the contrary, the group of maneuver would be approached by marches night, would be done in good conditions with all the required elements of surprise, strategic and tactical, and on the other hand, would have avoided serious losses of the Division".* [8, p.63].

4. AVIATION – AN ELEMENT OF COVERAGE

Also in the journal "*România Militară"* towards the end of 1933, General Virgil Economu debated maneuvers carried out that year, a "*true school of realities"*, as the author confessed in *„The maneuvers of the royal autumn"*. [9, p. 77] In the author's opinion, the core of these maneuvers it was the broader use of aviation and its cooperation with other combat arms. Such maneuvers have emphasized that aviation plays an important role in preliminary operations of the war, especially in the case of external aggression. [9, p. 81] The author emphasized the need for aviation, whatever the political color has the government: *"Aviation, whatever the attitude of a party - offensive or defensive -, besides other missions, must to attack, because in the air is more than on earth the best way is <to attack>. Aviation created a high impression, and most people have been impressed to see that the air is important for aviation and to better understand its role to give impetus needed for this warfare".* [9, p.81.]

General Economu made a number of proposals in terms of preparation for war, based on integration the regiments and training units operated higher. In this context,!, said the general. As element of coverage, the aviation is the first called into action. In 1933, the author concluded his statement with the affirmation of the king that the army will be equipped with suitable material technical advances, and with the speech of Minister of national Defense, which said that "*we must not expect the war to prepare our army to*

resist under the pressure of outside events and conditions which very often can be harmful". [9, p. 82.] It was 1933s...

CONCLUSIONS

In the nineteenth century, Romanian military theorists had as a landmark work the studies of Carl von Clausewitz. The German thinker's ideas led to the formation of many Romanians military life personalities. *„Each period, therefore,* Clausewitz said, *would have held its own theory of war, even if the urge had existed always and universally to work things out on scientific principles. It means that the events of every age must be judged in the light of its own peculiarities"*. [5, p. 593]

I appreciate that the Romanian military thought, especially in the interwar period, had a significant role in promoting the key ideas and concepts, opening the way to knowledge of European military thought, later the universal one. Also, military theorists of that period were able to propose a series of military solutions to the problems that our country had. In this context, I believe that the study of Romanian military thought represents an experience in order to know how to get future, because *„the army means the whole country, which embodies the entire Romanian people, and we must know our past like our Holy Bible, like a guide to faith and duty"*. [10, p. 324].

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CONSIDERATIONS REGARDING THE PERFORMANCE OF COMBUSTION CHAMBERS FOR TURBO-JET ENGINES

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Abstract: *The proposed systems are capable of generating o form of energy transferred to a fluid and transformed into work process. The turbojet combustion chambers uses air as work fluid, it forms a chemical mixture transforming energy fuel (petrol and air) into thermal energy through a process of isobaric fire. The article aims to highlight the role and the design of the combustion chambers for jet engines construction.*

Keywords*: turbojet engine, combustion chamber, GasTurb, numerical simulation*

1.INTRODUCTION

1.1. Overviews

The proposed systems are capable of generating o form of energy transferred to a fluid and transformed into work process. These systems consist mainly of fluid propulsion (air or gas combination) and an energy source capable of generating the energy required for fluid acceleration.

The jet engine is a part of the mechanical propulsion systems with air-jets which have air as working fluid, the energy source is represented by turbocharger group compressor and the propulsion system is represented by a reaction nozzle.

In figure 1.1 we can observe the jet engine on a multirole aircraft General Dynamics F16 Fighting Falcon, a version being present and used by Romanian Air Force.

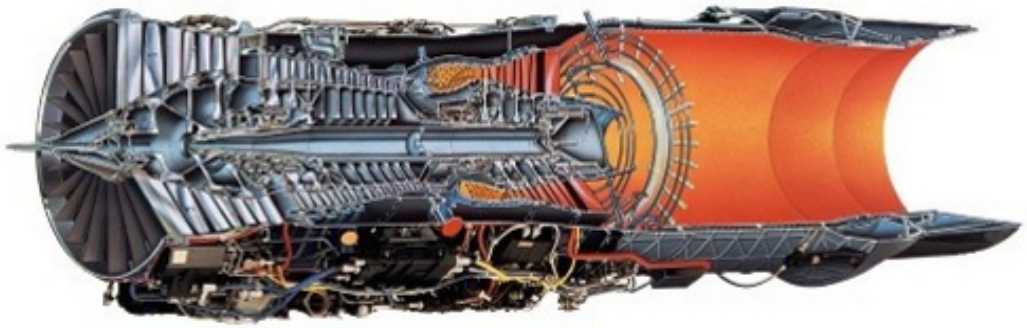
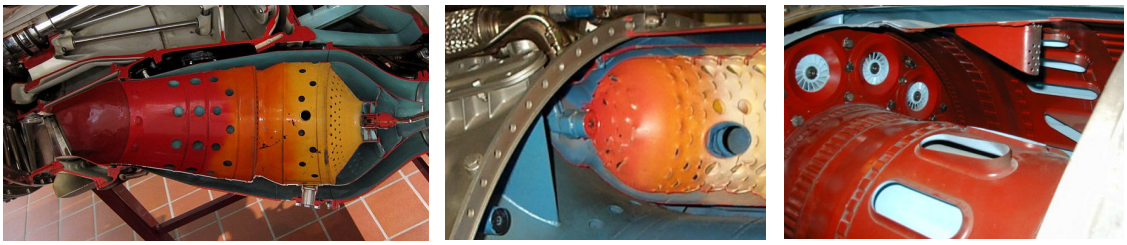


FIG. **1.1** Pratt-Whitney F100-PW220, [4].

1.2. The classification of turbo engines from the combustion chambers point of view

There are three types of constructive combustion chambers known from the following points: functional and constructive. These are individual, ring and mixed, see figure 1.2, [2, 3].

Another classification criterion is the flow direction of the working fluid in the combustion chamber: parallel flow chambers (flow purpose has the same direction as the system), countercurrent chambers, radial combustion chambers (the fluid flowing direction is radius with the directorate of the combustion chamber).



(a) (b) (c)

FIG. 1.2 Chamber combustiont ypes , a.individual, b.mixt c. ring,

2. COMBUSTION CHAMBER

2.1. Constructive principles

The combustion chamber uses air as a working fluid at a speed of Mach 0.2-0.3. She transforms the chemical energy of the fuel mixture (air and oil) into thermal energy by means of some isobaric combustion process. The combustion chamber has two streams: central flow (primary) and secondary flow. The primary air stream is combined with the fuel (the temperature is less than 225^0C) in the combustion chamber ensuring a stoichiometric combustion process, the combustion takes place at a temperature range of $2000^0 \div 2300^0$ K. In the process of combustion (exothermal) resulting combustion products which have to be cooled to enter the turbine, the cooling is conducted by means of secondary flow which together with the products of combustion form combustion gases, see Figure 2.1, [1, 7, 8, 9, 10, 13] .

Under theoretical combustion conditions we considered the maximum speed is fresh, mixtures that work using a combustion chamber with minimum overall dimensions and minimum weight.

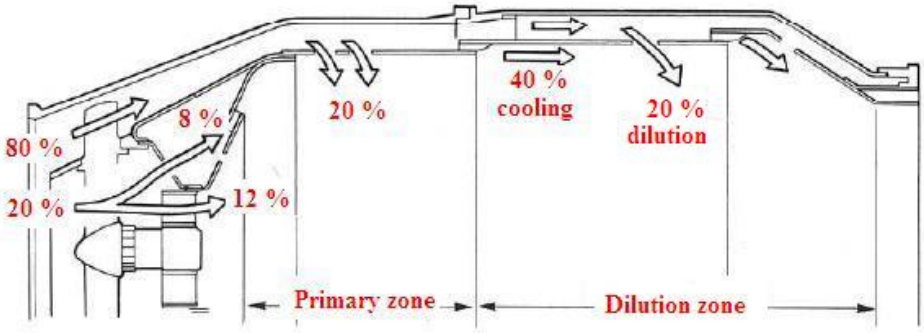


FIG. 2.1 Air flow in combustor

The temperature T_3 of the combustion gases out of the combustion chamber and the turbine depends on the composition of the combustion gases, if the temperature is low when the excess air from the secondary flow will be higher in the composition of the combustion gases.

In order to calculate the excess air we use the equation of energy conservation and the combustion mixture in the combustion chamber, namely: the sum of the total energies of the substances entering into the combustion chamber summed with the energy resulting from the combustion of air-fuel mixture and is equal to the total energy of the leaving substances from the combustion chamber, see equation 1, [6].

$$\dot{M}_a \cdot i_2^* + \dot{M}_c \cdot i_c + \xi_{ca} \cdot \dot{M}_c \cdot P_{ci} = \dot{M}_g \cdot i_3^* \quad (1)$$

Where $M_a \cdot i_2^*$ energy due to airflow in the combustion chamber

i_2^* the energy of a kilogram of air,

i_C Enthalpy of one kilogram of fuel in gaseous state,

$M_C \cdot i_c$ Energy due to fuel injection is,

$\dot{M}_c \cdot P_{ci}$ The heat released from burning,

P_{ci} The heat released by burning one kilogram of fuel and is equal to the lower calorific value of the fuel,

$\xi_{ca} \cdot \dot{M}_c \cdot P_{ci}$ It is taken from the exhaust gas energy (including losses due to heat transfer to the environment and incomplete combustion ξ_{ca})

$\dot{M}_g \cdot i_3^*$ Is the energy of one kilogram of gas out of the combustion chamber.

We also say:

$$\dot{M}_a \cdot i_2^* + \dot{M}_c \cdot i_c + \xi_{ca} \cdot \dot{M}_c \cdot P_{ci} = \dot{M}_g \cdot i_3^* \quad (2)$$

$$\dot{M}_a \cdot i_2^* + \dot{M}_c (i_c + \xi_{ca} \cdot P_{ci}) = \dot{M}_g \cdot i_3^* \quad (3)$$

where $i_c \approx 200\text{-}300$ kJ/kg, iar $P_{ci} \approx 43\,000$ kJ/kg, deci $i_c << \xi_{ca} \cdot P_{ci}$, deci:

$$\dot{M}_a \cdot i_2^* + \dot{M}_c \cdot \xi_{ca} \cdot P_{ci} \cong \dot{M}_g \cdot i_3^* \quad \text{şi} \quad \dot{M}_a \cdot i_2^* + \dot{M}_c \cdot \xi_{ca} \cdot P_{ci} \cong (\dot{M}_a + \dot{M}_c) \cdot i_3^*$$

$$i_2^* + \frac{\dot{M}_c}{\dot{M}_a} \cdot P_{ci} \cdot \xi_{ca} = (1 + \frac{\dot{M}_c}{\dot{M}_a}) \cdot i_3^* \quad (4)$$

and $$\frac{\dot{M}_c}{\dot{M}_a} = f(\alpha)$$

where α the excess of air.

In real combustion, excess air is between 0.4 ÷ 1.7, for rich blend value is 0.4, 1.7 for the lean, and the excess value for optimal air is 0.8. Limits are specific to each fuel, limits that lead to control and stabilize the flame in front of the tube fire, and when air excides a value of 1.7 the burning stops.

2.2. Requirements for combustion chambers

a. The combustion chamber must ensure a stable combustion process with a continuous flame and must be geometrical well-defined. The efficiency of the combustion process to be at maximal high (0.94 ÷ 0.98) with total and static pressure loss as small, see the equation 5.

$$\sigma_{ca}^{*} = \frac{p_3^{*}}{p_2^{*}} \tag{5}$$

Pressure losses in practice are between 0.95 ÷ 0.98 [10].

b. The combustion chamber must achieve uniform distribution of kinematic parameters and maximum temperature in the inlet section of the turbine (see Figure 2.2), by forming proper combustion chamber and the choice of an optimum number of tubes of fire, which is a compromise between pressure losses and distribution gear exiting the combustion chamber.

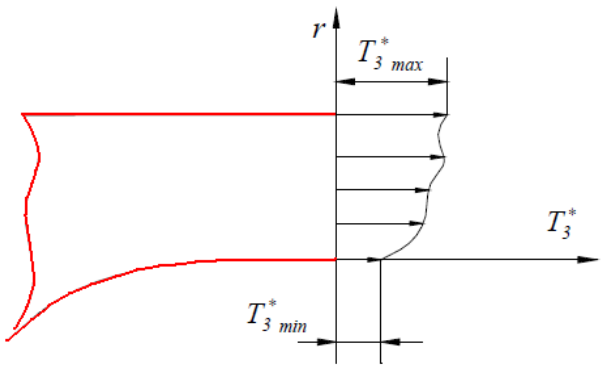


FIG. 2.2. The real distribution of the maximum temperature

Where can you define the degree of unevenness of distribution:

$$\delta_{ca} = \frac{T_{3\max}^{*} - T_{3\min}^{*}}{T_{3\max}^{*}} \tag{6}$$

For a well-designed combustion chamber value ratio is less than 0,2.

c. The combustion chamber must have a thermal load and a large operating resource.

d. The combustion chamber should be reduced to minimize the length sizing the compressor-turbine shaft and thus reduce weight and mechanical strength.

Combustion chambers as basic requirements are: simple manufacturing technology and the price of the lowest possible cost, cheap exploitation technology and satisfactory mechanical strength, [10, 11].

2.3. Fundamental performance

These are: the total pressure loss (and static), which is caused by three processes: friction, heating and mixing; the degree of heating of the fluid; combustion efficiency or burn perfection.

Total and static pressure loss is reduced with increasing air velocity through the chamber, but if airspeed out, C_2 of the compressor increases when its yield decreases, so the choice C_2 is a compromise between compressor efficiency and pressure drop in the combustion chamber . The same applies to compromise given the choice C_3 seeing a loss of the turbines efficiency in the combustion chamber.

The efficiency in the combustion chamber (ξ) is directly proportional to the heat loss and loss by mixing streams, see equation 7.

$$\xi_{ca} = \frac{Q_{ca}}{M_c \cdot P_{ci}} = 1 - \frac{Q_t + Q_{ai}}{M_i \cdot P_{ci}} \tag{7}$$

Where Q_t *is the heat that is lost through transfer between the flue gas and the environment,*

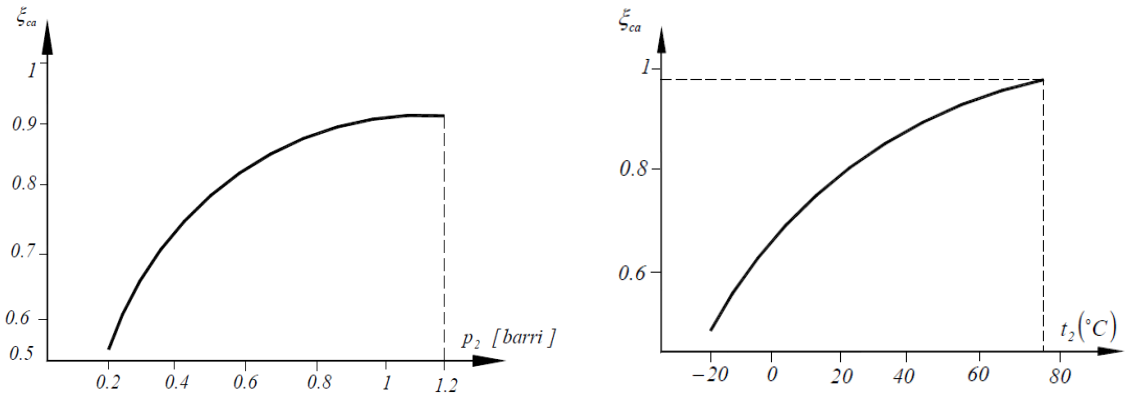
Q_{ai} *is the heat that is lost through incomplete combustion.*

Experimentally it is established that the efficient position for burning is below, equation 8 and Figure 2.3., it depend on pressure, temperature and air velocity exiting the compressor and excess air

$$\xi_{ca} = f(p_2, T_2, \alpha, C_2) \tag{8}$$

.

From the charts in Figure 2.3a and 2.3b we can observed that the efficiency of the combustion chamber becomes quasi-constant after 1.2 Barrs and temperatures over 80^0C, and the influence on the yield excess air combustion chamber is given in Figure 2.4.



(a) (b)

FIG. 2.3. Dependence on burning efficiency T_2 and p_2

In figure 2.4 we can observe that at any flight height there is an excess amount of air (α_{opt}) that is the maximum combustion efficiency and while increasing flying height we decrease the amou nt of excess air and at the same time we lower the maximum combustion efficiency.

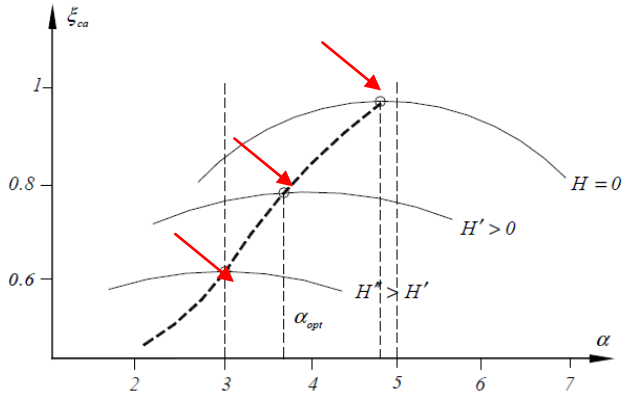


FIG. 2.4. Excess air influence on the efficiency of the combustion chamber.

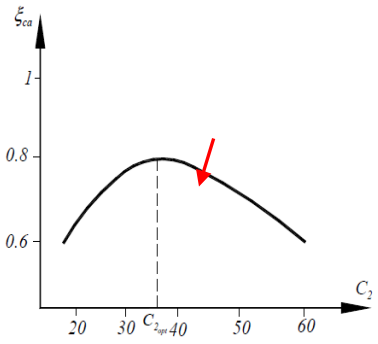


FIG. 2.5. Combustion efficiency according to C_2

Speed variation of the combustion efficiency of the compressor for the air leaving / entering the combustion chamber, shown in Figure 2.5. The physical explanation of the graphics is that at low speeds increase fluid component that is lost through heat transfer and thermal component increases at high speeds due to incomplete combustion, so there is an optimal speed C_{2opt} which is maximum combustion efficiency.

In Figure 2.6 we can observe the theoretical distribution on every subsets of the main parameters of a jet engine combustion chamber have constant pressure, an increase in temperature, flue gas velocity and hence the tractive force.

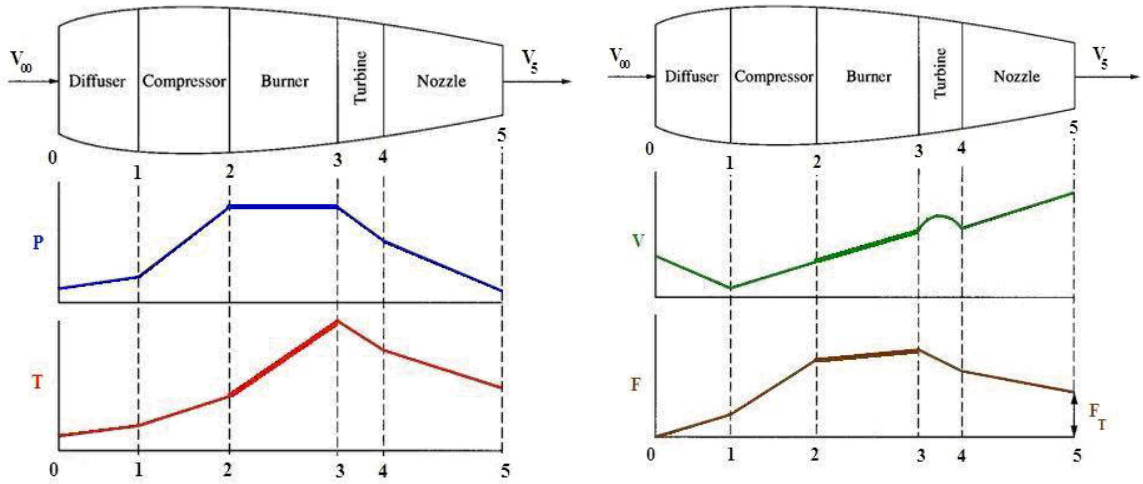


FIG. 2.6 The variation of main parameters of jet engine

3. NUMERICAL SIMULATIONS

3.1. Single cycle

To highlight the influence of operating parameters on the performance of the combustion chamber for a jet engine flight we used a software tool, GasTurb 9 and the parameters from Table 3.1 in two modes of operation, [5].

Table 3.1. Operating parameters of the combustion chamber

Mode A		Mode B	
T_1 / P_1		280 K / 99 kPa	
ξ_C / ξ_T		0,85 / 0,89	
Fuel		generic	
Traction coefficient nozzle / nozzle angle slats		$1 / 20^0$	
T_{A4}	1200 K	T_{B4}	1230 K
P_{A4}	0,9	P_{B4}	0.9

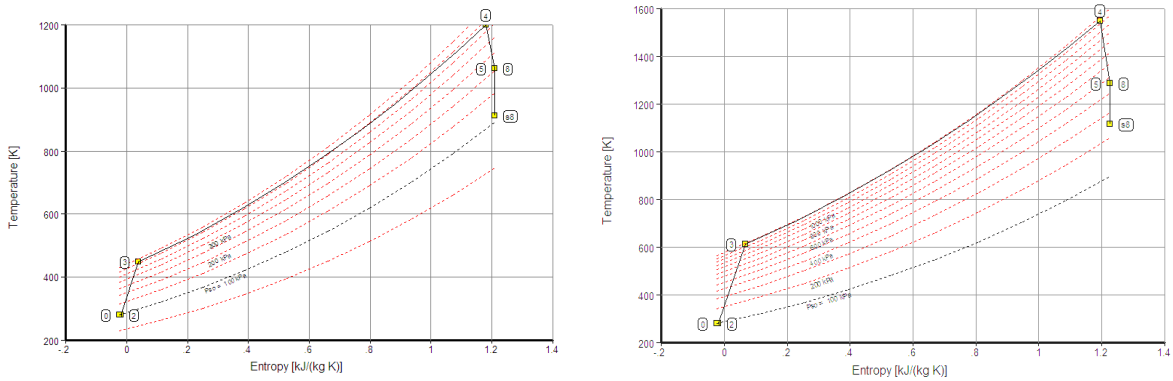


FIG. 3.1. Depending on the temperature variation of entropy, mode A (a), mode B (b)

In figure 3.1 we observed differences in variation of entropy (in both cases) depending on temperatures (1350 K to 1550 K) which runs the burning fuel mixture (with preheating the fuel to 40^0C) for a burning temperature of 1200 K engine develops a trust of 17.66 kN to 1230 K and we value 18.12 kN thrust calculated values close to those conveyed in references specialty [12].

3.2. Parametric case

For parametric study we used the initial data in Table 3.2 following the evolution of the main features of jet engine analyzed.

Table 3.2. Combustion parameters

Temp. T_1	280K	Inlet flow	26,1 kg/s
Pres. P_1	99kPa	Temp. T_4	1200 ÷ 1300K
Relative humidity	0%	Burner pressure ratio	0.8 ÷ 1

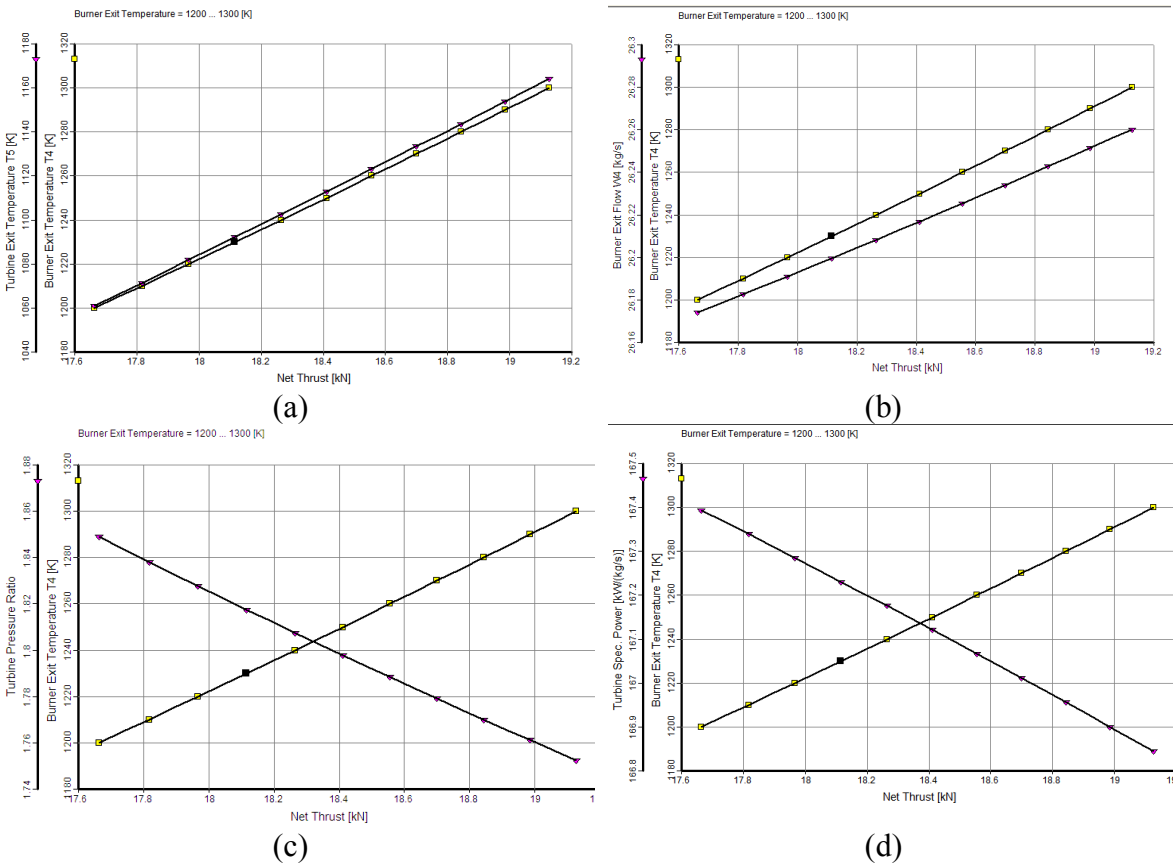


FIG. 3.2. Turbojet engine characteristics

In Figure 3.2.a is observed for the linear dependence of the net traction depending on the exhaust gas temperature T_4 at the exit of the combustion chamber and the temperature T_5 at the outlet of the turbine. Linear traction motor function and increase the amount of flue gas (see Figure 3.2.b).

For optimal values of T_4 and turbine parameters (P_5 and specific power) results in an optimal range of between 18.2 ÷ 18.4 kN thrust (see Figure 3.2.c and d).

4.CONCLUSIONS

The efficiency of the combustion chamber increases with increasing altitude and due to the specific characteristics of the fuel, such as vaporization latent heat, the viscosity, the temperature of solidification (freezing), the content of the gums or the temperature of flammability and explosion hazard.

The combustion process in the combustion chamber to the jet-engine, according to the specialized references [9, 13], can be streamlined and geometric optimization methods and experimental CFD

Using software tools for the study of variation parameters for turbojet engines we can highlight the operating limits for components considered singular or interdependent.

ACKNOWLEDGEMENT

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FORECASTING THE BEHAVIOR OF FRACTAL TIME SERIES: HURST EXPONENT AS A MEASURE OF PREDICTABILITY

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Abstract: *The Hurst exponent (H) is a statistical measure used to classify time series. H = 0.5 indicates a random series while H > 0.5 indicates a trend reinforcing series. The larger the H value is the stronger trend. In this paper we investigate the use of the Hurst exponent to classify series of financial data representing different periods of time. In this paper we show that series with large values of the Hurst exponent can be predicted more accurately than those series with H value close to 0.5. Thus the Hurst exponent provides a measure for predictability.*

Keywords: *Hurst exponent, time series analysis, forecasting*

1. INTRODUCTION

The Hurst exponent, proposed by H. E. Hurst [1] for use in fractal analysis, has been applied to many research fields, ranged from vibration and control, to biomedical signal processing, to temperature and velocity fluctuations in viscous fluid flows, and to climate change studies [2, 3]. It has recently become popular in the finance community [4, 5, 6] largely due to Peters' work [7, 8]. The Hurst exponent provides a measure for long-term memory and fractality of a time series. Since it is robust with few assumptions about underlying system, it has broad applicability for time series analysis, i.e., the origin of the time series is unimportant for this analysis. In view of this, the conclusions drawn in this study are universal and can be employed in any area of research, in which forecasting of the time series behavior is necessary.

The values of the Hurst exponent range between 0 and 1. Based on the Hurst exponent value H, a time series can be classified into three categories: (1) $H = 0.5$ indicates a random series; (2) $0 < H < 0.5$ indicates an anti-persistent series; (3) $0.5 < H < 1$ indicates a persistent series. An anti-persistent series has a characteristic of "mean-reverting", which means an up value is more likely followed by a down value, and vice versa. The strength of "mean-reverting" increases as H approaches 0. A persistent series is trend reinforcing, which means the direction (up or down compared to the last value) of the next value is more likely the same as current value. The strength of trend increases as H approaches 1. Most financial time series are persistent with $H > 0.5$.

In time series forecasting, the first question we want to answer is whether the time series under study is predictable. If the time series is random, all methods are expected to fail. We want to identify and study those time series having at least some degree of predictability. We know that a time series with a large Hurst exponent has strong trend, thus it is natural to believe that such time series are more predictable than those having a Hurst exponent close to 0.5.

In this paper we show that series with large values of the Hurst exponent can be predicted more accurately than those series with H value close to 0.50. Thus the Hurst exponent provides a measure for predictability.

In this study, we chose a financial time series, because of its data easy availability in the public domain. Yet, it is noteworthy to emphasize here once again that the conclusions drawn in this study are universal and can be employed in any area of research, in which forecasting of the time series behavior is necessary, including any risk management analysis.

2. HURST EXPONENT AND R/S ANALYSIS

The Hurst exponent can be calculated by rescaled range analysis (R/S analysis). For a time series, $X = X_1, X_2, ..., X_n$, R/S analysis method is as follows:

(1) Calculate mean value m:

$$m = \frac{1}{n}\sum_{i=1}^{n} X_i \tag{1}$$

(2) Calculate mean adjusted series Y:

$$Y_t = X_t - m, \qquad t = 1, 2, ..., n \tag{2}$$

(3) Calculate cumulative deviate series Z:

$$Z_t = \sum_{i=1}^{n} Y_i, \qquad t = 1, 2, ..., n \tag{3}$$

(4) Calculate range series R:

$$R_t = \max(Z_1, Z_2, ... Z_t) - \min(Z_1, Z_2, ... Z_t), \qquad t = 1, 2, ..., n \tag{4}$$

(5) Calculate standard deviation series S:

$$S_t = \sqrt{\frac{1}{t}\sum_{i=1}^{t} (X_i - u)^2}, \qquad t = 1, 2, ..., n \tag{5}$$

Here u is the mean value from X_1 to X_t.

(6) Calculate rescaled range series (R/S):

$$(R/S)_t = R_t / S_t, \qquad t = 1, 2, ..., n \tag{6}$$

Note $(R/S)_t$ is averaged over the regions $[X_1, X_t]$, $[X_{t+1}, X_{2t}]$ until $[X_{(m-1)t+1}, X_{mt}]$, where m = floor(n/t). In practice, to use all data for calculation, a value of t is chosen that is divisible by n.

Hurst found that (R/S) scales by power-law as time increases, which indicates:

$$(R/S)_t = c^* t^H \tag{7}$$

Here c^* is a constant and H is called the Hurst exponent. To estimate the Hurst exponent, we plot (R/S) versus t in log-log axes. The slope of the regression line approximates the Hurst exponent. For $t < 10$, $(R/S)_t$ is not accurate, thus we shall use a region of at least 10 values to calculate rescaled range. Fig. 1 shows an example of R/S analysis.

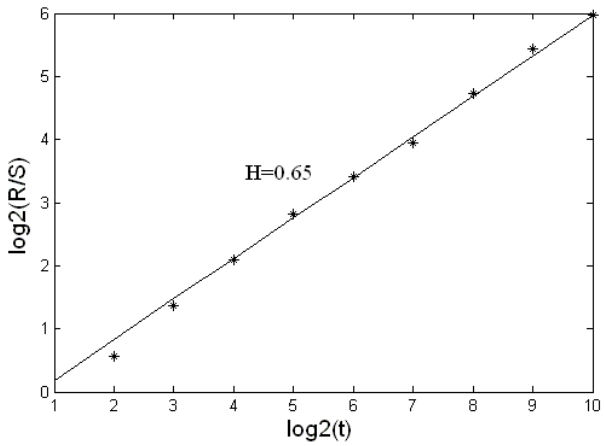

FIG. 1. R/S analysis for Dow-Jones daily return from 11/18/1969 to 12/6/1973

In our experiments, we calculated the Hurst exponent for each period of 1024 trading days (about 4 years). We use $t = 2^4, 2^5, \ldots, 2^{10}$ to do regression. In the financial domain, it is common to use log difference as daily return. This is especially meaningful in R/S analysis since cumulative deviation corresponds to cumulative return. Fig. 2 shows the Dow-Jones daily return from Jan. 2, 1930 to May 14, 2004. Fig. 3 shows the corresponding Hurst exponent for this period. In this period, Hurst exponent ranges from 0.4200 to 0.6804. We also want to know what the Hurst exponent would be for a random series in our condition.

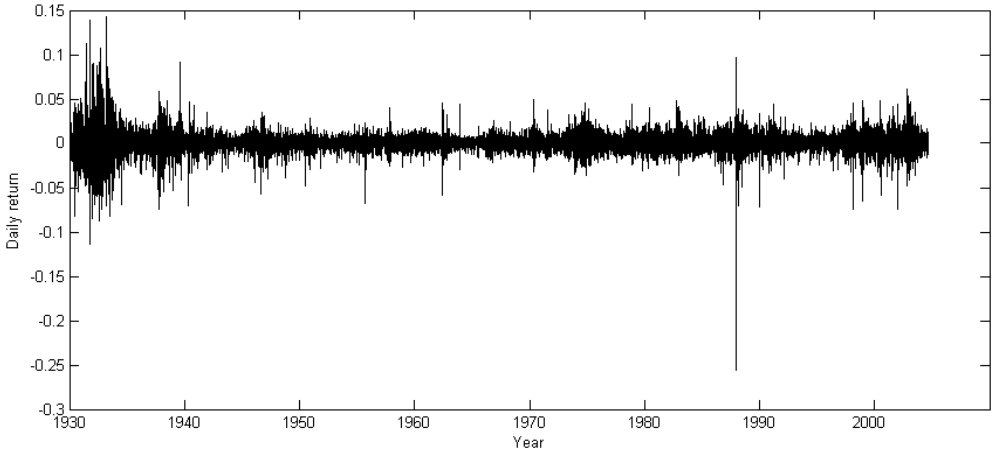

FIG. 2. Dow-Jones daily return from 1/2/1930 to 5/14/2004

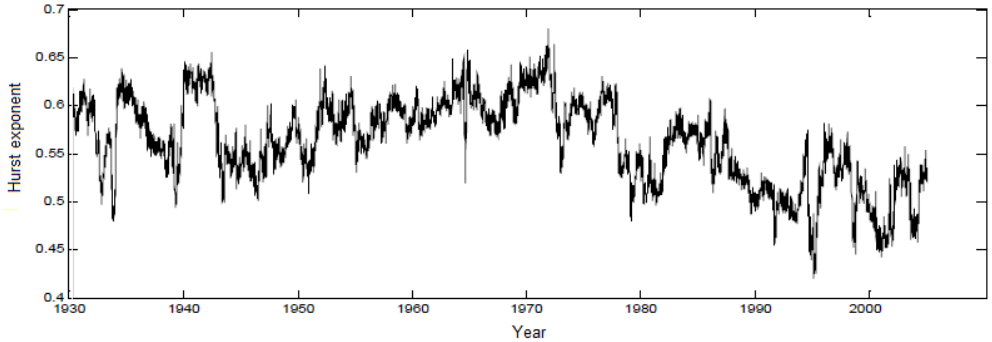

FIG. 3. Hurst exponent for Dow-Jones daily return from 1/2/1930 to 5/14/2004

3. MONTE CARLO SIMULATION

For a random series, Feller [13] gave expected $(R/S)_t$ formula as (8):

$$E\left[(R/S)_t\right] = (n\,\pi/2)^{0.50} \tag{8}$$

However, this is an asymptotic relationship and is only valid for large t. Anis and Lloyd [14] provided the following formula to overcome the bias calculated from (8) for small t:

$$E\left[(R/S)_t\right] = \left\{\Gamma\left[0.5\,(t-1)\right]/\left[\sqrt{\pi}\;\;\Gamma\left(0.5\,t\right)\right]\right\}\sum_{r=1}^{t-1}\sqrt{(t-r)/r} \tag{9}$$

For $t > 300$, it is difficult to calculate the gamma function by most computers. Using Sterling's function, formula (9) can be approximated by:

$$E\left[(R/S)_t\right] = (t\,\pi/2)^{-0.50}\sum_{r=1}^{t-1}\sqrt{(t-r)/r} \tag{10}$$

Peters [8] gave equation (11) as a correction for (9):

$$E\left[(R/S)_t\right] = \left[(t-0.5)/t\right](t\,\pi/2)^{-0.50}\sum_{r=1}^{t-1}\sqrt{(t-r)/r} \tag{11}$$

We calculate the expected (R/S) values for $t = 2^4, 2^5, \ldots, 2^{10}$ and do least squares regression at significance level $\alpha = 0.05$. Results are shown in table 1.

Table 1. Hurst exponent calculation from Feller, Anis and Peters formula

log2(t)	log2[$E(R/S)$]		
	Feller	*Anis*	*Peters*
4	0.7001	0.6059	0.5709
5	0.8506	0.7829	0.7656
6	1.0011	0.9526	0.9440
7	1.1517	1.1170	1.1127
8	1.3022	1.2775	1.2753
9	1.4527	1.4345	1.4340
10	1.6032	1.5904	1.5902
Regression Slope (*H*)	**0.5000** ±5.5511e-16	**0.5436** ±0.0141	**0.5607** ±0.0246

From table 1, we can see that there are some differences between Feller's, Anis' and Peters' formulae. Moreover, their formulae are based on large numbers of data points. In our case, the data is fixed at 1024 points. So what is the Hurst exponent for random series in our case?

Fortunately, we can use Monte Carlo simulation to derive the result. We generate 10,000 Gaussian random series. Each series has 1024 values. We calculate the Hurst exponent for each series and then average them. We expect the average number to approximate the true value. We repeated this process 10 times. Table 2 below gives the simulation results.

From table 2, we can see that in our situation, the Hurst exponent calculated from Monte Carlo simulations is 0.5454 with standard deviation 0.0485. Our result is very close to Anis' formula.

Based on the above simulations, with 95% confidence, the Hurst exponent is in the interval 0.5454 ± 1.96·0.0485, which is between 0.4503 and 0.6405. We choose those periods with Hurst exponent greater than 0.65 and expect those periods to be bearing some structure different from random series. However, since these periods are chosen from a large sample (total 17651 periods), we want to know if there exists true structure in these periods, or just by chance. We run a scramble test for this purpose.

Table 2. Monte Carlo simulations for Hurst exponent of random series

	Simulated Hurst exponent	*Standard deviation (Std.)*
1	0.5456	0.0486
2	0.5452	0.0487
3	0.5449	0.0488
4	0.5454	0.0484
5	0.5456	0.0488
6	0.5454	0.0481
7	0.5454	0.0487
8	0.5457	0.0483
9	0.5452	0.0484
10	0.5459	0.0486
Mean **Sdt.**	**0.5454** ±2.8917e-4	**0.0485**

4. SCRAMBLE TEST

To test if there exists true structure in the periods with Hurst exponent greater than 0.65, we randomly choose 10 samples from those periods. For each sample, we scramble the series and then calculate the Hurst exponent for this scrambled series. The scrambled series has the same distribution as the original sample except that the sequence is random. If there exists some structure in the sequence, after scrambling the structure will be destroyed and the calculated Hurst exponent should be close to that of a random series. In our experiment, we scramble each sample 500 times and then the average Hurst exponent is calculated. The results are shown in table 3 below.

Table 3. The average Hurst exponent on 500 scrambling runs

	Hurst exponent after scrambling	*Standard deviation*
1	0.5492	0.046
2	0.5450	0.047
3	0.5472	0.049
4	0.5454	0.048
5	0.5470	0.048
6	0.5426	0.048
7	0.5442	0.051
8	0.5487	0.048
9	0.5462	0.048
10	0.5465	0.052
Mean	**0.5462**	**0.048**

From table 3, we can see that the Hurst exponents after the scrambling of samples are all very close to 0.5454 which is the number from our simulated random series. Given this result, we can conclude that there must exist some structure in those periods making them different from random series and that scrambling destroys the structure. We hope this structure can be exploited for prediction.

5. HURST EXPONENTS AS A MEASURE OF PREDICTABILITY

The efficient market hypothesis (EMH) asserts that financial markets are "efficient", or prices on traded assets, e.g. stocks, bonds, or property, already fully reflect all available information and therefore are unbiased in the sense that they reflect the collective beliefs of all investors about future prospects. In other words, the efficient market hypothesis implies that it is not possible to consistently outperform the market – appropriately adjusted for risk – by using any information that the market already knows, except through luck. The efficient market hypothesis follows from the assumption that the price formation is a random walk process. The random walk theory asserts that price movements will not follow any patterns or trends and that past price movements cannot be used to predict future price movements.

The paradox hidden behind the EMH is the same as the paradox of instantaneous energy propagation behind the classical diffusion (heat transfer) model. In physics, this paradox is overcome by assuming a finite time lag between the onset of a disturbance upon a physical system and the system's response to it. A similar assumption of phase-lagging behavior must be made to realistically describe the behavior of markets.

Introducing a finite time lag between receiving a new piece of information and response to it, allows one, in turn, to introduce a quantitative measure of the market *inefficiency* at any given moment of time (the inefficiency coefficient). The more inefficient market is the more predictable its behavior. Hence, computing the inefficiency coefficient as a function of time and, from its value, the predictability measure, one should be able to forecast the market behavior. The forecast will be more exact for larger values of the inefficiency coefficient and less exact for smaller values, becoming zero at those instances when market becomes fully efficient (see [15] for details).

In the preceding sections we showed that the Hurst exponent, a measure of the time series persistency, can be viewed as a predictability measure of those time series. It is hypothesized here that the time series in question are in fact solutions to fractional (non-integer order) partial differential equations, in which the Hurst exponent is the order of the time derivative and is itself a function of time. This presents the main mathematical challenge of the model: to develop methods for solving fractional partial differential equations with time-variable order [16].

From the practical point of view, the knowledge of the value of the inefficiency coefficient provides one with an edge with respect to an average (unknowledgeable or uninformed) market participant. Hence, the Kelly theorem can be used to maximize one's gain (the expected rate of return) from trading an asset. The Kelly theorem asserts that, to maximize one's return, the fraction of the current bankroll to wager must be equal to the ratio of the expected net winnings to the net winnings if one wins [17].

Indeed, the amount of information, obtained from one's knowledge of the Hurst exponent's value is

$$S = -H\log(H) - (1-H)\log(1-H) \tag{12}$$

The function, given by (12), reaches its maximum at $H = 0.5$, S(0.5) = 1 and is symmetric with respect to its maximal value, that is, $S(0) = S(1) = 0$. At the same time, it is obvious that the behavior of time series becomes totally predictable at S = 0, while the case of S = 1 represents a totally unpredictable time series. From this, a predictability measure can be introduced merely as

$$P = 1 - S \tag{13}$$

At the same time, P merely plays the role of the probability to win and the Kelly criterion gives

$$f = \frac{P(b+1)-1}{b} \tag{14}$$

where f is the fraction of the current bankroll to wager, i.e. how much to bet and b is the net odds received on the wager ("b to 1"), that is, one could win \$b (on top of getting back your \$1 wagered) for a \$1 bet.

CONCLUSIONS

In this paper, we analyze the Hurst exponent for all 1024-trading-day periods of the Dow-Jones index from January 2, 1930 to May 14, 2004. We find that the periods with large Hurst exponents can be predicted more accurately than those with H values close to random series. This suggests that stock markets are not totally random in all periods. Some periods have strong trend structure and this structure can be used to benefit forecasting.

Since the Hurst exponent provides a measure for predictability, we can use this value to guide data selection before forecasting. We can identify time series with large Hurst exponents before we try to build a model for prediction. Furthermore, we can focus on the periods with large Hurst exponents. This can save time and effort and lead to better forecasting.

It is noteworthy to emphasize here once again that the conclusions drawn in this study are universal and can be employed in any area of research, in which forecasting of the time series behavior is necessary, including any risk management analysis [18, 19].

AKNOWLEDGMENT

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A THEORETICAL APPROACH OF A NEW ELECTROMAGNETIC LAUNCH SYSTEM

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Abstract: *This paper presents a theoretical study of a new design of an electromagnetic launch system (EMLS). The presented system does not follow the path of the previous systems. Instead to accelerate a conductor like in the previous systems this new design accelerates permanent magnets made ring, based on Halbach array arrangements. In the first part of the paper are presented the objectives of the new EMLS design. Then the existing solutions are presented in order to identify the limitations. Based on these observations a new design is presented. In order to analyze the interaction between all elements of this design, an interactive software package based on finite element method (FEM) was used to analyze, solve 3D electromagnetic field problems, and simulate the movement of Halbach array armature. All simulation data confirm this new design has a great potential of development.*

Keywords: *railgun, coilgun, Halbach array, Lorentz force*

1. INTRODUCTION

Different kinds of energy can be used in order to accelerate an object of mass *m*. If we want to obtain also great performance the chemical energy may be used. In time the launch systems based on chemical energy achieved their limits. In order to expand the limits of launch systems the electromagnetic energy can be used [1]. Different electromagnetic launch systems were developed in time. The most promising systems were based on Lorentz Force. According to the theory the Lorentz force is:

$$\vec{F} = q\vec{v} \times \vec{B} \tag{1}$$

Because in EMLS we don't use a singular charge but many, it is much easy to use the equation of Lorentz force based on current intensity. This form of Lorentz force is sometimes presented as Laplace force.

$$\vec{F} = I \cdot \vec{l} \times \vec{B} \tag{2}$$

$$F = I \cdot l \cdot B \cdot \sin\alpha \tag{3}$$

where α is the angle between vectors $\vec{l}$ and $\vec{B}$;

The force has a maximum when $\alpha = 90^0$ and a minimum (null) when $\alpha = 0^0$ or $\alpha = 180^0$.

This is an important remark because when we create an EMLS the magnetic flux density $\vec{B}$ must be perpendicular on a current-carrying wire.

The objectives of this theoretical study are to accelerate a projectile of mass $m = 1kg$ from speed $v_0 = 0\,m/s$ to $v_1 = 3000\,m/s$ on a distance $x = 10m$. The kinetic energy of the projectile with muzzle velocities $v_1 = 3000\,m/s$ will be:

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}\cdot 1\cdot 3000^2 = 4.5\cdot 10^6 = 4.5MJ \tag{4}$$

If we consider the projectile uniform accelerated on the length $x = 10m$ we can find the acceleration value:

$$v_1^2 = v_0^2 + 2a(x - x_0) \tag{5}$$

$$a = \frac{v_1^2}{2\cdot x} = \frac{9\cdot 10^6}{20} = 4.5\cdot 10^5\ m/s^2 \tag{6}$$

The value of force acting on projectile must be:

$$F = m\cdot a = 1\cdot 4.5\cdot 10^5 = 450kN \tag{7}$$

According with these determinations, we are looking for an EMLS able to create a *450kN* force which will act on projectile on the length of 10m.

2. THE EXISTING SOLUTIONS

Different designs of EMLS were studied in time. One of the best designs is called railgun. A railgun consists of two parallel conductors called rails and a sliding conductor between rails called armature. The projectile is mechanically connected with armature.

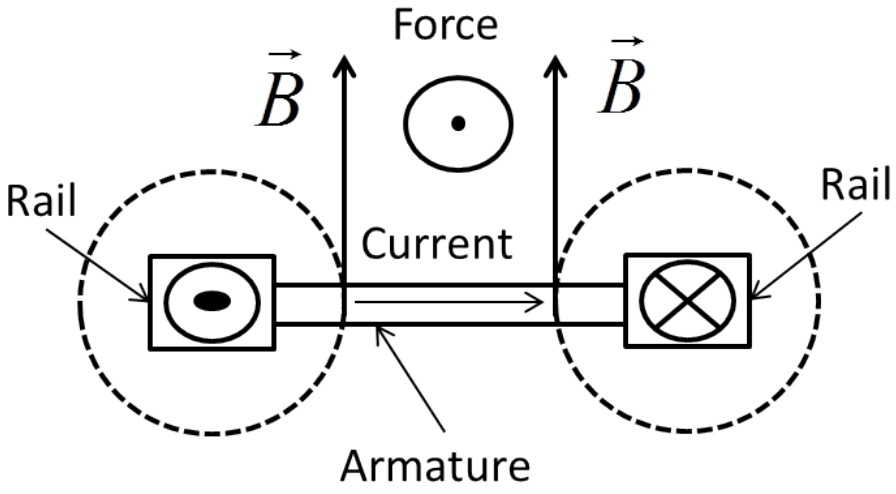

FIG. 1 Railgun

A very high current I flows through rails. The combination between this simple design and very high currents creates the condition to obtain a great Lorentz force on armature according with figure 1.

Studying figure 1 we can observe some advantages of this design:

- the magnetic flux density $\vec{B}$ is perpendicular on armature;
- the current I create the magnetic field around rails and the current on armature. By increasing the current I the Lorentz force is also increased;
- the length of rails can be calculated according with the performance of the launcher.

The expression of force acting on armature can be approximate according to (8) [2].

$$F = \frac{1}{2} I^2 L' \tag{8}$$

where L' is magnetic gradient inductance.

Because this design uses only straight conductors the value of magnetic gradient inductance is very low. The only way to obtain a high value of force is to increase the current I which flows through conductors.

We can name this design a **current based EMLS**.

Another important advantage of this design is the angle between magnetic field and armature, which is 90^0. Even the magnetic field created by rails is not so strong compared with a magnetic field created by a coil, the armature is touching the rails and use very efficient the magnetic field created.

This big advantage comes also with a big disadvantage of this design: sliding contacts between armature and rails.

In order to create a great EMLS design we should preserve the advantages of railgun design and to avoid his great weakens-sliding contacts. We are looking also for a design which doesn't use high currents to obtain desired force.

The second direction of development of EMLS is induction coilgun. In order to reduce the value of current I the rails can be replaced by coils. By using coils we can obtain the same value of magnetic flux density $\vec{B}$ created by the rails with less amount of current. The current inside armature can be obtained by using induction instead of sliding contacts.

$$u_i = -\frac{d\phi_B}{dt} \tag{9}$$

$$u_i = -\frac{d}{dt}(BA\cos\theta) = -\left(\frac{dB}{dt}\right)A\cos\theta - B\left(\frac{dA}{dt}\right)\cos\theta + BA\sin\theta\left(\frac{d\theta}{dt}\right) \tag{10}$$

where θ is the angle between $\vec{B}$ and $\vec{n}$ (normal unit of surface area A).

We assume the magnetic field is uniform distributed in space.

The coilgun design was developed based on Faraday's law.

In this particular case the only variable in (10) is the magnetic field, the surface A and angle θ being constant. The Faraday's law can be written:

$$u_i = -\left(\frac{dB}{dt}\right)A\cos\theta \tag{11}$$

A possible design consists of coils which create a gun barrel and allow a projectile made by aluminum to move inside them, presented in figure 2.

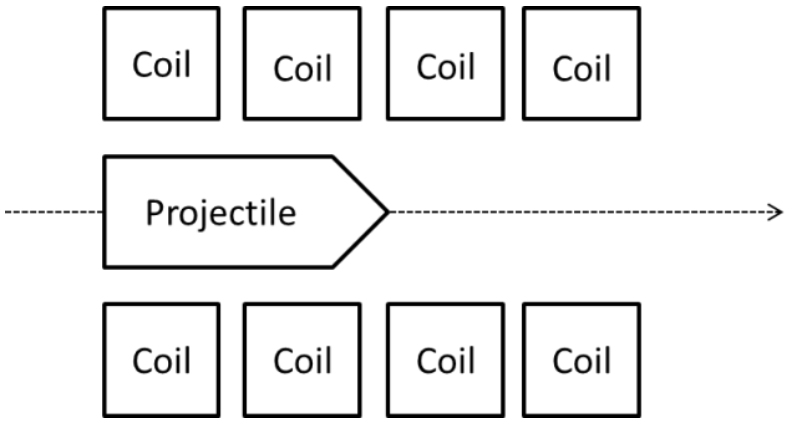

FIG. 2 Induction coilgun

The axial component of magnetic flux density $\vec{B}_a$, inside coil creates the induced current inside projectile, which interact with radial component of magnetic flux density $\vec{B}_r$.

The induced current depends on rate of change of the axial magnetic flux density $\vec{B}_a$ and the radial magnetic flux density $\vec{B}_r$ depends on amount of magnetic flux. The magnetic flux is created by the coil and is the only one which induces current in projectile, providing simultaneously the radial magnetic field on induced current [4-6].

It is difficult to control with a coil both the rate of change of the axial magnetic flux density $\vec{B}_a$ and the radial magnetic flux density $\vec{B}_r$. Also it is difficult to control the phase of induced current in projectile and the phase of the radial magnetic flux density $\vec{B}_r$.

Compared with railgun, the coilgun creates a strong magnetic field using only a fraction of current and avoiding sliding contacts.

The coilgun design is also much complex than railgun because the position of projectile must be synchronized with powered coils. Also the coilgun use AC currents instead DC currents and the phase must be tighten controlled.

In order to increase the radial magnetic flux density $\vec{B}_r$ and to decrease the current inside the coil a design with magnetic circuit made by ferromagnetic materials was proposed. The magnetic circuit creates also a zone where the magnetic field is radial on conductor, in our case a ring (figure 3) [7]. The E shaped design use the soft magnetic materials and use the Lorentz force to accelerate projectiles but that design does not allow to control the difference of phase between induced current in projectile and the phase of the radial magnetic flux density $\vec{B}_r$ [8].

We can name this design a **magnetic flux density based EMLS**.

The induction coilgun design presented in figure 3 is important for our study because the projectile is not located inside a gun barrel like in railgun and classical coilgun but is located outside acceleration system.

Because we use electromagnetic energy to accelerate the projectile we do not need a barrel like guns which use chemical energy. This is a very important remark.

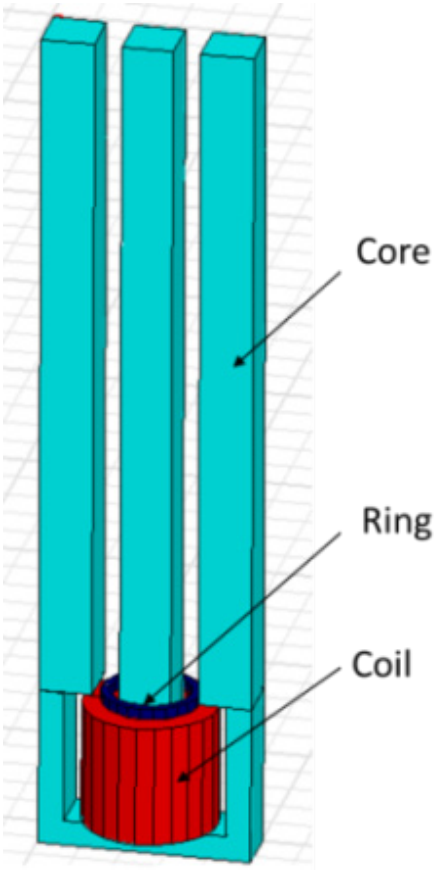

FIG. 3 E shaped coilgun

At this point we can identify the main aspects which should be taken into consideration when a design of an EMLS is created:

- the Lorentz force should be used to accelerate the projectile;
- the magnetic field should be perpendicular on current-carrying conductor;
- the contact between the projectile and the accelerator should be avoided.

If possible, the EMLS should be simple as a railgun and efficient as a coilgun. A design which respects all this conditions is presented in the following chapter.

3. THE NEW HALBACH ARRAY GUN

Before the presentation of a new electromagnetic launch system we will analyze again the equation of Lorentz force (3).

In order to obtain maximum force the angle must be $\alpha=90^0$.

It is not necessary to create the magnetic field by using current *I*. The magnetic field can be created by an independent source like permanent magnets. The *1T* magnetic flux density *B* can be easy obtained with permanent magnets. A value of *10T* is relatively hard to obtain, so increasing the force value in this way is not justified. In the near future it is possible to obtain permanent magnets with magnetic field larger than *1T*.

The value of current *I* can be easily increased as we saw in railgun design. Because the conductor must to be linked with a powerful current source the moving element can be the permanent magnet.

The permanent magnet can act as an armature like in railgun design with a projectile mechanically attached.

The next element is *l* (length of conductor inside magnetic field) and apparently its value cannot be modified, but if we use more wires (let's say *N* turns) like in a coil we can increase easily the value of force by *N* times.

If we manage to increase the number of conductors inside magnetic field by *N* times, we can increase the total force acting on armature by *N* times [9]. This is an easy way to increase the force. This number depends by the size of wire and the space volume where the magnetic field is strong enough to create a useful Lorenz force. For our design the determined value of *N* is *4000*.

In order to obtain a magnetic field perpendicular on conductors, a circular Halbach array with linear field inside should be used.

For our design we chose a circular Halbach array made by 8 permanent magnets like in figure 4.

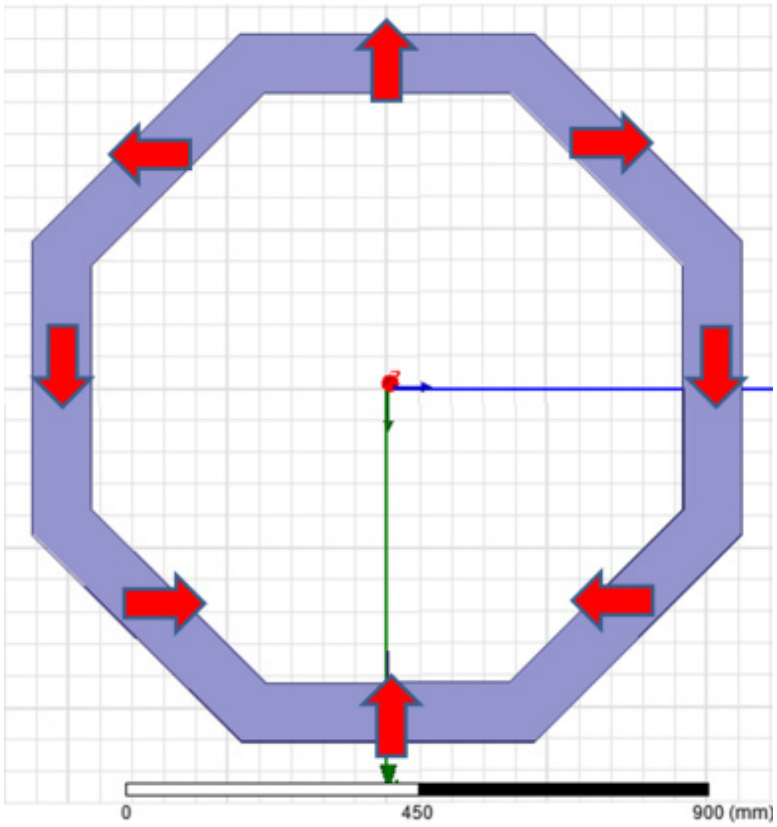

FIG. 4 Cylindrical Halbach array with uniform field inside

We marked with arrows the direction of magnetization of each piece of permanent magnet from circular Halbach array. We obtain a magnetic field with linear flux lines from the bottom of figure to the top.

The **Maxwell** interactive software package that uses the finite element method (FEM) was used to simulate the magnetic field created by the circular Halbach array.

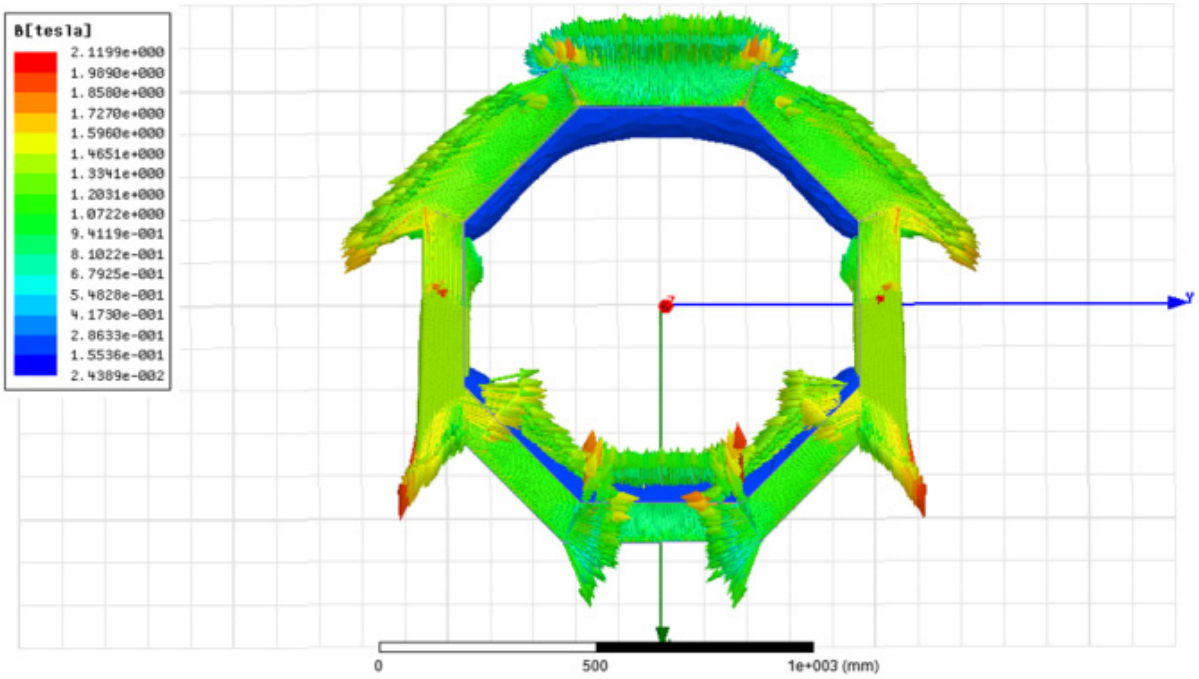

FIG. 5 Top view of a circular Halbach array

In figure 5 is displayed a simulated top view of direction of magnetization of each piece from circular Halbach array.

The two marked areas on top and bottom of figure represent the space where magnetic field is strong enough to act on conductors.

In order to obtain a strong force, the conductors must be placed inside these two marked areas. Their volume influences the number of conductors *N*.

Because the magnetic field is not uniform, on every conductor will act a different value of magnetic field density *B*. In the center of array the magnetic field is very weak. We use this space to connect conductors in a proper way.

According to the theory the magnetic flux lines are linear inside array.

In figure 6 is displayed a simulated side view of the array magnetic field. We can also observe the magnetic field is not uniform, so if we place conductors nearby permanent magnets (where the magnetic field is strong enough), on every conductor will act a different value of magnetic flux density *B*. Also in the center of array the magnetic field is very weak.

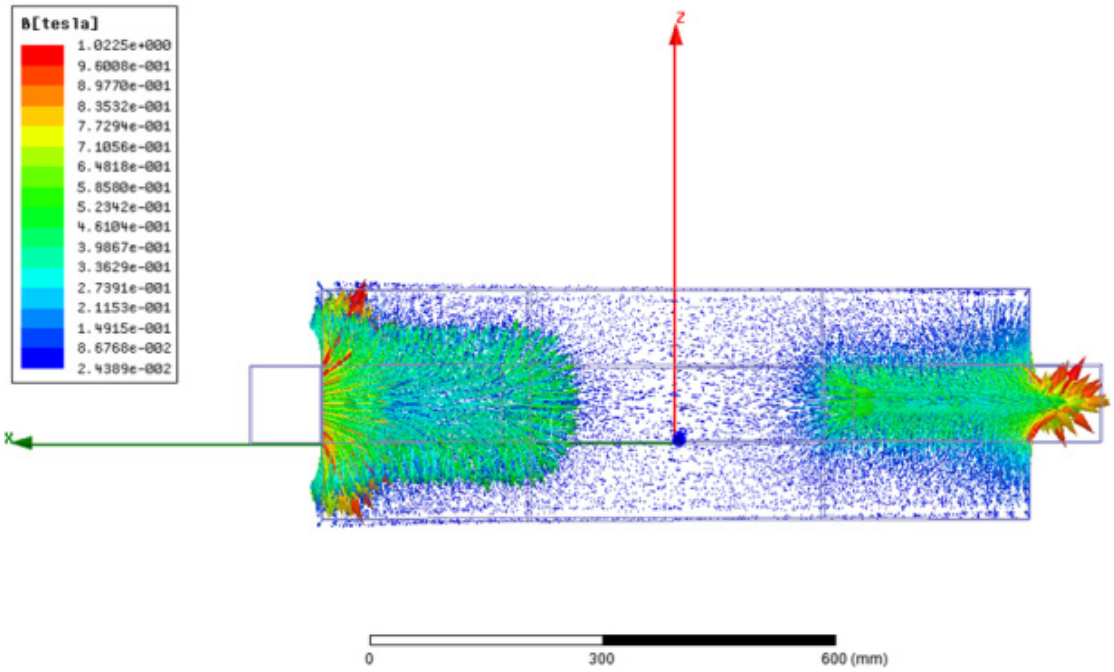

FIG. 6 Side view of a magnetic field created by a circular Halbach array

The non-moving part of electromagnetic launch system is represented by conductors arranged as displayed in figure 7.

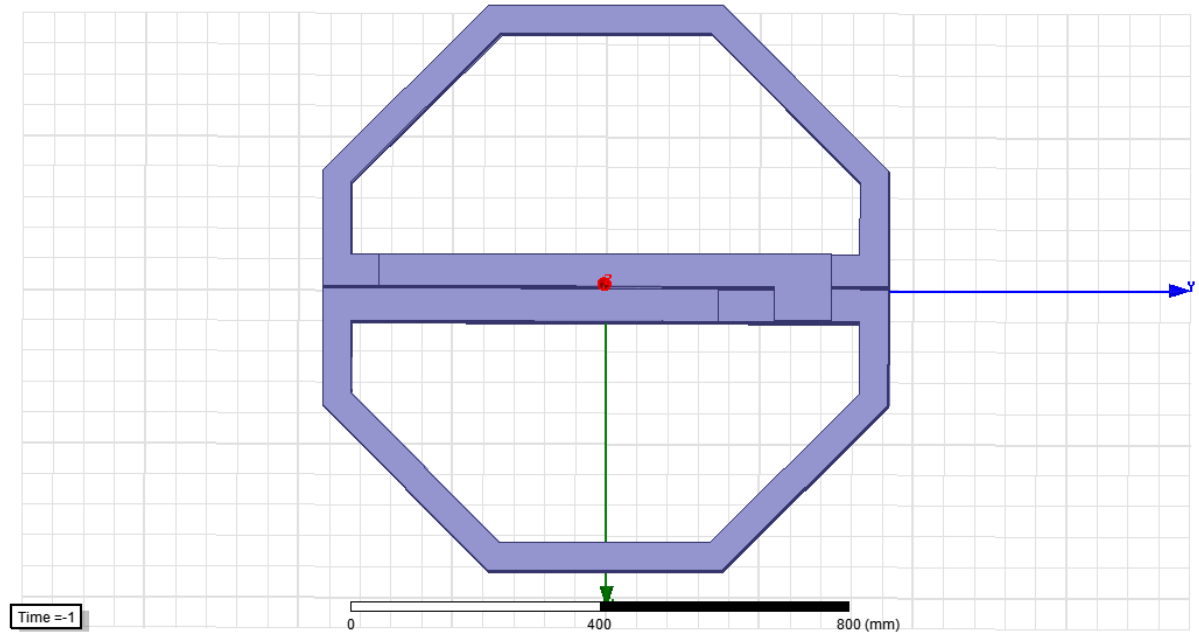

FIG. 7 Top view of conductors

In order to obtain a cumulative Lorentz force acting on Halbach array on z positive direction the sense of current in conductors placed in bottom of figure 7 must be the same like in conductors placed on top.

This is not possible with a normal coil configuration. For this reason we use the center of the array to connect conductors. Because the magnetic field in the center of array is weak, the Lorentz force created is also weak.

The conductors are placed where the magnetic field has the highest value on x axis of the array and are placed in such a way to obtain all conductors with the same direction of the flowing current.

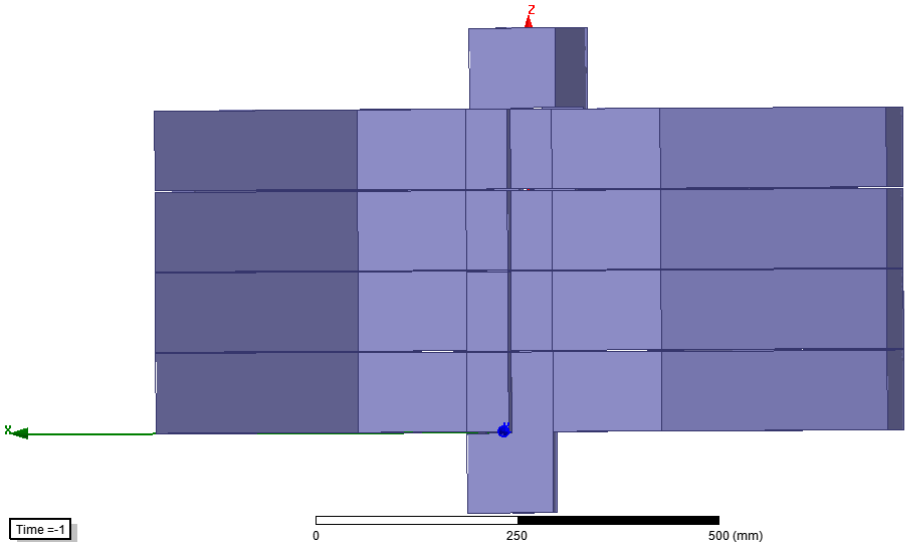

FIG. 8 Side view of conductors

For our simulation the conductors are divided in 4 stages of the length equal to the one of permanent magnets, like in figure 8. For each stage we have two sets of conductors in order to obtain the Lorentz force with same orientation on both sides of Halbach array. According with the destination of EMLS, the number of stages may be increased in order to obtain a desired distance of acceleration. All conductors are connected to the same DC power source.

The magnetic flux density B is acting on conductors and with this configuration we have N conductors of length l placed inside magnetic field.

The conductors are arranged in such a way to carry the same intensity of current in each of them. We can increase now the value of current in order to obtain the desired value of force.

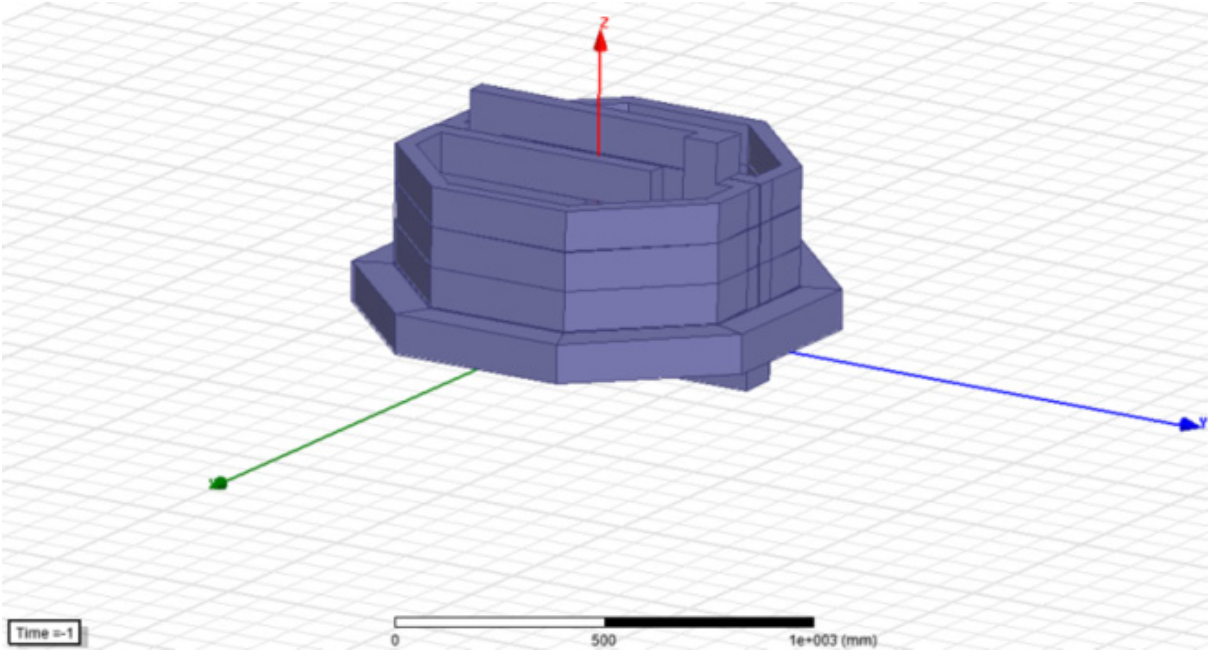

FIG. 9 The Halbach array launch system

Figure 9 shows this new design of an electromagnetic launch system. It is a different approach.

The moving part is placed outside like in E shaped coilgun but now the ring is made by permanent magnets instead of a conductor.

The static parts which accelerate the Halbach array don't form a gun barrel like in railgun and coilgun designs.

The Halbach array is the armature which is moving outside conductors in z positive direction. This design is indeed simple as a railgun design and efficient as a coilgun design.

In the following chapter the simulation results of this new design are presented. Even every conductor of this design has the same current, the magnetic field acting on every conductor is different, according with figure 6.

In order to obtain a well approximated value of the cumulative force acting on Halbach array ring, we used the above mentioned **Maxwell** interactive software package based on finite element method (FEM) to analyze, solve 3D electromagnetic field problems, and simulate the movement of Halbach array armature.

4. THE SIMULATION RESULTS

The permanent magnets with a height of *100mm* are arranged as a cylindrical Halbach array with magnetic field inside in one direction, along x axis. The conductors are placed in cylinder inner space and are divided into four stages. The number of stages depends on the necessary acceleration distance to obtain desired muzzle velocity of projectile. In our simulation the acceleration distance is *400mm*.

Each stage has two sets of conductors in order to control the direction of current inside. In this way the direction of Lorentz force is the same for both sets of conductors of each stage. The conductors are powered with a DC source. Each set of conductors can accommodate *4000* separate conductors. The inner radius of Halbach array is $R_i = 500mm$ and the outer radius is $R_o = 600mm$. The dimensions of Halbach array ring were determined taking into consideration the value of magnetic field in the center of the ring (very low value) and the volume of *4000* conductors accommodated in the area of strong magnetic field. The total mass of moving object (armature plus projectile) is $m = 1kg$.

The interaction between all elements of the design was checked for different values of current in conductors. The results for *I=500A* are presented in the following graphs.

The time variation of Lorentz force acting on z positive direction on armature is presented in figure 10.

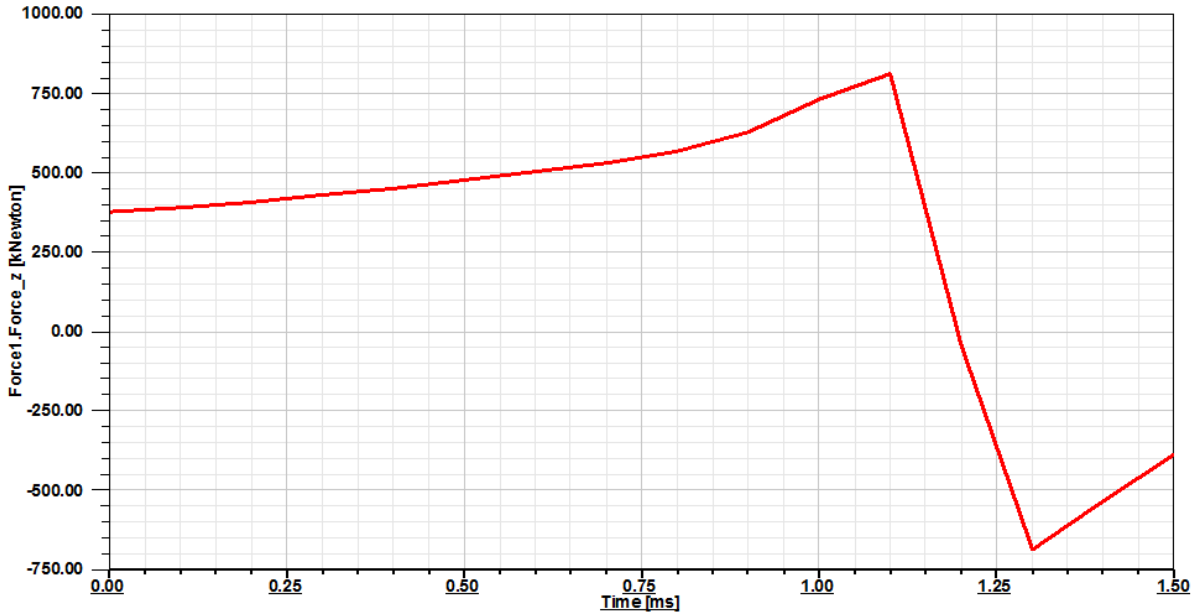

FIG. 10 Lorentz force acting on armature

The Lorentz force acting on armature starts at *377kN* and increases in time up to *811.61kN*.

When the armature left conductors the force decreases rapidly and acts in opposite direction. This is not bad because our intention is to accelerate a projectile and at this stage the projectile is released by armature.

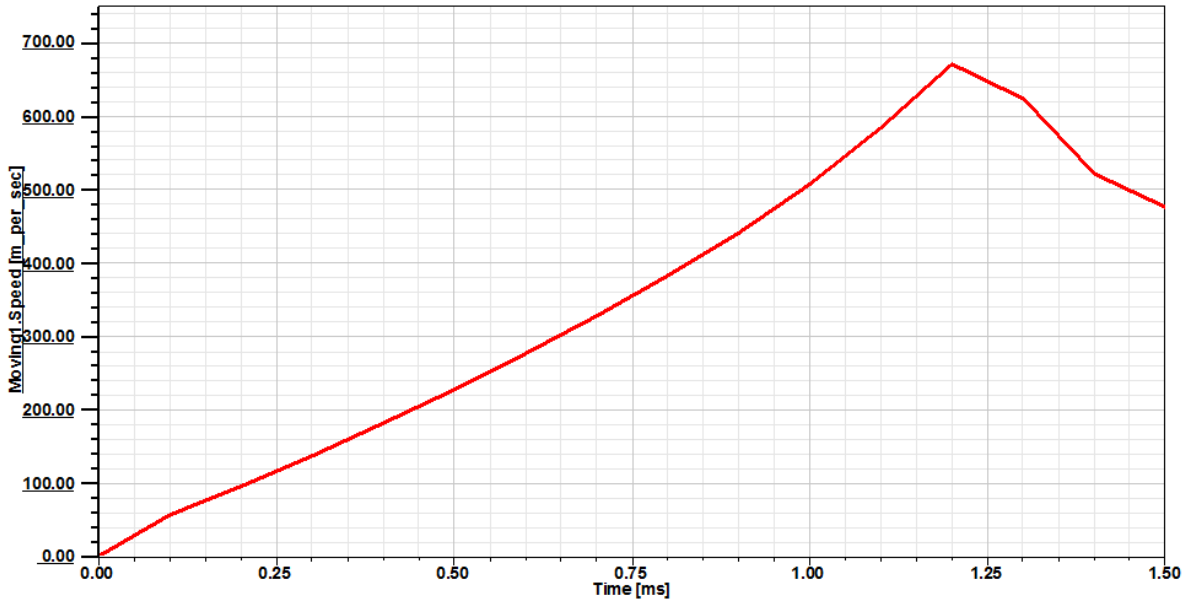

FIG. 11 Muzzle velocity of armature

Based on force acting on armature the muzzle velocity is calculated. In figure 11 the time variation of the speed of the armature is displayed. The armature is accelerated up to *669m/s*. At this point the projectile is released and the speed of armature is slowing down.

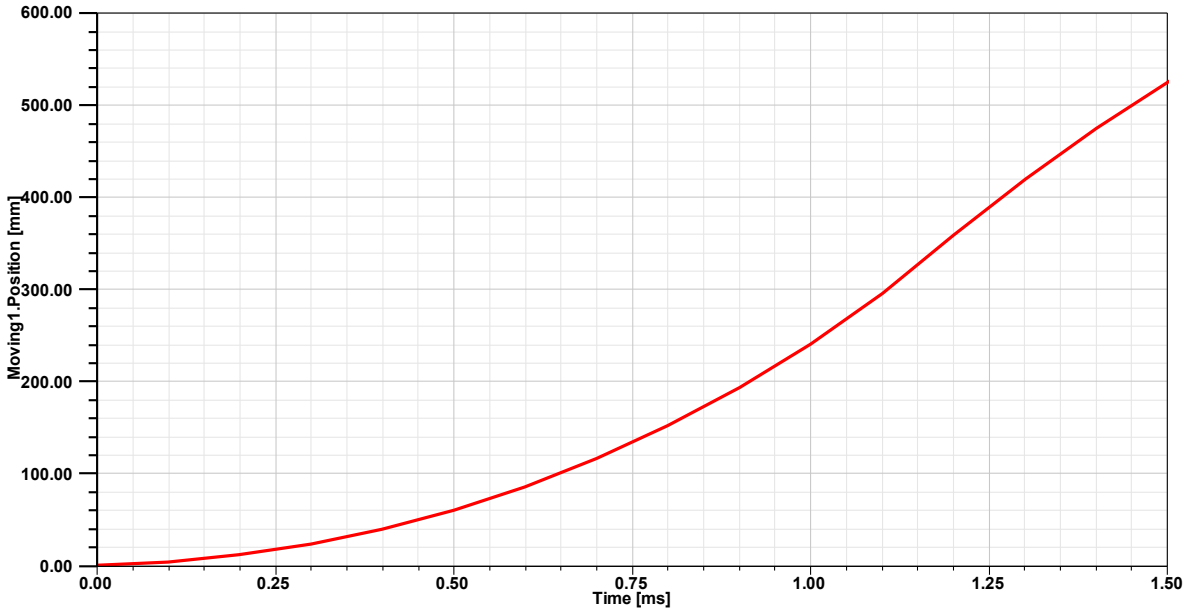

FIG. 12 The moving position of armature

In figure 12 is displayed the position of Halbach array ring in time. The simulated acceleration distance is only *400mm*. According to figure 12 the armature leaves the accelerator in *1.26ms*. For our simulation the length of power current pulse should be *1.26ms*.

In figure 13 are displayed the time variation of force, speed and moving position of armature, together.

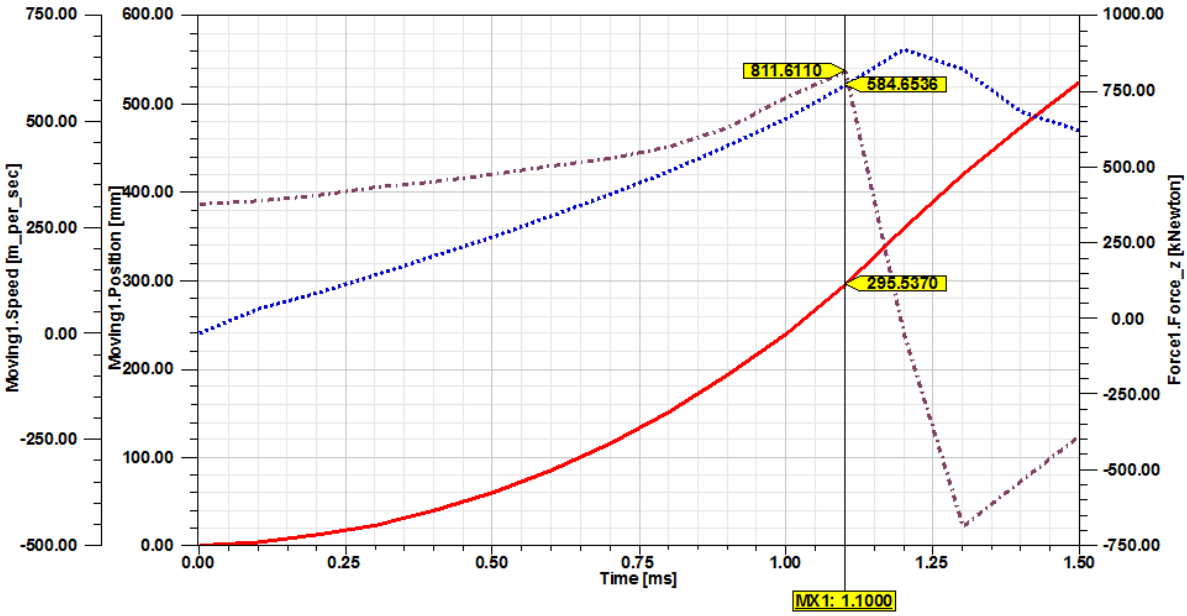

FIG. 13 The time variation of force, speed and moving position of armature

From figure 13 we can observe the maximum force is obtained when the armature is in the third stage (of four) of acceleration, *295mm*.

In the last stage of acceleration the force decreases rapidly because fewer conductors are inside magnetic field and the direction of magnetic field acting on conductors is different.

If we increase the number of stages in order to obtain the length of acceleration $x = 10m$ we will expect the force acting on armature will decrease only during the last stage.

The maximum force obtained on our simulation was *811.61kN* which is more than the necessary value to achieve our objective. The muzzle velocity of armature after *400mm* of acceleration is *669m/s*.

The average force acting on projectile calculated based on these values is *550kN*. Based on these values, we conclude that is possible to obtain the desired muzzle velocity of *3000m/s*.

This great performance was obtained using a *1T* magnetic field and a *500A* current.

CONCLUSIONS

This design has great advantages over current EMLS. The static part of accelerator can be easily powered with high currents according with destination of accelerator.

The number of conductors and the length of acceleration path can be calculated according with destination. For instance if we use the same configuration with a length of acceleration equal to *10m* the muzzle velocity of armature will be *3000m/s*, like in a railgun design. Our design uses a current of *500A* and there is no contact between stator and armature; the armature is moving freely during acceleration.

Despite the fact our study doesn't present an optimized EMLS it theoretical proves is possible to achieve hypervelocity with *1T* magnetic field and low values of currents.

Also because the armature is outside acceleration path we can use multiple Halbach array launch systems to accelerate a projectile or other object with mass greater than *1kg*.

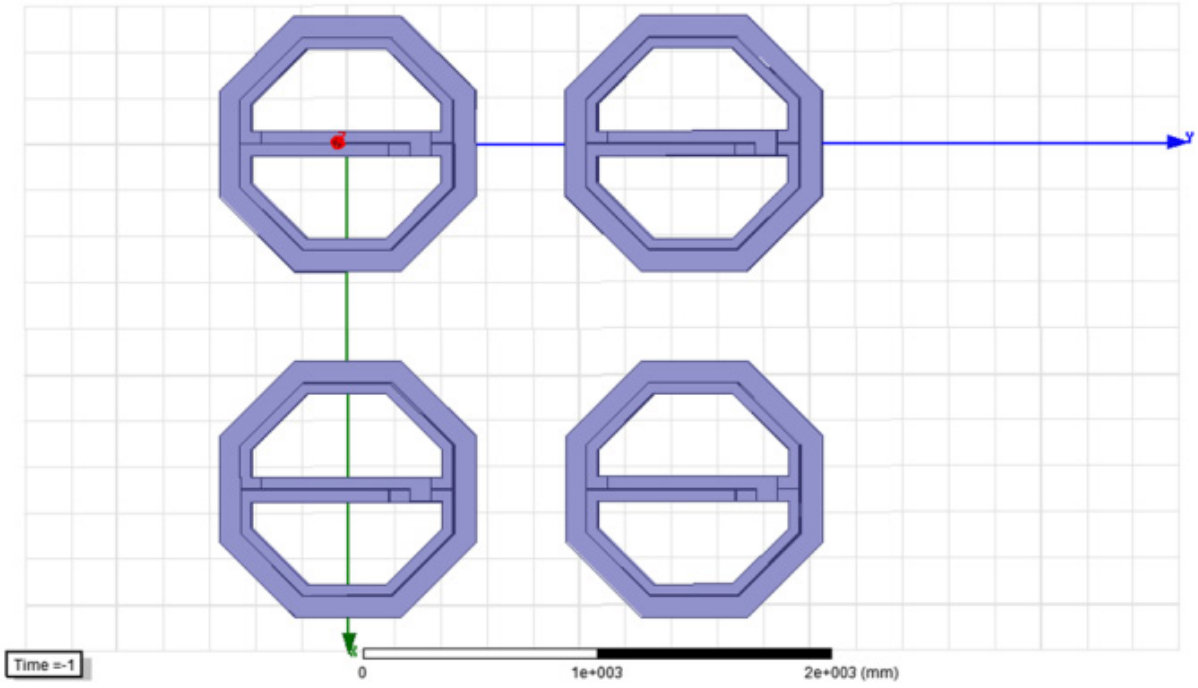

FIG. 14 Configuration with four systems

The object which will be accelerated is placed in the center of configuration shown in figure 14, and is mechanically connected with armatures. With this configuration we can reduce the length of acceleration or increase the mass of projectile for the same muzzle velocity and the same value of current.

Taking into consideration all this aspects we can conclude this Halbach array gun has a great potential of development, and we consider it worth to do.

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MATHEMATICAL MODEL AND CFD ANALYSIS OF PARTIALLY PREMIXED COMBUSTION IN A TURBOJET

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Abstract: *In this paper are presented some results about the study of combustion chamber geometric configurations that are found in aircraft gas turbine engines. The CFD simulations were made with jet A fuel (which is presented in the Fluent software database) for an annular flame tube with 24 injectors. The temperature profile at the turbine inlet exhibits nonuniformity due to the number of fuel injectors used in the circumferential direction, the spatial nonuniformity in dilution air cooling and mixing characteristics as well as other secondary flow patterns and instabilities that are set up in the flame tube. The results show that a spiral (helicoidal) holes distribution could improve the flame tube efficiency, turbulent vortex influence and the actual rate of heat release.*

Keywords: *partially-premixed combustion, aircraft engine, flame tube, turbine temperature profile, flame stability.*

1. INTRODUCTION

The essential elements of turbomachines are the blade rows where the whole flow is the result of blades network which impart the force and more relevantly, the moment of the flow. In axial compressors and turbines it is often possible to consider flows in rotor passages by merely adopting a moving frame of reference and for stator blades a fixed coordinate system. The pressure and shear stresses in the blades of a compressor or turbine produce a moment about the axis of rotation that could be evaluated and integrated but instead it is usual to consider the momentum for the flow entering and leaving. Because the tangential stresses at the casting and the hub are usually very small, the total work of the blade row can be inferred from measurements of the velocity components upstream and downstream. Radius changes may have important effects on axial machines where for each stages the static enthalpy might be approximately with $0.4U^2$, where U is the local blade speed. A small change in radius can produce changes in static enthalpy of the same order of magnitude as those produced by the deflection and deceleration of the flux in the blades [1].

A gas turbine engine is usually specified for operation at a design point, so that it will develop a value of the pressure ratio with a predicted value of thermodynamic efficiency at a value of the shaft rotational speed, while a design value of the mass flow rate exists in each stage. The flow rate may vary from one stage to the next because of bypass elements or extraction of the flow for cockpit pressurization or for fuel flow transfer.

All of the design requirements are associated with a particular working fluid and with the design values of total pressure and total temperature distribution in the engine.
The flow is viscous and compressible, with regions of both supersonic and subsonic local flow. Local regions of laminar, transitional and turbulent boundary layer flow may exist, accompanied by separation of flow from the blades or end walls and both the blade surfaces and the end wall boundary layers are generally three-dimensional.

2. AXIAL FLOW GASDYNAMICS

The mathematical model of the flow field in axial turbomachines is based on the concepts of streamlines, stream surfaces and stream tubes in the flow path. In order for streamlines and path lines to coincide, the flow must be steady, this being and additional restrictive assumption in gas turbine study. The combustion gases enter the turbine in a nonuniform distribution, which is random in the circumferential direction. The randomness of the temperature distribution causes the first stator stage to be designed for the maximum temperature of fluid coming out of the combustion chamber (Fig. 1).

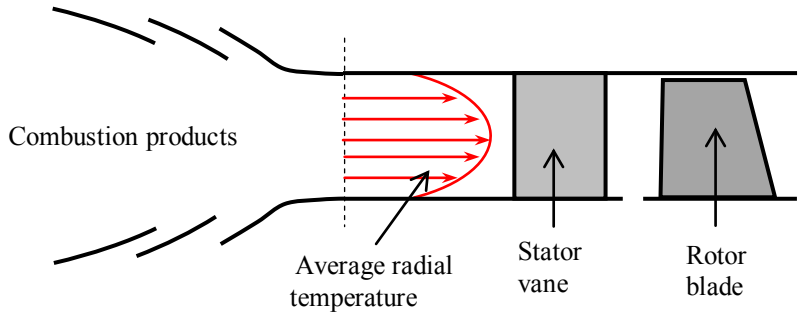


FIG. 1. Turbine blade radial temperature profile

The first rotating blade row is exposed to lower temperatures because of circumferential averaging, dilution of turbine gases with first stator vane cooling air and relative velocity effects. The second stator vane is exposed to a lower temperature because of cooling air dilution, work extraction from the turbine gases and mixing that dilutes the hot spots (Fig. 2). The first stator vane is fed by compressor discharge air that bypasses the combustor, because it requires a very high supply pressure. The first rotor blade is also fed by compressor discharge air. This amount of air is accelerated through a row of nozzles pointed in the direction of rotation [2]. The effect of this is to reduce the amount of work required to pump the cooling air and to reduce the cooling air temperature within the blade. In gas turbines, the heat transfer coefficients to the blades are very high and the conductivities of the materials are fairly low.

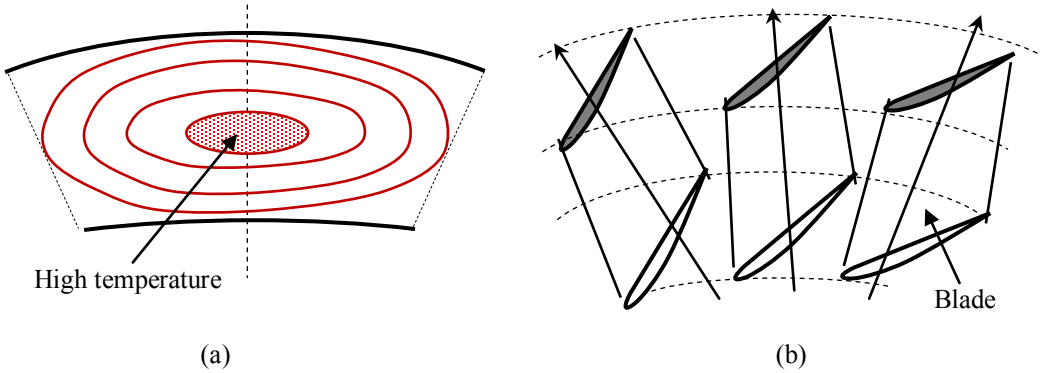
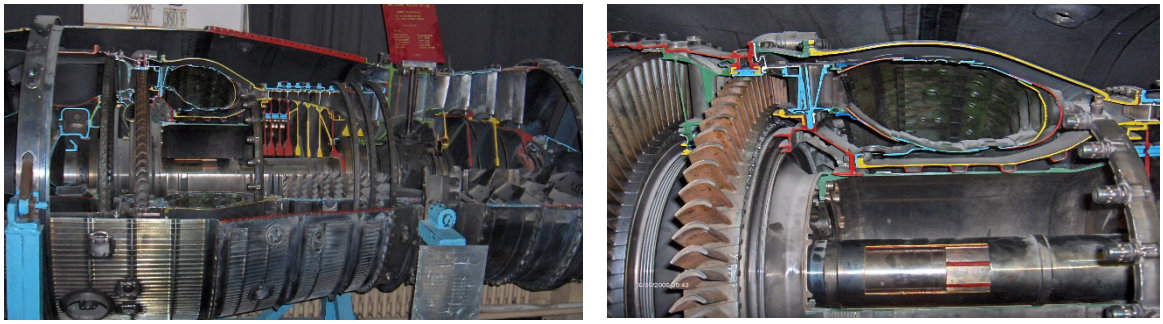


FIG. 2. The radial and circumferential temperature distribution for an annular combustion chamber (a) and surfaces in blade-to-blade flow passage (b)

This combination makes it imperative that the heat transfer coefficient distribution over a hole airfoil must be known in detail. At the stagnation point this coefficient can be correlated as that of the stagnation point of a cylinder in a cross flow that is affected by the freestream turbulence.

On the concave or pressure side of the blade airfoil, the boundary layer trips to turbulent flow and attains a heat transfer coefficient level corresponding to a low Reynolds number turbulent flow. On the convex or suction side of the blade airfoil, the boundary layer is often at first laminar, but has heat transfer coefficients higher than those corresponding to laminar flow because of the effects of freestream turbulence. The heat transfer coefficient distribution to a blade airfoil is calculated utilizing two-dimensional boundary layer theory. The end wall regions are exposed to a lower gas temperature than the corresponding airfoils. In developing the governing integral equations which describe the flow in the turbine, the local density appears under the integral sign. Excepting the case of incompressible flow with small temperature differences, it becomes necessary to determine the variation of the density across the boundary layer. Since the static pressure is constant across the boundary layer, the gas law gives the product of local density and local temperature as constant, thus the problem becomes one of specifying the local temperature [3].

In the usual steady turbulent boundary layer equations, if the laminar transport term is not neglected with respect to the turbulent transport, the governing equations are everywhere parabolic. In certain cases, the neglect of the laminar transport term can result in a hyperbolic set of equations, but this depends on the precise nature of the model of the turbulence transport. The boundary layer equations are nonlinear when they are expressed in term of velocity variables but implicit methods make a formal linearization at some points. In the axial turbojet engine the hub and casing boundary layers can be thought of as a swirling axially symmetric boundary layers. The hub and casing surfaces are often not continuous and frequently stationary surfaces lie adjacent to the rotating components. Leakage and coolant flows often occur through gaps in the surface, but all these difficulties shrink to insignificance when compared to the effect of the blade of stator rows (Fig. 3).



(a) (b)

FIG. 3. The aircraft jet engine (a) and the combustion chamber (b)

In the pitch averaging approach, the azimuthal variations are expressed as a mean value plus a small perturbation and the equations of motion averaged in the azimuthal direction. Within turbomachinery, three-dimensional flows are encountered with unfortunate regularity in the boundary layers and the freestream. An additional feature of the extended boundary layer equations concerns the absence of zones of influence which are the regions bounded by the body surfaces, the boundary layer edges and a pair of characteristic surfaces, one of the surface normal envelope passing through the external streamline and the other, the surface normal envelope passing through the surface streamline.

3. DEVELOPMENT OF THE NUMERICAL METHODOLOGY FOR CFD CALCULATION

A basic structure model for separated flow regions interacting with an inviscid outer flow region leads to expect considerable economy of computation relative to solving the full Navier-Stokes equations. If the external flow can be assumed irrotational, a single scalar potential equation may be used and the correction perturbation to this inviscid outer flow may be obtained from linearized theory (in transonic flow some perturbation potential must be solved throughout the flow). The conventional boundary layer approach leads to a parabolic system of equations but the interacted boundary layer is not well posed as an initial value condition [4].

The governing equations for interacting boundary layer can be written in the form

$$\begin{cases} (\rho u)_x + (\rho u)_y = 0 \\ \rho u u_x + \rho v u_y = -p_x - (\mu_T u_y)_y \end{cases} \tag{1}$$

where μ_T is the sum of the laminar and turbulent effective viscosity, x and y subscripts denote differentiation, u and v are the velocities, p_x is the pressure gradient and ρ is the gas density.

These equations are subject to the wall and freestream boundary conditions

$$\begin{cases} y = 0, \ u = v = 0 \\ y = \delta, \ p = p_e(x) \end{cases} \tag{2}$$

where δ is the thickness of boundary layer.

The rotating external blade boundary layer are very thin and the effects of the Coriolis and centrifugal forces on the mean flow are negligible.In partially-premixed combustion, fuel and oxidizer enter the reaction zone in distinct streams and the mixture fraction*f* can be written in terms of the atomic mass fraction as [5]:

$$f = \frac{Z_i - Z_{i.oxidizer}}{Z_{i.fuel} - Z_{i.oxidizer}} \tag{3}$$

where Z_i is the elemental mass fraction for element i.

The mean time averaged mixture fraction equation is:

$$\frac{\partial}{\partial t}\left(\rho \bar{f}\right) + \nabla \cdot \left(\rho \bar{v} \bar{f}\right) = \nabla \cdot \left(\frac{\mu_t}{\sigma_t} \nabla \bar{f}\right) + S_m \tag{4}$$

The source term S_m is due to solely to transfer of mass into the gas phase from liquid fuel.

The mixture fractions variance, $\overline{f'^2}$ could be find from equation:

$$\frac{\partial}{\partial t}\left(\rho \overline{f'^2}\right) + \nabla \cdot \left(\rho \bar{v} \overline{f'^2}\right) = \nabla \cdot \left(\frac{\mu_t}{\sigma_t} \nabla \overline{f'^2}\right) + C_q \cdot \mu_t \left(\nabla^2 \overline{f'^2}\right) - C_d \rho \frac{\varepsilon}{k} \overline{f'^2} \tag{5}$$

where $f' = f - \bar{f}$ and μ_t is the subgrid-scale viscosity.

The $p(f)$probability density function can be thought of as the fraction of time that the fluid spends at the state f, so

$$p(f)\Delta f = \lim_{T \to \infty} \frac{i}{T} \sum_i \tau_i \tag{6}$$

where T is the time scale and τ_i is the amount of time that f spends in the Δf band.

The analytical shape of the function $p(f)$ depends on the turbulent fluctuations in f and it is expressed as a mathematical function that approximates the shapes. The temporal fluctuations describing by function $p(f)$ can be used to compute the time averaged values of variables that depend of f with the equation:

$$\overline{\varphi_i} = \int_o^1 p(f)\varphi_i(f)df \tag{7}$$

where

$$\varphi = \frac{(fuel/air)_{actual}}{(fuel/air)_{stoichiometric}} \tag{8}$$

The expression of $p(f)$ is

$$p(f) = \frac{f^{(\alpha-1)}(1-f)^{(\beta-1)}}{\int f^{(\alpha-1)}(1-f)^{(\beta-1)}df} \tag{9}$$

where

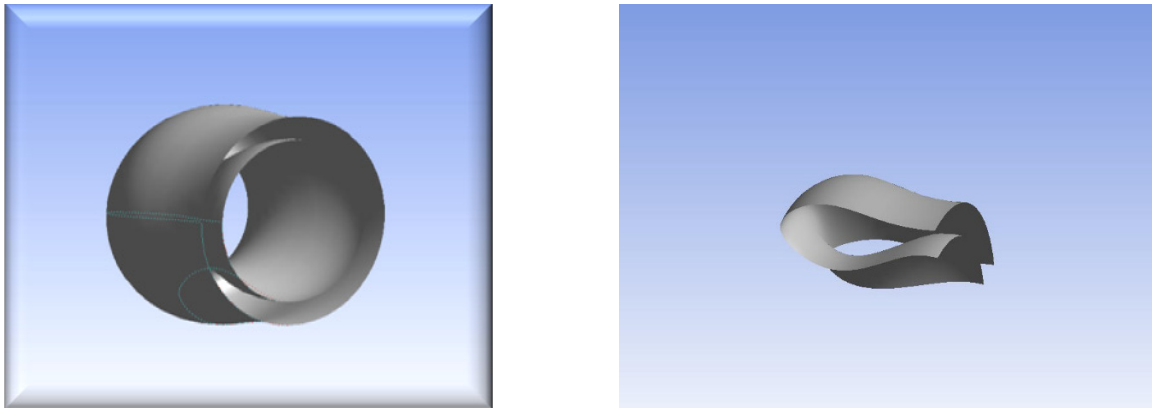
$$\alpha = \bar{f}\left[\frac{\bar{f}(1-\bar{f})}{\overline{f'^2}} - 1\right];\ \beta = (1-\bar{f})\left[\frac{\bar{f}(1-\bar{f})}{\overline{f'^2}} - 1\right] \tag{10}$$

At each point in the flow field, the $p(f)$ can be computed and used as the weighting function to determine the time-averaged mean values of species mass fraction, density and temperature.

4. NUMERICAL RESULTS

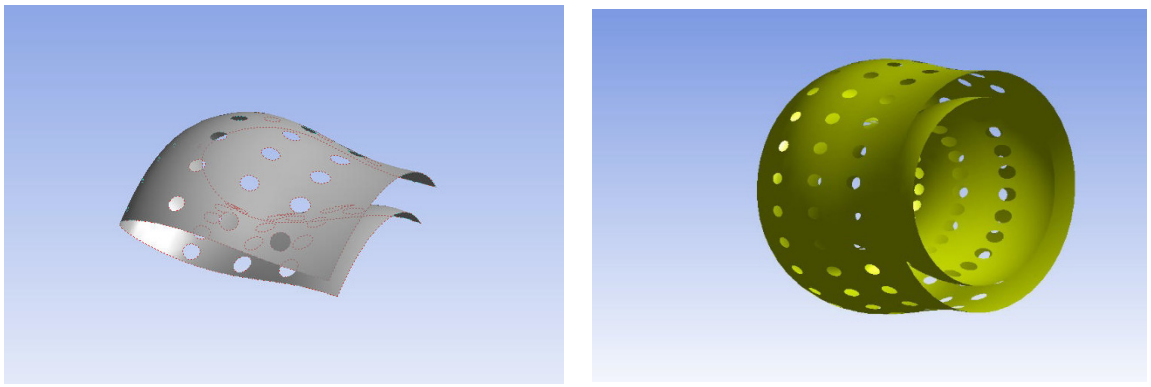
The effect of turbulence on premixed flame speed is to enhance momentum transfer between the burning front and the unburned reactants. In addition, turbulence increases the total surface area of the flame and hence increases the heat transfer between the reaction zone and the unburned gas. A recirculation zone in the burner is needed to stabilize a premixed flame. To stabilize the flame in the primary zone of a main burner, air is introduced through single or double rows of swirl vanes and in order to create a stirred reaction zone in the flame tube, part of excess air is injected through the primary air holes as radial jets.

Some important CFD results and flame tube geometrical shapes are presented in the following pictures.



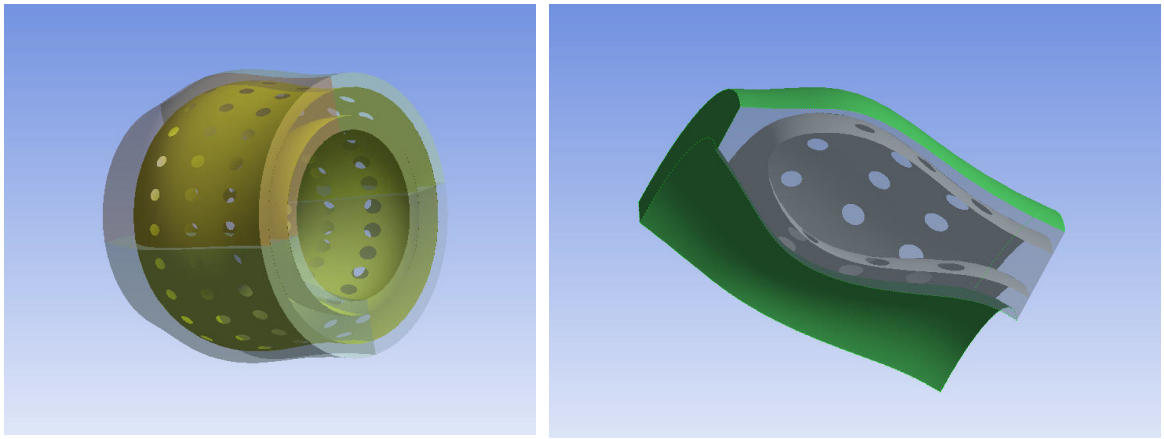
(a) (b)

FIG. 4. The geometrical shape of the flame tube, 3D view (a) and quarter view (b)



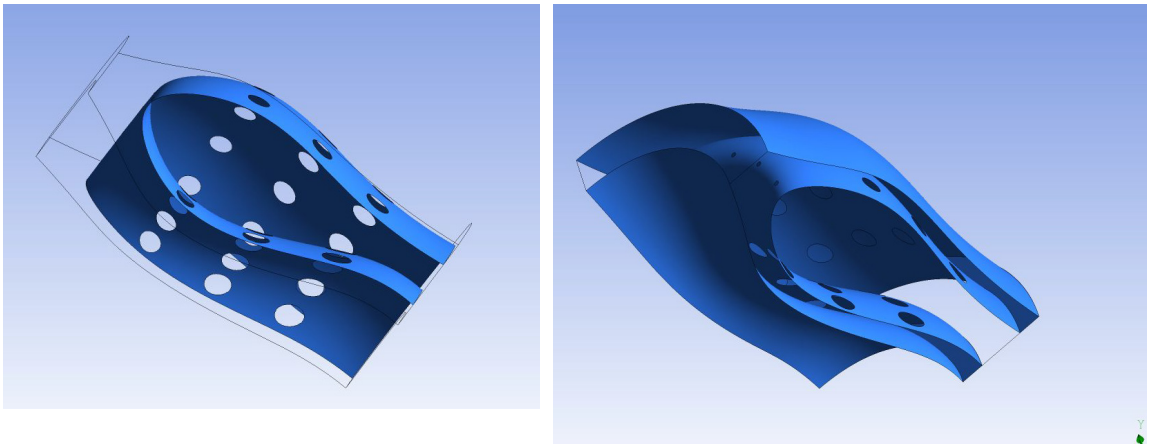
(a) (b)

FIG. 5. The hole distributions, quarter view (a) and 3D view (b)



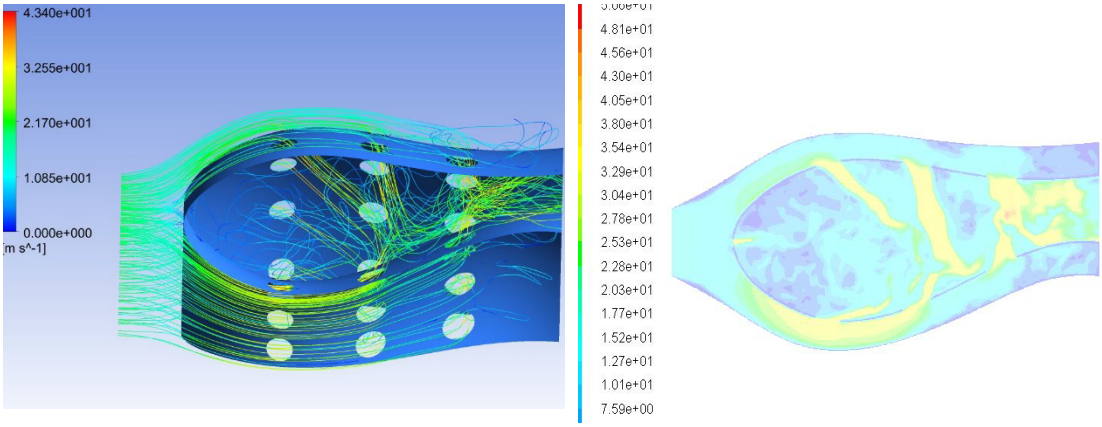
(a) (b)

FIG. 6. Combustion chamber geometrical shape (a) and inner view (b)



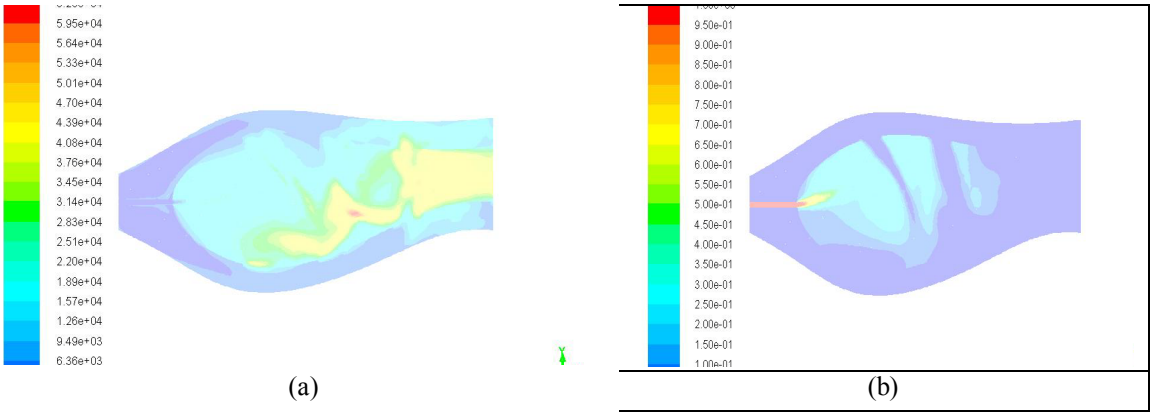
(a) (b)

FIG. 7. The inlet section (a) and the injectors holes (b)



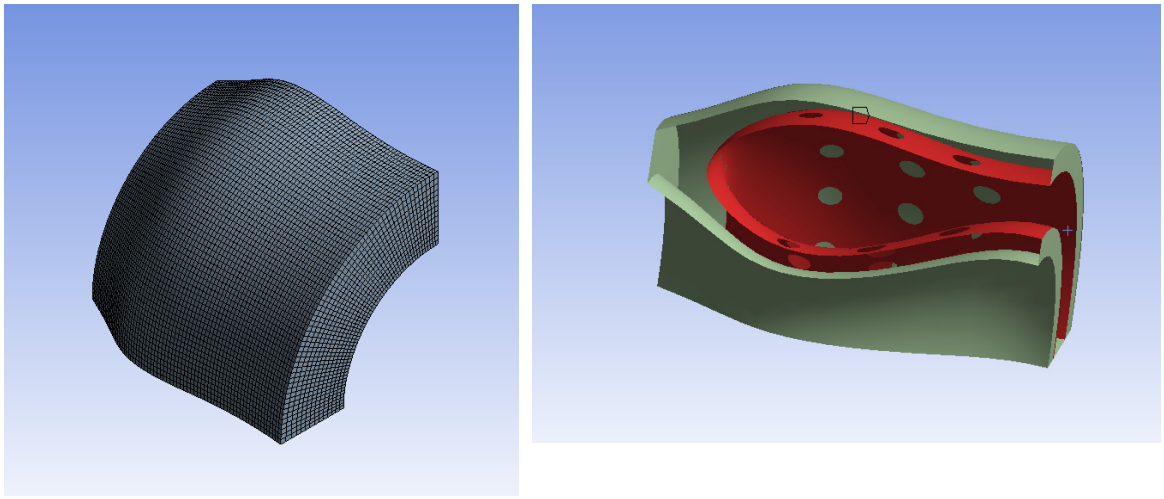
(a) (b)

FIG. 8. Stream lines (a) and velocity distribution (b)



(a) (b)

FIG. 9. Turbulent intensity (a) and Mass fraction of jet A fuel (b)



(a) (b)

FIG. 10. The flow domain mesh (a) and flame tube wall position (b)

CONCLUSIONS

The model used in this paper to describe the combustion process in an annular flame tube has the advantage of cleanly separating aerodynamic and chemical features of the process. The ignition time was calculated from a global model of the chemical reaction rate and the chemical concentrations and temperature used in the combustion chamber are taken from a mathematical model of the mixing zone that is based on time-averaged measurements. Concentration profiles for the products of combustion are similar to the temperature profiles and the vortex structures lie in the region with a strong average velocity gradient.

AKNOWLEDGMENT

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REMOTE CONTROL FOR A MICROCONTROLLER BASED GRAPHIC EQUALIZER USED IN LIGHT ORGANS

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Abstract: *This paper presents how a graphic equalizer is implemented with a microcontroller circuit that controls an array of LEDs depending on the frequency components of a computer audio file. The software component consists of the application itself, which is performed in C++ and C# programming languages. The hardware consists of the system hardware circuit: system components, PCB and the physically circuit. For the implementation an Atmel ATmega 328p microcontroller, a Bluetooth HC05 module and a RGB of 8x8 LED matrix have been used. The graphic equalizer has Bluetooth communication that is achieved through an UART interface and the LEDs are controlled by an SPI interface. The system is very useful because it has wireless communication, high speed execution, low power consumption and it is implemented with low costs components.*

Keywords: *Graphic equalizer, light organs, Bluetooth, microcontroller, triac, LED*

1. INTRODUCTION

At the end of World War II, through a series of "happy accidents" the light organs were created, by transforming discovery-lights of planes into a light spectacle.

This discovery is, in fact, the first light organ ever used by people. After that, many entrepreneurs have realized that a good light show increases the comfort of the people and began to build light organs on an industrial scale. The first models that fulfilled these needs were implemented with magnetic amplifiers, because in that period the electronic amplifiers were very expensive and the actuators and control systems were very complex.

The light organs are electronic lights in which a number of colored lights flash in different colors, depending on the frequency components of the music. With the development of technology, especially in the second half of the 1980s, when thyristors and power transistors started to be available for general consumption, magnetic amplifiers were replaced by electronic amplifiers. [1, 2]

Light organs can be of several types: with thyristor, with triac, controlled by transistors, or with fluorescent piping. Another classification of light organs can be depending on the type of filters used: light organs containing analog filters with piping and magnetic amplifier, light organs with analog filters and triacs, light organs with digital filters (CMOS (Complementary metal-oxide-semiconductor), TTL (Transistor Transistor Logic)) and thyristors and triacs, light organs with filters implemented in EEPROM (Electrically Erasable Programmable Read-Only Memory) memory and microprocessor based or light organs having digital FIR (Finite Impulse Response) filters implemented in microcontroller and transistorized control bulbs. [2]

Organ light with QL-98-6A bulbs is another type which has dynamic light in six colors, the bulbs can light up to the music using a microphone to capture the audio signal and it can be adjusted with a button to determine the lighting rhythm [7]. Dynamic organ light DJ319D it reacts to the music, from the base panel the lighting speed and the microphone sensibility can be adjusted.[8]

The majority of light organs have several drawbacks, among them being: using a microphone, the type of the bulbs that are used, the high energy consumption and the fact that they do not have a wireless transmission.

Following the market study it can be seen that our implemented system actually improves the current systems available on the market, because it has wireless communication and it is implemented with a microcontroller circuit which is a solution for reducing the electronics components number and the cost of designing and development of the product. Another advantage is the use of LED bulbs that have low power consumption, long life, color stability and do not emit infrared or ultraviolet rays. They are made without toxic materials that require disposal as hazardous waste.

In this paper our contribution to the extension of the LED display control system with different devices (Smartphone, tablet, PC) for improving the ambient atmosphere is explained. This is creating a system that works with any type of audio file and any program that plays audio files, without depending on a particular song extension or a program. The system can be used easily in public places because it uses Bluetooth communication. This technology provides solutions for wireless data communication using low-power energy and low-cost technologies that can be easily integrated into any device and opens the way for total mobility.

2. SYSTEM IMPLEMENTATION AND EXPERIMENTAL RESULTS

Equalization is the process that increases or decreases the selective frequencies of the audio signal. Our graphic equalizer divides the frequency spectrum into bands, allowing control frequency amplitudes in each band independently. The frequency spectrum of this system is divided into 8 zones between 20Hz - 20KHz: low frequency (bass), between 20Hz and 250Hz, medium frequency, between 250Hz and 4kHz, and high frequency, between 4kHz and 16kHz.

The block diagram of the graphic equalizer consists of the modules shown in the Fig. 1 below.

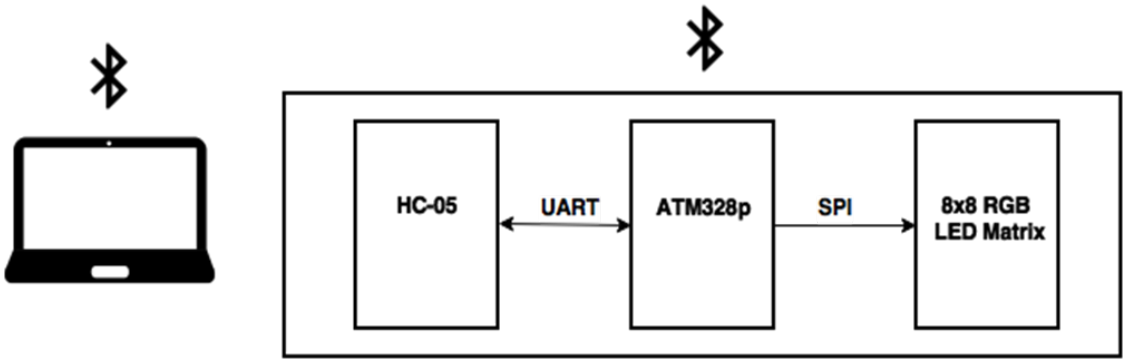

FIG. 1. The system block diagram

2.1 Hardware Implementation. ATMega328p is a chip created by Atmel belonging to mega AVR series. The microcontroller ATMega328p includes as main features 32KB of Flash memory with reading and writing capabilities, 1KB of EEPROM memory, 2KB of SRAM, 23 pins I/O for general use, 32 registers for general use, 3 counters, intern and extern interrupts, USART (Universal Synchronous/Asynchronous Receiver/Transmitter), SPI (Serial Peripheral Interface), I2C (Inter-Integrated Circuit) and a watchdog with internal oscillator. The device has a maximum operating frequency of 20MHz and operates between 1.8V-5.5V [3].

MOD-LED8x8RGB is a 8x8 LED matrix size of 60x60 mm, which allows chaining multiple matrices. The matrix operates at a 5V supply voltage and has an embedded PIC16F1503 microcontroller. This matrix is controlled by the SPI interface [4].

HC-05 module is a Bluetooth SPP (Serial Port Protocol) module easy to use, designed for wireless serial communication. The Bluetooth module is qualified with Bluetooth v2.0+EDR (Enhanced Data Rate), 3Mbps baseband modulation and radio transceiver of 2.4GHZ. The module uses CSR (Cambridge Silicon Radio) 04-Bluecore and it has CMOS technology with AFH (Adaptive Frequency Hopping Feature) [5].

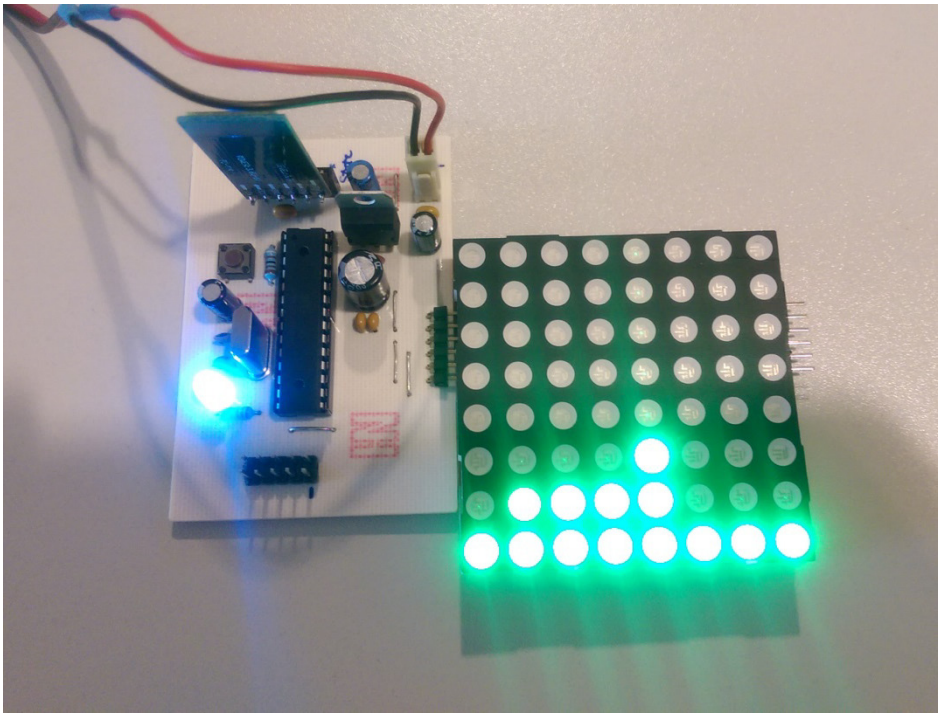

FIG. 2. The hardware component of the system

2.2 Software Implementation. For software implementation the following tools were used: Atmel Studio v.6 for designing the microcontroller application and Visual Studio Express for the user interface. C++ and C# were the programming languages used for this application. The software application establishes the connection between the Bluetooth module and the hardware circuit. After that, the song is played and the FFT (Fast Fourier Transform) filtering is performed. At the same time the application sends the sampled data to the microcontroller and the matrix LEDs will light up depending on the frequency of the song.

As an example, the text below represents the function for send data to the microcontroller via Bluetooth:

```
Stream peerStream; //define the data stream
      int skeep_frame_indx;
      int no_of_frames_to_skeep;
public void write_to_Bluetooth(List<byte> list_buffer)
      {
         {
            skeep_frame_indx ++;
            byte[] buffer = new byte[list_buffer.Count() + 1]; //initialize buffer
            byte[] buffer_tosend = new byte[1]; //initialize buffer that is send to bluetooth
            try
            {
               peerStream = bluetoothClient.GetStream(); //get the data stream
               buffer[0] = (byte)'0';
               Console.WriteLine("Buffer" + " [ " + 0 + "]" + buffer[0]);
               for (int i = 0; i < 8; i++)
               {
                  buffer[i + 1] = (byte)(list_buffer[i] / 32); //because spectrum buffer has
255 number of values, for matrix display I divide the buffer to 32 to obtain 8 values (max
number for 1 column)
                  //if the data is not 0 then the data increase until 8 values
                  if ((list_buffer[i] % 32) != 0)
                  {
                     buffer[i + 1]++;
                  }
                  Console.WriteLine("Buffer" + " [ " + (i + 1) + "]" + buffer[i + 1]);
                  buffer_tosend[0] = buffer[i];
               }

               peerStream.Write(buffer, 0, buffer.Length); //write the data stream to
bluetooth
               Console.WriteLine("Send to placuta:" + buffer.GetEnumerator().ToString());
               Console.WriteLine("Send to placuta:  no_of_data = " + buffer.Length);
            }
            catch (Exception ex)
            {
               Console.WriteLine("ERROR(Mi-s in error catch in Form3.cs): Bluetooth not
connected! error type :" + ex.ToString());
            }
         }

      }
```

The user interface which we designed consists of two main components: the specific window for Bluetooth settings and the window for graphic equalizer settings.

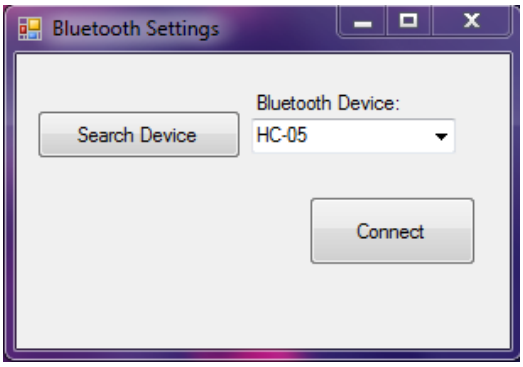

FIG. 3. The window user interface for Bluetooth settings

The window for Bluetooth connectivity (Fig. 3) has four functions: search device, device selection, establishing the connection and sending the data to the Bluetooth hardware circuit (slave).

The user can press the "Search Device" button in order to start searching for available and discoverable Bluetooth devices. Following the search, the devices which were found are displayed in the "Bluetooth Device" box. The user has the ability to select the prefered Bluetooth device by clicking on the right arrow, as this list shows all the found devices. After the preffered device was selected, in order for the connection to be fully established, the user must press the "Connect" button.

The window for setting the graphical equalizer consists of the following functions: spectrum processing, spectrum display, audio device selection and enabling of the entire process.

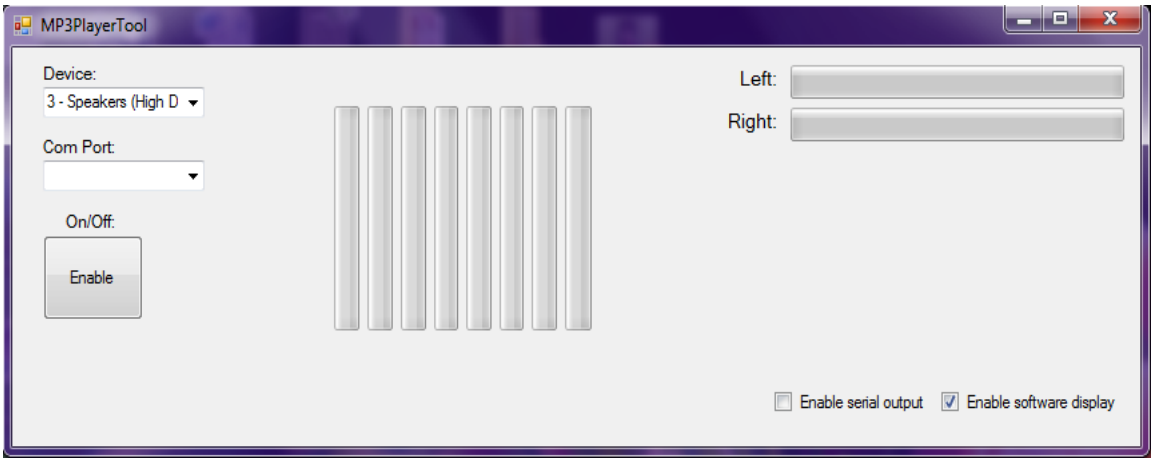

FIG. 4. The window user interface for graphic equalizer settings

The "Enable software display", if checked, enables the spectrum display. The "Device" box is used to select the prefered audio device and has a list of tools that are capable of loopback. These devices should be: laptop speakers, headphones or more. If the user clicks on the right arrow the preffered audio output can be selected. The "Com Port" box is used to select the desired serial port where the Bluetooth connection was established. As in the "Device" box case, it has a list of serial ports available and the user can select the desired port. "Left" and "Right" represents the volume signal from the selected audio device and the middle bars represent the spectrum frequencies of the audio file. To run the application, the user must press the "Enable" button and the application will start running. The last step is to play an audio file (song, video, film and more).

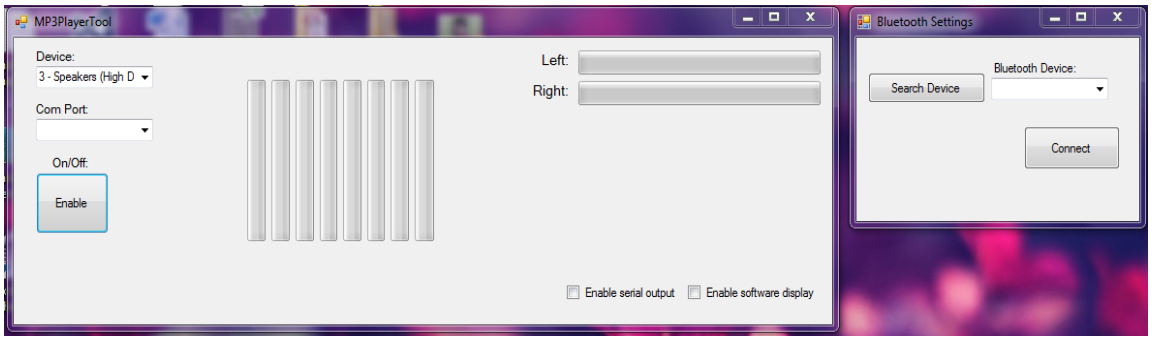

FIG. 5. The user interface

At this point, the application is running, and the LED matrix is lighting providing a simple scenario of a light organ show.

3. CONCLUSIONS AND FUTURE WORK

The main advantage of the designed graphic equalizer is that it is controlled by wireless communication and it can be used easily in public places. Bluetooth technology is an economical solution for wireless communication and the Bluetooth devices can create networks between computers, notebooks, mobile phones and other devices.

Another advantage would be that the devices do not need to be set each time to communicate between them. Also, security is a very important aspect in wireless communication. Thus, Bluetooth specifications define a security model based on three components: authentication, encryption and authorization. Encryption is performed on 128 bits and uses a PIN authentication. Once the authentication is set, the connection is secure and safe for the transmission period.

Furthermore the graphic equalizer offers another benefit from the fact that it is not dependent on a specific type of audio file format or audio program and it has graphical user interface that is easy to use for any user. The product, also can be extended to any audio-video equipment.

For future development, the software can be extended for devices such as tablets, Smartphones and other gadgets. To do this, the software will require implementation of Android or iOS operating systems. Also, the hardware circuit can be developed by extending the capacity of different types of LEDs.

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PEER-TO-PEER REAL-TIME CLOUD COMMUNICATION SOLUTIONS

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Abstract: *Telecommunications are part of a developing field that tries to improve constantly. Related services require accuracy, speed, and integration simplicity in complex applications. New technologies aimed at efficient and low cost communication, involving the internet and taking place in real-time. This paper is dedicated to WebRTC (Web Real-Time Communication) technology, presenting its architecture, development environment, advantages, targeted markets as well as the implementation of a real-time communication application using Unify Circuit, Node.js, Express Framework and OpenSSL.*

Keywords: *real-time communications, peer-to-peer, application programming interface, plugin free communications, internet of things (IoT).*

1. INTRODUCTION

WebRTC, short for Web Real-Time Communications, is a new standard that the W3C (World Wide Web Consortium) and the IETF (Internet Engineering Task Force) have defined to enable web browsers to conduct peer-to-peer real time communications through a series of common protocols.

Before WebRTC, in order to achieve real-time audio, video or data communications on the web browsers, the users had to install third party plugins that made the experience complicated and troublesome, and those plugins needed to be updated very often because of security vulnerabilities.

With WebRTC (an application and plugin free technology), HTML5 and JavaScript, can be used to get access to the webcam and the microphone from a computer, and send audio and video content to another browser as well as data content [1]. A web browser can become a multimedia endpoint revolutionizing the way users communicate over the Internet. Now a WebRTC gateway can be used to obtain a connection to a traditional carrier network or a PBX (Private Branch Exchange). This gateway uses SIP (Session Initiation Protocol), an arduous protocol to talk to the traditional network, but provides a RESTful (Representational state transfer) API based on HTML5 and JavaScript [2] facilitating the process of signaling. A web developer can use a PaaS (Platform as a Service) to embed real time communication into a web application with web RTC. WebRTC enables point-to-point or point-to-multipoint [3] communications without plugins as it can be simply embedded into browsers - a web server is only needed to exchange information and control data between peers.

The idea of RTC isn't new in itself - Technologies are new! Recently, Huawei performed a 5G demonstration providing ”around 1 Gbps per UE”(User Equipment) claiming ”a latency of 0.5 milliseconds”[4].

2. WEBRTC ARCHITECTURE

Traditional web architectures are built on client-server model where communication is made unidirectional, from server to client over HTTP.

WebRTC architecture improves the client-server model by adding the concept of peer-to-peer communication between web browsers. In WebRTC the most common model is the triangular architecture - Fig.1(a) (or trapezoidal architecture Fig.1(b) in some cases), browsers accessing a web application on a server through which signaling messages are transmitted via HTTP or WebSocket [5]. The server is used to connect the data control, but then the media stream is only peer-to-peer between browsers.

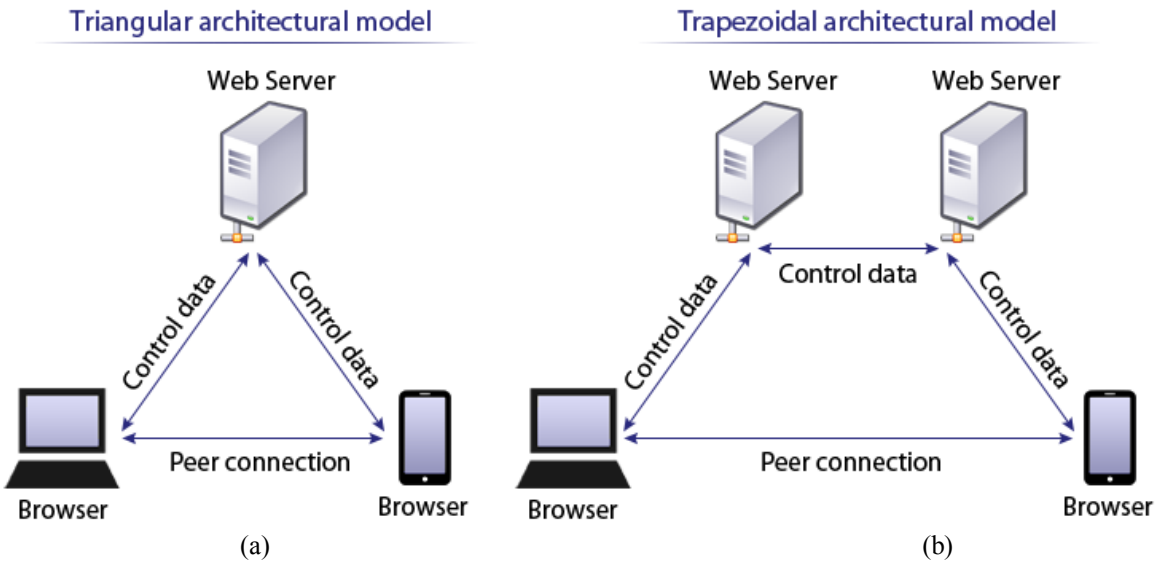

FIG. 1. WebRTC triangular and trapezoidal architectural models

3. WEBRTC APPLICATIONS

WebRTC applications are typically written in JavaScript and HTML5 and are processed by the browsers using the WebRTC API integrated into them, through which it performs functions of connection management, encoding and decoding, media control and NAT translation.

NAT is short for Network Address Translation and is the process whereby a limited set of IPs (IPv4 only support about 4 billion addresses [6]) are divided to work on more devices. In this way many computers can connect to a router interface and the router to the Internet.

4. SIGNALING IN WEBRTC

WebRTC standard does not define a specific signaling protocol other than the generic SDP (Session Description Protocol - a protocol similar to SIP because it uses the same technology) used to exchange control messages.

WebRTC signaling is left opened, allowing flexibility in design, granting developers choosing between using a gateway like WebSocket, Socket.io, XMPP, SIP or Smoke signals. The signaling process in WebRTC is based on a new standard proposed by IETF called JSEP - JavaScript Session Establishment Protocol, which is a collection of interfaces used for signaling identification.

5. WEBRTC API

The WebRTC API is an extension to HTML5, having the ability to start setting up a call information or a communication information and can be integrated into standalone or embedded web browsers and even intro smartphone applications that have the web browsing technology built intro them. Web RTC offers several standard tools used in web technologies, HTML for displaying the objects and JavaScript for programming the communication part and controlling the information objects.

The WebRTC API stack, as showed in Fig.2 is built on three concepts, MediaStream, PeerConnection, and DataChannel:

- *MediaStream* - is an interface that defines a stream media type content. A stream is represented by several audio or video tracks. Each track is defined as an instance of the MediaStreamTrack interface (Fig. 3);
- *PeerConnection* - is an interface that defines a connection between the local browser and a remote peer;
- *DataChannel* - defines methods to connect to a remote peer, monitoring and maintaining the connection and close the connection when it is no longer necessary.

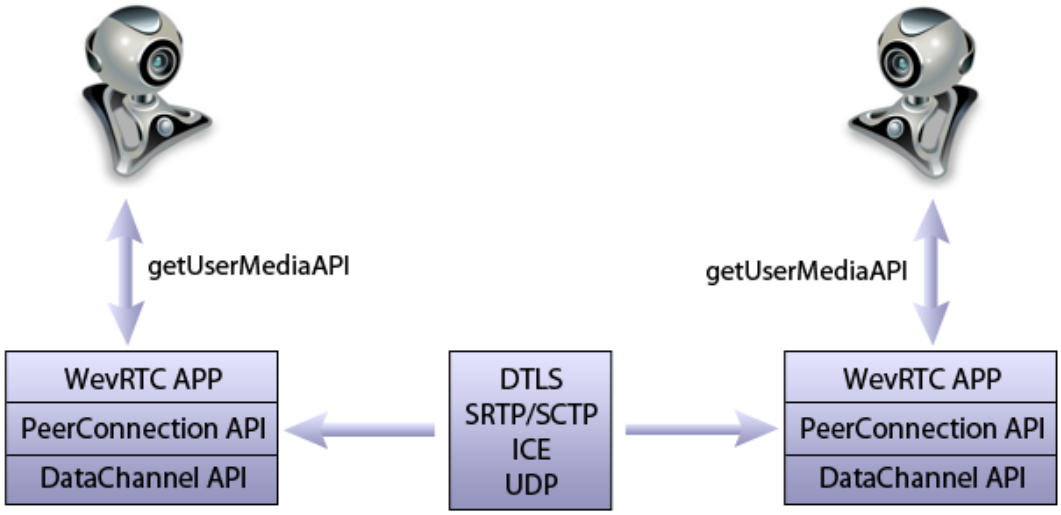

FIG. 2. WebRTC API Stack

```
<video id="videoSource" autoplay></video>
<script type="text/javascript">
    var video = document.getElementById('videoSource');
    navigator.getUserMedia('video', success, error);
    function success(stream) {
        video.src = window.URL.createObjectURL(stream);
    }
</script>
```

FIG. 3. MediaStream *getUserMedia()* function

ICE, short for Interactive Connectivity Establishment, is one of the lower layers in the protocol stack, above UDP, used to solve the problem of establishing the connection through a NAT device like a router or a firewall, without setting up port forwarding to get packets that are coming from unknown hosts outside the network and to be forwarded to a specific machine inside the network.

ICE is an amalgamation of two protocols: STUN (Session Traversal Utilities for NAT) and TURN (Traversal Using Relays around NAT). ICE is specified in a way supposed to be independent from SIP (Session Initiation Protocol), and uses SDP (Session Description Protocol) like an interchange format describing the local addresses to encode and send them through a third party to the peer needed to connect to, as shown in Fig.4.

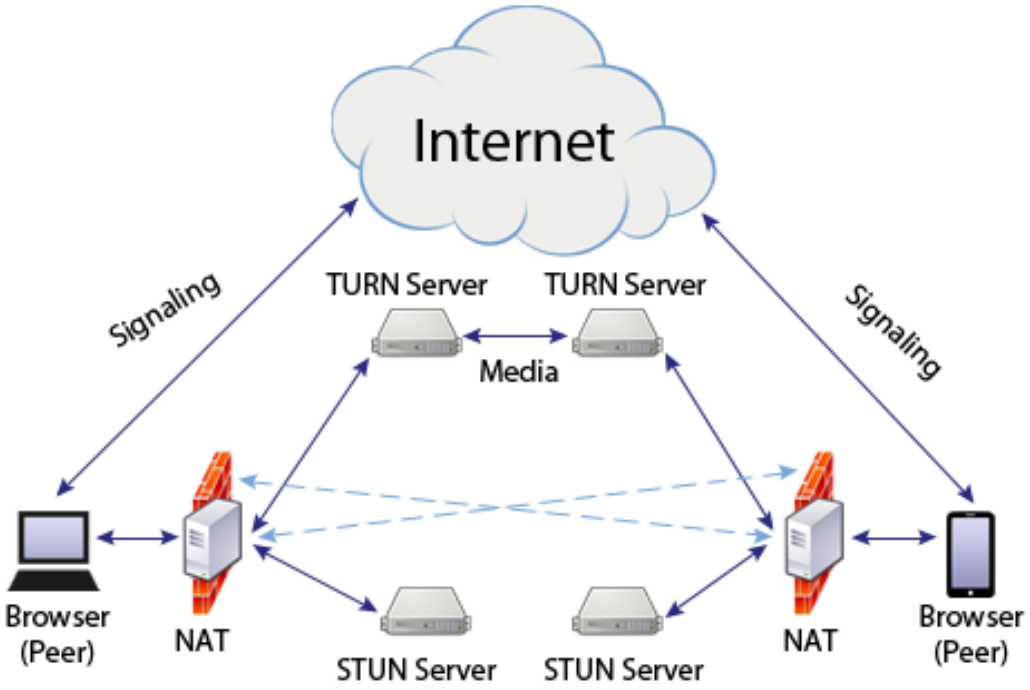

FIG.4. ICE - Interactivity Connection Establishment using STUN and TURN

6. WEBRTC MARKETS

The WebRTC technology offers practical and decentralized tools for communication and in conjunction with the widespread browser support, generates feasible applicability to a variety of market niches such as:

- *Healthcare* - there could be created derived products used to develop telemedicine providing encrypted connections in P2P system and ensuring enhanced security connections that allow for the development of physician patient healthcare services, remotely transmitting medical information, and even wearable devices providing remote diagnosis. A patient can communicate with a hospital in a website like a "nurse hot-line" - speak or have a videoconference - without having an arrangement with the hospital, an appointment or filling in an application. The patient can go to a web page and have instant live (real time) access to medical services through the click of a button;

- *Training and higher education* - students can bring their own devices into the campus environment enabling those students to communicate with university staff and professors or with other students, not having to worry about different operating services or applications support, basically they can have access through a web application (without plugins or downloading and install native applications to their devices);
- *Conferencing* - a very large use in the conferencing marketplace, especially on the business environment, there are already applications developed for web conferencing through WebRTC enabled web pages starting conferencing by a click distance without pre-installed software or downloading extra code;
- *Customer service* - the use of WebRTC could revolutionize and democratize the customer service solutions and support using applications enabled with voice, video and data communication, especially to e-commerce business or technical support services enabling the possibility to do co-browsing assisting to help a customer resolve a problem;
- *Social media* - social networks continue to grow rapidly creating a large marketplace for new applications and products. Most of the popular social media platforms already started to use and adapt WebRTC.

7. ADVANTAGES AND REASONS TO USE WEBRTC

7.1. Need for rapid development - in a very fast moving world, the possibility to build quick and reliable applications become an important asset in the growth on the business sector. Using WebRTC built-in technology into the web browser allows to rapidly deploy and develop new scalable applications that can be accessed by users instantly;

7.2. Embedded communication - because the web browsers implement an underlying technology HTTP and HTTPS and underneath that is HTML which represents the format of the information that comes down, it can be embedded anywhere, not only on the web browsers - web technology is the ability to go to the web servers to grab the information and to display (render) it and can be built into any native applications on smartphones or other modern devices;

7.3. Viruses, Malware, Business and industrial Spying and Ransomware - People are growing reluctant to download plugins and installing new software, companies are locking down systems, not allowing employees to install programs without the accept of the organization because downloading programs to the devices can open security risks, making the IT department overloaded. With WebRTC the IT costs can be lowered, not having to worry about downloading new software because the technologies needed for communication are built into the web browser itself and into the protocol that the browser uses. In WebRTC communication the signaling encryption can be achieved with DTLS (Datagram Transport Layer Security) and the media can be encrypted using SRTP (Secure Real-time Transport Protocol) avoiding "man-in-the-middle" attacks [7];

7.4. Internet of Things (IoT) - the IoT concept assumes controlling via the Internet al the internet enabled devices that surround us [8] - smartwatches, phones, appliances, lighting systems and even cars [9]. WebRTC technology can attain greater connectivity, easy access to data, interconnected ecosystems, achieving lower costs and optimizing resource efficiency.

8. BUILDING A WEBRTC APPLICATION

8.1. Application development environment is extensive, comprising installing software development services and software platforms for security and encryption such as Java SDK (Java software development kit), Node.js, Python, Circuit and OpenSSL.

8.2. Call control module: in Node.js, all modules export an item that can easily be called anywhere in the code [10, 11] and for logging an instance of Express module called app was used. Express is a rapid web development module that provides various functions for viewing, testing, routing, negotiation content in a web page, but also for generating an executable application.

After calling the logger function the app.get function was used to get users from database with user.js subprogram. App.get function is structured as (route, reply) and is used for routing the endpoints (URIs) and responding to customer demand through HTTP GET method. In this case, the function points to the directory users, demanding the user list as a response.

The user.js subprogram, which is the software solution driver, connects the sub composing web application and creates a number of variables Java Script connecting them in different packages, dependencies, Node functionality or routes, when a new Express Node.js project starts.

The logon() function compares the login email and password with the database from the Circuit platform, then creates a Client instance and through events method grants user access in the application. (Fig. 5.)

```
_client.logon($email.value, $password.value).then(function(user){
_localUser = user;
$email.disabled = true; //default filled field
$password.disabled = true; //default filled field
$login_wall.style.display = 'none';
$content.style.display = '';
$logonButton.style.display = 'none';
document.getElementById('name').innerHTML = user.displayName;
document.getElementById('right_side').style.display = '';
})
```

FIG.5. *logon()* function

The second operation after the login, is grabbing conversations already taken by the user. For exceptions, the catch function was used to verify if the logging takes place successfully, or if the username or password are incorrect. The log out function sets the Client module off, leaving the application and returning to the original page.

The function that changes the connection status of the application is performed by addEventListeners() method, attaching an event to the Client element, without overwriting other already created events, as showed in Fig.6.

```
function addClientEventListeners() { //adding a client
 if (_client) {
    _client.addEventListener('connectionStateChanged',
    function onConnectionStateChanged(evt) { //change status
 prin crearea unui eveniment
    console.log('Received connectionStateChanged event-state=',
 evt.state)
   $logonState.textContent = evt.state;
   //adding "connected" or "disconnected"
   if (evt.state === Circuit.Enums.ConnectionState.Disconnected){
   //in case of disconnection returns to initial interface
        resetCallUI(); //interface reset
     }
 });
```

FIG.6. *addClientEventListeners() function*

8.3. Connection management: to make the connection between the two entities, the data link layer: path and app.js were set. The app.set function (name, value) sets the name and value of the local port where the ('port') application is running.

The index.js subprogram contains the request-response function which exports the web page that includes the application. Creating the virtual server that hosts the application, in this case https://localhost:8080 is made by the function showed in Fig.7.

```
//creating virtual server
var httpsServer = https.createServer(credentials, app);
httpsServer.listen(app.get('port'));
```

FIG.7. *addClientEventListeners()* function

Another connection aspect is adding the <script> tag containing the sub-interface elements index.ejs. The tags refer to a link either to a script document type or to a local client.js file. The code in Fig.8 connects the index.ejs interface to all subprograms and functionality of the main program called client.js.

```
<script src='https://circuitsandbox.net/circuit.js'></script>
<script src='js/client.js'></script>
```

FIG.8. *index.ejs* interface

8.4. Flow management: the start() function first checks if the user is logged on and creates average time variables, then a conversation is selected and media is streaming. The join() function also checks if the user is logged in, create variables for media types and allows the user to choose a conversation. To attend a conversation, the function must state "started". The leave() function has the same elements as the join() function, but user the leave() module and depending on the ID of the conversation, removes the user from

the conference. Changing the conference status when the conference ends takes place through the updateList(call) function as showed in Fig.9.

```
function updateList(call) { //updates conversations list
   if (call.state === Circuit.Enums.CallStateName.Terminated) {
   //if the conference ends
       getListOption(call.convId).textContent =
                   _conversations[call.convId].title;
   } else {
       getListOption(call.convId).textContent =
       _conversations[call.convId].title + '('+ call.state +')';}
   //if not ended further display the status
```

FIG.9. *updateList()* function

8.5. Graphical user interface (GUI): A setCallUI() function was created and used every time when it came to setting or resetting the user interface. In the following function the button which accesses the conference is changed.

The button has two options: "Start" - which refers to the start of a conference, or 'Enter' - which refers to join a conference that has already begun. (Fig. 10.).

```
function setCallUI() {
 updateButtons(); //text based on conversation
 var convId = document.getElementById('convList').value;
  if (!_conversations[convId]) {
     return;
 }
 var call = _calls[convId]; //returns the ID
 $convId.textContent = call.convId;
 $callState.textContent = call.state; //conversation status
 $callId.textContent = call.callId;
```

FIG.10. *setCallUI()* function

When joining a conversation, audio and video stream is automatically activated and sent to onVideoChange() function. The resetCallUI() function, showed on Fig. 11, is called for every change made by other functions while accessing the application or conversation.

```
function resetCallUI() {
 updateButtons(); //change button after joining conversation
 $callState.textContent = ''; //button status after join
 $media.textContent = '';
 $callId.textContent = '';
 $convId.textContent = '';
 $localVideo.src = ''; //local video
 $remoteVideo1.src = ''; //video from other users
 $remoteVideo2.src = ''; //... for 6 users
 $remoteAudio.src = ''; //audio from other users
 $enableVideo.checked = false; //does not allow video stream
 $enableVideo.disabled = true; } //inactive checkbox
```

FIG.11. *resetCallUI()* function

The updateButtons(), shown in Fig.12, relates to the button that changes its text depending on the state of the conversation. If the conference has already started, the function will output "Join" and if the users starts the conference the function will output "Start" and hide the "Join" button. If the conference is not started the function will hide the "Exit conference" button.

```
function updateButtons() {
 $startButton.classList.add('hide'); //hide "Start" button
 $joinButton.classList.add('hide'); //hide "Join" button
 $leaveButton.classList.add('hide'); //hide "Leave" button
 if (!call) { //If user has not yet entered a conference

   $startButton.classList.remove('hide'); //hide "Start" button
 } else if (call.state === Circuit.Enums.CallStateName.Started) {
                //if a conversation is already "Started"
   $joinButton.classList.remove('hide'); //hide "Join" button
 } else if (call.state === Circuit.Enums.CallStateName.ActiveRemote){
     $leaveButton.classList.remove('hide'); //hide "Leave" button }}
```

FIG.12. *updateButtons()* function

4. CONCLUSIONS AND FURTHER DEVELOPMENTS

The usage of WebRTC technology reduces physical resources: cables, physical input-output ports, memory and also software maintenance resources: operating system (OS) updates, installing or uninstalling software on endpoints and even security aspects, monitoring and controlling them on a shared server. The solution was tested using "Circuit" API-s, in real-time applications of video-conferencing (as the main target were cloud communications, other forms of live streaming - e.g. instrumental acquired data flows - are intended in future developments). There are already solutions like Google Duo providing live preview of the caller's face from her/his smartphone front-camera.

A WebRTC success factor is that its core technologies (HTML, HTTP, TCP / IP) are open and implementable. Already integrated with the best solutions for voice and video, WebRTC includes firewall traversing technology using STUN (datagram user protocol through NAT - network address translation), interactive connectivity and RTP-over-TCP support for proxies. Also, the developer can use any protocol according to its usage scenario, such as XMPP, Jingle or SIP, which gives more freedom of choice.

The specific of our solution is the ”seamless” integration of the RTC in the network - in the ”Web” - assuming a high performance. We consider to include a micro-test of network state (benchmarks of bandwidth or, at least, a connectivity check) in our solution in order to react on different network states. Given the highly interactive character of our conferencing Web-RTC solution, a subjective ”down-grade” reaction is possible (blocking video to allow a better voice service or blocking both streams to allow at least a written chat).

As our proof-of concept illustrated, WebRTC can be integrated and adjusted for any user and customer demand. Currently, some of the largest companies in the world - Google, Amazon, Oracle, Facebook, Twilio, Citrix, etc - have already implemented this technology in their applications just one year after its appearance on the market.

This underlines the upsurge of developing and integrating WebRTC in web applications and the trend remote communications will take via Cloud.

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THE RESONANCE FREQUENCY CORRECTION IN CYLINDRICAL CAVITIES IN AXIAL DIRECTION

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Abstract: *The paper presents a model for determining more precisely the axial resonance frequency in cylindrical resonant cavity. It is known that resonance frequencies on axial direction of the electric field in cylindrical resonant cavity are determined by null points of the Bessel function J_0 but, in practical experiments be noticed a shift in positive direction of the real resonance frequency compared to that calculated. Just this correction is made in this paper.*

Keywords: *electromagnetic field, distribution, Bessel.*

1. INTRODUCTION

To calculate the resonance frequencies in cylindrical and elliptical cavities, it requires a full analysis of electromagnetic (EM) phenomena that happen in this volume. In addition to the Bessel function for field oscillation, the paper presents the analytical field distribution function in opening cavity radius, phenomena taking place simultaneously.

The paper is structured in three parts: deduction of distribution function of electromagnetic field, attaching the J_0 Bessel distribution function, conclusions on the result obtained.

2. DEDUCTION OF DISTRIBUTION FUNCTION OF EM FIELD

For deduction of the distribution function of EM field, is used drawing in FIG. 1 and Maxwell's equations for dynamic field.

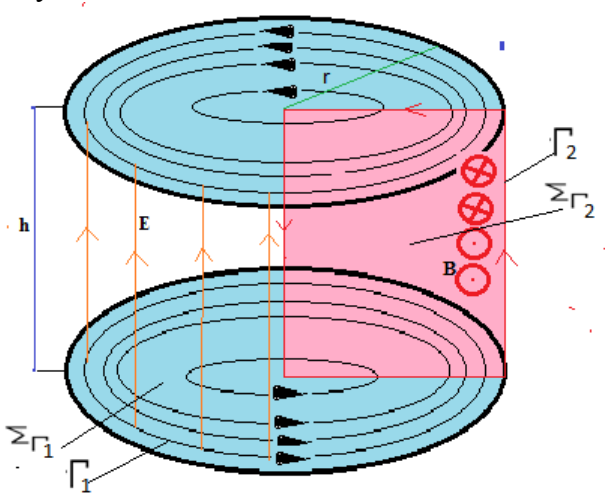

FIG. 1. Schematic representation of the oscillation phenomenon of cavity

$$c^2 \cdot \nabla \times B = \frac{\partial}{\partial t} E \tag{1}$$

$$\nabla \times E = -\frac{\partial}{\partial t} B \tag{2}$$

=>

$$c^2 \oint_{\Gamma_1} B \, dl = \frac{\partial}{\partial t} \iint_{\Sigma\Gamma_1} E \, ds_1 \tag{3}$$

$$\oint E \, dh = -\frac{\partial}{\partial t} \iint B \, ds_2 \tag{4}$$

$$ds_1 = 2\pi r \cdot dr$$

(I) The first iteration

$$c^2 \cdot 2\pi r \, B_1 = E_0 e^{j\omega t} \cdot j\omega \iint_{\Sigma\Gamma_1} 2\pi r \, dr \tag{5}$$

$$B_1 = \frac{j\omega}{2c^2} E_0 e^{j\omega t} \cdot r \tag{6}$$

Writing relation (4) for the contour Γ_1, is obtained:

$$\oint_{\Gamma_1} E_1 \, dl = -\frac{\partial}{\partial t} \iint_{\Sigma\Gamma_2} B_1 \, ds_2 \tag{7}$$

$$ds_2 = r \cdot dh$$

Solving integrals, equation (7) becomes:

$$-hE_1 = -\frac{\partial}{\partial t} \left(E_0 e^{j\omega t} \cdot \frac{j\omega}{c^2} \right) \frac{r^2}{2} h \tag{8}$$

After derivation, follow:

$$-E_1 = E_0 e^{j\omega t} \cdot \frac{\omega^2 r^2}{2c^2} \tag{9}$$

$$E_1 = -E_0 e^{j\omega t} \cdot \frac{\omega^2}{2c^2} \cdot r^2 \tag{10}$$

(II) The second iteration

$$c^2 \cdot 2\pi r \, B_2 = \frac{\partial}{\partial t} \iint_{\Sigma\Gamma_1} E_1 \, ds_1 \tag{11}$$

=>

$$c^2 \cdot 2\pi r B_2 = -\frac{j\omega^3}{c^2} E_0 e^{j\omega t} \int r^2 \cdot 2\pi r \, dr \tag{12}$$

$$B_2 = -\frac{j\omega^3}{2 \cdot 4 \cdot c^4} E_0 e^{j\omega t} \cdot r^3 \tag{13}$$

$$\oint_{\Gamma_2} E_2 \, dl = -\frac{\partial}{\partial t} \iint_{\Sigma\Gamma_2} B_2 \, ds_2 \tag{14}$$

=>

$$E_2 = \frac{\omega^4}{2 \cdot 4 \cdot c^4} \cdot E_0 e^{j\omega t} \cdot r^4 \tag{15}$$

(III) The third iteration

$$c^2 \cdot 2\pi r \, B_3 = \frac{\partial}{\partial t} \iint_{\Sigma\Gamma_1} E_2 \, ds_1 \tag{16}$$

=>

$$B_3 = \frac{j\omega^5}{2 \cdot 4 \cdot 6 \cdot c^6} E_0 e^{j\omega t} \cdot r^5 \tag{17}$$

$$\oint_{\Gamma_3} E_3 \, dl = -\frac{\partial}{\partial t} \iint_{\Sigma\Gamma_3} B_3 \, ds_2 \tag{18}$$

=>

$$E_3 = -\frac{\omega^6}{2 \cdot 4 \cdot 6 \cdot c^6} \cdot E_0 e^{j\omega t} \cdot r^6 \tag{19}$$

If it continues, is obtained the overall intensity of the electric field E_T as an expression of the form:

$$E_T = E_0 e^{j\omega t} \left[1 - \frac{1}{2}\left(\frac{\omega r}{c}\right)^2 + \frac{1}{2^2}\frac{1}{2!}\left(\frac{\omega r}{c}\right)^4 - \frac{1}{2^3}\frac{1}{3!}\left(\frac{\omega r}{c}\right)^6 + \cdots \right] \tag{20}$$

If we denote $\frac{\omega r}{c} = x$, we get the expression:

$$E_T = E_0 e^{j\omega t} \left(1 - \frac{1}{2}\frac{1}{1!}x^2 + \frac{1}{2^2}\frac{1}{2!}x^4 - \frac{1}{2^3}\frac{1}{3!}x^6 + \cdots \right) \tag{21}$$

This relation can be written as:

$$E_T = E_0 e^{j\omega t}\left(1+\frac{1}{2^i}\sum\frac{x^{2i}}{i!}(-1)^i\right) \tag{22}$$

This is the series expansion of the function:

$$E_T = E_0 e^{j\omega t} e^{-\frac{1}{2}x^2} \tag{23}$$

Or,

$$E_T = E_0 e^{j\omega t} e^{-\frac{1}{2}\left(\frac{\omega r}{c}\right)^2} \tag{24}$$

This expression represents the global electric field intensity distribution, function of the radius cylindrical resonator:

$$E_T = E_0 e^{j\omega t}\cdot f(r) \tag{25}$$

In this expression, for a resonance frequency known,

$$f(r) = e^{-\frac{1}{2}\left(\frac{\omega r}{c}\right)^2} \tag{26}$$

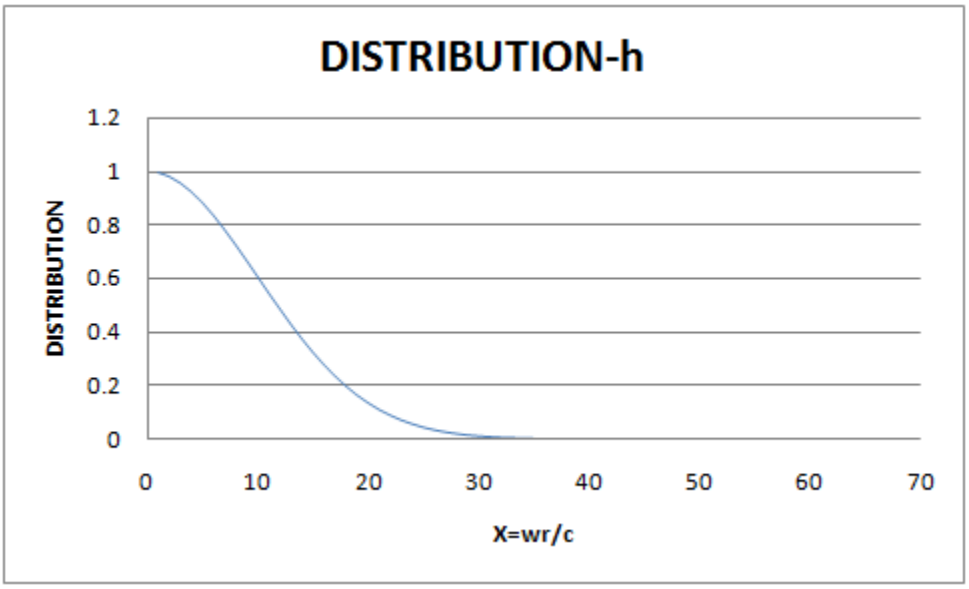

FIG. 2. The distribution of EM field

3. ATTACHING THE J_0 BESSEL DISTRIBUTION FUNCTION

If the calculation is repeated with iterations I, II, III... where is considered that $ds_1 = 2\pi r\cdot dr$ and $ds_2 = r\cdot dh$ (phenomenon development on radius) is obtained the series:

$$E = E_0 e^{j\omega t}\left[1-\frac{1}{(1!)^2}\left(\frac{\omega r}{2c}\right)^2+\frac{1}{(2!)^2}\left(\frac{\omega r}{2c}\right)^4-\frac{1}{(3!)^2}\left(\frac{\omega r}{2c}\right)^6+\cdots\right] \tag{27}$$

This expression, in restricted form, is:

$$E = E_0 e^{j\omega t} J_0\left(\frac{\omega r}{c}\right) \tag{28}$$

J_0 is the Bessel function of the first kind and zero order and describes at zero crossings, the frequencies around which is carried out the resonance phenomenon of the cylindrical cavity. In practical measurements it has been observed that the real resonance frequencies are shifted slightly to the right compared to the zero crossings of Bessel function,

$J_0(X)|_{X=\frac{\omega r}{c}}$.

This frequency deviation, *Δf,* results from overlapping the function E_T over the function E, the two components of the electric field intensity taking place simultaneously.

$$E_{resultant} = \frac{E_T + E}{2} = \frac{1}{2} E_0 e^{j\omega t}\left(J_0(X) + e^{-\frac{1}{2}X^2}\right) \tag{29}$$

Thus, the correction function is:

$$P(X) = J_0(X) + e^{-\frac{1}{2}X^2} \tag{30}$$

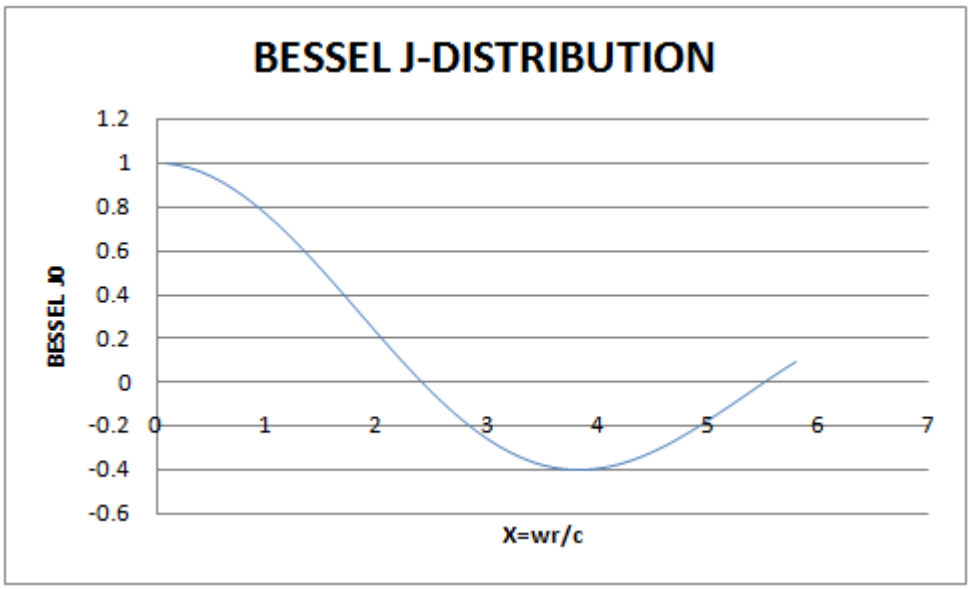

FIG. 3. The Bessel function J_0.

3. CONCLUSIONS

The diagrams in FIG. 2 and FIG. 3 represents the EM field radius distribution, respectively the Bessel function J_0, with independent action. In the diagram in FIG. 4, the Bessel function J_0 and the correction function $P(X)$ are simultaneously represented. This figure shows the displacement frequency correction (zero-crossing of $P(X)$) compared to Bessel function, in this way:

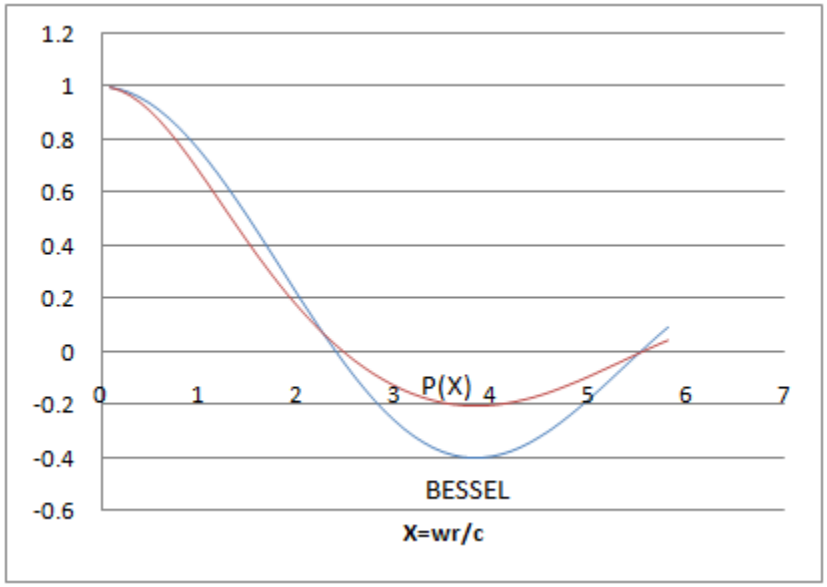

FIG. 4. The Bessel function J_0 and the correction function P(X)

The first null of Bessel function is x = 2.405.
The first null of *P(X)* function is x = 2.47.
The second null of Bessel function is x = 5.52.
The second null of *P(X)* function is x = 5.543.

The resonance frequencies obtained from the correction function *P(X)* have better accuracy with an order of magnitude compared to Bessel function.

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ABOUT GENERAL CONFORMAL ALMOST SYMPLECTIC N-LINEAR CONNECTIONS ON K-COTANGENT BUNDLE

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Abstract: *In the present paper starting from the notions of: almost symplectic structure and conformal almost symplectic structure, we define on k-cotangent bundle the notions of: conformal almost symplectic N-linear connection and general conformal almost symplectic N-linear connection. We determine the set of all general conformal almost symplectic N-linear connections in the case when the nonlinear connection is arbitrary and we find important particular cases.*

Keywords: *k-cotangent bundle, almost symplectic structure, conformal almost symplectic structure, conformal almost symplectic N-linear connection, general conformal almost symplectic N-linear connection.*

1. INTRODUCTION

The notion of Hamilton space was introduced by R. Miron in $[6]-[8]$. . The Hamilton spaces appear as dual via Legendre transformation, of the Lagrange spaces.

The differential geometry of the second order cotangent bundle was introduced and studied by R. Miron in [12] , R. Miron, D. Hrimiuc, H. Shimada, V.S. Sabău in [11], Gh.Atanasiu and M. Târnoveanu in [1], etc.

The differential geometry of the $k-$cotangent bundle was introduced and studied by R. Miron [10], [12].

In the present section we keep the general setting from R. Miron $[12]$, and subsequently we recall only some needed notions. For more details see $[12]$.

Let M be a real $n-$dimensional C^∞ $-$manifold and let $\left(T^{*k}M,\pi^{*k},M\right)$, $\left(k\geq 2, k\in N\right)$ be the $k-$cotangent bundle, where the total space is:

$$T^{*k}M = T^{*k-1}M \times T^*M. \tag{1}$$

Let $\left(x^i, y^{(1)i},...,y^{(k-1)i}, p_i\right), (i=1,2,...,n)$, be the local coordinates of a point $u=\left(x, y^{(1)},...,y^{(k-1)}, p\right)\in T^{*k}M$ in a local chart on $T^{*k}M$.

We denote by:

$\widetilde{T}^{*k}M = T^{*k}M - \{0\}$ where $0: M\to T^{*k}M$ is the null section of the projection π^{*k}.

A change of local coordinates on the manifold $T^{*k}M$ is given by:

$$\begin{cases} \widetilde{x}^i = \widetilde{x}^i\left(x^1,...,x^n\right), \det\left(\dfrac{\partial \widetilde{x}^i}{\partial x^j}\right) \neq 0, \\ \widetilde{y}^{(1)i} = \dfrac{\partial \widetilde{x}^i}{\partial x^j} y^{(1)j}, \\ ..... \\ (k-1)\widetilde{y}^{(k-1)i} = \dfrac{\partial \widetilde{y}^{(k-2)i}}{\partial x^j} y^{(1)j} + ... + (k-1)\dfrac{\partial \widetilde{y}^{(k-2)i}}{\partial y^{(k-2)j}} y^{(k-1)j}, \\ \widetilde{p}_i = \dfrac{\partial x^j}{\partial \widetilde{x}^i} p_j, \end{cases} \tag{2}$$

We denote with N a nonlinear connection on the manifold $T^{*k}M, (k \geq 2, k \in N)$, with the coefficients:

$$\left(\underset{(1)}{N}{}^{j}{}_{i}\left(x, y^{(1)},..., y^{(k-1)}, p\right),..., \underset{(k-1)}{N}{}^{j}{}_{i}\left(x, y^{(1)},..., y^{(k-1)}, p\right), \right. \tag{3}$$

$$\left. N_{ij}\left(x, y^{(1)},..., y^{(k-1)}, p\right)\right), (i, j = 1,2,...,n).$$

The tangent space of $T^{*k}M$ in the point $u \in T^{*k}M$ is given by the direct sum of vector spaces:

$$T_u\left(T^{*k}M\right) = N_{0,u} \oplus N_{1,u} \oplus ... \oplus N_{k-2,u} \oplus V_{k-1,u} \oplus W_{k,u}, \forall u \in T^{*k}M \tag{4}$$

A local adapted basis to the direct decomposition (4) is given by:

$$\left\{ \frac{\delta}{\delta x^i}, \frac{\delta}{\delta y^{(1)i}},..., \frac{\delta}{\delta y^{(k-1)i}}, \frac{\delta}{\delta p_i} \right\}, (i = 1,2,...,n), \tag{5}$$

where:
$$\begin{cases} \dfrac{\delta}{\delta x^i} = \dfrac{\partial}{\partial x^i} - \underset{(1)}{N}{}^{j}{}_{i} \dfrac{\partial}{\partial y^{(1)j}} - ... - \underset{(k-1)}{N}{}^{j}{}_{i} \dfrac{\partial}{\partial y^{(k-1)j}} + N_{ij} \dfrac{\partial}{\partial p_j}, \\ \dfrac{\delta}{\delta y^{(1)i}} = \dfrac{\partial}{\partial y^{(1)}_i} - \underset{(1)}{N}{}^{j}{}_{i} \dfrac{\partial}{\partial y^{(2)j}} - ... - \underset{(k-2)}{N}{}^{j}{}_{i} \dfrac{\partial}{\partial y^{(k-1)j}}, \\ ..... \\ \dfrac{\delta}{\delta y^{(k-1)i}} = \dfrac{\partial}{\partial y^{(k-1)i}}, \\ \dfrac{\delta}{\delta p_i} = \dfrac{\partial}{\partial p_i} \end{cases} \tag{6}$$

and its dual basis $\{\delta x^i, \delta y^{(1)i}, \ \delta y^{(k-1)i}, \delta p_i\}$ determined by N and by the distribution W_k.

2. CONFORMAL ALMOST SYMPLECTIC STRUCTURE

Let D be an $N-$linear connection on $T^{*k}M$, with the local coefficients in the adapted basis (5):

$$D\Gamma(N)=\left(H^{i}{}_{jh},\underset{(\alpha)}{C}{}^{i}{}_{jh},C_{i}{}^{jh}\right),(\alpha=1,...,k-1). \tag{7}$$

D determines the $h-$, w_1-, w_2-,...,w_{k-1} covariant derivatives in the tensor algebra of d-tensor fields.

We consider on $\widetilde{T}^{*k}M$, $(k\geq 2,k\in N)$, an almost symplectic structure A given only by a nonsingular and skewsymmetric d-tensor field a_{ij}, of the type (0, 2) :

$$\begin{aligned}&A\left(x^{i},y^{(1)i},...,y^{(k-1)i},p_{i}\right)=\tfrac{1}{2}a_{ij}\left(x^{i},y^{(1)i},...,y^{(k-1)i},p_{i}\right)dx^{i}\wedge dx^{j}+\\&+a_{ij}\left(x^{i},y^{(1)i},...,y^{(k-1)i},p_{i}\right)dy^{(1)i}\wedge dy^{(1)j}+\tfrac{1}{2}a_{ij}\left(x^{i},y^{(1)i},...,y^{(k-1)i},p_{i}\right)\delta p_{i}\wedge\delta p_{j},\\&(i,j=1,2,...,n)\end{aligned} \tag{8}$$

The contravariant tensor field a^{ij} is obtained from the equations:

$a_{ij}a^{jk}=\delta_{i}^{k}$

Definition 1 An N−linear connection D is called almost symplectic if:

$$a^{ij}{}_{|h}=0,\ a_{ij}\overset{(\alpha)}{|}{}_{h}=0,\ a^{ij}\,|^{h}=0,(\alpha=1,...,k-1). \tag{9}$$

We associate to the lift A the operators of Obata's type given by:

$$\Omega_{hk}^{ij}=\frac{1}{2}(\delta_{h}^{i}\delta_{k}^{j}-a_{hk}a^{ij}),\ \Omega_{hk}^{*ij}=\frac{1}{2}(\delta_{h}^{i}\delta_{k}^{j}+a_{hk}a^{ij}). \tag{10}$$

Let $A_2(\widetilde{T}^{*k}M)$ be the set of all skewsymmetric d-tensor fields, of the type (0,2) on $\widetilde{T}^{*k}M$ $k\geq 2,k\in N$. As is easily shown, the relations for $a_{ij},b_{ij}\in A_2(\widetilde{T}^{*k}M)$ defined by:

$$\begin{aligned}&(a_{ij}\approx b_{ij})\Leftrightarrow((\exists)\lambda(x,y^{(1)},...,y^{(k-1)},p)\in F(\widetilde{T}^{*k}M),\\&a_{ij}(x,y^{(1)},...,y^{(k-1)},p)=e^{2\lambda(x,y^{(1)},...,y^{(k-1)},p)}b_{ij}(x,y^{(1)},...,y^{(k-1)},p))\end{aligned} \tag{11}$$

is an equivalence relation on $A_2(\widetilde{T}^{*k}M)$.

Definition 2 The equivalent class $\hat{A}$ of $A_2(\widetilde{T}^{*k}M)/\approx$ to which A belongs, is called conformal almost symplectic structure on $T^{*k}M$.

Thus:

$$\begin{aligned}&\hat{A}=\{A'\mid a'_{ij}(x,y^{(1)},...,y^{(k-1)},p)=e^{2\lambda(x,y^{(1)},...,y^{(k-1)},p)}a_{ij}(x,y^{(1)},...,y^{(k-1)},p),\\&\lambda(x,y^{(1)},...,y^{(k-1)},p)\in F(\widetilde{T}^{*k}M)\}.\end{aligned} \tag{12}$$

3. GENERAL CONFORMAL ALMOST SYMPLECTIC N-LINEAR CONNECTIONS

Definition 3 An N-linear connection, D, with local coefficients: $D\Gamma(N) = \left(H^i{}_{jh}, \underset{(\alpha)}{C}{}^i{}_{jh}, C_i^{jh} \right)$, $(\alpha = 1,...,k-1)$, is called general conformal almost symplectic N-linear connection with respect to $\hat{A}$ if:

$$a_{ij|h} = K_{ijh},\ a_{ij}\overset{(\alpha)}{|}{}_h = \underset{(\alpha)}{Q}{}_{ijh},\ a_{ij}|^h = \dot{Q}_{ij}{}^h, \tag{13}$$

where $|_h,\ \overset{(\alpha)}{|}{}_h\ and\ |^h$, denote the $h-, v_\alpha -$ and $w_k -$ covariant derivatives with respect to D and $K_{ijh}, \underset{(\alpha)}{Q}{}_{ijh}, \dot{Q}_{ij}{}^h$ are arbitrary tensor fields on $T^{*k}M$ of the types (0,3), (0,3) and (2,1) respectively, with the properties:

$$K_{ijh} = K_{jih},\ \underset{(\alpha)}{Q}{}_{ijh} = \underset{(\alpha)}{Q}{}_{jih},\ \dot{Q}_{ij}{}^h = \dot{Q}_{ji}{}^h,\ (\alpha = 1,...,k-1). \tag{14}$$

Definition 4 An N-linear connection, D, with local coefficients: $D\Gamma(N) = \left(H^i{}_{jh}, \underset{(\alpha)}{C}{}^i{}_{jh}, C_i^{jh} \right)$, $(\alpha = 1,...,k-1)$, for which there exists the 1-form ω, $\omega = \omega_i dx^i + \underset{(1)}{\dot{\omega}_i}\, \delta y^{(1)i} + ... + \underset{(k-1)}{\dot{\omega}_i}\, \delta y^{(k-1)i} + \ddot{\omega}^i \delta p_i$, such that:

$$\begin{cases} a_{ij|h} = 2\omega_h g_{ij},\ a_{ij}\overset{(\alpha)}{|}{}_h = \underset{(\alpha)}{\dot{\omega}_h}\, a_{ij}, \\ a_{ij}|^h = 2\ddot{\omega}^h a_{ij}, \end{cases} \tag{15}$$

where $|_h,\ \overset{(\alpha)}{|}{}_h\ and\ |^h$, denote the $h-, v_\alpha -$ and $w_k -$ covariant derivatives with respect to D, $(\alpha = 1,...,k-1)$ is called conformal almost symplectic N-linear connection, with respect to the conformal almost symplectic d-structure $\hat{A}$, corresponding to the 1-form ω and it is denoted by: $D\Gamma(N, \omega)$.

We shall determine the set of all general conformal almost symplectic N-linear connections, with respect to $\hat{A}$.

Let $\overset{0}{D}\Gamma(N) = \left(\overset{0}{H}{}^i{}_{jh}, \underset{(\alpha)}{\overset{0}{C}}{}^i{}_{jh}, \overset{0}{C}{}_i^{jh} \right)$ $(\alpha = 1,...,k-1)$ be the local coefficients of a fixed N- linear connection $\overset{0}{D}$, where $(\underset{(\alpha)}{N}{}^j_i(x, y^{(1)},..., y^{(k-1)}, p), N_{ij}(x, y^{(1)},..., y^{(k-1)}, p))$, $(\alpha = 1,...,k-1), (i, j = 1,2,...,n)$ are the local coefficients of the nonlinear connection N.

Then any N-linear connection, D, with the local coefficients $D\Gamma(N)=\left(H^{i}{}_{jh},\underset{(\alpha)}{C^{i}}{}_{jh},C_{i}^{jh}\right),(\alpha=1,...,k-1)$, can be expressed in the form [13]:

$$\begin{cases}\overline{H}^{i}_{sj}=H^{i}_{sj}-B^{i}_{sj},\\ \underset{(\alpha)}{\overline{C}}{}^{i}{}_{sj}=\underset{(\alpha)}{C}{}^{i}{}_{sj}-\underset{(\alpha)}{D}{}^{i}{}_{sj},(\alpha=1,...,k-1),(k\geq 2,k\in N),\\ \overline{C}_{s}^{ij}=C_{s}^{ij}-D_{s}^{ij}.\end{cases} \tag{16}$$

Using the relations (13), (16) and the Theorem 1 given by R.Miron in ([5]) for the case of Finsler connections we obtain:

Theorem 2 Let $\overset{0}{D}$ be a given N -linear connection, with local coefficients $\overset{0}{D}\Gamma(N)=\left(\overset{0}{H}{}^{i}{}_{jh},\underset{(\alpha)}{\overset{0}{C}}{}^{i}{}_{jh},\overset{0}{C}_{i}^{jh}\right)$ $(\alpha=1,...,k-1)$. The set of all general conformal almost symplectic N-linear connections, with respect to $\hat{A}$, corresponding to the same nonlinear connection N, with local coefficients $D\Gamma(N)=\left(H^{i}{}_{jh},\underset{(\alpha)}{C^{i}}{}_{jh},C_{i}^{jh}\right),(\alpha=1,...,k-1)$ is given by:

$$\begin{cases}H^{i}{}_{jh}=\overset{0}{H}{}^{i}{}_{jh}+\frac{1}{2}a^{im}(a_{mj|\overset{0}{h}}-K_{mjh})+\Omega^{ir}_{sj}X^{s}_{rh},\\ \underset{(\alpha)}{C}{}^{i}{}_{jh}=\underset{(\alpha)}{\overset{0}{C}}{}^{i}{}_{jh}+\frac{1}{2}a^{im}(a_{mj}\overset{(\alpha)}{\underset{0}{|}}{}_{h}-\underset{(\alpha)}{Q}{}_{mjh})+\Omega^{ir}_{sj}\underset{(\alpha)}{Y}{}^{s}{}_{rh},(\alpha=1,...,k-1),\\ C_{i}^{jh}=\overset{0}{C}_{i}^{jh}+\frac{1}{2}a^{mj}(a_{mj}\overset{0}{|}{}^{h}-\dot{Q}_{mi}{}^{h})+\Omega^{jr}_{si}Z_{r}^{sh},\end{cases} \tag{17}$$

Where $\underset{|h}{0}$, $\overset{(\alpha)}{\underset{0}{|}}{}_{h}$,and $\overset{0}{|}{}^{h}$ denote the $h-,v_{\alpha}-$ and $w_{k}-$ covariant derivatives with respect to $\overset{0}{D}$, $X^{i}_{jh},\underset{(\alpha)}{Y}{}^{i}{}_{jh},Z_{i}^{jh}$ are arbitrary d-tensor fields and $K_{ijh},\underset{(\alpha)}{Q}{}_{ijh},\dot{Q}_{ij}{}^{h}$ are arbitrary d-tensor fields of the types (0,3), (0,3) and (2,1) respectively, with the properties $K_{ijh}=K_{jih},\underset{(\alpha)}{Q}{}_{ijh}=\underset{(\alpha)}{Q}{}_{jih},\dot{Q}_{ij}{}^{h}=\dot{Q}_{ji}{}^{h},(\alpha=1,...,k-1)$.

Particular cases:

1. If we take $K_{ijh}=2\omega_{h}a_{ij},\underset{(\alpha)}{Q}{}_{ijh}=2\underset{(\alpha)}{\dot{\omega}_{h}}a_{ij},(\alpha=1,...,k-1),\dot{Q}_{ij}{}^{h}=2\ddot{\omega}^{h}a_{ij}$ in Theorem 2, we obtain:

Theorem 3 Let $\overset{0}{D}$ be a given N -linear connection, with local coefficients $\overset{0}{D}\Gamma(N)=\ =\left(\overset{0}{H}{}^{i}{}_{jh},\underset{(\alpha)}{\overset{0}{C}}{}^{i}{}_{jh},\overset{0}{C}_{i}^{jh}\right)$ $(\alpha=1,...,k-1)$.

The set of all conformal almost symplectic N-linear connections with respect to $\hat{A}$, corresponding to the 1-form ω, with local coefficients $D\Gamma(N,\omega) = \left(H^i{}_{jh}, \underset{(\alpha)}{C}{}^i{}_{jh}, C_i^{jh}\right), (\alpha = 1,...,k-1)$ is given by:

$$\begin{cases} H^i{}_{jh} = \overset{0}{H}{}^i{}_{jh} + \frac{1}{2}a^{im}(a_{mj\,|\,\overset{0}{h}} - 2\omega_h a_{mj}) + \Omega^{ir}_{sj}X^s{}_{rh}, \\ \underset{(\alpha)}{C}{}^i{}_{jh} = \overset{0}{\underset{(\alpha)}{C}}{}^i{}_{jh} + \frac{1}{2}a^{im}(a_{mj}\overset{(\alpha)}{\underset{0}{|}}{}_h - 2\underset{(\alpha)}{\dot{\omega}_h}\, a_{mj}) + \Omega^{ir}_{sj}\underset{(\alpha)}{Y}{}^s{}_{rh}, (\alpha = 1,...,k-1), \\ C_i^{jh} = \overset{0}{C}{}_i^{jh} + \frac{1}{2}a^{mj}(a_{mi}\overset{0}{|}{}^h - 2\ddot{\omega}^h a_{mi}) + \Omega^{jr}_{si}Z_r^{sh}, (i,j,h = 1,2,...,n), \end{cases} \tag{18}$$

where $\underset{|}{}_{\overset{0}{h}}$, $\overset{(\alpha)}{\underset{0}{|}}{}_h$, and $\overset{0}{|}{}^h$ denote the $h-, v_\alpha -$ and $w_k -$ covariant derivatives with respect to $\overset{0}{D}$, $X^i{}_{jh}, \underset{(\alpha)}{Y}{}^i{}_{jh}, Z_i^{jh}$ are arbitrary d-tensor fields, $(\alpha = 1,...,k-1)$, $\omega = \omega_i dx^i + \underset{(1)}{\dot{\omega}_i}\,\delta y^{(1)i} + ... + \underset{(k-1)}{\dot{\omega}_i}\,\delta y^{(k-1)i} + \ddot{\omega}^i \delta p_i$, is an arbitrary 1-form and Ω is the operator of Obata's type given by (10).

2. If $X^i{}_{jh} = \underset{(\alpha)}{Y}{}^i{}_{jh} = Z_i^{jh} = 0$, in Theorem 2 we have:

Theorem 4 Let $\overset{0}{D}$ be a given N -linear connection, with local coefficients $\overset{0}{D}\Gamma(N) = \left(\overset{0}{H}{}^i{}_{jh}, \overset{0}{\underset{(\alpha)}{C}}{}^i{}_{jh}, \overset{0}{C}{}_i^{jh}\right)$ $(\alpha = 1,...,k-1)$. Then the following N-linear conection K, with local coefficients $K\Gamma(N) = \left(H^i{}_{jh}, \underset{(\alpha)}{C}{}^i{}_{jh}, C_i^{jh}\right), (\alpha = 1,...,k-1)$, given by (19) is general conformal almost symplectic with respect to $\hat{A}$:

$$\begin{cases} H^i{}_{jh} = \overset{0}{H}{}^i{}_{jh} + \frac{1}{2}a^{im}(a_{mj\,|\,\overset{0}{h}} - K_{mjh}), \\ \underset{(\alpha)}{C}{}^i{}_{jh} = \overset{0}{\underset{(\alpha)}{C}}{}^i{}_{jh} + \frac{1}{2}a^{im}(a_{mj}\overset{(\alpha)}{\underset{0}{|}}{}_h - \underset{(\alpha)}{Q}{}_{mjh}), (\alpha = 1,...,k-1), \\ C_i^{jh} = \overset{0}{C}{}_i^{jh} + \frac{1}{2}a^{mj}(a_{mi}\overset{0}{|}{}^h - \dot{Q}_{mi}{}^h), \end{cases} \tag{19}$$

where $\underset{|}{}_{\overset{0}{h}}$, $\overset{(\alpha)}{\underset{0}{|}}{}_h$, and $\overset{0}{|}{}^h$ denote the $h-, v_\alpha -$ and $w_k -$ covariant derivatives with respect to $\overset{0}{D}$, and $K_{ijh}, \underset{(\alpha)}{Q}{}_{ijh}, \dot{Q}_{ij}{}^h$ are arbitrary d-tensor fields of the types (0,3), (0,3) and (2,1) respectively, with the properties: $K_{ijh} = K_{jih}, \underset{(\alpha)}{Q}{}_{ijh} = \underset{(\alpha)}{Q}{}_{jih}, \dot{Q}_{ij}{}^h = \dot{Q}_{ji}{}^h, (\alpha = 1,...,k-1)$.

3. If we take a general conformal almost symplectic N-linear connection with respect to $\hat{A}$ as $\overset{0}{D}$, in Theorem 2 we have:

Theorem 5 Let $\overset{0}{D}$ be on $T^{*k}M$ a fixed general conformal almost symplectic N-linear connection with respect to $\hat{A}$, with the local coefficients $\overset{0}{D}\Gamma(N)=\left(\overset{0}{H}^{i}{}_{jh},\overset{0}{C}{}^{i}_{(\alpha)}{}_{jh},\overset{0}{C}{}_{i}^{jh}\right)$ $(\alpha=1,...,\ k-1)$. The set of all general conformal almost symplectic N-linear connections, with respect to $\hat{A}$, with local coefficients $D\Gamma(N)=\left(H^{i}{}_{jh},C^{i}_{(\alpha)}{}_{jh},C_{i}^{jh}\right),(\alpha=1,...,k-1)$ is given by:

$$\begin{cases} H^{i}{}_{jh}=\overset{0}{H}{}^{i}{}_{jh}+\Omega^{ir}_{sj}X^{s}{}_{rh}, \\ C^{i}_{(\alpha)}{}_{jh}=\overset{0}{C}{}^{i}_{(\alpha)}{}_{jh}+\Omega^{ir}_{sj}Y^{s}_{(\alpha)}{}_{rh},\ (\alpha=1,...,k-1), \\ C_{i}^{jh}=\overset{0}{C}{}_{i}^{jh}+\Omega^{jr}_{si}Z_{r}^{sh}, \end{cases} \tag{20}$$

where $X^{i}{}_{jh},Y^{i}_{(\alpha)}{}_{jh},Z_{i}^{jh}$ are arbitrary d-tensor fields, $(\alpha=1,...,k-1)$.

4. If $K_{ijh}=Q_{(\alpha)}{}_{ijh}=\dot{Q}_{ij}{}^{h}=0,(\alpha=1,...,k-1)$ in Theorem 2 we obtain the set of all almost symplectic N-linear connection in the case when the nonlinear connection is fixed:

Theorem 6 Let $\overset{0}{D}$ be a given N -linear connection, with local coefficients $\overset{0}{D}\Gamma(N)=$ $=\left(\overset{0}{H}{}^{i}{}_{jh},\overset{0}{C}{}^{i}_{(\alpha)}{}_{jh},\overset{0}{C}{}_{i}^{jh}\right)$ $(\alpha=1,...,k-1)$. The set of all almost symplectic N-linear connections, with respect to $\hat{A}$, corresponding to the same nonlinear connection N, with local coefficients $D\Gamma(N)=\left(H^{i}{}_{jh},C^{i}_{(\alpha)}{}_{jh},C_{i}^{jh}\right),(\alpha=1,...,k-1)$ is given by:

$$\begin{cases} H^{i}{}_{jh}=\overset{0}{H}{}^{i}{}_{jh}+\frac{1}{2}a^{im}a_{mj}{}_{|\overset{0}{h}}+\Omega^{ir}_{sj}X^{s}{}_{rh}, \\ C^{i}_{(\alpha)}{}_{jh}=\overset{0}{C}{}^{i}_{(\alpha)}{}_{jh}+\frac{1}{2}a^{im}a_{mj}\overset{(\alpha)}{|}_{h}+\Omega^{ir}_{sj}Y^{s}_{(\alpha)}{}_{rh},\ (\alpha=1,...,k-1), \\ C_{i}^{jh}=\overset{0}{C}{}_{i}^{jh}+\frac{1}{2}a^{mj}a_{mj}\overset{0}{|}{}^{h}+\Omega^{jr}_{si}Z_{r}^{sh}, \end{cases} \tag{21}$$

where $\underset{|h}{0}$, $\overset{(\alpha)}{|}_{h}$, and $\overset{0}{|}{}^{h}$ denote the $h-,v_{\alpha}-$ and $w_{k}-$ covariant derivatives with respect to $\overset{0}{D}$, $X^{i}{}_{jh},Y^{i}_{(\alpha)}{}_{jh},Z_{i}^{jh}$ are arbitrary d-tensor fields.

Theorem 7 *The mappings* $D\Gamma(N) \to \overline{D}\Gamma(N)$ *determined by* (20), *together with the composition of these mappings is an abelian group.*

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AN ANALYSIS OF 3G-4G TRAFFIC GUIDANCE METHODS

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Abstract: *As the LTE radio access technology is deployed in more and more world areas, a new challenge - apart from the well-known signaling and scalability issues - arises. The need to direct all the radio mobile network's subscribers' traffic optimally and the question of whether to choose the legacy networks or the new and improved one become problematic. This paper discusses a number of traffic directing methods, compares them with a series of criteria and offers recommendations regarding network choices, based on points of view like LTE penetration, traffic volumes, and subscribers' LTE capabilities.*

Keywords: *3G,4G, traffic methods, simulation, carrier, throughput.*

1. INTRODUCTION

Next generation wireless networks are designed in order to be operational in areas where there already is signal coverage provided by other networks of different technologies, e.g. 2.5G, 3G, LTE. These new networks have the ability to integrate radio access technologies such as Long Term Evolution and LTE-Advanced over existing networks GSM (Global System for Mobile Communications), UMTS / HSPA (3GPP Universal Mobile Telecommunications System / High Speed Packet Access) and Wi-Fi (Wireless Fidelity) [1, 2].

All types of networks mentioned above work with different sets of frequencies and each of them use particular cell sizes. These dimensions can vary from macro-cells that can have an approximately 15km diameter, to pico or femto-cells that are typically used in order to provide additional coverage in small areas or so-called "islands".

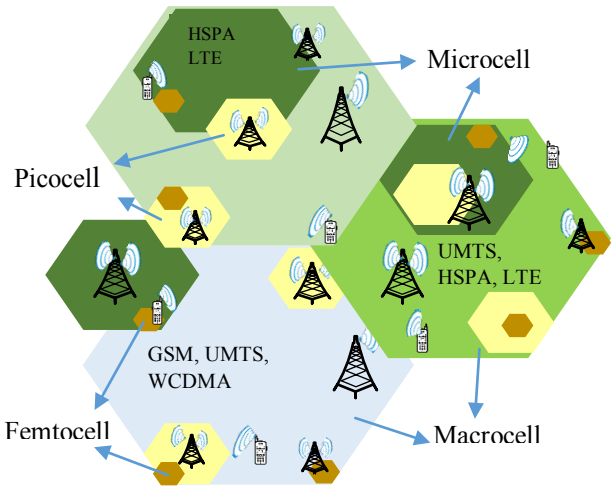

FIG.1. General mobile network infrastructure

Interconnecting these networks is not without a number of difficulties. The main problems include: traffic congestion, interference management in the numerous cases of overlapping channels, continuous adjustment of the small cell coverage, handover procedures between all the networks involved and directing traffic to the network able to offer best performance from the points of view of both the subscriber and the network. The scope of this paper is choosing the optimal traffic directioning method, when faced with different congestion scenarios, which attempt to resemble real-life situations as much as possible.

2. TRAFFIC COORDINATION ALGORITHMS

Traffic coordination assumes that it would be directed towards a carrier belonging to a radio access technology, which would be available at that moment, and which would transport the respective service to a subscriber or a number of subscribers. This aspect may cause significant load on the signaling network. Consequently, several criteria in above question must be taken into account, such as resource load balancing, minimizing end user terminals power consumption as well as signaling headers, being among the most important [3-7]. These aspects are all chosen keeping in mind the growth of end user satisfaction. Also, these objectives are all in direct correlation with the traffic directing policies of each mobile telecom operator.

There are a number of articles concerned with load balancing and handover parameters, as discussed in [8] and [9]. These all are presented regarding the LTE radio technology; [10] present a number of traffic directing types and their respective planning.

This article discusses several methods for coordinating traffic between HSPA and LTE on the downlink direction of the macro-cells, aiming to maximize the transfer rate or the flow of traffic, measured at the subscriber's terminal. Based on a theoretical model for coordinating traffic, the best traffic load balancing between the two carriers is estimated. It also assesses the impact on end user terminal capabilities.

The study of traffic coordination in 3G and 4G networks can be done using a number of methods that can be classified as static or dynamic, taking into account the carrier capabilities and the way their load is managed. The methods of coordinating users on different carriers can be made using different possibilities ranging from the use of random techniques, to considering the SINR parameter (Signal to Interference plus Noise Ratio) and the instantaneous traffic load as a starting point for the calculation.

Taking into account the access to services provided by mobile networks, this study starts from the premise that directing subscribers is possible only when connected and afterwards every subscriber will remain active and does not intend to receive services in another carrier than the one which is assigned to it, from the connection moment until the call is terminated.

The carrier capacity is defined as the average cell throughput (measured in Mbps), and the load is assessed by the number of users on a particular carrier.

2.1. The random method (A)

The random method randomly directs subscribers towards a carrier. For instance, considering the case of having 2 carriers, approximately about half of the subscribers are directed towards each carrier, but, at a given time, their distribution on those 2 carriers may be not even close to equal. The main benefit of this method is the absence of any prior load or traffic information necessity. The random method is a static method.

2.2. The "Best Carrier" method (CMBP)

This method relies on the fact that carrier's capabilities are known. A number of subscribers is defined, chosen by the operator, which will be coordinated to each carrier. It is recommended that the number of subscribers that will be directed should be chosen in order to maximize traffic flow. The target is to achieve a more balanced load between the carriers that are supposed to have equal capacities.

CMBP method may be used in combination with the random method. An operator wishing to use the best carrier method can only define a relationship of load-bearing between carriers and users can be directed randomly to any carrier according to the report previously defined.

The INR or the load of any carrier at any given time will not be taken into account for this type of hybrid traffic directing method.

The best carrier method is also a static method.

2.3. The Subscriber Load method

This method, unlike the two above, directs traffic dynamically, keeping account of the loading of each carrier. The goal is that subscribers should be directed to the carrier with the lowest normalized load.

Normalized load [1] is defined as the ratio between the number of subscribers of each carrier and the carrier capacity

$$arg\min_{N_p \in P}\left(\frac{nUN_p}{CN_p}\right)$$

where the arg min (arguments of the minima) are computed considering

N_p = carrier number

nUN_p = the number of users of the N_p carrier

C N_p = carrier capacity

P = the range of available carriers (be them from the same layer or from overlaid layers)

2.4. User Throughput method (DTU)

The starting point of this method is the estimation of each carrier's traffic mean, for a subscriber that attempts to connect to the mobile network. This estimation takes into account three parameters:

- the SINR of that subscriber, which in turn is determined by a stochastic model;
- the number of active users of each carrier;
- a throughput curve for each carrier that tracks the flow of traffic of SINR to the user. The latter can derive from Shannon's formula or can be determined from each operator's measurements.

The user *u* will be directed towards the N carrier that is offering the maximum possible throughput (T_{max}). As such, the mean user throughput can be estimated as follows [9]:

$$T_{med} = \frac{SINR_{Tmax}(SINR)}{nUN_p + 1}$$

$$arg\min_{N_p \in P}(T_{med})$$

where SINR = SINR of user *u* which is placed on carrier N_p

$SINR_{Tmax}$ = the function which is mapping the user SINR to its throughput (this is just for a single call)

T_{med} = mean throughput estimation carrier N_p

3. MODELLING TRAFFIC DIRECTIONING

Directing traffic can be done depending on the carrier used and this is based on a Markov process that directs traffic between two radio access technologies. Supposedly there are two carriers, P1 and P2, between which traffic directing is analyzed.

There are two states regarding the two carriers, which are named Px,y, where

x = number of users belonging to carrier 1 (x=0 ... N_1)

y = number of users belonging to carrier 2 (y=0 ... N_2)

λ_1 = probability to receive new calls on carrier 1

λ_2 = probability to receive new calls on carrier 2

It is assumed that the probability to receive new calls is independent of the number of subscribers on a particular carrier.

μ_1 = probability of a call to end on carrier 1

μ_2 = probability of a call to end on carrier 2

It is assumed that all subscribers are generating equal amounts of traffic. It is also assumed that the whole capacity of a carrier is equally split among all subscribers which are using it.

N_1 = maximum user number belonging to carrier 1

N_2 = maximum user number belonging to carrier 2

The aspects described above lead to a Poisson process that can map equal probabilities of calls sent and received.

The probability of a call to end when it is situated on a layer that can carry *n* subscribers can be represented using the formula: $\mu = \frac{C}{A}$

where C = cell capacity where the user is connected [bps]

A = bit size of the call

It is assumed that A is not system-dependent. C is different because it depends on the carrier.

Using the information presented in [11], the state probability can be expressed as follows

$$P_{x,y} = P_x \cdot P_y,$$

where $P_x = \frac{\left(\frac{\mu_1-\lambda_1}{\mu_1}\right)\cdot\left(\frac{\lambda_1}{\mu_1}\right)^x}{1-\left(\frac{\lambda_1}{\mu_1}\right)^{N_{GSM}+1}}$ and $P_y = \frac{\left(\frac{\mu_2-\lambda_2}{\mu_2}\right)\cdot\left(\frac{\lambda_2}{\mu_2}\right)^x}{1-\left(\frac{\lambda_2}{\mu_2}\right)^{N_{LTE}+1}}$

Each user's mean throughput can be calculated as being the mean throughput of a state depending on this state's probability. As such, the mean throughput for an user belonging to carrier 1, can be defined as follows

$$D_{P_1} = \sum_{x=1}^{N_1}\sum_{y=1}^{N_2} P_{x,y} \cdot \frac{C_1}{x}$$

where C_1 = carrier 1's capacity.

Being given any cell, different subscribers have different bit rates depending on the place they occupy in the cell, from a geographical point of view.

For example, a subscriber situated at the edge of the cell will have a much lower speed compared to a subscriber located near the antenna that is placed in the center of the cell.

The likelihood that a user will benefit from the traffic flow of*t*, can be expressed as a function of traffic flow *t*, assuming no other user on the same carrier is using all the resources of the cell.

It is assumed that there is no other subscriber on the carrier so that the subscriber in question benefits from all of the resources of the cell.

Depending on the location of the subscriber in the cell, the bit rate that it benefits from may change. Thus, one can estimate the probability of bit rate *r* has on the carrier 1 as:

$$P(D_{P_1} = t) = \sum_{x=1}^{N_1} \sum_{y=1}^{N_2} P_{x,y} \cdot f(xt)$$

This analytic model can also be used on the algorithms described above. For example, considering the random algorithm, λ_1 will be equal to λ_2. In the case of the CMBP algorithm, several values of λ are required.

4. PROBABILITIES SIMULATION

In the simulations presented below, subscribers per cell records are generated according to a Poisson distribution. SINR values of subscribers are drawn from a SINR distribution that differs depending on the simulation scenario chosen. The simulation was made using OPNET with vendor-specific plug-ins.

The chosen scenario is 3GPP macro 3, which is used by an operator from Romania where the average distance between sites is 1600m. The SINR of each subscriber is considered to be constant during calls because it is assumed that subscribers do not move significantly. Consequently, fading phenomenon is also negligible.

Table 1 The simulation parameters.

Traffic coordination method	A, CMBP, IU, DTU
Load	2; 4; 6; 8 Mbps
User generation	Poisson arrivals
Planning algorithm	Round robin
HSPDA user class	$\leq 15\ codes; \leq 64QAM$
LTE coverage	100%
Antenna configuration	1x2 antenna
Channel Bandwitdh	3G and 4G: 5MHz
Traffic model	Finite buffer 600kB

Two carriers are considered, the LTE "high" frequency one of 2.1GHz and the 3G "lower" frequency of 800 MHz. The cumulative distribution function (which traces the bit rate difference between subscribers) differs by a level less than 1 dB between the two radio access technologies (3G and 4G). It is also assumed that cell resources are shared equally among all active subscribers.

5. RESULTS

In this section the numerical results concerning the static methods of directing traffic (random method and the method of "the best carrier") compared to the results of the analytical method, will be discussed.

Figure 2 shows 10% of traffic flow in Mbps when using static methods, depending on the possible load of the cell. 3G and 4G curves indicate 10% of the traffic of 3G and 4G technologies when using the random method. When using the CMBP algorithm there can be seen an improvement over the random method. The reason the random method can not improve its results is because of the congestion that occurs on the 3G carrier as the traffic is approaching the 50% threshold. Also, the figure indicates that there is a significant approach between the simulation (sml) results and those of the analytical (anl) method.

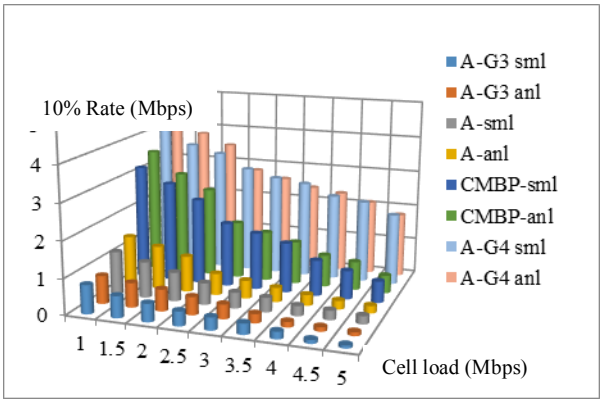

FIG.2. 10% of traffic flow depending on the cell load for the random and "best carrier" methods compared to the analytical method and results of the simulation

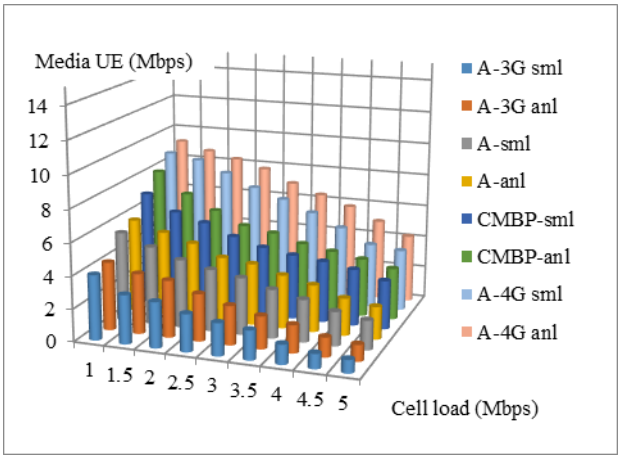

FIG.3. Comparison of average subscriber throughput in terms of analytical results and in those of the simulation results.

Fig.3 depicts average traffic flow based on cell load considering the same conditions as those of fig.2. Here it can be seen that the random method has similar performances in particular 3G and 4G cases compared to the case when this method is applied to both radio access technologies.

The method "best carrier" is proving to be more effective than the random method. Generally speaking, the analytical results are aligning with those obtained from simulations.

A cell load limit of 5Mbps has been chosen because the simulation results lose precision when the system load exceeds 6Mbps. Thus, the analytical model is valid only for stable systems. If a higher load of 6Mbps is desired, the analytical model is not recommended.

It can be concluded that the field results resemble a lot to the expected results from theoretical analysis. Also the best carrier method had the best performance and thus, this method will be used as the benchmark in the next section.

An analysis between the load-based method and the traffic flow method, based on the subscriber's throughput, both compared to the CMBP method.

Fig.4 depicts the average throughput depending on the available cell load. Here, the method "best carrier" has the worst performance. Note that the network becomes congested at a load higher than 6 Mbps.

Thus, when using the CMBP method, subscribers situated at the edge of the cell do not receive a high quality signal. Instead, other methods manage to provide an acceptable data rate which can increase when the number of connection requests grows.

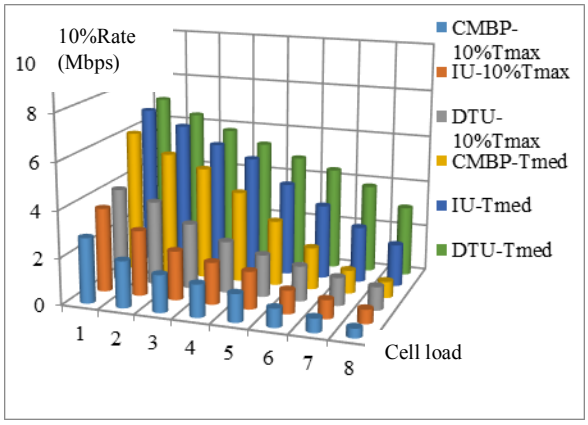

FIG.4. 10% user data rate, depending on cell load

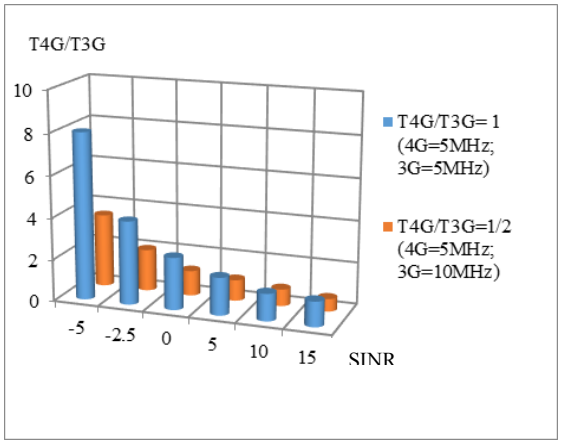

FIG.5. 4G throughput gain compared to 3G

Looking at the throughput, the load-based method and the throughput-based method offer better quality, when compared to the best carrier method. For loads up to 5 Mbps, the two methods in question have close performances, so it can be concluded that there is no gain when the subscriber's SINR is also taken into account. At loads of over 5 Mbps, the subscriber's throughput-based method has proven to be the best algorithm.

For 6 Mbps uploads, i.e. the load used in the previous case, the CMBP method used to offer a 1.3 Mbps speeds. Using the same load, the load-based method and the throughput-based method offer speeds of 2.7Mbps and 3.4Mbps, respectively. This can translate into gains of 112% and 162%.

These gains can not be regarded as entirely real. They appear to be so high because the CMBP method does not use information "photographed" at a particular moment in time, but it is based only on the carrier's capabilities. In contrast, the other two methods are directing subscribers while taking into account information such as instantaneous load on the carrier at a particular moment in time and thus allow a dynamic alignment to the cells' and network's requirements.

The large gain obtained by the throughput-based method comes from instantaneous SINR subscriber information processing. The SINR of the subscriber is used to estimate the throughput per subscriber for each carrier, given an instantaneous load.

Figure 5 shows the 3G and 4G throughput ratio, depending on SINR. Given a small SINR, the 4G throughput is about 7.5 times greater than the 3G one. On the other hand, considering high values of SINR, the above mentioned ratio drops to around 1.5 values. This graph was presented in terms of a of 5 MHz bandwidth.

Hence it can be concluded that the subscriber's throughput method leads the lower SINR subscribers towards the 4G technology and those with higher SINR to the 3G carrier. The imperative condition is to maximize traffic flow, according to the formulae regarding the subscriber's throughput.

It should be kept in mind that such a gain resulting from the use of the throughput-based method depends on the ratio of subscriber traffic flow between 4G and 3G.

This ratio is calculated depending on a number of factors specific to each operator, such as each system's spectral efficiency, using or not using MIMO (Multiple Input Multiple Output) and so on. The closer to 1the ratio 4G / 3G is, the lower possible gain becomes, when using the throughput-based method compared to the one based on subscriber's load.

6. THE IMPACT OF SWITCHING TO 4G

This paragraph will consider two cases in which 3G and 4G, both with bandwidths of 5 MHz, have loads of 2 Mbps and 5 Mbps. For the third case the bandwidth of 10 MHz for 3G (Dual Carrier) and 5 MHz for 4G is considered, and the load is 5 Mbps.

Fig.6 shows the average throughput gain when using the throughput method versus CMBP in all the three cases above.

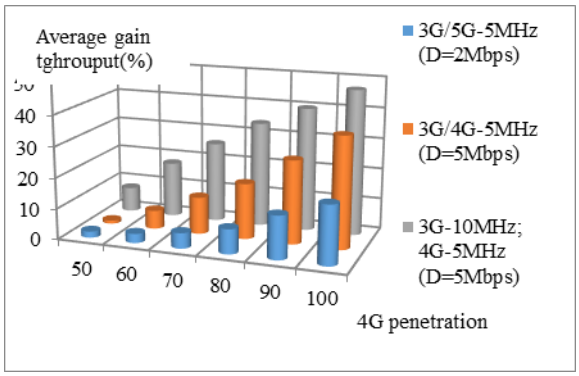

FIG.6. Average gain from the throughput point of view based on 4G penetration, using the throughput method versus best carrier method

The graph is described depending on the subscribers' capability of using LTE. It starts at 50% and is reached if all subscribers are able to use the LTE technology.

If the optimal case, e.g. 100% LTE capability, the gain from using the traffic-based algorithm is greater for a higher load, but this aspect can be extracted from figure 5 also. The explanation resides in the fact that on smaller loads, the probability of having few subscribers on a carrier is high, thus in this case there was no significant difference between methods.

When using 3G Dual-Carrier, the gain is bigger than LTE's, disregarding the LTE penetration. In this case, we basically have two carriers instead of one, so the throughput doubles, so most subscribers will be directed here, as shown in Figure 6. Consequently, the gain of the throughput method is higher because this algorithm can highlight this issue, unlike the method CMBP, which chooses its subscribers randomly.

For a network with 5 MHz bandwidth, all subscribers sent towards LTE will notice a gain, even if the biggest appears to subscribers on the cell edge that are also directed to LTE, but they have the slightest influence on the cell throughput therefore they would have received a smaller gain, have they used the throughput method.

It may be admitted that in all 3 cases, the gain using the throughput method decreases in direct proportion with the LTE capabilities of the subscribers. This is because when not all subscribers can use the LTE technology, they will be directed towards the 3G carrier, even if it is not the optimal solution. Situations can occur where everything that the throughput method can do is to direct all subscribers with LTE capabilities to the LTE carrier.

Quality-wise, this method is not different at all from the CMBP method. In these circumstances there is no gain from employing the traffic flow versus the "best carrier" one.

From the level of penetration of LTE technology point of view, at a level of maximum 45%, it can be concluded that the best method carrier offers the same performance as the more advanced methods.

When LTE penetration is increased to minimum 70%, then it is recommended to use a more advanced method. The inflection point, i.e. when deciding when to change the method, depends on the field conditions. For example, if the LTE carrier capacity increases and LTE penetration is high, then a simpler method is enough. On the other hand, if the capacity of other carriers rises, and LTE penetration is reduced, then it is recommended the use of a more advanced traffic direction method.

The amount of traffic should also be taken into consideration. In this case it was considered that each subscriber generates the same traffic volume and is independent of the terminal type. But it is expected that LTE subscribers will generate more traffic than the 3G ones, and so there arises another reason for using advanced methods when having reduced LTE penetration.

7. CONCLUSIONS

This paper presented a number of static and dynamic traffic directing methods. Static methods, the random and the "best carrier" were analyzed and then compared with the dynamic methods that were simulated using close to reality cases, and the results showed significant similarities in certain conditions.

Considering complete LTE penetration, it has been demonstrated that the dynamic throughput-based method, shows better results than all of the other methods discussed above.

It has been demonstrated that dynamic methods, based on both the subscriber load and the subscriber throughput, show gain only when the LTE penetration level exceeds the 70% mark. Below this level, we see that the "best carrier" method provides as good results as the ones from the dynamic methods.

The inflection point, i.e. when it is recommended to make the transition from one method to another, depends on the amount of generated traffic and subscribers' capabilities to connect to the LTE technology.

In conclusion it can be said that choosing the best traffic directing method depends mostly on the level of LTE penetration. When this is high, the use of dynamic methods is recommended because they can detect cell load at a given time, and when penetration is not significant, it is recommended to direct all subscribers with LTE capabilities to the carrier with the same name.

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MAKING A VOICE CALL USING ARDUINO UNO R3 AND GSM GPRS SHIELD A-GSM v2.68

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Abstract: *This paper describes how to integrate a GSM module with Arduino and make them to call a particular mobile number. For this project, the GSM module is interfaced with the prototyping platform Arduino Uno R3, which makes the hardware circuitry simple and easy to be coded, using the C based programming environment Arduino Software IDE.*

Keywords: *Arduino Uno, GSM Shield, GPRS, Voice Call*

1. INTRODUCTION

Over the years, Arduino has become one of the most accessible and flexible open-source projects for building interactive objects that can sense and control external devices.

Arduino and Arduino-compatible boards use printed circuit expansion boards called *shields*, which plug into the normally supplied Arduino pin headers. This way the Arduino board is interfacing with the world: shields can provide motor controls, GPS (Global Positioning System), Ethernet, LCD (Liquid Crystal Display), or bread boarding (prototyping). Several shields can also be made DIY (Do It Yourself) [1].

In the last 10 years, many application ideas were implemented using the Arduino board and the GSM/GPRS shield: remote control of appliances (send SMS while you are at your office to turn on or off your washing machine at home), remote weather station or a wireless sensor network (create a sensor node capable of transferring sensor data to a web server), interactive voice response system (couple the GPRS shield with an MP3 decoder and a DTMF decoder – besides an Arduino), vehicle tracking system (couple the GPRS shield with and Arduino and GPS module, install it in the car and publish your location on the Internet) [2].

In order to understand how a mobile phone can be realized using the Arduino Uno R3 and the A-GSM shield, there must be specified what a mobile phone is: an electronic device used for mobile telecommunications over a cellular network of specialized base stations known as cell sites. A cell phone offers full Duplex Communication and transfer the link when the user moves from one cell to another. As the phone user moves from one cell area to another, the system automatically commands the mobile phone and a cell site with a stronger signal, to switch on to a new frequency in order to keep the link. This sophisticated device is using SMD components, microprocessor, flash memory, etc. In addition to the circuit board, it also has antenna, LCD (Liquid Crystal Display), keyboard, microphone, speaker and battery [3].

The A-GSM shield allows the Arduino board to make calls using a GSM library. The high performance GSM GPRS module (Quectel M85) with worldwide coverage and integrated GSM antenna bring flexibility and easiness in integration of the platform and application. The shield is configured and controlled via its UART (Universal Asynchronous Receiver/Transmitter) using simple AT (Attention) commands [4].

A cell phone can be used with any cellular networks around the globe if the proper SIM card is inserted in it. This fact is possible because there is a device inside the cell phone which follows a global standard (GSM), enabling the connection with different cellular networks. The mobile phones have built in GSM modules, which can be used by the processor inside the phone to make a call, send or receive message or even connect with the GPRS network.

Voice call: how does it work? In multiple applications, the microcontroller based systems requires to be connected to the GSM network, which will enable the user to control the system by sending messages or making a call. Therefore, a separate GSM module is used rather than using the mobile phones. There are GSM modules that allow serial communication with microcontroller based systems. The communication is realized by sending or receiving AT commands [3].

2. SYSTEM IMPLEMENTATION AND EXPERIMENTAL RESULTS

2.1 Equipment used. The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital I/O pins (of which 6 can be used as PWM – Pulse Width Modulation - outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [4].

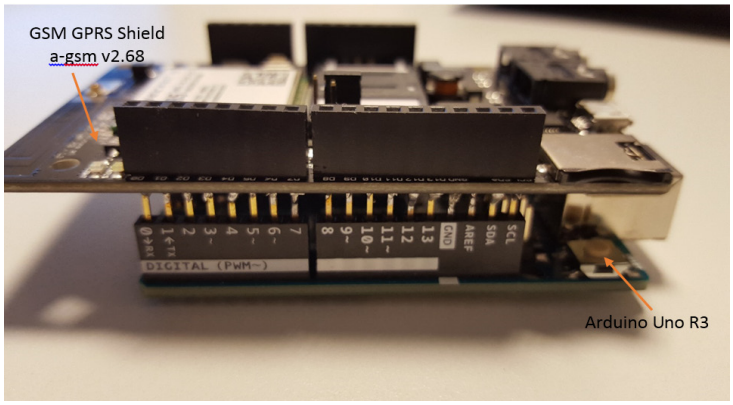


FIG. 1. Equipment used

The A-GSM v2.68 shield GSM / GPRS / SMS / DTMF for Arduino and Raspberry PI is a quad band Quectel M85 module. It has the GSM antenna integrated and the uFL connector for the external antenna, dual sim 850/950/1800/1900 MHz, 3-5V TTL serial interface and two 3.5mm jacks for headphone (700mW RMS) and microphone [5].

In order to connect the shield to Arduino, it was stuck directly into Arduino board (after a set of pins was pasted to the board – FIG. 1.). Arduino is connected to the laptop through the USB cable. For completing the system, a SIM card, a microphone and a set of headphones are also needed.

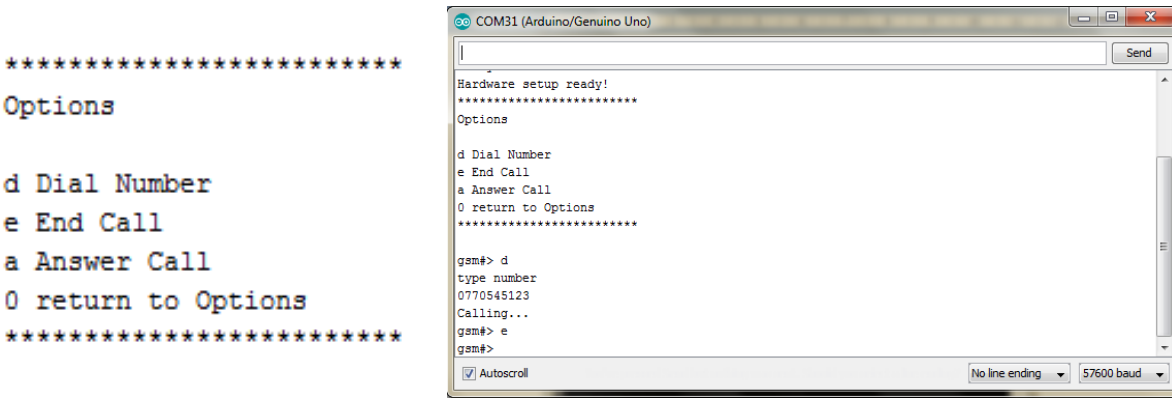
2.2 Application Description. Arduino is an open-source prototyping platform based on easy-to-use hardware and software. The board can be controlled by sending a set of instructions to its microcontroller. To do so, the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing, must be used [4].

The Arduino IDE (Integrated Development Environment) contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them [6].

Before uploading the sketch, it needs to be selected the correct items from the **Tools > Board** (select Arduino/Genuino Uno) and **Tools > Port** (the correct port can be checked in Windows Device Manager > Ports > USB serial device > COM32) menus.

Two digital pins of Arduino are used for serial communication between Arduino and GSM module. Two PWM enabled pins of Arduino have to be selected (for this particular system - pins 2 and 3). This method is possible by using the SoftwareSerial Library of Arduino. SoftwareSerial is a library of Arduino which enables serial data communication through other digital pins of Arduino. The library replicates hardware functions and handles the task of serial communication [7].

After the code is uploaded, the serial monitor (**Tools > Serial Monitor**) initializes the data exchange with the connected board, on the selected port. Initially, the board is reset. After the data exchange is initialized, a menu will be displayed for the user (FIG 2. (a)), in order for him to select the option he wants to perform.



(a) (b)

FIG. 2. (a) Menu displayed for the user; (b) Typing the phone number

When the Arduino board receives through the serial the'd' value, the user has to insert the phone number he wants to dial (FIG. 2. (b)).

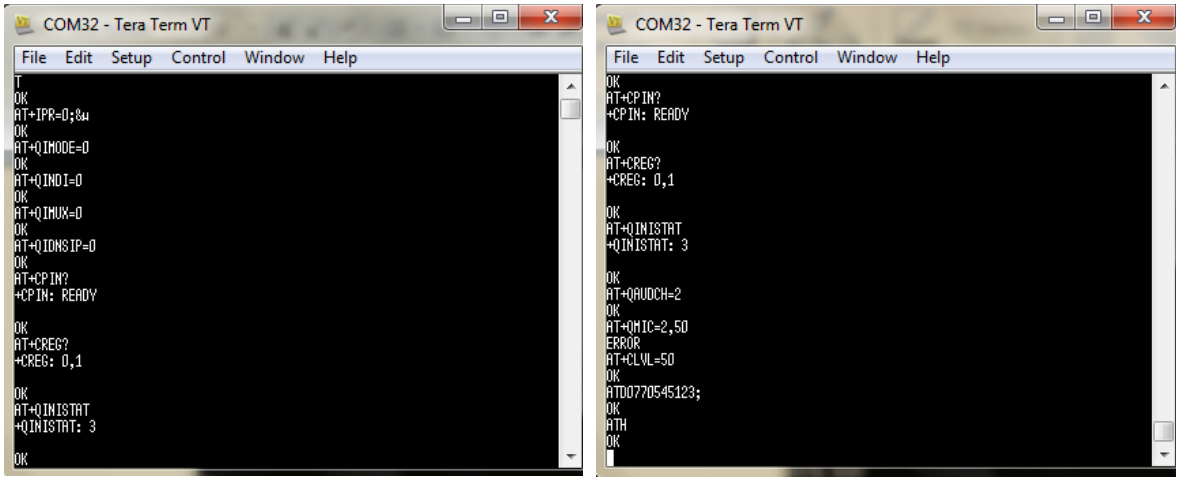
Afterwards, Arduino commands the A-GSM shield through AT commands. Many functions of the phone can be accessed by AT commands (FIG 3 (a)). Cell phone manufacturers also define their own AT commands. If a command is accepted, OK is returned, along with response (FIG 3. (b)). If command is not recognized, ERROR is returned. Some commands will be accepted in certain phone states and rejected in others.

The board may also receive calls. When the shield detects a call (the RING command will be displayed while monitoring the serialized shield – e.g. Tera Term), the user can answer the receiving call by sending the 'a' value to the Arduino board.

sendATcommand ("ATA", "OK","ERROR",2);

The user has also the option to end the on-going call by sending the ‘e’ value to the Arduino board.

sendATcommand("ATH", "OK","ERROR",2);



(a) (b)

FIG. 3. (a) Hardware setup; (b) Making/Ending a call

When none of the displayed options are selected, the user will receive the ‘Bad Command’ message and he will be redirected to the main menu.

3. CONCLUSION AND FUTURE WORK

The system presented in this paper is the first step made in realizing the design of a cell phone, by exploring various materials, shapes and functions (make/receive a phone call, reject an incoming call). Although there are multiple options when choosing to make an open source, open hardware cell phone; combining the Arduino Uno with the A-GSM v2.68 shield offers multiples opportunities for this system to be continuously developed and improved.

The application can be upgraded by adding new functionalities such as: make and receive text messages, include a phone book and a caller id, keep the time.

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CAREER COUNSELING – INVESTIGATIVE ENDEAVOUR FOR THE PROJECTION OF A CAREER PLAN

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Abstract: *Career planning is an action which takes place over a long period of time – starting from school and continuing with university of masters. A special importance in career counseling has the making of the career plan. The study brings to light, through the realization of an intervention in the area, the necessity to support young people in the access to jobs, but also the differences that can appear between participants depending on their specialization in studies. A number of 121 students took part in this study from four different specializations: geography, history, political science and journalism.*

Key words: *career, professional aspirations, career counseling, professional insertion.*

1. INTRODUCTION

Career orientation consists of those specific activities, programs or interventions through which the participants are sustained in the assimilation and the integration of the knowledge, the experience, in correlation with:

- Understanding oneself – which includes knowing one's own personality, one's own axiological system, one's own interests, the factors which determine one's own development and, at the same time the way one rapports oneself towards others, in the interaction with other people.
- The understanding of the mechanisms through which society functions, of the factors which contribute to its continuous change, of the real possibilities of insertion on the labour market, of the dynamics of the labour market.
- being aware of the role free time can play in personal life;
- understanding of the implication of multiple factors with an active role in career planning;
- understanding of the necessity of information and of the development of abilities in gaining success, of work satisfaction, but also the role of the activities done in their spare time;
- learning of the decision-making process in the choice and development of a career.

Employers prefer people who communicate easily, as this ability qualifies them for teamwork, people who think, as this will lead them to more solutions to the same problem, people who learn as this will lead to a permanent development. One can thus concede that employers are also interested in the performance one has in a specialized field, the one they took the time to create a position for at a contest, but also other aspects that complete the profile of the future employee, such as the willingness to develop, creativity and/or sociability.

Career orientation can be realized on three different approaches:

1. Career orientation in terms of the formation options and the support of the participants for getting through the formation programs;
2. Career orientation in terms of the placement options in the occupational roles and in different work places;
3. Individual orientation/counseling – being focused on the real possibilities of each participant.

The one doing the counseling can be useful to the people who take part in this process, in issues such as finding a work place or accommodating to the requests of the job description or the environment from the organization this work place can be found in. He or she can help people get a better understanding of one's own self and of the labour market, to correlate one's own interests and talents with the job responsibilities associated to the different occupational and career opportunities. Counseling becomes a significant component of the given services on the labour domain, but also on work place relations, as well as a condition for an adequate placement on the labour market.

Throughout the whole duration of the interventions which partake in regard to career orientation the following aspect proves important - the way in which one defines and perceives the participant to the intervention. "Most people experience enough success in the relationships with other people so that they have a positive concept of oneself". [1] The way in which we understand ourselves, the others and the relationship between these two parts can lead to a better integration in a workplace. An aspect not to be neglected is motivation – both in choosing one's career, and in its accomplishment. In the context of work, motivation can be defined as "the degree of availability of the employer to take part in and to make a sustained effort in order to attain certain professional objectives, defined individually or organisationally" [2]

Golu sustained that "a profession is an essential determination of one's personality, both on a personal, and on a psychological level. On one hand, it gives the measurement of the objective value of the individual in its relation with the one's around him or her, but also with society as a whole; on another hand, it represents the main manner of socialization and culturing of any individual, in a bigger or smaller consonance with its natural inclinations or predispositions" [3]

Career planning is an action which takes place on a longer time frame and starts in school and continues throughout university, and after during their masters. This process can be recommenced throughout time with each change of the organization we work in, or when our career makes a significant change. The efficiency of this process is dependent on the abilities people attain in the following competencies: self-knowledge, educational and occupational exploration, career decision and personal promotion. [4]

Traditional selection techniques rarely take into consideration the specific characteristics of the organization in which these positions exist. The selection practices more often than not take into consideration the characteristics of the person that are not relevant for the specialty requests of the position. Thus, one can see the commencement of a new type of selection, which is oriented towards the idea of the employment of a person who is the closest match to the culture that is specific to the employer's organization.

From a traditionalist perspective of the Human Resources position, such a practice can seem amiss and somehow extravagant, but it is well integrated in the new characteristics of the human management practices, especially in the management of human capital. The employees' competencies are differentiated as such, both in terms of recruitment and in terms of selection, but also in terms of learning and development. Starting from this reality, in order to come as support for future employees, one has initiated, during their university, in several specializations, a project that targeted counseling for the career access of students.

2. OBJECTIVES

The identification of dominant orientations of the subject, of the manner of relating to oneself, as well as with others, the stability or instability of certain emotional treats and particularities;

The identification of the types of professional orientations of the subject;

The finding of the factors that could contribute to a better professional insertion.

3. HYPOTHESES

The comparative analysis of the data obtained on the initial testing allows for the tracing of the areas susceptible to contain success practices for each separate specialization.

Performances tied to professional insertion of the participants in the study can be ameliorated through an intervention in the career area

4. INSTRUMENTS AND SAMPLE

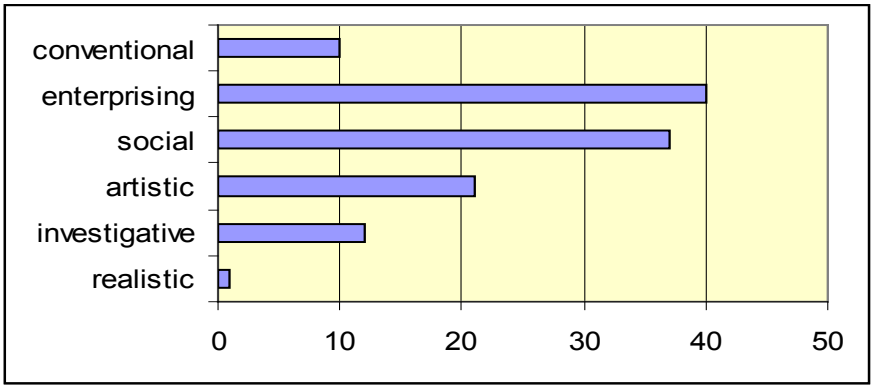
The sample of participants was formed of 121 students in different subjects. IN order to carry out the study, one started from amassing data on the subjects, through the application of a set of tasks, session followed by an intervention on the career counseling theme. The participants were students in the following subjects: geography (54 people), history (31 people), political science (21 people) and journalism (15 people). The tests used were the following: the self-knowledge test – targeting the investigation of the dominant orientations of the subject, the manner in which it relates to oneself and to other people, the stability or instability of certain treats, emotional particularities and the interests questionnaire CI-RQ – with 144 items, provided with 3 response options, resulting in 6 types of professional orientations of the personality of the subject: realistic, investigative, artistic, enterprising and conventional, as well as a preference for the occupations in a certain profession.

Following the presentation of the results of the tests we have realized an intervention in terms of achieving a career plan for the participants in the study.

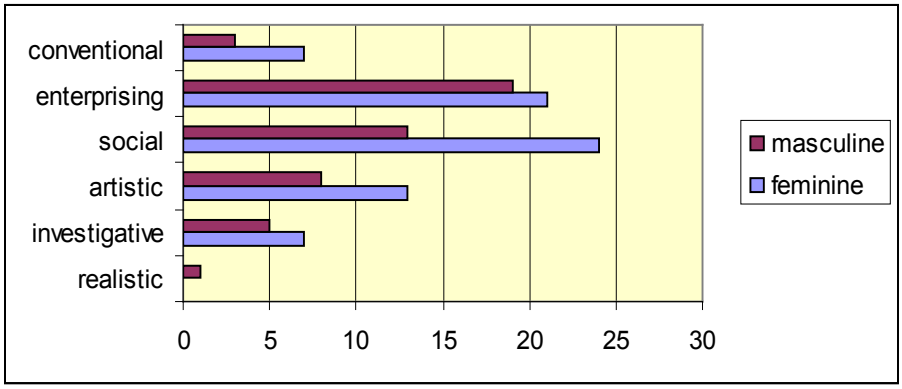
5. RESULTS OF THE STUDY

Hypothesis 1: The data obtained in this hypothesis are useful for building a personalized intervention on the specificities of each specialization from which the participants in the study were part of. Generally, choosing one's career goes along with our personality, thus there are no pure types, but only combinations of these types, with a different weight of each type on the component of the personal pattern. The questionnaire allows for the identification of a personal code formed of the first types of predominant interests. The degree of similarity between these types of interests determines the coherence of the personal pattern, reflecting the measure in which ulterior conflicts of interests are possible.

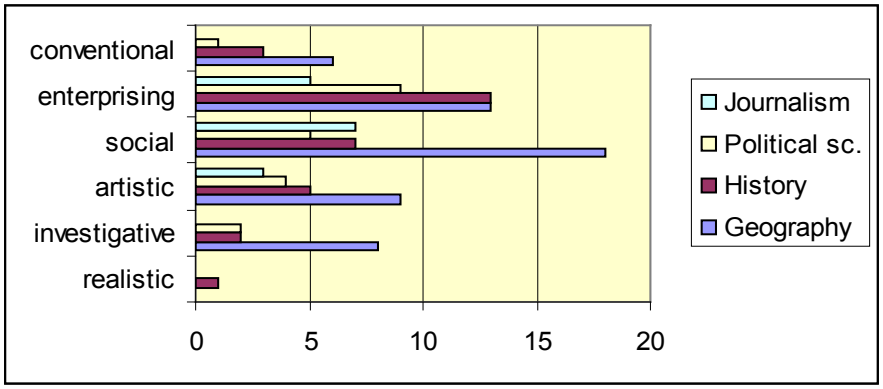
The more the types of interests that compose the personal pattern have a higher degree of similarity, the more the coherence is bigger and the probability of a conflict starting from these structures is small, which facilitates the career decision. To this data we add the values tied to self esteem, personal values, the dynamics of the relations in the year of study (as an indicator of teamwork). The data presented in the following likes represent the first choice of the participants. Due to the fact that the data obtained is extensive, in this article we present solely the first choice. The data thus obtained is:



(a)



(b)



(c)

FIG.1. Results of hypothesis 1 - **a)** for the entire sample, b) on gender , c) on specializations

Hypothesis 2:

The intervention in the career domain was built on each study specialization, so that it allows the following: making personal development more efficient, the accommodation of the search on the labour market depending on the job one seeks, the preparation for sustaining the interview to access the profession, the education for team work.

The importance of the personality traits in the person – organization match generated quite a success in a myriad of jobs. This reason has made many companies modify their selection systems in order to accentuate the personal characteristics of the applicant and, starting from here, our intervention in the domain of the career was centered on self-knowledge as a starting indicator for the development of the counseling program. As of the present day, one considers that the evaluation of one's personality can play an important role in selection processes. [5]

Human capital management assumes an alignment between the individual and the organization, and this takes place in three main areas: organizational identity and culture, human activities and human development. The career counseling program was created taking this specific structure into account. Depending on these areas, the objectives of the balance between the relation of the organization with the individual are: loyalty, dedication and motivation - the preparation of the person in the specifics of the job, but also in what concerns the dynamics of the relationship, it makes a reference to human activities, and these are tied to the dimension of dedication, the manner in which the person manages to find out data on organizational identity will lead to the development of the loyalty dimension, and the manner in which a person will understand to develop him or herself will lead to the development of the motivation dimension.

The alignment of the personal characteristics, of the attitudes and the competencies of the available human capital with the needs of the organization is a participative process. Organizations innovate, and the technologies and markets are in a permanent change.IN order to keep up with these changes, the employees – the human capital – must develop themselves in sync through the attainment of new competencies and abilities, and this thing is better to start ever since they start university.

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THE EMOTIONAL INTELLIGENCE – SOCIAL INTELLIGENCE RELATIONSHIP IN THE PARTICULAR CASE OF PSYCHOTHERAPISTS AND SOCIAL WORKERS

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Abstract: *Benefiting from a fathomable study of the values of emotional and social intelligence in therapists and social workers, one can reify certain developmental directions of these components. It is a known fact that in the jobs with a social impact, and not only, emotional intelligence has an important role and thus its development becomes even more necessary. The study brings to discussion the values of emotional and social intelligence for two distinct categories – psychotherapists and social workers, and also offers certain directions for the extension and actualization of the potential of these categories from these points of view, towards the benefit of those assisted.*

Keywords: *emotional intelligence, social intelligence, psychotherapist, social worker.*

1. INTRODUCTION

One of the important qualities in social life is the way in which we know how to communicate our emotions. It is thus even more important if our job has a high social impact, as is the case for psychotherapists and social workers. Ekman cited by Goleman "uses the term of rules of expression in order to designate the social consensus in terms of feelings that must be manifested in certain moments" [1]. Hence in the social interaction we create certain expectations from people, from certain contexts, in certain moments, and thus, even from those from whom we expect support and understanding. Emotional expression makes sense for each of us and we learn this very early in life. "Each emotion separately offers a distinctive desire to take action; each shows us the best direction to approach the inherent challenges of life" [2]. This capacity of ours to respond in the most adequate way to our emotions, given by the interaction with others, or of others is represented by interpersonal intelligence. This notion, introduced by Gardner, supports the outing of the belief people had about the importance of the role of general intelligence and brings thus emotions and their role at the forefront. "Emotional intelligence is our capacity to self-govern - ourselves, our relations with others - so that we live according to our intentions. More precisely, emotional intelligence refers to the choices we make"[3]. The benefits brought by the feelings that we have towards attested work and towards those we work with, by our capacity to find solutions for the misunderstandings that may arrive, to work in a team for a common goal. Hence, any psychotherapist or social worker is all the more efficient as their emotional intelligence is higher.

Depending on the familial climate, on the relations with people of the same age, them being either models, or not, people build their value, find themselves, look for answers to the many questions that go through each age in turn.

It happens that in this period of search, of development, people close inside themselves, they might look for answers to the questions that distress them in places or entourages that are not adequate and in this way they might block certain contents or even develop in an inappropriate manner. On this road, when they don't find adequate answers or when they find it difficult, people look for support in psychotherapists or are helped by social workers. In the jobs with a social impact, the social dynamic plays an important role. Generally, in relationships this happens in a natural manner, depending on the quality of the relationship the people in it have. Starting from what Adler said „man knows more than he understands", the interpersonal diagnosis that results following psychotherapy targets: the structural analysis of the social behavior, having as dimensions control and affiliation (the control dimension – to take or give the control and the affiliation dimension – how one rapports him or herself to the significant persons in his or her life) and the access to a set of personal inventories that look at significant relationships, life scenarios, personal themes [4]. „Each interaction has an emotional underlining. [.....] We take part in this interpersonal economy every time a social interaction has, as a result a transfer of feelings – which is something that happens almost always" [5]. It is known that therapists bring to the surface and generally work with many of the client's emotions. Concentrating on emotions does not transform the person in one that is weak or vulnerable, but on the contrary, it gives him or her the power to manage relationships, changes, conflicts, choices with great success [6]. It is not sufficient to discover what exactly is not working well, but it is necessary to orient yourself towards finding a solution for it, and this endeavour can be attended by a therapist. Gaylin said "there exists a considerable – if not an absolute – relationship between knowing good and doing good. That certainly was an assumption I carried around with me when I first started my psychotherapeutic training, and beyond"[7]. In the case of social workers, they support the underprivileged categories and the result is most of the times positive, thing that can be seen in the lives of the assisted through the partial or total solution of their issues. This endeavor is based in grand terms on the collaborative spiral model, introduces by Fivush, cited by Rime – the abilited person ensures the essential of the work task, as an initiative and content and the assisted brings his or her contribution in modest contributions at the start and then contributes more and more as he or she has the abilities for the task at hand. The entire experience is centered on doing things in common and on conveying, for the assisted, real possibilities to make the change in the sense of personal growth and autonomy [8]. The research in psychotherapy and social work, especially those that refer to the efficacy of a therapeutic or social assistance program raise a complex problem, i.e. what intervention applied by whom can give the best result. This issue refers to the interrelationship – between the psychotherapist, social worker and assisted person. In the dynamics of the relation, the personality of the therapist or of the social worker, and his or her attributes matter, and among the ones who obtain performing results are those who have a high level of emotional and social intelligence. In support of this idea, the study tries to bring to attention these two components that are in an interrelation, but also the differences between them in the case of the two jobs taken into study.

2. OBJECTIVES

1. The operationalisation and the evaluation of emotional and social intelligence in target groups.
2. The analysis of the two groups under the aspect of identifying the level of social and emotional intelligence they register.

3. GENERAL HYPOTHESIS

The level of social and emotional intelligence registers levels that are significantly higher in the case of psychotherapists, than in the one of social workers.

3.1. Hypothesis

Hypothesis 1

We assume that social and emotional intelligence constitute a psychological pluralism for all the investigated participants.

Hypothesis 2

There are differences on the social and emotional intelligence levels between the group of psychotherapists and the group of social workers.

3.2 .Data from the participant group

The research hereby was realised on a number of 140 subjects, out of which 97 were women and 43 were men, with ages between 24-59 years old, having an average age range of 40,6 years and a standard deflection (AS= 14,57). The identification and the inclusion of these subjects took place in a haphazard manner, a part of them being contacted at their workplace. Hence, in the situation of the social workers, they were contacted through the Centers that belong to the Direction for Child Protection – D.C.P. Bucharest, while psychotherapists were contacted through the Psychotherapy Associations they took part in through their courses and basis and continuous professional formation workshops. The participant psychotherapists belong to different competency levels and represent several therapy schools. Regarding the coverage of the people in the two research groups, it had the following configuration:

- 70 participants between the ages of 24 and 59, age average = 41,5 years (standard deflection= 11,25) which have created the psychotherapist group, named research group A throughout the given endeavor.
- 70 people between the ages of 24 and 59, age average = 34,8 years (standard deflection =10,12) which have created the group of social workers, respectively research group B.

The manner in which they were sampled was one of convenience [9]. being co-opted in the study the participants who were simply available. This situation was created following practical considerations and has determined us not to use competency or psychotherapeutic orientation criteria throughout the work.

4. TOOLS USED IN RESEARCH

1. The social intelligence scale, construction and adaptation after Tromsø Social Intelligence Scale – TSIS [10]. The scale comprises a number of 21 items, each of them reflecting in a conceptual manner inferences specific to social intelligence. The items are rated on a Lickert scale from 1 to 7 (where 1 = barely characterizes me, up to 7 = highly characterizes me). The scale measures three areas of social intelligence: the social procedural information; social ability; social conscience. A high score reflects a superior degree of social intelligence.

2. Feature- emotional intelligence questionnaire [11], [12], [13]. The questionnaire comprises a number of 30 items in its short form, and these are scored on a Likert from 1 to 7, where 1= completely disagree and 7 = completely agree.

The basic instrument is based on a long form that is constituted initially, which comprises a number of 153 items that are built on 15 scales. The tool was used with the purpose of offering a comprehensive image of emotional intelligence as a treat.

Obs. For utilizing the tests in this study, we have asked for permission from their authors.

4.1. Processing and interpreting data

Hypothesis 1.

The results obtained after applying the Social intelligence scale

In what regards the *„Social Intelligence Scale"*, the results obtained by psychotherapists reflect an average score of 117,34 – score that situates itself in the high zone of the declaration of the level of social intelligence reported by the participants. From the perspective of frequencies, 15,7% from the respondents have reported scores that are registered in the low area with regards to social intelligence; 68,6% have reported average scores, while 15,7% were situated in the very high area of social intelligence.

Emotional Intelligence Questionnaire (feature)

With regards to emotional intelligence, the results of research group A (psychotherapists) show an average value of the score for the general-emotional score of 101,11. The scores obtained have varied between 40 points for a minimal score and 194 points for the maximum score (which shows a very high level of emotional intelligence). The distribution of the scores obtained, as it emerges from the frequency table is the following: 18,6% have reported a low level of emotional intelligence (as a treat); 65,7% have reported a medium to high level, while 15,7% of the subjects have shown an especially high level of emotional intelligence.

4.2. Elements of descriptive statistics for the social worker group

Results obtained by applying the Social Intelligence Scale

In what regards the *„Social Intelligence Scale*, the results obtained by social workers reveal an average score of 63,54 – score that situates itself in the average area of the levels of social intelligence reported by the participants. From the frequencies perspective, a percentage of 31,4% from the participants have reported score that are labeled as low in terms of social intelligence, while 68,6% have situated themselves in the average area of social intelligence.

Emotional Intelligence Questionnaire (feature)

With regards to emotional intelligence, the results of the subjects from the social workers group have varied between 20 points, as a minimum score and 150 points as the maximum score (high level of emotional intelligence). The distribution of the scores, as it comes out of the frequency table is as follows: 34,8% have reported a low level of emotional intelligence (as a treat); 53,5% have reported a medium level, while 11,7% of the subjects have demonstrated unusually high levels of emotional intelligence.

4.3. The check-up of research hypotheses

General hypothesis

The level of social and emotional intelligence registers rates significantly higher in the case of psychotherapists, than in the case of social workers.

Hypothesis 1

We assume that between social and emotional intelligence there is a correlation for all the investigated subjects.

In order to be able to study the relation between the variables we are following we have applied the calculation of the Pearson correlation coefficient (r). Hence, for all the investigated subjects we have registered a correlation in which the value calculated of the correlation coefficient ***r=0,675; p<0,000*** allows us to sustain the work hypothesis of the research (1), i.e. the fact that there *is an association between social and emotional intelligence in the rows of participants.*

Hypothesis 2

There are differences on the social and emotional intelligence between the psychotherapist and the social workers group.

The results assert towards the significant differences between the two groups, thus the value of the test t (df=58) is of -4,677; p=0,001<0,05 which indicates the fact that the average of the scores for social intelligence of the subjects from the social worker group is significantly lower that the average of the scores for social intelligence from the psychotherapist group. Furthermore, in the case of the value of the t test for emotional intelligence, t(df=58) is of -3,219; p=0,002<0,05 which indicates the fact that the average of the scores for this factor is significantly lower for social workers, compared to the psychotherapists.

In order to have psychotherapists and social workers that are well prepares and are successful in what they do, studies show they should have the following qualities on the first places – tolerance to stress, an assertive character, the control of impulses, independence, optimism, all characteristics of emotional intelligence [14]. The critical factors of success in any job, are those that determine the performance of the individual and are given by the dimensions of the axiological aspect of the individual, transposed in specific needs to be successful in that specific job.

CONCLUSIONS

The data obtained attracts the attention over the fact that in the jobs with a social impact, the levels of social and emotional intelligence is important, as it can represent a factor of success and performance in that specific job. Furthermore, the fact that the data reveal lower scores for certain participants (for example for social workers compared with psychotherapists, but also inside the same category of respondents) takes us to the necessity of elaborating knowledge and education programs of the two studied dimensions. In the practice of the jobs with social impact, the identification of emotions, the adequate perception of relations, of their dynamic and the desire to be there or to offer support constantly become abilities that deserve to be optimized.

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CHALLENGES OF INTERCULTURALITY

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Abstract: *The alert pace of changes in the contemporary society defies a human being's capacity of adjustment. Uncertainties, the unpredictable, alienation from one's self, loss of meaningfulness and of the self, all of these have become defining characteristics of the human condition. A new undefined, uniform socio-cultural space has sprung up under the globalization tug, lacking axiological landmarks or sense, and bearing strong effects on the experience of human identity and human existence, in general. This phenomenon, associated with pluralism and value relativism, brings about the problem of the rapport between identity and culture, identity and alterity, but, most of all, the problem of requirements to be met, in order to assure the "openness" of interculturality and the mutual understanding of people.*

Keywords: *interculturality, individualism, ethnocentrism, humanity.*

1. INTRODUCTION

From the psychological perspective, cultural identity (individual and group) represents a major component of the self-perception and of self-awareness. Together with the need for belonging somewhere, it is one of the fundamental needs of a human being, nurtured by and through culture. We are what we are through the language we talk, the language being a key component of culture, through our traditions and customs, rites and values that we spread and in the light of which we became a people. Based on our "cultural heredity", on our soul structure, we can only have a thorough understanding of our own culture, whose creations we are. In this context, avoidance of ethno-centrism, as a judgment of other cultures by comparison with ours, is almost impossible. In the light of this relationship, "a culture needs to be studied based on its own meanings and values" (Giddens, 2000:33). This is the supposition that has to constitute the foundation of any sociologic or psycho-sociologic study, according to the English sociologist Anthony Giddens, an exigency that is not at all easy to fulfill.

The idea of an existing relationship between culture and identity is generally accepted and it becomes the source of all intercultural approaches challenges. "Cultures are, by definition, exclusivist and highlight the difference. They long for the feeling of identity (…) They are the main resource of identity (Malița, 2000:14). Culture is the one that tells us who we are and what meaning we can give our lives. The Romanian philosopher, Lucian Blaga, in his works "Trilogy of Culture" underlined the intimate connection between culture and the ontological status of an individual: "Culture is an individual's accomplishment, to such an extent, that the individual cannot deny culture, just as well as he cannot deny his own appearance" (Blaga, 1968:212).

2. FROM INDIVIDUALISM AND ETHNOCENTRISM TO INTERCULTURALITY

Initially, the term *individualism* belonged to Physics: individual is synonymous with atom, considered initially an indivisible particle. In Biology, it signifies a characteristic specific to any organism – the unit that cannot be segmented without having its life threatened. The term derives from the Latin "individuum", which stands for the liberal translation of the Greek „a-tomon" (indivisible), and at the beginning it stood for separate being (especially in the physical world), indivisible in itself and different from any other being. At the end of the eighteenth century, the term enters the political discourse and soon its derivate – individualism – appears, in French. If for the Ancient Greece the individual represented the intrinsic part of the Citadel (community), outside it the term he loses its reality, modernity launches the concept named "individualist" in relation with the human being and society within which the individual represents the supreme value. The power of seduction of this theory consists of the modern idea of man's rights and liberties. Yet, this is only one of the facets of this doctrine. Numerous thinkers have warned against the threats to which individualist societies are exposed. Anomie, social fragmentation, exacerbation of selfishness, excesses of liberty - are only a few of the effects that erode the social corpus. The famous historian and theoretician of politics, A. De Tocqueville, uses the term in one of his referential books "Democracy in America" (1835-1840) in order to characterize the preponderant attitude of Americans, as a form of moderate selfishness. Individualism is the actual form of selfishness, "it is of democratic origin and threats to develop once conditions get equal" (Tocqueville, 1995:109). If in aristocratic societies people are "almost always tightly bonded to something that is placed outside them, and are always ready to forget themselves", then, with democratic communities "new families show up out of the blue, others keep disappearing, and all the one that stay in place change their appearance; the canvas of time is torn apart every second and the trace of generation vanishes (…). Each class, coming closer to the others and all of them getting mixed, their members become indifferent and alienated toward one another" (Ibidem: 110). The individualist character of the modern society nowadays has been sensed, analyzed and criticized by numerous thinkers of the nineteenth century. From this perspective, the first diagnostician was the German philosopher G. W. F. Hegel, who, in his "Phenomenology of Spirit" (1807) and in "Principles of Law Philosophy"(1821), labels it as a the disease of the modern European society, caused by the disappearance of social connection, of the relationships between individual and community, fostered, within the previous societies, by values, common beliefs and shared experiences. This net of connections has gradually been diminished throughout modernity and post-modernity, a phenomenon that nurtures forms of individualism and ultra-individualism specific to these epochs.

Postmodernity perceived as late modernity or a radicalized one, is based on specific driving forces. Contingency, risk, rapidity of changes, fragmentation, relativization of values etc. are characteristic for this world. Lack of models, the dilution of "us" and the exacerbated development of "I" confer a problematic character, generally, to the human condition, and, particularly, to its experience, identity and recognition.

"… the pressure of being an individual, of creating one's own identity and experience, is the product of modern era. Postmodern era changes rules, again. Artificiality of fiction is no longer denied" (Anderson, *apud* Malița, 2001:97). A man's ambition to make choices connects with the generous offer of postmodernism. Under these circumstances, each individual builds its own reality on the reality market that offers ideas to people for their public consumption: "We all become consumers of reality and a larger number of us also become creators and sellers of reality (…). Mass media facilitate the creation and dissemination of new reality structures" (Ibidem). Self-identity occupies a central place among the postmodernist interests. In the context of the contemporary epoch's fluidity, cultural identity is not given, and the individual is subjected to the peril of being taken apart from its cultural group. In a cultural environment of the mosaic, collage, collection type, the individual needs to make up his identity by himself, out of a diverse, heterogeneous and fragmented offer.

Just like in case of a defense system, people cluster around their systems of beliefs that offer them stability and the safety of their identity within the group. We live a time when the question of how it is like to feel a human comes forward strongly. The Italian philosopher Remo Bodei has discovered that the evolution of individuality and the identity construction occur in a manner that is totally different in our society nowadays from previous ones: "Evolution of individuality does no longer occur through the Other's assimilation or defeat, nor through an engagement in the collective process of building macro-topics, but through the exploitation of connection energies that are set free at the same time with the deconstruction of being. There is, of course, a relationship between the reformulation of identity and the transformations of former "ethical forces": family, class, state, church. They made possible for the individual to be freer, but, equally, they made the process of building the self-identity sound like a burden, because the individual is overwhelmed with responsibilities and obliged to meet standards in broad areas, which are publicly regulated. In a polycentric world, the reference points and the loyalty duties are multiplied and become more diverse, forcing the individual to continuously divide and modify the map of own identity. (…) No one lives in a unique world, but in a plurality of "life's worlds", of "finite sense provinces", as Alfred Schutz named it. Changing identity similarly with a worn out coat or getting accustomed only partially, remaining immune to conflicts is not very easy to do, just as well as it is not easy to get isolated from a larger context of events and epochs, while remaining anchored in the "new" and the "future": the past holds an almost dense tenacity, whereas the future a load of restlessness, which ends up by throwing out of one's shelter anyone who takes refuge in the near present" (Bodei, *apud* Enciclopedie, 2004:485).

The spirit of economy, specific to the classical period of capitalism is replaced by selfishness, through the individual's concentration on own needs and interests. On the other side, the consumption society nurtures a hedonistic mentality. Mass culture lacks the aspiration to universal validity and, being characterized by value accessibility, looks for its social function very seriously: entertainment production. Masses become soon consumers of entertainment. The industrialized entertainment alters the human personality, its critical thinking, through symbolical violence, stimulation of antisocial impulses and conducts.

At the same time, another effect of this type of culture is the phenomenon through which the cultural power increasingly and secretly converts into political power, given the omnipresent and more and more refined manipulation. Analyzing the civilized mankind's "diseases", from a ethological perspective, Konrad Lorenz warns against mankind's manipulation and indoctrination with a false code of values, corresponding only to the manipulators' interests.

The western cultural being, pretended free, is , in reality, manipulated through the commercial decisions of the great manufacturers (Lorenz, 2006:99-100). Among the methods used, the most efficient proves to be fashion, which, besides the uniformization of needs, answers a generally human necessity of making his belonging to a group visible, which strengthens the idea of need of identity, in a fluid and insecure world.

In the old dichotomy sensibility-sensitivity, the latter is exclusively proclaimed. If Leibnitz advised people to be calculated, postmodernism urges them to find pleasure. This is how the vision of the world as a spectacle was born. Through excessive cultivation of sensitivity, of emotions, we witness the augmentation of the esthetical dimension – the estheticization of existence – to the detriment of the cognitive and ethical ones. Through postmodernity we are placed at the antipode of sensibility and abstractionism of the enlightening modernity.

Moreover, the world complexification process leaves its print on human condition. This situation generates the task of "helping humanity adapt to the complex means of *feeling, understanding, and doing, all of which exceed everything it possesses*" (Lyotard, 1997:78).

People increasingly feel the need for clarity, restoration of clear values, in a world in which models have vanished and chaos replaced order. In order to meet this need for clarification and understanding, numerous thinkers have attempted to reveal the world and look for solutions.

Jacques Delors, the former president of the European Commission and president of the International Board for Education in the Twenty-First Century, has asserted that one of the major challenges of the current century consists of correlating internal progress with the external one. The excessive focuses on the economic development and the increase in material heritage have led to neglecting those aspects connected with people's adjustment to the requirements of the "planetary village": respect for nature and human condition, cultural adaptation, modernization of mentalities. The contemporary human condition is marked by a continuous oscillation, tearing apart, between the globalization challenges and search for models, roots, or feeling of belonging: "The artificial world culture brings about implicit value systems and can determine the appearance of a feeling of lost identity" (Delors, 2000:31). In this context we witness an accentuated claim of *ethnocentrism*, as an escape from an insecure and unpredictable space, taking the shape of armor, a defensive shield when facing the avalanche of requirements from the living environment. From an ethnological and anthropological perspective, ethnocentrism represent a concept that " take for reference the cultural models of a human group where people belong, considering them "natural", "universal", "original" and "true" (Enciclopedie, 2004:309).

This acceptance of the term, which we are going to call the "weak" (inoffensive) sense of it, leads us to the field of psychology. The process of every human's becoming, takes place in a certain cultural space that confers it a specific and unique internal architecture, in which, and through which, it builds the entire existence. We cannot get rid of it, as if we discarded a no longer used coat. If this gesture were possible, then things would be far easier, and the very topic of interculturality would be just useless. The man would become a chameleonic being, turning instantly into the "colors of the environment", for a perfect adjustment and assurance of survival. Cultural identity though, represents the very core of our mankind, and we cannot discard it. The human being is the only one to possess two legacies: the biological legacy is doubled by the "cultural legacy", and both of them will define and configure his life. In other words, we can fully understand only our own culture, which corresponds to our structure, and the judgment of others is achieved by comparison with the culture where we belong, filtering the new one through its set of values. Any form of openness toward and affiliation to another culture presupposes considering the existent "given reality". A key-supposition of sociology, but equally, of psychology, is the fact that a "culture need to be studied in terms of its own meanings and values", which implies both an intellectual effort and an emotional one as well (Giddens, 2000:33). Cultural diversity is responsible for the frequency at which people coming from a specific culture hardly understand, if they do, ideas or behaviors generated by it.

Ethnocentrism, though, also holds a meaning which we are going to characterize as "strong", due its negative effects and which consists of "pronouncement of own identity and of the negation of other ethnical groups' identity, quite often leaving room to some forms of conflict, intolerance and exploitation" (Enciclopedie, 2004:309). This ethnocentrism must be overcome, and its superseding has led to the promotion of cultural relativism, supported by the American school of "culture and personality", which claims the universality of culture and the value of all cultural behavior models.

3. CONCLUSIONS

The etymology of the term *ethnocentrism* (*ethnos*, from Greek – race, *centrum*, from Latin - center) suggests us the privileged positioning of own culture, ethnicity or community. Starting from this relation, there are two different approaches to it, holding two various values. The use of own culture as a model of reference in decoding other cultures represents a natural process which we cannot ignore. Our own culture defines us as human beings and it offers us the register, the code by means of which we *read* and understand the diversity of the cultural world. What needs to be excluded represents the underestimation or rejection attitude toward everything that is alien in rapport with ourselves, as being non-culture or as lacking value. The acceptance of diversity and the effort of understanding it, even if it is limited by one's own belonging to a space and by cultural identity, the openness and happiness manifested in front of the cultural polychromy of the world, is the only acceptable manner for the settlement of harmony among people, whereas the way to cultivate it is and will be the education.

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IS HYBRID WARFARE A NEW MANNER OF CONDUCTING WARFARE?

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Abstract: *The current type of warfare - hybrid warfare - which humanity is apparently experiencing every moment, while being unaware of it, is no longer used by conventional techniques. It will never be announced by an official announcement. This form of war uses both conventional and, unconventional, undercover means, regular or irregular, with the support of more or less hidden governmental agencies and mass media. The virtual environment is the new battlefield, computer technology being a determining factor in conducting hybrid actions.*

Hybrid warfare has a complex and varied operation area, reaching all fundamental sectors of today's society: its economy, the ethno-cultural dimension, diplomacy, technology, media, strategic and operational segments as well.

Keywords: *instability, extremist groups, cyber operations, Hezbollah special forces*

1. INTRODUCTION

The current international environment is characterized by new threats resulting from the energy crisis, economic crisis, demographic conflicts, amplification of the non-military aspects, access to information, religious and ethnic separatism.

The technological revolution has transformed the war, giving it a new meaning, especially by the disappearance of boundaries between military and civilian actions. The new type of war, hybrid war, involves the use by states or non-state actors of conventional or unconventional warfare, and measures of political, economic, social, humanitarian, diplomatic and informational conjunction with the involvement of local people in taken actions. Non-state actors, sometimes represented by terrorist organizations or paramilitary receive weapons, money and even political support from states and take action for the accomplishment of their strategic interests.

During the last decades, the nature of conflict has changed a lot and at a fast pace, moving from conventional battles between armies of nation-states to irregular/ hybrid conflicts and instability.

2. HYBRID WARFARE - DEFINITION

Warfare is a social-historical phenomenon, a violent manifestation of conflicting political relations between large groups of people (classes, nations, states, coalitions of states), organized militarily, groups that pursue economic, political, territorial or religious goals[1].

Although hybrid warfare is an old concept, its study by scholars, especially theorists of the Western countries, began after the Second World War and focused on asymmetric threats against conventional superiority of Western countries.

The attacks of 11 September 2001 and the Israel-Lebanon war of 2006 played an important role in the evolution of hybrid warfare theories.

In the 70s, Evgeny Messner defined the new type of warfare (later on referred to as hybrid warfare) as an insurgent war, unreported, with the participation of the civilian population, as well, in which the rapport war - peace is unclear and where no one knows who signs for its ending[2]. This type of warfare will not require the deployment of large armed forces but it will be carried out by extremist groups that resort to terrorist tactics.

The Messner definition is taken over by Valery Gerasimov, Chief of Staff of the Russian Army, who, in February 2013, in an article issued by the Russian press, described the hybrid warfare as *"a war mixed with peace, where the conflict methods changed... while political, economic, informational, humanitarian and other non-military measures being involved to a greater extent. All of these can be supplemented by inciting the local population and by using armed forces in disguise"*[3].

Since 2000, the term *hybrid* has been used to describe contemporary wars, in which there is an increase in the complexity and lethality of violent actions carried out by non-state actors, and in the potential of informational (cyber) war.

Hybrid warfare is *"a combination of symmetrical and asymmetrical armed conflicts, in which the intervention forces conduct traditional military operations against enemy military and targets, while they simultaneously and decisively act to get control over the indigenous people in the theater of military actions, by stability operations"*[4].

Frank Hoffman argues that *"hybrid warfare incorporates a full range of different types of warfare, including conventional capabilities, irregular tactics and formations, terrorist acts, including generalized violence and coercion, as well as criminal disorder"*[5].

The former Secretary General of NATO, Anders F. Rasmussen, defined hybrid warfare as *"a combination of concealed military operations combined with sophisticated information and disinformation operations"*[6]. His successor, Jens Stoltenberg, described the hybrid warfare as the type of war that combines the power of unconventional means with cyber operations and information as well as covert military operations[7].

David Kilcullen, in the book "The Accidental Guerrilla: Fighting Small Wars in the Midst of a Big One," says that "hybrid" is best suited term to describe modern conflicts, conflicts that include a combination of irregular war, civil war, insurgency and terrorism[8].

Peter R. Mansoor (military historian) defined hybrid warfare as "a conflict involving regular and irregular armed forces (guerrillas, insurgents and terrorists), which may involve both states and non-state actors in order to achieve a common political purpose "[9].

In the hybrid warfare combat at the contact line disappeared, as well as that in trenches or fortifications, while complex methods of combat are employed, combining force categories (especially special forces), lethal and non-lethal means and conventional combat tactics with the unconventional ones. Frequently it manifests itself by terrorist attacks, assassination operations, information, disinformation and propaganda, by cyber attacks, by the use of media as a battle space, all actions being aimed at a justification in the international background and at weakening of the power of the enemy[10] (Fig. 1).

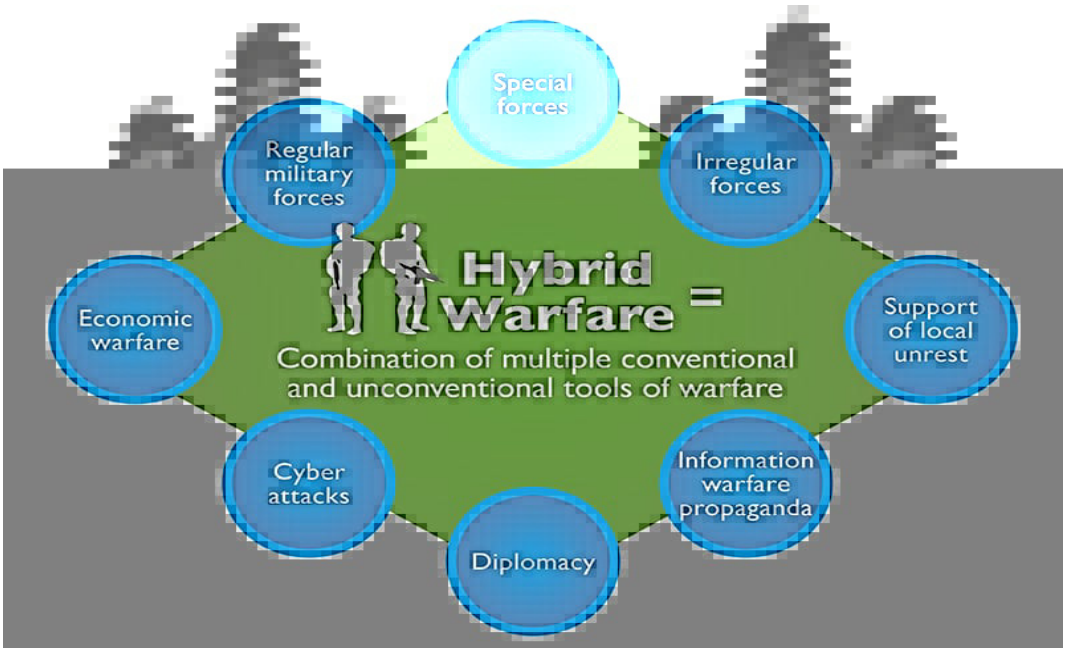

FIG.1. Hybrid war and its components [11]

The modern adversary uses conventional or unconventional means, covert, regular or irregular, and exploits all sides of warfare to counter its opponent's superiority in the conventional war. Conventional armies are used, preferably in the final stages of the conflict. Hybrid warfare is based on carefully combining the military kinetic action with operations meant to disunite, irregular activities, including information and cyber operations. They are often accompanied by intense activity of special forces, of mercenaries and of other paramilitary groups.

The 2006 conflict between Israel and Hezbollah militias represents the model of warfare that corresponds to contemporary definitions of hybrid warfare. Hezbollah fighters, trained and equipped with modern weapons and fighting technique (probably by Iran), surprised Israel by combining tactics of guerrilla with conventional military operations, employing last generation weapons (long range missiles, cruise missiles, sophisticated anti-tank weapons, UCAV) and modern communications systems (drones, satellites).

Low intensity conflicts, kinetic and non-kinetic threats to peace and international security, including cyber warfare, asymmetric conflicts of low intensity, global terrorism, piracy, transnational organized crime, demographic challenges, resources security, reduction of globalization and the proliferation of weapons of mass destruction were identified as the so-called "*hybrid threats*".

Hybrid warfare is conducted following a comprehensive strategy that involves combining long-term efforts in progressive steps, in such areas as political, economic, social, ethnic and religious, information and, finally, military.

3. DIMENSIONS, STAGES AND OBJECTIVES OF HYBRID WARFARE

a) The dimensions involved in running the hybrid warfare are:

- A political dimension resulting from the diversity of general interests or of objectives of establishing and exploiting the weak political points of the target state[12];

- An economic dimension - economic resources are especially employed as weapons in approaching a hybrid conflict. A state - dependant economically on potential enemy states, corroded by corruption, easily penetrated at the level of strategic decision, may be a potential target in hybrid warfare;
- An ethno-cultural dimension - the ability of a state/ non-state actors to exploit the existing ethnic and cultural tensions existent in the target state;
- A diplomatic dimension - able to develop an environment that will allow, through diplomatic means, the discrediting of the target state;
- A technological dimension – that includes the existence and the use of high technology in combat (anti-satellite weapons and cyber warfare against adversaries);
- A mass-media dimension – that reflects the ability of the aggressor to influence the people in the hybrid conflict deployment area. Weak states may be the favorite target of hybrid warfare, because the enemy can exploit people's discontent. Hybrid confrontation is "*a struggle beyond the physical aspects of the conflict, in which the manipulation of the media, the use of Internet and information operations integration with strategic communication programs are as important as the weapon systems on the battlefield*"[3];
- A strategic dimension – that requires complex actions, prepared in advance, diversified and constantly updated to create advantages over a possible adversary;
- An operational dimension - combining hybrid lethality of a conflict with irregular warfare[14].

The destructive component of the hybrid warfare is represented both by high-tech and crime, the latter being used to support hybrid actions or to spread disorder among the target nation members[15].

All of these actions are interconnected and overlapping in different segments, following one long-term strategy. The action begins in the information field, are pursued simultaneously in the economic-financial and social areas, and finally, if necessary, the military field is employed as well. The fight will take place on several spaces, with varied means, in most cases isolated and without any connection with other actions of the campaign. It will continue to be led by a collective idea, in the absence of a central command and control structure. These actions would circumvent international law by not taking responsibility for the action by either party, by denying the physical presence of the soldiers who violate the territorial integrity of an occupied country, by denying involvement in a cyber attack aimed at disrupting critical infrastructure or by influencing the minds of the people that should remain loyal to their authorities in order to preserve the integrity of their state.

b) Future hybrid conflicts may take place following the next steps:
- Weakening a country's economy through the aggressor's intentional actions;
- Collapse of the financial-banking sector or even pushing towards its total collapse;
- Involvement of the population in certain areas in social and economic life, to create widespread civil disobedience and disorder, used to justify political movements and insurgency;
- Support of the aggressor's actions by the local population both intentionally and as a result of fear of possible actions from the aggressor against them;
- Use of ethnic / religious minorities as an excuse for the outbreak of a conflict or its extension among all people of the area;
- A strong and intense international support, not always visible to the regular population;

- Use of unique symbols, very well known and easily to spot among the population in that area, as well as internationally ("little green men" present in eastern Ukraine, recognized by the local population and international environment as soldiers in the Russian regular armed forces);
- Assurance of personnel recruitment or fundraising to finance actions;
- Demoralization of the armed forces of a state or of government forces.

Hybrid warfare can be implemented through cyber attacks on citizens, whether civilian or military networks of a target state, facts that cannot be considered military operations, but which create a strong impact on the population. Use of cyber attacks in the full range of military and non-military operations produce strategic advantages over an unprepared opponent. Offensive cyber attacks are of three types: destruction, disruption or disinformation.

The objectives of a cyber attack are as follows:
- Loss / deterioration of the information integrity by its alteration;
- Loss / decrease in the availability, in the circumstance of the information systems being accessed by unauthorized users;
- Loss of confidentiality, where information is disclosed by unauthorized users;
- Physical destruction, where information from the systems is deliberately destroyed.

Cyber attacks are most frequently targeting critical infrastructure (financial services, manufacturing, telecommunications, transport and supply, electricity, water supply). Their conduct involves fewer people (but highly trained and equipped with the latest technology) and does not require a thorough check over the territory in which it is to be carried out.

Although most countries have invested considerable amounts of money in the development and operationalization of defensive cyber capacities, it was found that the cyber threat in the information environment is growing and it intends to transmit its effects from the civil society toward the military in order to damage national security.

Also, hybrid warfare involves actions related to information warfare. It consists of combat operations conducted in a highly tech battle environment, in which both parties use information technology, media, equipment or systems to obtain, control and use information[16].

Information warfare is based on three principles: gathering information, launching attacks and protecting assets. Some specialists consider that electronic warfare, information warfare and cyber warfare are synonymous.

CONCLUSIONS

Considering the technological development which takes place today and the global geopolitical changes, it is expected that future security threats will be more and more varied and lethal.

Future wars will involve all elements of national power in a continuous process of activities, from humanitarian missions, military operations up to stability operations, security and reconstruction, all of which will be conducted simultaneously. Wars will include hiring and simultaneous combination of conventional and unconventional means, lethal and non-lethal support units, combat equipment available for rapid deployment, terrorism, organized crime, cyber and electronic attacks, all conducted by the same aggressor.

Because of the diverse forms of materialization of hybrid warfare, a generalization of the counter-reaction to this type of warfare is not possible. In this respect, separate solutions for each challenge are required, the opponent (in most cases incomprehensible, elusive and irrational) concealing its intentions and actions through the involvement of paramilitary groups, separatists, pressure groups, militant states or Trojan-like type of states.

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THE HUMAN RESOURCES MANAGEMENT ROLE IN ENSURING THE NATIONAL DEFENCE

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Abstract: *The aim of national defense is to ensure the democratic normality that the society, and the citizens aspire, based on the efforts that aimed at the establishment of legality, the economic growth, the social harmony and the political stability. This is achieved through the full exercise of civil rights and liberties, through conscious assumption of responsibilities, and the affirmation of a state as an active member of the community and international organizations.*

In order to ensure the national defence, and in order to furnish a high security state level, the human resources represent an extremely important resource of the national defense and public order.

Keywords: *national defense; human resources; society; security environment; management.*

1. INTRODUCTION

Obviously, an effective National Defence, able to ensure a high level of defence is given by the human resources quality, employed in the Public Order and National Defence System. It is imperative that, permanently, the human resource to be recruited, trained and instructed with rigor and responsibilty, and this aspect means sustained financial allocations assumed by all the responsible structures of the state. In this context, we should note that financial austerities from last years, imposed to the national defense system, affected some stages of professional training of human resources, and this could be also revealed in the the Strategy of the military profession promoting from 2011 to 2015 in the sense in which ”this couldn’t be implemented only partially and with great efforts.”[1]

2. THE CURRENT SITUATION

Currently, due to great financial constraints resulting from the global economic crisis, the quality of human resources belonging to the national defense system recovers the deficit created in last years. In the same context of financial deficits, the national campaigns regarding the promoting of the military profession, largely conducted through various forms of information fro mass-media, have confronted many obstacles, in the sense that were not conducted according to the established and approved plan, being replaced with alternatives options, less expensive and not so effective as the original. It is obvious that, if the trend of promoting the military profession would have been maintained on the same poor financial line, the consequences would have found in more many plans, affecting even the national defense.

We should mention that in recent years, the national strategy for promoting the military profession was replaced by various campaigns conducted on locally planes through regional, county and district military centers, with the support of local authorities and representatives of military educational institutions of the Ministry of National Defence. But, after these campaigns completing, it was found that these were not conducted in the best conditions, meaning there have not been produced and distributed enough promotional materials and broadcasts were not always the best form of presentation. Critics anf the sensitive eye of the public could see that clips, banners and videoclips used during these campaigns were rather outdated, which denotes a system struggling between quite drastic financial limits, a system thta is not able to keep up and to stay on the same line with the armies belonging to much more developed countries, military strucures that implemented year by year, modern conception regarding the campaigns for promoting the military profession.

Another important element of promoting the military profession was the conceiving by the Human Resource Management Directorate with the support of the Staff and Mobilization Directorate from General Headquarter, of a series of promotional materials that were presented (shown) in the military expo-conferences organized by the Ministry of National Defense (e.g. EXPOMIL or BSDA - Black Sea Defense&Aerospace).

To increase the q u lait y of human resources, which in time should visibly and effectively contribute to ensure an appropriate level of national defense, it was realized that for a correct identification and recruitment, it is necessary to conduct modern campaigns for promote the military profession, and this is possible only through an adequate and realistic financing.

Considering the extremely rapid evolution of technology, and adapting the entire national defense system to this development, it has adopted the idea to promote the military profession in the online space by creating a virtual space designed to the recruitment process which, currently, is in the final phase and which is expected to largely replace, with ones of the best results, the classic and perhaps obsolete promoting campaigns. In this sense, we remark that ”it was designed a new recruitment site and were created profile pages on social media platforms as Facebook and Twitter”[1]

3. THE ROLE AND THE FEATURES OF THE HUMAN RESOURCES IN THE CONTEXT OF THE NATIONAL DEFENSE

Our century society is in a constant motion and it presents itself as a network of organizations and structures that arise, develop or simply disappear, and in their place many others similar appear.

To these many and fast changes, it is necessary that the Public Order and National Defense system should fastly adapt, therefore, the Romanian military structures, and implicitly, the human resources belonging to this system. In such circumstances, people, representing the key resource, the vital resource of the military organization, through carried out actions and through the activities they participate in, should be able to ensure the continuity, the development and the achievement of all objectives, including here and the national defense.

The experience of the past and the reality of the present increasingly emphasizes that achieving organizational goals and achieve outstanding performance chariot military organization lies in its human resource and quality. Thus, it is obvious that human resource is the Romanian army one of the most important investment needed to fulfill obieectivelor organization.

Like any other performant organization, firm or company, the military organization spends significant amounts with the financial rights of the personnel (both military and civilian), and with other staff costs, and due to the percentage of expenditures rights staff throughout the whole budget, we can affirm that this category of costs is one of the largest expenditure and shows that the human resource is an obvious investment. But as is stated above, the investment in people has proven, over time, to be the surest way to guarantee the performance of an organization or company and is able to provide an attractive and competitive imagine, but also the interest in it from different points of view.[2]

Likewise, given the major changes produced by the human resource in the information society, we can say that the human factor has become even a strategic resource, replacing, without doubts, the financial capital. This is due to the fact that human resources, being the active part of the organization, are the single ones who are able to produce and reproduce any other resource existing in the inventory of an organization, contributing in an activ way to the increase of the organizational efficiency and effectiveness, and to the shaping of a positive image of the everyday life organization, on a local but also on an international plan.

To explain from another point of view the role of human resources in the ensuring of the appropriate level of national defense, it must be emphasized that decisions made by stakeholders on the effective management of human resources, in achieving the level we talked about, are among the most difficult.This is due to the fact that all human resources management functions and activities require the preparation and adoption of highly complex personnel decisions that need to assess various situations both legally and morally or ethically.

To illustrate what have been affirmed before, we can show that decisions on the selection and ranking of candidates with specific qualifications and experience for a management position in a central structure of the Public Order and National Defense System or for an abroad important permanent job assumed by Romania under international agreements, or the decision to improve staff on niche areas and even the dismissals decisions in the context of major system restructuring , are some of the personnel decisions that are extremly difficult to adopt.

However, decisions in the field of human resources management should be responsible, assumed, thought and prepared in terms of social responsibility and liability, and examined in terms of their impact, as well as that of the possibility of minimizing costs. In the decisions making process, regarding the use of human resources for the ensuring of an appropiate level of the national defense, the responsible factors must not neglect the traits/features or adaptability conditions of those who lead them for achieving the proposed real targets, such as: the experience in the domain where persons operate, people character and behaviour, their reactions in different situations (both positive and in case of a failure), the reactin to various material aspects and the impact in the event of unforeseen circumstances. Thus, the participation in solving these unforeseen events (that took place over time), revealed people experience or skill in different areas, and also, different qualities related to the stringent and specific soldierly life.

Human resource management decisions should always be adopted in accordance with both the personality, background and experience of persons which reffered to, and the interests of the parties involved in this process. Therefore, the staff and the personnel of the Public Order and National Defense System, even if it is guided by norms, values and strict principles, cannot be treated similarly as being part of the same human typology, and must be approached differently because every military (officer, non-commissioned officer, soldier, public servant/ clerk or contractual civilian personnel is an individuality or a unique and distinct personality, with specific traits/features and having habits inherited from the area where they originated.

As we stated at the beginning of the chapter, given the dynamics of regional and international security environment, Romania must take account of all these changes and therefore must identify the best methods for fast adaptation of human resources to these changes. This is because people have a certain strength and a relative inertia to these changes (even if they are sudden or occur over a long period of time). But, all history and the experience in human resource management, accumulated over time, proved that human resistance to major changes is compensated, in an almost equal proportionality, by a great adaptability and by a integration to new situations.[3]

Although the man is able to adapt to the new, the practice of management in human resources domain proved that there were situations where organizational changes and units reorganization/restructuring are full of difficult moments, some of them - unforeseen and these can be regarded as legislative traps for those who have not managed them in accordance with all applicable legal prov sion .s At the same time, these reorganizations/restructuring involve specific level of risk, determined by a dose of unpredictability, and in some cases, even the behavior of those who strive to accept the new or to make the necessary changes may generate resistance to change.

Continuing in the same way, given the permanent reconsideration in time of the human resources in front of changes dictated by the integration of National Defence to specific international agreements, we may affirm that people are influenced by the time factor, because it takes a period of time to adapt mindsets, behaviors, habits, etc. at everything that is new, unknown or that suppose the implementation of new policies. It was also found that as strong as organizational and human resistance would be to new situations, the mentality and behavior changes are normal and will occur gradually, in the same time with changes in the system of human values. However, in the same context, it is neccessary the leaders from the Public Order and National Defense system (regardless of field or specifics in operating) must be aware that, all this set of measures necessary to ensure the national defense, not must disregard that on the basis of occuring of these changes and human resources adaptation to, the human set of principles and values will change much harder, although this aspect is not always easily visible. This is because the personality features of those who are subject to change are firmly fixed in time, and some new rules imposed on them do not always have the same meanings as before.[4-5]

In relation to the fast development of society, dictated by the technological development, another problem identified at the level of the modern human resources management and, reported to their role in the organization development, is moving from practice work based on daily living needs to the work based on vocation that requires talent, originality, implementation of more convenient patterns or, simply, work that identifies with ourselves.

Another important element of how human resources in the Public Order and National Defense system can influence the application of some measures necessary to ensure the national defense is given by the cooperation between political leaders with responsibilities in this area, central structures chiefs/commanders of this system, local political leaders, military leaders/commanders and their subordinates. In this regard, the relations between all these people must unquestionably be generated by the principles of realism, objectivity, respect for human and organizational requirements, human dignity, regardless of the hierarchical position occupied throughout this whole relationship. If everyone involved in this relational system are aware that through their joining and cooperative efforts, will be implemented the steps necessary to achieve an adequate level of national defense, in accordance with foreign and domestic requirements, then all these decision makers must organize the resources they manage by the specific of the position they held, as to be able to achieve organizational goals.

Also in the process of providing an appropriate level of national defense, it is necessary that the Public Order and National Defense system, through the mechanisms that holds them, to motivate in a suitable way the human resources involved in this process, and the leaders of this system must get personally involved, as much as possible, related how the human resource is used but, at the same time, they must also directly participate next to it in order to perform, to achieve different missions and tasks.

Given the above mentioned, we may conclude that to achieve an appropriate level of national defense, is necessary to implement a modern conception regarding human resource management, and this should highlight the fact that people are not recruited and selected just simply to fill certain vacancies, but they should be identified based on their training and have to be atracted into the Public Order and National Defense system just to indicate their important role whitin this system.

CONCLUSIONS

As shown in this article, the human resource is an extremely important resource of the Public Order and National Defense system which produces and contributes to a steady an appropriate level of national defense.

Under another aspect, the human resources of this system are thus formed, instructed trained, equipped and operated as to be able to protect people and precious property against risks that can appear both social scale and community, and, of course at a macro scale, much higher.

From another point of view, by the traits exposed above, human resources have the posibility to capitalize at a superior level, all other resources of the national defense system, including natural ones that are managed through the positions occupied by military leaders or others stakeholders/decision makers from this system.

Throughout this article, we could also see that human resources are extremely heterogeneous, in terms of their physical appearance, and in terms of intelligence level, education and creation. Human resources are different from person to person in several ways, not only physically and intellectually, but also in terms of moral-volitional or emotional configuration. Starting from these peculiarities of individuals, a proper management of human resoursec from the Public Order and National Defense system can be an important step for an appropriate level of national defense and the military organization needs this.

Reading this article, we understand that to defend Romania's national interests, thus ensuring national defense, as well as obligations under international treaties and agreements, it is expected the army to participate in the future at various missions abroad. But this time, the current level of training and endowment, and as it was proved in the recent years, Romanian forces can be deployed over long distances, in a relatively short period of time, for indefinite periods, under varying terrain and climate conditions, being in contact with different civilization and culture areas.

We believe that, as long as Romanian military forces will participate in multinational activities and missions, the national defense will be guaranteed, being a definite element of stability for our country.

Thus, considering the events related to the attacks of various important areas of the world, which took place lately, we must emphasize that for the maintaining of an appropriate level of national defense, military personnel Romanian forces will have to act, both now and in the near future in a modern and complex battlefield, fully computerized, that could take place in an urbanized area, and also have to exploit a technique more and more advanced and sophisticated. Therefore, it results the necessity that all Romanian army units and, in particular those already operational, to be optimally employed (staffed), as much as possible in a 100% percentage, with well-trained staff, motivated and supported in all actions.

We conclude that economic and social developments and the private sector developments will directly influence the military body. Thus, in the short term, the low number of jobs in the economy and maintaining a high unemployment rate on the labor market, coupled with a low number of vacancies allocated to students and pupils that absolved highschools and superior educational institutions, as a result of the restructuring of the workforce overall system-wide national does not affect the current needs of military personnel and therefore, neither the required national defense level.

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A SPECIALIZED DICTIONARY, NECESSARY IN ROMANIAN AIR FORCE

Review of the volume *Dicționar de aviație englez-român* by Elena-Raluca Constantin and Alexandra Ionescu, Bucharest, Ars Docendi, 2016

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FIG.1 Elena-Raluca Constantin & Alexandra Ionescu, *Dicționar de aviație englez-român.* Front cover.

English has become a universal language in civil and military aviation, in communication used in aviation. Given this contemporary reality and a particular need of specialized dictionaries, Elena-Raluca Constantin, lecturer in the Department of Foreign Languages and Intercultural Communication, Military Technical Academy in Bucharest, helped by Alexandra Ionescu, has proposed a very useful and necessary English-Romanian dictionary, the only one in this area in Romania (Constantin & Ionescu, 2016).

Aviation dictionaries are necessary for the acquisition of the specialized terminology used by the staff, the civil and military aviation operators, the maintenance crews and all those working in the aviation industry. Unlike general aeronautical dictionaries, aviation

dictionaries easily fix the technical terms and are very practical for all those who operate in the large area of aeronautics, from pilots to technicians.

The authors of this dictionary have emphasized their projective intention, considering this linguistic tool to be focused on the area of aeronautical engineering:

This dictionary meets all those seeking clarification and information about civil and military aviation lexis. More specifically, the work includes technical terms frequently used within the specialized language and it is a linguistic tool necessary for aviation engineers and officer-engineers[1]. (Constantin & Ionescu, 2016:5)

Even if the dictionary focuses on the terminology necessary to operate within aeronautical engineering, it is a useful linguistic tool in Romanian Air Force, especially in 'Henri Coanda' Air Force Academy, for adequate training of aviation students (pilots, navigators, air traffic controllers, meteorologists). The need to use this dictionary within the specific university of the Romanian Air Force is strictly connected to the main utility of a dictionary, i.e. utility in the process of learning.

Besides the more than 5.000 defined terms that make the dictionary comparable with the monolingual specialized dictionary of David Crocker (2012), it is very practical due to the pragmatics' examples, especially designed by authors to exemplify the effective use of terms in particular linguistic contexts. The pragmatic aspect of the dictionary is very relevant, as the examples of using the specialized terminology in context are presented bilingually, both in English and Romanian. In this respect, we chose to randomly exemplify, by a particular term, in order to illustrate the usefulness of operating with this linguistic tool:

fatigue *subst.* oboseală; **aircraft** ~ oboseală constructivă; **flight** ~ oboseală de zbor; **thermal** ~ oboseală termică; ~ **crack** fisură survenită din cauza rodajului; ~ **strenght** rezistență la oboseală. *Fan blades must be resistant to fatigue and thermal shock./ Elicele ventilatorului trebuie să fie durabile și rezistente la șocul termic.* (Constantin & Ionescu, 2016:147)

This example is important because one single term in Constantin & Ionescu's dictionary corresponds to six different entries (terms and phrases) defined in Jeppesen`s monolingual dictionary (see, for example, 2006:131) that contains 10,000 definitions. In relationship with Crocker's, the present dictionary contains the context of using terms in both languages, English and Romanian.

Constantin & Ionescu bilingual dictionary (2016) is useful in developing a specific lexis (a professiolect), in knowing and correct using of aviation terminology, in relation to the context of language use. The dictionary is characterized by a very rigorous selection of information and by pragmatic correlations, useful in defining concrete linguistic contexts. The requirement of rigor is fundamental in constructing such a linguistic tool, because the professional area of aviation requires coherent, fluent and intelligible communication, comprehensive and accurate expression in transmitting information, necessary for taking decisions on the spot, often in matters of life and death.

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[1] „Dicționarul de față vine în întâmpinarea tuturor celor care doresc clarificări și informații în legătură cu lexical aviatic civil sau militar. Mai exact, lucrarea cuprinde termeni tehnici cu o frecvență ridicată în limbajul de specialitate, fiind un instrument lingvistic necesar inginerilor și ofițerilor ingineri de aviație", in original.

ON TOP. SCIENCE MARKETING IDEAS THROUGH MUSIC MARKETING LESSONS

Review of the volume *În top. 7 modele de marketing în muzică* by Andreea Mitan, Galați, Galați University Press, 2016

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Andreea MITAN

FIG.1 Andreea Mitan, *În top. 7 modele de marketing în muzică.* Front cover.

The book *În top. 7 modele de marketing în muzică* (*On top. 7 models of music marketing*), written by Andreea Mitan (2016) is unique both in approaching/style and as a framework of analysing a scientific area poor in information in Romania. Taking into account that one single university is dedicated to issues that fall under umbrella-concept of *music marketing*, i.e. Berklee College of Music from Boston, Massachusetts, the intention of designing and writing a scientific work that approaches the above mentioned concept from the perspective of at least three distinct areas of study: economics / marketing, communication and (ethno)musicology, is really venturesome.

The book of the young researcher Andreea Mitan, teaching assistant at the National University of Political Science and Public Administration in Bucharest, is the result of a complex and long research on *music marketing*, starting from the communication sciences perspective, completed in 2011 with an important dissertation entitled *Muzică, imagine și propagandă în campaniile electorale* (*Music, image and propaganda during election campaigns*), coordinated by associate professor Nicolae Frigioiu, PhD, respectively in 2014 with an outstanding doctoral thesis entitled *Popular culture și identitatea tinerilor în era digitală. Preferințe muzicale și profiluri identitare la studenții români* (Popular culture and young's identity in the digital era. Musical preferences and identity profiles of Romanian students), coordinated by Professor Grigore Georgiu, PhD. The two previous works, accompanied by articles sporadically published in various scientific journals, are the starting point in shaping this book. The author's firm positioning on the marketing area reshapes the scientific design and allows the public / the readers (initiated or not in *music marketing*) to approach the issues of the Romanian music market, characterized by particular relationships between the young *digital natives* and *popular music*, in the context of weakening their identity linkage with music.

This trend remains the fundamental characteristic of a dynamic society where values are fragmented, where marginal and plural tendencies are constantly claimed. Despite the modern general trend of association with belonging groups with definite and well defined identity, the young people tend to prefer a variety of music, without feeling connected in terms of identity with the music they listen to. The young people do not follow the various cultural challenges and do not accommodate with the crossbred genres of *popular music* that are a mix of unstructured stylistic elements with different cultural origins. The author abandons the 'hard' foundation of the relationship between music consumer and his/her music preferences for a 'weak' one (*debole*), and focuses on the study of cultural hybridization, experienced at the level of music consumption. Music is used to maintain cultural identity, to create cohesion and to deepen the ideological division especially within the clusters of immigrants. The awareness of weakening the role of music in identity clotting of *digital natives*, while the music is further understood as a map of mental representations of values is, pointedly, the awareness of dissipation and dispersion of dominant values within a trans-ethnic and trans-linguistic society that is in a severe identity crisis.

The novelty of this book consists of highlighting the characteristics of the environment that allows a weak liaison between young people and music genres. Moreover, the novelty also consists of asserting that no one can speak about patterns of relating the young Romanians to their favourite music genres. For example, subsections II.2 *Repere istorice: popular music în România înainte de '89* (*Historical landmarks: popular music in Romania before '89*) and II.3 *Manelele: Orient, marginali, samsarul cultural* (*The 'manele': East, marginals, and the cultural broker*), see Mitan (2016:35-59) are excellent, as well. The mass fragmentation, understood as preferences fragmentation, is seen as a weak association with certain patterns (of music preferences, for example), that are fluid, not enough solidified in a society that leads to removal of values specific to the 'hard' historicism.

Given these characteristics of the interaction between the Romanian consumers and the music industry, i.e. those characteristics of the Romanian music market, the author proposes – and here the focus is deliberately moved on *music marketing* area – "7 idei SMART din marketing pentru artiști" (7 SMART marketing ideas for artists), thus justifying the title of the book: "III.1 *Storytelling?* Desigur! Te rog, spune-mi o poveste!; III.2 *I fink U freeky and I like U alot!* Echilibristică pe linia fină dintre genius și *prea mult*; III.3 *Umbrella brand.*

Unde-s mulți puterea crește; III.4 Challengeri? Clubul din Balcani și strategia *me-too*; III.5 *Retromarketing. The 90s are back!* Și *the 80s.* Și *the 70s*; III.6 *Product placement.* Videocliclipurișisi branduri comerciale; III.7 Un alt fel de *celebrity endorsment*[1]". The exemplification of marketing ideas in the Romanian music market through titles of subsections is not accidental. It is illustrative for the author's style, attractive for a large mass of people. The author 'sells' scientific information in a package with a label of popularization of the scientific knowledge and facilitates, therefore, the access of the middle public to the consistent scientific information. For example, the association under umbrella brands is excellently illustrated by the Romanian saying "Unde-s mulți puterea crește" (*Many hands make light work*), reflecting the creation of sub-brands that symbolically take the franchise of the mother-brand on a market with particular nuances, dynamics and scalability:

In some cases, the strategy chosen by those who are behind the artists and provide their "infrastructure" for the conception of the music products, consists in creation of brands for the recording studios, a sub-brand cord tied with the mother-brand being 'allocated' to each artist or band. In some cases we cannot talk even about sub-brands, but about brands with supportive role, that helps in maintaining the credibility and consistency of the studio brand's offer[2] (Mitan, 2016:100).

Proposing a topic of *music marketing*, Andreea Mitan produces in this paper (probably with an assumed intention) *science marketing*, consequently positioning herself on a science market saturated by the neutral and devoid of attractiveness style, present in many works that disseminate the results of the scientific research.

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[1] „III.1 *Storytelling?* Of course! Please, tell me a story!; III.2 *I fink U freeky and I like U alot!* Balancing on the fine line between genius and *too much*; III.3 *Umbrella brand.* Many hands make light work; III.4 Challengers? Balkan club and *me-too* strategy; III.5 *Retromarketing. The 90s are back! The 80s* too. *The 70s* too; III.6 *Product placement.* Video clips and commercial brands; III.7 A different kind of *celebrity endorsement*".

[2] "În unele situații strategia aleasă de cei care sunt în spatele artiștilor și asigură „infrastructura" pentru nașterea produselor muzicale și a brandurilor asociate constă în crearea unor branduri ale studiourilor de înregistrări, fiecărui artist sau fiecărei formații fiindu-i „alocat" câte un subbrand, legat ombilical de brandul mamă. În unele situații nu discutăm nici măcar de sub-branduri, ci despre branduri cu rol de susținere, care ajută la menținerea credibilității ofertei brandului studioului și la consecvență" in original.

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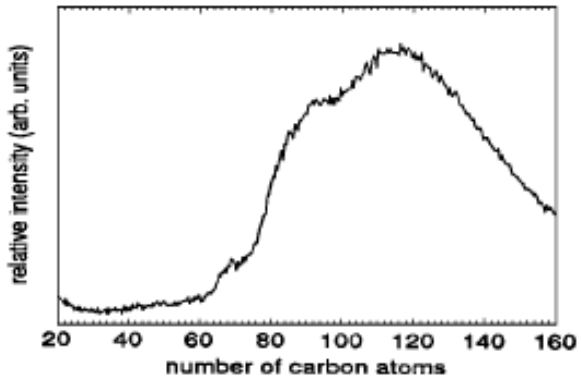

(a)

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Second set of values	1.1	1.0	0.9	0.8

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