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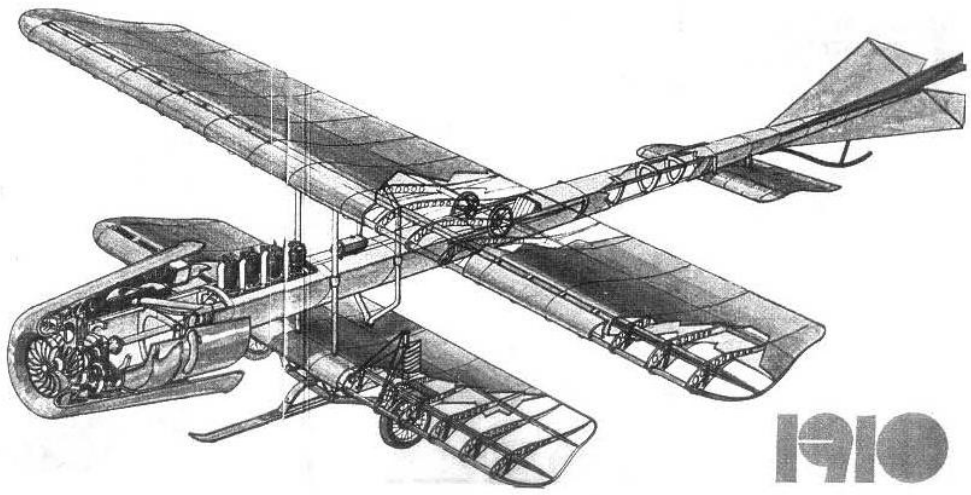

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C O N T E N T S

FUTURE WAR – WAR OF THE ROBOTS?

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Abstract: *The article deals with security situation in the Middle East where the armed conflicts have remained for years in Syria, Afghanistan and Iraq. The complexity of the situation adds diverse interests of the world powers in this area. The contribution refers to the recent fights in the area where the most modern weapons systems of Russia were used against militants of the Islamic State. Unmanned airborne and ground means to successfully carry out strikes on Islamist positions and allow the Syrian troops occupy their positions. It also shows the individual robots that have been controlled over a long distance.*

Keywords: *soldier, weapons, battle, tactics, operation, robot, Islamist*

1. INTRODUCTION

The security situation in the world since the Second World War has never been as complicated as in the past years. In Africa (Egypt, Algeria, Morocco, Sudan, Libya, Somalia, Nigeria, Central African Republic), in Europe (Ukraine) and mainly in Asia (North Korea, The most difficult situation is in Iraq, Afghanistan and in Syria, where the expansion of the Islamic State (IS) has forced all the world power (the USA, Russia, UK, France) and other NATO countries from the region to engage in the armed conflict. Each of the parties of the conflict follows its own interests and so there comes odd situations. The U.S. and allies are attacking forces and installations of the Islamic State, but they also support opponents of the Asad regime who are called the rebels. Russia attacks the Islamic State but also the rebels, whom they call terrorists. The rebels, or terrorists trained to fight by the USA should in particular fight against Asad, but they collaborate with Islamists. France has the hit centre in Africa, but after the Paris events it has participated also in the Middle East, Turkey also attacks the Islamists, and the Kurdish units as well, which make the core of the land forces fighting against IS today. Saudi Arabia and Egypt are leading strikes against Islamists mainly in their or nearby territory (1). It is actually very difficult today to find out who fights with whom and who supports whom. One thing is certain; however, in the fight against Islamists we are not missing the tactical knowledge, competence or skills, but the strategy of problem solving, coordination of operation from the air and on the ground, and the clarification of who is the real enemy number one.

In addition to the clear political or economic interests in the given area, the armed conflict means an excellent opportunity for the great powers to test new weapon systems and ways of the armed operation.

2. NEW WEAPON SYSTEMS AND THE WAYS OF THEIR COMBAT USE

Development of new weapon systems conditions the emergence of new kinds of forces as well as the new ways and forms of leadership of the armed struggle, the tactics, combat and operational use of troops. The quality of the combat potential and devastating effects of the weapon systems have been considerably changing as well. The development is moving forward and the old truths that every other war is completely different from the previous one, still applies.

When it comes to ground forces, on the one hand, we can observe the improvement of the quality of individual equipment, equipment and the protection of the soldier, where many versions of the soldier of the 21st century evoke earlier characters from science fiction movies or robotic characters from fairy tales rather than the typical soldier, an infantryman of 20th century – fig. 1.

FIG. 1 A soldier of 21st century

On the other hand, it is a qualitative shift in terms of the different types of weapon systems, for example, modernization of tanks or armoured vehicles, better or more efficient rocket means or artillery, more modern equipment for engineering troops or logistics. What is most essential of this fact is that many modern means do not have the human crew, but they're robots remotely controlled by robots. This is not only about the drones or UAV, which have been used for decades, but mainly about new ground-based robots with massive firepower.

Combat use of robots in Syria and new types of Russian combat robots

In January 2016 Russian robotic unit carried out an attack on one of the support points of the Islamists in the Syrian Latakia in conjunction with Syrian soldiers. Robots conquered the strategic heights that were occupied by Syrian troops. The attack involved six robots Platform M and four robots ARGO (Fig.2). The survey was provided by unmanned aircrafts Orlan 10 and information was passed down through the field open centre management Andromeda (D) (Fig.3) directly to the National Centre for management of Defenses of the Russian Federation, where the entire operation was controlled from (2).

FIG. 2a Robot Platform M

FIG. 2b Robot Argo

FIG.3a Unmanned aircraft Orlan 10

FIG.3b Field control centre Andromeda D

Russian combat robots at the head of Syrian units destroyed the epicenters of rebellion and allowed Syrian soldiers to occupy height without serious protest with virtually any losses, while on the side of the Islamists more than 70 gunmen were killed and the others fled from the battlefield.

For the first time, Russia used the combination of air and ground robots in the combat operation. It confirmed the effectiveness of the concept of the use of robotic systems in offensive operations. According to sources from the Russian general staff, Russia will seek the full robotisation of battle tactics, and any time soon we may be witnessing that the robots will lead individual combat operations.

The process of robotisation of the Russian Army has rapidly been progressing, recently there has been the robot URAN-9, which has excellent fighting and maneuver characteristics (Fig.4), included into the robotic equipment. The armament consists of 30 mm 2A72 cannon, coupled with a machine gun calibre 7.62 mm, four anti-tank missiles ATAKA and six antiaircraft missiles IGLA.

The robot is equipped with a system for the detection of laser beam irradiation, equipment for detection, identification and monitoring of objectives and a video surveillance system permitting activity during the day and at night. URAN-9 is intended for reconnaissance and fire support and may act in the field as well as in the towns. The formation consists of two fighting robots, towing vehicle for their transport and mobile control unit.

FIG. 4 Combat robot URAN – 9

Very soon, there will be the completion of the robotisation of tank T-14 ARMATA, which has a number of unique elements, conducted. Non-crew tower is operated by a crew from the tank hull protected by composite armour. The wiev is replaced by cameras and display, the power drive is ensured by the engine with a power of 1500 HP (Fig. 5).

FIG. 5 Tank T-14 ARMATA

Cannon of the tank has calibre of 125 mm or 152 mm with sophisticated system of fire control, sensors and a perfect self-defence system. All of this ensures its superiority over other similar tanks such as M1A2SEP ABRAMS or Leopard 2A7.

3. CONCLUSION

Some time ago, I said at the end of the Conference: "It can be assumed that the new kinds of forces, such as space will appear, the battle and the war will be decided by the sophisticated UAVs, on Earth, the war of robots will start to be controlled remotely from the centres hundreds of miles away.

Could this be science-fiction? Let us look at the development of military affairs in Let us look at the development of military. When we look at the published data from the Syrian Latakia, we see that the predictions are not too far, since we can assume that the best and the most powerful hotshots are hidden by each party in there.

However, the fact has been fully confirmed that the most important factor which influences combat use of modern weapon systems remains simply a man – his intelligence, education and technical thinking. Modern weapon systems, technical resources and information security increasingly require a high-quality education, training, and their perfect mastery. And here is the space for military education, military science researchers, which have ceased to exist in recent years.

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COMPOSITE MATERIALS IN MILITARY AVIATION AND SELECTED PROBLEMS WITH IMPLEMENTATION

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Abstract: *In the work three groups of composite materials (laminates) today used and developed for aerospace industry were described. These are Fiber Reinforced Plastics (FRP), hybrid composites – Fiber Metal Laminates (FML) and Metal Matrix Composites (MMC). Their characteristics and implementation for examples in military aviation were also presented. From the point of operation for each group, it defined problems and risks, which are: cracks, delaminations and other mechanical degradations which have high influence on fatigue life of aviation structure. Further problems concern issues of connecting composite materials and related consequences of damage in connectors area. Other problems are methods of mechanical processing and manufacturing methods, which significantly increase costs of these materials.*

Keywords: *aviation, materials, laminates, exploitation problems*

1. INTRODUCTION

In recent years, the rising trend of using composite materials in aircraft constructions is observed. The reason is reduced weight of structures, while maintaining high strength properties. Presently, from composites there are produced load-bearing structures of gliders, motor gliders, ultralight category airplanes and Unmanned Aircraft Vehicles (UAV's). Moreover, composite materials allowed to build elements of passenger airplanes, such as vertical and horizontal stabilizers, wing structure and its plating, fuselages and other parts. In gyroplanes composites are used to produce blades, rotors and their fuselages. Furthermore, they are involved in constructing of power units in aircraft, such as: engine blades, tail airscrews and fans.

Fiber Reinforced Plastics composites with glass, carbon and aramid fibers, hybrid composites – Fiber Metal Laminates as well as laminates with metal and ceramic matrix are most commonly used in aircraft constructions. In the context of aircraft construction it is expected a lot from them not only from mechanical point, but also thermal one determined by high-speed movement and often ballistic in relation to military aircraft.

The subject of research in the publication are composites materials used in aviation. The purpose of the survey is to identify major problems connected with the materials which are applied in aviation structures.

2. FIBER REINFORCED PLASTICS MATERIALS – GLASS AND CARBON FIBERS REINFORCED PLASTIC IN MILITARY AVIATION

Composite materials used in military aviation are given high requirements, not only mechanical, but thermal, chemical, and often even ballistic as well. Fiber Reinforced Plastics composites fulfill these requirements perfectly.

They are lightweight, and very durable mechanically. Initially in the construction of aircraft they were used as a replacement for metal parts.

Today, clearly visible is an increasing trend in their application. Now it happens that there are over 90% [1] airframe structures and their participation in design of aircraft allows to reduce its weight up to 25%. As a result aircraft is able to carry more weapons and increase its range, what makes it more effective in combat missions.

Carbon and Glass Fibres Reinforced Plastic (CFRP and GFRP) are used commonly in modern military aviation. In the most modern fighter aircraft in the world the Lockheed Martin F-35 Lightning II. CFRP laminates were used in many elements of load-bearing structure of aircraft, such as: vertical stabilizer, tailplane, flaps and wings skin [2]. These items are about 40% of weight of aircraft and are responsible for aerodynamic lift creation and maintaining aircraft in the air. The fuselage also consists of CFRP laminate. Another advantage of the application of FRP in the F-35 is low detectability by radars, by joining them with very small tolerances of about 0.2 mm [3].

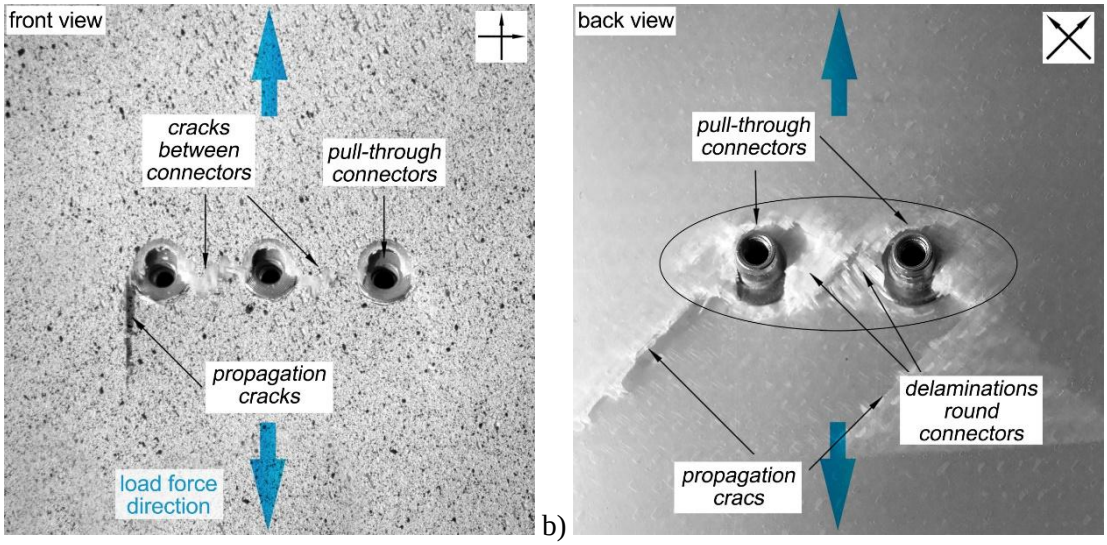
CFRP and GFRP laminates used in construction of aircraft apart from many advantages have some disadvantages. One of them being a major problem is so-called a brittle crack. It spreads rapidly and goes deeper into the structure. This process is often accompanied by delamination, or separation of adjacent reinforcement layers (laminas) [4]. In aircraft construction the phenomenon of brittle crack is very dangerous. During flight and activity of strong mechanical interaction on aircraft's construction, this type of defect may cause damage to the structure with very serious consequences.

Another problem, at the stage of designing aircraft is mechanical treatment of composites. GFRP and CFRP laminates while drilling, grinding or other mechanical treatments are susceptible to local degradations [5]. Many difficulties focus on the effect of local delamination of setting while impacting of a cutting tool on the material. In this case, it is necessary to use appropriate tools, machines and cleaning equipment. Modern techniques of mechanical machining, such as cutting by Abrasive Water-Jet Machining (AWJM) and laser methods are being increasingly applied. They are considered as very adequate and effective. On the other hand, it is a very expensive solution.

Riveting is still one of the main joining methods of thin-walled aircraft structures. Such features as simplicity of implementation, possibility of connecting two different materials (e.g. metallic with non-metallic ones) and the fact that is it a well-known (reliable) method makes riveting so popular [6, 7].

Riveted connections aviation composite structures entail problems. One of them is initiation and propagation of mechanical damages. For example, the connection of rivet-nuts in the structure of aircraft was provided, which was built from GFRP composites. Two types of fiber orientation were established – $[0_2/90]_S$ (Fig. 1a) and $[-45_2/45]_S$ (Fig 1b). Bearing structure was joined by rivet-nuts connection and was made in accordance with a model – single lap. Connection was subjected to tensile tests. The result of the tests are the following images showing mechanical damages (Fig. 1).

In the rivet connection visible matrix cracks, delaminations and fibers break are defined. The propagation cracks are in accordance with the direction of the reinforcement (perpendicular orientation - Fig.1a, oblique orientation – Fig.1b) in relation to the load force. The cracks propagate from the connectors into the structure. Around the rivets in the back view (Fig.1b) there appear local delaminations by the pull-through. Fibers breakings are visible around and between rivet holes. They lead to the failure path. This type of composite damages applied in the aviation construction are very dangerous and can lead to a loss of lift force by aircraft.



a) b)

FIG. 1. Mechanical degradation in GFRP connection around the rivet area

3. ARAMID FIBERS REINFORCED PLASTIC AND HYBRID COMPOSITES

In modern air structures there is often used Aramid Fiber Reinforced Plastic (AFRP) for example Kevlar. It is one of the strongest synthetic fibers ever created. A common feature of the family of these products is high tensile strength with low specific weight. At the same weight it is five times stronger than steel. The material is outstanding for its excellent thermal strength , dimensional stability and low elongation at break. It is anti-corrosion and resistant to most chemicals. Kevlar fibers are: uninflammable, non-conducting wear resistant. With this unique combination of properties of this material it is used in many aviation constructions. In the design of aircraft, large module of Kevlar fibers in conjunction with its high impact resistance, allows designers to reduce the weight of many structural elements and to improve the mass-load characteristics.

An example of the application of composite materials type of Kevlar is the American helicopter Boeing AH-64 Apache. From Kevlar rotor blades (main and tail) were made. An interesting solution is so-called "Kevlar bath". Inside "Kevlar bath" the seats are embedded, where the crew is located. Its task is to protect against artillery shell up to 23 mm. Massive use of Kevlar in the construction of aircraft is rather negligible, due to high price. Mainly it is used as a material to reinforce elements of the heavily thermally and mechanically loaded.

In recent years, a lot of interest is given to Fiber Metal Laminates – FML. These are materials made of thin layers of metal sheets and fibers. The first study done on the wing of the aircraft S-11 and F-27 confirmed their increased mechanical properties, which have helped to conduct further research. As a result of the application of strengthened glue that connects the metal and fibres, the effect of cracks propagation was three times slower. The result of this point to the significant benefits that give possibility to use FML for the aircraft construction. Besides delaminations connected with cracks significantly decreased the propagation speed.

On the basis of this knowledge, and subsequent research there was created – GLARE (GLAss Reinforced/Glass-Reinforced Aluminum Laminates [8]) composite. It consists of 2 to 6 layers of aluminium (GLARE 1 i HS – 7475-T761; GLARE 2÷6 – 2024-T3), thickness of 0.2 to 0.5 mm. Between the layers of aluminium there are alternately layers of fibers and metal. S-glass fiber oriented of a thickness of 0.25 to 0.5 mm are connected by matrix of epoxy resin and combined with aluminium.

In view of its specific properties the GLARE became the subject of research in the context of military aviation. During the bullet hole caliber 16.5 mm, penetrating an obstacle with composite GALRE with the speed of 171 m/s there was observed only local destruction at the site of impact of the projectile and its area – see in Fig. 2 [9, 10].

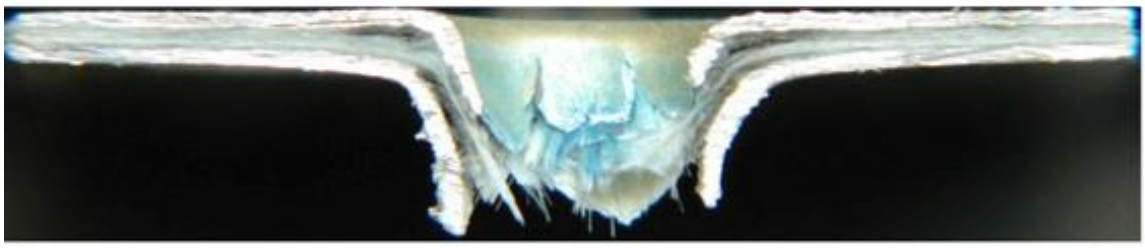


FIG. 2. Cross-section of bullet hole in GLARE [9, 10]

No occurrence of brittle cracks, very dangerous in aviation structures were noted. Besides tests for concentrated dynamic loads finished successfully. Deformation caused by point loads were plastics and visible visually.

GALRE material is characterized by low weight, high corrosion and fire resistance. Despite these and many other advantages of these materials have certain restrictions that limit their use for aviation. A significant impact on their use have adhesive (glued) connection applied between its layers. During using the connection in the GALRE composite can be adhesively and cohesively destroyed. The maximum cohesively strength between thin layers is about 100 MPa adhesive strength and typically lower and it indeed depends on the preparation of the combined surface for bonding. Even if there is applied an effective preparation of the surface for gluing, for example in the pickling form or anodizing of aluminium alloys, allowing high adhesive strength of the connection, local stresses in the adhesion layer order of 100 MPa should destroy it – cause delamination of laminar composite.

4. METAL MATRIX COMPOSITES MATERIALS IN MILITARY AVIATION MARKET

In modern air structures increased usage of Metal Matrix Composites (MMC) is observed [11]. Matrix of MMC composites were made from iron and its alloys, nickel alloys, non-ferrous metals and alloys, mainly: aluminum, magnesium, copper, silver, tin, lead, titanium, intermetals (NiAl, Ni3Al, Ti3Al, TiAl, MoSi2), and superalloys. MMC used in construction of military aircrafts should take into account the requirement to reduce density, which basically means using matrix of only light metals such as aluminium, magnesium, titanium or beryllium.

Example of using MMC is 5^{th} generation aircraft Lockheed Martin F-22 Raptor. In its design many varieties of composite materials, reinforced dispersion composites based on aluminium alloys and titanium carried out by Automated Fiber Placement (AFP) [12] were used. Composites are dispersion reinforced were made from metal matrix, forced with very fine ceramic or metallic particle with a diameter of 0.01-0.1 μm to about 15% of the composite volume.

MMC composites from other types of composites can be distinguished by mechanism of strengthening. In the case of dispersion reinforcement occurs at the microscopic level (atomic or molecular) and is intended by the dispersed particles motion of dislocation in the matrix.

External load is transferred in the vast majority of the matrix, so reinforcement dispersion does not improve significantly the characteristics and strength of composite in elevated temperature. The impact of the reinforcement on the other hand, is pronounced at high temperatures, up to 80% of the melting temperature. Even a small participation of the particles dispersion significantly improves for example fatigue resistance compared with matrix of material. This is important especially in working under a heavy load at high temperatures, such as aircraft engine blades.

Another example of using metal composites such as MMC in military aviation is a heavy transport plane Boeing C-17 Globemaster III. In the construction of the aircraft manufacturer used MMC composite based on the alloy TiAl6V4 and continuous fibre made of silicon carbide. This material has been used in turbine aircraft engine – Fig. 3 [13].

FIG. 3. Pratt & Whitney PW2000 engine with fan blades from MMC [13]

MMC composite – B-Al is used in many military aviation projects. In this role the matrix is aluminum alloy and reinforcement are particles of boron. The advantage of this solution is high temperature resistance. It allows for safe operation up to 510°C, where the average composite can withstand just 190°C. This type of laminates were used on leading edges of main and tail rotor blades of helicopters: Sikorsky S-76D, Sikorsky S-92 or Sikorsky S-70 [14] and others.

Very high material expectations are set for hypersonics aircraft. They are undoubtedly the future of global aviation market. Assumption of the construction of this type of object is its very high speed, reaching a few numbers of the Mach speed. High stiffness, strength, and resistance to fracture and ability to work in high and very low (cryogenic) temperatures is desirable. In the case of work composite for a long period of time, in elevated temperature thermodynamic stability reinforcement becomes a critical parameter. Reactions between matrix and reinforcement during service in a progressive manner can degrade its mechanical properties. Such requirements are able to be met by the titanium matrix composites and Intermetalic Matrix Composite (IMC). They are applied in all four engines of a B-2 bomber. Cooling system, decreased exhausting gas stream from engines from 800°C to 400°C.

Such solution allows to detect and surveillance aircraft by missiles thermally homing on the target, making the design more secure during the war operations. On the other hand, this type of composites are very expensive.

CONCLUSION

Fibres Reinforced Plastic composites such as Carbon and Glass Fibres Reinforced Plastic (CFRP and GFRP) materials due to high mechanical properties and the relatively low price are the direction of the future development of materials used for military aviation industries. However, their using is connected with a number of operational issues, such as: mechanical degradations – delaminations and propagations cracks, using expensive tools and manufacture method, as well as problems with their merging.

Aramid Fibres Reinforced Plastic (AFRP) and GLARE composite are another direction of development of composite materials for aviation and have high mechanical-thermal properties. They show a high impact strength and ability to reduce cracks, dangerous for aircraft structures. The disadvantage, however, is a small adhesive and cohesive strength between laminas.

Metal composites are a class of materials with high thermal properties. They are appropriate material in highly loaded thermally and mechanically aircraft components, such as engine blades, or leading edges of wings. Their disadvantage yet is a very high cost.

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COMMUNICATION PROTOCOL FOR A MULTIPLE INTERFACE GATEWAY IN IoT SYSTEMS

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Abstract: *The concept of the IoT (Internet of Things) has become a very hot topic in fields like networking and embedded electronics, thanks to the fast development in the different types of processing units which gave rise of powerful, very compact and highly efficient systems like: SOC's (System on Chip) and OBC's (On Board Computer). These systems can also offer networking functionalities, and together with the IPv6 and its myriad number of IP addresses, the IoT can become the part of every household. In this paper, a particular system will be presented, which could be used as a part of an IoT system.*

Keywords: *IoT, OBC, networking, smart home*

1. INTRODUCTION

The original architecture of the classical internet was created long before the idea of internet of things (IoT) would be conceptualized, which means that it is necessary to realize a different type of communication method, which can handle an exponentially increased data streams from diverse sources like sensors, actuators or other kind of electronic devices with the capability to transmit data in a given medium.

The information transmitted by these devices will also be really different from the type of data that is exchanged in the traditional internet in the sense that it is more redundant, with a slow variation of the measured values. The medium in which the data is transmitted, in the most cases will be "low fidelity", the attenuation and the interference may cause some loss of data, but in this case a big portion of data is insignificant and can be extrapolated by the correctly received values. [1]

Considering the waste list of protocols used in IoT (RFID, ZigBee, GPRS, GSM, Bluetooth, Wi-Fi, Ethernet, …)[5] for wired and wireless communication it is really important to have a system which can handle multiple protocols. Based on these multiple protocols, a generic protocol could be created.

In order the receive data in IoT systems, an efficient method is to use the MQTT (Message Queue Telemetry Transport) or a similar protocol which is based upon a publish-subscribe system. This protocol allows the end user to choose only the necessary data, by subscribing to the published information using a broker, which has the role to manage the coordination of subscriptions and data reception.[6] After the data had been collected from the various sources, it could be sent to a Cloud network. The Cloud network can provide a decentralized system, which is highly reliable and accessible from anywhere and anytime.[4]

In this paper, a simple protocol is presented, which will encapsulate the transmitted data into a specific data packet with additional information to realize a publish- subscribe system similar to MQTT. In order to make the system easier to integrate into Cloud systems, it will use the httpRest protocol, which is based on the HTTP protocol (GET, POST, DELETE,...), which will provide semantic information, to realize a customizable back-end application.[3]

2. THE GATEWAY SYSTEM AND THE COMMUNICATION PROTOCOL

The description and the functionalities of the system realized and tested by the authors is presented below. The system uses a specific protocol, implemented using the UDP (User Datagram Protocol) transfer protocol, which has the role to organize data and to give additional meta-information which will be useful for further data processing. Also, it realizes a dialog between the main components of the system. This protocol will run in the Application OSI (Open System Interconnection) layer which presumes an existing connection between the communicating devices. The software program used for this system was developed in Python.[2]

Three types of data packets are used within the protocol between the gateway and the devices, each having a different purpose and slightly different structure, as follows:

a) The simple data packet

This type of packet is used for simple data transfer only, between the devices and the gateway. The dialog in the case is unidirectional.

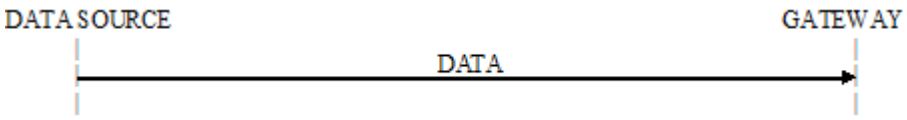

FIG. 1. Simple data packet

b) The management packet

The management packet is used to obtain status information from the device, if this kind of information is available, about the parameters measured by the device, in order to be able to respond with a corresponding control packet, to create a log file or a visual representation of the desired data.

When this type of packet is used, the dialog is bi-directional, first the gateway asking for the information using this type of packet, and, subsequently, if the device receives at least one packet, then it starts its own response stream. When the gateway receives the response, it means that the request was successful. Else, the streaming will continue for a given time value, after that the streaming being repeated. As an example, this packet is used to get information about the quality of the radio connection, the current channel, etc.

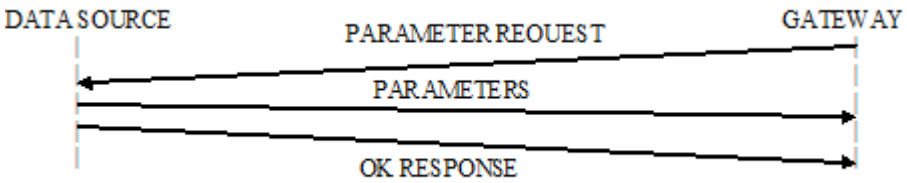

FIG. 2. Management data packet

c) The control packet

The purpose of this packet is to control the different kind of settings of the devices connected to the gateway, or to eventually stop the communication with the device, if necessary. After a stream of control packets the gateway will wait for a response packet from the device and in the case, that it doesn't had received any response it will retry the transmission for a given amount of time. If the communication is successful the gateway will receive a packet about the result of the command.

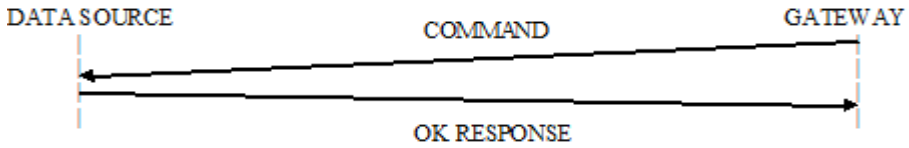

FIG. 3. Control data packet

This part of the system will use UDP or a similar protocol, for example L2CAP (Logical Link Control and Adaptation Protocol) in the case of Bluetooth communication (if different kind of communication modules like the SIM800L GPRS module is used the communication will be over UART - Universal Asynchronous Receiver/Transmitter, or other available communication interface, so in this particular case there is no need of continuous data streams or retransmissions).

The reason for this decision is that the data in the majority of cases has a really slow variation in time and the use of a protocol which is connection-oriented requires an excessive overhead, which is quite unnecessary in this case, because the same data will be transmitted over a long period.

The connectionless transmission has its drawbacks too, which in this case is the increase of the complexity of the communicating software, which requires a way to assure at least best-effort communications.

The second protocol which is used between the gateway and the main server is similar to the one described before, having the difference that it uses a connection over TCP (Transmission Control Protocol). The difference is that instead of continuous data streaming, it is enough to transmit a data only once.

2.1. The data packet structure. The packet type used by these communication, uses the structure illustrated below:

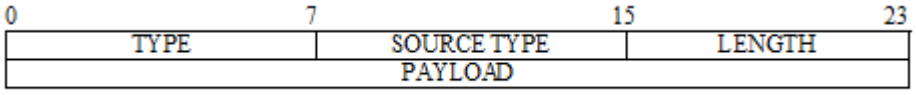

FIG. 4. Data packet

This structure contains two main parts: a header and a payload part, which is used to differentiate the communication packets used by the protocol. The header section consists of three parts each with its own use in the detection of: the used communication type, the source which have sent the data and the payload length (in the examples presented in the paper the payload length is 1 byte, because the source of the data which will be transmitted is an 8-bit microcontroller, and the length of the measured value is also 8 bits).

The PAYLOAD section contains the value which was measured in one side, and is transmitted to the other side. The length of this section can differ by the nature of the data transmitted, the data size used by the measuring unit, or the type of the packet. When different communication types are used, other than simple data communication, the payload content is the value that was requested by the transmitting end.

The TYPE section has a set of predefined values which the communicating parts can use to decide what kind of data had been sent or received (Command Packet, OK, Error, Management, …).

The SOURCE TYPE is used in order to decide from which interface did the data arrived and what kind of procedures can be used in the case of management or control communication.

The LENGTH part of the header section, is used by the receiving part to proceed in a way that all the data transmitted could be received without errors.

3. USE CASE SCENARIO OF THE SYSTEM

To demonstrate how the system works, a practical representation of the system will be shown below. From the devices listed above (RFID, ZigBee, GPRS, GSM, Bluetooth, Wi-Fi, Ethernet, …), the communication realized with the Wi-Fi device will be presented here. There will be three major parts in this section of the paper, which refers to the different kind of data packets which can appear in a conversation between the gateway and the device. Each of these cases will be monitored by the Wireshark program and presented, to put emphasis on the structure and the content of the data used in the respective communication.

Case 1. The simple data packet

This packet contains the value measured by a temperature sensor and send forward to the gateway for future processing and/or retransmission to the final server. To watch the variation of the incoming data a graphical user interface was added to the program in the gateway side, realized with the Python scripting language. In the picture below, the decoded information coming from the data source can be seen:

FIG. 5. The graphical interface of the program containing the received data

In order to decide the information type and source, the program uses the respective sections from the received datagram which can be seen in the following Wireshark capture:

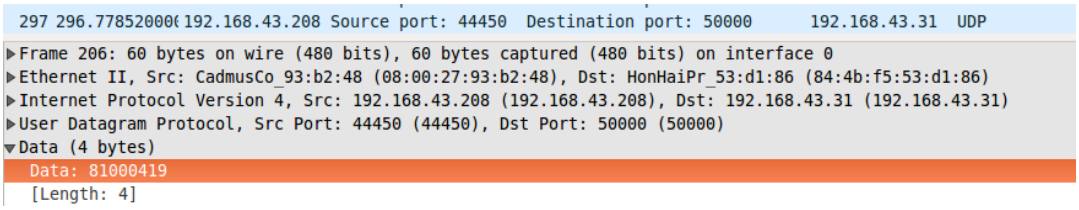

FIG. 6. Wireshark capture of the received data

In the Fig. 6. it can be seen that 40 bytes have been received, from which the first 5 are useful and the rest are used to fill the empty sections in order to have similar sizes with the management and control packets. The 5 bytes are 81.00.04.19 which corresponds to 1000.0001 – TEMPERATURE, 0000.0000 - WIFI, 0000.0100 – 4 bytes of useful data, and 0001.1001 – the value 25.

Case 2. The management packet

The management data packet is used to obtain information from the measuring side, in our case about the RF (Radio Frequency) channel parameters and the access data. After pressing the get parameters button the program will send a request to the data source and it will receive the requested data, and at last the response message, which stops the request stream.

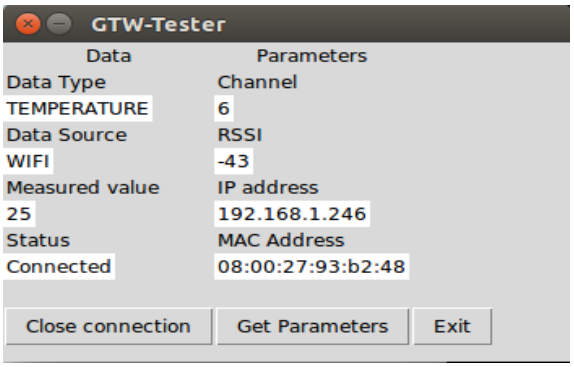

FIG. 7. Parameters received from the data source

The parameter request packet can be seen below and the first response packet also, which contains the requested parameters.

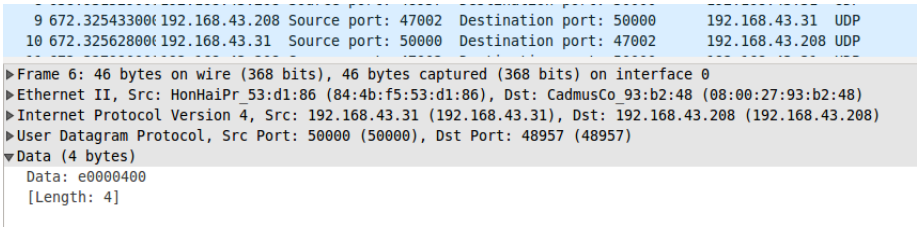

Fig. 8. Wireshark capture of the data request

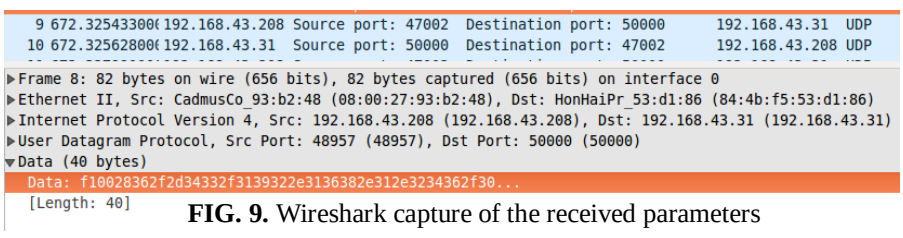

FIG. 9. Wireshark capture of the received parameters

Case 3. The control packet

The control packet is used to control the transmission from the measuring side and to obtain a response from the measuring side about the state of the execution of the command.

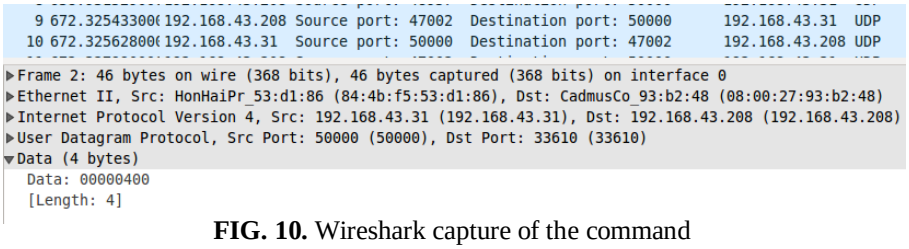

FIG. 10. Wireshark capture of the command

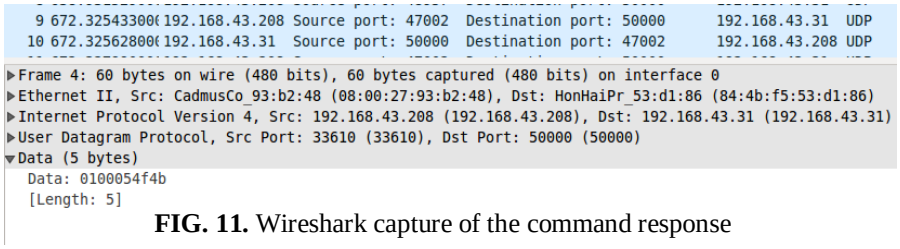

FIG. 11. Wireshark capture of the command response

In the captures from the Fig. 10 and 11 the sent command is presented with the response from the data source.

CONCLUSIONS AND FUTURE WORK

An example of a particular realization of a communication gateway which can be developed further and can be integrated inside a more complex system was presented in this paper.

For future development, it is planned to design a network interface with a server, making the role of a gateway similar to a broker used in MQTT systems, which can ask for the desired data, in a subscription manner, and also to transmit commands and parameter requests. These actions will be fulfilled using the same protocols which was presented in the previous chapters but in this case using the TCP and HTTPREST protocols, which can offer the security of the transmitted data.

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APPROXIMATION AND COMPARISON OF ORDINARY DIFFERENTIAL EQUATION USING BY NEW ITERATION METHODS

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Abstract: *In this study, Modified Ishikawa, Modified Krasnoselskii, Extra Modified Ishikawa and New Modified Ishikawa Iteration methods are presented. The approximate solution of the different type of the problems is solved subject to the initial condition. Then comparisons of these methods with exact solutions are considered. Finally some numerical examples are introduced and related tables are given and the graphs are sketched.*

Keywords: *Ordinary Differential Equation, Euler Method, Fixed Point, Numerical Analysis, Modified Ishikawa Iteration, Modified Krasnoselskii Iteration, Picard successive Iteration Method*

2012MSC: *65K15, 65L07, 65L06, 65L70.*

1. INTRODUCTION

The most of the academician studied many kinds of the numerical methods which are used to solve different types of differential equations up to now [19-24]. Namely L.E.J. Brouwer first presented the fixed point theory on normed linear space [8]. Later on this, there has been growing interest in approximation of fixed point theory on normed linear spaces [1,4,8,9], Banach spaces [2,10,12,14,16,18], and Hilbert spaces [11,17], respectively.

In one of our previously studies, we have dealt with Modified Ishikawa iteration to solve the different type of differential equations and compared the results with the method of the Runga-Kutta, Euler, and Picard [6]. On the other hand, we recently worked on Modified Krasnoselskii method to solve some of the differential equations and at the end, compared the results with the method of Runga-Kutta, Euler, and Picard [5].

In this work, firstly we picked different type of differential equations and showed that how to applied New Modified Ishikawa iteration method and Extra Modified Ishikawa iteration method to the given problems. And later on, we considered the comparisons between the Modified Ishikawa, Modified Krasnoselskii, New Modified Ishikawa and Extra Modified Ishikawa iteration methods each other. And following this, we gave the tables and sketched the graphs. Consequently, we decided that which one of these iterations is more powerful or the best approximation.

Now, Let us give some of the important theorems and definitions.

Theorem 1.1. (Banach constraction principle) Let (X,d) be a complete metric space and $T: X \to X$ be a constraction with the Lipschitzian constant L. Then T has a unique fixed point $u \in X$.

Furthermore, for any $x \in X$ we have $\lim_{n\to\infty} T^n(x) = u$ with $d(T^n(x),u) \le \frac{L^n}{1-L} d(x,T(x))$ [1]

Corollary 1.2. Let (X,d) be a complete metric space and let $B(x_0,r) = \{x \in X : d(x,x_0) < r\}$, where $x_0 \in X$ and $r > 0$. Suppose $T: B(x_0,r) \to X$ is a constaction (that is, $d(T(x),T(y)) \le Ld(x,y)$ for all $x,y \in B(x_0,r)$ with $0 \le L < 1$) with $d(T(x_0),x_0) < (1-L)r$. Then T has a unique fixed point in $B(x_0,r)$ [1].

Definition 1.3. Let X be a normed linear space and $T: x \to x$ a given operator. If the sequence $\{x_n\}_{n=0}^{\infty}$ provides the condition $x_{n+1} = Tx_n$ for $n = 0,1,2,\ldots$, then this is called the Picard iteration [7,18].

Definition 1.4. Let X be a normed linear space and $T: x \to x$ a given operator. If $x_0 \in X$, $\lambda \in [0,1]$ and also the $\{x_n\}_{n=0}^{\infty}$ sequence provides the condition

$$x_{n+1} = (1-\lambda)x_n + \lambda T x_n \quad \text{for} \quad n = 0,1,2,\ldots$$

then this is called the Krasnoselskii iteration [3].

Definition 1.5. Let $x_0 \in X$ be arbitrary. If the sequence $\{x_n\}_{n=0}^{\infty}$ provides the condition

$x_{n+1} = (1-\alpha_n)x_n + \{\alpha_n\}Ty_n$

$y_n = (1-\beta_n)x_n + \{\beta_n\}Tx_n$

for $n = 0,1,2,\ldots$, then this is called the Ishikawa iteration where (α_n) and $\{\beta_n\} \subset [0,1]$ is sequences of positive numbers that satisfy the following conditions:

(i) $0 \le \alpha_n \le \beta_n < 1$ for all positive integers n

(ii) $\lim_{n\to\infty} \beta_n = 0$

(iii) $\sum_{n\ge 0} \alpha_n\beta_n = \infty$. [12,13]

Definition 1.6. If $y_0 \in X$, $\lambda \in [0,1]$ and T is defined contraction mapping regard as Picard iteration and also the $\{y_n\}_{n=0}^{\infty}$ sequence provides the conditions

$y_{n+1} = y_0 + \int_{x_0}^{x} F(t,y_n(t))dt$ for $n = 0,1$

$y_{n+1} = (1-\lambda)y_n + \lambda T y_{n-2}$ for $n = 2,3,\ldots$

$Ty_{n-1} = y_n \quad , \quad 0 < \lambda < 1$

, then this is called the Modified Krasnoselskii iteration where $T = \int_{x_0}^{x} F(t,y_n(t))dt$ and $y'(t) = F(t,y(t))$ [5].

Definition 1.7. If $y_0 \in X$, $\lambda \in [0,1]$, $\gamma \in [0,1]$ and T is defined contraction mapping with regard to Picard iteration and also the $\{y_n\}_{n=0}^{\infty}$ sequence provides the conditions

$$\left.\begin{aligned} y_{n+1} &= \lambda y_{n-1} + (1-\lambda)Ty_{n-1} \\ y_n &= (1-\gamma)y_{n-2} + \gamma T y_{n-2} \end{aligned}\right\} \text{ for } n = 2,4,\ldots$$

$y_{n+1} = y_0 + \int_{x_0}^{x} F(t,y_n(t))dt$ for $n = 0$

$Ty_{n-1} = y_n \quad , \quad 0 < \lambda,\gamma < 1$

, then this is called the Modified Ishikawa iteration where $T = \int_{x_0}^{x} F(t,y_n(t))dt$ and $y'(t) = F(t,y(t))$[6].

Definition 1.8. If $y_0 \in X$, $\lambda \in [0,1]$, $\gamma \in [0,1]$ and T is defined contraction mapping with regard to Picard iteration and also the $\{y_n\}_{n=0}^{\infty}$ sequence provides the conditions

$$\left.\begin{aligned} y_{n+1} &= (1-\lambda)y_{n-1} + \lambda T y_{n-1} \\ y_n &= \gamma y_{n-2} + (1-\gamma)Ty_{n-2} \end{aligned}\right\} \text{ for } n = 2,4,\ldots$$

$y_{n+1} = y_0 + \int_{x_0}^{x} F(t,y_n(t))dt$ for $n = 0$

$Ty_{n-1} = y_n \quad , \quad 0 < \lambda,\gamma < 1$

then this is called the New Modified Ishikawa Iteration where $T = \int_{x_0}^{x} F(t,y_n(t))dt$ and $y'(t) = F(t,y(t))$

Definition 1.9. If $y_0 \in X$, $\lambda \in [0,1]$, $\gamma \in [0,1]$ and T is defined contraction mapping with regard to Picard iteration and also the $\{y_n\}_{n=0}^{\infty}$ sequence provides the conditions

$$\left.\begin{aligned} y_{n+1} &= \lambda y_{n-1} + (1-\lambda)Ty_{n-1} \\ y_n &= \gamma y_{n-2} + (1-\gamma)Ty_{n-2} \end{aligned}\right\} \text{ for } n = 2,4,\ldots$$

$$y_{n+1} = y_0 + \int_{x_0}^{x} F(t, y_n(t))dt \quad \text{for} \quad n = 0$$

$$Ty_{n-1} = y_n \quad , \quad 0 < \lambda, \gamma < 1$$

, then this is called the Extra Modified Ishikawa Iteration where $T = \int_{x_0}^{x} F(t, y_n(t))dt$ and $y'(t) = F(t, y(t))$

2. APPLICATION OF METHODS

Example 2.1. Let us consider the differential equation $y' = \sqrt{|y|}$ subject to the initial condition $y(0) = 1$ [15]. Firstly, we obtained the exact solution of the equation as $|y| = \frac{1}{4}(x+2)^2 = 1 + x + \frac{x^2}{4}$. By Theorem 1.1 and Corollary 1.2, since $T = \int_{x_0}^{x} F(t, y_n(t))dt$ and $y'(t) = F(t, y(t))$, then

$$|T(x) - T(y)| = \left|\int_0^x \sqrt{t}dt - \int_0^y \sqrt{t}dt\right| = \left|\tfrac{2}{3}\sqrt{t^3}\Big|_0^x - \tfrac{2}{3}\sqrt{t^3}\Big|_0^y\right| \leq \tfrac{2}{3}\left|\sqrt{x^3} - \sqrt{y^3}\right| \leq \tfrac{2}{3}|x-y|.$$

So, $|T(x) - T(y)| \leq \frac{2}{3}|x-y|$ is found. Thus T has a unique fixed point, which is the unique solution of the integral equation $T = \int_{x_0}^{x} F(t, y_n(t))dt$ or the differential equation $y' = \sqrt{|y|}$,

Firstly, we consider the approximate solution using by the Picard iteration method. Thus

$$y_1 = 1 + x$$

$$y_2 = \frac{1}{3} + \frac{2}{3}(1+x)^{3/2}$$

are obtained. If we take the series expansion of the function $(1+x)^{3/2}$ for the seven terms, then

$$y_2 = 1 + x + \frac{x^2}{4} + \frac{x^3}{24} + \frac{x^4}{64} + \frac{x^5}{128} + \frac{7x^6}{1536}$$

is found. Now we calculate the approximate solution by the Euler method. At first we use the formula

$$y_{n+1} = y_n + hF(x_n, y_n)$$

with $F(x,y) = \sqrt{|y|}$, $h = 0.2$ and $x_0 = 0$, $y_0 = 1$ from the initial condition $y(0) = 1$, we have $F(0,1) = 1$. We now proceed with the calculations as follows:

$$F_0 = F(0,1) = 1$$

$$y_1 = y_0 + hF_0 = 1 + 0.2 = 1.2$$

$$F_1 = F(0.2, 1.2) = 1.095445115$$

$$y_2 = 1.2 + 0.2F_1 = 1.419089023$$

$$F_2 = F(0.4, 1.419089023) = 1.19125523$$

$$y_3 = 1.419089023 + 0.2F_2 = 1.657340069$$

Finally, applying the Runga-Kutta method to the given initial value problem, we carry out the intermediate calculations in each step to give figures after the decimal point and round off the final results at each step to four such places.

Here $F(x,y) = \sqrt{|y|}$, $x_0 = 0$, $y_0 = 1$ and $h = 0.2$ .Using these quantities, we calculated successively k_1, k_2, k_3, k_4 and K_0 defined by

$$k_1 = hF(x_0, y_0)$$

$$k_2 = hF\left(x_0 + \frac{h}{2}, y_0 + \frac{k_1}{2}\right)$$

$$k_3 = hF\left(x_0 + \frac{h}{2}, y_0 + \frac{k_2}{2}\right)$$

$$k_4 = hF(x_0 + h, y_0 + k_3)$$

and $K_0 = \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$, $y_{n+1} = y_n + K_0$ .Thus we find k_1, k_2, k_3, k_4 for $n = 0$ as follows:

$k_1 = 0.2$
$k_2 = 0.209761769$
$k_3 = 0.210226628$
$k_4 = 0.220020601$

So, $y_1 = 1.209999565$ is obtained for $x_1 = 0.2$. On the other hand, we calculated k_1, k_2, k_3, k_4 for $n = 1$ as follows:

$k_1 = 0.21999996$
$k_2 = 0.229782466$
$k_3 = 0.230207801$
$k_4 = 0.240017279$

Hence $y_2 = 1.4399999194$ is calculated for $x_2 = 0.4$. Finally we get k_1, k_2, k_3, k_4 for $n = 2$ as follows:

$k_1 = 0.239999993$
$k_2 = 0.249799913$
$k_3 = 0.2250131316$
$k_4 = 0.260014756$

Thus, $y_3 = 1.689999654$ is obtained for $x_3 = 0.6$. Now, applying the New Modified Ishikawa Iteration Method to the equation for different value of λ and γ, then

$y_1 = 1 + x$
$y_2 = 1 + 0.5x$
$y_3 = 1 + 0.75x$
$y_4 = 1 + 0.625x$ for $\lambda = 0.5$ and $\gamma = 0.5$
$y_5 = 1 + 0.6875x$
$y_6 = 1 + 0.65625x$
$y_7 = 1 + 0.671875$

$y_1 = 1 + x$
$y_2 = 1 + 0.75x$
$y_3 = 1 + 0.875x$
$y_4 = 1 + 0.84375x$ for $\lambda = 0.5$ and $\gamma = 0.25$
$y_5 = 1 + 0.859375x$
$y_6 = 1 + 0.85546875x$
$y_7 = 1 + 0.857421875x$

$y_1 = 1 + x$
$y_2 = 1 + 0.5x$
$y_3 = 1 + 0.875x$
$y_4 = 1 + 0.6875x$ for $\lambda = 0.25$ and $\gamma = 0.5$
$y_5 = 1 + 0.828125x$
$y_6 = 1 + 0.7578125x$
$y_7 = 1 + 0.810546875x$

are obtained, and also Extra Modified Ishikawa Iteration Method to the equation for different value of λ and γ, then

$$y_1 = 1 + x$$
$$y_2 = 1 + 0.5x$$
$$y_3 = 1 + 0.75x$$
$$y_4 = 1 + 0.625x \quad \text{for} \quad \lambda = 0.5 \text{ and } \gamma = 0.5$$
$$y_5 = 1 + 0.6875x$$
$$y_6 = 1 + 0.65625x$$
$$y_7 = 1 + 0.671875x$$

$$y_1 = 1 + x$$
$$y_2 = 1 + 0.75x$$
$$y_3 = 1 + 0.875x$$
$$y_4 = 1 + 0.84375x \quad \text{for} \quad \lambda = 0.5 \text{ and } \gamma = 0.25$$
$$y_5 = 1 + 0.859375x$$
$$y_6 = 1 + 0.85546875x$$
$$y_7 = 1 + 0.857421875x$$

$$y_1 = 1 + x$$
$$y_2 = 1 + 0.5x$$
$$y_3 = 1 + 0.625x$$
$$y_4 = 1 + 0.5625x \quad \text{for} \quad \lambda = 0.25 \text{ and } \gamma = 0.5$$
$$y_5 = 1 + 0.578125x$$
$$y_6 = 1 + 0.5703125x$$
$$y_7 = 1 + 0.572265625x$$

are calculated. Now, as it is seen [5] and [6] we compared the results that we already obtained with the methods of Picard, Euler and Runga-Kutta. Let us give the table of the absolute error with respect to the Example 2.1 for different value of λ and γ as follows:

Table 1 Absolute Error

		$x = 0.2$	$x = 0.4$	$x = 0.6$
Modified Ishikawa Iteration	$\lambda = 0.5, \gamma = 0.5$	0.12398437	0.173203126	0.289804688
	$\lambda = 0.5, \gamma = 0.25$	0.129110108	0.278220216	0.447330323
	$\lambda = 0.25, \gamma = 0.5$	0.09571167	0.21142334	0.34713501
	$\lambda = 0.25, \gamma = 0.2$	0.148429452	0.316858903	0.505288354
	$\lambda = 0.75, \gamma = 0.2$	0.090887414	0.201774827	0.33266224
	$\lambda = 0.25, \gamma = 0.7$	0.049999962	0.119999924	0.209999886
	$\lambda = 0.75, \gamma = 0.7$	0.02541195	0.070823899	0.136235849
Picard		0.0003	0.002328	0.007369875
Runga-Kutta		0.000000435	0.000000081	0.00000046
Euler		0.01	0.020910977	0.032659931
Modified Krasnoselskii Iteration	$\lambda = 0.0001$	0.000311511	0.002331767	0.007378137
	$\lambda = 0.4$	0.003007729	0.012791855	0.030099087
	$\lambda = 0.5$	0.003641293	0.01527775	0.03577398
	$\lambda = 0.9$	0.008516208	0.035355368	0.082333947
New Modified Ishikawa Iteration	$\lambda = 0.5, \gamma = 0.5$	0.075625	0.17125	0.286875
	$\lambda = 0.5, \gamma = 0.25$	0.038515625	0.09703125	0.175546875
	$\lambda = 0.25, \gamma = 0.5$	0.047890624	0.11578125	0.203671875
Extra Modified Ishikawa Iteration	$\lambda = 0.5, \gamma = 0.5$	0.075625	0.17125	0.286875
	$\lambda = 0.5, \gamma = 0.25$	0.038515625	0.09703125	0.175546875
	$\lambda = 0.25, \gamma = 0.5$	0.095546875	0.01890625	0.133359375

After the necessary calculation which is done above, the comparison is shown schematically in Fig.1.

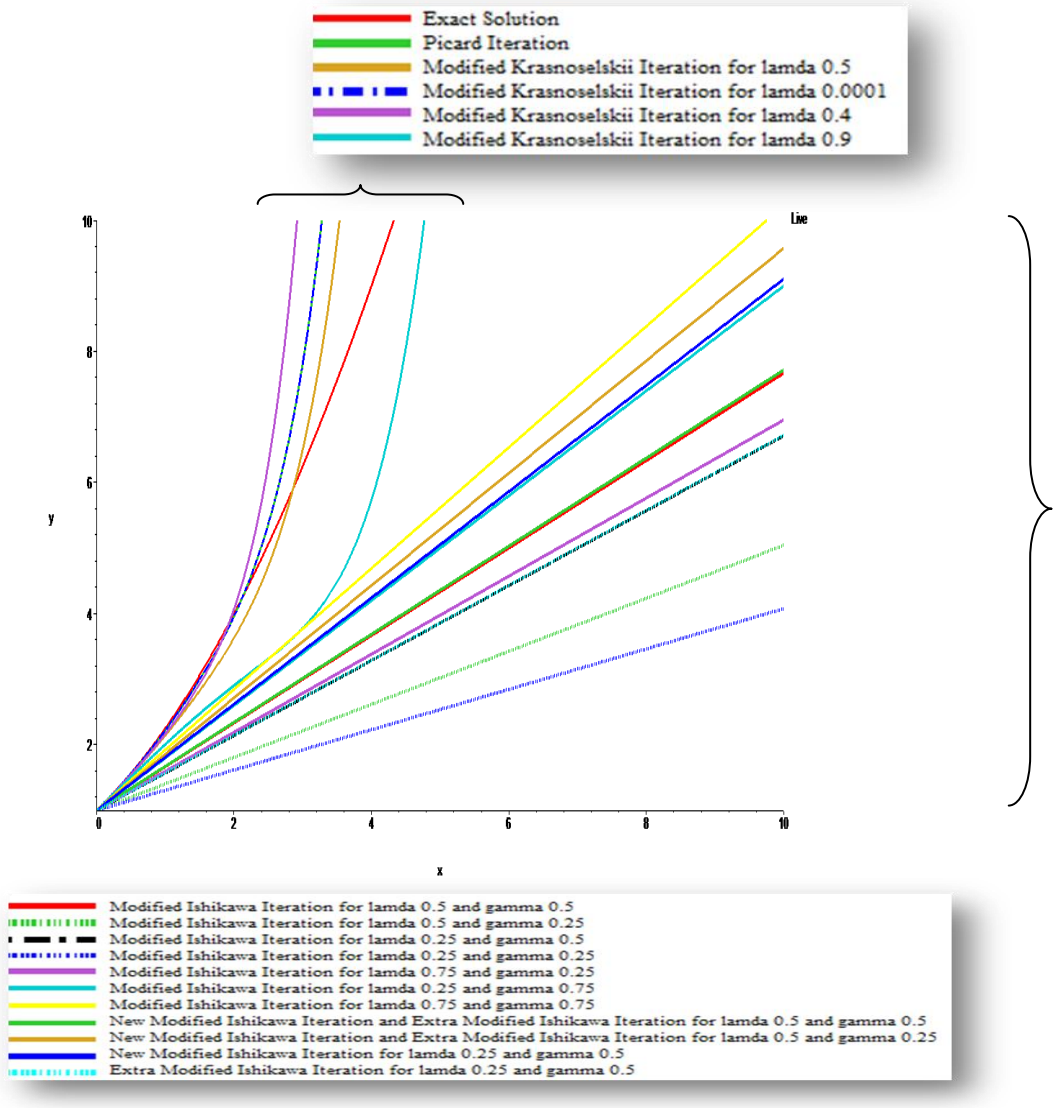

Fig. 1 The comparison of the exact solution and approximate solution of the Example 2.1 for different value of λ and γ.

Corollary 2.1. Absolute error of the Modified Krasnoselskii iteration method is computed taking different values of λ is more effective than Euler, Modified Ishikawa iteration method, New Modified Ishikawa iteration method and Extra Modified Ishikawa iteration method but not better than Runga-Kutta and Picard iteration methods. Absolute error of the Modified Ishikawa iteration method is computed taking different values of λ and γ, which is not more effective than Runga-Kutta, Picard and Euler iteration methods. On the other hand, the New Modified Ishikawa Iteration Method and Extra Modified Ishikawa Iteration Method are compared with the results of absolute errors for Runge-Kutta and Euler methods with the exact solution. And we pointed out that these two methods have more sensitive solution than Modified Ishikawa Iteration method and also indicated that these methods are taken the same value for $(\lambda = 0.5 \text{ and } \gamma = 0.5)$ and $(\lambda = 0.5 \text{ and } \gamma = 0.25)$.

In the conclusion, the comparisons indicate that there is a very good agreement between the numerical solution and the exact solution in terms of accuracy. The result shows that some of the iteration methods are very effective and convenient for solving different type of the equations having the initial conditions with respect to the other methods in the literature.

Example 2.2. Let us consider the differential equation $y' = 2x(y+1)$ subject to the initial condition $y(0) = 0$ [7]. Using Theorem 1.1 and Corollary 1.2, since $T = \int_{x_0}^{x} F(t, y_n(t))dt$ then T has a unique fixed point, which is the unique solution of the differential equation $y' = 2x(y+1)$ with the initial condition $y(0) = 0$.

Firstly, we obtained the exact solution of the equation as $y = e^{x^2} - 1$ .Then we approach the approximate solution using by Picard iteration method as follows:

$y_1 = x^2$

$y_2 = x^2 + \frac{x^4}{2}$

$y_3 = x^2 + \frac{x^4}{2} + \frac{x^6}{6}$

$y_4 = x^2 + \frac{x^4}{2!} + \frac{x^6}{3!} + \frac{x^8}{4!}$

Now we calculate the approximate solution using by Euler method with $F(x,y) = 2x(y+1)$, $h = 0.2$ and $x_0 = 0$, $y_0 = 0$ which subject to the initial condition $y(0) = 0$ .So we proceed with the calculations as follows:

$F_0 = F(0,0) = 0$

$y_1 = y_0 + hF_0 = 0$

$F_1 = F(0.2,0) = 0.4$

$y_2 = 1.2 + 0.2F_1 = 0.08$

$F_2 = F(0.4,0.08) = 0.864$

$y_3 = 0.08 + 0.2F_2 = 0.2528$

Finally, applying the Runga-Kutta method to the given initial value problem, we carry out the intermediate calculations in each step to give figures after the decimal point and round off the final results at each step to four such places.

Here $F(x,y) = 2x(y+1)$, $x_0 = 0$, $y_0 = 0$ and $h = 0.2$. Using these quantities, we calculated successively k_1, k_2, k_3, k_4 and K_0 which are defined before. Thus, we find k_1, k_2, k_3, k_4 for $n = 0$ as follows:

$k_1 = 0$

$k_2 = 0.04$

$k_3 = 0.0408$

$k_4 = 0.083264$

So $y_1 = 0.040810666$ is obtained for $x_1 = 0.2$. On the other hand, we calculated k_1, k_2, k_3, k_4 for $n = 1$ as follows:

$k_1 = 0.083264853$

$k_2 = 0.129893171$

$k_3 = 0.13269087$

$k_4 = 0.187760245$

Hence $y_2 = 0.173509529$ is calculated for $x_2 = 0.4$. Finally we get k_1, k_2, k_3, k_4 for $n = 2$ as follows:

$k_1 = 0.187761524$

$k_2 = 0.253478058$

$k_3 = 0.260049711$

$k_4 = 0.344054217$

Thus $y_3 = 0.433321409$ is obtained for $x_3 = 0.6$. Now, applying the New Modified Ishikawa Iteration Method to the equation for different value of λ and γ, then

$$y_1 = x^2$$
$$y_2 = 0.5x^2$$
$$y_3 = 0.75x^2$$
$$y_4 = 0.625x^2 \quad \text{for } \lambda = 0.5 \text{ and } \gamma = 0.5$$
$$y_5 = 0.6875x^2$$
$$y_6 = 0.65625x^2$$
$$y_7 = 0.671875x^2$$

$$y_1 = x^2$$
$$y_2 = 0.75x^2$$
$$y_3 = 0.875x^2$$
$$y_4 = 0.84375x^2 \quad \text{for } \lambda = 0.5 \text{ and } \gamma = 0.25$$
$$y_5 = 0.859375x^2$$
$$y_6 = 0.85546875x^2$$
$$y_7 = 0.857421875x^2$$

$$y_1 = x^2$$
$$y_2 = 0.5x^2$$
$$y_3 = 0.875x^2$$
$$y_4 = 0.6875x^2 \quad \text{for } \lambda = 0.25 \text{ and } \gamma = 0.5$$
$$y_5 = 0.828125x^2$$
$$y_6 = 0.7578125x^2$$
$$y_7 = 0.810546875x^2$$

are obtained, and also Extra Modified Ishikawa Iteration Method to the equation for different value of γ and λ, then

$$y_1 = x^2$$
$$y_2 = 0.5x^2$$
$$y_3 = 0.75x^2$$
$$y_4 = 0.625x^2 \quad \text{for } \lambda = 0.5 \text{ and } \gamma = 0.5$$
$$y_5 = 0.6875x^2$$
$$y_6 = 0.65625x^2$$
$$y_7 = 0.671875x^2$$

$$y_1 = x^2$$
$$y_2 = 0.75x^2$$
$$y_3 = 0.875x^2$$
$$y_4 = 0.84375x^2 \quad \text{for } \lambda = 0.5 \text{ and } \gamma = 0.25$$
$$y_5 = 0.859375x^2$$
$$y_6 = 0.85546875x^2$$
$$y_7 = 0.857421875x^2$$

$$y_1 = x^2$$
$$y_2 = 0.5x^2$$
$$y_3 = 0.625x^2$$
$$y_4 = 0.5625x^2 \quad \text{for } \lambda = 0.25 \text{ and } \gamma = 0.5$$
$$y_5 = 0.578125x^2$$
$$y_6 = 0.5703125x^2$$
$$y_7 = 0.572265625x^2$$

are calculated.

Now, let us give the absolute error table of Example 2.2 for different value of λ and γ as follows:

Table 2 Absolute Error

		$x = 0.2$	$x = 0.4$	$x = 0.6$
Modified Ishikawa Iteration	$\lambda = 0.5, \gamma = 0.5$	0.014131067	0.066792042	0.193212053
	$\lambda = 0.5, \gamma = 0.25$	0.024632796	0.108798958	0.287727608
	$\lambda = 0.25, \gamma = 0.5$	0.017953108	0.082080207	0.22761042
	$\lambda = 0.25, \gamma = 0.25$	0.028496655	0.124254392	0.322502337
	$\lambda = 0.75, \gamma = 0.25$	0.016988257	0.078220802	0.218926758
	$\lambda = 0.25, \gamma = 0.75$	0.008810767	0.045510383	0.145329346
	$\lambda = 0.75, \gamma = 0.75$	0.003886985	0.025815712	0.101015305
Picard		0.000000002	0.000000899	0.000053574
Runga-Kutta		0.000000108	0.000001342	0.000008005
Euler		0.040810774	0.093510871	0.180529414
Modified Krasnoselskii Iteration	$\lambda = 0.01$	0.000019984	0.000837604	0.00913569
	$\lambda = 0.5$	0.000260774	0.004710871	0.02874414
	$\lambda = 0.9$	0.000665974	0.011194071	0.06156534
New Modified Ishikawa Iteration	$\lambda = 0.5, \gamma = 0.5$	0.013935774	0.066010871	0.191454414
	$\lambda = 0.5, \gamma = 0.25$	0.006513899	0.036323371	0.124657539
	$\lambda = 0.25, \gamma = 0.5$	0.008388899	0.043823371	0.141532539
Extra Modified Ishikawa Iteration	$\lambda = 0.5, \gamma = 0.5$	0.013935774	0.066010871	0.191454414
	$\lambda = 0.5, \gamma = 0.25$	0.006513899	0.036323371	0.124657539
	$\lambda = 0.25, \gamma = 0.5$	0.017920149	0.081948371	0.227313789

After the following absolute Error Table 2 and the necessary calculation which is done above, the comparison is shown schematically in Fig.2.

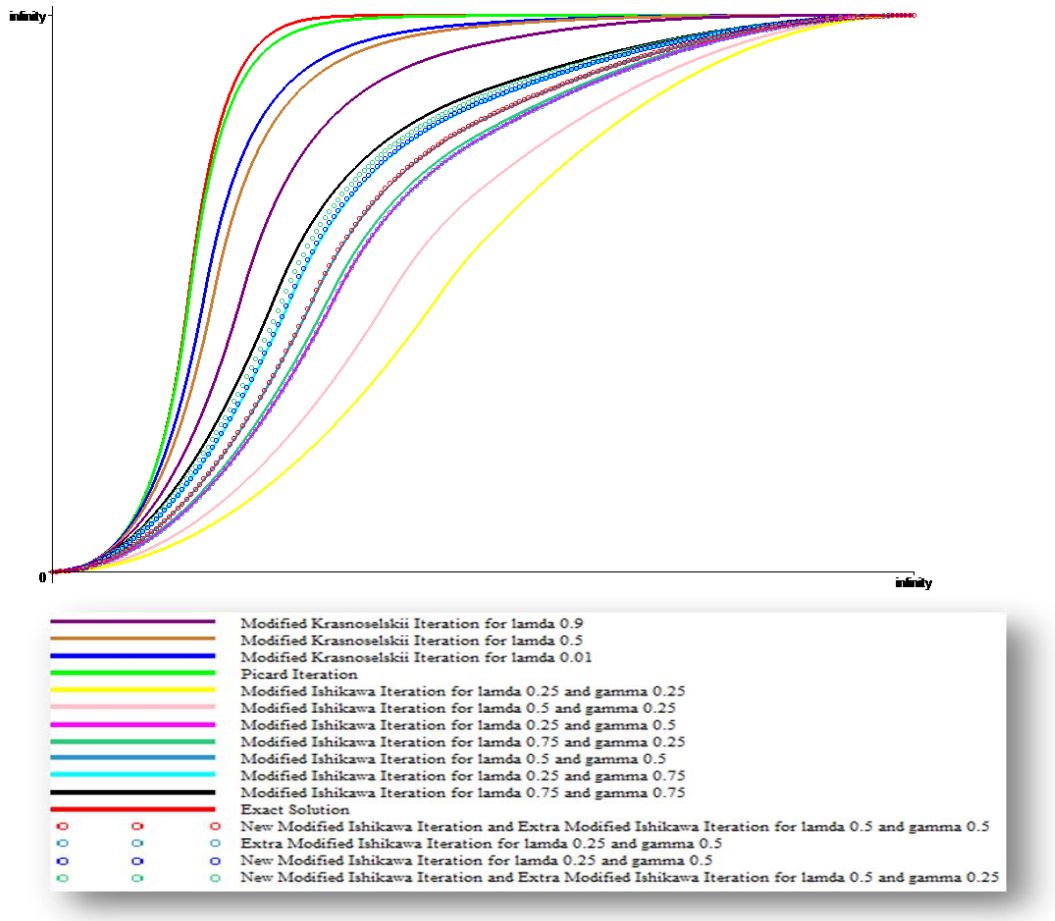

Fig. 2: The comparison of the exact solution and approximate solution of the Example 2.1 for different value of λ and γ.

Corollary 2.2. Absolute error of the Modified Krasnoselskii iteration method is computed taking different values of λ which is more effective than Euler, Modified Ishikawa iteration, New Modified Ishikawa iteration and Extra Modified Ishikawa iteration method but not better than Runga-Kutta and Picard iteration method. On the other hand, the New Modified Ishikawa Iteration Method and Extra Modified Ishikawa Iteration Method compared with the results of absolute errors for Runge-Kutta methods, Euler methods and the exact solution. In the conclusion, the comparisons indicated that there is a very good agreement between the numerical solution and the exact solution in terms of accuracy. The result shows that the New Modified Ishikawa Iteration Method and also Extra Modified Ishikawa Iteration Method are more sensitive than Modified Ishikawa iteration but not more effective than Modified Krasnoselskii Iteration.

Additionally it is observed that New Modified Ishikawa Iteration and Extra Modified Iteration method are taken same value for $(\lambda = 0.5 \text{ and } \gamma = 0.5)$ and $(\lambda = 0.5 \text{ and } \gamma = 0.25)$.

3. CONCLUSION

In this paper, we applied Picard iteration, Modified Krasnoselskii, Modified Ishikawa, Extra Modified Ishikawa and New Modified Ishikawa iteration methods selecting to the different type of the examples and also compared the results of absolute errors for Runga-Kutta and Euler methods with the exact solution. In the conclusion, the comparisons indicated that there is a very good agreement between the numerical solution and the exact solution in terms of accuracy.

The main result shows that some of the methods among the Modified Krasnoselskii, Modified Ishikawa, Extra Modified Ishikawa and New Modified Ishikawa Iteration methods are sometimes very effective and convenient compared with the other methods not only we used but also in the literature as well.

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ABOUT THE BEST APPROXIMATION OF CONTINUOUS FUNCTIONS BY POLYNOMIALS

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Abstract: *This paper presents some preliminary notions connected to the existence and the uniqueness of the best approximation polynomials.*

The following are discussed: limits, function oscillation and the distance between two functions.

The polynomials of Tchebychef are mentioned for continuous functions, their property of admitting a single polynomial of the best n *degree approximation.*

Keywords:*.approximation, polynomials, functions, continuity, boundedness*

1. BOUNDED FUNCTIONS. THE OSCILLATION OF A FUNCTION

In the following, we will consider the real functions $f(x)$, of a real x random, uniform and defined in a finite and closed interval (a,b), $a<b$.

A function $f(x)$ has a *superior limit* if there is an A number so that all the values considered by the function to the smaller than A. Contrarily, the function *does not have a superior limit*.

Let's mark with $M(f)$ the superior limit or the maximum of the function $f(x)$. The definition of this number is:

If $f(x)$ is not superior limited, $M(f)$ equals $+\infty$.

If $f(x)$ is superior limited, $M(f)$ is defined by the condition that whatever is the positive number ε, *there is at least a point x for which*

$f(x) > M(f) - \varepsilon$

And whatever x is

$f(x) \le M(f)$

It is now clear what we have to understand by an *inferior limited* function and by a function that is *not inferior limited*. The definition of the *inferior limit* or that of the minimum $m(f)$ of the function $f(x)$ is analogue with that of the maximum $M(f)$.

A function that is limited both superior and inferior is a *limited function.* The difference $M(f) - m(f)$ is called the oscillation of the function $f(x)$ *in the* (a,b) *interval.*

2. CONTINUOUS FUNCTIONS

A continuous function on the (a,b) interval is known and understood. A continuous function is limited. A continuous function on an interval is *uniformly continuous* in this interval. This means that, being given a positive number ε we can determine another positive number δ in order to have $f(x') - f(x'') < \varepsilon$

Whatever the points x' and x'' checking the condition
$|x'-x''|<\delta$

A continuous function reaches the maximum $M(f)$ *and the minimum* $m(f)$ *of it.* Therefore, there is at least a point x'' so that $f(x'')=m(f)$. Moreover, we can state that $M(f)$ is also the *superior limit* of the function $f(x)$. In other words, $M(f)$ has the property that, whatever the positive number ε , there is an infinity of *x* points, so that
$f(x) > M(f) - \varepsilon$

And *at least one limited number of x points* so that
$f(x) > M(f) + \varepsilon$

The same, the minimum $m(f)$ coincides with *the inferior limit of the function* $f(x)$, this inferior limit having an analogue definition with the superior one.

The above mentioned extend immediately at functions that have more finite independent variables in a limited and closed domain.

Along these lessons we will need other properties that will be mentioned at the right time.

3. THE DISTANCE BETWEEN TWO FUNCTIONS

$f_1(x)$ and $f_2(x)$ being two functions, the number $M(|f_1 - f_2|)$ can be called their *distance.* If one of the functions is limited, and the other is not, their distance is boundless. If none of the functions is limited, their distance can be finite. If one of the functions is limited and their distance is finite, then the other function must be limited as well. The distance has the following properties, easily demonstrated:

a. $M(|f_1 - f_2|)$ is a positive or null number
b. $M(|f_1 - f_2|)=0$ only if $f_1(x) \equiv f_2(x)$
c. $M(|Cf|)=CM(|f|)$, C being a positive constant
d. $M(|f_1 - f_2|) \le M(|f_1 - f_3|)+M(|f_2 - f_3|)$.

The best approximation problem, stated and studied below considers this distance definition.

4. THE BEST APPROXIMATION PROBLEM BY POLYNOMIALS

Let's study the problem. Let's consider the family or the *array* of the polynomials
$P(x)=a_0x^n+a_1x^{n-1}+...+a_n$

of *n* degree. A polynomial of the array is completely determined by the $a_0, a_1, ..., a_n$ factors that are some negative, null or positive numbers. Therefore, any polynomial of *n* degree is also of $m>n$ degree. In other words, the array of polynomials of *n* degree contains the array of polynomials of a degree smaller than *n*.

Considering a function $f(x)$ we will say, by definition, that the distance $M(|f-P|)$ between this function and a $P(x)$ polynomial is the error or the *approximation* which $P(x)$ represents the $f(x)$ function.

For all polynomials of *n* degree, $M(|f-P|)$ has an inferior limit $\mu_n(f)$ or more simple μ_n. μ_n is by definition, *the best approximation* of the function $f(x)$ by *n* degree polynomials.

The problem of the best approximation by polynomials is the following:

Being given a function $f(x)$ *, determine the n degree polynomials for which* $M(|f-P|)$ *reaches its inferior limit* μ_n *and study this number* μ_n.

A $P(x)$ polynomial of *n* degree for which μ_n is reached will be called *a polynomial of the best approximation of n degree of the function* $f(x)$. Shortly, we will say that such a polynomial is a T_n polynomial and we will mark it with $T_n(x;f)$, $T_n(x)$ or T_n.

The problem of the best approximation polynomials has been first raised by the Russian mathematician P. L. Tchebychef. The results have been mentioned and completed by P. Kirchberger, E. Borel, L. Tonelli, Ch. De la Vallee Poussin.

5. DETERMINING THE T_N POLYNOMIALS IN SIMPLE CASES

The problem of the best approximation is not raised for a function that is not bounded, $M(|f-P|)$ being permanently equal with $+\infty$, because a polynomial is evidently a bounded function (in the interval (a,b)).

If $f(x)$ is a *n* degree polynomial, the best approximation is equal to zero because the function is itself a T_n polynomial. The reciprocal is true.

If we know the T_n polynomials for the $f(x)$ functions, then we know the T_n polynomials corresponding to the functions $f(x)+Q(x)$ and $Cf(x)$, where $Q(x)$ is a *n* degree polynomial and C a constant. Indeed, we have

$$M(|f-P|)=M(|f+Q-(P+Q|)=\mu_n(f)$$

And if $R(x)$ is a *n* degree polynomial,

$$M(|(f+Q)-R|)=M(|f-(R-Q)|)\geq\mu_n(f).$$

Therefore, $P(x)+Q(x)$ is a T_n polynomial for the function $f(x)+Q(x)$ and that any T_n polynomial corresponding to this function is of $P(x)+Q(x)$ form. We have

$$\mu_n(f+Q)=\mu_n(f)$$

Together with the relations

$$|C|M(|f-P|)=M(|Cf-CP|)=|C|\mu_n(f),$$

$$M(|Cf-R|)=M\left(\left|Cf-C\frac{R}{C}\right|\right)=|C|M\left(\left|f-\frac{R}{C}\right|\right)\geq|C|\mu_n(f)$$

Then $CP(x)$ is a T_n polynomial for the $Cf(x)$ functions and that any T_n polynomial corresponding this functions is of $CP(x)$ form. We have

$$\mu_n(Cf)=|C|\mu_n(f)$$

6. PRELIMINARY LEMMA

Let's suppose that certain $P(x)$ polynomials of *n* degree have

$$P(x)<A \text{ in } (a,b). \quad (1)$$

We want to show that a_r factors are limited. For this, we take n+*1* distinct points $x_1,x_2,...,x_{n+1}$, situated in the interval (a,b) and consider the system

$$a_0x_r^n+a_1x_r^{n-1}+...+a_n=P(x_r),\ r=1,2,...,n+1.$$

The determinant of this system is different than zero, being no more than the Van Der Monde determinant of the numbers $x_1, x_2, ..., x_{n+1}$. By pulling out the values of $a_0, a_1, ..., a_n$ with the help of the Cramer rule and regarding the relation (1) we state the following *preliminary lemma*:

If a $P(x)$ polynomial of n degree remains limited by a number A, in the (a,b) interval, then the factors $a_0, a_1, ..., a_n$ remain limited by a number λA, where λ depends only on n and on the (a,b) interval.

The value of λ can be specified. What is really important for us is that this number does not depend on the considered $P(x)$ polynomial.

The property remains evidently true as well for the case when the polynomials would be considered only on any linear and limited array having at least $n+a$ distinct points.

7. THE CONTINUITY OF $M(|f-P|)$.

The maxim $M(|f-P|)$ is definitely reached only if the function $f(x)$ is continuous.

Take ε an arbitrary positive number and write

$$A = M(|x|^n + |x|^{n-1} + ... + 1).$$

Let's suppose that

$$|a_r - a'_r| < \frac{\varepsilon}{A}, \qquad r = 0,1,2,...,n$$

Considering

$$P(x) = a_0 x^n + a_1 x^{n-1} + ... + a_n$$

$$P_1(x) = a'_0 x^n + a'_1 x^{n-1} + ... + a'_n,$$

We have

$$M(|P - P_1|) \le [\max(|a_r - a'_r|)] M(|x|^n + |x|^{n-1} + ... + 1)$$

Where we usually write with $\max(c_1, c_2, ..., c_k)$ or $\max_{r=1,2,...,k}(c_r)$, or simpler, with $\max(c_r)$, on the biggest among the numbers $c_1, c_2, ..., c_k$. We will use an analogue notation to indicate the smallest number between c_r.

We can then write

$$M(|P - P_1|) < \varepsilon$$

Here we deduce that

$$M(|f-P|) \le M(|f-P_1|) + M(|P-P_1|) < M(|f-P_1|) + \varepsilon$$

$$M(|f-P_1|) \le M(|f-P|) + M(|P-P_1|) < M(|f-P|) + \varepsilon$$

Consequently

$$|M(|f-P|) - M(|f-P_1|)| < \varepsilon$$

Which shows that:

$f(x)$ being a limited function, $M(|f-P|)$ is a continuous function of $a_0, a_1, ..., a_n$ coefficients.

Therefore, the inferior limit μ_n coincides with the inferior limit of the numbers $M(|f-P|)$.

8. THE EXISTENCE OF THE BEST APPROXIMATION POLYNOMIALS

We now examine the problem of the existence of the T_n polynomials. From the following, we can see that there are an unlimited number of *n* degree polynomials.

$$P_1(x), P_2(x),..., P_m(x),... \quad (2)$$

So that

$$M(|f - P_m|) \to \mu_n \ , \ m \to \infty$$

But the existence of a polynomial for which μ_n to be reached does not result yet, that is a polynomial $P(x)$ so that $M(|f - P|) = \mu_n$.

This does not come to surprise us. It is true that $M(|f - P|)$ is a continuous function compared to the *P* polynomial coefficients, but the variation domain of these factors is boundless and open.

If $M(|f|) = \mu_n$ then the zero polynomial is a T_n polynomial. In this case, the existence of at least a polynomial of the best approximation is proven.

Let's suppose the contrary case, that is $M(|f|) > \mu_n$. It is enough to only consider the *P* polynomials so that

$$M(|f - P|) < M(|f|)$$

There is an infinite number of such polynomials of *n* degree.

But,

$$M(|P|) \le M(|f - P|) + M(|f|)$$

$$M(|P|) < 2M(|f|) \quad (3)$$

In other words, we can suppose that the (2) polynomials are chosen in such a way that they check the equality (3).

If we write

$$P_m = a_0^{(m)} x^n + a_1^{(m)} x^{n-1} + ... + a_n^{(m)}, \ m = 1,2,...$$

We know that there is a *B* number, that only depends on $M(|f|)$, $[B = 2\lambda M(|f|)]$, so that

$$\left|a_r^{(m)}\right| < B, \ r = 0,1,2,...n; \ m = 1,2,...$$

From the array

$$a_0^{(1)}, a_0^{(2)},..., a_0^{(m)},...$$

Which is limited, we can extract a partial array to have a a_0^* finite limit

$$a_0^{(k_1)}, a_0^{(k_{12})},..., a_0^{(k_{1m})},... \to a_0^* \quad (4)$$

We then consider the array

$$a_1^{(k_1)}, a_1^{(k_{12})},..., a_1^{(k_{1m})},...$$

From this array we can extract a partial array to have a a_1^* finite limit

$$a_1^{(k_1)}, a_1^{(k_2)}, a_1^{(k_{23})},..., a_1^{(k_{2m})},... \to a_1^*$$

We will also have

$$a_0^{(k_1)}, a_0^{(k_2)}, a_0^{(k_{23})}..., a_0^{(k_{2m})},... \to a_0^*$$

Because this array is extracted from (4).

By repeating this procedure de *n+1* times, we see that, in the end, from the (2) polynomial array we can extract a partial array

$$P_{k_1}, P_{k_2},..., P_{k_m},...$$

So that

$a_r^{(k_1)}, a_r^{(k_2)}, a_r^{(k_3)} ..., a_{r0}^{(k_m)}, ... \quad r = 0,1,2..., n$

a_r^* being finite numbers

If we now write

$P^*(x) = a_0^* x^n + a_1^* x^{n-1} + ... + a_n^*,$

We see that

$$M\left(\left| f - P^* \right|\right) = \mu_n \tag{5}$$

The polynomial $P^*(x)$ for which we have the equality (5) is therefore a best approximation polynomial of *n* degree of the function $f(x)$. Therefore, we can state the following property:

Any limited function $f(x)$ admits at least one polynomial of the best n degree approximation.

The necessary and adequate condition for μ_n to be zero is that $f(x)$ is an n degree polynomial.

We know that this condition is adequate. Its necessity results from the fact that there is a $P(x)$ polynomial so that $M\left(\left| f - P \right|\right) = 0$, where $f(x) \equiv P(x)$. In the case when $f(x)$ is not an *n* degree polynomial, μ_n is a positive number.

9. THE POLYNOMIALS OF TCHEBYCHEF FOR A CONTINUOUS FUNCTION

We will now suppose that the $f(x)$ function is continuous and take $T_n(x)$ a polynomial of the best approximation of *n* degree. The result of $f(x) - T_n(x)$ will necessarily reach one of the values $\pm \mu_n$. We state the number of points in which these values are reached.

Let's suppose that

$f(x_r) - T_n(x_r) = \pm \mu_n, \quad r = 1,2,..., m$

where $x_1, x_2, ..., x_m$ are *m* distinct points and $m \le n+1$. In all the other points of the interval (a,b), we have $\left| f - T_n \right| < \mu_n$.

Take $Q(x)$ the Lagrange polynomial conditioned by

$Q(x_r) = f(x_r) - T_n(x_r) = \pm \mu_n, \quad r = 1,2,..., m$

The LAGRANGE polynomial, given by the interpolation formula of LAGRANGE, is the *smallest degree* polynomial taking the values $A_1, A_2, ..., A_k$. This polynomial is *unique* and its degree is at most equal with $k-1$.

The $Q(x)$ polynomial is therefore of *n* degree.

We close every point x_r in an I_r interval, having as a centre the point x_r and as length δ_r.

Being given a positive number $\varepsilon < \mu_n$, we can select a positive number δ together with the lengths δ_r so that:

1^0. Taking $\delta_r \le \delta$, the intervals $I_1, I_2, ..., I_m$ should not have any common point.

2^0. The oscillation of the functions $f(x) - T_n(x)$ and $Q(x)$ should be smaller than ε in any length interval $\le \delta$.

Hence it appears that in an I_r interval, the $f - T_n$ and *Q* functions cannot be cancelled, therefore, they keep a constant sign (the same sign)

Let's suppose that x_r is a point in which $f(x_r)-T_n(x_r)=Q(x_r)=\mu_n$, then in the I_r interval, we have

$\mu_n-\varepsilon<f-T_n\le\mu_n$

$\mu_n-\varepsilon<Q\le\mu_n+\varepsilon$.

Let's select the λ positive number so that

$$\lambda<\frac{\mu_n-\varepsilon}{\mu_n+\varepsilon} \tag{6}$$

Then in the I_r interval, we have

$0<\mu_n-\varepsilon-\lambda(\mu_n+\varepsilon)<f-T_n-\lambda Q<\mu_n-\lambda(\mu_n-\varepsilon)$

In an x_r point where $f(x_r)-T_n(x_r)=Q(x_r)=-\mu_n$, we have

$-\mu_n\le f-T_n<-\mu_n+\varepsilon$

$-\mu_n-\varepsilon<Q<-\mu_n+\varepsilon$

And in addition to the same condition (6) we deduce

$-\mu_n+\lambda(\mu_n-\varepsilon)\le f-T_n-\lambda Q<-\mu_n+\varepsilon+\lambda(\mu_n+\varepsilon)<0$

It appears that in the I_r intervals

$|f-T_n-\lambda Q|<\mu_n-\lambda(\mu_n-\varepsilon)<\mu_n$

From our initial hypothesis it also appears that in all points of the closed domain, obtained from the (a,b) interval, by taking out the I_r intervals, we have

$|f-T_n|\le\mu'<\mu_n$,

Where μ' is a fixed number

If we take a small enough λ so that

$$\lambda<\frac{\mu_n-\mu'}{2M(|Q|)} \tag{7}$$

We will also have

$|\lambda Q|<\frac{\mu_n-\mu'}{2}$,

$|f-T_n-\lambda Q|\le|f-T_n|+|\lambda Q|<\mu'+\frac{\mu_n-\mu'}{2}=\frac{\mu_n+\mu'}{2}<\mu_n$

Besides the I_r intervals and in the extremities of these intervals.

Hence it results that in the entire (a,b) interval,

$|f-T_n-\lambda Q|<\mu_n$

Therefore, if λ checks the inequalities (6) and (7), the $T_n+\lambda Q$ polynomial renders a better approximation, contrarily to the hypothesis, and so we have the following property:

The result of $f(x)-T_n(x)$ *reaches the values* $\pm\mu_n$ *in at least n+2 points*

10. THE COMPLETION OF THE PREVIOUS RESULT

We can complete the previous result. The result of $f(x)-T_n(x)$ must reach both $+\mu_n$ and $-\mu_n$ values. Let's suppose, for example that $+\mu_n$ would not be reached, we then have

$-\mu_n\le f-T_n\le\mu'<\mu_n$

μ' being a fixed number. By taking a positive constant λ we will have

$-\mu_n+\lambda\le f-T_n+\lambda\le\mu'+\lambda$

Therefore, if we take $\lambda < \mu_n - \mu'$, we have everywhere
$|f - T_n + \lambda| < \mu_n$.

The $T_n - \lambda$ polynomial gives a better approximation, which is contrary to the hypothesis.

Moreover, we can state the number of the points where μ_n and the number of the $-\mu_n$ points is reached. Let's suppose, for example that
$f(x_r) - T_n(x_r) = \mu_n, \quad r = 1,2,...,m.$

In all the other points having
$-\mu_n \le f - T_n < \mu_n$.

Take the intervals I_r having the centre in x_r and a small enough δ_r length for the intervals I_r to have no common point. Take x'_r, x''_r as extremities of the I_r interval and then form the polynomial
$Q(x) = (x - x'_1)(x - x''_1)(x - x'_2)(x - x''_2)...(x - x'_m)(x - x''_m)$

We have $Q(x) < 0$ in the open intervals I_r and $Q(x) > 0$ besides I_r closed intervals.
$\mu' \le f - T_n < \mu_n$

μ' being a positive number $< \mu_n$.

If the positive number λ checks the inequality

$$\lambda < \frac{\mu'}{M(|Q|)} \tag{8}$$

Then we have in the I_r intervals
$0 < \mu' + \lambda Q \le f - T_n + \lambda Q \le \mu_n + \lambda Q < \mu_n$

The last inequality is justified because we could not have an equality except in a point where we have in the same time $f - T = \mu_n$ și $Q=0$.

In the entire closed domain, obtained from *(a,b)* by taking out the I_r intervals, we have
$-\mu_n \le f - T_n \le \mu'' < \mu_n$,

μ'' being a fixed number.

Taking λ so that

$$\lambda < \frac{\mu_n - \mu''}{2M(|Q|)} \tag{9}$$

We have in this domain
$$-\mu_n \le -\mu_n + \lambda Q \le f - T_n - \lambda Q \le \mu'' + \frac{\mu_n - \mu''}{2} = \frac{\mu_n + \mu''}{2} < \mu_n .$$

The first inequality is explained exactly as above.

Therefore, if λ verifies the inequalities (8),(9) we have in the entire *(a,b)* interval
$|f - T_n + \lambda Q| < \mu_n$

And we can see that the $T_n - \lambda Q$ polynomial gives a better approximation than μ_n.

The *Q(x)* polynomial is of *2m* degree, so we reach an inconsistence $2m \le n$.

If x_r would be points where $-\mu_n$ is reached, we can bring absolutely analogue arguments, therefore, we can state the following property:

The result between $f(x) - T_n(x)$ reaches in at least $\left[\frac{n+2}{2}\right]$ points the value μ_n and in at least $\left[\frac{n+2}{2}\right]$ points the value $-\mu_n$. $[\alpha]$ stands for the number of integers covered in α.

11. ABOUT THE ARRAY OF THE T_n POLYNOMIALS.

Let's assume that the $f(x)$ function takes two T_n distinct polynomials. If P, P_1 are these two polynomials, then we have

$$M(|f-P|)=M(|f-P_1|)=\mu_n$$

If α,β are two positive numbers, we have

$$\begin{aligned}\mu_n &\le M\left(\left|f-\frac{\alpha P+\beta P_1}{\alpha+\beta}\right|\right)=M\left(\left|\frac{\alpha(f-P)}{\alpha+\beta}+\frac{\beta(f-P_1)}{\alpha+\beta}\right|\right)\le \\ &\le \frac{\alpha M(|f-P|)+\beta M(|f-P_1|)}{\alpha+\beta}=\mu_n \\ M\left(\left|f-\frac{\alpha P+\beta P_1}{\alpha+\beta}\right|\right)&=\mu_n\end{aligned} \tag{10}$$

Hence it results that the polynomial $\frac{\alpha P+\beta P_1}{\alpha+\beta}$ is as well a T_n polynomial, therefore:

If a limited function admits two T_n distinct polynomials, then it admits infinity (countless) of such polynomials.

Each $P(x)=a_0x^n+a_1x^{n-1}+...+a_n$ polynomial can have point A $a_0,a_1,...,a_n$ coordinates in the ordinary space with *n+ 1* dimension. We can then see that:

Points A corresponding to the T_n polynomials of a limited function, form a convex, closed and limited domain.

If the T_n polynomial is unique, then this domain is reduced to a single point.

If the *(a,b)* interval is symmetrical compared to the origin, $a=-b$, and if $f(x)$ is an even function, $f(x)=f(-x)$, there is a T_n polynomial which is even a well. Indeed, we can immediately see that $T_n(-x)$ is a T_n polynomial as well. In the same manner, $\frac{T_n(x)+T_n(-x)}{2}$, is an even polynomial. In this case $\mu_{2n+1}(f)=\mu_{2n}(f)$

If the function is odd, $f(-x)=-f(x)$, there is a T_n polynomial which is odd as well. In this case $\mu_{2n}(f)=\mu_{2n-1}(f)$.

12. THE UNIQUENESS OF THEBYCHEF POLYNOMIALS

In the case of continuous functions, the preceding ones allow us to draw an important conclusion.

If P, P_1 are two T_n distinct polynomials, the $P_2=\frac{P+P_1}{2}$ polynomial is a T_n polynomial as well. The inequality (10) shows us that in a x' point where we have $f(x')-P_2(x')=\pm\mu_n$, we also have to have

$$f(x')-P(x')=f(x')-P_1(x')=\pm\mu_n$$
$$P(x')=P_1(x')$$

In the virtue of the above properties, the P, P_1 polynomials coincide in at least *n+2* points, they are therefore, identical. Hence it results the property:

A continuous $f(x)$ function admits a single polynomial of the best n degree approximation.

The uniqueness results only from the fact that $|f - T_n|$ reaches its maxim in at least *n+ 1 points*. Indeed, two *n* degree polynomials which have the same value in *n+ 1 point*, have the same value everywhere.

If the interval *(a,b)* is symmetrical compared to the origin and $f(x)$ is an even function, the $T_n(x)$ polynomial is even as well, therefore, $T_{2n+1} = T_{2n}$. If the function is odd, the $T_n(x)$ polynomial is odd as well, and $T_{2n} = T_{2n-1}$.

If the function is not continuous, the T_n polynomial is not generally unique. We can observe that T_0 is always unique and equal with $\frac{M(f) + m(f)}{2}$. Take the function

$$f = \begin{cases} -1, & -1 \le x < 0 \\ 1, & 0 \le x \le 1 \end{cases}$$

It can be seen that we need to have $\mu_n \ge 1$.But the zero polynomial approximates 1, therefore $\mu_n = 1$ whatever *n*. All T_n polynomials must be null in origin. The Cx polynomials where *C* is a constant, there are T_n polynomials for $0 \le C \le 2$ and whatever $n > 0$ is.

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SMART WATCH CONTROLLED BY MOBILE PHONE VIA BLUETOOTH

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Abstract: *The design and realization of a system similar to a smart watch is described in this paper. From a mobile phone, via an application created in Studio Android, notifications are transmitted to a system similar to a smart watch. Arduino Pro Mini is the basic module of this system and it connects the OLED (Organic Light-Emitting Diode) display and the Bluetooth Module HC-06 controller. After receiving and processing the notifications package, an individual page is assigned to each notification. The main purpose of the smart watch is to allow the user to see the notifications (emails, SMS, calls and current hour) without having to take the smart phone from the pocket .*

Keywords: *Arduino Pro Mini, Bluetooth, Android, Notification transfer*

1. INTRODUCTION

With the advancement of technology in the field of smart devices (phones, tablets, etc.) the user requirements also increased (buyers). For certain simple features user wishes no longer depend on direct interaction with the device (phone, tablet, etc.) but to be able to run on other devices, in order to see the incoming notifications such as emails, SMS, calls and current hour without having to interact with the smart phone. So, new types of smart devices that enable interaction between the user and the phone/tablet, smart watches and bracelets have been developed.

Mimo Loga (1941) is presented as the first smart watch. In 1972 came another smart device called Pulsar, which has been manufactured by the Hamilton Watch Company. "Pulsar" became a brand name, and in 1978 was bought by Seiko. It was able to store 24 digits, then Seiko started to develop smart watches able to store 2000 characters. Currently many electronic companies are producing smart watches. [1]

A smart watch can execute different functions, but the most important functions are displaying time/date, receiving and sending notifications from the smart phone and the ability to alert the user when receiving a new notification.

The system described in this paper was built like a smart watch but with greater size, consisting of a Bluetooth module HC-06, a Arduino Pro Mini plate, a monochrome display, a mobile phone (Android), keys and wires, etc. The developed app sends through Bluetooth from the mobile phone messages, emails, current date and time (Analog/ Digital format), in order to be displayed on OLED.

A very important feature of Bluetooth is to allow devices produced by different companies to work together.

2. SYSTEM IMPLEMENTATION

2.1 Equipment used. The Arduino Pro Mini, which has been chosen in order to reduce the size of the smart watch, is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM – Pulse Width Modulation - outputs), 6 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers. There are two types of Arduino Pro Mini: one at 3.3V and 8 MHz, and the other at 5V and 16MHz. In this application it was used the 3.3V variant. ATMEGA328 has 32KB memory for code storage, 2KB of SRAM and EEPROM 1kB.[2]

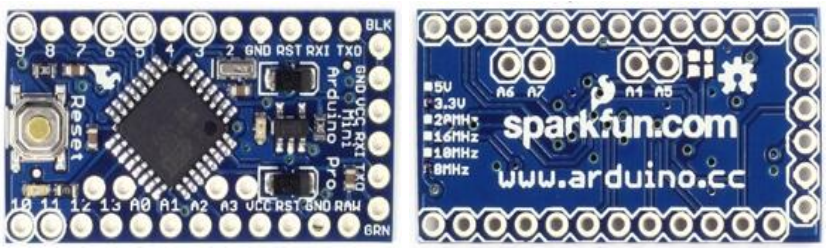

FIG. 1. The Arduino Pro Mini board used to develop the application

HC-06 module enables Bluetooth communication between devices and computers, mobile phones (Android, iOS).[3]

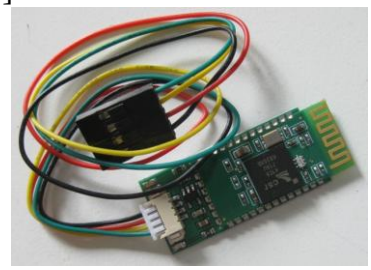

FIG. 2. HC-06 Bluetooth Module used for wireless communication between the smart phone and the Arduino board

The display used is small in size, has a diagonal of 1.3", but it is very easy to read, because of the OLED display. This display consists of 128x64 pixels, each of which is turned on or off by a controller chip. Because the screen produces its own light, no backlight is needed.[4]

2.2 Application description. The system block diagram is shown in Figure 3. The app on the mobile phone connects to the designed system via Bluetooth. Arduino Pro Mini is the core module, which binds all modules: OLED display, Bluetooth HC-06 Module, and the control key (button). The power supply consists of a battery. [5]

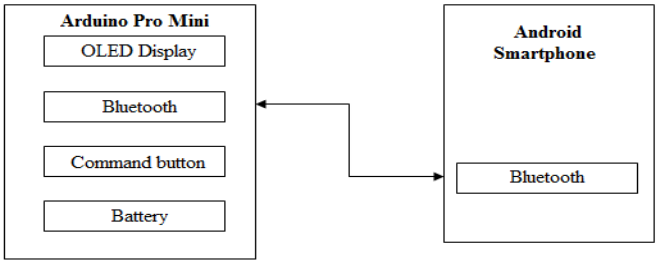

FIG. 3. System block diagram

OLED display uses I2C bus to communicate with Arduino. I2C supports multiple devices, and each device has a unique address on the bus.

The software is divided into two major parts. The first one is programming the Arduino module, which contains the microcontroller. Programming of this module was performed using the compiler provided by Arduino. The second part is the application software running on the mobile phone which was created in Android Studio. Images appearing on the OLED screen of the watch were created in Photoshop and then converted in array.

As mentioned above, the Arduino module receives data from the mobile phone using Bluetooth. The content of these data packets includes incoming messages, emails and calls from the mobile phone. In addition to these packages, Arduino receives the current hour from the phone.

Package = Call + SMS + Notification (Email)

The Arduino module receives each packet and should separate the calls, messages and emails. Once this separation has been accomplished, to each notification is assigned an individual display page, so it will result different viewing pages, as follows. Homepage (introductory page): displays the date, time, battery level and an alert if there was a new notification. Second page: displays received SMS notifications (sender and message content). The third page: displays notifications of incoming emails (sender and email content). The fourth page: displays the incoming call notifications (numbers/caller number or the total number of incoming calls if there are several unanswered calls).

Navigating from page to page is performed via the button on the clock. This button has dual functionality, detecting two events: short press or long press. Navigation is as follows:

If the initial page is the introductory then briefly pressing the screen causes the display to show notifications.

If briefly pressing the button is performed again, it scrolls between the pages of display notifications.

The return to the introductory page is accomplished by a long press of the button.

The distinction between a short and a long press is based on how much time the button is held down, the corresponding function being handle_button function ()

```
int handle_button()
{ int event;
  byte button_now_pressed = digitalRead(buttonPin); // pin High -> pressed
  if (!button_now_pressed && button_was_pressed) {
   if (button_pressed_counter < 50)
     event = EV_SHORTPRESS;
   else
     event = EV_LONGPRESS; }
  else
   event = EV_NONE;

 if (button_now_pressed)
   ++button_pressed_counter;
 else
   button_pressed_counter = 0;
   button_was_pressed = button_now_pressed;
 return event; }
```

At the end the function returns an integer set in compliance with the detected event:
EV_NONE = 0 if not detected touch of a button;
EV_SHORTPRESS = 1 if detected a short press of a button;
EV_LONGPRESS = 2 if detected a long press of a button.

The main task of the Android application is to retrieve notifications received by the mobile device, to process and transmit them via Bluetooth to the smart watch. [6]

In order to obtain notifications, the application uses a listening notifications service, registered at application startup.

<service android:name=".NotificationListenerReceiver"
android:label="NotificationListener"
android:permission="android.permission.BIND_NOTIFICATION_LISTENER_SERVICE"> [7]

The task of this service is to fetch notifications, processing and sending them to class CeasMain through intents.

The notifications are extracted in the status bar of the mobile phone. For each notification is extracted its title content and the package it belongs. Through the package it differentiates between various notifications types (email, SMS, missed call, etc.).

For example, if the package contains the string "android.gmail" it can be said that the notification received is due to an incoming e-mail. After the type of notification is determined, the information is transmitted to the smart watch.[7]

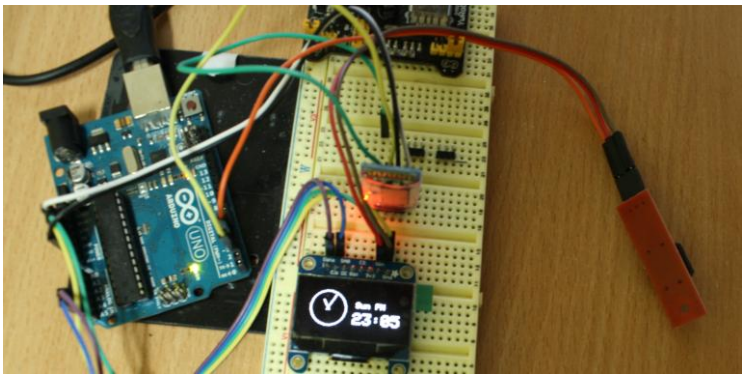

FIG. 4. The physical imlementation of the system

3. CONCLUSION AND FUTURE WORK

The system presented in this paper is the first step in designing a smart watch. One of the most important future development is to decrease the watch size and to extend the range of notifications that can be processed/displayed. To remove the physical button a color touchscreen LCD display will be chosen.

Regarding the Android app, it will be replaced with a widget that will have representation on the phone's home screen and will run in the background all the functions offered by the current application.

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STOCHASTIC OPTIMAL CONTROL OF pH NEUTRALISATION PROCESS IN A WATER TREATMENT PLANT

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Abstract: *This paper opens a new research exploration direction in a real time MATLAB/SIMULINK simulation environment to optimize the pH neutralization process level of a generic wastewater treatment plant following a stochastic approach. The control system design of pH neutralization process is a very difficult task to be accomplished due to its severe nonlinearity and complexity characterized by a persistent change in the chemical systems with complex kinetic and thermodynamic reactions, nonlinear responses, a sensitive environment uncertain results and large variety of operating conditions to be covered. Furthermore, the standard control strategies design fail unfortunately when the system performance is concerned. In the new approach the proposed control strategy proved its effectiveness and high accuracy in terms of its performance compare to the traditional control mechanisms. To validate all these results a simplified intuitive nonlinear model of the neutralization reactor from the literature is considered. The solution of the optimization problem is found in a Linear Quadratic Gaussian optimization framework. In this new approach the nonlinear dynamics of the neutralization reactor must be linearized around an equilibrium point, the cost function is quadratic, and the process and measurement noises are white Gaussian noises, independent, of zero mean, and normally distributed. The system's control is Markovian and linear as a combination of observable or estimated states. In addition the implementation of stochastic optimal control approach is more restrictive by introducing a few key concepts and requirements such as controllability, stabilizability, observability, and the certainty-equivalence principle, as well as the well-known separation principle between optimal estimation and optimal control.*

Keywords: *LQG stochastic control, control system optimization, Linear Quadratic regulator, Linear quadratic estimator, neutralization reactor, MATLAB/SIMULINK*

1. INTRODUCTION

The acidity of any solution is assessed by measuring its pH level (e.g. the concentration of positive Hydrogen ions (H^+) in the solution) that ranges in a scale from 1 to 14. The value of 7 for the pH level in any solution at room temperature indicates that the solution is neutral. According to this scale if the pH of the solution at the room temperature is less than 7, the concentration of Hydrogen ions (H^+) in the solution is high, and the solution is considered to be acid [1]. On the other hand if the pH level of the solution at room temperature is greater than 7, the concentration of negative hydroxyl ions (OH^-) in the solution is high and the solution is considered to be alkaline or a base [1]. According to environmental safety standards for industry all treated water effluents must have the pH level of either 8 or 6 [1]. The control system design of pH neutralization process is a very difficult task to be accomplished due to the following reasons [1, 2, 3]:

1) the dynamics of pH neutralization process is severely nonlinear and of high complexity as is shown in Fig. 1(a, b) for a particular case of the titration curve for acid-base process reaction [1].

2) a persistent changes in the chemical systems
3) complex kinetic and thermodynamic reactions
4) nonlinear response of the process,
5) a sensitive environment uncertain results
6) a large variety of operating conditions to be covered.

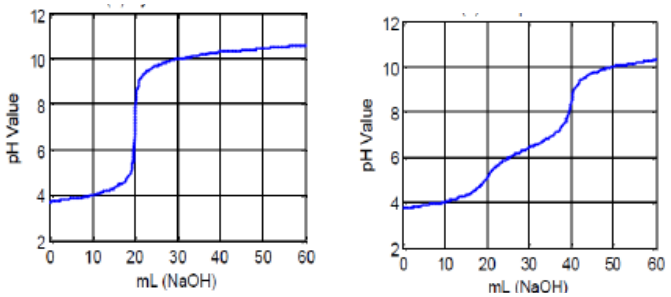

FIG. 1. Titration curve for acid-base process reaction (a snapshot from [1], p.36)
(a) Hydrochloric acid
(b) Phosphoric acid

The classical control strategies design fail in the majority of the cases when the system performance is concerned. In the new stochastic approach the proposed optimal control strategy proved its effectiveness and high accuracy in terms of its performance compare to the traditional control mechanisms. To find an optimal solution to this optimization problem a Linear Quadratic Gaussian (LQG) control strategy is proposed. To implement the new LQG strategy the following requirements need to be satisfied [4, 5, 6, 7, 8]:

(1) the nonlinear dynamics of the neutralization reactor must be linearized around an equilibrium point

(2) the cost function is quadratic

(3) the process and measurement noises are white Gaussian, independent, of zero mean, and normally distributed

(4) the system's control is Markovian and linear as a combination of observable or estimated states.

The optimization problem consists of two distinct parts, that can be easily implemented in MATLAB/SIMULINK framework [4, 5, 6, 7]:

(a) Linear Quadratic Regulation (LQR) problem
(b) Linear Quadratic Estimation (LQE) problem

Combining the solutions of the both LQR and LQE problems is a practical real time implementation tool of the LQG control strategy in a feedback closed-loop control system to find the optimal values of the pH level for a neutralization reactor based on a nonlinear intuitive generic model [4, 5, 6, 7, 8].

2. THE NEUTRALIZATION REACTOR DESCRIPTION

In Figure 2 is shown the layout of a simple neutralization reactor used in the chemical industry, where an alkaline input flow (fluent) is neutralized with acid (reagent) in a continuously stirred tank reactor (CSTR) [2]. For this case study the waste water enters the reactor with a federate of $\frac{dV_F}{dt} = \dot{V}_F = 2000[\frac{l}{h}]$ at a $pH_F = 13$ (strongly alkaline); the input acid $\frac{dV_A}{dt} = \dot{V}_A$ and base $\frac{dV_B}{dt} = \dot{V}_B$ flows are dosed and controlled by a PI regulator.

A *pH*-probe measures *pH*-actual value of the neutralized solution inside the reactor during the transient and steady state neutralization process, transmitting its feedback to the controller with a lag time of 50 seconds. The reactor volume is assumed to be constant, with a capacity of $4000[l]$, and the maximum value of the HCl-acid flow with a 25% concentration is $30[\frac{l}{h}]$. The pH target value is 10 and to simplify the dynamic model only acid addition is considered, due to the fact that the waste water is already alkaline.

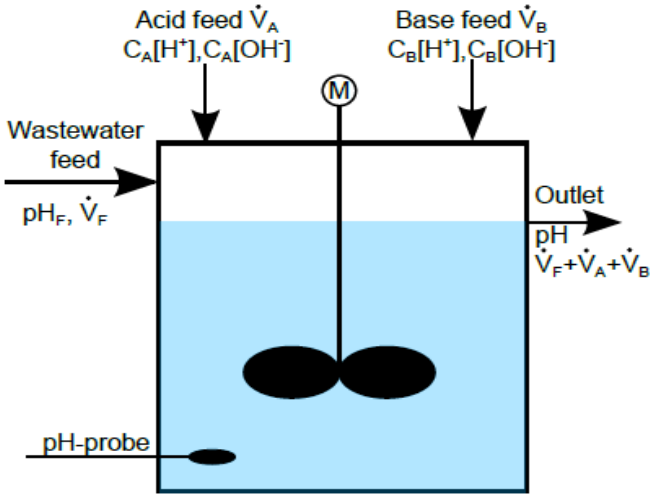

FIG.2. Neutralization CSTR reactor (a snapshot from [2], p.2)

3. FORMULATION OF THE CONTROL OPTIMIZATION PROBLEM

The control optimization problem is formulated based on the well-known optimality principle [4, 5, 6, 7]. According to this principle the optimization problem consists in a sequence of consecutive stages such that "*from any point on an optimal trajectory, the remaining trajectory is optimal for the corresponding problem initiated at that point*" [4].

The optimality principle is a key concept for defining a control optimization problem (*COP*) by the following elements given in [4]:

1. *....."The dynamics of the plant represented in continuous and discrete state-equation (law motion):*

$$x_{t+1} = f(x_t, u_t, t) \tag{1}$$

where $t = 0,1,2,...$ *is the discrete-time that takes integer values,* $x_t \in \Re^n$ *is the value of the control system state vector at time* $t \in \Im$*, calculable from known quantities and obeys a law motion (1),* $u_t \in \Re^m$ *is the control system input vector value at time* $t \in \Im$*, that is chosen on basis of knowing the set of previous controls up to time* $t-1 \in \Im$*,* $U_{t-1} = \{u_{t-1}, u_{t-2}, ..., u_0\}$*.*

2. *The cost function to be optimized:*

$$C = \sum_{t=0}^{s-1} c(x_t, u_t, t) + C_s(x_s) \tag{2}$$

by a suitable choice of the set of controls $U_{s-1} = \{u_{s-1}, u_{s-2}, ..., u_0\}$

3. *An optimal control law attached to the law motion (1) and the cost function* (2)*, known as the optimality equation (dynamic programming equation (DP) or equivalent Bellman equation) to find the optimal value of the control (optimal actuator effort of the control system):*

$$F(x_t,t)=\inf_{u_t}[c(x_t,u_t,t)+F(f(x_t,u_t,t),t+1)],\ for\ t<s \tag{3}$$

with the terminal condition: $F(x_t,s)=C_s(x_s)$

where the future cost function defined in (2) from time $t\in\Im$ *onwards is defined as:*

$$C_t=\sum_{\tau=t}^{s-1}c(x_\tau,u_\tau,\tau)+C_s(x_s) \tag{4}$$

with the minimal value calculated as solution of an optimization problem over the sequence of controls $\{u_{s-1},u_{s-2},...,u_t\}$*:*

$$F(x_t,t)=\inf_{\{u_{s-1},u_{s-2},...,u_t\}}[C_t] \tag{5}$$

Furthermore, the DP equation (3) defines an optimal control problem that is related also to a feedback or closed – loop control, defined as:

$$u_t=k(x_t,t)\ , \tag{6}$$

so function only of x_t *and* t*, in contrast to open-loop control system where the sequence of controls* $U_s=\{u_{s-1},u_{s-2},...,u_0\}$ *must be calculated all once at time* $t=0$ *....''*[4].

Closing, the DP equation expresses the optimal control solution in close form as in (6) and is also a recursive backward equation in time that gives the optimal control solution $u_{s-1},u_{s-2},...,u_0$, recursively at the time moments $s-1,s-2,...0$, governed by a simple rule that the latter control policy is decided first [4]. Let now to consider the stochastic evolution of the neutralization reactor plant by introducing two sequences $X_t=\{x_t,x_{t-1},...,x_0\}$, and $U_t=\{u_t,u_{t-1},...,u_0\}$ that incorporate the history of evolution at time t of plant states and controls, x and u respectively. The evolution of the pH level of neutralization process is described by a state vector denoted by a variable x that takes the value x_t at time t that satisfies the following requirements given in[4]:

1. *''...The state vector incorporates a Markov dynamics, i.e. the stochastic version of the dynamics equation of the plant, given by*:
   $$P(x_{t+1}\mid X_t,U_t)=P(x_{t+1}\mid x_t,u_t) \tag{7}$$
2. *The COP cost function is decomposable with respect to* X_t,U_t*, as is shown in* (2).
3. *The current values of all state vector components* x_t *are observable, i.e.* x_t *is known at the time at which the control* u_t *must be chosen*…''

Let us now to designate the observed history of the plant evolution at time t by

$$W_t=(X_t,U_{t-1}), \tag{8}$$

that is related to the cost function C given in (2) at time s [4]:

$$C=C(W_s) \tag{9}$$

Also, the minimal expected cost function from time $t\in\Im$ onwards is defined as in [4]:

$$F(W_t)=\inf_{\pi}E_\pi[C_t\mid W_t] \tag{10}$$

where $E_\pi[.]$ is the stochastic expectance operator (stochastic average) of the conditional cost C_t with respect to W_t, and π is a control policy, i.e. a rule to chose the plant control sequence $u_{s-1},...,u_0$.

Based on this preparatory elements can be formulated the following remarkable result from the control optimality (see Theorem 1.3 in [4], p. 4):

"*…The minimal expected cost* $F(W_t)$ *is a function of* x_t *and* t *alone, let say* $F(W_t) = F(x_t, t)$, *that obeys the optimality DP equation* (3)*:*

$$F(x_t, t) = \inf_{u_t} \{c(x_t, u_t, t) + E[F(x_{t+1}, t+1) | x_t, u_i]\} \text{ for } t < s \tag{11}$$

with the terminal condition

$$F(x_s, s) = C_s(x_s) \tag{12}$$

Moreover, the minimizing value of the control $u_t = k(x_t, t)$ *in* (11) *is optimal….".*

The stochastic approach from this section is useful in the next section to develop a particular case of linear quadratic Gaussian optimization problem.

4. THE LINEAR QUADTRATIC REGULATION OPTIMIZATION PROBLEM

In this section the Linear Quadratic Regulation (LQR) optimization problem will be defined, and in the next section LQR will be implemented in a MATLAB/SIMULINK simulation environment to control the pH level of feedback closed-loop control system CSTR chosen as case study.

Using the preliminary theoretical results from previous section the LQR optimization problem will be defined based on the following elements [4]:

(a) The process dynamics linearized in a state-space representation, including the process and measurement noise:

$$\begin{aligned} x_{t+1} &= Ax_t + Bu_t + w_t \\ y_t &= Cx_t + Du_t + v_t \end{aligned} \tag{13}$$

with w_t, v_t the process (w_t) and measurement (v_t) white Gaussian noises (i.e., with normal distribution functions) at time $t \in \Im$ are independent, of zero mean, and with the covariance matrices Q_w, and R_v respectively :

$$E[w_t] = 0, E[v_t] = 0, \; E[w_t w_t^T] = Q_w, \; E[v_t v_t^T] = R_v, \; E[w_t w_s^T] = 0, \; E[v_t v_s^T] = 0, \text{ for } s \neq t \tag{14}$$

and, also

$$E[w_t v_t^T] = 0, \tag{15}$$

For independent stochastic noise variables, *A, B, C, D* are matrices of dimensions $n \times n, n \times m, p \times n,$ and $p \times m$ respectively. The variable $y_t \in \Re^p$ from equations (13) represents the measurable plant output.

(b) No all of the n^{th} – components of the state vector $x_t \in \Re^n$ are observable (measurable) at a given time $t \in \Im$

(c) A quadratic optimization criterion given by:

$$J = \sum_{t=0}^{s-1} c(x_t, u_t, t) + J_s(x_s) \tag{16}$$

with one step ahead and a terminal costs [4]:

$$c(x,u) = x^T P_{xx} x + u^T P_{ux} x + x^T P_{xu}^T u + u^T P_{uu} u = \begin{bmatrix} x \\ u \end{bmatrix}^T \begin{bmatrix} P_{xx} & P_{xu}^T \\ P_{ux} & P_{uu} \end{bmatrix} \begin{bmatrix} x \\ u \end{bmatrix}, P_{xu} = P_{ux} = S \tag{17}$$

$$J_s(x) = x \Pi_s x^T \text{ (terminal quadratic cost)}, \; \Pi_s \in \Re^{n \times n} \tag{18}$$

The quadratic forms P_{xx}, S, P_{uu} in (17) have appropriate dimensions and are non-negative definite (i.e., $x^T P_{xx} x \geq 0, u^T S x \geq 0, x^T S^T u \geq 0$). In addition, the matrix P_{uu} is assumed to be positive definite (i.e., $u^T P_{uu} u > 0$), and the matrices P_{xx}, P_{uu}, Π_s must be symmetric [4].

This model is suitable for control system regulation for which the state trajectory x is controlled by u such that to end in the point (0, 0) (i.e., steering to a critical value) [4].

Also, the closed form of optimal solution of the COP defined in (13)-(18) is given for free noise but can be adapted to the noise disturbances included in the dynamic model of the plant as is [4], p. 25.

5. KALMAN FILTER – CERTAINTY EQUIVALENCE AND SEPARATION PRINCIPLES

In this section is introduced the famous Kalman Filtering concept concerning the stochastic state estimation, and also two of the most used principles in a stochastic control system optimization will be related to the this concept:

(a) the certainty equivalence principle
(b) the separation principle

The Kalman Filter is a powerful and popular tool for the stochastic state estimation that was proposed by R.E. Kalman in 1960. It can be viewed as an important moment in the evolution of control system theory related to that time.

The full Linear Quadratic Gaussian (LQG) model is based on four main assumptions [4]:

(1) *The dynamics of the process is linearized (i.e., represented by stochastic differential equations given in (13))*

$$\begin{aligned} x_{t+1} &= Ax_t + Bu_t + w_t \\ y_t &= Cx_t + Du_t + v_t \end{aligned} \tag{19}$$

(2) *The cost function is quadratic:*

$$c(x,u) = x^T P_{xx} x + 2u^T S x + u^T P_{uu} u \tag{20}$$

(3) *The process and measurement noises are Gaussian (normal distributions,* $w_t \propto N(0, Q_w), v_t \propto N(0, R_v)$*) with* w_t, v_t *the process (*w_t*) and measurement (*v_t*) white Gaussian noises (i.e., with normal distribution functions) at time* $t \in \Im$*, of zero mean, independent (uncorrelated), and the covariance matrices* Q_w*, and* R_v *respectively :*

$E[w_t] = 0, E[v_t] = 0, E[w_t w_t^T] = Q_w, E[v_t v_t^T] = R_v, E[w_t w_s^T] = 0, E[v_t v_s^T] = 0$, for $s \neq t$, and $E[w_t v_t^T] = 0$, since stochastic noise variables are independent

(4) *No all the components of the state vector of the control process are observable (measurable).*

A remarkable result related to the Gaussian random variables is provided by Lemma11.1 together with its proof in [4], p. 41.

This Lemma makes the link between Gaussian nature of the random variables and the stochastic state estimation, well-known in the literature as "*linear least squares estimates*". According to this Lemma "*if x and y are two Gaussian random variables jointly normal distributed with zero mean and the covariance matrix:*

$$E\left(\begin{bmatrix} x \\ y \end{bmatrix} [x \quad y]\right) = \operatorname{cov}\left(\begin{bmatrix} x \\ y \end{bmatrix}\right) = \begin{bmatrix} V_{xx} & V_{xy} \\ V_{yx} & V_{yy} \end{bmatrix} \tag{21}$$

then the distribution of x conditional on y is also Gaussian, with:

$E(x \mid y) = V_{xx}V_{yy}^{-1}y$ (conditional mean), *and* (22)

$\text{cov}(x \mid y) = V_{xx} - V_{xy}V_{yy}^{-1}V_{yx}$ (conditional covariance) (23)

*The linear least square estimate of x in terms of y (*also, known for Gaussian case as *the maximum likelihood estimator) is defined as* [4]:

$\hat{x} = Hy = \hat{P}_{xy}\hat{P}_{yy}^{-1}y$, with $H = \hat{P}_{xy}\hat{P}_{yy}^{-1}$ ….”

Remark: Even without the assumption that *x* and *y* are jointly normal distributed, this linear function of *y* has a smaller covariance matrix than any other unbiased estimate for *x* that is a linear function of y [4].

Closing, the control system state trajectory starts from the initial state x_0 distributed conditional on W_0 as normal Gaussian, $x_0 \propto N(\hat{x}_0, \hat{P}_{xx,0})$, and obeys together with the observable plant outputs to the recursions of the full LQG model given in a discrete state-space stochastic equations (19). Then conditional on W_t ,the actual current state is Gaussian normal distributed $x_t \propto N(\hat{x}_t, \hat{P}_{xx,t})$. The conditional mean and variance obey the following updating recursions [4] (see Theorem 11.2, p.42):

$\hat{x}_t = A\hat{x}_{t-1} + Bu_{t-1} + K_t(y_t - C\hat{x}_{t-1})$ (24)

$P_{xx,t} = Q_w + AP_{xx,t-1}A^T - (L_{wv} + AP_{xx,t-1}C^T)(R_v + CP_{xx,t-1}C^T)^{-1}(L_{wv}^T + CP_{xx,t-1}A^T)$ (25)

and the Kalman matrix gain K_t is given by:

$K_t = (L_{wv} + AP_{xx,t-1}C^T)(R_v + CP_{xx,t-1}C^T)^{-1}$ (26)

The equations (24)-(26) are developed based on the following assumption:

$$\text{cov}\begin{pmatrix} w_t \\ v_t \end{pmatrix} = E\left\{\begin{pmatrix} w_t \\ v_t \end{pmatrix}\begin{pmatrix} w_t & v_t \end{pmatrix}\right\} = \begin{bmatrix} Q_w & L_{wv} \\ L_{wv}^T & R_v \end{bmatrix} \quad (27)$$

and, also taking into account that at the moment $t-1$ when the plant control u_{t-1} becomes known but the plant output observation y_t is not available (known) yet the distribution (x_t, y_t) conditional on (W_{t-1}, u_{t-1}) is jointly normal with the means:

$E(x_t \mid W_{t-1}, u_{t-1}) = A\hat{x}_{t-1} + Bu_{t-1}$ (Markov stochastic process also) (28)

$E(y_t \mid W_{t-1}, u_{t-1}) = C\hat{x}_{t-1}$ (29)

For the independent sequences of noises (w_t, v_t) the matrix covariance becomes more simple $\text{cov}\begin{pmatrix} w_t \\ v_t \end{pmatrix} = \begin{bmatrix} Q_w & 0 \\ 0 & R_v \end{bmatrix}$, a diagonal matrix that simplify also the equations (24)-(26), very useful for algorithm implementation in practice.

The main idea of <u>*equivalent uncertainty principle*</u> is that “*the optimal control u_t is exactly the same as it would be if all unknowns were known and took values equal to their linear least square estimates (equivalently, their conditional means) based upon observations up to time t*” [4].

Finally, the following two main issues concerning the state estimation and optimal control must be considered:

(1) The state estimate $\hat{x}_t$ can be calculated recursively from the Kalman Filter stochastic equation (24):

$\hat{x}_t = A\hat{x}_{t-1} + Bu_{t-1} + L(y_t - C\hat{x}_{t-1})$

that contains two main terms: $A\hat{x}_{t-1} + Bu_{t-1}$, and $L(y_t - C\hat{x}_{t-1}$ that seems to reproduce the noise contaminated plant dynamics, L representing the estimated observer gain:

$x_{t+1} = Ax_t + Bu_t + w_t$

where the process noise w_t is given now by an innovation stochastic process:

$$\tilde{w}_t = \tilde{y}_t = y_t - C\hat{x}_{t-1} \quad (30)$$

that can be viewed as a *colored noise* rather than a *white noise*.

(2) If the controlled plant is complete observable in terms of the components of the plant state vector, i.e., $y_t = x_t$ the optimal plant control is given by:

$$u_t = K_t x_t, \text{ as linear combination of the plant states,} \quad (31)$$

then if the controlled plant is partially observable the optimal plant control is given by:

$$u_t = K_t \hat{x}_t, \quad (32)$$

as a linear combination of the best linear least squares state estimates of x_t based on the available input-output measurements (observations) (Y_t, U_{t-1}) at time *t*.

A remarkable result can be obtained by evaluating the residual of the state:

$$\varepsilon_t = \hat{x}_t - x_t = A\hat{x}_{t-1} + Bu_{t-1} + L(y_t - C\hat{x}_{t-1}) - x_t = \ldots.$$

$$= (A - LC)\hat{x}_{t-1} + Bu_{t-1} + LCx_t - Ax_{t-1} - Bu_{t-1} = (A - LC)\hat{x}_{t-1} + LCx_t - Ax_{t-1}, \quad (33)$$

The residual of the state given by (39) does not depend on the sequence of the past history of plant controls U_{t-1}. This result is very important to decouple the optimal control from optimal estimation, well known in the control systems literature as *separation principle* [4, 5, 6, 7, 8] corresponding to a control system structure shown in Fig. 3. This structure it is also easy to be implemented in real time MATLAB/SIMULINK simulation environment.

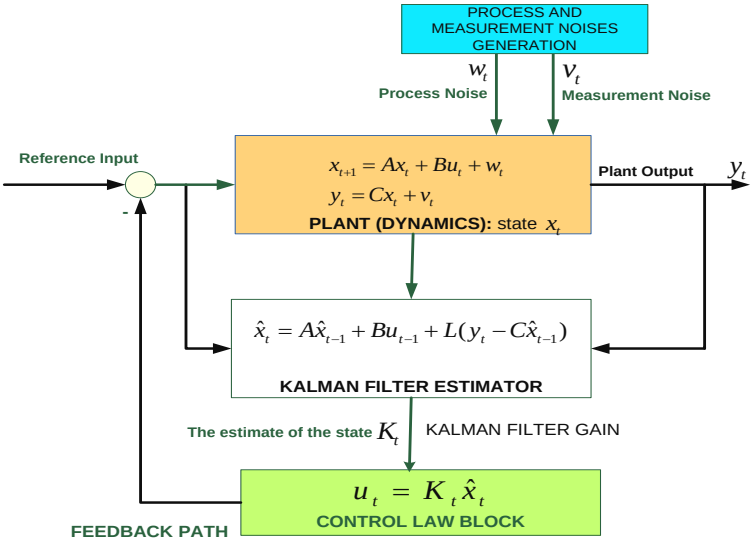

FIG. 3. Separation Principle Control System Structure

A consequence of the separation principle is that the observer and controller can be designed separately–the controller gain K can be computed independently of the estimated Kalman observer gain, L, with two decoupled dynamics: the control plant dynamics controlled by the dynamics of the observer estimator through its optimal gain as is shown in Fig. 4, and from SIMULINK model in Fig.10.:

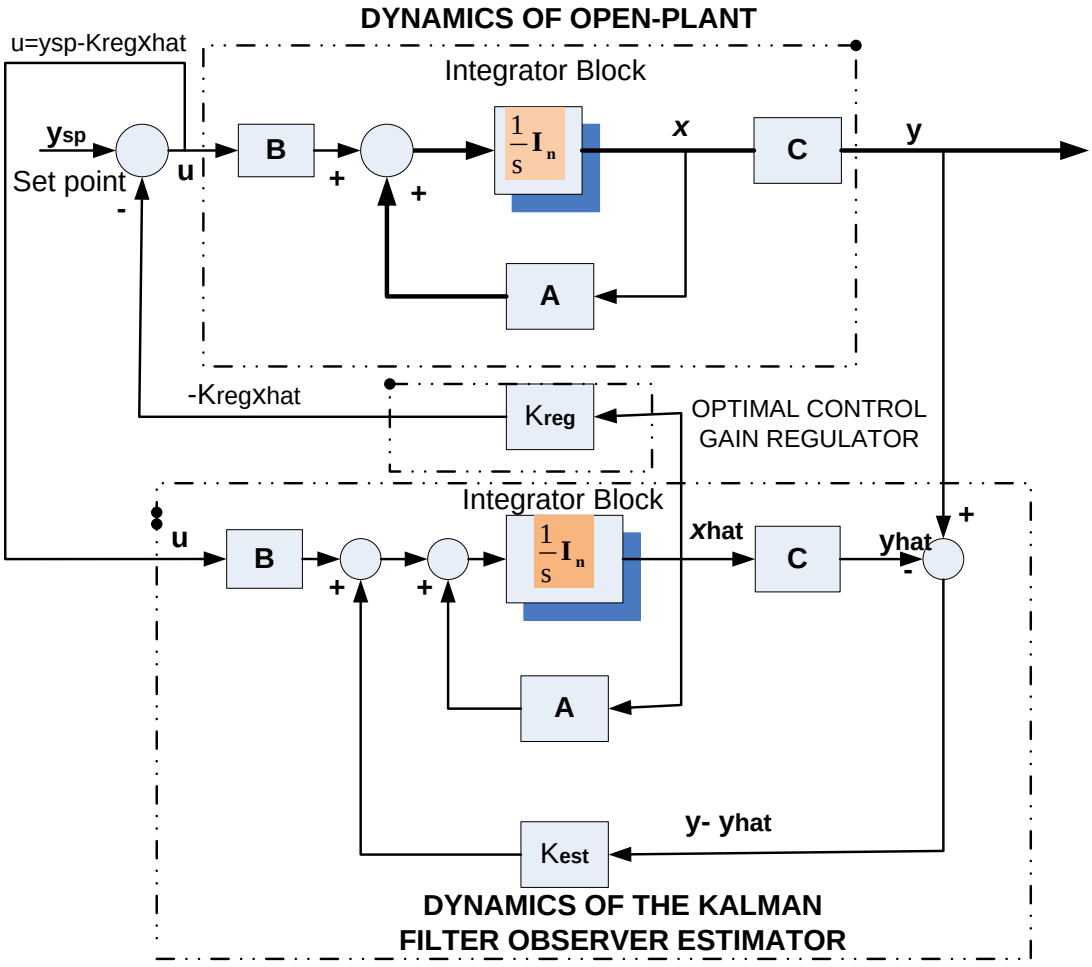

FIG. 4. Detailed Decouple Dynamics of Control System Structure

6. THE CASE STUDY – NEUTRALIZATION REACTOR INTUITIVE GENERIC MODEL

The dynamic and steady state simulation model for pH neutralization process consists of a system of equations based on mass and charge balances on the continuous stirred tank reactor (CSTR). An intuitive simple and complete generic dynamic model of CSTR in a state-space representation is developed in [2], very useful to implement the proposed optimal control system strategy and to evaluate its effectiveness in a stochastic approach. In the document paper [2] the modeling part is quite fast implemented and validated in SIMULINK environment, but it is quite difficult to propose a stable feedback control closed-loop for this highly non-linear system [2]. The following two crucial issues in developing a pH neutralization reactor dynamic model which describes the nonlinearity of the neutralization process have emerged from published literature research [2]:

(1) The positive hydrogen ion (H^+) or negative hydroxyl ion concentrations (OH^-) from material balances equations is extremely difficult to record, due to the fact that the dissociation of water and resultant (effluent) slight change in water concentration must be accounted.

(2) Instead, the material balances equations are performed on all other atomic species and all supplementary equilibrium interactions are used in addition with the electro-neutrality principle of the positive and negative ion concentrations to simplify the equations.

The dynamic model of the neutralization process is developed based on the component material balance and the equilibrium equations under the following assumptions [2, 3]:

(a) The acid-base reactions inside the CSTR system are ionic and take place at a constant reaction rates.

(b) The CSTR system is ideal without any pollutant influence.

(c) Linear mixing volume (i.e., no miscibility gap) of acid and waste water.

(d) The valve dynamics are much faster compared to the neutralization process dynamics, therefore is neglected.

(e) The pH sensor dynamics is represented by a first order lag element with a delay time of 50 seconds.

(f) The volume V of the tank is constant.

The basic intuitive model developed in [2] is suitable for this case study since it is very simple and captures with enough precision the sharp nonlinear characteristics of a single acid-single base continuous stirred tank reactor (CSTR) neutralization process.

6.1The nonlinear dynamics of CSTR – The nonlinear intuitive model

The nonlinear dynamics of the CSTR neutralization process shown in Fig. 2 is described in [2] by following first-order state-space differential equation:

$$\frac{dx(t)}{dt} = -\frac{\dot{V}_F}{V}x(t) + (-\frac{1}{V}x(t) + \frac{b_A}{V})u_1(t) + \frac{\dot{V}_F b_F}{V} = f(x(t), u_1(t), u_2(t)) \quad (34)$$

$$y(t) = -\log_{10}[0.5(x(t) + \sqrt{(x(t))^2 + 4\times 10^{-14}})] = g(x(t)) \quad (35)$$

where:

- the process state $x(t) = C[H^+] - C[OH^-]\left[\frac{mol}{l}\right]$ (the difference between the positive ions concentration $C[H^+]$ and negative ions concentration $C[OH^-]$)

- $\dot{V}_F$ is the waste water feed flow $\left[\frac{l}{h}\right]$

- the neutralization process inputs $u_1(t) = \dot{V}_A$ (HCl-acid flow) and $u_2(t) = \frac{\dot{V}_F b_F}{V}$ as a new constant step input (disturbance).

- $b_F = C_F[H^+] - C_F[OH^-]$ (the difference between the positive ions concentration $C_F[H^+]$ and negative ions concentration $C_F[OH^-]$ in the waste water feed flow $\dot{V}_F$)

- $b_A = C_A[H^+] - C_A[OH^-]$ (the difference between the positive ions concentration $C_A[H^+]$ and negative ions concentration $C_A[OH^-]$ in the HCl-acid flow $\dot{V}_A$)

-the neutralization process output $y(t) = pH$

- f, g are two nonlinear functions used to describe in a compact form the nonlinear dynamics of the neutralization process and of the observable process output respectively.

- V is the constant volume of the CSTR [l]

6.2 The linearized dynamics of CSTR – The linear intuitive model

A standard linearized version of the intuitive CSTR model can be obtained by linearizing the nonlinear functions f and g around an operating point (i.e., an equilibrium point obtained in steady state, when), keeping only the linear terms from a Taylor series development. In state-space representation standard form the intuitive linear model of CSTR neutralization process is the same with those developed in scalar form as in [2].

$$\frac{dx(t)}{dt} = Ax(t) + Bu(t) \tag{36}$$

$$y(t) = Cx(t) \tag{37}$$

with the Jacobean matrices (scalars) given by:

$$A = \left(\frac{\partial f}{\partial x}\right)(x_e, u_e) = -\frac{\dot{V}_F + u_e}{V}, B = \left(\frac{\partial f}{\partial u}\right)(x_e, u_e) = \frac{b_A - x_e}{V}$$

$$C = \left(\frac{\partial g}{\partial x}\right)(x_e, u_e) = -\frac{1}{\ln(10)} \frac{1}{\sqrt{x_e^2 + 4 \times 10^{-14}}} \tag{38}$$

$$x_e \cong -10^{-4}, u_e = -\dot{V}_F \frac{10^{-4} + b_F}{b_A + 10^{-4}} = \dot{V}_F \frac{x_e - b_F}{b_A + x_e}$$

In the linear standard state-space representation the free term from the nonlinear intuitive CSTR model $u_2(t) = \frac{\dot{V}_F b_F}{V}$ is removed and can be viewed as a constant disturbance (i.e., a new step input).

6.3 The nonlinear CSTR Reactor step response – Simulation results

The step response simulation results for the nonlinear and linearized CSTR intuitive models are shown in Fig.5 to Fig.8 with the following process parameters values set to the same values as those given in [2]:

-the feed rate of the waste water $\dot{V}_F = 3000[\frac{l}{h}]$,

-the *pH* in the waste water feed rate is $pH_F = 13$,

-the concentration of the H^+ positive ions in the waste water is $C_F[H^+] = 10^{-pH_F} = 10^{-13}$,

-the concentration of the OH^- negative ions is $C[OH^-] = 10^{\frac{-14}{C_F[H^+]}} = 10^{-1}$,

- $b_F = (C[H^+] - C[OH^-])\left[\frac{mol}{l}\right] = 10^{-13} - 10^{-1} \cong -0.1\left[\frac{mol}{l}\right]$,

-maximum feed rate of the *HCl*-acid pump is $Q_{acid\_pump} = 45\left[\frac{l}{h}\right]$

-*HCl*-acid mass concentration is $C_{A,m} = 25\%$,

- *HCl*-acid mol weight is $C_{A.wt} = 36.46\left[\frac{g}{mol}\right]$,

- *HCl*-acid density is $C_{A,\rho} = \frac{(37 - C_{A,m})}{37} \times 1000 + \frac{C_{A,m}}{37} \times 1190 = 1.1284$ [g/l]

-the concentration of the H^+ positive ions in the *HCl*-acid is $C_A[H^+] = C_{A,m}/100 \times C_{A,\rho}/C_{A,wt} = 7.7371\left[\frac{mol}{l}\right]$,

- the concentration of the OH^- negative ions in the HCl-acid is $C_A[OH^-] = 10^{\frac{-14}{C_A[H^+]}} = 10^{\frac{-8}{6.1171}} \cong 1.2925e-15\left[\frac{mol}{l}\right]$ - $b_A = (C_A[H^+] - C_A[OH^-])\left[\frac{mol}{l}\right] \cong 7.7371\left[\frac{mol}{l}\right]$

- the volume of CSTR V=3000[l],

- the initial value of pH is $pH_0 = pH_F = 13$,

- the initial value of the concentration of the positive ions H^+ of the solution inside the reactor is $C_{CSTR,0}[H^+] = 10^{-pH_0} = 10^{-13}\left[\frac{mol}{l}\right]$,

- the initial value of the concentration of the negative ions OH^- of the solution inside the reactor is $C_{CSTR,0}[OH^-] = 10^{(pH_0 - 14)} = 10^{-1}\left[\frac{mol}{l}\right]$,

- $b_{CSTR,0} = (C_{CSTR,0}[H^+] - C_{CSTR,0}[OH^-])\left[\frac{mol}{l}\right] \cong -0.1\left[\frac{mol}{l}\right]$

- the set point value of the pH for linearized intuitive model is $pH_{sp} = 11$,

- the plant output equilibrium point is $y_e = pH_{sp} = 11$,

- the steady-state equilibrium point is $x_e = 10^{-pH_{sp}} - 10^{(pH_{sp} - 14)} = 10^{-11} - 10^{-1} \cong -0.1$,

and $u_e = \frac{V_F(x_e - b_F)}{b_A - x_e} = \frac{3000(-0.1 + 0.1)}{-0.0492 + 0.1} \cong 0$,

-initial value of CSTR state is $x_0 = b_F \cong -0.1$, so closed enough to the equilibrium point.

In Figure 5 is shown the step response of the open-loop nonlinear intuitive model that behaves as the titration nonlinear curve of the dynamics of the neutralization process. This step response correspond to a maximum step value of the HCl acid flow variation shown in Fig. 6. (i.e., 45 l/h HCl).

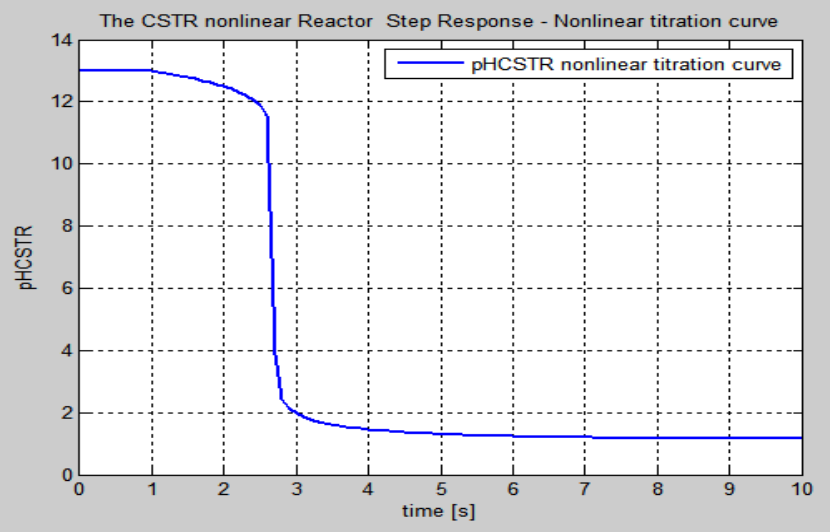

FIG. 5. The nonlinear titration curve of CSTR neutralization reactor – Step response

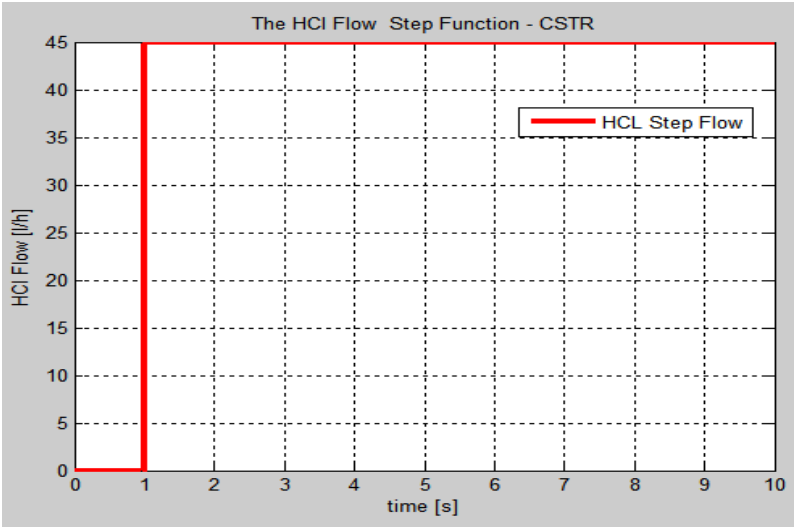

FIG. 6. The HCl CSTR Flow step function

For the linearized CSTR dynamics of the neutralization process similar results are shown in Fig. 7 to a HCl step flow shown in Fig. 8.

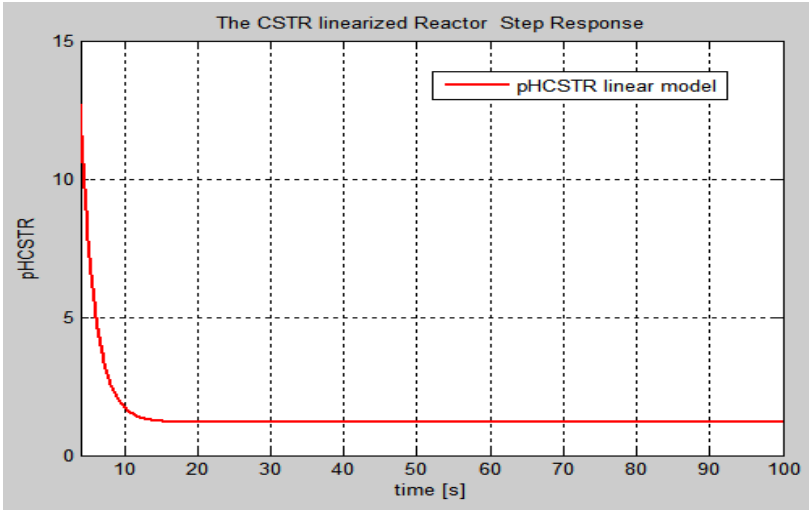

FIG. 7. The step response of linear CSTR neutralization reactor

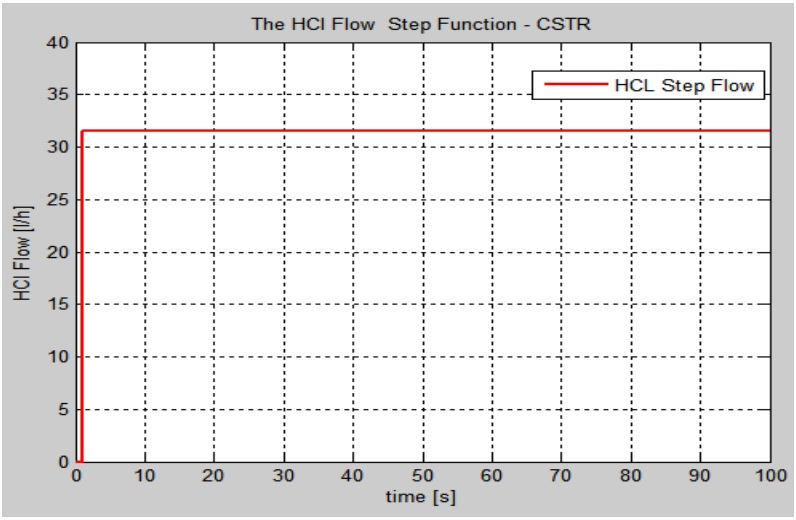

FIG. 8. The HCl of linear CSTR Flow step function

In Fig. 9 is shown the SIMULINK model of intuitive CSTR nonlinear model, similar to those presented in [2] , used as experiment set up to determine the nonlinear titration curve. Of the neutralization process, as is shown in Fig.5.

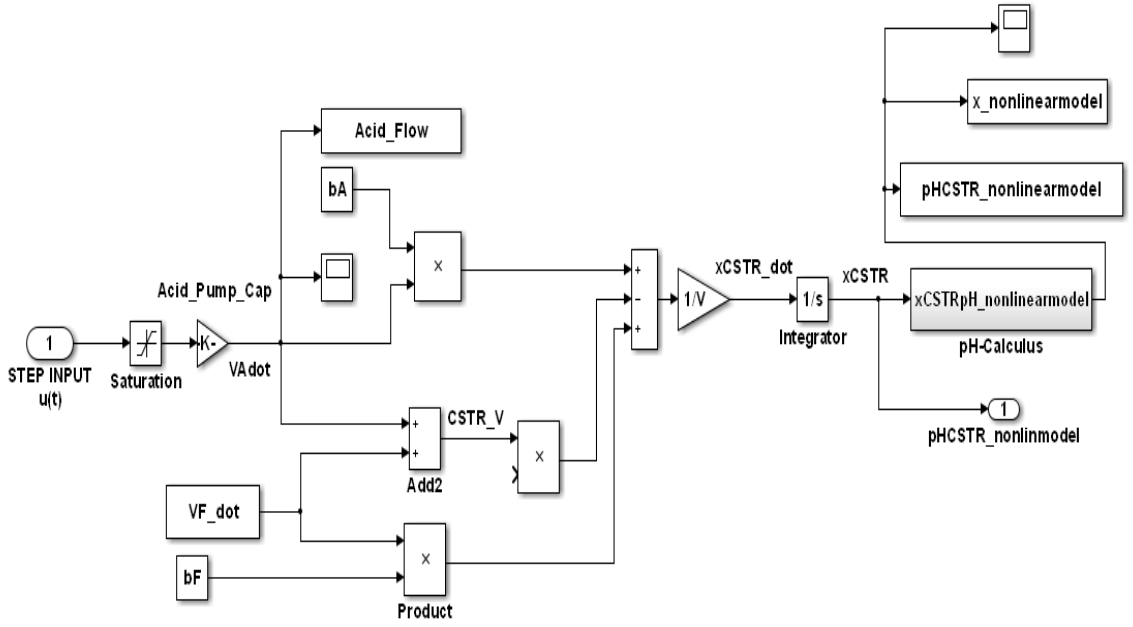

FIG. 9. The SIMULINK model of intuitive CSTR nonlinear model

7. IMPLEMENTATION IN REAL TIME OF LQR CONTROL STRUCTURE IN MATLAB/SIMULINK – SIMULATION RESULTS

According to the development from section 4 and based on the optimal control structure shown in Fig. 3, the complete LQG model is well defined by the following elements:

1. The discrete time linearized process dynamics of the intuitive CSTR model in state-space representation obtained from (42) – (43) by replacing the derivative of the state using the Euler approximation:

$$\frac{dx(t)}{dt} = \frac{x_{t+1} - x_t}{T_s}, \tag{39}$$

were T_s is the sampling time [s], $t = kT, k = 0,1,2,...,N$ - the discrete-time moments

$$\begin{aligned} x_{t+1} &= (1 + A \times T_s)x_t + T_s B u_t + w_t \\ y_t &= Cx_t + v_t \end{aligned} \tag{40}$$

$\operatorname{cov}\begin{pmatrix} w_t \\ v_t \end{pmatrix} = E\left\{\begin{pmatrix} w_t \\ v_t \end{pmatrix}\begin{pmatrix} w_t & v_t \end{pmatrix}\right\} = \begin{bmatrix} Q_w & 0 \\ 0 & R_v \end{bmatrix}$, w_t, v_t -white Gaussian process and measurement noises, zero mean and independent, with the covariance matrices Q_w and R_v respectively.

2. Quadratic optimization criterion:

$$J_0 = \min_u E\left(\sum_{t=0}^{s-1} x^T P_{xx} x + 2u^T S x + u^T P_{uu} u\right) + J_s(x_s), \tag{41}$$

3. The recursive stochastic Kalman Filter state estimate equation:

$$\hat{x}_t = A\hat{x}_{t-1} + Bu_{t-1} + K_t(y_t - C\hat{x}_{t-1}) \tag{42}$$

4. The optimal value of the plant control:

$$u_t = K_t \hat{x}_t \tag{43}$$

The scalars *A*, *B*, *C* from description (42)-(43) of the intuitive linearized CSTR model are given in the section 7.3. The combined decoupled LQG SIMULINK control structure in LQR and LQE for linearized CSTR dynamics is shown in Fig. 10. To eliminate the steady-state error between the pH input set point and the output pH actual level in the LQG structure it will be also integrated a PI controller. In the unit feedback path between the pH sensor and the comparator it will be integrated a Transport delay block, with a time delay of 50 seconds. The subsystems of full control structure are shown as SIMULINK blocks in Fig. 11 to Fig. 13.

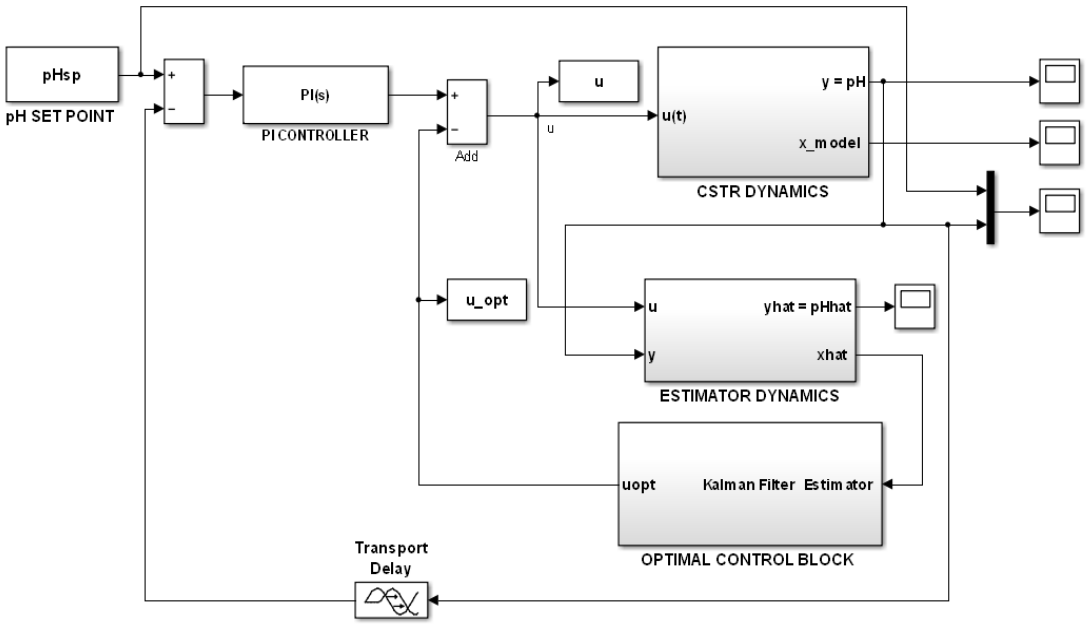

FIG. 10. The SIMULINK model of the decoupled combination LQR and LQE of the intuitive CSTR nonlinear model

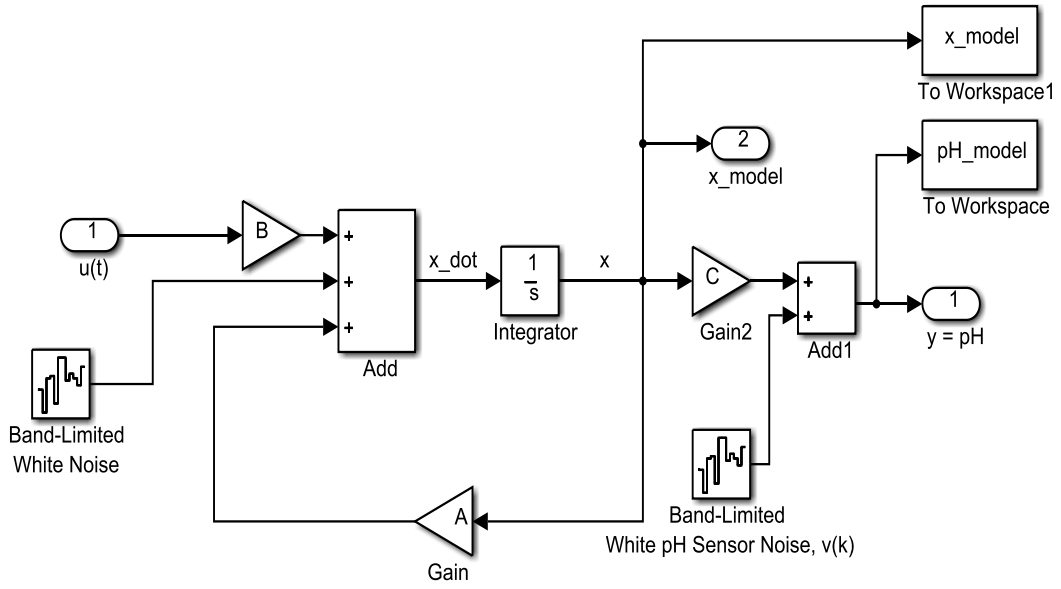

FIG. 11. The SIMULINK model of linear dynamics of LQR CSTR control system

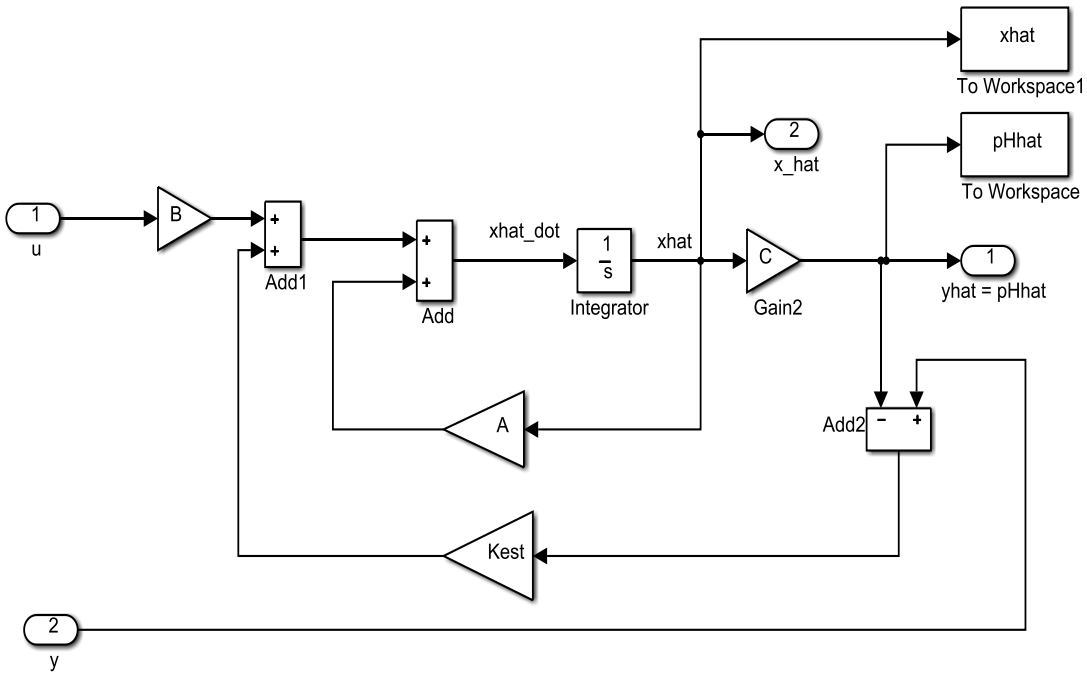

FIG. 12. The SIMULINK model of linear dynamics of LQE CSTR control system

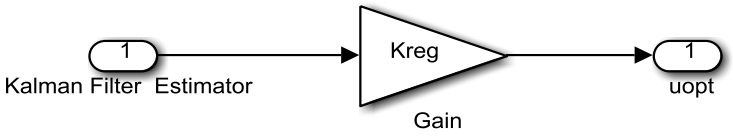

FIG. 13. The SIMULINK model of the optimal control block of the LQG control system

Starting with a pH13 as initial level of the CSTR pH and choosing as a set point of pH level as pH11 in a combined control structure LQG with a PI controller tuned for an integration time coefficient to $K_i = -0.3936$ and proportionality coefficient to $K_p = -9.7736$ the simulation results are shown in Fig. 14 to Fig. 17. To eliminate the variations of high frequency in the useful signal a Moving Average Filter (MAV) it will be used. The windows lengths for MAV are set randomly to 50, and 100 respectively

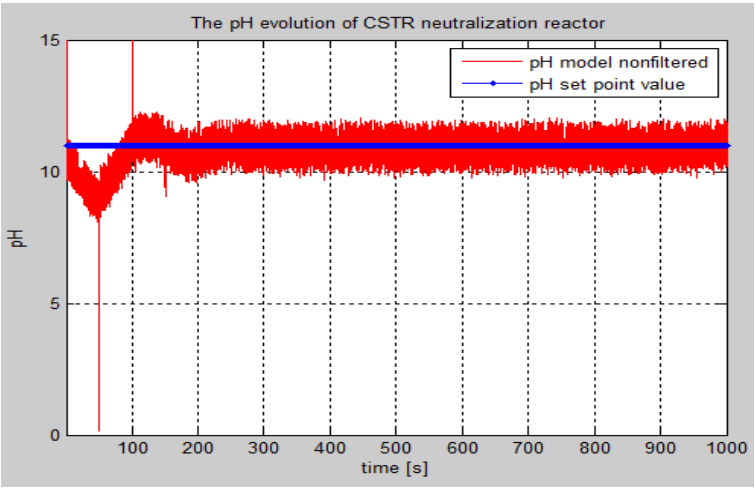

FIG. 14. The control of pH value for the linearized CSTR neutralization plant from pH13 to pH11 using LQG control combined with PI controller (no filtered)

The filtered pH waste water level and the states are shown in Fig. 15 to Fig.16, and in Fig. 17 it shown the actuator effort to keep this pH level to pH11.

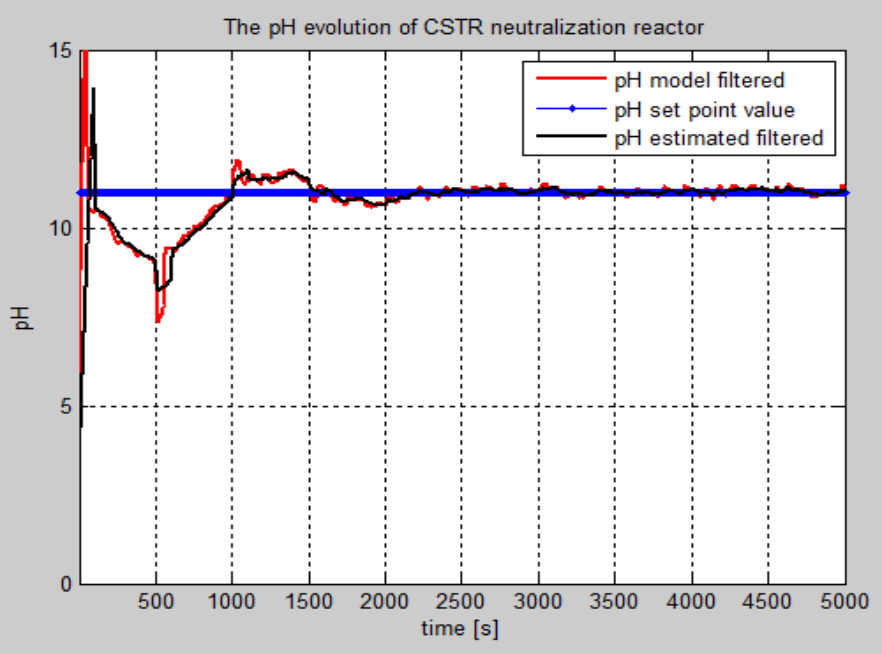

FIG. 15. The control of pH value for the linearized CSTR neutralization plant from pH13 to pH11 using LQG control combined with PI controller (filtered by using a Moving Average Filter)

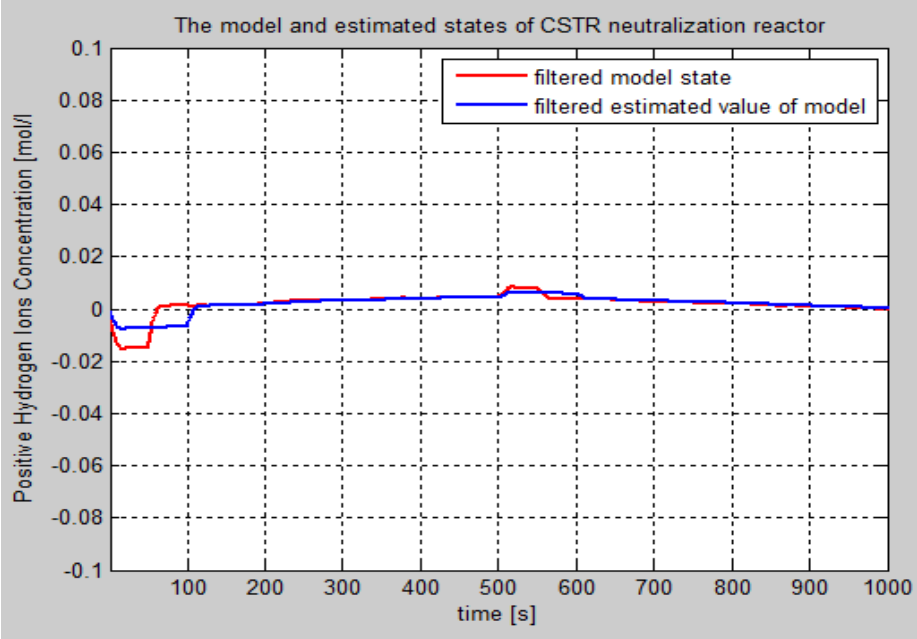

FIG. 16. The filtered model and estimated states for the linearized CSTR neutralization plant from pH13 to pH11 using LQG control combined with PI controller (filtered by using a Moving Average Filter)

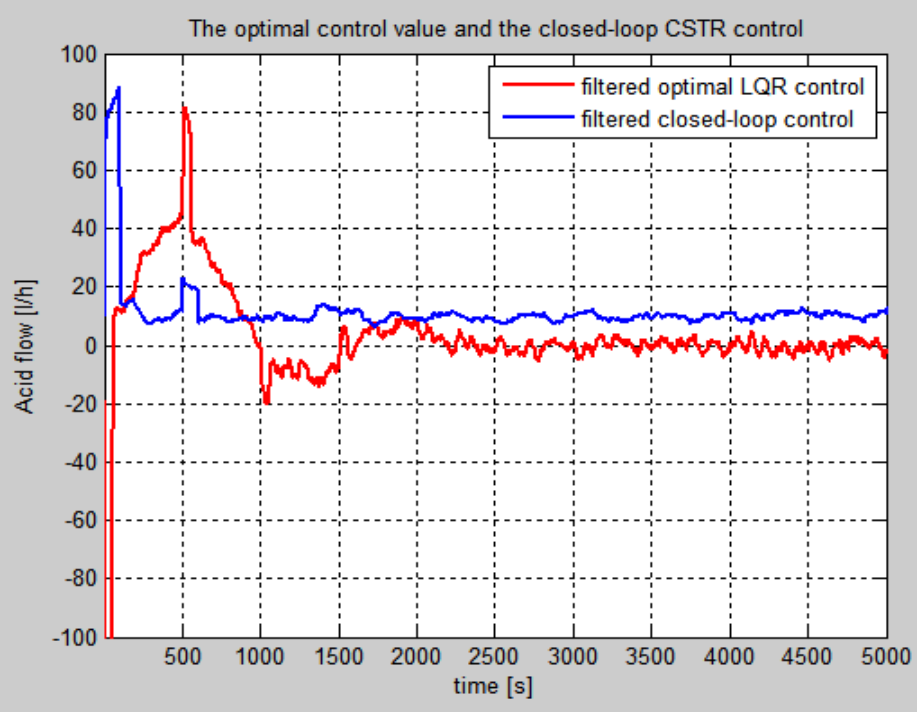

FIG. 17. The filtered optimal LQR control for the linearized CSTR neutralization plant from pH13 to pH11 using LQG control combined with PI controller (filtered by using a Moving Average Filter)

For a new set point of pH level starting the neutralization process from pH13 to pH10.5, using a combined control structure LQG with an I controller having the integration time coefficient set to $K_i = -0.0229$ the simulation results are shown in Fig. 18 and Fig. 19. The windows lengths for Moving Average Filter at this time are set to 500, 250 respectively.

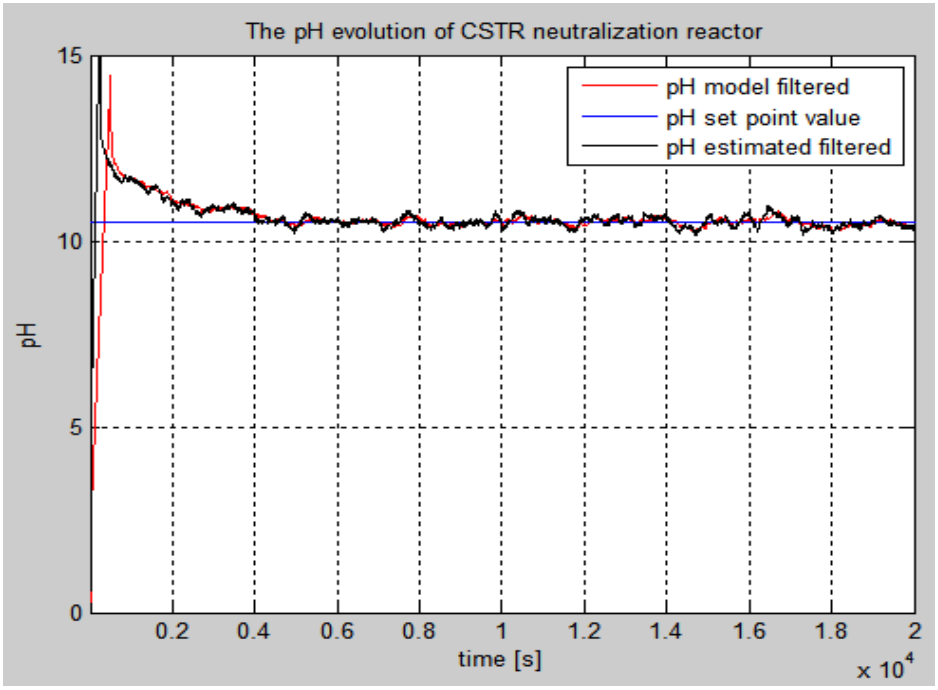

FIG. 18 The control of pH value for the linearized CSTR neutralization plant from pH13 to pH10.5 using LQG control combined with an I controller (filtered by using a Moving Average Filter)

In figure 18 it is easy to see the good accuracy of the controlled level of the CSTR pH neutralization plant from pH13 to pH10.5 with a controller effort shown in Fig.19. After almost 600 seconds the optimal effort of the LQR controller becomes very small.

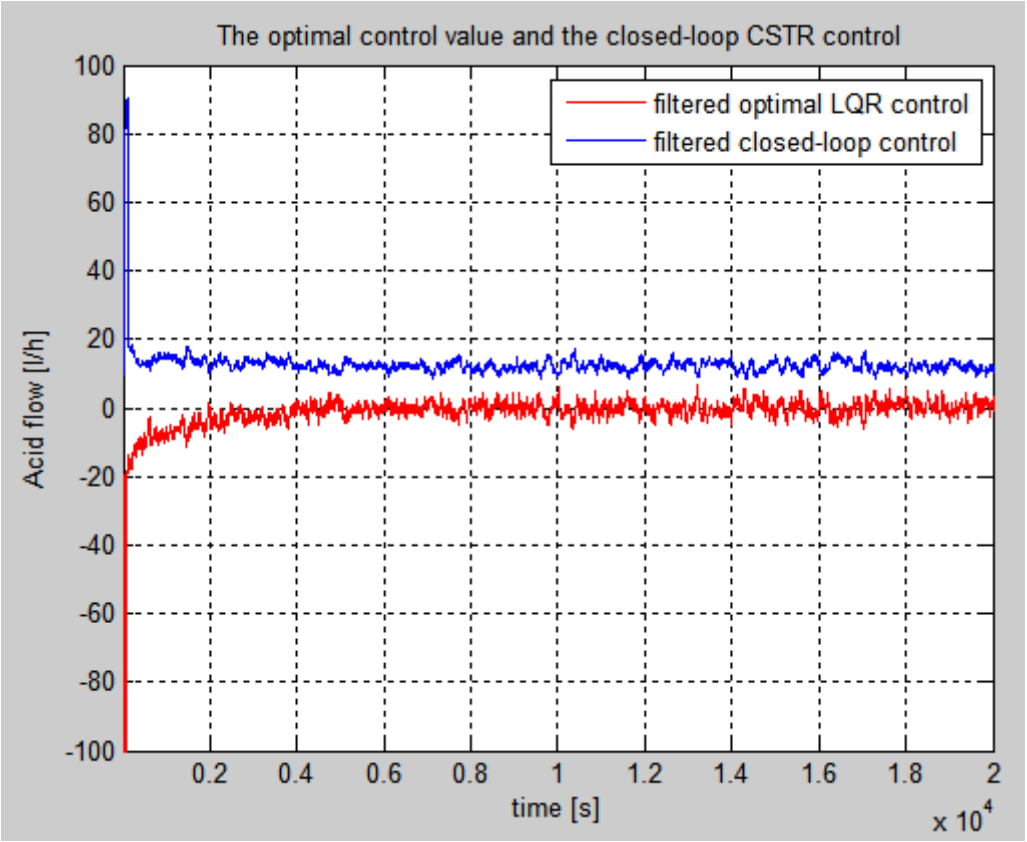

FIG. 19. The filtered optimal LQR control for the linearized CSTR neutralization plant from pH13 to pH10.5 using LQG control combined with an I controller (filtered by using a Moving Average Filter)

CONCLUSIONS

In this research paper is developed a stochastic LQG approach to solve a particular optimization problem, such as the optimal control of pH level of the waste water CSTR neutralization plant. The control system design of pH neutralization process is a very difficult task to be accomplished since the model of CSTR neutralization plant is highly nonlinear (see the titration curve), and also it is very complex. Furthermore, the standard control strategies design fail unfortunately when the system performance is concerned. In the new approach the proposed control strategy proved its effectiveness and high accuracy in terms of its performance compare to the traditional control mechanisms. The simulations results are carried out in an attractive real-time MATLAB/SIMULINK environment and presented in detailed in the last two sections.

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A PRACTICAL APPROACH OF A CERTAIN CLASS OF DYNAMICAL SYSTEMS

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Abstract: *The differential equations and system of differential equations represent the kernel of the mathematical modeling, offering tools to predict the natural phenomenon from science, technics, medicine, biology, etc. In this study we will present the general case of a system of differential equations with many applications is engineering and we will derive all properties of its trajectory. The present study starts from the analyze of a dynamical system which trajectory is an ellipse. It is realized a classification of trajectories. The equation of trajectory is reduced to the canonical form to simplify the calculus. Different geometrical properties of the trajectory are deduced using the analytical and differential study. At the end of this study it is formulated a property regarding the Podar of the trajectory. The trajectory will be represented using the Matlab software.*

Keywords: *dynamical systems, geometrical properties*

1. INTRODUCTION

All mechanism that evolve in time can be represented through a dynamical system. Elementary examples can be found in mechanics, computer science and medicine. The most important thing is the evolution of the system, that is represented by the functions that desctivbe the state of the system as a function of time and satisfy the equation of motion of the system, [1,2,6]. The dynamical systems are encountered also in chemistry. In the paper [3] is studied a chemical phenomenon, an example of an autocatalytic reaction. Using the stability in first approximation and the theory of bifurcations is studied the stability the autocatalytic reaction. The fractals can be also interpreted as dynamical sistems. Its geometry can be seen as a language that describes models and analyzes complex forms from nature. The basics of fractal geometry are algorithms that can be visualized as structures and different forms using the computer, [4,5].

Let us conside the following system of differential equations of first degree:

$$\begin{cases} \dot{x} = ax - by \\ \dot{y} = ax - ay \end{cases} \tag{1}$$

where $ab - a^2 = b^2$, $a, b, k \in \mathbb{Z}$. The characteristic polynomial is:

$$P(\lambda) = det(A - \lambda I_2) = \begin{vmatrix} a - \lambda & -b \\ a & -a - \lambda \end{vmatrix}$$

that leads to the following algebraic equation of second degree:
$\lambda^2 - a^2 + ab = 0 \Leftrightarrow \lambda^2 + k^2 = 0$
with the roots of characteristic equation that are the eigenvalues of the system: $\lambda_{1,2} = \pm ki$.
The general solution of the above system is:

$$x(t) = C_1 \cos kt + C_2 \sin kt$$
$$y(t) = \frac{aC_1 - kC_2}{b} \cos kt + \frac{aC_2 + kC_1}{b} \sin kt \quad (2)$$

Taking into account the initial conditions:
$x(0) = x_0; y(0) = y_0$
we obtain the values of the constants from te general solution: $C_1 = x_0; C_2 = \frac{ax_0 - by_0}{k}$
therefore the solution of the above system with initial condition is:

$$x(t) = x_0 \cos kt + \frac{ax_0 - by_0}{k} \sin kt$$
$$y(t) = y_0 \cos kt + \frac{ab(x_0 - y_0)}{k} \sin kt \quad (3)$$

Next we want to prove that the trajectory of the system (1) is an ellipse. Deriving of the trajectory equation is made by solving the differential equation total exact obtained from the system in the following way:
$$\frac{\dot{y}}{\dot{x}} = \frac{ax - ay}{ax - by} \Leftrightarrow (ax - ay)dx - (ax - by)dy = 0$$

It is necessary to find a function $F(x, y) = C$ whose differentiate of first degree is:

$$dF = \frac{\partial F}{\partial x} dx + \frac{\partial F}{\partial y} dy = (ax - ay)dx - (ax - by)dy = 0$$

Through identification we have to solve the following system:

$$\frac{\partial F}{\partial x} = ax - ay$$

$$\frac{\partial F}{\partial x} = -ax + by$$

and the solution of the differential total exact equation will be:
$$F(x, y) = \frac{ax^2}{2} - axy + \frac{by^2}{2} = C$$

By computation we obtain the trajectory equation:
$(ax - y)^2 + (b - 1)y^2 = C \quad (4)$
that represents the equation of an ellipse.

2. THE CLASSIFICATION OF TRAJECTORY

In this section we wand to realize a classification of the conics from this family. We consider our particular conic:

$(\Gamma): a^2x^2 - 2axy + by^2 - c = 0$

and by comparing with the general form of a conic:

$(\Gamma): a_{11}x^2 + 2a_{12}xy + a_{22}y^2 + 2a_{13}x + 2a_{23}y + a_{33} = 0$

we make the identifications: $a_{11} = a^2, a_{12} = -a, a_{22} = b, a_{13} = a_{23} = 0, a_{33} = -c$.

Therefore the big invariant of the conic will be:

$$\Delta = \begin{vmatrix} a^2 & -a & 0 \\ -a & b & 0 \\ 0 & 0 & -c \end{vmatrix} = -a^2c(b-1)$$

For the case when $a \neq 0, c \neq 0$ and $b \neq 1$ the conic (Γ) is non degenerate.

The small invariant of the conic is:

$$\delta = \begin{vmatrix} a^2 & -a \\ -a & b \end{vmatrix} = a^2(b-1)$$

Next we have to discuss some cases:

1. If $\delta = 0$ then we obtain that $\Delta = 0$. In this situation the conic (Γ) can not be a parabola $\forall a, b, c \in \mathbb{R}$. If $a = 0$ or $b = 1$ then the big invariant in also null: $\Delta = 0$ and we obtain that the conic could be formed by two lines: $(\Gamma) = (d_1) \cup (d_2)$ where $(d_1) \mathbb{P} (d_2)$ or $(d_1) = (d_2)$, or the conic is empty: $(\Gamma) = \varnothing$

2. If the small invariant is negative: $\delta < 0$ then we have $b < 1, a, c \neq 0$ and the conic (Γ) is a hyperbola.

3. If the small invariant is positive $\delta > 0$ and $I \cdot \Delta < 0$ with $a, c \neq 0, b \neq 0$ then the conic (Γ) is an ellipse. Here: $I = a_{11} + a_{22} = a^2 + b$. The above conditions give us the following restrictions for the elliptic case: $c > 0, b > 1, a \neq 0$.

Taking into account that the trajectory of our system (1) is an ellipse we will consider the third case into a particular representation. We chose: $a = 1, b = 2, c = 1$ then the conic is: $(\Gamma): x^2 - 2xy + 2y^2 - 1 = 0$

3. THE CANONICAL FORM OF THE TRAJECTORY

Because $a_{12} = -1 \neq 0$ we will realize a rotation of the axis. Let A be the matrix of the quadratic form of conic's equation:

$$A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} = \begin{pmatrix} 1 & -1 \\ -1 & 2 \end{pmatrix}$$

Then the characteristic equation corresponding to the matrix A is: $det(A-\lambda I_2)=0$ that leads us to the following algebraic equation: $\lambda^2-3\lambda+1=0$ having the roots:

$$\lambda_{1,2}=\frac{3\pm\sqrt{5}}{2}.$$

The canonical form of the quadratic form is: $\lambda_1 x'^2+\lambda_2 y'^2$. We do not effectuate the translation in the cnter because the general equation of the conic (Γ) does not contain terms of first degree. We chose λ_1 and λ_2 i.e. $sgn(\lambda_1-\lambda_2)=sgn(a_{12})$ and we will obtain:

$\lambda_1=\frac{3-\sqrt{5}}{2}, \lambda_1=\frac{3+\sqrt{5}}{2}$. The canonical form of the ellipse equation is:

$$(\Gamma):\frac{x'^2}{\frac{3+\sqrt{5}}{2}}+\frac{y'^2}{\frac{3-\sqrt{5}}{2}}-1=0$$

Applying the roto-translation method we obtain the angle θ with which the reference coordinate rotates: $tg2\theta=\frac{2a_{12}}{a_{11}-a_{22}}\Leftrightarrow tg^2\theta+tg\theta-1=0\Leftrightarrow tg\theta_{1,2}=\frac{-1\pm\sqrt{5}}{2}$.

Because $tg2\theta=2>0\Leftrightarrow 2\theta<\pi\Leftrightarrow\theta<\frac{\pi}{2}\Leftrightarrow tg\theta>0\Leftrightarrow tg\theta=\frac{-1+\sqrt{5}}{2}$. Taking into account that $\cos^2\theta=\frac{1}{1+tg^2\theta}$ using basic computations we will obtain that: $\frac{2}{\sqrt{10-2\sqrt{5}}}>0$ and $\sin\theta=\frac{\sqrt{10-2\sqrt{5}}}{2\sqrt{5}}>0$.

The rotation matrix for the base change is:

$$S=\begin{pmatrix}\cos\theta & -\sin\theta\\ \sin\theta & \cos\theta\end{pmatrix}\Leftrightarrow S=\begin{pmatrix}\frac{2}{\sqrt{10-2\sqrt{5}}} & -\frac{\sqrt{10-2\sqrt{5}}}{2\sqrt{5}}\\ \frac{\sqrt{10-2\sqrt{5}}}{2\sqrt{5}} & \frac{2}{\sqrt{10-2\sqrt{5}}}\end{pmatrix}.$$

From $X=SX'$ we obtain the connection between the coordinates before the rotation and the coordinates after the rotation.

We want to determine the center of symmetry of ellipse in the initial reference system. Considering the function: $f(x,y)=x^2-2xy+2y^2-1$ we will solve the below system of equations:

$$C:\begin{cases}\frac{\partial f}{\partial x}(x,y)=0\\ \frac{\partial f}{\partial y}(x,y)=0\end{cases}\Leftrightarrow\begin{cases}2x-2y=0\\ -2x+4y=0\end{cases}$$

and the solution is $O(0,0)$ that expresses the missing of the translation.

The differential study on the conic is realized in the reference coordinates system: $(x'Oy')$:

$$(\Gamma): \frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} - 1 = 0$$

where the parametrisation of the ellipse is:

$$(\Gamma): \begin{cases} x' = a' \cos t \\ y' = b' \sin t \end{cases} \quad \text{where} \quad a' = \sqrt{\frac{3+\sqrt{5}}{2}}, b' = \sqrt{\frac{3-\sqrt{5}}{2}}$$

The equation of the osculator circle for the elliptical trajectory in $A(t_0 = 0) \Leftrightarrow A(a',0)$ is: $(\mathsf{C}): (X-\alpha)^2 + (Y-\beta^2) - R^2 = 0$,

where $\alpha = x_0^{'} - \frac{\dot{y}_0^{'}(\dot{x}_0^{'2} + \dot{y}_0^{'2})}{\dot{x}_0^{'}\ddot{y}_0^{'} - \ddot{x}_0^{'}\dot{y}_0^{'}} = \frac{3\sqrt{2}\sqrt{3-\sqrt{5}}}{2}$, $\beta = y_0^{'} + \frac{\dot{x}_0^{'}(\dot{x}_0^{'2} + \dot{y}_0^{'2})}{\dot{x}_0^{'}\ddot{y}_0^{'} - \ddot{x}_0^{'}\dot{y}_0^{'}} = 0$ and

$R = \frac{(\dot{x}_0^{'2} + \dot{y}_0^{'2})^{\frac{3}{2}}}{|\dot{x}_0^{'}\ddot{y}_0^{'} - \ddot{x}_0^{'}\dot{y}_0^{'}|} = \frac{3-\sqrt{5}}{2}$.

The equation of the osculator circle for the ellipse in $A(a',0)$ is:

$$(\mathsf{C}): \left(X - \frac{3\sqrt{2}\sqrt{3-\sqrt{5}}}{2}\right)^2 + Y^2 - \left(\frac{3-\sqrt{5}}{2}\right)^2 = 0$$

The curvature of the elliptical trajectory is:

$$K(t) = \frac{\dot{x}^{'}(t)\ddot{y}^{'}(t) - \ddot{x}^{'}(t)\dot{y}^{'}(t)}{(\dot{x}^{'2}(t) + \dot{y}^{'2}(t))^{\frac{3}{2}}} = \frac{ab}{a^{'2}\sin^2 t + b^{'2}\cos^2 t} > 0, \forall t \in \mathsf{R}$$

The length of the curve bow $\mathsf{L}_{A_1B_1}$ between two points $A(t_{A_1})$ and $B(t_{B_1})$ found on the elliptical trajectory is:

$$\mathsf{L}_{A_1B_1} = \left| \int_{t_{A_1}}^{t_{B_1}} \sqrt{\dot{x}^{'2}(t) + \dot{y}^{'2}(t)}\, dt \right| = \left| \int_{t_{A_1}}^{t_{B_1}} \sqrt{a^{'2} + \cos^2(b^{'2} - a^{'2})}\, dt \right|$$

Next we compute the tangent and the normal in a point $M(t)$ at the elliptical trajectory

$$(\Gamma):\begin{cases} x' = a'\cos t \\ y' = b'\sin t \end{cases} :$$

$$(d_{tg|M}): Y - y'(t) = \frac{\dot{y}'(t)}{\dot{x}'(t)}(X - x'(t)) \Leftrightarrow$$

$$(d_{tg|M}): Y - \sqrt{\frac{3-\sqrt{5}}{2}}\sin t = \frac{\sqrt{5}-3}{2} ctgt\left(X - \sqrt{\frac{3+\sqrt{5}}{2}}\cos t \right)$$

$$(d_{n|M}): Y - y'(t) = -\frac{\dot{x}'(t)}{\dot{y}'(t)}(X - x'(t)) \Leftrightarrow$$

$$(d_{n|M}): Y - \sqrt{\frac{3-\sqrt{5}}{2}}\sin t = \frac{2}{\sqrt{5}-3} tgt\left(X - \sqrt{\frac{3+\sqrt{5}}{2}}\cos t \right)$$

The segment of the tangent, the segment of the normal, the sub-tangent and the subnormal of the elliptical trajectory $(\Gamma): \frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} - 1 = 0$, where $a' = \sqrt{\frac{3+\sqrt{5}}{2}}$ and $b' = \sqrt{\frac{3-\sqrt{5}}{2}}$ in the regular point $M(x', y')$ will be derived in the following. The lengths of the forth segment are computing using the formula:

$$S_{tg} = \left|\frac{y'}{m}\right|\sqrt{1+m^2}, S_n = |y'|\sqrt{1+m^2}, S_{stg} = \left|\frac{y'}{m}\right|, S_{sn} = |y'm|,$$

where $m = -\frac{dy}{dx} = -\frac{F_x^{'}}{F_y^{'}} = -\frac{b'^2}{a'^2}\frac{x'}{y'}$ and $y' = f(x)$ is the explicit representation of the curve: $(\Gamma): y' = \pm\frac{b'}{a'}\sqrt{a'^2 - x'^2}$.

Replacing in the above formula we obtain the value of $m = \mp\frac{b'}{a'}\frac{x'}{sqrta'^2 - x'^2}$ and the lengths of the found elements will be:

$$S_{tg} = \left|\frac{a'^2 - x'^2}{x'}\right|\sqrt{1+\left(\frac{b'}{x'}\right)^2\frac{x'^2}{a'^2 - x'^2}}, S_n = \left|\frac{b'}{a'}\sqrt{a'^2 - x'^2}\right|\sqrt{1+\left(\frac{b'}{x'}\right)^2\frac{x'^2}{a'^2 - x'^2}}$$

$$S_{stg} = \left|\frac{a'^2 - x'^2}{x'}\right|, S_{sn} = \left|\left(\frac{b'}{a'}\right)^2 \cdot x'\right|.$$

Proposition 1 *The geometrical place of the projections of a fixed point I on the tangents at the elliptical trajectory* $(Gamma)$ *is the Booth leminscate. (the podar trajectory)*

Prove. We consider the vectorial equation of the curve $(\Gamma): \vec{r} = \vec{r}(t)$, where $\vec{r}(t) = a'\cos t\vec{i} + b'\sin t\vec{j}$ and $I(x_0, y_0)$ is a fixed point having the position vector $\vec{r}_0$. The position vector $\vec{R}$ of the projection P of the point I on the tangent vector $\dot{\vec{r}}$ in a regular point M with the position vector $\vec{r}$ of the curve (Γ) is $\vec{R} = \vec{r} + \lambda\dot{\vec{r}}$. To find the scalar λ we will use the orthogonality of the vectors $\dot{\vec{r}}$ and $\overleftarrow{IP}$ where:

$\overleftarrow{IP} = \vec{R} - \vec{r}_0 = \vec{r} + \lambda\dot{\vec{r}} - \vec{r}_0$

Multiplying the above equality with $\dot{\vec{r}}$ we obtain:

$0 = \dot{\vec{r}} + \lambda \| \dot{\vec{r}} \| - \vec{r}_0 \cdot \dot{\vec{r}} \Leftrightarrow \lambda = -\frac{(\vec{r} - \vec{r}_0)\cdot\dot{\vec{r}}}{\| \dot{\vec{r}} \|}$

The vectorial equation of the podar trajectory is:

$$(\mathrm{P}): \vec{R} = \vec{r} - \frac{(\vec{r} - \vec{r}_0)\cdot\dot{\vec{r}}}{\| \dot{\vec{r}} \|}\cdot\dot{\vec{r}}$$

and the parametric equations of the podar are:

$$(\mathrm{P}): \begin{cases} X = x' - \dfrac{\dot{x}'(x' - x_0) + \dot{y}'(y' - y_0)}{\dot{x}^2 + \dot{y}^2}\dot{x}' \\ Y = y' - \dfrac{\dot{x}'(x' - x_0) + \dot{y}'(y' - y_0)}{\dot{x}^2 + \dot{y}^2}\dot{y}' \end{cases}$$

In our case the parametric equations of the Podar of elliptic trajectory

$(\Gamma): \begin{cases} x' = a'\cos t \\ y' = b'\sin t \end{cases}$ in report with $I = O, x_0 = y_0 = 0$ are:

$$(\mathrm{P}): \begin{cases} X = \dfrac{a'b'^2\cos t}{a'^2\sin^2 t + b'^2\cos^2 t} \\ Y = \dfrac{a'^2 b'\sin t}{a'^2\sin^2 t + b'^2\cos^2 t} \end{cases}$$

from the above equations through elimination of t the implicit equation of the searched podar is the Booth lemniscate:

$(\mathrm{P}): a'^2X^2 + b'^2Y^2 - (X^2 + T^2)^2 = 0$

where $a' = \sqrt{\frac{3+\sqrt{5}}{2}}, b' = \sqrt{\frac{3-\sqrt{5}}{2}}$, see Fig. 1

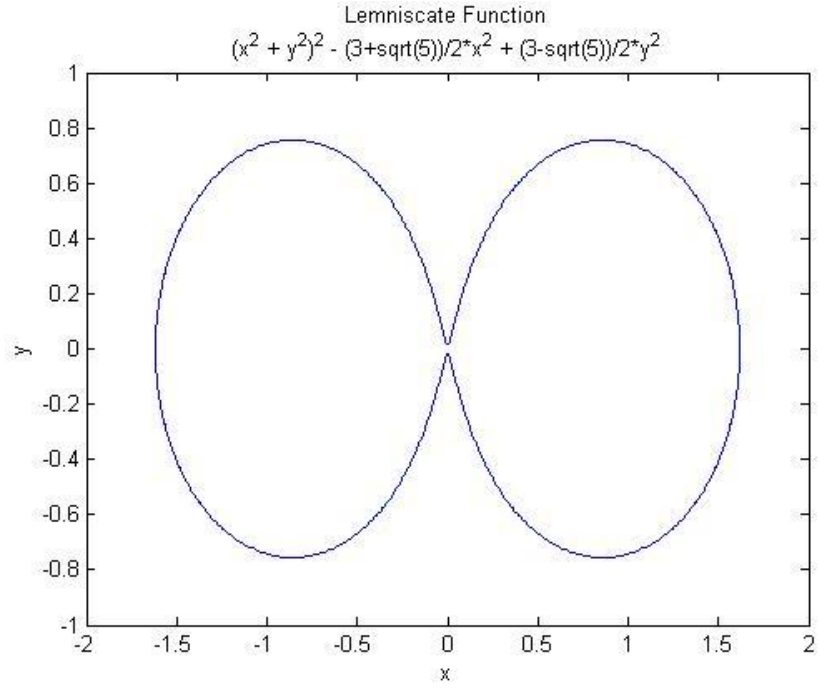

FIG. 1. The Lemniscate function

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PHYSICAL SECURING OF AN OPTICAL RING NETWORK BY USING THE REDUNDANCY

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Abstract: *A voice communication testing through a ring topology based on fiber optics is presented in this paper. The data packets were forwarded to an alternate route, without call interruption, in case of physical link failure. The alternate route was chosen by Spanning Tree Protocol Loop Guard. The protocol is specific to the tree topology, and this study shows the accuracy of a ring topology. A small network was created to test the protocol's efficiency, but the solution should be implemented in complicated networks with high traffic.*

Keywords: *network, security, ring topology,spanning tree protocol, loop guard*

1. INTRODUCTION

The concept of telecommunication represents the transfer of information from an emission source to a power receiver via a link. To make the connections a physical environment can be used, like copper or fiber optic cables, or by means of wireless media such as radio links or infrared waves.

In a world surrounded by advanced technology systems, the most important attributes are efficiency and speed of transmission. However, there are various factors that prevent good communication such as failure of terminals, interruption of the line caused by third parties or redundancy factors like software overhead.

To ensure the network functions properly, it is being taken into account the safety devices on the network, especially for the transmission medium.

Over time, the size of a network has grown substantially, which resulted in the development of different configurations and new topologies.

There is no value in not having the information sent correctly via the network or having it being read by unauthorized individuals [2]. The latter consitutes a serious security breach.

Many network attacks are from the inside and because it is very difficult to keep a record of all entities and all operations that are used at a time, it is a hard task to manually manage a network, in an efficient way [3].

Complexity is cause by several factors, which may include geographical dispersion and involving several organizations to ensure the network integrity or safety. Other causes may includ the existence of devices and different operating systems, a large number of entities in the network, etc.

There are several network topologies from which, the ring and mesh are well suited for providing protection.

The ring topology distinctive mark is that all the nodes are connected in succession, and the last one is connected to the first node.

Each node receives the transmitted signal and forwards it to the next one from the loop, keeping a copy of the message, if it is intended. The message will be removed from the loop when it will return to the node from where it was sent. To control access to the network, a token is used, which means that the node that is bound to send the token further, is the only one that has the right to do so [1].

In case of system failure, the desired behavior is to not interrupt the cycle, therefore, each node has a passive bypass mechanism.

The data transmission inside a ring topology is circular and the information is transferred between devices in a single way. So, each device from that ring is like a repeater. It become a receiver for the node, from which it receives the message, and a signal transmitter for the node, where the message is being sent [5].

An important advantage of this method is that each node sends data only when it receives an available token. This way, the number of colisions is reduced. Even if new devices are being added, each one has the same resources access type - the network performance will still be better than the bus topology. More than this, there is no need for a network server to control the connexions between devices.

The ring topology has some disadvantages, like the transmission of data packets is being done through all devices which have their sources and destinations connected. If a port is inactive, it affects the entire network. Also, the network is strictly dependent on the network cable that connects different components.

For that situations when a link is interrupted, there are implemented protocols which switch the traffic automatically. This way, the data transfer is able to be continued. One of the most known protocols for the switching traffic is STP (Spanning Tree Protocol).

STP is a link management protocol between components which take part of OSI layer 2 (Open System Interconnection). This protocol generates alternative routes preventing the loop links and it creates links between terminals by choosing the route with the lowest cost [6].

The protocol defines a tree with a root switch and links without loops. If a network link is interrupted and an alternative route is available, then the traffic is transferred on the alternative link. To create this route, the algorithm takes into account the port priority and the cost between ports [4].

Additional configurations can be made for the spanning tree protocol, like the one for STP Loop Guard. The protocol efficiency is seen when the entire network is implemented. If the operating mode is PVST (Per VLAN Spanning-Tree), Loop Guard prevents the root or the alternate ports from becoming designated ports when an unidirectional link is interrupted, and the spanning-tree doesn’t send BPDUs (Bridge Protocol Data Unis) on this ports [7]. If the chosen mode is MST (Multiple Spanning Tree Protocol), and the port is blocked by Loop Guard in all MST instances, BPDUs are not sent on nonboundary ports. If there is a boundary port, Loop Guard blocks it in all MST instances [7].

Also, starting from STP, there are other automatic routing protocols involved and used in a ring topology like MSTP (Multiple Spanning Tree Protocol), RSTP (Rapid Spanning Tree Protocol) and REP (Resilient Ethernet Protocol).

2. COMMUNICATION SYSTEM SETUP AND TESTING

In this study, the voice communication was tested in a ring topology based on fiber optics.

In order to build the communication system, the next components were needed: 3 switches Cisco Catalyst 2950SX-24, 6 media converters StartBitCom, a console cable, UTP cables, optical fiber cable, 2 laptops as terminals and a virtual PBX (Private Branch eXchange).

Between terminals a VoIP (Voice Over IP) call was generated, which had to keep in touch when the fiber optic was interrupted intentionally. For these things to be possible, the Spanning Tree Protocol Loop Guard was used.

As it was mentioned before, the Loop Guard method prevents the alternate or root ports from becoming designated when a unidirectional connection is interrupted.

An advantage of STP is being able to be activated even the switch is working in the PVST or MSTP mode. Also, Loop Guard is working only with the ports which are considered point-to-point by STP [7].

The pair of media converters is able to convert an electrical signal from a FastEthernet port, of the source switch, into an optical signal and then convert it back into an electrical signal, to forward data to a FastEthernet port, of the target switch. One of this media converters was configured to have its transmission wavelength set to 1550nm and the reception wavelength set to 1310nm. The second media converter was set to send data on 1310nm and to receive data on 1550nm.

For the switch configuration a console cable was needed. The terminal used in this study, didn't have a serial interface. In this case, a USB to RS232 DB9 serial adapter cable was used.

In the Fig. 1 the media converters for the 2nd switch are presented. The black cable connects the first switch to a media converter and the gray cable connects the third switch to the other media converter.

In figure the Fig. 2 the network structure is presented. The switches were connected with the media converters and the terminals through UTP (Unshielded Twisted Pair) cables. The media convertors (MC) were interconnected through optical fiber cable.

For testing the network, the Axon Virtual PBX Windows Software [8] and the Express Talk VoIP Softphone for Windows [9], both developed by NCS Software, were installed. The PBX software supports up to 64 lines and an unlimitted number of extensions. The chosen softphone is able to make audio and video calls.

(a) (b)

FIG. 1. a), b) Media convertors

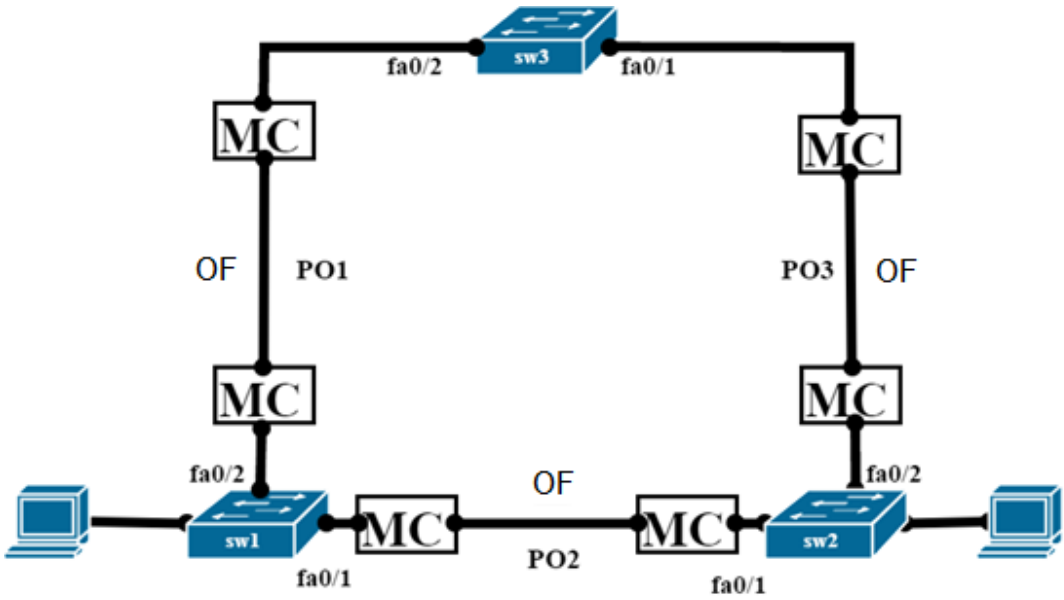


FIG. 2. Network connections

To clarify the test process, it is mentioned that one terminal is connected to the 1st switch and the other terminal is connected to the 2nd switch. Initially, the data traffic was carried out on the PO2 interface due to having the lowest cost. Also, the alternate route – composed from the PO1 and PO3 interfaces – had blocked ports not being able to transfer data through them.

The information was sent only through the port, which was connected with the terminal, and the ports which constituted the current link. Afterwards, a call was performed in order to ensure that the network was functioning under normal parameters.

The next step was to simulate a problem on the link by interrupting the optical fiber. The STP Loop Guard blocked the PO2 interface and the traffic was transferred on the alternate link. The root port channel became PO1 (in forwarding state). As it is presented in the Fig. 3, PO2 received the designation role (in „broken" state). This caused the „BKN*" message to appear next to the state section and the „P2P *LOOP_Inc" message next to the type section. This means that the PO2 is in a Loopguard inconsistence state.

During the experiment described above, the voice transmission had a short interrupt, but the call continued, as can be seen in the Fig. 4. That was possible because the data transfer was switched on the alternate link in about 1 second.

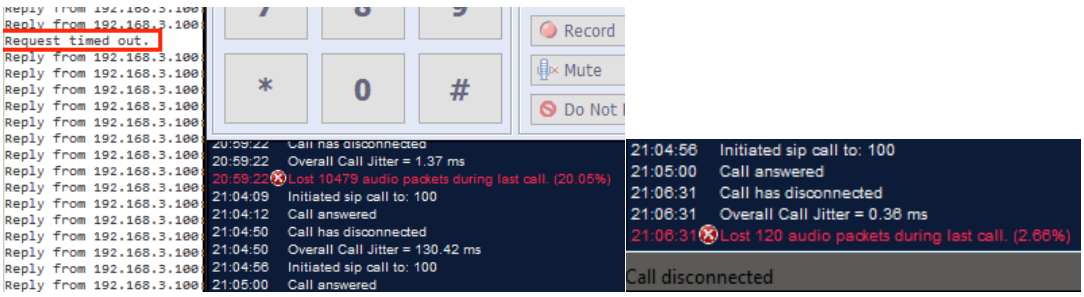
Once the network failure was fixed – by reconnecting the fiber optic cable to the media converter - the data traffic was forwarded back to the initial route, without losing data packets.

Even though the transfer was forwarded in a rapid way, there were still some data packets that were lost – the exact number may vary from case to case – because of the lack of connection and the implemented protocol reaction time.

In the same way the link between the 1st and 3rd switches or the link between the 2nd and 3rd switches can be interrupted. The implemented protocol will work in the same mode to bypass the failure.

```
sw1#sh spanning-tree active

MST00
  Spanning tree enabled protocol mstp
  Root ID     Priority    32768
              Address     0006.525e.54c0
              Cost        2016
              Port        66 (Port-channel2)
              Hello Time   1 sec  Max Age  6 sec  Forward Delay 15 sec

  Bridge ID   Priority    32768  (priority 32768 sys-id-ext 0)
              Address     000c.ce0a.ca00
              Hello Time   1 sec  Max Age  6 sec  Forward Delay 15 sec

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/11           Desg FWD 200000    128.11   Edge P2p
Po1              Altn BLK 200000    128.65   P2p Bound(RSTP)
Po2              Root FWD 2016      128.66   P2p

sw1#
05:32:31: %SPANTREE-2-LOOPGUARD_BLOCK: Loop guard blocking port Port-channel2 on M
ST00.sh spanning-tree active

MST00
  Spanning tree enabled protocol mstp
  Root ID     Priority    32768
              Address     0006.525e.54c0
              Cost        200000
              Port        65 (Port-channel1)
              Hello Time   1 sec  Max Age  6 sec  Forward Delay 15 sec

  Bridge ID   Priority    32768  (priority 32768 sys-id-ext 0)
              Address     000c.ce0a.ca00
              Hello Time   1 sec  Max Age  6 sec  Forward Delay 15 sec

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/11           Desg FWD 200000    128.11   Edge P2p
Po1              Root FWD 200000    128.65   P2p Bound(RSTP)
Po2              Desg BKN*2016      128.66   P2p *LOOP_Inc
```

FIG. 3. Messages during the connection interruption



(a) (b)

FIG. 4. Examples of connection interruption: a) a connection interruption with 10479 audio packets lost during a call; b) a connection interruption with 120 audio packets lost during a call

3. CONCLUSIONS

The purpose of this study was to demonstrate an optical ring network redundancy using the three Cisco Catalyst 2950 switches as core components. To forward data through the alternate link, the Spanning-Tree Protocol Loop Guard was used. For testing the connection, a VoIP call was generated – done through a virtual PBX and a softphone.

Applying the described method, during the experiment, generated good results: while the main route was interrupted, the traffic was forwarded to an alternate route created by STP taking into account the lowest cost. Although, during the call there were some voice packets that got lost, the call didn't stop.

Using the network redundancy, by routing the data packets through other links, the physical security was assured, also canceling the sabotage effects.

The main difficulty for implementing this experiment was to find out the best protocol to match our purpose and to set up the proper software on the devices used within the created network.

A small network was created to test the protocols efficiency, but the solution should be implemented in complicated networks with high traffic. Using VLANs (Virtual Local Area Network), optical fiber cables and network redundancy, for networks with a massive number of users, is beneficial for network operators. The focus is on being able to ensure service continuity, high availability and minimum downtime.

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MODERN PRACTICES FOR MEASUREMENT OF GAS PATH PRESSURES AND TEMPERATURES FOR PERFORMANCE ASSESSMENT OF AN AXIAL TURBINE

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Abstract: *Instrumentation of gas turbines is a wide ranging subject, covering aspects from the minimum required for safe operation to the comprehensive instrumentation of one or more components on a test rig or development engine. This paper refers to the instrumentation required during the development phase of an axial turbine, highlighting the custom designs of total pressure and total temperature rakes and also the numerical results obtained after their virtual testing in CFD environment. The study reveals the factors that influence the designs of pressure and temperature rakes and deals with the technological aspects of manufacturing this type of probes.*

Keywords: *axial turbine, custom design, total pressure rake, total temperature rake.*

1. INTRODUCTION

Worldwide a large number of research organizations have developed their own design practices for the application and evaluation of instrumentation.

In the context of a multitude of geometric and aerodynamic conditions offered by the gas turbine, such as space limitations, static and dynamic stress requirements, operating temperatures and pressure ranges, the total pressures and temperatures as well as static pressures need to be measured with great accuracy.

A probe design will always represent a compromise between dimensional limits resulted from the available space, strength criteria and the adequate aerodynamic probe characteristics to meet the required measurement accuracy.

2. DATABASE AND METHODS

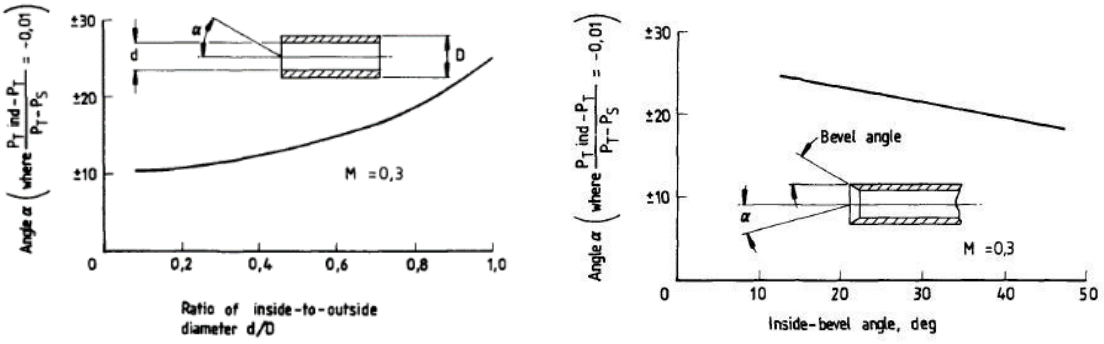
The database used for this study was [1]. The report summarizes various test results conducted on different types of probes and probe geometries over time, leading to a series of guidelines on the application of measurement systems.

2.1 Total pressure rake design. The key factors that influence and ultimately decide the design of a pressure probe are:

- flow direction variation during operating conditions;
- pressure gradients;
- interaction between sensor, sensor support, adjacent sensor, duct wall and upstream or downstream blade rows;
- effect of probe installation on the flow field.

Generally, total pressure can be measured by placing the open end of a tube into the flow field facing the oncoming flow. However, flow direction varies significantly due to the operating ranges of the gas turbines and consequently the probe must be designed in order to meet these requirements, as provided by [1] in "**FIG. 1**.".

Flow direction insensitivity is achieved through a smaller ratio between the inside to outside diameter (thin wall tubes) as indicated in "**FIG. 1**." (a). "**FIG. 1**." (b) indicates an increase in flow direction insensitivity by beveling the inlet of the tube.



(a) (b)

FIG. 1. Variation of angle α with ratio of inside to outside diameter (a) and variation of angle α variation with inside bevel angle (b) [1]

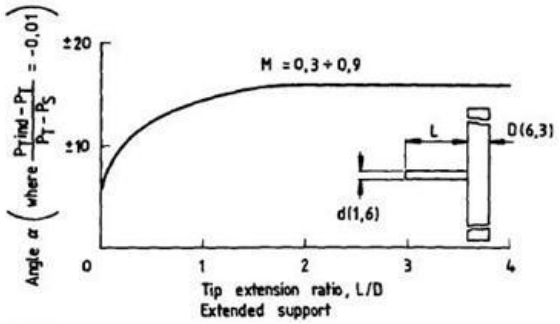
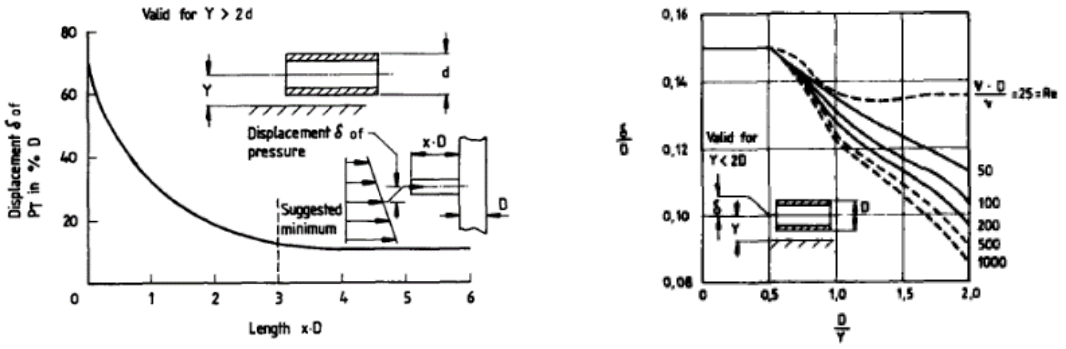


FIG. 2. Variation of angle α with tip extension ratio L/D [1]

The information given above is based on the assumption that the measurement is not affected by the sensor support. Practice however, illustrates that for ratios L/D<3 (L – tube length, D – tube diameter) this effect cannot be neglected, as stem interference will change the flow direction sensitivity of the probe, as shown in "**FIG. 2**."



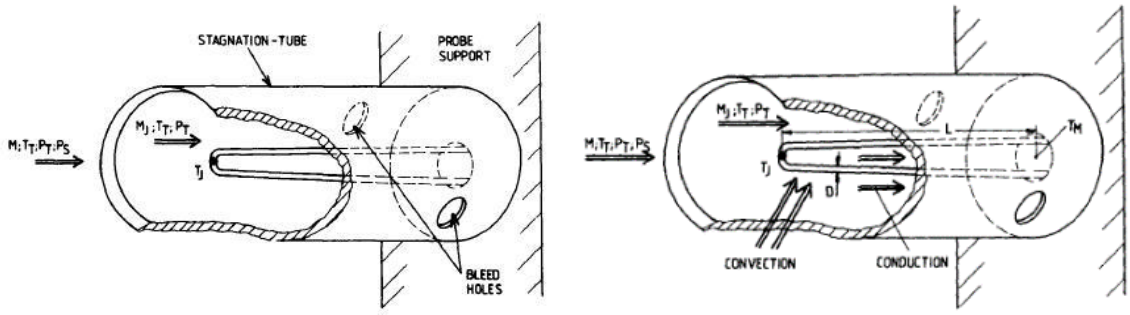
(a) (b)

FIG. 3. The effect of the probe length in a pressure gradient field (a) the effect of shear flow and wall in boundary layer (b)

A pressure probe consisting of a sensing element mounted on a support will deflect the flow so that the indicated pressure is not representative of the actual pressure at the center line of the tube. The stream lines of the flow field become displaced by the presence of the probe. This displacement is a function of the ratio of the length of the sensing element to the diameter of the support [1]. In practice, a ratio d/D>3 (d – length of sensing element, D – support diameter) is indicated to reduce this displacement by up to 10% of the support diameter, as shown in "**FIG. 3**." (a). In a similar way, for distances y<2D (D – stagnation tube diameter) the measured pressure is lower than the pressure at the center line of the sensor, as shown in "**FIG. 3**." (b).

2.2 Temperature probe design. Thermocouples represent the most common gas temperature sensors used in gas turbines development. Their advantages over other sensors are their small size, ease of manufacture, adaptability to high temperature application and costs.

The scope of a temperature probe design is to produce an environment which will allow the thermocouple to measure the gas temperature with the required accuracy, as indicated in "**FIG. 4**.".



(a) (b)

FIG. 4. Typical total temperature sensor [1]

The key factors that shape the design of a temperature probe are:

- velocity error (Y_V);
- conduction error (Y_K);
- radiation error (Y_R);
- catalytic error (Y_C).

Due to the fact that in the probe the gas is not brought to rest adiabatically, the indicated temperature at the junction (T_J) is below the total temperature of the gas (T_T). Thus, the velocity error can be expressed as:

$$Y_V = T_T - T_J = (1 - r) * \frac{\frac{\gamma-1}{2}M_J^2}{1+\frac{\gamma-1}{2}M_J^2} * T_T \quad (1)$$

$$r = \frac{T_J - T_S}{T_T - T_S} \quad (2)$$

Equation (2) defines the recovery factor of a thermocouple, a ratio of the total thermal energy available from the adiabatic deceleration of the gas stream at the junction. The literature [1] recommends that r can be varied between the following limits (bare thermocouple wires):

wires normal to flow r = 0.68 ± 0.07

wires parallel to flow r = 0.86 ± 0.09

As we can observe in the equation (1) by decreasing the Mach number at the thermocouple junction M_J by means of a stagnation tube, the velocity error can be minimized. The expression summarizes various test results presented in the literature [2]. M_J represents a function of the free stream Mach number (M_F), the entry to exit (bleed holes) ratio A_E/A_B of the stagnation tube and the gas density and its expression is:

$$M_J = \frac{M_F}{\left(\frac{A_E}{A_B}\right)}\left(1 + \frac{\gamma-1}{2} * M_F^2\right)^{1/\gamma-1} \quad (3)$$

, where γ - ratio of specific heats

Under the assumption that the thermal energy transferred from the fluid to the junction wires by means of forced convection is equal to the thermal energy transfer by means of conduction along the thermocouple wires and the junction is generally treated as one dimensional fin, as shown in "**FIG. 4**."(b) an expression for the conduction error (Y_K) is obtained:

$$Y_K = T_T - T_J = \frac{T_T - T_M}{\cosh L\left[\frac{4h_e}{D*k_s}\right]^{1/2}} \quad (4)$$

, where T_M - mount temperature (temperature at the thermocouple base) determined by the action of the external environment on the support and the stagnation tube; L - wire length; D - wire diameter; h_e - convective heat transfer coefficient; k_s - thermal conductivity coefficient of the thermocouple wire.

Increasing L/D ratio up to the limit of mechanical stability and space available represents the most effective way of reducing the conduction error. Another way of reducing the conduction error is by selecting thermocouple wires with a very small coefficient of thermal conductivity. In our case, type K thermocouple wires with a thermal conductivity coefficient of 17 W/m/^{o}C.

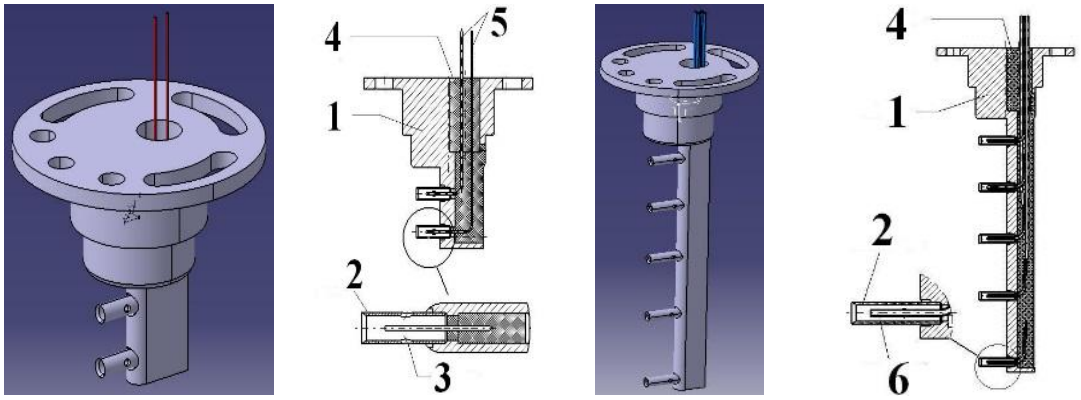
Care must be taken when the thermocouple wires are mounted in the rake body to prevent conduction error. The wires are isolated from the rake body and from each other as well by an insulator composite, as shown in "**FIG. 5**.", containing ceramic fibers. The composite also can fix the wires in the desired position.

3. NUMERICAL SIMULATIONS

In order to obtain, in a direct manner, the total pressures and temperatures in two measurement sections of an axial turbine (inlet section and outlet section), rake probes are needed. The custom design of the rakes results from the uniqueness of each application and its own requirements.

The total pressure rakes as well as the total temperature rakes feature two measurement locations for the inlet section of the turbine and five measurement locations for the outlet section resulted from the available space, as presented in "**FIG. 5**.". Their positions on the probe bodies were determined by the constant mass flow sections.

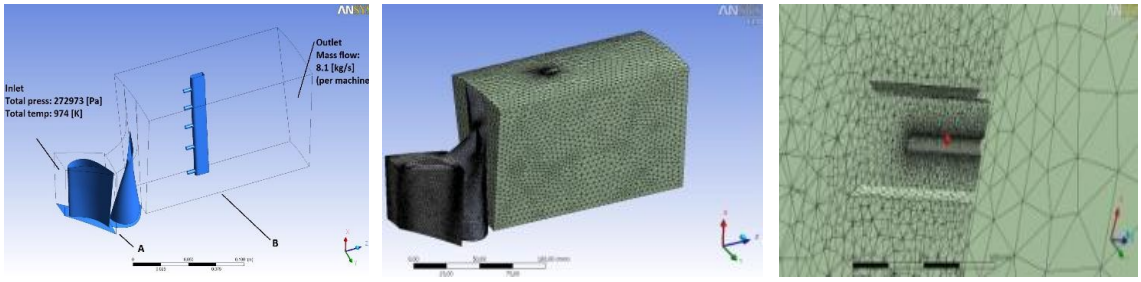
In order to verify the rakes aerodynamic characteristics and simulate the conditions that they will encounter in an experimental axial turbine testing, a CFD analysis has been performed using ANSYS 13.0 CFD software.



(a) (b)

FIG. 5. Total temperature rake inlet section (a) and total pressure rake outlet section (b) (1 – rake body, 2 – stagnation tube, 3 – bleed holes, 4 – insulator composite, 5 – thermocouple wires, 6 – pressure duct)

The geometry subjected to CFD analysis consists in: the third stage of the axial turbine reduced, due to its complexity, to a single stator-rotor passage, featuring frozen rotor type interfaces (A); an outlet duct section featuring instrumentation (a total temperature rake) (B), as shown in "**FIG. 6**"(a).



(a) (b) (c)

FIG. 6. Analyzed geometry (a), entire domain mesh (b) and a detail of the total temperature sensor mesh for the inlet section (c)

Periodic boundaries are used to allow only a small section of the full geometry to be modeled. The mesh used is unstructured, consisting in tetrahedrons, numbering 2403576 elements, as presented in "**FIG. 6**"(b).

"**FIG. 6**"(c) indicates the mesh around the stagnation tube and sensor.

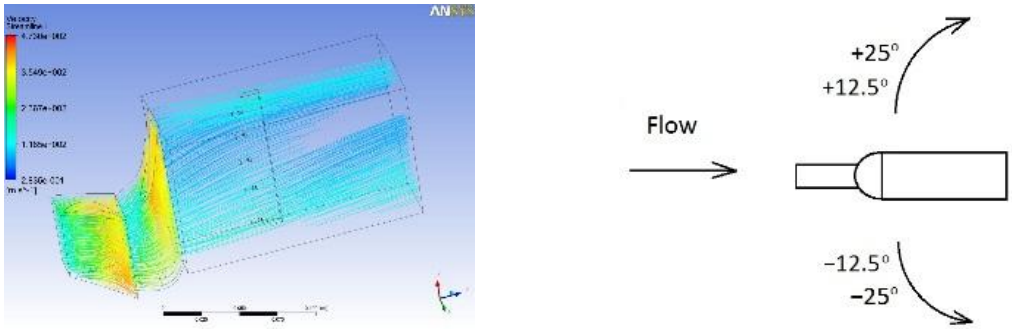
The boundary conditions are extracted from the thermodynamic cycle proposed for the gas turbine to work with this axial turbine (similitude conditions): total pressure at inlet: 272973 [Pa]; total temperature at inlet: 973 [K]; mass flow (at outlet) per machine: 8.1 kg/s.

The rotational speed of the rotor is set to 22000 rpm, the working fluid is air ideal gas and the model used for the simulation case is Shear Stress Transport.

The simulation results are presented in the following section.

4. RESULTS

Due to the fact that the flow direction at the outlet of the stage 3 rotor varies significantly, as we can observe in "**FIG. 7**"(a), numerical simulations with the rake positioned at various yaw angles were performed, as shown in "**FIG. 7**"(b), and the results obtained at the junctions were compared with the reference hub to shroud line located in front of the stagnation tubes in order to analyze their accuracy in the context of flow direction instability conditions.



(a) (b)

FIG. 7. Velocity streamlines and rake position in the flow

In "**FIG. 8**" velocity vectors are plotted in each junction horizontal plane in order to visualize the difference in flow direction. Although the flow direction varies significantly, it can be observed the fact that no vortices are present around the junctions (also in all other rake positions), thus excluding one potential factor that could affect the measurement at the junction.

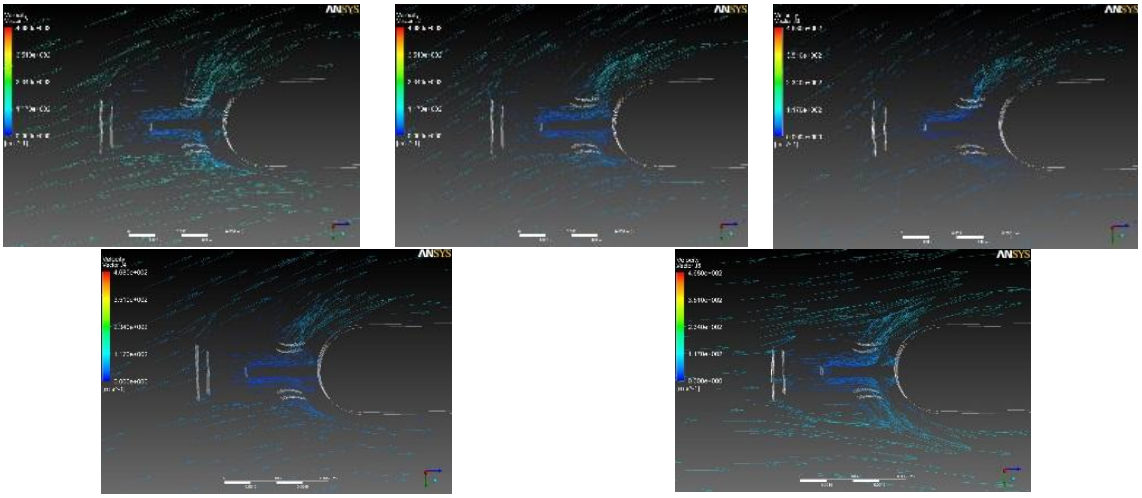


FIG. 8. Velocity vectors for each junction horizontal plane (rake position: 0 degrees)

"**FIG. 9**" presents a comparison between the total temperature measurements at each junction for different positions of the rake in the flow.

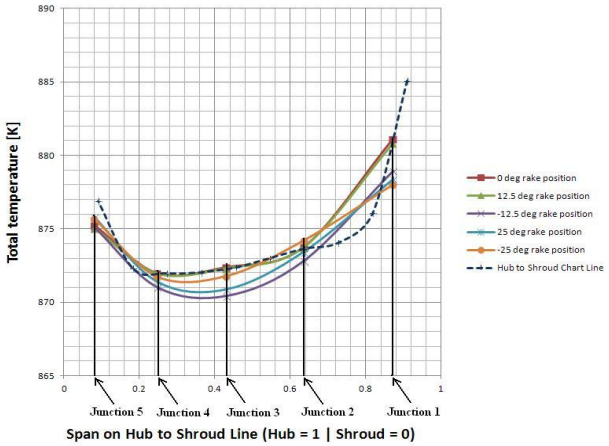


FIG. 9. Total temperature measurements

These results are then confronted with the reference hub to shroud line located in front of the stagnation tubes leading to a maximum difference in reading between the highest and lowest total temperature of 1.21%. The highest total temperature is registered at junction 1 (rake position: 0 degrees) and has a value of 870.41 K while the lowest total temperature is registered at junction 3 (rake position: -25 degrees) and has a value of 870.41 K.

In a similar way, "**FIG. 10**" presents a comparison between the total pressure measurements at each junction for different positions of the rake in the flow.

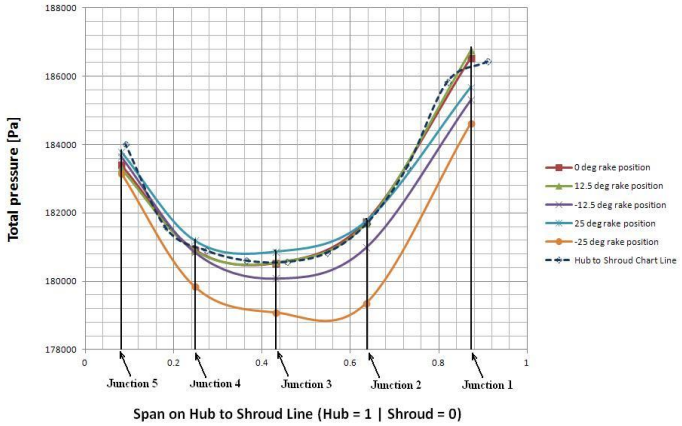
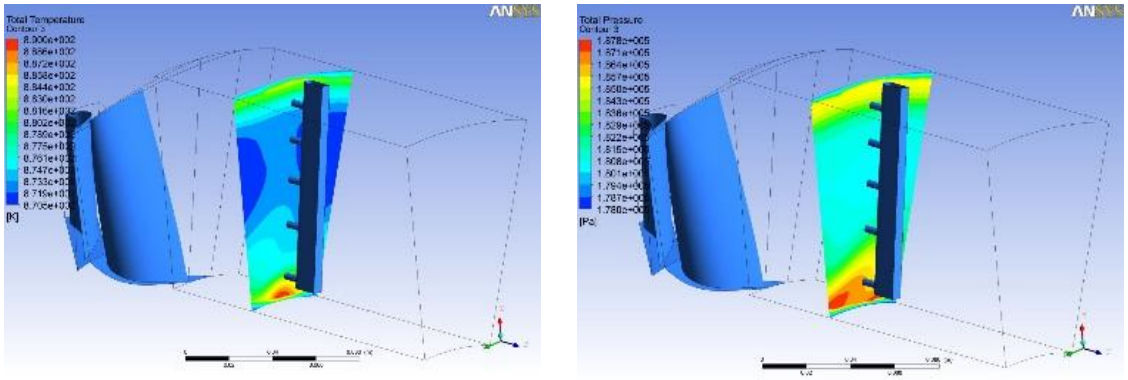


FIG. 10. Total pressure measurements

These results are then confronted with the reference hub to shroud line located in front of the stagnation tubes leading to a maximum difference in reading between the highest and lowest total pressure of 4.1%. The highest total temperature is registered at junction 1 (rake position: 12.5 degrees) and has a value of 186757 Pa while the lowest total temperature is registered at junction 3 (rake position: -25 degrees) and has a value of 179090 Pa.



(a) (b)

FIG. 11. Total temperature (a) and total pressure contours (b) in reference plane

To justify the difference in measurements at each junction, the total temperature contour is illustrated in the plane reference (located at 0.5 mm in front of the stagnation tubes), as shown in "**FIG. 10**" (a).

In order to identify the position of the rake that offers best readings to be used in the calculus of turbine performance, the total temperature area average and total pressure area average are calculated using the ANSYS 13.0 software and used as reference. In our case the values are 874.755 K and 182643 Pa.

The average total temperature per rake position is then calculated and the closest value to the reference mentioned above is 874.78 K (rake position: 12.5 degrees).

In a similar way, the average total pressure per rake position is then calculated and the closest value to the reference mentioned above is 182648.2 (rake position: 12.5 degrees).

CONCLUSIONS

Pressures and temperatures in gas turbines are measured with a variety of probes. This paper focuses on the total pressure and total temperature rakes designs, custom made for the instrumentation of an experimental three stage axial turbine developed at the Romanian Research & Development Institute for Gas Turbines, Bucharest.

The theoretical aspects are covered in the first part of the paper, highlighting the critical factors that determine a rake's design. The rakes' designs presented in this paper are in accordance with these theoretical aspects from the literature.

A CFD analysis is conducted in order to simulate the conditions that these types of probes will encounter in the turbine. Initially, the conditions for measurement are studied, illustrating the velocity vectors in each horizontal plane of the junctions. Even though the flow direction is different in each plane, the condition for measurement is not altered, as no vortices form around the sensors.

From the comparison analyses presented between the total temperature measurements at each junction for different positions of the rake in the flow a resulting 1.21% difference in readings is registered, while from the comparison analyses presented between the total pressure measurements at each junction for different positions of the rake in the flow a resulting 4.1% difference in readings is registered. This indicates the fact that more accurate thermocouples are needed to measure the total temperature in the respective flow field.

Also, the position of the rake that offers best readings to be used in the calculus of turbine performance is identified by comparing area average values for total temperature and total pressure (provided by the software) against the average values obtained at each rake position.

Further numerical studies will be performed at various working regimes of the turbine, recording the parameters and monitoring the reading obtained from the sensors. Their accuracy will be closely monitored to ensure adequate performance calculus that will be finally validated by the turbine experimentation.

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ASPECTS REGARDING THE UNGUIDED ROCKET EFFECTIVENESS

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Abstract: *The inaccuracy on the unguided rockets impact can be caused by many factors, like initial conditions perturbations as a small displacement of the firing pods between two launches due to its oscillations. As a consequence, all those parameters have to be taken into account in order to obtain an efficacy firing. This paper will focus on the unguided rocket effectiveness. Using the physical model for the trajectory, we will study the accuracy of the unguided rocket through a statistical analysis and several target models.*

Keywords: *Ballistics, unguided rocket, accuracy, impact probability and destruction*

1. INTRODUCTION

The unguided rockets are mainly used for missions such us: destroying personnel, military devices, and making target inoperative on large area; slowing down enemy movements, or imposing to enemy troops a specific move; preventing access to specific tactical areas through barrage firing; and providing support by fire tactical maneuvers to friendly troops.

The use of the unguided rockets implies the study of the problematic of their efficiency. Through a preliminary physical and ballistic study completed by some simulations, we tried to set up a model evaluating the efficiency of the weaponry system, in terms of impact accuracy on target [8]. We managed to set up a physical system of trajectories, considering the ballistic parameters. By implementing this theoretical model in numerical methods, we have created a simulating interface for calculating the ballistic results and statistical data. It focuses mainly on the accuracy of multiple rocket launching systems [1]. This algorithm returns useful results and allows to handle different cases corresponding to missions.

2. THE MATHEMATICAL MODEL FOR THE UNGUIDED ROCKET TRAJECTORY

The main goals of external ballistics are to set up equations whose solutions will describe as realistically as possible the unguided rockets trajectory [2]. This requires firstly to have in mind all the aerodynamic forces that are applied to the rockets. Thereupon, this part aims to describe the physical problematic of an unguided rocket flight, by calculating its trajectory system of equations. In addition, a second aim of this paragraph is to realize a numerical model solving this mathematical complex system for one unguided rocket trajectory [3].

As an object moving in the air, the rocket is subject to aerodynamic forces [5]. Those are consequences of the rocket moving in the air. The dynamic pressure distribution P_s on the rocket surface is $P_s = \frac{1}{2}\rho V^2$, which is generated by the movement of the rocket in the air [6]. The aerodynamic forces result from this dynamic pressure, moreover three resultant forces are deduced on each direction from the velocity referential system. All those forces are applied on the centre of pressure [6].

The first is called drag $\overrightarrow{F_x}$, it's opposed to the rocket velocity $\vec{v}$

$$\overrightarrow{F_x} = -\frac{1}{2}\rho V^2 S C_x \overrightarrow{x_v} \tag{1}$$

The second is the lift $\overrightarrow{F_y}$, this force is perpendicular to the velocity:

$$\overrightarrow{F_y} = \frac{1}{2}\rho V^2 S C_y \overrightarrow{y_v} \tag{2}$$

The third is $\overrightarrow{F_z}$, horizontally deviating the rocket :

$$\overrightarrow{F_z} = \frac{1}{2}\rho V^2 S C_z \overrightarrow{z_v} \tag{3}$$

where C_x , C_y $C_z$are coefficients linked to α angle between velocity and rocket longitudinal axis.

The mathematical model of the unguided rocket trajectory [2], [4] is done by the following system of differential equations:

$$\begin{aligned}
&\frac{dV}{dt} = -K_x V^2 - g\sin(\theta_v) + a_r\cos(\alpha_v)\\
&\frac{d\theta_v}{dt} = K_y^{\alpha}\alpha_v V - K_y^{\omega}\frac{d\eta}{dt} - \frac{g}{V}\cos(\theta_v)\\
&\frac{d\theta_h}{dt} = K_z^{\alpha}\alpha_h V - K_z^{\omega}\frac{d\xi}{dt}\\
&\frac{d\alpha_v}{dt} = \frac{d\eta}{dt} - K_y^{\alpha}\alpha_v V + K_y^{\omega}\frac{d\eta}{dt} + \frac{g}{V}\cos(\theta_v)\\
&\frac{d\alpha_h}{dt} = \frac{d\xi}{dt} - K_z^{\alpha}\alpha_h\alpha_h V + K_z^{\omega}\frac{d\xi}{dt}\\
&\frac{d^2\xi}{dt^2} = -K_m^{\alpha}\alpha_h V^2 - K_m^{\omega} V\frac{d\xi}{dt} - \frac{K_{\xi}}{J_{\xi}}\frac{d\xi}{dt}\\
&\frac{d^2\eta}{dt^2} = -K_m^{\alpha}\alpha_v V^2 - K_m^{\omega} V\frac{d\eta}{dt} - \frac{K_{\eta}}{J_{\eta}}\frac{d\eta}{dt}\\
&\frac{dx}{dt} = V.\cos(\theta_v).\cos(\theta_h)\\
&\frac{dy}{dt} = V.\sin(v)\\
&\frac{dz}{dt} = V.\cos(\theta_v).\sin(\theta_h)
\end{aligned} \tag{4}$$

where:

$$a_r = \frac{T_{thr}}{m};\ K_x = \frac{1}{2m}\rho S C_x;$$
$$K_y^{\alpha} = \frac{1}{2m}\rho S C_y^{\alpha};\ K_y^{\omega} = \frac{1}{2m}\rho l_{ref} S C_y^{\omega};$$
$$K_z^{\alpha} = \frac{1}{2m}\rho S C_z^{\alpha};\ K_z^{\omega} = \frac{1}{2m}\rho l_{ref} S C_z^{\omega}$$
$$K_m^{\alpha} = \frac{1}{2J_\xi}\rho S l_{ref} C_m^{\alpha} = \frac{1}{2J_\eta}\rho S l_{ref} C_m^{\alpha};\ K_m^{\omega} = \frac{1}{2J_\xi}\rho S l_{ref}{}^2 C_m^{\omega} = \frac{1}{2J_\eta}\rho S l_{ref}{}^2 C_m^{\omega}.$$

The equation systems (4) is solved using a program presented in Fig. 1

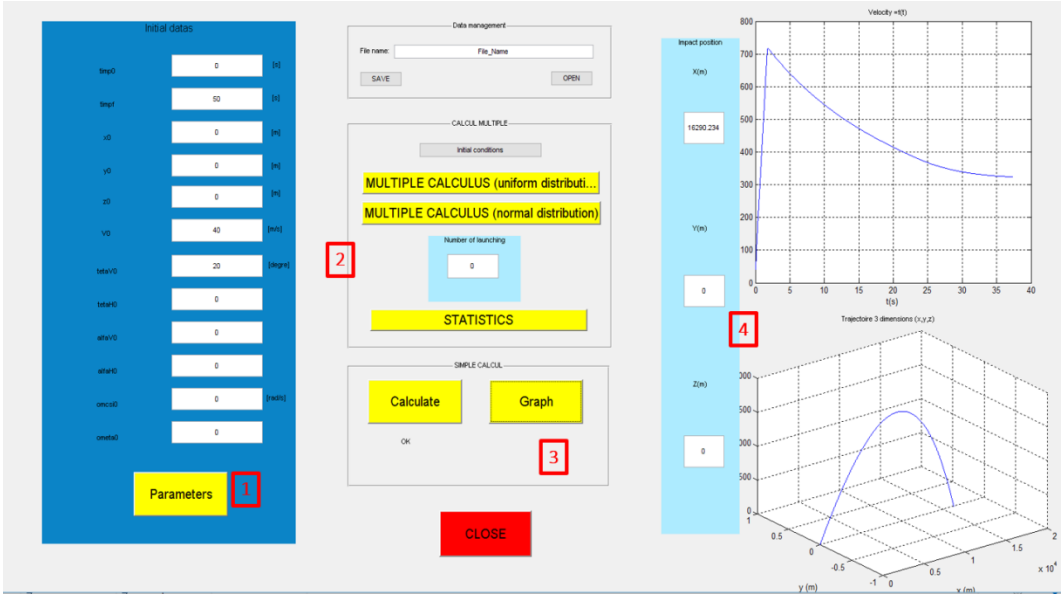

FIG 1. The interface of the computer program used for trajectory model

The program has the following modules:

(1) Initial conditions module;
(2) Multiple launching module;
(3) Single launching module;
(4) The results.

3. NUMERICAL RESULTS

We will use the unguided rocket trajectory (4) solved by the program presented in Fig 1. We have a precise model of target with health gauges, and we will analyze the effectiveness of firing. In this study, a 64 launching campaign will be used with a large scale of perturbation.

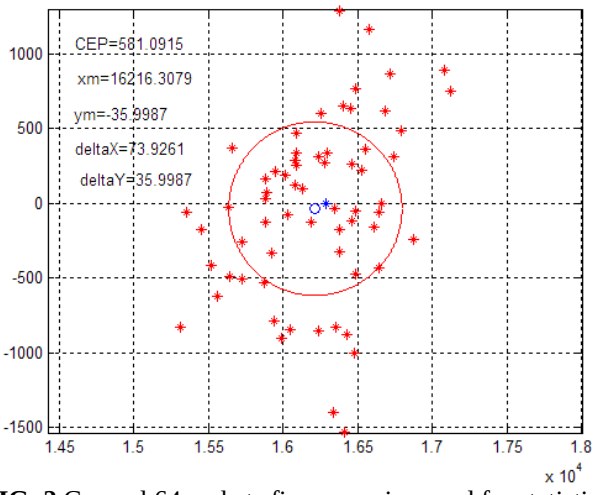

FIG. 2 General 64 rockets fire campaign used for statistic study

Next we will change the number of parts inside the target. We will consider a target with an uncertain position. Therefore the mean point of impact will be situated at 357 m from the centre of the target. Here are the 3 types of target used, seen in Fig 3.

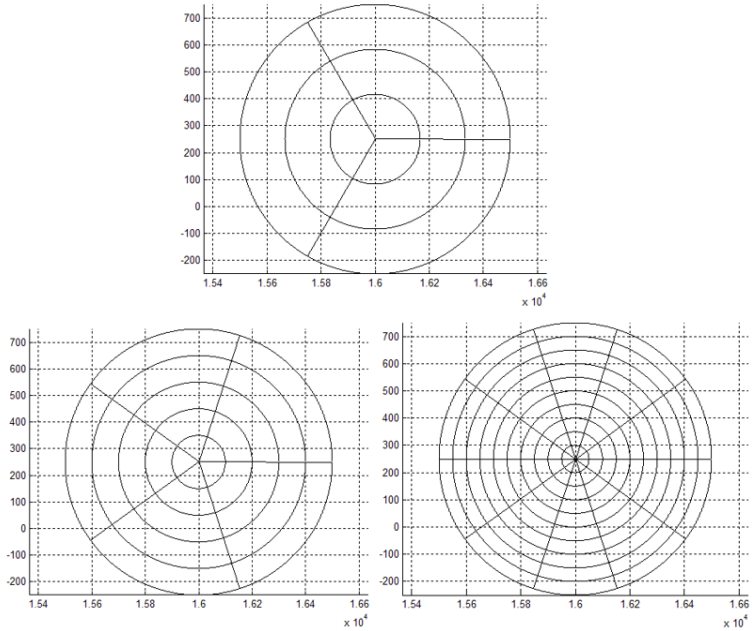

FIG. 3 Target used for comparative study : (3x3), (5x5) and (10x10)

With a small number of parts, the target is totally destroyed with this firing campaign. We see that all the parts suffer hit and even the ones suffering one hit are destroyed because of the shrapnel effect. This target has a total of 180 life points.

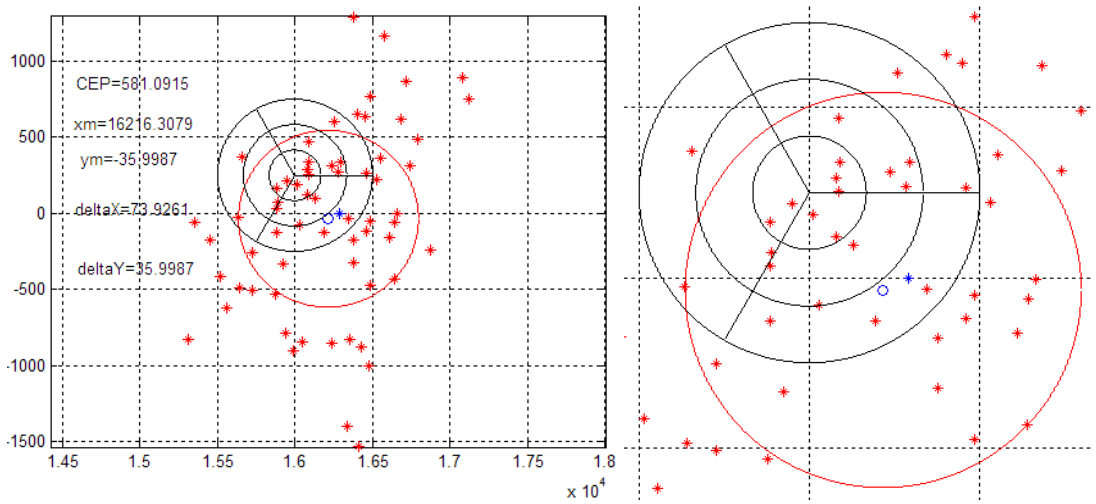

FIG. 4 Large scale target with (3 x 3) parts

CEP= 581.0915 [m]

Median point along X= 16216.3079 [m]

Median point along Y= -35.9987 [m]

Hit probability= 0.34375

Number of part impacted= 9

number of hit= 22

Destruction percentage (%) = 100

Matrix number of hit=	Matrix destruction proportion=
3 2 2	0 0 0
4 1 3	0 0 0
2 2 3	0 0 0

FIG. 5 Results in the case of a large scale target with (3 x 3) parts

Therefore we could add that, to entirely destroy the target with a 34% probability to hit, the first statistical number $D_{95\%}$ of rockets launching in order to obtain a 95% destruction of the target, is:

$$D_{95\%} = \left(\frac{95 * \text{number of life}}{100}\right) * \text{hit percentage}$$
$$D_{95\%} = \left(\frac{95 * 180}{100}\right) * \frac{34}{100} = 58 \quad (5)$$

As we can see on those different schemes results, from 64 launches, only 22 reach the target in 15 parts (Fig. 6 and 7). The hits are distributed on all the rings composing the target. The hit probability is about 34. The additional data of this simulation is the destruction percentage which is about 41%. In that case the target has a total of 3040 life points, $D_{95\%} = 242$.

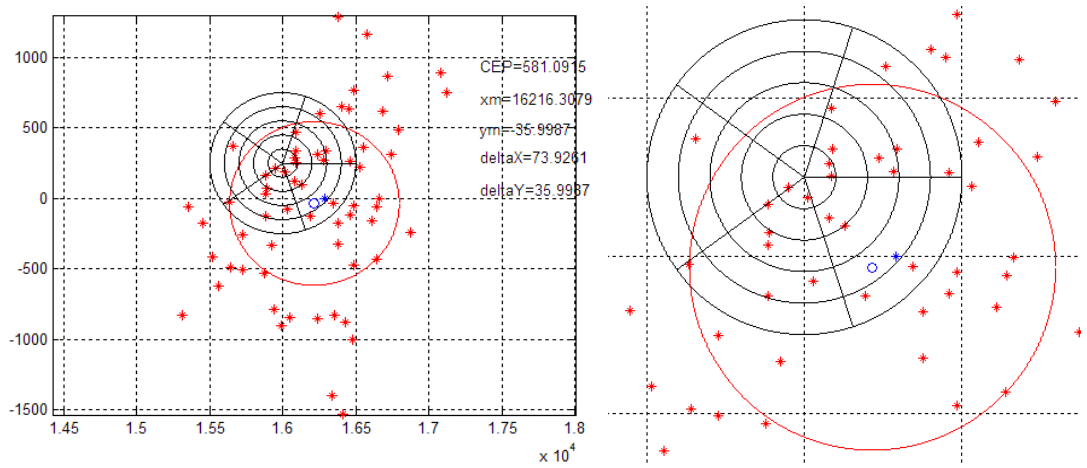

FIG. 6 Large scale target with (5 x 5) parts

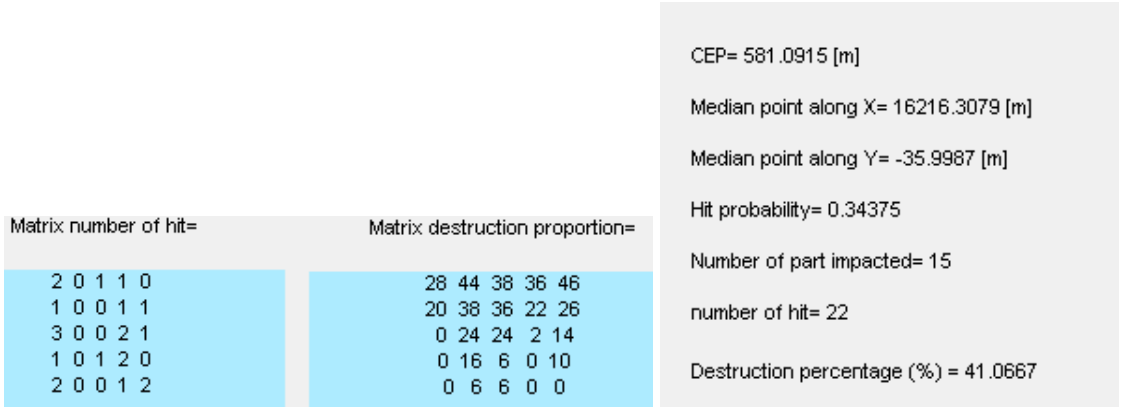

FIG. 7 Results in the case of a large scale target with (5 x 5) parts

With a large number of parts (Fig. 8 and 9), the destruction percentage reaches only 6%, because only 19 parts are impacted and an even fewer number are impacted several times. Therefore only some peripheral ones reach 100% destruction, and the target remains quite unaffected. With a total of 5500 Life points, we have: $D_{95\%} = 1776$.

In this part we have mainly studied the algorithm capacity on several cases. We have seen the way the algorithm was creating random disruption in the initial conditions of launching. How it was able to compute several disturbed trajectories and the impacts on the ground. Furthermore we have conducted a statistic study on the effect of the disruption on the unguided rocket accuracy [7]. In addition the durability of various kinds of targets on several situations has been examined.

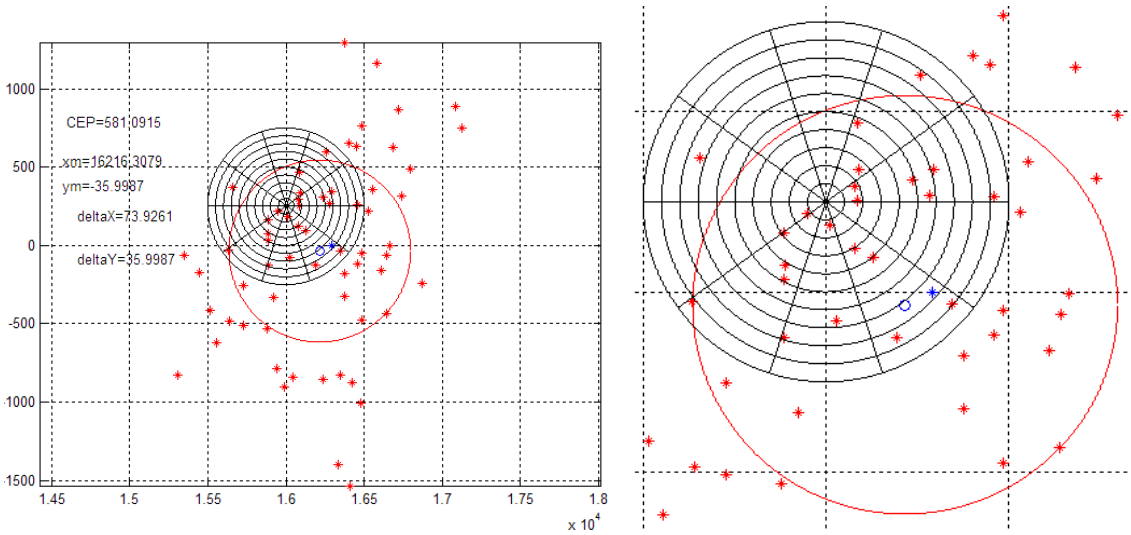

FIG. 8 Large scale target with (10 x 10) parts

Matrix number of hit=

0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	0	1	0	0
0	1	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	1	0
1	1	0	0	0	0	2	0	1	0
1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1	0	0
0	0	0	0	1	0	0	1	0	0
0	1	0	0	0	0	0	0	2	0
1	0	0	0	0	0	1	0	0	0

Matrix destruction proportion=

96	100	100	100	100	98	100	98	100	100
70	84	90	90	88	80	84	80	88	90
74	70	78	80	80	76	70	76	78	80
68	66	70	70	70	70	64	68	58	68
46	48	58	60	60	56	40	54	48	58
36	46	50	50	50	50	46	48	48	50
28	38	40	40	38	40	38	28	38	40
28	28	30	28	20	28	28	18	24	30
16	10	18	20	18	20	18	14	0	16
0	6	10	10	10	8	0	8	6	10

CEP= 581.0915 [m]

Median point along X= 16216.3079 [m]

Median point along Y= -35.9987 [m]

Hit probability= 0.34375

Number of part impacted= 19

number of hit= 22

Destruction percentage (%) = 6.9091

FIG. 9 Results in the case of a large scale target with (10 x 10) parts

This model remains limited by its targets panel, it can only generate circular ones. Furthermore the dividing logic of the targets can be improved, likewise the general geometry. Another way of improving this model would be to realize a Probability to Kill study. For this purpose, the condition when the target is considered killed has to be established. Two kinds of conditions can be chosen. The first one would be hit on some vital points. The second would involve reaching one pre-decided destruction percentage from which the target is considered destroyed.

CONCLUSIONS

In this study we ran a physical analysis conducting to a final equation system whose parameters were included in a ballistic model. Implementing it on computer program by creating a code with an interface, enabled us to find an approximate solution of the system thanks to Runge-Kutta method. It can simulate a trajectory whose order of magnitude in terms of range and velocity is matching with real launching parameters and results. This first code validates our previous ballistic theoretical system.

The last part of the study focused more precisely on validating an algorithm by analyzing multiple launchings [1] campaigns trajectories. This algorithm is able to simulate several launches sequences with initial conditions disturbed. This model aimed to describe the influence of perturbations in the initial conditions that could have big consequences on their accuracy on impact [7].

It also described how the nature of the target according to its position and its capacity to endure direct hits influenced the final results of a multiple rocket launching. The various and precise data resulting from those tests also allowed us to validate this program.

This program can also be developed in several ways. The model describing the probability to kill if hit can also be implemented on the algorithm. In addition, the statistical model more generally used in this program fits with the simple type of target and could be modified according to more realistic parameters.

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AIRPLANE PROPELLERS AERODYNAMIC DESIGN AND PERFORMANCES ANALYSIS

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Abstract: *The present paper analyzes the aerodynamic characteristics of aircraft propellers, starting from the operational requirements of the airplanes they are mounted on and some limitations related to the compressibility effect. The mathematical model for calculation of blade induced speed in the rotation movement is the one based on Goldstein's vortex theory, with approximation of proportionality constant of circulation with the one corresponding to the aerodynamic pitch angle at the tip of the blade. There has been written the integral form of propeller thrust and torque moment, and the dimensionless coefficients of blade and propulsive efficiency have been established. There have been highlighted differences from the fixed wing, with respect to the development of lift force, induced speed generation and limitations regarding the construction and operation of the propeller. Numerical solutions for establishing the thrust and power distribution along the propeller have been obtained for a propeller whose geometrical shape corresponds to a blade of a flight training plane.*

Keywords: *airplane propeller, aerodynamic design, pitch angle*

1. INTRODUCTION

The evolution of modern airplanes, their performances, stability and control are directly related on development and improvement of propulsion systems technology. The thrust, regarded as a reaction force is a result of the momentum and kinetic energy increase of the air which passes through the engine (inlet, compressor, combustion chamber, turbine and nozzle). Applying Reynolds Transport Theorem to a control volume that extends sufficiently far from the propulsion system, so that at the boundary enclosing this volume the air pressure is equal to the ambient (atmospheric) pressure, we have the equation of the thrust, *T*,

$$T = \dot{m}\left(V_{exit} - V_{free\ stream}\right) \tag{1}$$

where $\dot{m}$ is the mass flow rate, V_{exit} and $V_{free\ stream}$ are the velocities where the air exits and enters the control volume. The thrust developed by any propulsion system can be increased either by acting upon the mass flow rate or upon the velocity increment and based on the aircraft propulsion theory, the most increasing thrust is obtained by using a large mass flow rate with a small velocity increment (fig. 1). This requirement is accomplished by the engine-propeller system which produce relatively high flow rates because of the propeller large diameter, this type of propulsion system being the most efficient device commonly used for low speed subsonic flight [1].

One important development in aviation was the introduction of the variable-pitch and constant-pitch propellers, besides others improvements of blade aerodynamic shapes or of movement transmission mechanisms which connect the propeller and the reciprocating or turboshaft engines.

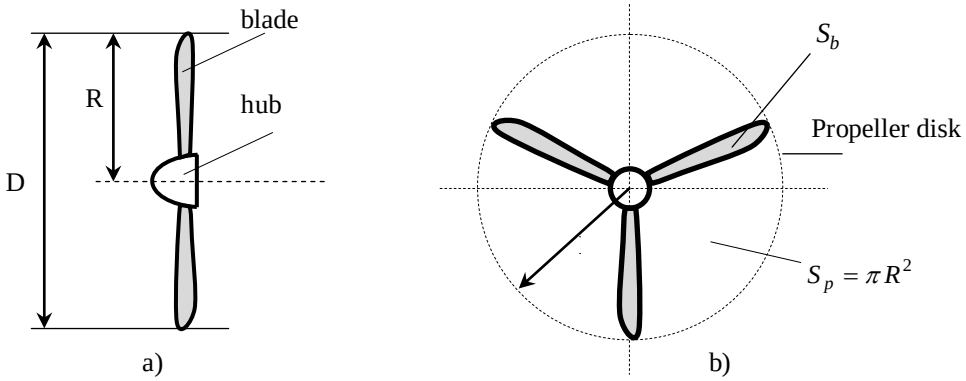

FIG. 1 Propeller geometry: a) lateral view, b) front view

The lift force developed by a wing is directed to support the airplane weight and keep it aloft, whereas the lift developed by a propeller is oriented with the direction of motion [2]. The relative airflow over a propeller blade is a result of its rotation movement, so that, the velocity of each section depends on the distance from the axis of rotation, the propeller blade having much more twist or geometric washout than a conventional wing. The sections close to the axis of rotation move slowly and form a large angle with the plane of rotation, while those close to the tip, move faster and form a smaller aerodynamic pitch angle, $\beta(r)$, which varies with the radial distance, r (fig. 2). The geometric pitch, $\lambda(r)$, represents the distance that a propeller would move forward in each revolution. Since the propeller blade has a finite length, it will be subject to both parasitic drag and induced drag and, taking into account that the drag is defined as the component of the aerodynamic force that is parallel to the relative airflow, the total drag on a rotating blade produces a moment about the axis of rotation that opposes the propeller movement [3]. The axis of propeller rotation being aligned closely with the flight direction, this propeller induced moment leads to a rolling moment which must be countered with an aerodynamic moment produced by a command surface.

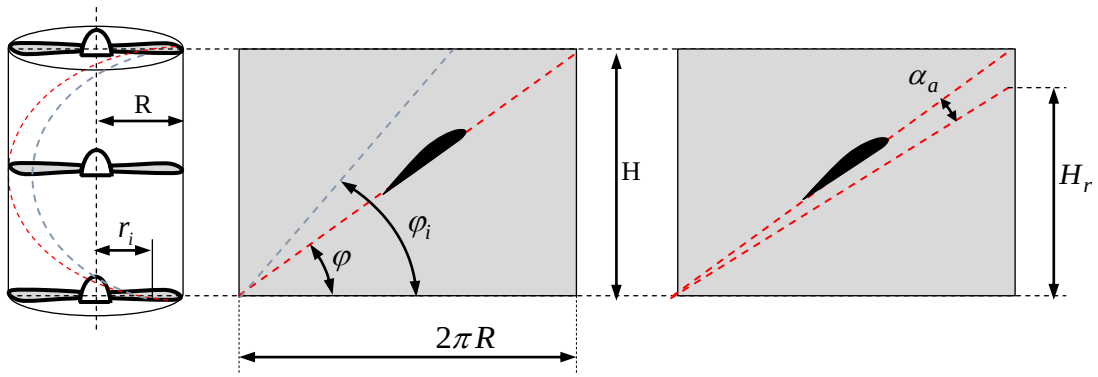

FIG. 2 Propeller theoretical pitch (H) and actual pitch (H_r)

The aerodynamic forces and moments acting on the rotating propeller are also affected by the axial component of the airplane airspeed, because this component of the airspeed is normal to the plane of rotation and it changes the blades angle of attack. This normal component of airflow changes the aerodynamic forces as in the case of finite wing [4].

In the rotation sequence, each blade acts behind the blade that precedes it, so a rotating propeller is equivalent to an infinite series of finite wings, following in a row, one behind the other and the induced velocity is a result so the total downwash generated by all the propeller blades, which are passing repeatedly through the same small section of the flow where the downwash is amplified with each successive pass (fig. 3).

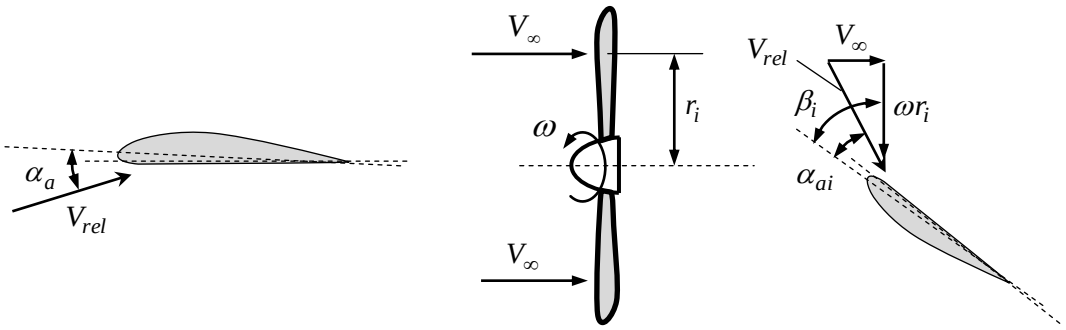

FIG. 3 Propeller velocity triangle

Also, like a wing, the thrust developed by a propeller is a result of the pressure difference between the upstream and downstream of the blade and this pressure difference acting on the air, generates a momentum in a direction opposite to the aerodynamic force acting on the propeller [5]. The engine-propeller combination regarded as a whole, depends on operating conditions and matching the propeller with the engine as well as the matching with the airframe.

2. PROPELLER BLADE THEORY

According to Kutta-Jukovsky theorem, lift force cannot be generated on a rotating propeller blade without the generation of vorticity, that is, for any cross section of a propeller blade, the lift is $L = \rho V_b \Gamma$, where ρ, V_b and Γ are the air density, relative airspeed and circulation. At the blade tip, where the pressure difference between the two sides of the blade cannot be supported, the lift goes to zero and this fact requires that vorticity must be shed from the blade tips of a rotating propeller and also, this shed vorticity produces the induced downwash [6]. The propeller blade tip vortices shed follows a helical path and the region inside the helical trailing vortex system is a region of very strong downwash, which represents the air movement behind a rotating propeller [7].

The velocity induced by each vortex has a component in the circumferential direction because the vortex lines follow a helical path rather than a circular path at any point in space, the resultant induced velocity is the vector sum of the velocity induced by the entire length of all vortex filaments in the slipstream [8]. Computing the velocity induced by the helical vortex system is more complex than for a finite wing and in order to predict this induced velocity we assume that the vortex sheet trailing from a rotating propeller lies along a helical surface of constant pitch and also, this induced velocity is normal to the vector sum of the rotation velocity and forward velocity [9].

3. SOLUTION FOR THE INDUCED ANGLE

From the above considerations to predict the velocity induced in the plane of the propeller disk (fig. 4), the local circumferential component of induced velocity, $V_{\theta i}$, is related to the local section circulation, Γ, by the equation

$$b\Gamma = 4\pi k f r V_{\theta i} \tag{2}$$

where

$$f = \frac{2}{\pi}\arccos\left\{\exp\left[-\frac{b\left(1-\frac{2r}{d_p}\right)}{2\sin(\beta_t)}\right]\right\} \tag{3}$$

and β_t is the aerodynamic pitch angle at the blade tip.

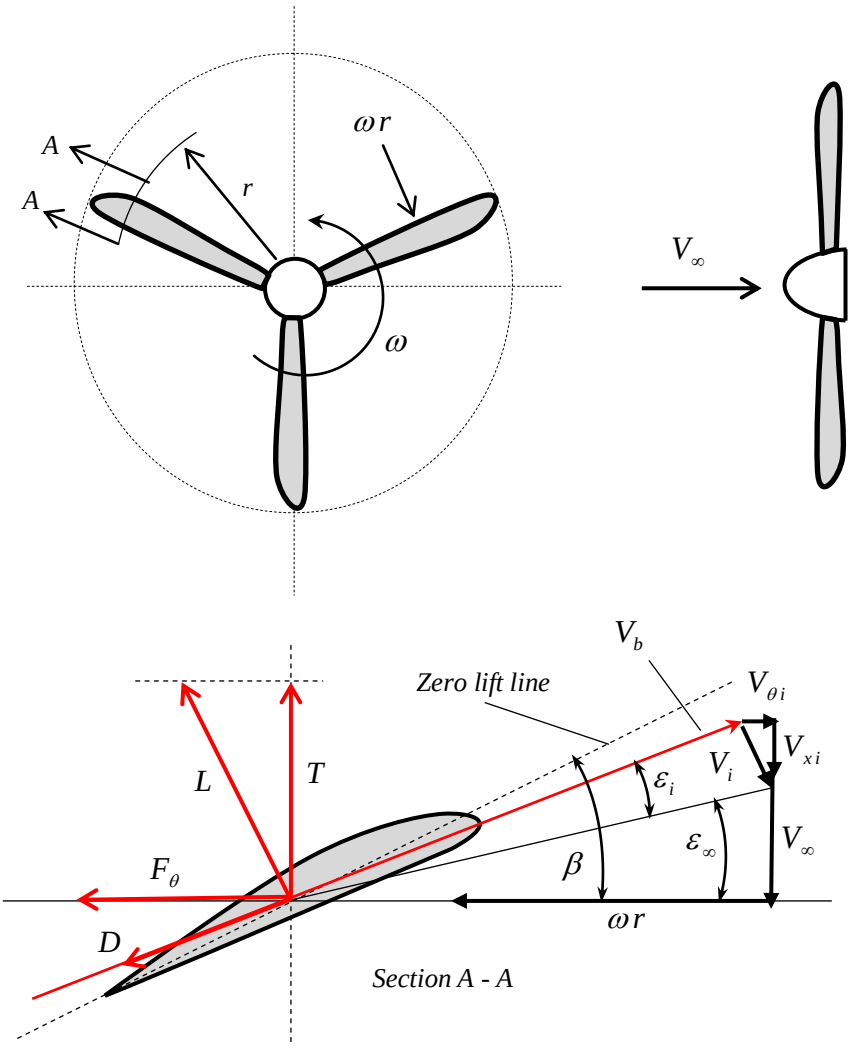

FIG. 4 Forces acting on a propeller blade

The most important component of $\vec{V}_b$ is that given by rotational movement, namely $r\vec{\omega}$. Induced velocity $\vec{V}_i$ has two components, one axial $\vec{V}_{xi}$ and another, circumferential, $\vec{V}_{\theta i}$. Induced velocity is a function of blade radius, where is considered the airfoil. The angles ε_b and ε_∞ can be determined from velocities triangle according to the following expressions

$$\varepsilon_b(r) = \arctan\left(\frac{V_\infty + V_{xi}}{r\omega - V_{\theta i}}\right) \tag{4}$$

$$\varepsilon_\infty(r) = \arctan\left(\frac{V_\infty}{r\omega}\right) \tag{5}$$

From above equations it follows,

$$\varepsilon_i(r) = \varepsilon_b(r) - \varepsilon_\infty(r) = \arctan\left(\frac{V_\infty + V_{xi}}{r\omega - V_{\theta i}}\right) - \arctan\left(\frac{V_\infty}{r\omega}\right) \tag{6}$$

In order to evaluate the thrust T and the circumferential force F_θ , we must write the mathematical expression of lift and drag for an airfoil with the area of $c_b \cdot 1$ where c_b represents the chord,

$$L = \frac{1}{2}\rho V_b^2 c_b \tilde{C}_l; \quad D = \frac{1}{2}\rho V_b^2 c_b \tilde{C}_d \tag{7}$$

The air relative velocity is

$$V_b^2 = (\omega r - V_{\theta i})^2 + (V_\infty + V_{xi})^2 = \omega^2 r^2 \left[\left(1 - \frac{V_{\theta i}}{\omega r}\right)^2 + \left(\frac{V_\infty}{\omega r} + \frac{V_{xi}}{\omega r}\right)^2\right] \tag{8}$$

and this expression leads to the following mathematical formulae for thrust, T and circumferential force F_θ

$$T = \frac{1}{2}\rho\omega^2 r^2 c_b \left[\left(1 - \frac{V_{\theta i}}{\omega r}\right)^2 + \left(\frac{V_\infty}{\omega r} + \frac{V_{xi}}{\omega r}\right)^2\right]\left[\tilde{C}_l \cos(\varepsilon_b) - \tilde{C}_d \sin(\varepsilon_b)\right] \tag{9}$$

$$F_\theta = \frac{1}{2}\rho\omega^2 r^2 c_b \left[\left(1 - \frac{V_{\theta i}}{\omega r}\right)^2 + \left(\frac{V_\infty}{\omega r} + \frac{V_{xi}}{\omega r}\right)^2\right]\left[\tilde{C}_l \sin(\varepsilon_b) + \tilde{C}_d \cos(\varepsilon_b)\right] \tag{10}$$

The above equations have as unknowns V_{xi} and $V_{\theta i}$ which can be estimated according to the vortex theory. The numerical theory can give a solution for induced angle, ε_i , then by integration between the blade hub and tip one can get the thrust and the torque moment

$$\frac{bc_b}{16r}\tilde{C}_L - \arccos\left\{\exp\left[-\frac{b\left(1 - \frac{2r}{d_p}\right)}{2\sin(\beta_v)}\right]\right\}\tan(\varepsilon_i)\cdot\sin(\varepsilon_i + \varepsilon_\infty) = 0 \tag{11}$$

Taking into account the relative velocity expression

$$V_b = \frac{\omega r}{\cos(\varepsilon_\infty)}\cos(\varepsilon_i) \tag{12}$$

one can get the propeller thrust, *T*, and torque moment, *l*, from equations (9) and (10)

$$T = \int_{r_{butuc}}^{r_v} bTdr = \frac{b\rho\omega^2}{2} \int_{r_{butuc}}^{r_v} r^2 \left[\frac{\cos(\varepsilon_i)}{\cos(\varepsilon_\infty)}\right]^2 c_b \left[\tilde{C}_L \cos(\varepsilon_b) - \tilde{C}_D \sin(\varepsilon_b)\right] dr \quad (13)$$

$$l = \int_{r_{butuc}}^{r_v} b \cdot r \cdot F_\theta dr = \frac{b\rho\omega^2}{2} \int_{r_{butuc}}^{r_v} r^3 \left[\frac{\cos(\varepsilon_i)}{\cos(\varepsilon_\infty)}\right]^2 c_b \left[\tilde{C}_L \sin(\varepsilon_b) + \tilde{C}_D \cos(\varepsilon_b)\right] dr \quad (14)$$

The power required for rotating propeller is $P = l \cdot \omega$

CONCLUSIONS

The dimensionless coefficients of the propeller can be determined knowing the platform shape of the blade and based on the pitch length and propeller diameter variations one can determine the advance ratio and pitch to diameter ratio. The thrust, torque and power coefficients are all functions of the chord length ratio and they depends on the blade cross section. The advanced ratio, $J = 2\pi V_\infty / (\omega d_p)$ depends on operating conditions and flight velocity and for any propeller the thrust and power coefficients decrease with increasing advance ratio. For the angles of attack where the blades are out of stall, the thrust coefficient decreases linear with the advance ratio increase, because the angle of attack is nearly a linear function of advance ratio and for large values of advance ratio the thrust became negative, that means that the propeller is operating as a wind turbine. Very large advance ratio can produce negative angles of attack, therefore there are some particular values for which the thrust developed by a propeller goes to zero and the maximum efficiency is attained for one specific value of advance ratio, so, propellers with low pitch to diameter ratios perform best at low advance ratio.

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SIMULATION OF MECHANICAL STRESSES OF A ASSEMBLY CONNECTING ROD

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Abstract: *Designing a software that simulate the state of strength in the material under conditions of strength offers the possibility of creating a virtual laboratory able to make applications to different areas: medicine, constructions, aeronautics. The aim of the paper is to develop interactive software for monitoring the technological process. The paper create interactive programmers for monitoring the results obtained after the analysis with finite elements for a assembly connecting rod. The method can also be applied for monitoring of the mechanical stress nodal of aircrafts, rockets, ballistic missiles and gun barrels.*

Keywords: *strength, von misses stress, finite elements, connecting rod.*

1. INTRODUCTION

The assembly connecting rod is a component of an internal combustion engine. The assembly rod is composed of: a body, a cap and screws. The assembly straight forward movement of the piston to the crankshaft that turns into rotation.

The materials used are fatigue-resistant and high breaking strength: OLC 35,OLC 45, steel allied with: Cr, NI, Mo, OL 50B, OL 60B. [1,2,3]

The assembly connecting rod is required by compressed gas pressure and bubbles. The inertia force of a group piston requires stretching and compression. The variable size of the applied load is required as a fundamental condition: to have superior mechanical strength.

2. STATICAL ANALYSIS OF A CONNECTING ROD AT TRACTION TEST

2.1 Aim of the application

The Generative Structural analysis programming module of CATIA environment allows the simulation of the test pieces mechanical behavior. [4]

2.2 Analysis model processing

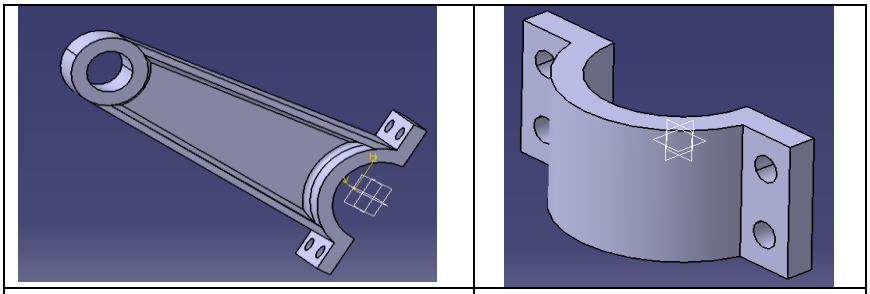
Geometrical modeling

Firstly, the solid model of the connecting rod is designed in the soft CATIA. The body(a) and the cap(b) of model is shown in fig. 1.

Modeling the characteristic o the material

The introduction of the values of the material characteristics necessary for the finite element analysis is made through using the CATIA programmer's library of materials.

The steel material is selected.



(a) (b)

FIG. 1. The model of the connecting rod: the body(a) and the cap(b)

Solving the assembly model

CATIA assembly design packed is launched for generating the assembly between the body and the cap of the connecting rod. The ensemble generate is shown in fig. 2.

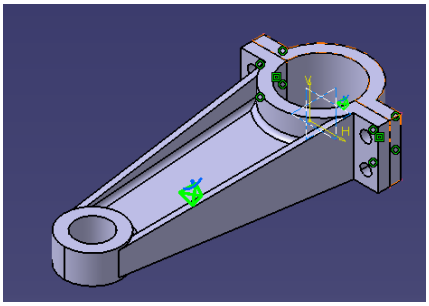


FIG.2 The ensemble between the body and the cap of the connecting rod

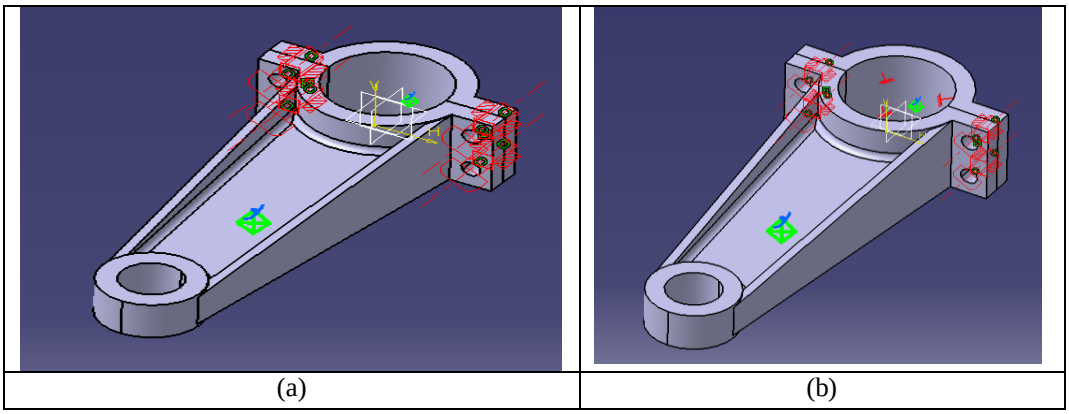
This packet makes the assembly between the body and the cap of the connecting rod when some constraints are imposed: constraints between the surfaces and constraints of co linearity.

Finite element modeling

CATIA Analysis & Simulation packed is launched for generating the finite element. This packet makes the static analysis of the structure when some constraints are imposed and when some stress is independent-time.

They're introduced constraints of bolt tightening connection for constraints of co linearity. The values for these constraints are: tightening force: -100N, orientation: opposite. These constraints are shown in fig.3.a.

They're introduced constraints for displacement: clamp. These constraints are shown in fig.3.b.



(a) (b)

FIG.3 Application of constraints: bolt tightening connection(a), clamp(b)

Load modeling

For load modeling is used: bearing load. The application of force F=3000N is shown in fig.4.

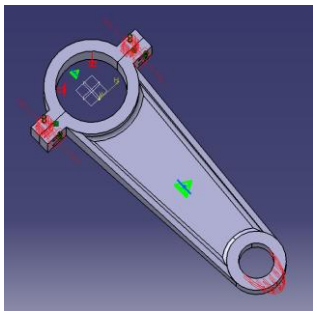


FIG. 4. Applying forces

Solving the model and post processing the result

Then the calculation model is lanched.

Figure no.5 shows the von Mises Stress.

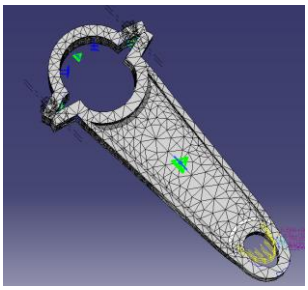


FIG.5 Von Mises Stress

Maximum value for Misses stress is 29.6 e+006 N/m2.

For simulation the traction is used a Wheatstone bridge. [5]

On the basis of the calculation of the bridge, the following equation result, as can be shown below:

$$\varepsilon^2(k^2\Delta u + k^2y^2\Delta u + 2k^2\nu\Delta u - k^2u + k^2\nu^2u) + \varepsilon(4k\Delta u - 4k\nu\Delta u - 2k\nu - 2k\nu u) + 4\Delta u = 0 \quad (1)$$

$$R = 150\Omega, \nu = 0.3, u = 10V, k = 2, \Delta u = masurabil$$

The values of results are shown in table 1.

Table 1. Data results

Δu[mv]	ε[10-5]	Δl[10-3mm]	σ[N/mm2]	F[N]
0.4	2.747	4.39	5.76	2430
0.5	4.121	6.59	8.65	3650
0.75	5.407	8.65	11.354	4791
0.8	5.494	8.79	11.537	4868
1	8.42	13.47	17.68	7461
1.2	9.616	15.38	20.19	8520
1.4	11	17.60	23.1	9748
1.8	13.73	21.96	28.83	12166

3. CONCLUSIONS

The method is a modern one and allows the simulation of the tensile test of the materials. This method permits the geometrical modeling of a test tube, the application of various materials stored in the library of the program, the modifications of these materials, making constraints and force application. The test results are graphically visualized. In this way, the user can simulate the behavior of different materials subjected to tensile test.

The simulation by using Catia software can be used to determine the tensions inside the structure of helicopters (blades), of aircraft's (fuselage, wings), and guns.

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TEMPERATURE AND HUMIDITY MONITOR AND CONTROL SYSTEM

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Abstract: *This paper presents how the environmental parameters can be controlled with a microcontroller circuit.. The software part of the application is performed in C++ and C# programming languages. For the hardware part implementation an Atmel ATmega328p microcontroller, a Bluetooth HC05 module, sensors (temperature, humidity, soil moisture) and DC fan have been used. The data is sent between master and slave devices using Bluetooth communication that is achieved through an UART interface .*

The application is very useful because it allows the user to set the needed thresholds of the environmental parameters and control them. Also, the application incorporates a mechanism by which the user is notified when the thresholds are exceeded.

Keywords: *Bluetooth, sensors, microcontroller, database*

1. INTRODUCTION

Data acquisition systems have seen an impressive development over the years and plays an important role in automation process. The data acquisition process is a branch of engineering dealing with collecting information from a number of numerical and/or analogue sources, the conversion of these data into a digital form, processing, storage and data transmission (e.g. for a computer/laptop through a graphical interface). [1]

Sensors have a significant role in real-time data acquisition process, without which the automation process would no longer exist. The sensors are devices that detects and responds to some type of input from the physical environment. They can measure different parameters : temperature, heat, pressure, humidity, etc. [2]

The content of the project is based on the system design and its characteristic functions, and on the design of the hardware part starting with the electrical scheme. The information captured by the sensors is stored in a database which is accomplished in MySql. Through a graphical interface achieved in C# programming language the data are displayed at certain time intervals. Based on values stored in the database during a day will be created graphs and determining the minimum and maximum values.

2. SYSTEM IMPLEMENTATION

This project can be structured in two major components, both in hardware and software point of view:

1. User interface
   - ✓ Hardware components
     - ○ Laptop/PC

- ✓ Software components
  - C# programming language
  - MySQL database

2. Wireless temperature and humidity monitor and control system

- ✓ Hardware components
  - ATmega328P microcontroller
  - Bluetooth HC-05 module
  - Temperature sensor
  - Humidity sensor
  - Soil moisture sensor
  - 5V DC fan
- ✓ Software components
  - C programming language

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

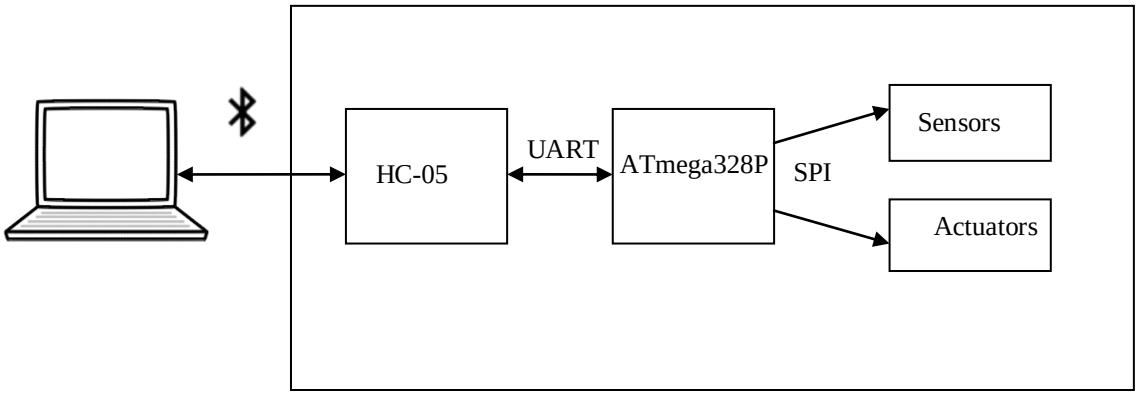

FIG. 1. The system block diagram

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].

HC-05 module is a Bluetooth SPP (Serial Port Protocol) module which is 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) [4].

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. This sensor has as main features the calibration directly in ˚ Celsius, linearity + 10.0 mV/˚C scale factor, 0.5˚C accuracy guarantee able (at +25˚C) , rated for full −55˚ to +150˚C range, suitable for remote applications, low cost due to wafer-level trimming, operating from 4 to 30 volts, less than 60 µA current drain. [5]

The HIH-5030/5031 series low voltage humidity sensors operates down to 2.7 Vdc, often ideal in battery-powered systems where the supply is a nominal 3 Vdc. As features can be mentioned: the low power design, operation down to 2.7 Vdc, near linear voltage output vs %RH. [6]

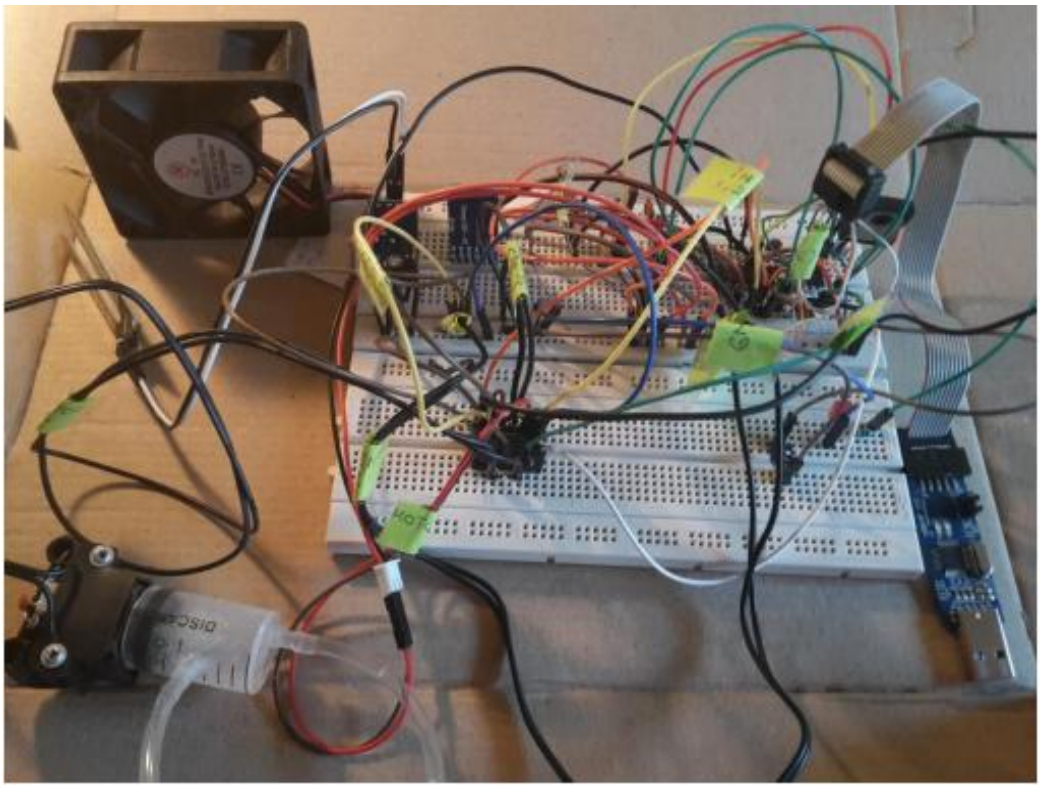

FIG. 2. The hardware part of the system

2.2 Software Implementation

For the implementation of the software part, Atmel Studio v.6 (for designing the microcontroller application) and Visual Studio Express (for the user interface) tools were used.

The programming languages used for this application are C++ and C#. The connection between the Bluetooth module and the hardware circuit is established by the software application. After that, the user needs to set the thresholds of the environmental parameters in order to monitor the temperature and humidity. These parameters are controlled by using the heating and cooling systems.

As example, below are listed a few functions used for developing the microcontroller application:

1) ReadADC() function - the below function is used to read the data from the ADC channel of the microcontroller.

```
uint16_t ReadADC(uint8_t channel_adc)
{

        channel_adc &= 0b00000111;
        ADMUX = (ADMUX & 0xF8)|channel_adc;
        ADCSRA |= (1<<ADSC) ;
        while(ADCSRA & (1<<ADSC));
        uint8_t thelow= ADCL;
        uint16_t theTenBitResults = ADCH<<2 | thelow>>6;

        return theTenBitResults;

}
```

FIG. 3. The ReadADC() function

2) USARTTransmitt() and USARTReceive() functions - The below code snippets are used to transmit and receive data through UART interface. During the data transmission, the 8-bit data is loaded into the UDR0 (UART Data Register) to be transmitted. On the receive part, firstly the whole data should be received and after that the values are stored in UDR0 register.

```
void USARTTransmitt(unsigned char  data)
{
        while(!(UCSR0A & (1<<UDRE0)))
        {
        }
        UDR0=data;
}
```

FIG. 4. The USARTTransmitt() function

```
char USARTReceive()
{

        while(!(UCSR0A & (1<<RXC0)))
        {
        }
        return UDR0;
}
```

FIG. 5. The USARTReceive() function

The user interface consists of two main components: the specific window for setting the needed parameters and selecting the COM port for transmission and the second window for displaying the graphic results.

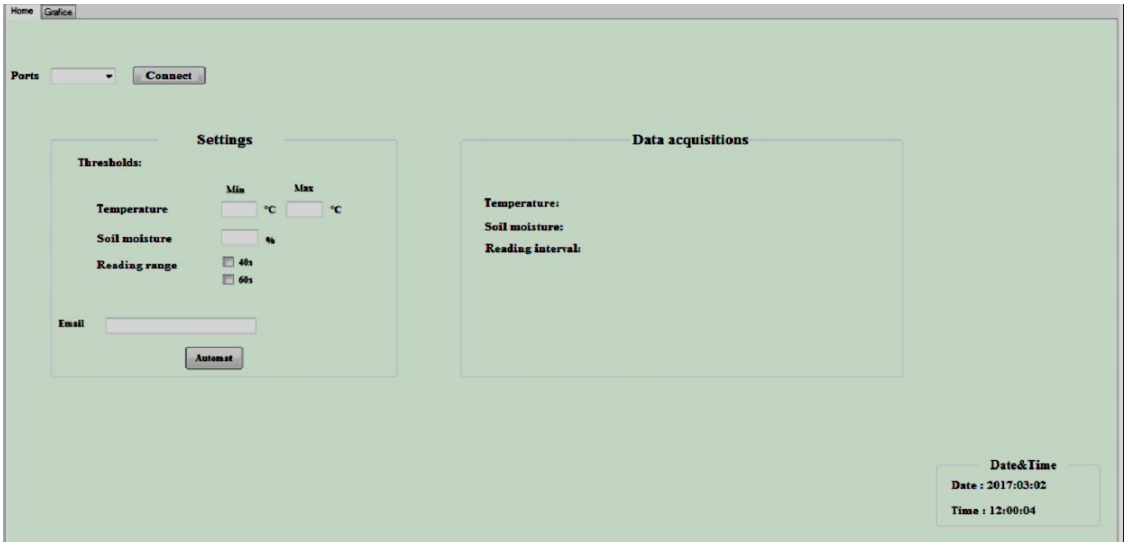

FIG. 6. The user interface

The window shown above allows the user to connect to a COM port after completing the pairing procedure between the Bluetooth module related to the slave module and the Bluetooth adapter of the master (laptop/PC). The user must press the "Connect" button in order for the connection to be fully established. After that, the user must to insert the required values for system operation (e.g. minimum/maximum temperature) and he can also enter the email address to be informed in case of the values are exceeded. When the "Automat" button is pressed the data is automatically transmitted in 2.4GHz wireless bandwidth. The data received from sensors is displayed in the user interface and stored in the database as can be seen in Fig.7.

FIG. 7. Data acquisition window

In the second window is presented how the user can view the data in graphics. He can select any date from past to visualize the graphics for that specific day, as well the minimum and the maximum values.

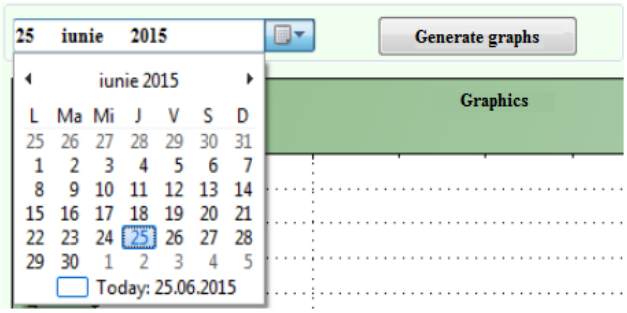

FIG.8 Date Time Picker

As an example, in the below image is presented the variation of the temperature during a specific day selected by the user.

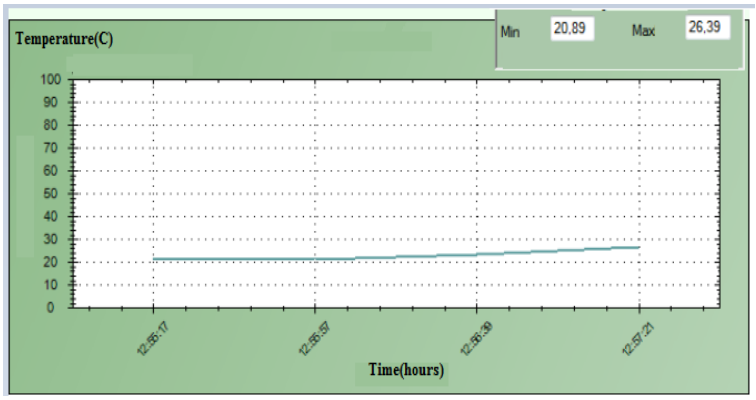

FIG.9 Temperature graph

3. CONCLUSIONS AND FUTURE WORK

The main advantage of the designed system is that it is controlled by wireless communication, so the user can read the values from distance. The devices do not need to be set every time to communicate between them, once they were connected the connection is kept.

Furthermore, a continuously monitoring and controlling of the environment and maintaining a real time updated database, represent as well an advantage.

The system can be improved by extending the software on other devices such as Smartphones, tablets and other gadgets. In order to extend this, an implementation of Android or iOS operating systems will be required.

Another future development is to improve the communication by monitoring the system from more than 10 meters distance via WiFi. ESP8266 module can be used in this purpose.

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THE INFLUENCE OF PRE-FLIGHT BRIEFINGS ON FLIGHT SAFETY

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Abstract: *This paper reveals the importance of pre-flight briefings and discusses the details of conducting effective briefings. It provides guideline about how to organize and conduct efficient pre-flight briefings. The study illustrates the fact that pre-flight briefings constitutes an important part of the flight and may considerable influence the flight safety. It is essential to conduct effective briefings. Only with a proper preparation the crew members will have the necessary abilities to fly at a maximum effectiveness and safety. Briefings should be conducted at different points of the flight, before take-off endless to the arrival gate and even after landing through debriefings.*

Briefings should help all the crew members to understand the logical sequence of events and activities, as well as the state of the aircraft and any special hazards or facts involved in the planned flight sequence. In order to achieved the safety and advantages of standard flight preparation, all crewmembers should take actions for high-quality briefings.

The study concluded that the flight safety is significantly increased through a compliant briefing.

Keywords: *briefing, flight safety, meteorological briefings*

1. INTRODUCTION

Flight briefing is part of the crossover from normal life to the highly active environment of flight. Being an essential part of the flight preparation the briefings are an essential moments for the team building, for the establishment of the leader and a good opportunity to study all the operational data applicable to the flight.

The important parts of pre-flight planning involve[8,11] checking flight information publications, aviation weather reports and determining airplane performance, including the computation of weight and balance and fuel requirements. The influence of altitude, temperature and wind should not be ignored and the pilots should be familiar with the pressure and density altitudes and the effect that they have on aircraft performance [4,6,7,8]. They have to verify the runway length and compare that to their takeoff requirements and the rotational and initial climb speeds recommended in the airplane's manual (POH).

In order to ensure a good cooperation and collaboration between members of the crew and to apply efficient the CRM, briefings should be conducted before each flight. Each crew member should remember that briefings are standardized and they should ignore the fact that a part of the team is familiar with the route, the flight plan or with each other.

This moment is one of the most crucial moments for building-up the synergy, because critical and expandable decisions are made (e.g. loading, fuel quantity, de-icing, diversions en-route).

At the end of pre-flight briefing the crew should have clearly define a mental model of the possible hazards that may arise in condition of normal operations and a mental model of flight plan. Also, the crew should know the procedures that will be use in case of unexpected events during the flight. During the pre-flight briefing, the following objective should be accomplished:

- Set out and communicate the plans of actions and expectation in normal and abnormal conditions;
- Establish practical task sharing (i.e. responsibilities' and duties' of members of the crew);
- Sum up each aspect to its appropriate details' level;
- Bear up questioning and feedback;
- Assure a good and complete understanding and assent of the correct sequence of action;
- Convey to other crewmembers the objectives and amplify the synergy;
- Improve the flight crew preparation for unusual flight conditions or responding to unforeseen conditions.

The quality of the pre-flight briefings forge crew performance throughout the flight. The pre-flight briefing starts at the office of the flight dispatches, when the crew receives the flight plan documentation.

At this stage the preflight briefing should include:

- Acquaintance with airports (departure, arrival, alternates airports) and routes;
- Aircraft state of maintenance ;
- Meteorological conditions for takeoff, landing (e.g. runway conditions, significant weather);
- Fatigue state of each member of the crew;
- Communications;
- Information about the status of the cabin;
- Abnormal procedures (e.g. rejected takeoff, diversion, missed approach);
- Reviews and discussions about takeoff and departures risks.

2. TECHNIQUES FOR CONDUCTING EFFECTIVE BRIEFINGS

Unfortunately, it is often happening to underestimate the importance of briefing techniques[9,12]. Interactive briefing are significant and recommended because they offers the crewmembers the opportunity to communicate, to check, and/or correct as necessary.

The briefing itself should be develop on the logical sequence of flight phases. Moreover, it is very important to avoid the routine and formal repetition of the same points on each sector, because it is often become counterproductive[1,2].

During briefings the speaking should be face-to-face, while the pilots has to remain cautious and vigilant in the monitoring the aircraft and flight progress. The briefing techniques of the captain should encourage effective listening to attract the copilots' attention. There are situations when the crew has to review the significant parts of the previously briefings (e.g. ATC clearance, significant weather, aircraft conditions). These are situations when a re-briefing is adequate.

Nowadays the importance of pre-flight briefing is emphasized from the beginning of pilots training programs within ATOs and military schools[1,2,5], along with a Safety Management System. The future pilots should be aware from initial training program about the influence of the pre-flight briefing on the flight safety.

3. METEOROLOGICAL DOCUMENTATION

A very important part of pre-flight planning is obtaining weather information. It is important to discuss the effects of significant weather conditions on flight. This is not important only for safety reasons but also because being informed about the weather conditions it will decrease the time of reaction.

All weather forecasts are results of the mathematical and statistical models and the pilots should be able to interpret them correctly. Crews must use their knowledge, skills and attitude, together with their experience in meteorological patterns and brief each other concerning atmospheric hazards.

Meteorological information for pre-flight planning and in-flight re-planning shall include any or all of the following information[4,5,6,9,12]:

a) current and forecast parameters (e.g. upper winds, upper-air temperatures);
b) tropopause height and maximum wind (e.g. direction, speed);
c) significant en-route weather phenomena and amendments;
d) take-off forecast;
e) METAR/SPECI (including landing forecasts) for departure, alternate, destination aerodromes;
f) TAF and amendments there to for departure, alternate, destination aerodromes;
g) SIGMET information and appropriate special air-reports;
h) AIRMET information for low-level flights;

Usually, each important airport have a briefing facility. However the pilot is able to interpret the information provided without help. In many countries, an aviation meteorological briefing can be obtained on-line, either in association with the aeronautical information briefing, or separately.

For example, in Romania, ROMATSA offers an Aeronautical Information Portal (http://flightplan.romatsa.ro/init/meteo). This portal, Fig.1. presents detailed information about the parameters necessary for flights, charts, radar and satellite images.

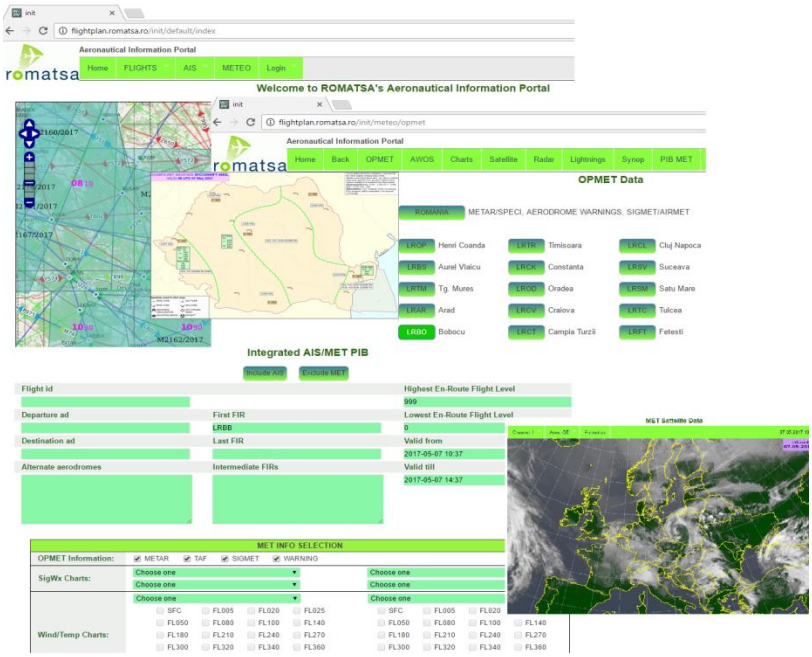

FIG. 1. Brief preview of ROMATSA portal[10]

The standard weather briefing is depicted in Fig. 2. and emphasize the equal importance of all sections included.

According to National Transportation Safety Board – Office of Aviation Safety (NTSB)[11] between 2000 and 2011 were reported 19,441 accidents and 29% of them are weather related. The table 1. and the Fig.3. emphasize the previous information. The same source has informed that in 41% of this weather related accidents the pilots did not obtain, receive or interpret correct the weather documentation.

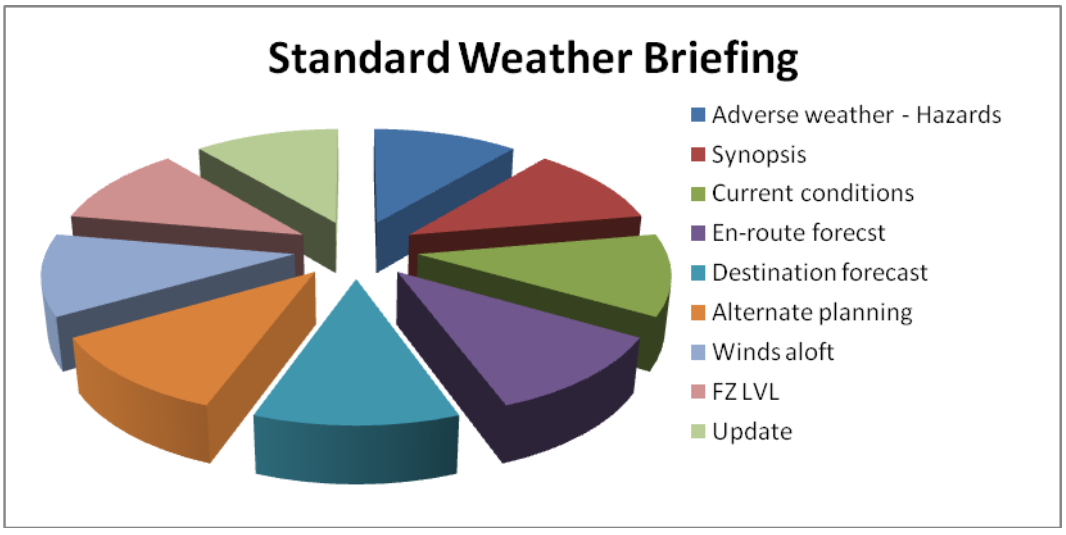

FIG. 2. Standard weather briefing components

Table1. NTSB statistics between 2000 and 2011

NTSB ACCIDENT STATISTICS (19,441 accidents) between 2000-2011	
ACCIDENTS	71%
WX RELATED	29%

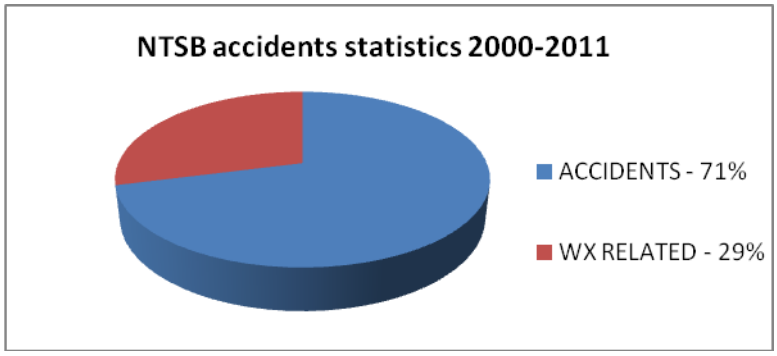

FIG. 3. Standard weather briefing components

The significant weather phenomena are frequently associated with root cause of aircraft accidents or they may be a factor that significantly contributes accidents generation. The analyses of accidents have revealed that adverse wind was the main factor with such a contribution having a 52%. The list[4,11] also includes low visibility (13%), density altitude (6%), carburetor icing (6%), up/downdraughts (4%), clouds (4%), structural icing (3%), turbulence (3%), thunderstorms (2%), sand storm/dust devils (1).

4. PRE-FLIGHT BRIEFING CALCULATIONS

After the analysis of the meteorological documentation has been carried out it is necessary to complete the flight planning calculations, the flight log, the weight and balance calculations and flight plan. A very good pre-flight briefing will significantly increase the flight safety and the potential of the crew members. All the calculations should be done in accordance with the Pilot Operating Handbook (POH)[8].

4.1 Flight planning.

Compass Heading:

$$TC + /- WCA = TH + /- VAR = MH + /- DEV = CH \quad (1)$$

Where CH represents[8,11] the Compass Heading, TC represents True Course, WCA represents the Wind Correction, TH represents True Heading, VAR represents Variation, MH represents Magnetic Heading and DEV represents Deviation.
Estimated time En-route (ETE):

$$Time = Dist./Speed \quad (2)$$

Weight Shift problems:

$$Dist.\,weights\ hifted \times weightshifted = total\ weight \times change \quad of\ C\ of\ G \quad (3)$$

Track error (1in 60 rule):

$$TE = \left({}^{60}\!/_{Dist.\ flown} \right) \times dist.\ from\ the\ track \tag{4}$$

Closing angle (1in 60 rule) :

$$CA = \left({}^{60}\!/_{Dist.\ to\ go} \right) \times Dist.\ from\ the\ track \tag{5}$$

4.2 Aerodynamics[3]

Load factor:

$$G = {}^{1}\!/_{\cos(bank\ angle)} \tag{6}$$

Higher stall speed in a turn:

$$v_{sacc} = v_s \times \sqrt{load\ \ factor} \tag{7}$$

Increased Stall Speed at higher weight:

$$v_{s\ new} = v_{s\ old\ \ weight} \times \sqrt{{}^{new\ weight}\!/_{old\ \ weight}} \tag{8}$$

Lift:

$$L = {}^{1}\!/_{2}\rho v^2 \times S \times C_L = IAS \times C_L \tag{9}$$

Dynamic pressure:

$$IAS = {}^{1}\!/_{2}\rho v^2 \tag{10}$$

True Airspeed:

$$TAS = IAS \times \sqrt{{}^{\rho_0}\!/_{\rho}} \tag{11}$$

Propeller Efficiency:

$$PE = Thrust \times TAS / Brake\ Horse\ \ Power \tag{12}$$

4.3 Aircraft performance.

Pressure Lapse Rate:

$$PLR = 96 \times {T}/{p} \tag{13}$$

Where T is the temperature in Kelvin and p is the local pressure expressed in hPa.
Pressure Altitude:

$$\text{Pressure Altitude} = Altitude + (1013 - QNH) \times 27 \tag{14}$$

Density Altitude:

$$Density\ Altitude = \text{Pressure Altitude} + (OAT - t_{ISA}) \times 120 \tag{15}$$

Specific Air Range (SAR):

$$SAR = \left({TAS}/{power}\right) \times \left({1}/{SFC}\right) \tag{16}$$

Specific Ground Range (SGR):

$$SGR = \left({GS}/{fuel\ flow}\right) = {GS}/{power} \tag{17}$$

Best Specific Fuel Consumption (SFC):

$$SFC = {TAS}/{power} \tag{18}$$

CONCLUSIONS

Due the fact that a good pre-flight briefing significantly increase the flight safety it becomes mandatory for each pilot to accomplish a standardized pre-flight briefing according to the international/national recommendations, rules and regulations. A special attention should be payed to the meteorological parameters, which may change during the flight.

Conducting efficient briefings is the most important part of flight preparation. Without standardized preparation, a crew will not have the adequate situational awareness to fly at maximum performance and safety. Briefings are necessary at different points in the flight from departure runway through the arrival gate.

The essential points to apply to all briefings are:

- Briefings should be applicable to the flight conditions and focus on the items that are relevant for flight.
- Briefings should be interactive and allow for dialogue between the captain, copilot and rest of the crewmembers.

- Briefings should be done during low-workload periods.
- Briefings should be done even if the crew has completed the same flight many times in the past.
- Briefings should cover abnormal procedures.
- Pilots should not focus on one particular aspect of information in a briefing, because important information may be missed.

The de-briefing also play an important role in pilots training and it may contribute to a very good personal development of the crew members.

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PNEUMO-HYDRO-MECHANICAL CONTROL SYSTEM FOR AN AIRCRAFT SUPERSONIC INLET WITH MOBILE RAMP

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Abstract: *The paper studies a plan supersonic inlet with external compression and mobile panel and deals with its control system, based on the second oblique shock-wave positioning and its total pressure ratio recovery. Inlet's gas-dynamic conditioning and control criteria are determined. Based on overall total pressure recovery maximization, inlet's optimal geometry was determined, as well as inlet's main control law (consisting of mobile's panel position with respect to inlet's front Mach number) and its complementary control law. The author has established mobile panel's control system's mathematical model; the block diagram with transfer functions description, based on the above-mentioned model was also provided. Some simulations, concerning the system's stability and quality were performed; furthermore, some conclusions and comment concerning system's time behavior were issued.*

Keywords: *inlet, supersonic, Mach number, control law, angle, shock-wave, pressure, step input.*

1. INTRODUCTION

Aircraft engine inlet is one of the most important components, especially when it's about a supersonic aircraft. On supersonic military jets, the inlets are usually much more complex than on any other aircraft or airplane and use shock waves to slow down the air, together with movable internal parts (ramps, panels, vanes) to shape and control the flow; thus, the inlet is not a simply air duct, but an especially profiled canalization, meant to capture an appropriate air flow from the freestream and deliver it to the engine; the necessary airflow for engine's supply requires some special conditions, concerning the pressure and the velocity in front of engine's compressor (a moderate subsonic value, about Mach 0.4), so such a supersonic inlet will reduce the supersonic freestream to subsonic speed, and will provide an appropriate air mass flow rate to the engine.

Aircraft gas turbine engine requires a supply of uniform high total pressure recovery air for good performance and operation, thus the quality of the airflow in front of the engine will significantly affect its performance; it is well known that a loss of 1% from intake's total air pressure will lead to 0.5÷1.2 % lowering of engine's thrust [4,9], therefore, it is important to maximize the total pressure recovery in front of the engine. The total pressure recovery is defined as the ratio of the airflow's total pressure in front of the engine and the one in the freestream (in front of the inlet). Meanwhile, inlet's design should take into account the induced external drag, which affects aircraft's total drag, as well as the other aerodynamic performances, so inlet's shape and dimensions should be carefully chosen and designed in correlation to those of the aircraft.

The bigger the flight Mach number is, the more important the inlet is and the more difficult its design becomes.

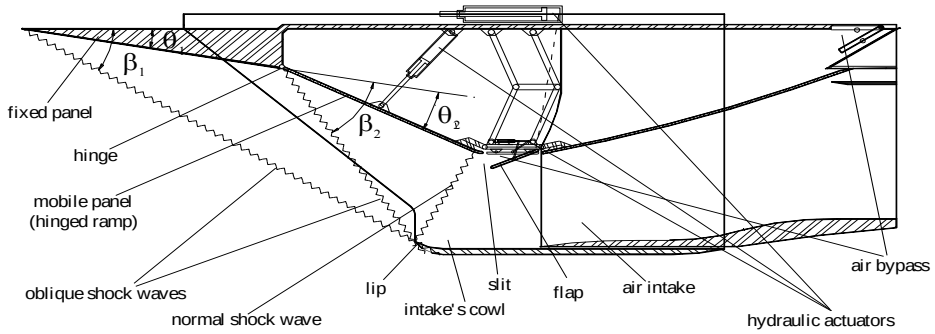


FIG. 1. Supersonic inlet with mobile panel "2+1"-type [12]

Because the inlet is so important to overall aircraft operation, it is usually designed and tested by the airframe company, not by the engine manufacturer; that is the reason because all engine manufacturers also employ aerodynamic engineers for inlet design.

An inlet, no matter its architecture, must operate efficiently over the entire flight envelope of the aircraft. At very low aircraft speeds, or when just sitting on the runway, free stream air is "sucked" into the engine by the compressor.

Meanwhile, at high speeds, an appropriate designed and manufactured inlet will allow the aircraft to maneuver at high angles of attack and sideslip, without disrupting the air flow to the compressor.

The paper is focused on a control possibility of a plan supersonic inlet with a mobile ramp, which operates as external compression inlet. Such an inlet is depicted in Fig. 1, similar to MiG-29's inlet, operating as "1+1" inlet for low supersonic flight Mach numbers and as "2+1" inlet for high supersonic Mach numbers.

2. INLET ARCHITECTURE

The inlet in Fig. 1 consists of an air intake with a mobile cowl and a spike-shape body with two ramps (a fixed panel, mounted at θ_1-angle versus O*x*-axis and a hinged panel, having a variable θ_2-angle), both cowl and mobile panel assisted by hydraulic actuators. During supersonic operating, the inlet has its own shock wave system, generated by the spike and by cowl's lip: one or two oblique shock-wave(s) due to spike's panels and a final normal shock wave attached to the cowl's lip.

The inlet is mounted below aircraft's wing; consequently, in supersonic flight, air speed in front of the air intake is less than the airspeed of the airplane, because of two shock waves: the first one is triggered by aircraft's nose (so it is a conical shock wave), the second one – by aircraft's wing.

The mobile panel could have three different positions, as follows: a) for subsonic flights it is completely retracted ($\theta_2 < 0$), offering to the intake the maximum air-breathing cross-section; b) for moderate supersonic flights, the mobile panel is on the fixed one's direction ($\theta_2 = 0$), extending it (the inlet operates as "1+1"); c) for high supersonic flights the mobile panel has variable position ($\theta_2 > 0$, as Fig. 1 shows), according to the air velocity in front of the inlet.

Inlet's slit, between the mobile panel and the flap, offers the possibility of air bleeding (or works as a by-pass), when the engine's air necessities are lower than the inlet's offer.

For an aircraft designed to reach a flight Mach number of 2.5, air velocity in front of this kind of inlet corresponds to a Mach number of 2.1, because of successive shock down of the air flow through the shock-waves triggered by aircraft's aerodynamic shape.

The air flow could be considered inviscid, with enough calculus accuracy, thus viscous effects and/or losses should be neglected. Inlet's shock wave system form and geometric parameters are depicted in Fig. 2.

Performance criterion for inlet's geometrical optimization is the maximum inlet efficiency, or else, maximum inlet total pressure loss co-efficient (pressure recovery) σ_i^*, given by

$$\sigma_i^* = \sigma_{osw1}^* \sigma_{osw2}^* \sigma_{nsw}^* \sigma_d^*, \tag{1}$$

where σ_{osw1}^*, σ_{osw2}^* are total pressure ratios for the oblique shock-waves, σ_{nsw}^* – total pressure ratio for the normal shock-wave and σ_d^* – total pressure ratio into intake's duct (assumed as constant, no matter the flight regime or the engine regime would be).

Algorithms of geometric optimization of external compression inlets, based on inlet's efficiency maximization, are presented in [10] and applied in [4, 15, 17]. This algorithm aims to determine optimum values of spike's angles θ_1 and θ_2, as well as an adimensional geometry of the inlet.

Terms in the right member of Eq. (1) are given by the aerodynamic and thermodynamic conditions of shock waves, using following equations:

- for the oblique shock waves

$$\sin^2\beta_k = \frac{1}{M_k^2} + \frac{\chi+1}{2}\frac{\sin\beta_k \cdot \sin\theta_k}{\cos(\beta_k - \theta_k)}, \tag{2}$$

$$M_{k_{av}}^2 = \frac{1}{\sin^2(\beta_k - \theta_k)} \frac{(\chi-1)M_k^2\sin^2\beta_k + 2}{2\chi M_k^2\sin^2\beta_k - (\chi-1)}, \tag{3}$$

$$\sigma_{oswk}^* = \left[\frac{(\chi+1)M_k^2\sin^2\theta_k}{2+(\chi-1)M_k^2\sin^2\theta_k}\right]^{\frac{\chi}{\chi-1}} \left[\frac{\chi+1}{2\chi M_k^2\sin^2\theta_k - (\chi-1)}\right]^{\frac{1}{\chi-1}}, \tag{4}$$

where $k = \overline{1,2}$, M_k – Mach number before the shock-wave, $M_{k_{av}}$ – Mach number behind the shock-wave;

- for the normal shock-wave

$$M_{av}^2 = \frac{(\chi-1)M_k^2 + 2}{2\chi M_k^2 - (\chi-1)}, \tag{5}$$

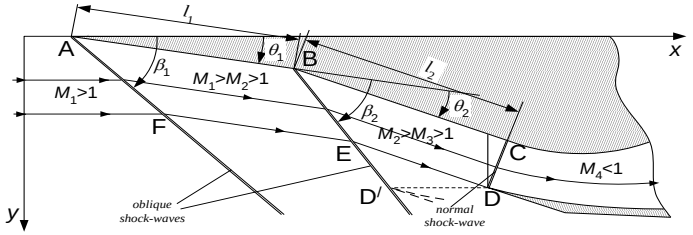


FIG. 2. Supersonic inlet "2+1"-type geometry

$$\sigma_{nsw}^* = \left[\frac{(\chi+1)M_k^2}{2+(\chi-1)M_k^2}\right]^{\frac{\chi}{\chi-1}} \left[\frac{\chi+1}{2\chi M_k^2 - (\chi-1)}\right]^{\frac{1}{\chi-1}}, \tag{6}$$

where M_k – Mach number before the normal shock-wave, M_{av} – Mach number behind the normal shock-wave, χ – air's adiabatic exponent.

First inlet configuration design issue is the determination of the spike's angles values, starting from the nominal Mach number value in front of the inlet. For a flight Mach number in front of the inlet $M_1 = 2.1$ one can apply the algorithm, in order to obtain the maximization of σ_i^*. One has obtained (as presented in [17]) for a fixed geometry inlet, the results: $\theta_{1_{opt}} = 11.14^\circ$, $\theta_{2_{opt}} = 12.22^\circ$, $l_1 = 0.8849$, $l_2 = 0.7624$ and the coordinates of the characteristic points as A (0,0); B (0.874; 0.142); C (1.569; 0.454); D (1.324; 1), as Fig. 2 shows.

For different M_1 Mach numbers, $M_1^{/} < M_{1_{nom}}$, but fixed inlet geometry, both external oblique shock-waves are depleting, so angles β_1 and β_2 in Fig. 2 are growing, which means that pressure recovery coefficient σ_i^* and flow coefficient C_D are modifying too. While σ_i^* can be calculated with above-mentioned formulas ((1), (4) and (6)), C_D is represented by the ratio of inlet's effective air-breathing area $A_H / A_{1^{/}}$, which is exactly the co-ordinate y_F in Fig. 2.

3. INLET CONTROL LAWS

3.1. Mobile ramp motion law. Operation of an inlet with fixed geometry architecture means a lot of losses from air flow rate's point of view, especially for low or medium Mach numbers, when flow coefficient C_D is far from the maximum value 1 and it could lead to buzz behavior of the inlet, especially when the engine's regime decreases. In order to grow the C_D-value, an appropriate solution is to keep the second oblique shock-wave tangent (attached) to the cowl's lip, by progressively growing the second spike angle θ_2, by rotating the mobile panel about its hinge. The condition of attaching the shock-wave is to keep constant the $\beta_2 -$angle, which means that one has to find the value of θ_2 which generates such an angle, with respect to the Mach number in front of the inlet; consequently, one has to solve the implicit equation

$$\sin^2\beta_2 = \frac{1}{M_2^2} + \frac{\chi+1}{2}\frac{\sin\beta_2 \cdot \sin\theta_2}{\cos(\beta_2 - \theta_2)}, \tag{7}$$

where β_2 is the constant angle value, given by the position of points B and D in Fig. 2, $\theta_2 -$equation's argument, $M_2 -$Mach number behind the first oblique shock-wave and before the second oblique shock-wave, which is given by the value of Mach number in front of the inlet and the spike's first angle θ_1. Eventually, one obtains a dependence $\theta_2 = \theta_2(M_1)$, as shown in Fig. 3, curve I, which is a possible motion law for the mobile panel and a theoretical control law for the inlet.

The curve in Fig. 3, determined in [17], is a bit non-linear and can be described as:

$$\theta_2(M_1) = 40.07 \cdot M_1^3 - 265.397 \cdot M_1^2 + 603.895 \cdot M_1 - 456.623\,[^\circ]. \tag{8}$$

Aerodynamics studies have proved that small values for spike angles (under 4^o) didn't generate appropriate oblique shock-waves [9, 11], so, in order to avoid the shock wave's detaching, the variation domain of θ_2 should begin at values bigger than $M_1^{//} = 1.8$, which correspond to a minimum value $(\theta_2)_{\min} = 4.2^\circ$, so the aspect of the control law should be as the curve II in Fig. 3 shows [17].

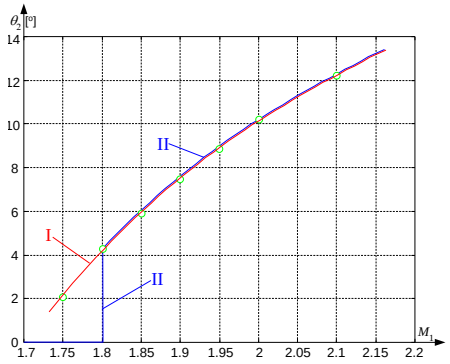


FIG. 3. Inlet's control law (mobile panel's angle versus Mach number in front of the inlet) [17]

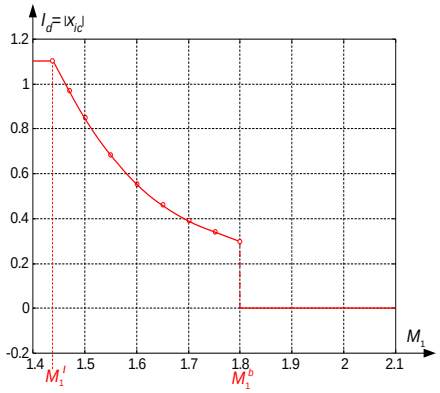


FIG. 4. Intake's cowl displacement (inlet's complementary control law) [17]

Consequently, the inlet operates as "1+1" external compression device until the airspeed in front reaches a Mach number $M_1 = 1.8$, because the fixed panel and the mobile one are building a single-flare spike $\theta_2 = 0^\circ$; for a Mach number $M_1 = 1.8$ the mobile panel moves sudden at $(\theta_2)_{\min} = 4.2^\circ$, then, over this limit, the inlet behaves like a "2+1" external compression device, but with the second oblique shock-wave tangent to its cowl lip, until the nominal flight Mach number value $(M_1)_{\text{nom}} = 2.1$ is reached, as determined in [17]. Inlet's flow rate characteristics is improved.

3.2. Intake's cowl displacement (complementary law). Inlet's behavior may be also improved for the "1+1" operation, from the flow rate characteristics point of view. Thus, in order to assure the maximum value of the flow coefficient C_D, the oblique shock-wave should be tangent to the cowl's lip, no matter the Mach number in front of the inlet.

Since the spike has a fixed single flare, the only adjustment possibility remains intake's cowl displacement; therefore, a complementary law can be issued, which is intake's cowl positioning x_{ic} with respect to the Mach number in front of the inlet M_1.

According to Eq. (2) and as Fig. 2 shows, the oblique shock-wave's angle β_1 is given by the spike's angle θ_1 and the Mach number M_1, while D-point's co-ordinates are fixed. Intake cowl's displacement should reduce till cancellation of the distance between the cowl's lip and the oblique shock-wave, which means that D-point's new position must be D$^/$; therefore, one has to determine the complementary law as:

$$x_{ic}(M_1) = x_{D^/}(M_1) - x_D = \frac{1}{\text{tg}\beta_1(\theta_1, M_1)} - 1.324\,. \tag{9}$$

From the intake's position point of view, when the Mach number in front of the inlet decreases, the cowl must be extended, so its extension should be equal to $|x_{ic}|$.

The complementary law for the intake's cowl displacement is graphically represented in Fig. 4; it has three important zones: a) the first zone, for subsonic and low supersonic airspeeds ($M_1 < M_1^/ = 1.438$), when the cowl is completely extended, b) the second (nonlinear) zone, between $M_1^/ = 1.438$ and $M_1^b = 1.8$ airspeeds. Respectively c) the third high supersonic airspeeds zone ($M_1 > M_1^b$), when the cowl is completely retracted. When the Mach number M_1 becomes equal to M_1^b, the cowl must be sudden retracted.

4. AUTOMATIC CONTROL SYSTEM'S MODEL

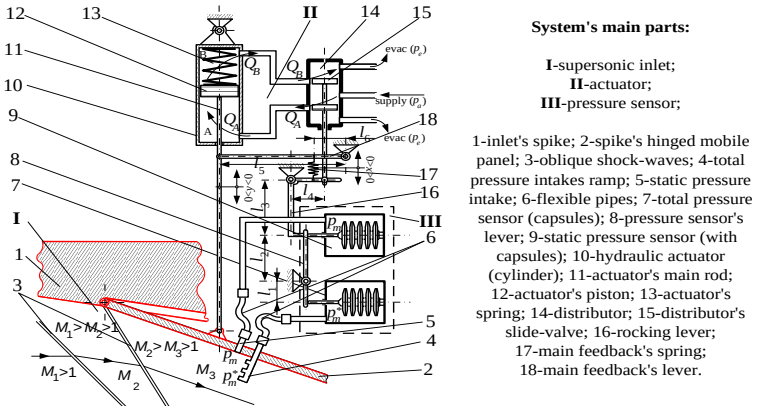


FIG. 5. Supersonic inlet's automatic control system's architecture [17]

4.1. Control system's architecture. The automatic control system is depicted in Fig. 5. It consists of a mobile panel (of the inlet's spike) with pressure intakes, a pressure sensor (with two capsules, one for the total pressure, the other for the static pressure) and a hydraulic actuator with a slide-valve distributor and a rigid feedback. System's main parts are identified in Fig. 3. Pressure intakes are positioned so as they measure the average total pressure p_m^*, a well as the average static pressure p_m behind the second oblique shock-wave. Pressures ratio φ_w, from aerodynamic and thermodynamic points of view, is a function of the Mach number behind the second shock wave M_3, as follows:

$$\varphi_w = \frac{p_m^*}{p_m} = \left(1 + \frac{\chi - 1}{2} M_3^2\right)^{\frac{\chi}{\chi - 1}}. \tag{10}$$

Inlet's control law, with respect to the flight regime, as determined in [14], has a form depending on the Mach number in front of the inlet M_1. Thus, Mach number(s) behind the shock-wave(s) (M_2 and/or M_3) are depending themselves on M_1. One may affirm that the pressure ratio behind the oblique shock-wave(s) should be preserved, which involves the panel repositioning with respect to the Mach number.

The inlet operates both as "1+1" and as "2+1" external compression device; for low values of Mach number M_1, the mobile panel is kept on its initial position (as an extension of the fixed panel of the inlet); after $M_1 = 1.8$ the mobile panel will be positioned with respect to the flight Mach number. To modify the Mach number means to modify the pressure balance, as well as pressure's ratio; when the mobile panel is repositioned, pressure ratio should be restored, in order to assure the same position of the second oblique shock-wave. Positioning law (8) is a non-linear one, but it could be linearised, accepting a mobile panel positioning error and, obviously, a better correlation with the complementary control law (which means the inlet cowl's displacement).

4.2. Control system's mathematical model. Non-linear mathematical model consists of each part's motion equation, but its form is impossible to be used for further studies. Based on the small perturbation hypothesis one can linearize these equations and, after appropriate transformation, they can be brought to an adimensional simplified form. This algorithm, completed with the Laplace transformation applying, is described in [16] and also applied in [2, 13, 14, 15]; in this particular case one obtains for each part as follows:

$$k_{mt}\,\overline{p_m^*} - k_m\,\overline{p_m} - k_r \bar{y} = \bar{x}, \tag{11}$$

$$k_x\bar{x}-\tau_y s\bar{y}=(\tau_{Ap}s+1)(\overline{p_A}-\overline{p_B})\approx(\overline{p_A}-\overline{p_B}), \tag{12}$$

$$\bar{y}=k_y(\overline{p_A}-\overline{p_B}), \tag{13}$$

where the coefficients involved in the equations are determined in [17].

System's transfer functions can be obtained based an the above-presented equations and have similar forms, as follows:

$$H_{mt}(s)=\frac{k_x k_y k_{mt}}{(k_y\tau_y s+k_r)}\overline{p_m^*},\ H_m(s)=-\frac{k_x k_y k_m}{(k_y\tau_y s+k_r)}\overline{p_m}. \tag{14}$$

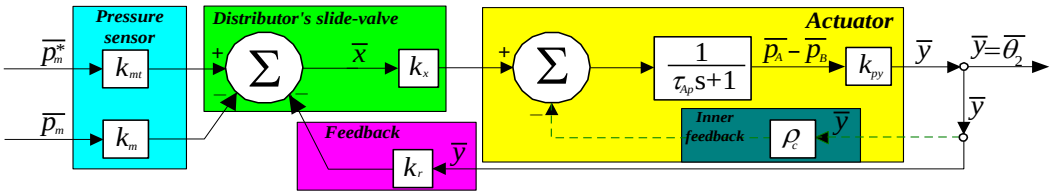


FIG. 6. System's simplified block diagram with transfer functions

System's block diagram with transfer functions is presented in Fig. 6; one should observe that the system has an outer rigid feedback, but its actuator may have its own inner feedback [16], in order to improve system's quality.

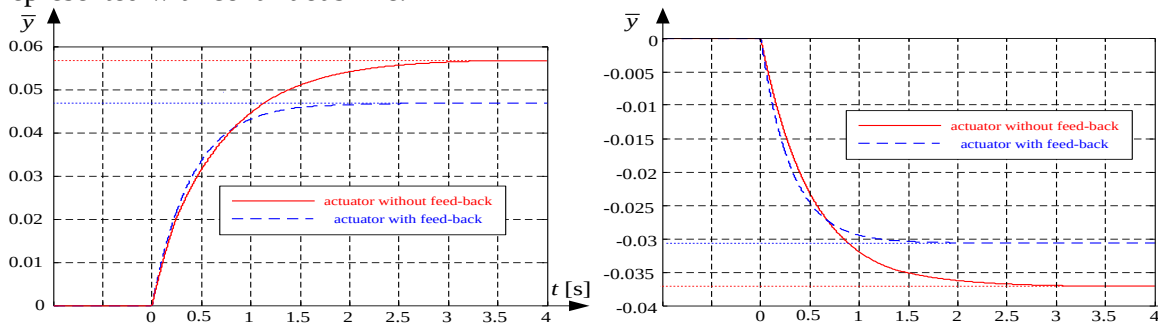
5. ABOUT SYSTEM'S STABILITY AND QUALITY

Since transfer functions expressions are first order, as far as one chooses appropriate values for the system's geometric parameters, the above-studied system should be always a stabile one. The conditions of stability ($k_y\tau_y$ and k_r to have the same sign, in this case strictly positive) are identically fulfilled if one chooses the values of the pressure sensor's lever arms as

$$l_1=\frac{S_a p_{m0}^2 l_4}{p_{m0}^*(l_3k_{r2}-l_3k_{r1}+S_a p_{m0})},\ l_2=\frac{S_a p_{m0}^2(S_a p_{m0}-l_3k_{r1})}{p_{m0}^* l_4 k_{r2}(l_3k_{r2}-l_3k_{r1}+S_a p_{m0})}, \tag{15}$$

which are depending on: capsules' surface area S_a, rocking lever arms length l_3, l_4, capsules' elastic constants k_{r1}, k_{r2}, steady state regime's values for pressures p_{m0}^*, p_{m0}.

In order to evaluate system's quality some simulations were performed, regarding system's output $\bar{y}$ behavior as time response, considering both situations of step inputs: a) step input of $\bar{p}_m^*$ and constant $\bar{p}_m$, respectively b) step input of $\bar{p}_m$ and constant $\bar{p}_m^*$. Results are graphically presented in Fig. 7 a) and b), for both of the studied situations; the curves are represented with continuous line.



a) step input for $\bar{p}_m^*$ and constant $p_m(\bar{p}_m=0)$ b) step input for $\bar{p}_m$ and constant $p_m^*(\bar{p}_m^*=0)$

FIG. 7. System's step response

For system's behavior improvement, a rigid feedback between the actuator and the distributor may be used; obviously, the presence of this feedback modifies system's mathematical model and transfer function (both new values of the time constant and of the gain are becoming smaller). System's new behavior was represented in Fig. 7 with dashed line.

CONCLUSIONS

The paper studied a plan supersonic inlet with mobile ramp, as controlled object; an automatic control system was described and mathematically modeled. As controlled parameter the system has the mobile panel's position and as control parameter one has chosen the pressure ratio through the second oblique shock-wave (which is proportional to the flow's Mach number behind this shock). Control system most important element is the pressure transducer, which should realize both the sensing task, as well as the comparing with the preset pressure ratio value, imposed by the lever's arm's length choice. For the complementary law, similar control systems may be used (as in [13, 14]).

If the system uses an actuator without inner feedback, the results for both of studied cases show that the system has appropriate stabilization time (around 3.2 seconds for both of cases a) and b)); meanwhile, it has static errors (5.5% positive for $\overline{p}_m^*$-step input and -3.7% negative for $\overline{p}_m$-step input). Using an actuator with inner feedback (by its rod displacement, as studied in [16]), system's step response was improved, but not essentially.

Thus, the stabilization times were reduced (from 3.2 seconds to $2.0 \div 2.5$ seconds), which means that the intensity of the command signal was diminished; meanwhile, system's static error were also reduced: from 5.5% to 4.7 % for $\overline{p}_m^*$-step input, respectively from -3.7% to -3.1 % for $\overline{p}_m$-step input.

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CHALLENGES TO GLOBAL SECURITY

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Abstract: *Now that world security is more fragile, when NATO, based mainly on the US financial contribution, seeks common resources and vision, when the European Union strives for its own stability and less for Europe's, when the US, after Donald Trump's election, is mainly looking for national solutions and only afterwards solutions for international support, when Russia can no longer accept the status of second place, desperately aspiring to be a global and regional hegemon, when China has shown that power comes from economic development and not necessarily military, we ask the question: is there any common or joint concern to combat global terrorism?*

Keywords*: security,airspace, terrorism, migration, risks and threats*

1. INTRODUCTION

The strategic objective of any democratic state or international organization is to prevent and manage any process or phenomenon that, by its evolution, could affect its own security or the citizen, thus becoming a crisis. Crisis management involves first of all identifying threats or dangers and initiating measures in order to preempt or eliminate them from the initial phase.

Under the Romanian defense strategy, the global security environment will be dominated by complex trends of major importance for the reconfiguration of regional and global geostrategic games, the reaffirmation of the military force as a factor of power in international politics, development of information technology, resurgence of nationalism and extremism, ethnic-religious fragmentation and ideological radicalization, with implications in the amplification of the terrorist phenomenon, adapting critical infrastructure to current needs. The beginning of the century and the millennium shows that the world tends to revert to multipolar, where most state actors are of regional importance. At a mondial level, we are witnessing the repositioning of the traditional actors, each acting for the first places in the hierarchy of power and in the new global political order with implications in the global security environment architecture.

In this context, the notions of security and risks outweigh the military dimension, the "crises" generating challenges and threats in the present, being much more complex. It is also the reason why global security has become the main concern of international political organizations, even if traditional state actors are trying to direct their actions to promote their own interests. Until recently, military threats were considered the most dangerous for security.

In the context of globalization, other dimensions of security: economic, political, informational, technical, administrative, ecological, cultural, are becoming increasingly clear. We can talk about global security.

In this context, the concepts of national territory, sovereignty, national interests have new meanings. The development of the technologies has led to many research, economic and military activities in the air and the cosmic space. National airspace must be approached as an element of national territory. And in terms of security.[2]

Without giving details of the concept in this article, we will understand through global security that state of the international system in which each state has the assurance that it is sheltered from any aggression or other interference likely to affect its fundamental values.

Against the background of the increasing complexity and unpredictability of international threats and challenges, increasingly difficult to predict and counteract, both civilian and military decision-makers have been called upon to address new threats to security.

The magnitude of terrorism and organized crime, of which significant support has been given by uncontrolled migration, or more precisely controlled by humanitarian principles and laws, has put all the states, irrespective of their economic or military power, at the negotiating table. The universal enemy, terrorism, without face or principles, can only be countered by joint international efforts, now that the hegemony of the world is in a situation of strategy change, and international organizations with a role in crisis management are looking for their own identities. Here are some of the events of the past few years that highlight the current security challenges.

2. TERRORISM IN THE WORLD SECURITY EQUATION

Recent security studies have shown that terrorism is one of the most common threats - hard to control. Thus, the security dimension of globalization is the most sensitive in terms of both the tendency of globalization of terrorism and the idea of maintaining the competence of national states.

Terrorist activities have experienced an alarming extent worldwide. Terrorist groups have diversified their methods of violent action, but especially the targets of these actions. Currently, it can not be said with certainty that a particular country or region in the world is safe from terrorist actions.Terrorist actions have a specific peculiarity to other types of violent events: they do not distinguish between officials and ordinary citizens. Most of the time, these actions have a devastating impact on an extended, publicly-frequented area. Many attacks are caused in order to inflict human and material damage, but also to attract public attention and to promote the destructive image of those who provoke them.[5]

Terrorist attacks in recent years prove they have no limits and borders. They occur in different geographical areas, human activities, calendar moments, and groups of people without apparent logic - the attack on Domodedovo International Airport in Moscow, the attack on a Christian church in the Egyptian city of Alexandria, the two explosions, the work of a suicide bomber who shook the holidays in 2010, Stockholm, in Taksim Square, Istanbul.

Terrorism, the major issue for all mankind, continued in recent years with increased intensity, targeting Turkey this time, but also countries pertaining the European Union, like Belgium, Germany or France. The following are the most significant European actions of the year 2016, listed and claimed as terrorist attacks:

- 12 Jan.– Turkey, in Istanbul's historic Sultanahmet area, resulting in 10 dead and 15 wounded; 17 Feb.– Turkey, car bombing attack resulted in with 28 dead and 61 injured. The deflagration occurred near the headquarters of the Turkish army headquarters in Ankara; 3 March – Turkey, Attack in Bayrampaşa, Istanbul, with 29 dead, against a police bus;

13 March – Turkey, attack using a bombed car intentionaly crashed in a municipal bus in an extremely frequented neighborhood, with 37 dead and over 125 injured; 22 March – Belgium, the three coordinated suicide attacks in the capital of Belgium, Brussels, two at Zaventem International Airport and one at Malbeek Metro Station, a few dozen meters from European Institutions, with 35 dead and 340 Wounded; 7 June – Turkey, 11 people, including 7 policemen and 4 civilians, were killed and 36 injured in the historic and very populated neighborhood of Istanbul, Vezneciler; 28 June – Turkey, 3 suicide attackers attacked the arrivals zone of Istanbul Atatürk International Airport. 47 people died and another 239 were injured; 14 July – France, a truck, struck the crowd gathered in Nice for the fireworks on the English Promenade with the occasion of the French National Day. The attack that left 86 dead and hundreds injured; 22 July – Germany, an armed attack that took place in Munich, Germany, resulted in the deaths of at least nine people and the injuries of another 21 people, of which 3 were in a very serious condition. Among the injured were children; 26 July – France, two men have taken several hostages in a church in the Normandy region, north of the country, near Rouen. The priest in whose church the hostage-taking took place was killed, while another hostage was seriously injured; 10 Aug. – Turkey, at least 6 people were killed and 25 injured in two explosions in the south-east of the country; 15 Aug. – Turkey, 4 Turkish policemen and 2 civilians, including one child, were killed in a car bomb attempt near Diyarbakir (southeast); 10 Dec. – Turkey, the double bombing in Istanbul resulted in at least 29 deaths, mostly police officers, and 166 injured. The two explosions took place in front of the stadium of the Beşiktaş football team and in a neighboring park on the European side of Istanbul; 19 Dec. – Germany, a truck hit the crowd gathered for a Christmas fair in central Berlin, leaving at least 9 dead and 50 injured.

3. RISKS TO GLOBAL SECURITY

Human migration - originally determined by the global economic and financial crisis, is also a more subtle, long-term threat.

A fundamental characteristic of our times, is the movement of people, moving from one place to another. This right has been recognized for more than 50 years with the adoption of the Universal Declaration of Human Rights. Since 1994, the issue of international migration has been debated every year at the UN General Assembly, and Resolution 56/203 of 21 December 2001 has been adopted in this regard.[4,6]

International migration, a phenomenon involving demographic, social, economic and political consequences. Debates on reduced fertility, population aging, unemployment, intelligence exports, human rights, social integration, xenophobia, trafficking in human beings and individual security forces international bodies to reconsider policies on international migration as well as the potential benefits or disadvantages involving transit countries or sending/receiving countries of migrants.

In the context of international migration, there are two processes closely interlinked and complementary: immigration and emigration. Migration flows from less developed countries to a high level of economic developed countries. There are important consequences of all aspects of security.

The clandestine trafficking of strategic material and human is being maintained and diversified - in recent years.

Both migrant smuggling and human trafficking are transnational crimes. Migrants trafficking, both legally and in terms of the content of the offenses included in this concept, is clearly differentiated in the two major components: smuggling people and trafficking in human beings.

If in the early 1990s, Germany and Austria were the main target countries subsequently were Britain, Holland, France and Italy, and now joining Spain, Portugal, Greece, Czech Republic, Sweden, Finland and Norway.

Trafficking in human beings has steadily increased in recent years, becoming a national and international problem. The phenomenon is not an episodic one, involving a large number of people, knowing profoundly social and economic connotations, demonstrating the deep violation of fundamental human rights and becoming a constantly aggravating problem. Determining factors that led to the emergence and development of human trafficking are corruption of authorities, poor control of borders, the lack of a system of evidence of emigrants, and in the country of origin a lack of legislative framework or the existence of a inadequate legal framework, inapplicable on migration, on combating human beings trafficking, protecting victims and witnesses.

Organized crime, as a complex social phenomenon, has deeper historical roots, but today it is - more and more common.

Organized crime has become one of the most serious dangers to the existence, stability and continuity of society because of the transformation of primitive mafia-type criminal groups into true criminal enterprises in order to oppose the authorities and terrorize the entire community by exacerbating violence, diversifying operating modes, diversifying criminal structures, and committing crimes from almost the entire spectrum of crime. Organized crime is not a new phenomenon; novelty is represented by the favorable environment that globalization has created and has led to a rapid development.

The proliferation of weapons and technologies with military uses knows shades from conventional weapons, weapons of mass destruction to less well-known dual technologies.

The proliferation of weapons of mass destruction has been and is a permanent threat to global peace and security.[1] The risks caused by this type of threat reside in the effects of weapons of mass destruction, which can cause irreparable losses.It is a threat and a deterrent. It is necessary, in order to ensure global security, to reduce the threat posed by these weapons of mass destruction. The action must be directed to states that legitimately own nuclear, biological or chemical weapons to ensure that they will never be used and that they will eventually be put out of use.

Drug trafficking – unmanageable. Supporting drug trafficking is another security threat that can not be controlled. An example of this is the increase in cocaine production in Colombia. The Colombia plan, aimed at enhancing security and eliminating drug-plantations, initiated by the US, failed in a very short time. Although they invested $ 6 million, 90% of cocaine consumed by Americans comes from this Latin American country. Also alarming are the figures of a UN study that places 27% increase in cocaine production in 2015, rising for 2016.If we add that these cocaine-based production markets finance paramilitary groups and guerrillas in the area, and that despite columbian military operations drug trafficking has not fallen, we see the magnitude that this "scourge" has taken in underdeveloped countries.[8]

Ilicit arms trafficking - smuggling whose fiscal value is difficult to assess.

We observe and judge the worldwide moral aspect, because weapons are shipped from developed countries and are delivered to the emerging or underdeveloped ones.

On a global level in the officially registered arms export ranking, the US is the leader with nearly 30%, followed by Russia with almost 24%. Officially, with regard to import, over 44% India, South Korea, Vietnam and China dominate this ranking.

Illicit arms trafficking accounts for around 20% of total arms sales and brings revenues between $ 2 billion and $ 10 billion a year.

Small arms have been present in 46 of the 49 conflict zones in the world over the past 10 years, and in 2015 it is estimated that they were the cause of over 13,000 deaths a day, with more than 80% of the victims being women and children.

Bank fraud - for the purpose of financing criminal and terrorist organizations. According to statistical data, around 200 million dollars are lost every half hour in the world due to frauds in the banking system. Bank fraud has become a growing and sophisticated phenomenon.

Regional conflicts, tensions and conflicts of an ethnic nature - which provoke the expansion of instability, often influenced by political and religious factors. Currently, regional conflicts on religious, ethnic or territorial disputes, have replaced the classic war. Regional conflicts are also threats that undermine the fundamentals of security and stability and create opportunities for terrorism, organized crime, as well as for the destruction of hope and the provocation of despair.

Aggressions on the state's strategic cyber space. It's a time when the increase and diversification of computer attacks are more present, the attackers relying on man's inattention or lack of experience. Criminal groups have diversified and improved their means and methods in order to affect the electronic systems and equipment of public institutions, financial-banking, medical, educational, and electronic communications operators. We are already talking about cybercrime, which is developing at a dizzying pace and is attracting more and more youth eager for adventure and fame.

The following can also be added:

- actions of subversion - revisionist objectives, undertaken by local or regional communities or organizations, directed towards territorial autonomies, nationalist-extremist movements, creating instability and regional chaos;
- natural disasters - most caused by man's uncontrolled intervention in nature;
- the use of energy imports and strategic raw materials as a means of influencing the states' policies, plus the pricing of exported raw materials according to political alliances and "sympathies";
- attacks of any kind on critical infrastructure of alliance member states;
- monopoly policy in certain economic domains influencing state security;
- national poverty - historically, the most aggressive states were not wealthy states, and this trend is still maintained today;
- espionage- intensifying specific, operative-informative actions of the Russian Federation at an European level.

Now, that we are living in a time when state borders are mostly only on the map, because labor migration is unrestricted and products circulate around the globe, clarifying the distribution of power as well as restoring world order depends most on establishing the borders of power and interest areas.[7]

Taking into account terrorist attacks, which also have no borders, we ask ourselves where is the world going. The first answer comes from the European Union, from members of the Schenghen Area, who decided to examine the possibility of reintroducing border controls under certain conditions.

4. CONCLUSION

The evolution of society is a complex process with different rhythms of development of its components. All state and non-state actors are concerned about their own security but do not always define security in the same way. Consequently, policies and action strategies are not converging.

To determine the causes of insecurity, specialists and politicians make the analysis of the environment and changes in the world to identify hazards. It is noted that the above risks intersect and interdepend. The action of states and collective security bodies is determined by how they perceive reality as well as their real, often unspeakable interests.

Analyzing the present geopolitical situation and looking at the international security situation, where terrorist attacks no longer have territorial boundaries, we realize that Europe wants to revive itself from the West to the East, to be more stable and to strengthen its position as a pillar of regional stability and security. Although weakened by the current crisis caused by UK leaving the European Union, EU is looking for a new identity, as it is already in an economic competition with the United States. The aim is to relaunch the European construction, with a major priority on security and defense policy, on the principle of a Europe with variable speed or multiple speed.

The Europe of Security and Defense must prove that it has not come to an end and it still has answers to give to its founders and members. In fact, in the future, European security will increasingly be linked to the EU's defense dimension.

Over this panoply, we see that Russia is trying to regain the status of global power in the international political arena, and even more so, the Russian military forces have carried out military actions in Latin America, a continent considered for a long time to be the "back yard" of the United States, and NATO member states such as Turkey and Bulgaria are opposed to the implementation of the NATO maritime component in the Black Sea, we ask ourselves where is the world heading.

In this scenario, it seems that Romania is merely a spectator and able to answer only when asked. It is concluded that Romania can not rely too heavily on Europe to solve its problems, nor on NATO intervention and not even on immediate neighbors concerning regional security and economic stability toward „East".

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SINGLE EUROPEAN SKY – THE SOLUTION FOR AN AIR TRAFFIC MANAGEMENT ADAPTED TO THE CHALLENGES OF THIS CENTURY

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Abstract: *At the beginning of this century has become obvious that the European air traffic management system has to be reformed in order to support the increasing number and diversity of airspace users within same limits. Thus, European Commission launched a legislative package – Single European Sky Initiative – with the intention of covering legal, economic, safety, environmental, operational, technological and institutional aspects of aviation with the aim of ensuring safe conditions for operating the aircraft. As to reach the envisioned level of ambition has been created an appropriate framework – Single European Sky ATM Research Program – to develop and implement a pan-European airspace management system that will enable tripling air traffic while reducing delays, improving air safety, reducing the environmental impacts and ATC cost. Moreover, has been agreed upon a continuous updated roadmap – the ATM Master Plan – with the aim to make possible the transformation of ATM operational concept in order to support SES objectives. The responsibility for the coordination and management of research and development of all necessary projects is SESAR Joint Undertaking which organizes, coordinates and ensures the necessary financing activities, ensures the involvement of European ATM sector stakeholders, organizes technical research and development, validation and study activities, and supervises activities related to the development of common products properly identified in the ATM Master Plan.*

Keywords: *Air Traffic Management, ATM Master Plan, Single European Sky, SESAR*

1. INTRODUCTION

It could be soundly affirmed that the twentieth century was a period of challenges for aviation from several points of view. If the detachment from the earth proved to be the biggest challenge in the dawn of this era and the ongoing desire for higher, further, and faster continued to be a target, we have got to witness at the beginning of this millennium a large amount of air space users within same limited air space and the new challenge proves to be the implementation of an effective air traffic management. It is obvious that the diversity of aerial platforms and the pace at which they were developed exceeded the capacity of the airspace management system that has evolved technologically and operationally more slowly.

The desire to provide quality services to the general public in order to improve trade and travel conditions was highlighted by the attention paid to specific means that allow airplanes navigate safely without delays or incidents.

The aviation safety system, based on a set of rules and procedures for airspace management and considering the necessity of maintaining the sovereignty of national

airspaces has been developed simultaneously with the Air Traffic Control (ATC) and led to the creation and development of dedicated organizations to provide air traffic services – Air Navigation Service Provider (ANSP).

Air traffic management (ATM) is defined by ICAO as „the dynamic, integrated management of air traffic and airspace – safely, economically and efficiently – through the provision of facilities and seamless services in collaboration with all parties. Nowadays those who provide these services are constantly pressured to tailor themselves in respect of organization, operating capacity, outlook on the rapid evolution of the socio-political business environment and surrounding technological progress. All these pressure aims at improving the quality of services.

The Single European Sky (SES) initiative launched in 2000 and the legislative package adopted in 2004 brought ATM under the competence of the European Union (EU) as to increase the capacity of European airspace and to reduce its fragmentation. However, the first legislative framework was necessary but not enough. Thus, a second package (SES II) proposed in June 2008 was adopted in November 2009 by the Council and Parliament with the objective of accelerating the establishment of a really single European sky beginning 2012. This is based on five pillars: performance, safety, technology, airports and the human factor. It was found that the performance objectives proposed cannot be achieved without an adequate institutional structure and in January 2013 SES II package was revised resulting package SES II+ which regulates the activity in certain areas covered by previous legislation and states clearly the roles and responsibilities of the institutions involved in the process.

During the economic crisis of recent years, the support of the entire ATM community was reaffirmed confirming the need of an urgent reform of ATM sector. This reform of European ATM will be achieved within the framework of Single European Sky ATM Research (SESAR) program. European Commission aims that SESAR program to develop and implement a system of airspace management in Europe that will enable tripling air traffic while reducing delays, improving air safety, reducing the environmental impacts and ATC cost. SESAR brings together key stakeholders to develop a new vision on European airspace management to be applicable from 2020.

Therefore, as the air transport plays a major role in the nowadays European Union economy and security, the European airspace must be continuous, safe and responsive to the requirements of civilian or military air operators alike. To achieve that it is essential to have an integrated European air traffic management to address in parallel the challenges of competitiveness, safety and durability.

2. SINGLE EUROPEAN SKY INITIATIVE

As one of the conditions for expansion of the European Union was to ensure unrestricted freedom of movement of goods and persons, the upgrade and expansion of transport networks has been recognized as a pivotal factor to achieve progress in all fields expected.

In terms of aviation, opening up the EU market in 1993 has made air travel more accessible and affordable, stimulating the growth of air services. Nevertheless, the use of a traditional air traffic management system within an unchanged air space volume but used concurrently by more and more civilian and military operators has inevitable conducted to various restrictions mainly reflected in noticeable delays.

2.1. The Down of Single European Sky Initiative

Since its establishment in 1960, European Organization for the safety of air navigation (Eurocontrol) has proposed eliminating national borders in European airspace but only after nearly half a century this idea took shape. Thus, in response to major flights delays recorded in 1999, the European Commission (EC) launched in 2000 the Single European Sky Initiative. EC proposed a legislative package on the ATM which covers legal, economic, safety, environmental, operational, technological and institutional aspects of aviation with the aim of ensuring safe conditions for operating the aircraft. This package is addressed to all airspace users and to those interested in air traffic control requesting their involvement in making possible the reformation of air traffic in the European Union to increase flight safety.

The package includes proposals on the creation of SES as of 31st of December 2004 and establishes the objectives and its operational principles together with other plans for specific regulations concerning the provision of air navigation services, organization and use of airspace and interoperability of equipment and procedures.

Following the counselling procedures between the representatives of the Council and the European Parliament in Brussels, on the 9th of December 2004 was signed the agreement on creating a single European airspace for the benefit of both civilian and military users setting goals and operating principles for SES.

SES initiative introduces a new organization regarding the provision of air navigation services independent of national borders, restructures the airspace at regional level, and presents an airspace management more integrated and complemented by the development of new concepts and procedures for ATM aiming to improve services, to comply with aviation security requirements, to reduce delays, and to increase the economic efficiency of services and environment protection. Thus, the airspace will be considered a common resource for all categories of airspace users which requires flexible use by all of them, ensuring fairness and transparency upon taking into account the security issues of Member States. Therefore, these countries have declared their willingness to cooperate, taking into account national military requirements, in order to implement completely and evenly the concept of flexible use of airspace in all Member States and by all airspace users.

The objectives proposed by the European Commission when created SES were:

- to develop the air traffic control capacity; the estimated air traffic annual growth rate will be about 5%;
- to improve safety; ATC in Europe is one of the safest in the world but it is differently organized from a Member State to another, therefore in response to an increased traffic a common and systematic approach has to be developed;
- to reduce fragmentation in ATC; a different ATC setup and organizational arrangements among Member States create inconsistencies which have harmful effects on fluency and regularity of air traffic;
- to ensure the involvement of the military sector in the organization of ATC and decision-making process;
- to facilitate the introduction of new technologies; it should be encouraged the cooperation between ATC services, equipment manufacturers and air companies in respect of introducing new and more performant equipment.

2.2. Single European Sky II – The Updated Regulations Package

In 2009 the European Commission adopted the second SES legislative package (SES II) which mainly targeted the increased safety, the reduced costs and delays, with positive effects on less fuel consumption, the reduced carbon dioxide emissions and costs. These measures meet the estimated growth of air traffic by 2020, two times more compared with the air traffic in 2008.

The SES II package brings a number of improvements to the SES initial regulations. It includes compulsory performance targets for the Air Navigation Service Providers, a European network management function to ensure convergence between national networks and an ultimate date for Member States to improve their performance, starting with a cross border cooperative approach, known as Functional Airspace Block (FAB).

Thus, the Single European Sky reform proposed by the Commission pursues in parallel:

• performance regulation – the air traffic management has to be improved together with the integration of service provision in order to transform FABs into genuine instruments of regional integration, to strengthen the network management function, which encompasses a series of tasks to be performed by various players including the design of European route network, slot coordination and allocation and the implementation of SESAR technologies and procedures;

• creation of a unique safety framework – the increased air traffic, overcrowded airspace and airfields and the use of new technologies all call for a common approach to developing and implementing harmonized rules to improve the safety of air transport and to extend the European Aviation Safety Agency (EASA) responsibilities in key areas as aerodromes, air traffic management and air navigation services;

• use of new technologies – the current ATC system is about to reach its limits working with obsolescent technologies and suffering from fragmentation. Therefore, it is recommended to accelerate the development of control system by implementing SESAR solutions in order to increase safety and traffic control capacity;

• management of ground capacity – it has to be made all necessary investments to adapt airports capacity to the air traffic management capacity with the aim of maintaining the overall efficiency of the network.

2.3. Single European Sky II plus (SES II+) – The Streamlined Regulations

Since the beginning of the ATM reform process existed the prerequisites for improvement. The suspension of the steady growth of ATM costs did not bring the expected cost reductions. It has been noticed a first evidence of slow decline of extra distances that aircraft were required to travel due to ATM restrictions. Moreover, was established the network administrator who managed in a very short time to gather together all stakeholders involved in the planning process to determine what will finally become a true European network of routes. Also, the regulatory framework has made some improvements with the implementation of the first rules SES and EASA but some Member States who are either owners or major shareholders of service providers, have a strong tendency to focus on recurring revenue stream generated by the air traffic control services financed by users and are therefore less willing to endorse a fundamental shift towards a more integrated operating airspace. In addition, SES decision-making processes still allow too easily the delaying progress by national decision makers.

For this reason, at the end of 2013 has been submitted for approval a new package of measures, SES II+, aiming to the structures and decision-making reforming processes to allow setting more ambitious targets, combined with greater flexibility where it is really needed, and increasing the enforcement. Approved by the European Commission on the 11th of March 2014, SES II+ package updates SES founding regulations and amends the rules governing EASA. The main updates concern the following areas:

• Improving safety and surveillance. National supervisory authorities set up in 2004 did not fully succeed to oversee the safety and performance of the air traffic control bodies and to ensure implementation of new rules. Therefore, as aviation safety remains the first priority, SES II + aims to remedy the situation by a complete institutional separation of authorities of entities they supervise to ensure a real decisional independence and by identifying a stable financing channel, to ensure financial independence.

• Performance objectives. The reform of the European air traffic management is driven by four key performance objectives: safety, cost efficiency, capacity and environmental protection. These objectives touch the core of the reform process and to meet them, air traffic control bodies must reform themselves and provide better services at lower prices. The Commission proposal will enhance the performance system since setting the targets will be done in a more independent and transparent way and subsequently can be more easily imposed. The proposal will strengthen the Commission's role in setting ambitious targets. The process of targeting will be shorter and will be based more on evidence in order to benefit from more recent and more accurate traffic forecasts.

• Support services. Support services normally generate most of the costs of air traffic management. Due to neutral reasons, air traffic control services are almost always assured by great service providers monopolists, and therefore their effectiveness must be based on careful economic regulation, namely on system performance. On the other hand, support services (meteorological services, communications, navigation, surveillance and aeronautical information) are different and could be provided under conditions of market competition. Commission proposal was to separate the support services, which could be the subject of competitive tendering in accordance with customary rules of public procurement to ensure transparency of the selection process and focus on quality and costs, instead of nationality.

• More customers oriented. Too many air traffic control bodies have transformed customer consultation – airspace users – a mere formality. SES II+ aims at establishing a of an increased client oriented attitude through introduction in legislation some of the best practices in the consultation sector and creating the possibility that different groups of airspace users should be involved in approving the investment plans of suppliers. This will ensure that users, representing raison d'être of the system are heard and that they in turn can provide synchronized introduction of new equipment and making other major investments both on the ground and in aircraft.

• Greater flexibility to allow industrial partnerships within FABs. The purpose of functional airspace blocks is to increase efficiency and reduce costs and emissions. However, these airspace blocks were rather prescriptive form of cooperation between states and service providers, aiming to create bigger entities in the provision of services and converted to fulfil administrative formalities in place to develop synergies. In the SES II+, FABs are transformed into more flexible industrial partnerships, which will allow also participating in several FABs, based on a necessary performance level.

• Enhanced Network Manager. SES II+ emphasizes the role of network manager making it a service provider for service providers which will focus on synergies at the network level and on industrial cooperation.

By 2017 Network Manager will implement and manage up to nine Centralized Services (CS) to the European ATM network, as follows:

• CS#1: Flight Plan and Airport Slot Consistency Service (FAS) – the synchronization of flight plans with times of arrival / departure to / from airports;

• CS#2: 4D Flight Trajectory Profiles Calculation Service for Planning Purposes (4DPP) – 4D trajectory profiles calculation and communication with greater precision;

• CS#3: European Tracker Service (ETKR) – producing a high-quality images of air situation at European level;

• CS#4: Advanced Flexible Use of Airspace Support Service (AFUAS) – ASM supply and data collection allowing a more efficient use of available airspace;

• CS#5: European ATM Information Management Service (EAIMS) – collecting, organizing and providing the ATM information at the network level as soon as possible using a variety of means;

• CS# 6: Management of Common Resources Network Service (CNR) – improved management at the network level to limited "resources" (ex. transponder codes, radio frequencies, etc.);

• CS#7: Network Infrastructure Performance Monitoring and Analysis Service (NIPS) – ensuring safe operation and resolve anomalies that may arise at Communications, Navigation and Surveillance (CNS) shared or distributed infrastructure;

• CS#8: Pan European Network Service (PENS) – providing terrestrial IP based communications between sites and partners;

• CS#9: Data Communication Service (DCS) – providing air-ground data communications in support of data links services, Airline Operation Centres, flight information services, airport coordination etc.

These services could be provided by the network administrator to local or regional ANSP which would lead to obtaining significant economies.

• EASA, Eurocontrol and the institutional landscape. Finally, the various bodies of the EU do not overlap, but their activities complement each other optimally and that the regulatory mechanism is able to provide high quality standards during the next stage of development of SES and SESAR. Eurocontrol must focus increasingly more on operational activities described above in connection with network administrator, using his considerable experience in the field and extensive operational knowledge. On the other hand, EASA should focus on coordinating the development of technical standards and ensure that they are subject to appropriate consultation and a high level of quality and consistency. Also, EASA must continue to fulfil its supervisory duties and to increase its support to Member States' authorities. Finally, the European Commission should focus on economic regulation (system performance, taxation, etc. FAB) and political strategy. This will prevent the waste of resources and ensure the possibility to avoid the implementation difficulties encountered in the past.

3. THE EUROPEAN AIR TRAFFIC MANAGEMENT MODERNIZATION PROGRAM

The European air routes network being an amalgamation of national routes is not yet sufficiently adapted to the needs of a modern pan-European air traffic. This reality makes flights within European airspace to be less efficient than domestic flights. Moreover, the provided air navigation services are divided along the borders using procedures, equipment and different operational policies.

To remedy these shortcomings, the Single European Sky ATM Research (SESAR) program proposes a more efficient management of air traffic in Europe supported by leading technology.

3.1. The European Airspace and Air Navigation Services

According to the Chicago Convention the European airspace is divided in air traffic controlled areas – Flight Information Regions (FIR) – airspace volumes which follow national borders and include air routes networks.

In the SES context, the legislation speaks about a single European Upper Flight Information Region (EUIR) which includes the upper airspace falling under the responsibility of Member States and additionally includes airspace adjacent to European countries but not EU members. Creating EUIR, above FL310 (9450 meters), allow this space to be reconfigured in defined control zones dissociated from national borders, thus ensuring a more efficient use of airspace, systems and specialized ATM personnel. Therefore, the European airspace will be reconfigured into several FABs.

The strategic objectives that must be met by a FAB are:

• Safety – ensuring an increasing level of safety despite the increasing civil air traffic;

•Capacity – requirements of civil air traffic is expected to increase significantly in the coming period;

•Cost effectiveness – achieving optimal and balanced costs to ensure operations inside FAB including ATC services;

•Flights efficiency – finding optimal continuous ascent / descent routes as to reduce flight distance and time;

•Environment – reducing environmental impact through optimal route selection, appropriate flight profile and reduced time in the air;

•The effectiveness of military missions – military flights executed within a FAB involves careful coordination between civil and military authorities of each country included in the block.

The term Air Navigation Services (ANS) comprises four main elements: communication, navigation and surveillance (CNS) services, meteorological services (MET), air traffic management (ATM) services and auxiliary aviation services like: search rescue (SAR) and aeronautical information (AIS) services.

Air Traffic Management (ATM) includes all services related to air navigation as follows: Air Space Management (ASM), Air Traffic Services (ATS) and Air Traffic Flow and Capacity Management (ATFCM).

Air Traffic Management is the set of functions provided on ground and in the air aiming to ensure safe and efficient movement of aircraft during all phases of operation. The general objective of ATM is to provide air operators with the appropriate information as they can maintain scheduled time for take-off and landing and the possibility of joining the preferred flight profiles with minimum constraints but without compromising agreed levels of safety.

Airspace management is a planning function with the main objective to maximize the use of available airspace within a defined airspace structure through a dynamic allocation process based on time and temporary airspace segregation between different categories of users upon their requirements. ASM task is to design and make known the airspace structure, airspace management, air routes and reserved areas for military activities and airports, while ensuring safety and traffic fluidity.

Air Traffic Flow Management and Capacity is a service that aims to ensure an optimum flow of air traffic in time and space in case of the demand exceeds available capacity of the ATC system and airport infrastructure.

3.2. Single European Sky ATM Research Program

Single European Sky ATM Research (SESAR) program is one of the most important research and development ATM projects ever launched by the EU. SES provides the legal framework for more efficient, better performing, safer and greener ATM procedures. SESAR will provide technological solutions, functionalities, systems and proposals for standards that would achieve performance objectives relating to SES aimed at tripling capacity, halving ATM costs, improving safety and reducing the environmental impact of each flight.

SESAR brings together airspace users, service providers, airlines, airport operators, industry representatives, partner institutions, regulators, military organizations, professional associations, research centres, all of them making its contribution under Eurocontrol expertise in defining and SES implementation of regulations in this pan-European program.

SESAR program is the technological pillar of the Single European Sky which provides the legal framework to meet future needs in terms of safety, capacity and efficiency at European level rather than nationally. SESAR concept is based on the principle that airspace users and controllers define together through a collaborative processes and information exchange, the most appropriate route of flight for an aircraft, predictable and without delay. This concept is founded on new innovative technologies and operational procedures resulted from a cycle of three interrelated continuous and evolutionary processes: definition of the content and priorities through an agreed roadmap, namely the ATM Master Plan; research, development and validation of technological systems, components and necessary operational procedures and, implementing the new systems and operational procedures, eventually.

Main features of SESAR concept of operation are:

• The transfer of operations based on airspace to trajectory based operations, so that each aircraft achieves its preferred route and time of arrival;

• Collaborative planning so that all parties involved in flight management from departure gate to arrival gate, can plan their activities based on the performance the system will deliver;

• Set up the Dynamic Management of the European Airspace Network (DMEAN) to help increase traffic capacity and flight efficiency by enhancing coordination between civil and military authorities;

• New technologies that provide greater precision navigation applications on board and an optimized scheduling between aircraft to maximize airspace and airports capacity. New technologies will be embedded into a harmonized and interoperable technical architecture that also come to support the needs of all European regions;

• Preponderant role of the human factor, largely based on advanced tools to work safely and without undue pressure.

SESAR program consists of three phases:

• The definition phase (2005–2008) – it has been defined the roadmap (SESAR ATM Master Plan) for achieving performance levels in terms of ATM and establishing a high level work plan that defines the content of the new generation of ATM systems by identifying the necessary elements to achieve it.

• The development phase (2009–2013) – it has been based on the definition phase and has been focused on developing the necessary elements. The SESAR Joint Undertaking has been designated to be responsible for the management of this phase. Research and development activities were launched immediately after the adoption of the ATM Master Plan. SJU's work program, consisting of 19 modules and implemented through around 300 projects carried out by the SJU members and their associates, is divided into the following areas as research on the operational air traffic route management, systems research (aircraft systems, management systems, en-route or approach air traffic operations, civil and military operational centres, airport systems, management systems, network information and communication systems, navigation, surveillance), Wide Information Management System, transversal activities (infrastructure validation, security, safety, environmental and human performance files development, the ATM Master Plan management and update, the target concept and its architecture).

• The deployment phase (2014–2020) aims at large-scale production and implementation of new ATM infrastructure. This infrastructure will be based on new technologies and procedures resulting from the development stage and will contribute to achieving SES objectives that will lead to high performance in European air transport.

The responsibility for the coordination and management of research and development of the SESAR projects is SESAR Joint Undertaking (SJU). This enterprise is a public-private partnership with the statute of an EU body established. SJU is made up of two founding members – EU and Eurocontrol – and 15 other members representing all stakeholders in ATM: civil and military ANSPs, aircraft and equipment manufacturers and airports. In addition, SJU involves airspace users, professional organizations, scientific institutions and a number of associated partners, whose activities complement the program. It was initially decided that the SJU cease to exist eight years after the approval by the Council of the ATM Master Plan but later its lifetime has been extended until 31st of December 2024. SJU aim is to ensure the modernization of European ATM system by coordinating and concentrating all relevant research, development and validation activities within SESAR project. Moreover, it is responsible for implementing the ATM Master Plan having a double role: custodian and executor.

SESAR Joint Undertaking organizes, coordinates and ensures the necessary financing activities during SESAR deployment phase, ensures the involvement of European ATM sector stakeholders, organizes technical research and development, validation and study activities, and supervises activities related to the development of common products properly identified in the ATM Master Plan.

The SJU modus operandi has the advantage that all relevant stakeholders are involved in decision making processes having shared responsibilities therefore the research and innovation can be continuous and undivided. Relations of mutual interdependence and coordination mechanisms between participants and projects are integrated into a comprehensive European concept and the architecture of the system is ensured through a multilateral contractual agreements.

At the end of 2011, when it was proposed that its lifetime to be extended, the main achievements the SESAR Joint Undertaking were: the management of 4D trajectories, System Wide Information Management (SWIM) infrastructure which introduces a completely new way to manage the information throughout the European ATM system, a functional remote control tower, etc.

The foundation for SJU working program is the ATM Master Plan which organizes the deployment of SESAR concept in three progressive stages: Stage 1 – it aims to provide the necessary technologies for synchronizing European ATM system through an efficient exchange of information between all stakeholders, Stage 2 – it will achieve a more efficient planning of flight paths, and Stage 3 – it aims to achieve the highest level of performance through a seamless integrated air / ground system.

3.3. The European Air Traffic Management Master Plan

The ATM Master Plan is the agreed roadmap updated and applied by the SJU with the aim to transition to a new ATM operational concept to support SES objectives. It should be considered as the European reference for a stable and credible planning, which allows stakeholders to anticipate new functionalities aligning them with investment cycles and planning retrofit activities. The definition phase of SESAR has been the basis for developing and implementing a new ATM concept, addressing research and development and validation activities which resulted in a total of six reports. One of these reports, *D5 - Production of the SESAR Master Plan* is considered as the first ATM Master Plan that integrates areas of performance improvements, elements of the new ATM concept, cost benefit analysis and lays out the roadmap for operational improvements into a coherent work program.

ATM Master Plan was first approved by the Board on the 30th of March 2009 and the Board of the SJU it adopted on the 12th of June 2009. It connects ATM research and innovation activities with the deployment scenarios, facilitating the achievement of SES performance targets helped by modernization of technologies and ATM procedures. ATM Master Plan is a living document that guides the work program for the development phase and also will be a key tool for the SESAR deployment phase. Coordination and interaction between development and deployment is essential for the success of SESAR project and full implementation of SES.

An updated version of the ATM Master Plan, Edition 2, approved in October 2012, has identified the most important operational changes to be implemented throughout three main stages in order to contribute to the full implementation of the new concept SESAR by 2030. Thus, during the first stage the work will focus on activating dormant capacity, notably by improving the exchange of information to optimize the network effects, in the second phase there will be developed information management concepts at system level and initial trajectory as to increase efficiency and in the third stage it will be introduced a comprehensive and integrated management of the initial trajectory, which will include new separation modes with the intention of achieving long-term political objective of SES.

A second valuable update, approved on the 15th of December 2015, improves the concept getting together performance and technology with an extended horizon up to 2035. It references to the key features of the SESAR 2020 Research and Innovation program and to the Pilot Common Project. The role of the human and the attitude to change management are emphasised whilst two precise topics affecting ATM are introduced: cyber security and drones. It also fosters a broader military involvement.

The deployment of new ATM operational concept proposed by SESAR will be accomplished in accordance with the ATM Master Plan. It is performance oriented following four key areas of performance: environmental protection, cost-effectiveness, safety and capacity.

To achieve this performance, the ATM Master Plan proposes ways forward for the essential operational changes grouped into six key characteristics, chosen for their

capacity to provide performance benefits in one or more operating media (airport, airways, terminal areas, and network). These operational changes will evolve over three complementary steps leading to achieving the target concept.

These steps are based on achieving capabilities and have no fixed terms of completion. So every once completed, will bring the system closer to the ATM target concept, as follows:

• Step 1 – Time-based operations. This step underpins the implementation of SESAR concept and focuses on flight efficiency, predictability and environment. The purpose of this phase is a synchronized European ATM system where partners are aware of ongoing operations and are working together to optimize the network. During this phase it is initiated that air traffic arrivals at airports to be orderly achieved. Will be widely used data links and will be run the first trajectory-based operations using aerial trajectories (by ground systems) and controlled time of arrival (for ordering and managing traffic queues).

• Step 2 – Trajectory-based operations. It focuses on a more advanced flight efficiency, predictability, environment protection and capacity which become an important goal. The goal of step 2 is to provide an ATM system based on the trajectory that optimizes partners' trajectories using shared information about 4D trajectories and users define priorities in the network. Trajectory-based operations initiate the management of 4D trajectory using SWIM and ground and air data exchange about the trajectory to allow tactical planning and identifying portions of routes without conflicts.

• Step 3 – Performance-based operations. At this stage all requirements of required high performance will be achieved to meet the SESAR concept target. The goal of this stage is to implement a high-performance European ATM system, integrated, network-based, collaborative, air and ground continuous. Performance-based operations are achieved by using SWIM performances and network-wide operations collaborative planning throughout the ordering process led by the user.

To trigger the deployment phase in 2012, it was necessary a new document – SESAR Concept of Operations-Step 1 – detailing specific actions to be performed during first step of deployment phase and defines the required final stage to be reach for commencing the new step. Thus, for initiating the deployment process, SJU has launched a pilot project carried out jointly – Pilot Common Project (PCP) – in order to coordinate and synchronize the implementation of the most important ATM functionalities (AF) developed by SESAR. This constitutes the starting point for implementing future joint projects. PCP contains a first package of technical and/ or operational changes to be introduced during 2014 – 2024, grouped as follows:

• AF#1: Extended AMAN and PBN in high density TMAs;
• AF#2: Throughput Airport and functionalities Integration;
• AF#3: Flexible Route Airspace Management and Free;
• AF#4: Network Management Collaborative (Flow & NOP);
• AF#5: Ground-ground integration and aeronautical data management and sharing;
• AF # 6: Initial Trajectory Information Sharing: Towards i4D air-ground integration with enhanced performances Flight Data Processing;

Moreover, the centralized services proposed by SES II+ legislation prove to be the perfect vehicle for the implementation of the six PCP AF packages at pan-European level. This approach will lead to achieving the proposed performance levels in a faster pace than if the changes would be introduced separate at regional level.

CONCLUSIONS

Identifying the operational and technological limitations of the European air traffic management system directed to a new approach on the topic. Thus, in 2000 was launched the Single European Sky Initiative with the aim to standardize ATM practices through legislative packages proposed in 2004 and completed later in 2008 and 2013. If the initial goal was to increase the capacity of European airspace and to reduce fragmentation subsequently other goals were added, all aimed at increasing performance, improving safety, development of technologies and improved airport capacity.

The need to reform the ATM industry was mentioned constantly at different levels but now, backed by an appropriate legislative framework at European level and with the support of the entire ATM community, the reform of air traffic management in Europe will take place in the context of Single European Sky ATM Research Program.

SESAR program, the technological and industrial dimension of Single European Sky will develop and implement a new airspace management system in Europe that will enable tripling air traffic while reducing delays, improving air safety, reduce environmental impacts and ATC cost. The deployment of SESAR operational changes will be made in accordance with the ATM Master Plan aiming to produce benefits in one or more operating environments (airports, airways, terminal areas or entire network).

The ATM Master Plan connects ATM research and innovation activities with deployment scenarios, helping to achieve SES performance targets through the ATM modernization technologies and procedures. Responsible for implementing the ATM Master Plan is a public-private enterprise with the statute of an EU body, SESAR Joint Undertaking who aims to ensure modernization of the European ATM system by coordinating and concentrating all relevant research, development and validation SESAR projects.

Even if the envisioned horizon to deploy all SESAR innovations was 2035 we should imagine beyond this timeline towards 2050 when performance-based operations will be implemented all over Europe, continuous coordination between ANSPs or full end-to-end service will be provided at network level, and the flight will be considered as a whole within a flow and network context. Afterward, the vision will become reality across the whole ATM system.

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THE NOVEL *WHITE NOISE* AS A METAPHOR OF THE SPIRITUAL SEARCH

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Abstract: *The main focus of this paper is represented by the manner in which the novel White Noise by Don DeLillo illustrates various themes, such as: integrating the fear of the unknown into the every day life, the indirect communication with the unknown by means of the relationship with the mass media, and the family members, or the relationship with the social authorities. The unknown is defined as representing a danger which leads to the process of searching for empirical solutions against fear, such as tourism, experimental medicine, research, and shopping, to name but a few.*

Although the novel does not offer the reader the ultimate method for completely eradicating this fear, it is interesting to observe the manner in which its content explores ways of transcending it.

Keywords: *fear, transcendence, simulacrum, identity, unknown, authority, danger.*

1. INTRODUCTION

The novel *White Noise* has as its main themes the exploration of the urban setting which is marked by deep spiritual crises. These crises are caused by several factors, some of which are represented by the overstimulation provoked by such external factors as: redundant products, immature relationships, or concepts that are not fully understood. The unknown is a factor which represents the catalyst for the change brought about by the spiritual search. This is because the familiar concepts fail to nurture feelings, such as: safety, meaningfulness, authenticity or stability. This is precisely the reason why we argue that one of the causes of spiritual crises is constructing one's identity by means of associating oneself with the following external factors:

(1**) The act of buying and consumption of redundant products**;

(2) **Tourism -** the obsessive photographing;

(3) **Relationships** - long conversations centered upon repetative subjects, such as: natural disasters, celebrities, mystery detective cases and so on;

(4) **The mass media -** which represents the lens through which reality is perceived, including nature, and natural disasters such as the toxic cloud, which heralds the inevitability of change. This situation results in an existential crisis, similar to the concept proposed by the critic René Girard, who defines it as the sacrificial crisis.This situation is caused by the disappearance of categories, as well as by the destabilizing of the social hierarchy. These phenomena are all portrayed in the novel as a means of preceding the spiritual transcedence of the urban conflict-ridden settings.

Such examples of destabilizing the hierarchy are present throughout the entire novel: Steffie demonstrates that she has intuitively known the solution to her brother's crying

crises recommended by the doctor; Heinrich stirs up a debate about the present, which his father finds unconfortable; and Jack is using his position to support his less authoritarian colleague;

5. **Historicity** - a family discussion about time - the radio predicts rain, and as Jack believes that his sense cannot be trusted, he is certain that the radio is more accurate; Heinrich provokes his father rather violently to a discussion about time, which his father avoids in spite of all his son's efforts to make him admit the „here and now" hypothesis;

6. **Hyperbolization** of senses (a) – a telescope to see more clearly, hyperbolization of authority (b) - the image of Hitler, hyperbolization of information source (c) - the mass media as a source of accurate information.

As a result of all these factors, the feeling of unsafety is constantly growing, triggering the search for empirical solutions, and thus a genuine existential crisis. This crisis is the main focus of the novel's narrative, and proposes themes of urban research of considerable sociological and cultural importance.

2. *WHITE NOISE* AND THE CONCEPT OF SIMULACRUM

The crisis at the heart of the novel can be linked to the crisis of authentic values in the urban setting, in fact to what the sociologist Jean Baudrillard calls „the concept of **simulacrum"**. What the critic René Girard defines as the *sacrificial crisis,* a social process marked by the lack of differentiation between categories, represents another useful theoretical framework. Both these frameworks have been used to arrive at a better undestanding of the way in which the spiritual search is illustrated in the narrative of the novel *White Noise*.

The simulacrum can be defined by an absence of a referential reality, which can be associated with the dissolution of hierarchy. This dissolution is the main trigger of the sacrificial crisis. It also represents a reality that cannot be defined or categorized, because it conceals an absence, an illusion that makes no reference to the real life. It is, as Jean Baudrillard proposes, a hyperreal. Neither is it a parody, nor is it influenced by life or death. It is rather operational in nature. It is a descriptive machine that resembles the characteristics of the real, and replaces it, so that the need to produce the real disappears. Tourism, thus, becomes a spiritual experience because simulations can be produced infinitely by means of photographs: "*Being here is a kind of spiritual surrender. We see only what the others see. The thousands who were here in the past, those who will come in the future. We've agreed to be part of a collective perception. This literally colors our vision. A religious experience in a way, like all tourism. Another silence ensued.*" *They are taking pictures of taking pictures," he said.* (Page 12 *White Noise* Don DeLillo)

This concept of simulation triggers a passive attitude towards reality, which is already produced and multiplied. The individual doesn't have to ask questions or look for answers; he is no longer forced to doubt the validity of reality. This fact can be compared to the lack of hierarchical differentiation, which, according to the theoretical framework of the critic René Girard, leads to the outburst of the sacrificial crisis.

The information in the media as illustrated in the novel *White Noise* can be an example of the concept of simulacrum. This is because such information is excessively repeated, and is centered upon a reality already present in the mind of the audience: the world as a place of the apocalypse, where the individual enhances one's sense of safety by watching disasters that take place in far off areas of the world.

The fact that such disasters, accidents and violent acts occur in far off places is important, but it has to be noted that the novel also presents first-hand accounts of such disasters. It is only this experience that offers the possibility of reconnecting to the sacred

by the transcendence of fear. Vulnerability becomes here a source of developing compassion, love and authenticity.

Paradoxically, violence and fear represent the catalysts that raise awareness of the need for such spiritual values. The lack of authenticity results in a spiritual crisis, which is solved by empirical means, but which determines the presence of violence within the community. In the novel *White Noise* the lack of authenticity is exemplified by the lack of trust in one's own physical senses, which are obscured in favour of the information coming from the mass media. The media becomes thus, the trustworthy source of knowledge and this is why the individual loses their connection to their spiritual values. Jack is convinced that a defensive attitude is necessary for the prevention of negative events.

It is interesting to notice that, according to René Girard, the main focus of the religious rite of sacrifice is based upon the empirical assumption that there is a fear of being killed if one does not kill oneself.

The urban world depicted in the novel displays an illusion of abundance due to the richness of the images sharing the characteristics of the simulacrum concept. The lack of symbolical significance and the pure operational character of these images generate emotional imbalances and the need to look for valid spiritual solutions to the conflicts arising in this context. Reality is perceived through decoding of some cultural signs. The sociologist Jean Baudrillard explains the fact that the act of consumption stands for a subtle way of communication within the frame of the hypercivilized world. This has as main motivation the need of the individual to feel his/ her sense of belonging which, in turn, transforms itself into a sense of being protected against the dangers of non-existence.

Under these circumstances, an important question comes into the foreground: that of the search for authentic spiritual identity. This constitutes, in fact, the main theme of the novel.

In this novel, identity is an unstable concept which is constructed by means of reference to the imagery of simulations, such as: radio information, medicine against the fear of death, superficial conversations, false claims regarding knowledge, and so on.The simulacrum becomes so prevalent in all the imagery of the urban society that authenticity itself is simulated along with the very idea of God. In this respect, Jean Baudrillard explains that God himself can also become a simulation. A society of simulations can only be logically ruled by a simulated God:

Outside of medicine and the army, favored terrains of simulation, the affair goes back to religion and the simulacrum of divinity: "I forbade any simulacrum in the temples because the divinity that breathes life into nature cannot be represented." Indeed it cannot. But what becomes of the divinity when it reveals itself in icons, when it is multiplied in simulacra? Does it remain the supreme authority, simply incarnated in images as a visible theology? Or is it volatilized into simulacra which alone deploy their pomp and power of fascination - the visible machinery of icons being substituted for the pure and intelligible Idea of God? This is precisely what was feared by the Iconoclasts, whose millennial quarrel is still with us today.

Their rage to destroy images rose precisely because they sensed this omnipotence of simulacra, this facility they have of erasing God from the consciousness of people, and the overwhelming, destructive truth which they suggest: that ultimately there has never been any God; that only simulacra exist; indeed that God himself has only ever been his own simulacrum. (Page 169 Chapter *Simulacra and Simulation* Selected Writings Jean Baudrillard).

The media abounds in images that resemble to the characteristics of the concept of simulacrum. Its portrayal of the world is focused on the individual's lack of power to control his/her own life. The external factors, such as the atmospheric toxicity or the romantic betrayal are all threatening to destroy one's emotional, physical and financial balance. This situation explored by the narrative determines the outburst of violence whose resolution resides in the scape goat mechanism. It can be argued that the quest for authentic spiritual values brought about by the immersion in the urban profane lifestyle, as well as the lack of depth of a world ruled by simulated identities, account for the main causes of the excess in conflicts in the novel.

The redundant photography is also an indication of the obsession with simulated images. The image is not important in itself, but rather due to the fact that it triggers a great deal of attention. American culture itself is heavily influenced by the cult of celebrity. All public life is engaged in placing a high value on the opinion of famous people, as well as criticizing them. In the novel *White Noise,* value is ascribed to a place, especially due to its popularity and to the fact that it is obsessively photographed.

Several days later, Murray asked me about a tourist attraction known as the most photographed barn in America. We drove twenty-two miles into the country around Farmington. There were meadows and apple orchards. White fences trailed through the rolling fields. Soon the signs started appearing. THE MOST PHOTOGRAPHED BARN IN AMERICA. (Page 12 *White Noise* Don DeLillo)

As mentioned earlier, this valuing of images that have no power of transcedence, leads to the sacrificial crisis which is often resolved through the scape goat mechanism. In the novel, death is most often alluded to the scape goat. It is seen as the ultimate enemy and all efforts are directed towards its avoidance or its denial.

It is interesting to notice that the vulnerability of one's body, of the social or family structure, of the financial or the professional status quo represents the catalyst leading to the spiritual search for more meaningful solutions, rather than to the scape goat mechanism.

The threat of death becomes a means of going beyond the urban mindset and into the subconscious, where details become essential and life is no longer a repetition of mechanical acts aimed at conformity and approval of the outside sources. It is the dream-like state of the night that makes the urban setting a poetic landscape where every sound and image becomes an opportunity to display certain emotions: „There is an expressway beyond the backyard now, well below us, and at night as we settle into our brass bed the sparse traffic washes past, a remote and steady murmur around our sleep, as of dead souls babbling at the edge of a dream." (*White Noise* Don DeLillo page 9)

Life and death are thus, interconnected by means of dreams, and this is why the profoundly secularized setting is no longer a meaningless one, becoming the means for transcending the boundaries of time and space through a meditative attitude.

3. CONCLUSIONS - *WHITE NOISE* AND THE SPIRITUAL CRISIS

The novel *White Noise* illustrates a society which is apparently evolving from a material and social viewpoint, but which, in fact, is declining from a spiritual perspective.

This decline is solved by means of an attitude change concerning the profane reality. If the real itself is associated with the concept of simulacrum, which entails that creation is already completed, multiplied and non-referential, the individual finds no incentive to search for the meaning of existence. This has alredy been produced by an external source. The only role of the individual is to take its place in a mechanical structure which has no consideration for vulnerability.

The simulacrum is not concerned with vicissitude because its creation has been grounded upon the assumption that it destroys all possibilities of such vulnerability. In this regard, the critic Jean Baudrillard describes it, as follows:

It is no longer a question of imitation, nor of reduplication, nor even of parody. It is rather a question of substituting signs of the real for the real itself; that is, an operation to deter every real process by its operational double, a metastable, programmatic, perfect descriptive machine which provides all the signs of the real and shortcircuits all its vicissitudes. Never again will the real have to be produced: this is the vital function of the model in a system of death, or rather of anticipated resurrection which no longer leaves any chance, even in the event of death. A hyperreal henceforth sheltered from the imaginary, and from any distinction between the real and the imaginary, leaving room only for the orbital recurrence of models and the simulated generation of difference. (Page 167 Selected Writings Jean Baudrillard Chapter Simulacra and Simulation)

It is interesting to observe that the hyperreal is „sheltered" from the imaginary in the process of producing the simulacrum, in order to avoid the distinction between the imaginary and the real. This distinction would create the premises for the real to have vulnerabilities. Since the simulation aims at erasing all the vicissitudes of reality, and create a „perfect" model, it can be argued that this „perfection" transforms the simulated image into an object of no symbolic depth. This type of imagery becomes mechanical and thus, its spiritual dimension is lost. Existence is meaningful only if creation is in the process of becoming, incomplete and centered upon evolution. This incompleteness creates the feeling of invidual life purpose, enhancing his/her sense of worthiness.

The lack of meaning represents a real issue that can result in invidual and social chaos. It is because of this reason that the novel *White Noise* can be regarded as an attempt to recapture the meaning of life by empirical means represented by a change of perspective upon the profane reality. This can transform itself into a way of accessing the sacred in a profoundly urban cultural setting. A small act of innovation can facilitate this transformation: the shelves of the shops are rearranged and part of the anxiety is transformed into celebratory energy as a result. The reclaiming of the existential meaning is related to the reconnection to such traditional values as: innocence, celebration and compassion. The energy of anxiety is thus, transformed into celebration and this is the reason why the novel can be interpreted as a beacon of light harboring the hope that even in the darkest conflict-ridden profane environment, the reconnection to the transcendental is, nevertheless, possible.

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MILITARY CAPABILITIES THAT ROMANIA NEEDS FOR PREVENTING AND WAGING A HYBRID WAR

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Abstract: *Conflicts of the future will no longer be classified as conventional or irregular because the most capable opponents will pursue to combine a multitude of capacities and abilities in a complex typological mixture that relies to a great extent on the inaccuracy of approaches. In the current geopolitical and geostrategic, volatile and unpredictable context, hybrid warfare is a major concern and a strategic priority for international security and defense organizations. This article presents the most operative capabilities of the Romanian Armed Forces capable of responding timely to the present and future challenges and threats of the security environment in general, especially hybrid threats. In this context, we believe that the defense of the national territory must be approached as thoroughly and pragmatically as possible, thus generating an effective strategy for combating the modalities of expressing a hybrid conflict.*

Keywords: defense; terrorist actions; territory; military capabilities; ability to respond

1. INTRODUCTION

Soldiers describe war as an extremely violent and costly manifestation of the existing conflict at some point between large groups of people (states, peoples, nations), structured and provided with military equipment, using armed combat to achieve their targeted objectives (established by the political element)[1].

Wars and conflicts of the last decades were carried out following other principles than those associated with classical war, the demarcation line between combatants missing completely, whereas combatants are more invisible right now (see the Russia-Ukraine conflict, the wars of Afghanistan).

2. HYBRID WAR - BRIEF HISTORY

Current confrontations involve a reconsideration of the armed forces structures and their continuous adaptation based on the evolution of security environment. Although the national military structures will be preserved in the form stipulated by organizational charts - platoon, company, battalion, brigade, division and their corresponding equivalents, for crisis and war (hybrid) missions, the new structures must be modular / deployable, so that they can accomplish any mission assigned[2].

Since the beginning of the conflict in Ukraine, the concept of "hybrid war" has become somewhat of a buzzword, with an extensive use by media and news agencies, academic communities and the NATO to describe actions and operation methods used by Russia in Crimea, Donbass and Lugansk regions.

Currently, there are views that the war of the future will be nameless and the enemy faceless [3], or, war will be "hybrid" (a combination of classic and unconventional war, in which the lack of direct confrontation creates difficulties to the armies of powerful states, whereas classical laws of war are not being followed).

Hybrid war is "a combination of symmetrical and asymmetrical armed conflicts, where the intervention forces conduct traditional military operations against enemy forces and targets (military or/and civilian), while acting simultaneously and decisively to get control of indigenous population in the theater of military action, by stability operations"[4] .

In 2002, Major William Nemeth used the term *hybrid war*[5], to describe a "contemporary form of guerrillas" that "uses both modern technology and modern mobilization methods (in reference to the first Russian-Chechen war of 1994-1996, " flexible war, half regular, half irregular", based on conventional weapons, terrorist and organized crime methods)"[6].

Nathan Freier, senior associate, in the International Security Program at the Centre of Strategic and International Studies has defined hybrid war as a confrontation which involves four threats: traditionalism, asymmetry, catastrophic terrorism and disruptive terrorism employing technology to counterbalance the military superiority [7].

In 2007, Frank Hoffman, in his work, "Conflict in the 21st century. The rise of hybrid wars" emphasizes the impressive adaptability of new opponents that prepare and use different capabilities and asymmetric methods, in an innovative manner. The challenge will not come from one state, but from states or groups of states which choose from all the available arsenal, technologies and tactics that suit their own strategic geographies and cultures [8].

David Kilcullen, in his book, "The Accidental Guerrilla: Fighting Small Wars in the Midst of a Big One", says that hybrid war is the best explanation for modern conflicts, but he stresses that it includes a combination of irregular war, civil war, insurgency and terrorism [9].

The ways of waging the battle, in case of hybrid wars, are varied, including conventional capabilities, irregular tactics and formations, terrorist actions and criminal disorder. These actions will be carried out in order to obtain the synergistic effect on one or all levels of war. Thus, the ones waging hybrid wars "seek to obtain victory by merging irregular tactics and the most lethal means at hand, in order to attack the opponent and achieve their own political objectives[10] .

I will define hybrid war as the type of war that aggressively combines traditional irregular tactics, different techniques and procedures, including all elements of national power (diplomatic, informational, military and economic) in a unified effort focused on the achievement of victory in all aspects of war: tactical, operational and strategic. Future conflicts will take place between people, in the middle of people, limiting the utility of conventional applications of military power.

In hybrid war both military and especially non-military (societal) weaknesses are "exploited", which the abuser tries to capitalize: ethnic and religious tensions, weak and corrupt institutions, economic and energetic dependence. Based on these weaknesses, a hybrid war involves various actions, from terrorism to media propaganda, through irregular and not assumed military actions [11].

2. MILITARY CAPABILITIES THAT ROMANIA NEEDS FOR PREVENTING AND WAGING A HYBRID WAR

Preparing the territory for defense includes a set of measures and actions established and executed ever since peacetime, for the use of all human and economic potential of the country, to meet the needs of defense and to assure the continuity of economic and social activities in the event of mobilization or war [12].

The territorial defense is attributed to structures belonging to:

- Ministry of National Defense - all categories of forces;
- Ministry of Internal Affairs – Gendarmerie, Inspectorate for Emergency Situations, County Police Inspectorate, Border Police;
- Romanian Intelligence Service - territorial structures;
- National Administration of State Reserves and Special Problems;
- local public administration - local Police;
- National Reserve Forces [13].

In order to be able to meet the challenges and the current and future difficulties with concern to the continuous changes of security environment, the Romanian Armed Forces' capabilities must be integrated in defense planning both regarding the size of collective defense and the national defense, in accordance with the types of missions be them high intensity operations (collective defense operations, counterterrorism and non-proliferation, peace enforcement, extraction operation), operations of low intensity (CBRN defense and consequence management, peacekeeping, conflict prevention, imposing sanctions and embargoes) or humanitarian operations and support in case of disasters.

In reply to the hybrid threats, all security and defense organizations must combine productively all power elements in campaign plans and strategic actions that they conduct. Political, social, diplomatic components of power, as well as the informational ones must give full support to military organizations. At national level, in order to increase the quick reaction capacity related to non-military aspects of conflicts, the government needs to establish standards and cooperation procedures between agencies and within agencies that hold responsibilities in the field of defense, inclusive of nongovernmental organizations.

Military capabilities that Romania needs for preventing and waging a hybrid war:

- protection of resources and strategic assets (under state control) and their judicious use;
- critical infrastructure protection in order to prevent sabotage and espionage;
- correction of legal deficiencies (so that the hybrid aggression can be prevented);
- continuous and efficient communication between state authorities and civil society to prevent or defuse any ethnic and / or interreligious tension that would facilitate or support the actions of lobbying groups or agents of destabilization
- strengthening the safety culture at the level of both state authorities and population;
- design of a strategy and plan regarding responsibilities and the manner of preparation and conduct of military operations in case of hybrid attacks;
- development and assurance of capabilities necessary for participation in such actions, in major focus areas (police, gendarmerie, civil protection, administration, justice) and assurance of differentiated, specific instruction, but next to military structures;

- acquisition and implementation of state-of-the-art digital systems able to provide an improvement of knowledge regarding the environment in which operations are conducted and to increase the reaction against hybrid attacks, tending to obtain maximum effect at a minimal cost;

- structures capable of rapid transformation based on the assignment (battalion, regiment, brigade or its equivalent - which do not have a predictable structure), with high degrees of modularity at peace time, with modular forces, rapidly deployable on large spaces, with specific logistics to permit execution of actions independently and individually for a relatively long period of time;

- a flexible command and control system (centralized / decentralized) able to provide the time needed for the reaction in the context of the new physiognomy of war;

- a military intelligence system to assure the timely and efficient political, political-military and military leadership, at all hierarchical levels, for the purpose of avoiding surprise attacks and of assuring the decision-making processes;

- a communication and information system equipped with latest generation integrated equipment, methods, procedures, software and personnel, capable of assuring information exchange at all levels of command and control and interconnection with other systems of communication and information;

- ISR (Intelligence Surveillance and Reconnaissance) networks to collect, analyze, process and disseminate information in the system according to the situation and mission requirements;

-means air transport to assure strategic transport of deployable forces (planes, helicopters);

- flexible and modular groups of forces, self-sustainable, capable to operate both in conventional structures and in small, autonomous formations (especially in urban areas);

- modern combat equipment: combat armored and non-armored vehicles, attack helicopters, multirole aircraft, air defense systems, surveillance and electronic warfare systems;

- specialized structures (intelligence) prepared for counteracting actions that concern knowledge, influence, domination and control of attitudes, behaviors, will and decisions of the people;

- sharing, at inter-institutional level, of training facilities and designing a firing range for education / training for urban combat;

- structures ready to fight at all time, destined to surveillance and early warning, combat engagement, intervention in relation with military objectives, terrorist crisis and emergency situations;

- development of infrastructure necessary for deployment of intervention forces;

- improvement of quality of life by providing military living conditions, improvement of health care, enhancement of social dialogue and harmonization of legal framework concerning staff payment relative to national socio-economic realities;

- formation, training and use of volunteering reservists as well as a maintenance of a high level of readiness for mobilization of military structures;

- periodical training of the country population, in an organized background, by local administrative bodies, with the participation of representatives of the Ministry of National Defense / Romanian Intelligence Service, related to the execution of hybrid attacks by a possible aggressor and activities people need to carry out to prevent them or facilitate actions of specialized structures.

- preservation of a permanent freedom of movement and maneuver by controlling communication nodes (ports, airports, bridges, satellite stations, and other infrastructure elements) - military, police, gendarmerie, intelligence agents;

- establishment of territorial troops (county guards) made up of civilians and their training on procedures and methods of intervention in cases other than hybrid attacks, together with armed and public order forces in the area, until the deployment of specialized intervention forces;

- close monitoring of the borders to prevent infiltration of hostile elements, which can aim at discrediting or manipulating public opinion in the area, or destroying strategic objectives.

CONCLUSIONS

Although Romania committed itself to allocate at least 2% of GDP for defense, the decrease in the total budget revenues collected by the National Agency For Fiscal Administration in January and February 2017, decreasing by 0.9% compared to the same period last year, creates problems for the achievement of the strategic objectives proposed by the Ministry Of National Defense for 2017, implicitly also for the specific tasks of preparing the territory for defense (at this rate the total budget allocated to the MOD could be lower than last year's budget). This will affect the procurement of techniques, the improvement of existing techniques, as well as training.

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NEW OPERATIONAL REQUIREMENTS OF THE INTEGRATED DEFENCE SYSTEM IN THE HIBRID WAR CONDITIONS

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Abstract: *The assessment of the operational requirements characteristic of the hybrid war requires the integrated defence system to address new threats specific to the hybrid environment, in which the non-state or state adversary uses concerted and effective political, economic, military, informational or social means, as well as conventional or unconventional methods, procedures and actions, in order to achieve the planned objectives. An important aspect which differentiates the hybrid threats from past military conflicts is that in the current operational environment (hybrid type), the share of unconventional actions, especially those of asymmetric type, is clearly superior. In this article, we highlight the main aspects of the new operational requirements of the integrated defence system under the contemporary conditions imposed by the hybrid war.*

Keywords: *Operational requirements, integrated defence system, hybrid threats, hybrid warfare.*

1. INTRODUCTION

Specialists in the military science domain have analysed the phenomenon of hybrid war and have established that in the contemporary operational environment, complex weapons systems and high IT & C technology are not anymore a sufficient condition to carry out the mission and to achieve success, because the counteraction of a hybrid threat is the result of the action of people (force structures) who think creatively, who have initiative and who apply a wide range of tactics, techniques and battle procedures. Essentially, modern groupings of forces, used in a multinational system, in a complex, fluid and uncertain operational environment, have to carry out various missions in changing situations and circumstances.

When facing the hybrid opponent, the chances of success can increase significantly if all the power tools (political, military, economic, informational and legislative) are used and their vulnerabilities are identified and exploited. Moreover, the threat-type of hybrid war may be used by the belligerent force structure with low military power and this has in view balancing the ratio of forces and achieving major goals with very low losses. Typically, a belligerent who uses hybrid threats has an excellent adaptability capacity, effective combat capabilities; being highly motivated, extremely volatile and flexible.

To exploit the vulnerabilities of the opponent, the hybrid aspect of the war (specific to the contemporary operational environment) can be manifested on several planes. In *the structural plan* of the hybrid war are specified the operationalised forces (combatants, combat support, logistic support, special forces etc.), groups with expertise in psychological and informational operations, mass manipulation, espionage, influencing decisions at the economic, political, legislative level, etc.

The action plan details the following aspects: operating modalities; Individual weapons, fighting techniques and weapons systems; IT & C equipment; specific equipment to operate theatre conditions, etc.

Usually, the hybrid threat is not visible, and the perpetrators of this type of threat cannot be proven too easily to be punished under international law because they use specialized structures (sometimes different intermediaries), endowed with state-of-the-art technological means, they use new training criteria and innovative tactics, techniques and procedures specific to asymmetric warfare. An important feature of the hybrid threat is that this type of action involves a great amount of effort, allowing the unconventional opponent to extend the conflict over time to the limit of the war of wear, as well as combining it with asymmetric measures and asymmetrical operations such as sabotage or ambushes, in order to significantly diminish the combat power of the conventional type.

Essentially, the strategy of opponents who use the hybrid threats in the current operational environment is an efficient one, as it is easy to get asymmetric advantages through combinations of highly trained and highly technological capabilities.

2. NATO's APPROACHES TO OPERATIONAL REQUIREMENTS SPECIFIC TO HYBRID WARFARE

In the last decade, US military specialists have developed the concept of *hybrid war* to emphasise the need for the US military to permanently adapt to the new realities of the modern operational environment. Since 2005, initiators of the development of this concept (Frank G. Hoffman and James N. Mattis of the US Marine Corps) have published the article *„Future Armed Confrontations. The emergence of hybrid wars"* [1] in which they claim that the wars in Iraq and Afghanistan have influenced the whole process of American strategic thinking on how to respond to new threats to the American continent and US interests. In the same context, it is also underlined that the conventional threat will never disappear, and that *„the US Armed Forces must maintain their superiority in this area in order to be ready to carry a major, high-intensity war at any time"*.[2]

In 2008, Russel W. Glenn (renowned US military analyst) published the article *„Evolution and Conflict: Summary of the 2008 Israel Defense Forces"* defining the concept of a hybrid threat as *"an adversary who adaptively and simultaneously uses a combination of political, military, economic, social and informational means, within conventional, irregular, catastrophic, terrorist and disruptive / criminal methods"* [3]. After a year (2009) at the *"Hybrid Threat Seminar War Game"* conference in Santa Monica, Russel W. Glenn, supporting the concept of hybrid confrontation, shows that this concept represents a *complex amalgam of activities without any restriction*. On the other hand, the hybrid threat can be characterised by simultaneous non-military and military activities, decentralised, combined with the traditional asymmetrical ones, terrorist actions with disruptive criminal ones, under the complex operating environment, *"all with the intention of using time and space to make the right decision"* [4]. As a rule, this type of opponent may be a state actor, a non-state actor, or a combination of these.

During the same period, Frank G. Hoffman defined the hybrid threat as *"any adversary who simultaneously and adaptively uses a combination of conventional weapons, irregular tactics, terrorism, and criminal behaviour in the battlefield to achieve its political objectives."* [5] It is noticeable that Hoffman, in his definition, used only terms specific to tactical and operative level actions.

It did not include strategic-level actions or political, social or economic actions. Instead, he appreciates the very close links between asymmetric actions such as organised crime, terrorism, trafficking in human beings and drugs, destabilising actions of undermining local authorities and generating or amplifying the crisis.

In fact, organised crime structures operating on the American continent (with effort in Mexico) and opium production in the Afghanistan area are particularly damaging factors that support its theory.

Later in 2013, the US Army, in its military doctrine, detailed the two concepts (*hybrid threat and hybrid war*) and explicitly used them without creating confusion. Thus, the hybrid threat has been defined as a dynamic combination of heterogeneous, regular and / or irregular, criminal and / or terrorist forces, unified, under the unitary leadership, acting to achieve major effects in the common interest. Moreover, hybrid threats can combine the operations of regular forces (operating under norms, laws of international law and military traditions) with operations carried out by irregular forces (performing operations without precisely established objectives and without restrictions of violence). Unregulated forces include guerrilla troops, terrorists, and criminals who can combine various abilities depending on the situation (use of irregular/ regular weapons and tactics and techniques). These types of skills can generate important hybrid threats that, if used against the vulnerable elements of a conventional opponent, can be extremely effective.

Also, in US military doctrine it was specified that the US military considered the existence of the two main forms of war (irregular and traditional). The war is a duality involving both dimensions in both forms of combat (offensive or defensive). *"The basic forms of war are not in terms of `either one or the other` but in a variety of combinations, depending on the capabilities and strategy of the combatants"* [6]. For these reasons, the formulation of specific operational requirements for hybrid warfare is difficult to highlight. However, international democratic bodies must militate that, in any type of military engagement (including counter-terrorism, cross-border organized crime, etc.), at least the following operational requirements must be respected: to be legitimated, to be legal and based on regulations National and international specificities; to ensure the protection of the forces carrying out actions in compliance with the legal provisions; to adapt easily to the actual situation in order to quickly remove the effects produced; to respect the signs of the sovereignty of states when acting in the multinational environment; to act proactive and proportionate to the size and intensity of the crisis; to fulfil the missions established by the political-military leadership; to avoid creating disproportionate reactions; to ensure the protection of the population, institutions and national patrimony; to avoid and limit the collateral effects.

Under the conditions of the hybrid war, the planning of military actions (in the conditions of the globalization of the terrorist scourge and cross-border crime) has become very delicate in the sense that the limitations of the legal framework of military operations must be strictly known, especially when performing undercover actions, surveillance, information, monitoring, etc. In this respect, the functioning of the integrated national defence system must be properly assessed in order to ensure the coherence and the operational and decision-making efficiency, specific to the prevention and combating of the hybrid threats.

3. THE RUSSIAN FEDERATION'APPROACH REGARDING THE OPERATIONAL REQUIREMENTS SPECIFIC OF HYBRID WAR

In Russian conception there is a different approach regarding to the hybrid war and the hybrid threats, and this practice was applied in Russian-Ukrainian conflict. The fact that the rules of the war are already changed was confirmed by Valery Gherasimov (Chief of General Staff of Russia) in an article entitled *"The value of science in prediction",* where he presents a certain and lucid definition of the concept of hybrid war, affirming that: *"the centre of gravity of the methods applied into the conflict changed in the direction of using a large scale of political, economical, informational, humanitarian and other non-military measures ,applied in coordination with the potential protest of the population".*

Also, he supports that in modern conflicts, the asymmetric operations have a pretty important presence, which would make possible that in the future armed conflicts, the cancellation of some political, economical and military advantages of conventional enemy.

Gherasimov highlights the asymmetric actions generated by the use of forces of the special structures in order to generate and maintain, throughout the opponent's territory, a conflict situation with a permanent character. This scenario can be completed by joining special IT & C. Essentially, in modern contemporary conflict, the separate threats have diminished in intensity, and operational approaches are fundamentally different. The opponents have already been using different forms of action tactics and procedures, more important and effective, being that with a simultaneous character. In the hybrid war, *"the war no longer declares itself, but once it starts, it goes according to an unfamiliar model,"* added Gherasimov, an observation that promotes the effort of planning military operations in the area of irregular threats, which would impose a comprehensive abdication from opponents to facilitate the achievement of the objectives.

It should be noted that there is a big difference between the Russian approach, mainly applied in the Ukraine area and NATO's western approach. This difference is applied because of doctrinal conception of the Russian Army, lacking of the conventional threats, as Gherasimov even stated, in the same article: *"one of the main objectives pursued by the hybrid threats is the destabilization of the governing body and the main institutions of the opponent, Thereby creating chaos and vacuum of power."* This goal can be achieved only if the opponents will avoid using traditional methods if they do not carry out predictable actions and will seek to gain important strategical advantages through violent attacks by surprise that will immediately achieve the goals of the hybrid-specific operation.

The whole physiognomy of the hybrid conflict, supported by the military expert Gherasimov, it was applied perfectly to the Russian-Ukrainian war. At the same time, guerrilla actions have been combined with actions specific to cyber, informational, economical and political conflicts, amid a lot of psychological and media operations which aimed at vulnerable state building and causing chaos and destabilization of public authorities.

The key elements that supported the Russian approach were five, as follows: [7]

1. *Undertaking actions under the law* - creating or simulating a legality issue / moment in order to avoid any possible accountability to international security bodies (for example, the organization by Moscow and the holding of a referendum on the annexation of Crimea without international supervision as a follow-up Of the "will of the local population");

2. *The organization of demonstrations of military force* - important Russian forces and military equipment were deployed at the border with Ukraine for preparing a strong and fast intervention, if the crisis created requires entrance in the neighbouring territory, in order to solve it;

3. *Intervention with special forces* - on the territory of Ukraine, the Russian Army used insignificant force structures (the Vostok battalion) as "local security forces" to facilitate Russian intervention in the area and to protect the Russian population, atypical operation that has not attracted any political accountability to international democratic bodies;

4. *Creating a firewall to justify force intervention* - against the backdrop of the protection and support of dissatisfied Russian minorities, Russia launched military action on the territory of Ukraine, taking advantage of the local militias and the tensions maintained by the pro-Russian population;

5. *Expanding the media war through hostile and laborious propaganda* - aware of the importance of the media during the hybrid war, Russia has deployed massive mass-manipulation and disinformation campaigns, turning information into an effective weapon. At both global and regional level, they have promoted systematic disinformation, credible denial, humanitarian coverage, invoking historical arguments, etc.

The involving of Russia, using specifical procedures of the hybrid war, in different areas of the world became a method at the beginning of this millennium.

General Philip Breedlove, demonstrated in a meeting of the USA Senate on february 2016 that Russia used Syrian refugees for creating a weakness in the European continent, destabilizing the local economic goals and creates a major social anxiety. Also, in the same month Jussi Niinistö (Finnish Minister of Defence), declared, in a meeting of the defence ministers part of the NATO, that Finland has information that Russia would open another front, in the nord of the European continent, at the russo-finnish border for about 1 million migrants, for which they would facilitate the crossing of the border so they would reach west of the Europe. A declaration regarding the new front of the migration, round the Baltic Sea, was made by Ilkka Kanerva, president of the Parliamentary Commission of National Defence (ex external business minister of Finland). [8] Also, there is more and more information that support the interference of Russia into internal USA problems, on the 2016 elections, into the Russia-European Union relationship, as well as some accusations of destabilizing and intimidating the EU states, by extending the cybernetic war by the Federation of Russia.

An example, typical for our subject, is the Islamic state (of Iraq and Levant/ISIL) a non-statal actor which continues to use hybrid techniques and tactics against conventional forces of Irak army. ISIL has set goals that it wants to achieve using regular, irregular tactics and terrorism [9]. The Iraq State, in response, has adopted hybrid tactics, seeking to use international and non-state actors to counteract ISIL's intentions. Thus, the Syrian-Iraq hybrid war has become a conflict between groups of non-state and state actors, which have overlapping goals in the responsibility area of a weak state with divergent interests. [10]

To combat hybrid threats the people who are in charge must focus the efforts to win the trust of the population, choosing for long-term strategies and comprehensive approaches to counteracting hybrid threats, as well as for non-military tools, including intelligence operations.

CONCLUSIONS

Operational requirements specific to hybrid conflicts need to be adapted to the contemporary operations planning system (to combat the terrorist phenomenon, illicit acts specific to cross-border organized crime, internal corruption, etc.). Giving the existence of limitations and constraints, it is very important to know the restrictions of the war in order not to overcome the legal framework of military actions. This issue becomes even more sensitive if we look at the situation where undercover, surveillance, information, monitoring or even irregular combat actions are taking place, involving non-militarized structures, terrorist groups and criminal networks. Therefore, in the hybrid operation planning algorithm, the function of the integrated defence system should be assessed permanently to detect, eliminate or reconsider some malfunctions, to ensure policy coherence and efficiency, prevent, sanction, and combat hybrid threats.

In the hybrid operational environment, the borderline between the actions of state or non-state actors (terrorists, insurgents or criminal groups) is highlighted quite hard, because there is also the possibility of confronting opponents who can use unconventional means. This may favour the emergence of hybrid threats stimulated by unconventional, incidental or uncoordinated actors, used simultaneously and unitarily by identified opponents who can use hybrid threats to exploit operational vulnerabilities, generate military challenges, and trigger hybrid conflicts, in violation of the legal, ethical and democratic framework. Even if we are discussing about the new operational requirements of the hybrid war, the design and operation of the defence system under the conditions of hybrid threats is only a part of the integrated national security system that manages the whole set of actions and operations in different environments (diplomatic, political, democratic, economic, moral-spiritual, cultural, ecological, criminal, legal, humanitarian and military) by all public authorities, as well as by state powers, at peace and war.

Under these conditions, with the scientific implementation of an algorithm of the operationalization activities on the integrated combat system, following the model established by the NATO structures can efficiently approach the operational requirements in planning of military operations under the conditions of the hybrid war.

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DEVELOPING LEADERSHIP SKILLS. IDENTIFYING LEADERSHIP QUALITIES AND ATTRIBUTES

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Abstract: *One of the selection criteria for someone to join the military and especially to become an officer is to pass a psychological exam, which consists of a situational test in order to evaluate leader aptitudes and the capacity to work in a team. Passing that exam does not guarantee that a student will become a leader, he only has the potential to become one and skill developing requires other than a special educational program also self reflection on practice. In this article I developed a self-assessment questionnaire for identifying leadership qualities and attributes which can help both students and instructors as an initial evaluation of his students.*

Keywords: *leader, leadership, self-assessment*

1. INTRODUCTION

"*Leadership cannot be taught. It can only be learned***."**
- Harold S. Geneen

Leadership skills can be developed. Everybody has a certain potential to become a leader, which can be developed or left behind depending on many situational factors as the need to adapt to an environment and its requirement. Leaders are not born and from leadership skills can benefit anyone.

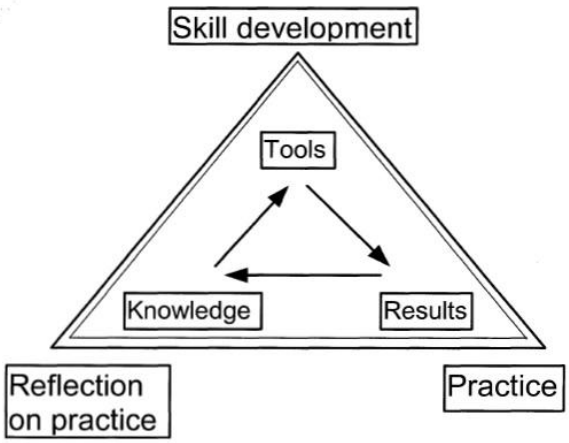

Fig. 1. Leadership skill development model

In this article I present a self-assessment questionnaire for identifying leadership qualities and attributes as one of the most important aspects of a leader development is relying on his own reflection on practice.

In order to define the most important qualities and attributes of a leader, I made an overview of the main theories on leadership which gives us an idea of this complex concept.

Self-evaluation is an essential element in the process of evaluation that helps the student to focus on his development by providing information about what has been achieved and what we need to accomplish. As important is the fact that students participating in the self-evaluation can develop metacognitive skills.

Like most learning activities does, self-evaluation is also a skill that must be developed. Students who rarely does evaluate themselves, need guidance in order to get used with the process, choose the right questions as many times the right question can be more important than a bias answer. Personal specific action plans, represents an ideal format of the questionnaire outcome.

As an instructor, this questionnaire can serve as an initial evaluation of students. The answers are marked in three different colors: red, yellow and green, which can serve as a criteria for the instructor to organize his groups in smaller groups and give specific group tasks depending on their developmental level on a specific criteria.

2. LEADERSHIP THEORIES OVERVIEW

Among the most popular and clearly defined theories in leadership approach are as follows:

- Great Man Theory
- Trait Theory
- Behavioral Theory
  - The Managerial Grid Model / Leadership Grid
  - Role Theory
- Participative Leadership
  - Lewin's leadership styles
  - Likert's leadership styles
- Situational Leadership
  - Hersey and Blanchard's Situational Leadership
  - Vroom and Yetton's Normative Model
  - House's Path-Goal Theory of Leadership
- Contingency Theories
  - Fiedler's Least Preferred Co-worker (LPC) Theory
  - Cognitive Resource Theory
  - Strategic Contingencies Theory
- Transactional Leadership
  - Leader-Member Exchange (LMX) Theory
- Transformational Leadership
  - Bass' Transformational Leadership Theory
  - Burns' Transformational Leadership Theory

One of the major aspects of the leadership process is *influence*. In this process a leader influences a number of individuals to fulfil a common mission, but those individuals are influenced not by power, authority, the imposed influence comes from a freedom of choice. Without this type of relations, we are talking about an order execution, which is a management feature. "Managers have subordinates, leaders have followers."-Murray Johannsen

Certainly, the existence of freedom does not mean the absence of any form of authority, but also the value of freedom rests on the authority which provides laws in front of which all men are equal.

By researching all the theories mentioned above in a chronological order, I found a few common characteristics:

- Leaders aren't born, they develop. Leadership is a process of training based on experience, education, learning and personal challenge. Even in societies ruled by a king who inherit the right to lead, his leadership is subjected to an education in this respect.
- You don't have to own the authority to be a leader. If we look on any definition we notice that no leader needs to be a commander, all commanders though should be leaders.
- Leaders are responsible for their actions. Tyranny is born due to absolute power without responsibility, freedom of the press and the justice are the means by which the highest levels of leaders are responsible for the actions.
- Leaders have a positive approach to carry out missions. Punishments, coercive methods to influence, extortion, are not the means by which a true leader exercises influence over the others.
- The leader must be moral. Adolf Hitler had fulfilled most of the features of a leader except the moral side and that is just one example of what leadership means without a moral component. " Bad leadership implies no leadership. I contend that there is nothing neutral about leadership; it is valued as a moral necessity " MacGregor Burns[1]

3. IDENTIFYING LEADERSHIP QUALITIES AND ATTRIBUTES.

As I stated before, my belief is that leadership skills can be developed and learned, and also in the military, the right kind of leadership and the most complete is most often "transformational leadership". A transformational leader can motivate his followers in crisis situations and build a team capable of meeting the next challenge even more effectively, inspiring vision of the future and manage the implementation of that vision.

A lot of this goes on within a potential leader's mind, however, as someone seeking to nurture leaders in a military academy, we can learn to recognize the traits shown by these people. By watching out for these traits, we can see if that person we're watching is thinking in the right way. Military students come into schools with a great potential that instructors need to ensure it’s developed.

So, while almost everyone can develop leadership qualities, some may already be more advanced in their ability to do well in leadership roles. The observed behaviors listed below show this high potential and by having this questionnaire as an initial evaluation, the instructor can form groups of students on the same level that can challenge each other and also have different standards set. This self-assessment questionnaire has three colors than can transform into a specific group by extracting the criteria of interest.

First, take time to honestly analyze yourself. Learn to understand yourself. It’s the first step to understanding others.

Red = NEVER, Yellow = SOMETIMES and Green = ALWAYS

At the end of the questionnaire, identify areas for improvement. Look for these personal attributes in others and develop them in yourself.

Table 1. Leadership qualities and attributes

Do you accept the status quo by settling for things the way they are? *By combining their technical ability with their strong conceptual skills, leaders are able to generate new ideas and build an inspiring vision of how the future could be.*			
Do you often think of new and practical ideas and suggestions?			
Do you stay aware of current issues and trends, understand the impact these can have, and is quick to define opportunities and threats?			
Do you enjoy bouncing ideas around and thinking laterally?			
Do you often look for bigger assignments and for opportunities to learn new skills?			
Are you passionate about leading? *Leaders have an internal drive to spearhead projects and take on the leadership role.*			
Do you usually see the "big picture" and plan at least the first few moves to accomplish your tasks?			
Do you commit to ideas and get results?			
Do you enjoy initiating new projects?			
Do you have a high level of self awareness? *Leaders know themselves. This means that they know what they're good at, they know what they're bad at, they exploit their strengths, and they manage their weaknesses (for example, by working with someone with complementary strengths).*			
Do you seek ways to increase your understanding of yourself –skills, aptitudes, and competencies?			
Are you open to all types of feedback?			
Do you ask for feedback and act constructively to make improvements?			
Do you usually listen without trying to justify or getting defensive?			
Do you see the impact that your behavior has on others and makes adjustments accordingly?			
Do you proactively turn mistakes into learning experiences?			
Do you have high integrity *Leaders are fair and trustworthy and expect the same from others. People trust what they say and have faith in what they do. Because of this, these leaders are respected and they treat others with respect as well.*			
Do you communicate openly with everyone?			
Are you afraid to be wrong or to have a different opinion?			
Do you share mistakes and bad news openly and honestly?			
Do you take responsibility without seeking blame?			
Do you provide valuable feedback to others?			

Do you resists making quick judgments on instinct, and prefer instead to observe what others do and the types of decisions they make?			
Have you consistently performed very well and deliver outstanding results?			
Do you respect other people? *While leaders aren't always people-people (being extroverted or charismatic helps, but isn't essential), they are genuinely interested and concerned about others welfare, and they work hard to help people in their teams make the most of themselves.*			
Do you invest in relationships with people?			
Do you see the value in others and want everyone to be the best they can be?			
Are you quick to ask for, give help and encourage collaborative work behavior?			
Do you bring a contagious enthusiasm to the workplace. *Leaders are inspirational – they have a positive and motivational energy.*			
Would you describe yourself as a fun, positive, generous person?			
Are you quick to give credit to others?			
Do you openly celebrate success?			
Do you focus on the positive, and try to make the best of a situation?			
Do you make solid decisions in highly uncertain situations?			
Are you good at simplifying complex issues?			
Are you mentally tough? *Whatever the challenge, you have to be strong, see things through a new lens, and take decisive action if you want to move through it successfully.*			
Do you accept and encourage change?			
Are you proactive?			
Do you believe in yourself?			
Are you purposeful and driven into getting the job done?			

CONCLUSIONS

Leadership skills development is important for any person that works in a team. Becoming a leader and create visions, values, inspire commitment, challenge and transform ways of thinking and acting requires more than a formal educational frame, it is a personal challenge.

The first step in becoming a leader starts with self-awareness, acknowledgement of strengths and weaknesses. In a military academy, instructors have to do more than transmitting knowledge to students, they need to be mentored and challenged to develop themselves.

Insight does not simply appear, formed from the consumption of professional content, growth brought on by experience, and the refinement that everyday discussion brings. Great leaders take this process intentionally, so that they are ready when problems arise.

Reflection is the step a leader takes in shaping the surrounding content into personalized insight. For example, after completing a self-assessment questionnaire as the one I presented, the reflection step is capturing how the text is specifically relevant and applicable. Reflection is intellectually challenging. Anyone can pick out a brilliant quote, but the great leader is able to convert that insight into lessons that resonate in his own leadership environment. Leaders draw insight from experience, lessons learned provided that they are open to learning from that experience.

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THE PREVALENCE OF CURRENT PATHOLOGIES AMONG MILITARY STUDENTS AND PROPHYLACTIC METHODS

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Abstract *: Purpose: In this paper, we aimed to analyze data regarding prevalence of certain pathologies that suit various organ systems of military students and also to expose prophylactic notions targeting these diseases.*

Introduction: Assuming that each domain has characteristic risk factors, we want to point out the importance of all the medical measures necessary for preventing and monitoring the dysfunctions that occur.

Methods: The retrospective statistical study conducted by applying a questionnaire of 10 items on a representative sample (150 people) has fundamented this research.

Results: Following interpretation of the obtained proportions we prioritized the possible disease categories (attention and/or concentration disorders - 56% of all central nervous system pathologies; anorexia / hiperorexia - 68% in the digestive system; burning when urinating - 47% in the urinary sphere; minor trauma - 51% of osteo-articular system), pointing also predisposing aspects, diagnostic, therapeutics and preventives.

Conclusions: According to the results above, there are three major considerations highlighted: the existence of cause-effect relation in the syndromes found, its materialization in the military environment and the importance of knowledge, and last, the application of prophylactic rules.

Keywords: *prophylaxis, military students, pathology, risk factors, therapy*.

1. INTRODUCTION

The War of Independence was marked by a high number of injured soldiers, due to the tactics employed in assaulting enemy entrenchments. Along with diseases caused by improper hygiene and unfavorable weather conditions (humidity, low temperatures, frequent precipitations), organizing personnel in large groups made them more susceptible to being infected by (and further transmitting) anthrax, smallpox and the flu. The situation was worsened by digestive problems (dysentery) caused by poor quality food and contaminated water. [1]

As time went on, an improving economy and advancements made in all medical fields (diagnostics, treatment, recovery), the number of recorded illnesses at a national level were on a steady decline, both in the military and the civil sector.

2. PURPOSE

This paper aims to show the prevalence of the main pathologies afflicting military students, so as to systemize them and propose measures for improving their condition and optimising their activities.

3. OBJECTIVES

The main objectives of this study can be surmised as follows:

- collecting and analyzing data obtained from a questionnaires filled out by students from the 5 higher military education institutions in the country (The `Henri Coanda` Air Force Academy – Brasov; The `Nicolae Balcescu` Land Forces Academy – Sibiu; The `Mircea cel Batran` Naval Academy – Constanta; The Military Technical Academy – Bucharest; The Military Medical Institute – Bucharest/ TarguMures)
- establishing the proportions of the each system organ diseases
- outlining the interrelation of risk and pathology, as well as upholding the importance of applying preventative measures to stop further infections and disease outbreaks

4. RESULTS

The 10 item questionnaire was applied to a sample of 150 people and yielded the following results:

- attention and/or concentration deficits accounted for 56% of pathologies concerning the central nervous system
- anorexia – 68% of those affecting the digestive system
- minor trauma - 51% of the afflictions of the osteo-articular system
- stinging during urination – 47 % of problems of the urinary system.

QUESTIONNAIRE

Hi! We would like to ask you to answer the following questions by submitting an "x" in the appropriate box according to your answer and we would like to identify yourself by filling:

Age
Sex
Year of study
Specialization / Branch
University / Academy

1. Do you consider that maintaining your health in the physiological parameters is one of the most important factors in your military career?

Yes
No
I do not know
I am not interested

2. Have you experienced having pathological consequences highlighted in your daily activities?

Yes
No
I do not know
I am not interested

3. On which organ system of those listed below do you consider that the military factors acted in a maximal way?

Central servous system
Digestive system
Urinary system
Osteo-articular system

4. From the point of view of the central nervous system you have experienced ...
... attention and / or concentrating disorders?
... depression?
... panic attacks?
... physical, emotional and mental exhaustion (burnout)?

5. Which of the following digestive symptoms did you have?
nausea / vomiting
anorexia (lack of appetite) / hyperpyrexia (overgrowth of appetite)
constipation / diarrhea
dysphagia (difficulty swallowing) / abdominal pain

6. In the urinary system were present...
... burning when urinating
... frequent urination
... oliguria (decreased level of eliminated urine within 24 hours)
... pain in the urinary tract

7. Regarding the osteo-articular system you have suffered...
... minor trauma (sprains)
... major trauma (fractures)
... pain in the various segments of the spine (cervical, thoracic, lumbar, sacral-coccygeal)
... bone deformities (kyphosis, scoliosis, lordosis)

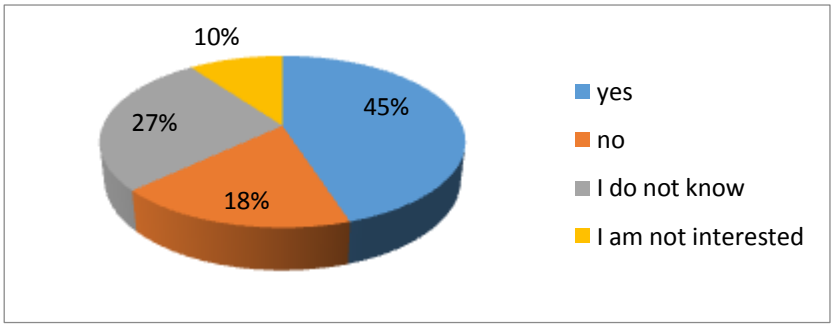
8. Do you believe that the repercussions of the daily schedule had a resounding:
maximum
moderate
minimum
meaningless

9. Which of the following characterize your attitude on those above?
indifference
latency
natural remedies
medical treatment

10. Do you consider that existing prevention methods at the moment are effective enough? Yes
No
I do not know
I am not interested

Thank you for your time !

1. Do you consider that maintaining your health in the physiological parameters is one of the most important factors in your military career?

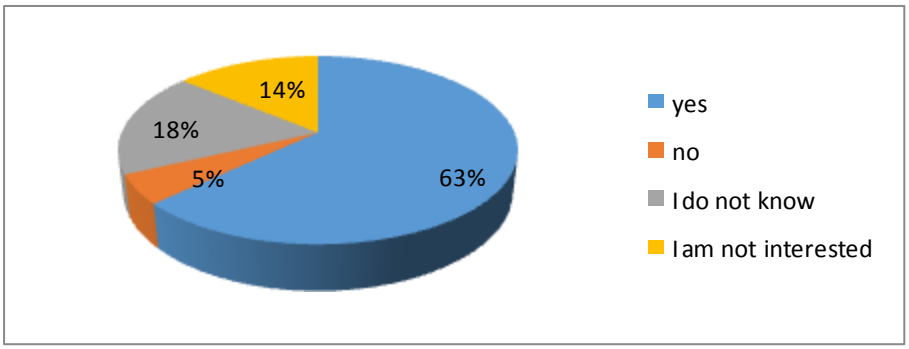


Most of the military students (45%) believe that maintaining physiological parameters of their health is one of the major determinants military career, 27% opted for the answer "I do not know", advocating for an insufficient knowledge of the implications of these variables, followed by 18% that answered "No" to this question, and choosing "I am not interested" representing 10%, which shows that these people are independent of the consequences that might arise in an imbalance.

The World Health Organization (WHO) provides in 1948 the consecrated health definition as: "the complete good state of physical, mental and social. It is not just the absence of disease or infirmity". The characteristics of this explanation are the following:

- it is accepted worldwide as a "aspiration"
- achieving it involves empowering society
- the definition emphasizes the positive and multiaxial character of health. [3]

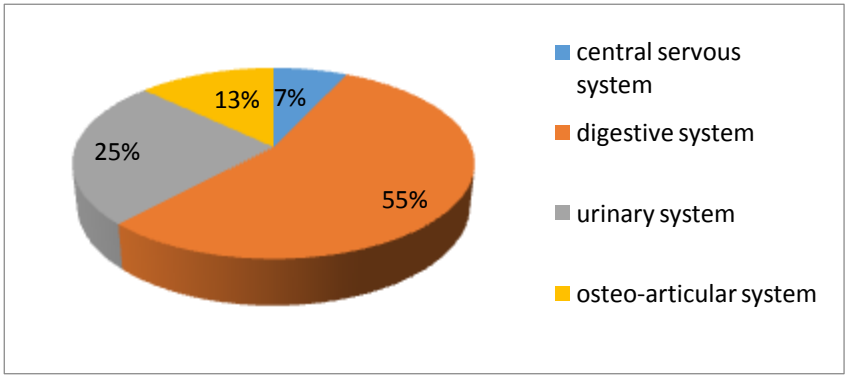
2. Have you experienced having pathological consequences highlighted in your daily activities?



Among the physiological factors that support work capacity is also the health status included, along with the psychological and the external nature ones (the work environment and socio-economic), in antithesis with the pathological factors which lead to diminishing the performances in a career.

Most of those surveyed had experienced pathological conditions with consequences highlighted in their daily activities (63%), and only 5% were not disturbed of such dysfunctions. 18% of participants can not decide if their schedule was influenced or not by negative symptoms, and 14% did not give importance to this aspect.

3. On which organ system of those listed below do you consider that the military factors acted in a maximal way?



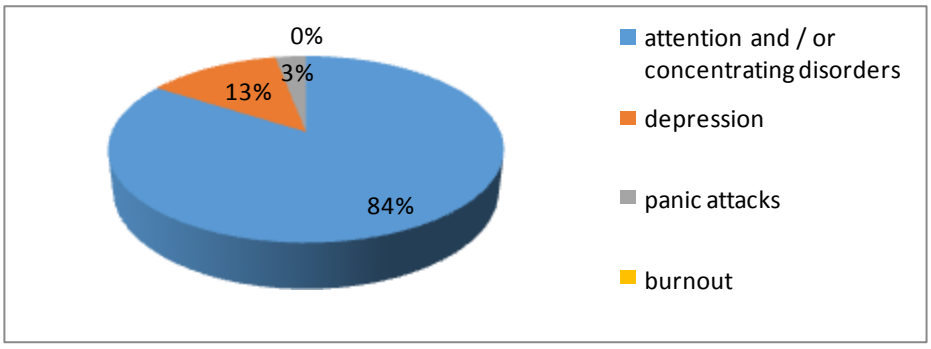
Each field shows, by its nature, a variety of risk factors, and the military system predispose also the appearance of various pathologies because of specific activities undertaken.

Predisposing factors can be classified into various categories, from which we remark:

- physical-factors: exposure to extreme temperatures, high humidity, excessive weather precipitations, intensity noise of over 90 dB (a normal conversation is about 65 dB)
- chemical-factors: toxic substances (irritating and asphyxiating), flammable (oil, petroleum)
- psycho-social factors: stress, disposed in collectivities, unpleasant tasks, the time needed to achieve the required pace of work. [3]

Notable is that the central nervous system is the last ranked at a ratio of 7%, and also gratifying because of the difficulty in treating these disorders, compared with the digestive system which, although occupyes a leading position (55%) does not exhibit usually a threat.

4. From the point of view of the central nervous system you have experienced...



Memory works by the following algorithm: information -> attention -> concentration -> storage and disrupting any steps can create disturbances with implications of different intensity. Thus, attention disorders (84%) involve two directions:

- hypertrophy of attention, including fixed ideas (simple, accompanied by emotions or impulsive form)
- atrophy of attention, admitting the impossibility of maintaining or even the constitution of attention.

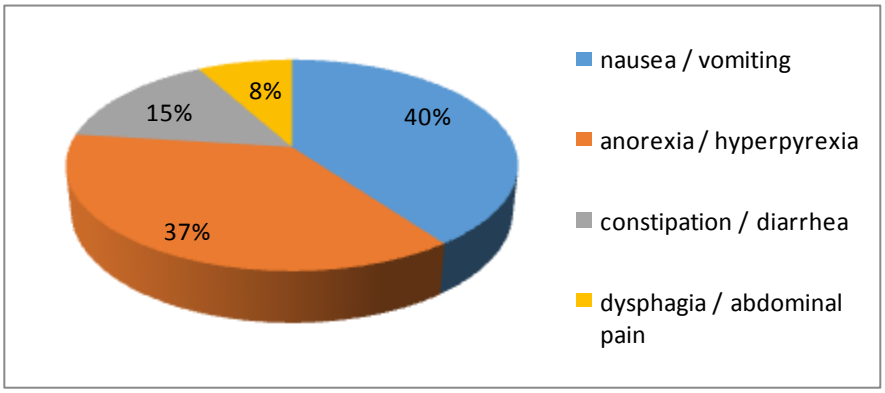
Concentration disorders may be caused by various factors, such as stress, anxiety, certain environmental factors (noise, sudden temperature increase or decrease), changing eating habits (quitting to drink coffee) and lack of sleep or disturbed sleep. [2]

Currently, major depression is the number fourth disease spreaded around the globe, representing one of the serious problems of contemporary man. According to estimates of the World Health Organization (WHO), in 2020, depression will be the second leading

cause of disability, soon after cardiovascular disease, with a prevalence twice as higher on women. [2]

13% of military students had at one time a depressive episode (diminution of interest in daily activities, sleep disturbances, psychomotor slowness, restlessness), 3% have accused the symptoms of a panic attack (palpitations, sweating, tremor, shortness of breath, imbalance, dizziness or fainting) and no recorded case of burnout (represented by physical and mental exhaustion and caused by prolonged exposure to stress, often accompanied by depression).

5. Which of the following digestive symptoms did you have?



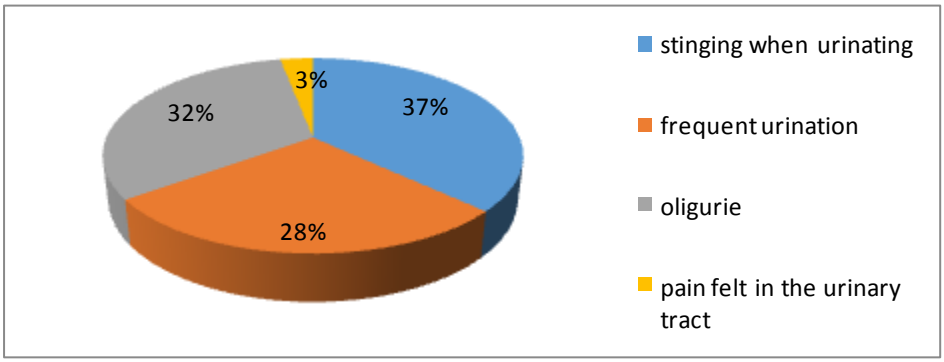
The percentage of 40% was represented by symptoms of "nausea / vomiting", which are, most often of short duration caused by indigestion, the latter being the result of several agents (too fast ingestion of food, smoking, gastritis and carbonated drinks); nausea and vomiting that last for a long period are reserved in cases of migraine, trauma, cancer etc.

Anorexia is an eating disorder with physical and emotional implications, having as main feature lack of appetite, unlike hiperorexie which involves uncontrollable need to ingest food in greater quantity, both with psychological substrate; 37% of students have opted for this answer.[3]

A balanced diet, rich in fiber, adequate fluid intake and maintained physical activity are some of the most important factors which prevent diarrheal syndrome and constipation, soldiers surveyed exhibiting these imbalances at a rate of 15%.

8% have enrolled variant response "dysphagia / abdominal pain", the first representing difficulty in ingesting food, both of which are generally caused by motility disorders, mechanical obstructions and disorders in the digestive tract.

6. In the urinary system were present...



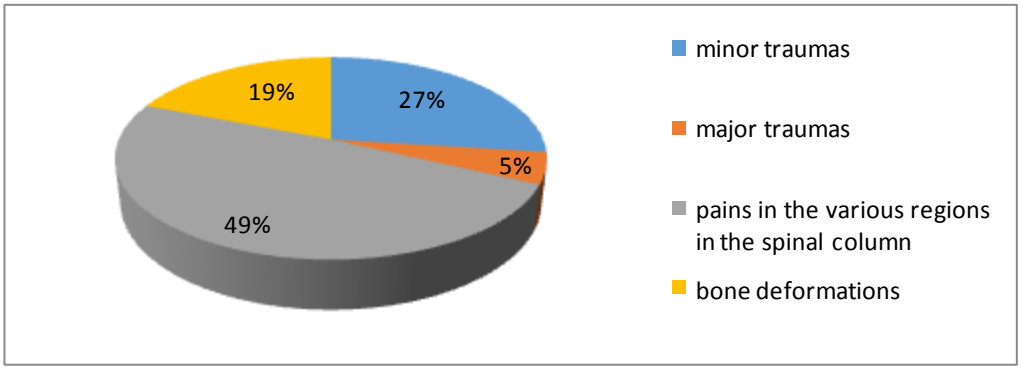
Stinging (37%) and frequent urination (28 %), along with pain felt in the urinary tract all suggest the presence of urinary infections. Statistics show that these are the most common types of infections worldwide, surpassing even those of the respiratory system, with females being more often affected (due mainly to anatomical reasons).

In 80% of common urinary infections are caused by Escherichia coli (E. coli), a bacteria usually found in the colon or anus area. [3]

Oliguria (32%) is the production of abnormally small amounts of urine in a 24 hour period (bellow 500 ml) and is most often due to an extremely low fluid intake, or by expelling liquids through other natural means (dehydration).

Pain felt in the urinary tract is usually experienced as a result of inflammations or from kidney stones . The present study shows the rarity of this type of condition.

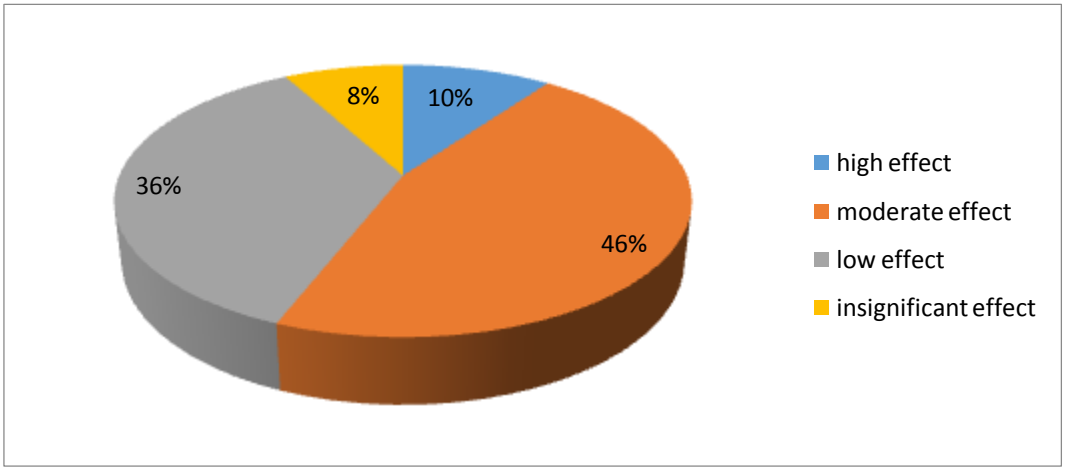
7. Regarding the osteo-articular system you have suffered...



Fortunately major traumas were only noted in 5% of the cases, followed by bone deformations (19%) and minor traumas (27%). Most common were pains in the various regions of the spinal column (cervical, thoracic, lumbar and sacral curve).

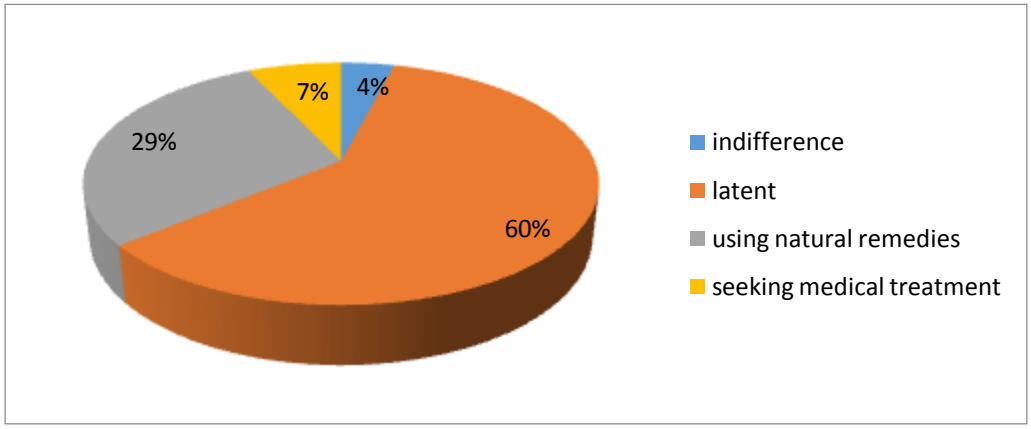
Bone deformations and spinal column pains are usually caused by improper posture and repeated pressure exerted by carrying heavy equipment, followed by unfavorable weather conditions and periods of intense physical activity. [3]

8. Do you believe that the repercussions of the daily schedule had a resounding :



The individuals questioned have stated that repercussions on the schedule have had either a high (10%), moderate (46%), low(36%) or insignificant effect (8%). This shows that they have varying individual capacities to adapt to changes, the gravity of their ailment influencing their choice.

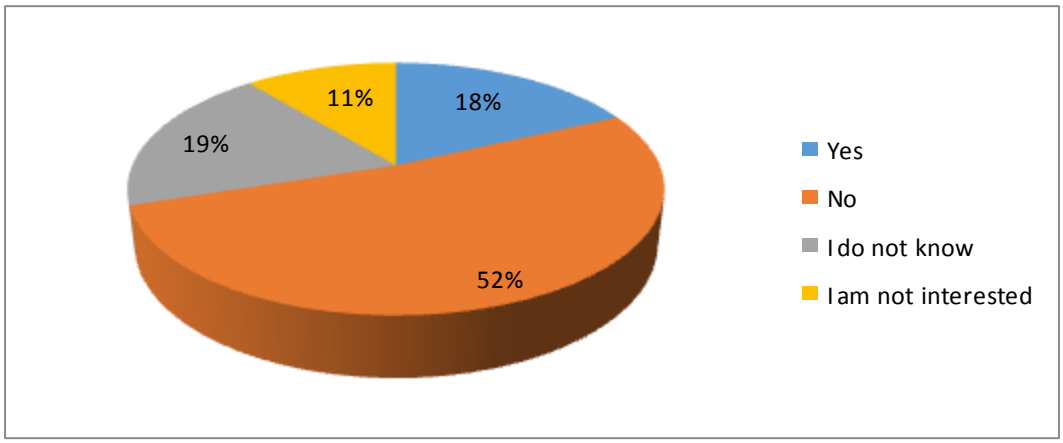
9. Which of the following characterize your attitude on those above?



The attitudes military students manifested as a response to the different afflictions:

- indifference (4%)
- latent (60%) – a state that can be viewed both in a negative, or positive light, as it is recommendable to avoid excessive treatment, but not to ignore the possible aggravation of the current affliction
- using natural remedies (29%) – a subject on the border between reality and myth (ex. products made from cranberries being used to treat symptoms of urinary infections)
- seeking medical treatment (7%) – choosing this answer shows that there were no severe pathologies noted, especially considering the lack of the comorbidities associated with these diseases in this age group. [2]

10. Do you consider that existing prevention methods at the moment are effective enough?



Prophylaxis represents all the measures taken to prevent disease and maintain a health. [2]

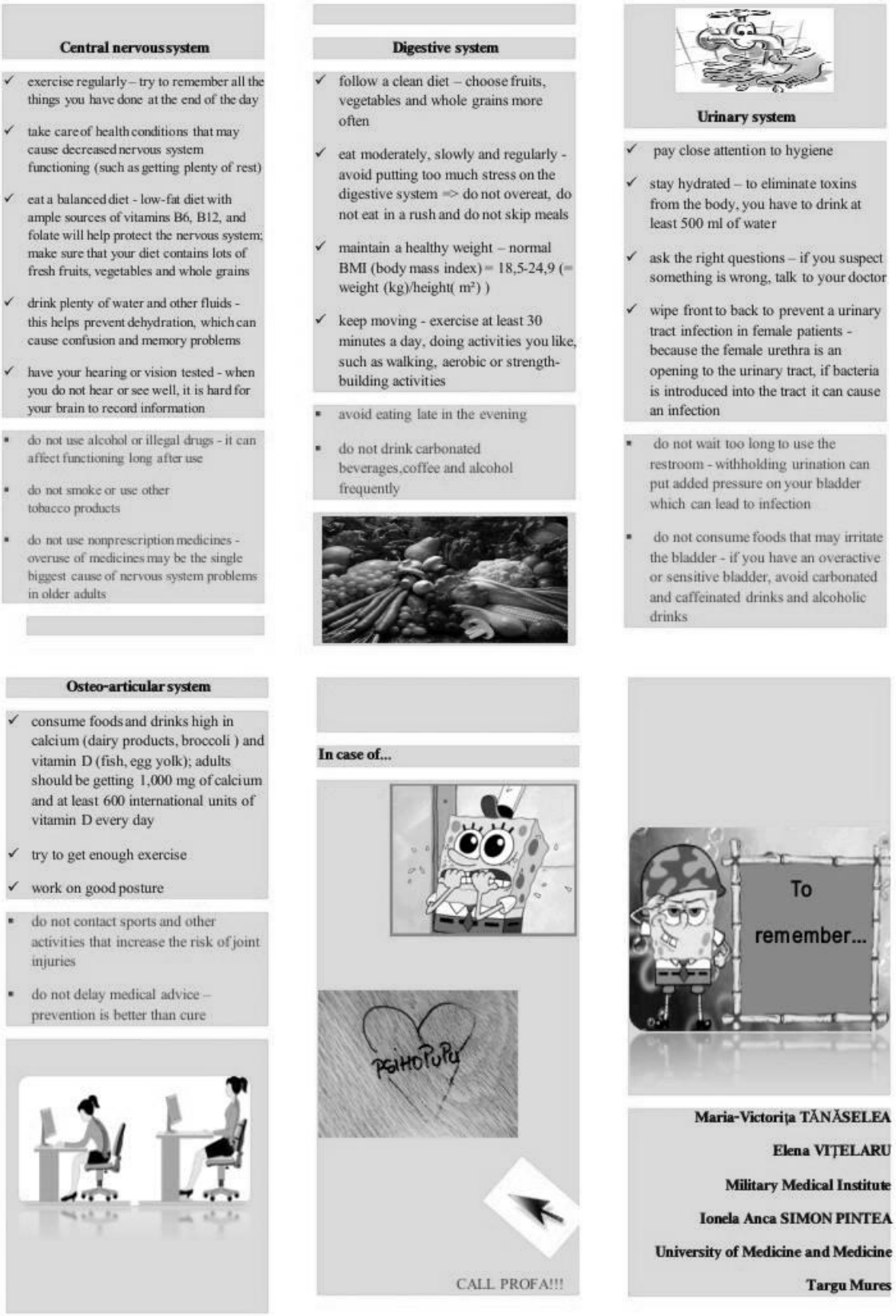
From the answers we have obtained, we can observe that prophylactic measures used at the present are not widely known. Only 18% claim to recognize the usefulness of these procedures, while 11% are not interested by them.

5. CONCLUSIONS

After conduction this study we can draw the following conclusions:

- prophylaxis is not a national objective at this moment, in regard to the afflictions and age groups presented previously. This calls for a bilateral implication to improve the situation

- the interdependence of the rick factor and pathology is confirmed, as a causal link was established and observed
- the study showed the variety of afflictions that military students suffer from. No extreme cases in large numbers were noted, however.



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REFLECTING A MYTH OF REFLECTING

Review of the volume *The Myth of Narcissus in the Albanian Literature. Monographic Study* by Roland Zisi, Rafina, Attica, GR, Orama Editions, 2011

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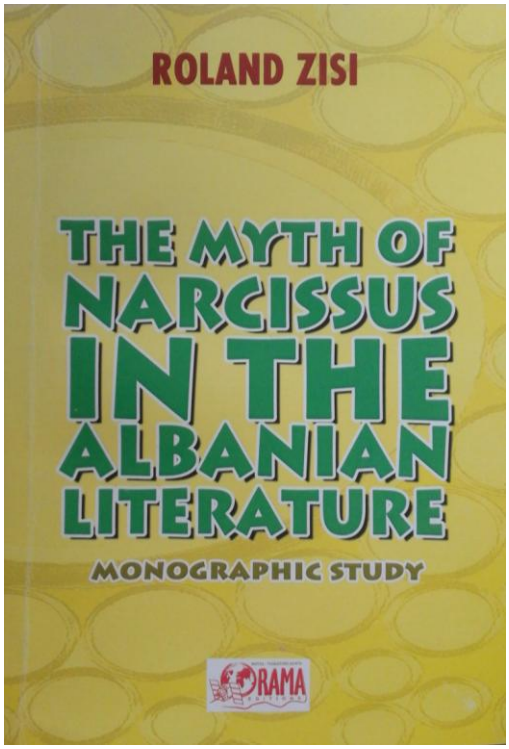

FIG.1 Roland Zisi, *The Myth of Narcissus in the Albanian Literature. Monographic Study*. Front cover.

Issued from an article prepared for a conference held in Pristine in 2006, under the influence of the Albanian journalist and writer Ernest Koliqi's work *Pasqyrat e Narçizit* (The Mirrors of Narcissus), the book of Professor Roland Zisi[1], *The Myth of Narcissus in the Albanian Literature. Monographic Study*, revisits the homonymous myth of Ancient Greece in a cultural space that still preserves some of the charm and depth of the Homeric world. Focused on emphasizing the echo, the reflection and the influence of the myth in Albanian literature, Professor Zisi's work, translated into English, transcends the limits of the language and aims at a higher goal, namely of opening gates to a literature known in Romania unfortunately only through one of its values, Ismail Kadare:

[1] Professor Roland Zisi, PhD, is the Rector of "Ismail Qemali" University, Vlora, Albania.

> Our aim in this case lies in the fact that the foreign reader, interested in our culture and literature, could find a new door in order to understand and enjoy our literature or the literary and cultural Albanian processes (Zisi, 2011:8).

Having such a target, the book does not only reflect the myth, but also the description of the socio-political context of the appearance, the representative works for the topic of study. Thus, after a first chapter treating the conceptual clarifications and a second one assuming a hermeneutical approach of the original network of the myth of Narcissus, Roland Zisi directly reports to the Albanian literature that reflects this myth, less frequented and exploited than others. The author builds his monographic study on four pillars, of different consistencies and structures: the work that has been the pretext of the present one, Ernest Koliqi's *Pasqyrat e Narçizit* (The Mirrors of Narcissus), published in 1936, Ismail Kadare's short story *Konkurs bukurie për burrat në Bjeshkët* e *Nëmuna* (Male Beauty Contest in the Accursed Mountains) published in 1996, Koço Kosta's novel *Ata të dy e të tjerë* (Those two and others) written in 1984 and published in 1994 and Agron Tufa's book of poetry *Kënga e Narcisit* (The song of Narcissus), 2002, each of them related to different politico-cultural stages of Albania in its inner quests. In As a rule, the Albanian writers preferred references to and reflections of Ancient Greece's "heavy myths". This is why they made use of the quaternary structure of the applied analysis of the work, made up of the existing material: the four most important books of the Albanian literature where Narcissus' myth is reflected directly or through psychoanalytical interpretations, symbolically or associatively, as architext (and pretext) or as an explicit reference.

The first of these books, the one signed by Ernest Koiqi, was originally published in 1936 in *Gazeta Shqiptare*, Bari. Koliqi's book contains seven short stories, deflecting a Narcissus taken from Freudian psychoanalysis, multiply mirroring in water (in various fluid media, from spring water to sea waves), in the depth of an ordinary Scutari (from Shkodër) mirror or in the transparent surface of a window. The seven short stories (or poems in prose, as author himself calls them) reflect, from previously mentioned mirroring and from reflections in the text waters, seven different themes: the Self, national Myths, Childhood, Homeland, Longing, Freedom and Knowledge. The work does not move away from the line of the myth, but the positioning is radically changed: "Koliqi initiates the stories as a real Narcissus and ends them as an Antinarcissist" (Zisi, 2011:32-33). The call to reflection does not belong to the Self as in the Greek myth, but symbolically to the spirit (*the request of spirit face*). The mirror is the meditation itself. Through such a position, Koliqi succeeds, according to Professor Zisi, to propose a palimpsest of the Albanian literature through Narcissus' myth. *The Mirrors of Narcissus* move the context of interpretation into a different symbolic space, reflecting the pride of the Albanian origin.

Konkurs bukurie për burrat në Bjeshkët e *Nëmuna* is a short novel of disturbing beauty written by Ismail Kadare, placed in a mountain area in Northern Albania (Malësi), where Lekë Dukadjini's *kanun* still produced effects late into the mid-20th century, as Marius Dobrescu pointed out (2006). The short story was written in 1996, in the context of Albanian liberation of dictatorship. Its action, placed in the North governed by *kanun*, takes place in a "time without time". The work is more complex than Koliqi's one, bearing successive semantic layers, suggesting the myth, motivating ethically/morally its action and describing, in hypertextual key, the social setting and the atmosphere of the delayed socio-cultural change.

The (fugitive) reflection belongs to a human Narcissus, as tragic as the hero of the ancient myth; it implies the action of nature (and of human nature, alike). There is, as Roland Zisi suggests, a case of the Greek myth transfer into the typical Albanian reality of a *kanun* still producing effects, doubled by Freudian complexes and desires, in a "typical literary Kadarean alchemistry".

A passing suggested reflection implies a suggested reflection in text of one of the main Kadarean themes, the Albanian vendetta. The narcissistic beauty of youngster Prenk Curri continues to be mirrored in the eyes of Gaspër Cara. But here,

> Behind the invisible relationship Gaspër Cara – Prenk Curri there is something far deeper, the author confesses: something about changing the face of this people, about changing anachronistic traditions that act hardly on the individual, limiting his personal freedoms. But people are not prepared for this, it seems to be the message of the short story,

writes Marius Dobrescu in the Romanian edition afterword of the Kadarean work (in Kadare, 2006:232).

The third work, *Ata të dy e të tjerë*, is a short story published in 1994 by Koço Kosta as a novel. It has a history anchored in the communist realities of an Albania that had already made the transfer from the dictatorial authority of Enver Hodja to that of Ramiz Alia. The first part of the work was published in *Nëntori* magazine in 1986, and the second one was rejected by the communist censorship in 1987. The main character of this book, the Handsome Guy, named after different standards than the one of the classical literature, is physically described in an impeccable manner, being a man of meditation and doubt. The myth of Narcissus is suggested by the text, without the name of Narcissus being mentioned at least once. The interpretation implies a fine association. Only a trained reader and a well connoisseur of the Albanian literature is able to do it: "so to say that only an ideal reader may put in formal-semantic co-accompaniment of these two figures to match the Handsome Guy to Narcissus" (Zisi, 2011:67-68). Unlike Kadare's work, a complete and intentioned Narcissus is reflected in the pages of Kosta's text; unlike Koliqi's work, a Narcissus taken from the Greek myth enters the pages without Freudian mediation (even if the work bears psychoanalytical interpretation). The Handsome Guy, differently set up from the new Man in the Communist party design, could not be brought to the light of a work, especially as long as its author refused the realist-socialist norms imposed on the Albanian creation. Through *Ata të dy e të tjerë* Koço Kosta does not rewrite or recreate the myth, but acts on its universal substance. The freedom is reflected into the face of an antihero, the Handsome Guy, as Professor Zisi suggests.

The fourth work, *Kënga e Narcisit*, is a collection of poetry written by Agron Tufa between 1988 and 1989 and published in 2002. As in the case of Koliqi's work, the reference to Narcissus is direct. Unlike Koliqi, Tufa changes the focus from the original semantics of the myth (whether in classical or psychoanalytic interpretation) onto the dialogue between the myth and the contemporary reality. The poetry collection is in itself a frame of reflection of the Albanian context of years of writing, in which literary existence and poetry itself could be considered a luxury. The myth, reflected in tragic and ironic traces, relies in text on a powerful allegoric apparatus. It is about the awakening, three centuries after, in Albania (and of Albania) that, as in the myth of Narcissus, isolated itself by watching its own inner beauty: "while the aim of the antique Narcissus is autoerotism and autosuggestion, the aim of the modern poet is literary and human perfection, the poetical ideal" (Zisi, 2011:96).

The four interpretative projections are followed, in Roland Zisi's work, by examples from the commented works (texts translated by Robert Elsie and Merita Isaraj). The myth of Narcissus in Albanian literature is more than a theme reflected into the textual waters of a literature. The myth reflects a vivid Albania, its identity, becoming, delaying, stunning, but mainly, its inner beauty in the waters of a European literature.

Upstream, the literary Albania, wanders through pages with the beauty of Kadare's Prink Curri or of Kosta's Handsome Guy, with the depth of meaning from Agron Tufa's poetry: "Albania is greater than its soil,/ Than the sky stretching upwards above it. /(...)/ It is not a part of this planet, but a star,/ A tear fallen from the eye of Lord" (Tufa, *Albania*, *apud* Zisi, 2011:121). The monographic study of Professor Roland Zisi succeeds to reflect not only the architext canvas, the Greek myth taken in layered exposure into the Albanian literature, but also this literature itself, in its own depth, rendering the whole in a fractal manner, despite language barriers.

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TENDENTIAL MODERNITY. UNDER THE SIGN OF ε

Review of the volume *Modernitatea tendențială. Reflecții despre evoluția modernă a societății* by Constantin Schifirneț, Bucharest, Tritonic, 2016

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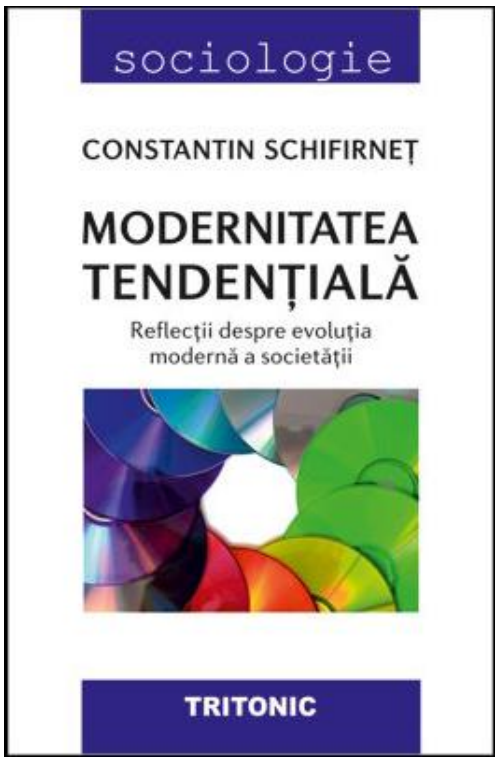

FIG.1 Constantin Schifirneț, *Modernitatea tendențiala. Reflecții despre evoluția modernă a societății.* Front cover.

Constantin Schifirneț is a reference name in social sciences, professor at the Faculty of Communication and Public Relations, National University of Political Studies and Administration, Bucharest, with an important activity of researcher, coordinator of book editions and manger in the Ministry of Culture. The recognition of his academic value and merits comes from his scientific activity, which focuses on modernity issues, mass media, Europeanization, sociology of communication, sociology of culture, sociology of ages etc. Constantin Schifirneț is the author of the most important synthesis work regarding the different faces of the theory of forms without substance within Romanian culture, *Formele fără fond. Un brand românesc* (2007), and holds the paternity of a concept that includes the complex tendencies of the modernization of South-eastern European countries, the 'tendential modernity'.

Starting from the realities of the Romanian modernization – the concept of 'tendential modernity' was launched within the above-mentioned paper on the Romanian modernization way (Schifirneț, 2007:205) –, from the need to synthesize the distinct stages of modernization, the distinct values and standards specific to each stage, the critical (and often antagonistic) elites' position in relation to the theory of forms without substance, Professor Schifirneț highlights a concept able to define the differentiated manifestation of different aspects of modernization. This concept of 'tendential modernity' was more comprehensive and applicable in other contexts than those projected in 2007. First, the concept proved its explanatory potential in relation to the modernization efforts of the entire Romanian society, regardless of the way of social change. A critical history of the Romanian change underlines three major ways of dealing with social and cultural change. There is, firstly, a dialectic of cultural closing and opening, that has been analyzed within conjunctive or disjunctive logics; secondly, there is the reference cu exteriority – the Western model – by appealing to different logics in relation to diffusionism: the selective retrieval of external forms (the theory of forms without substance) or non-selective retrieval in order to recover the gaps in the development of society (the theory of synchronism); thirdly, there is an appetence for a Europe that serves both as a home and as a model for the development of Romanian society. Professor Schifirneț felt immediately the potential of the concept and extended its signification to the entire variety of forms and standards of the Romanian society. Moreover, the umbrella-concept of 'tendential modernity' was useful in order to explain other models and ways of modernization. It became in general an explanatory model of societal evolution, of gradual and tendential change in all the Eastern states where there was a gap in as compared to the Western modernization, naturally produced. In relation to this form of modernization, explained as follows:

Modernity, in the initial meaning of the term – that of progress or linear evolution, of unlimited advancement over a predetermined distance of development towards a certain social actor – appeared in Western space; we call it classical (Western) modernity (Schifirneț, 2016:19),

Professor Schifirneț (2016:25) has redefined the concept: "the Western model of modernity has spread all over the world as tendency", publishing in this respect the book that is the subject of our analysis.

Under these circumstances, the tendential modernity can be defined in relation to (organic) one, taking into account a set of assumptions regarding the delay of the first one and the its specificity, and the peculiarities of its forms on spatial-temporal coordinates, i.e. in relation to the socio-historical context. If the classical modernity implies a natural way, sometimes understood as a liner one, constituting itself as a model of development for non-Western European societies, then we can discuss about principles and characteristics of modernity. We can also take into account the differentiated and discretionary application of those principles in the case of tendential modernity and the tendency to align its characteristics with those of the classical modernity. Once operationalized the term 'modernity', meaning its forms, principles, and characteristics, the operationalization of the alignment function becomes necessary, i.e. of the modernization understood as a "path to modernity":

Modernity is an effect of modernization. There is no modernity without modernization. Modernity is a standard that becomes a goal of the societies evolution, and modernization is the process of achieving this goal (Schifirneț, 2016:41);

Sociologically, modernization is defined as a transformation of traditional, rural and agrarian society into a secular, urban and industrial one, so that trade and industry becomes dominant aspects of economy (Schifirneț, 2016:45).

Taking into account the modernization process as a function, mathematically defined as admitting asymptotes, we can consider a small positive number, ε, tending to zero, which expresses the gap within the classical and the tendential modernity. The exceptional understanding and explanation of the synthesis-concept 'tendential modernity' consists in this association of modernization with the mathematical set of functions that admits asymptotes. Professor Schifirneț refers in his work to the modernization of modernity as a continuous process, as Ursula Beck proposed, namely: "The modernization of modernity expresses the dynamic, continuously regenerative, asymptotic character of the modernization process" (Schifirneț, 2016:60), that means modernity can be understood only in tendential terms, in dynamics, and not in the attempt to clarify contents. The sociological concept 'tendential', characterizing the process of modernization, requires also an operationalization in the framework of the present work, and Professor Schifirneț's referral is obvious and broader than the meaning used by the Romanian sociologist Dumitru Sandu:

The meaning given by Dumitru Sandu to the term 'tendential'– reducing of diversity to the essential characteristic – intersects, in some historical contexts, with the term 'tendential modernity'. Tendential, from the examples given by Sandu, refers to the trend, to the general orientation. I refer to the asymptotic meaning of tendential: something that tends to something else or approaches a landmark, but never touches it (Schifirneț, 2016:91).

Understanding tendential modernity as a result of a mathematical function that admits asymptotes is the key to understanding Constantin Schifirneț's perspective on a reality described by the planned outcome and the related process, of modernity and modernization. This reality could not have been circumscribed so far under another umbrella-concept. Even if the tendential evolution is probabilistic, "the concept of tendential modernity does not refer to its statistical dimension" (Schifirneț, 2016:95), but to an evolution under the sign of an always present ε, however small, able to allow the description of function in relation to the asymptote it admits. From this perspective, it is easy to understand why Professor Schifirneț considers that "the *tendential* notion signifies unfulfillment, postponement, zigzagging of the tendency" (Schifirneț, 2016:90) – the latter part illustrating the path of social/cultural change following different trajectories, in terms of a transient, oscillating regime, described by an ε that varies in value and in mathematical sign –, respectively why tendential modernity implies unfulfillment of the modernity project, as Habermas stated, in the completeness of the "dimensions and principles of modernization processes" (Schifirneț, 2016:93).

The work of Professor Constantin Schifirneț is complex and deals with fundamental topics regarding 'tendential modernity' concept's settlement in the field of scientific debate: *Modernity; Modernization, the path to modernity; Types of modernity; Tendential modernity; Elites, between modern rhetoric and reality; The space of modern reality; The modernization of countryside; The State – a source of modernity*, to conclude under the umbrella of the *universal tendential state of modernity*. Each of these chapters that deals with the previously listed topics requires a consistent analysis, but, within the limits of this review, we aim at highlighting the complexity, validity and universality of the concept 'tendential modernity', that radically changes the projection of Romanian critical thinking on the ways of social and cultural change. It is worth noting Professor Constantin Schifirneț's openness and flexibility in the analysis of the concept.

He started the book by describing the modernization in relation to a linear Western model, but, after the analysis of multiple models of modernity, he admits to redefine the concept: tendential modernity begins to "express the inclination of some social actors to imitate and take on conducts and conceptions outside their national space" (Schifirneț, 2016:161). To understand struggles of the current Romanian society, we recommend the last four chapters of the book, especially the one that refers to the elites.

Professor Constantin Schifirneț's work *Modernitatea tendențială. Reflecții despre evoluța modernă a societății* is fundamental in a broad field of disciplinary areas, in the proximity of Aaron V. Cicourel's interdisciplinary alliance (including sociology, anthropology, linguistics, and philosophy). The work is the space where the concept proposed ten years ago gains an operational form.

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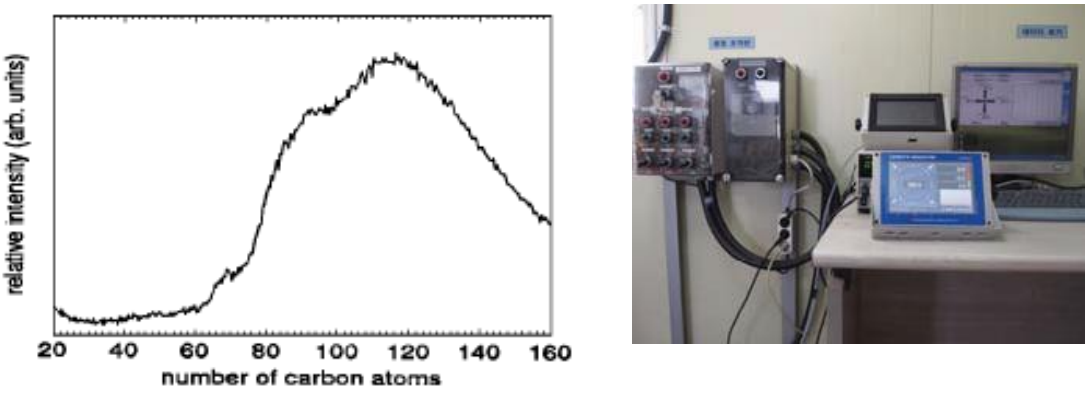

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