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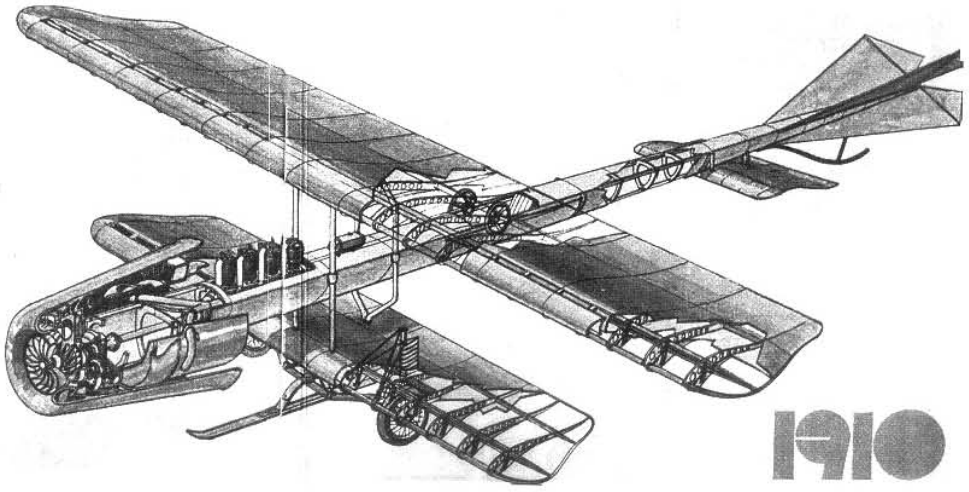

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C O N T E N T S

3D FLIGHT PATH PLANNING FOR MULTIROTOR UAV

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Abstract: *In recent days, the multirotor UAV urban and semi urban applications predict a need for flight automation both in standard flight missions and in emergency flight tasks performed by UAV automatic flight control systems. The standard flight mission of the multirotor UAV might cover take-off, ascend, leveled flight, descend, and landing phases of the flight. If the flight is organized beyond visual line of sight (VLoS) the UAV onboard flight control system is a necessary condition. If any multirotor UAV flight is planned to be executed between the limits of the safe flight envelope of VLoS, in case of emergency, the multirotor UAV automatic flight control system can select the safe landing zone and it can conduct flight on safe landing paths. Military forward operation bases (FOB) are typically of very limited size and are very busy with military personnel, vehicles, weaponry, ammo, facilities and different equipment. They mostly serve for reconnaissance purposes, and any UAV platform used at FOB can improve their military value and importance. It is easy to see that in such a context the only UAV propulsion system proper to apply, is a rotorcraft propelled aircraft. Their special capabilities of vertical, or very short take-off and landing, and hovering put them into a privileged UAV class accessible to use. This paper deals with 3D flight path planning for multirotor UAVs giving solutions for problems handled in UAV take-off and in UAV landing flight phases.*

Keywords: *multirotor UAV, urban area applications, war theatre military applications, 3D flight path planning, UAV take-off and landing.*

1. INTRODUCTION AND LITERATURE REVIEW

The multirotor UAVs have a unique capability of vertical take-off or landing, which makes them very special in several flight missions. Additionally, UAVs might conduct take-off or landing as a STOL aircraft, and, this property, in many flight missions and applications, such as monitoring constructions, bridges, roads, pipelines etc., is used very effectively. Small UAVs require very small spaces to organize flights, however, ore attention must be paid for take-off and landing of the aircraft.

UAV applications are projected to increase tremendously in the closest period one cannot imagine. After several years of adjusting to the EU, the EASA accepted and published the drone regulation, awaited for so many years [1]. The basic idea of the procedures and rules of the UAV flights in urban area is related to the manual control of the UAV in the VLoS flight envelope. The flying of UAV near aerodromes might create difficulties in standard safety operation procedures of the aerodromes, and the UAV air space integration is still an ongoing one [10].

The wide variety of the UAV applications are discussed in [2, 3]. The UAV path planning for different flight phases and for different measurement technique used by the UAV is outlined in [4, 5, 6, 7, 8, 9].

Recently, there are many pilot projects of the UAV applications far beyond the VLoS, when an unmanned aircraft must be controlled autonomously, and the aircraft must be prepared for a given set of emergency situations, like collision avoidance, bird strike, loss of thrust, low level of energy available, forced emergency landing etc.

The wide range spread of UAVs used in different civilian and military missions and mostly flown by common non-expert users predicts a need of flight automation minimizing, or as the best, eliminating threat of the UAV crash. Thus, for the safe UAV's use the flight automation is necessary, however, cheap and easy-to-use solutions are highly preferred.

2. MULTIROTOR UAV FLIGHTS IN URBAN AND SEMI URBAN ENVIRONMENT

Many UAV applications are planned to be conducted in urban area. Delivering gifts, medical equipment, medicines, post, or, the traffic management, air pollution measurement might be based upon multirotor UAV platforms. As the first step in UAV regulations, only the manual control up to the limits of the VLoS is discussed in [1]. Figure 1 depicts the basic idea of the UAV flights: the flight must be conducted not to threaten any human or facility in the flight envelope.

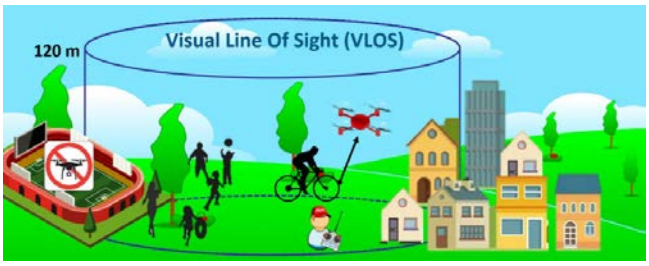


FIG. 1 The UAV urban flight in limited flight envelope [1].

If it cannot be omitted, the flight above humans is allowed for the minimum time durations at safe heights and at safe distances. The flight above crowds, like in sport facilities, is not allowed. The UAV regulations will delegate many new rights and, at the same time, responsibility, in all meanings to the UAV operator.

In modern cities, due to very limited spaces, the UAV flight must be designed very carefully, with the highest level of automations (Fig. 2). If the UAV flight is allowed to be conducted between buildings, in order to ensure successful flight missions with proper flight safety level, special flight paths planned for the given UAV mission are required. If UAV flight between buildings is not allowed the roofs might be used for take-off and landing zones.

FIG. 2 The UAV urban flight in limited flight envelope

The smart city concept integrates different sources of information to handle and support life in the modern cities. Figure 3 shows a sight of the public place in a capital.

FIG. 3 Modern capital 3D reconstruction plan animation

Figure 3 depicts the smart city concept integrating different sources of information to handle and support life (i.e. transport management) in the modern cities. Figure 3 shows a sight of the reconstructed public place in a capital. It is easy to see that due to numerous forms of transport like public or private one, and due to a square public place busy with old and modern buildings there is created a very good atmosphere for inhabitants and tourists, too. Taking a look at this 3D plan, there are tight however well enough spaces available to serve as UAV take-off, or landing zones, if it is necessary to conduct landing or take-off of the UAV. If a UAV arrives to the intersection from the right, with a slight right turn it might be landed on an emptied road having enough length for safe landing.

The multirotor UAV can be applied very effectively in semi urban area to monitor the environment, and any artificial object being erected for IT services, for harvesting wind energy etc. For this purpose, [1] gives the flight scenario depicted in Fig. 4.

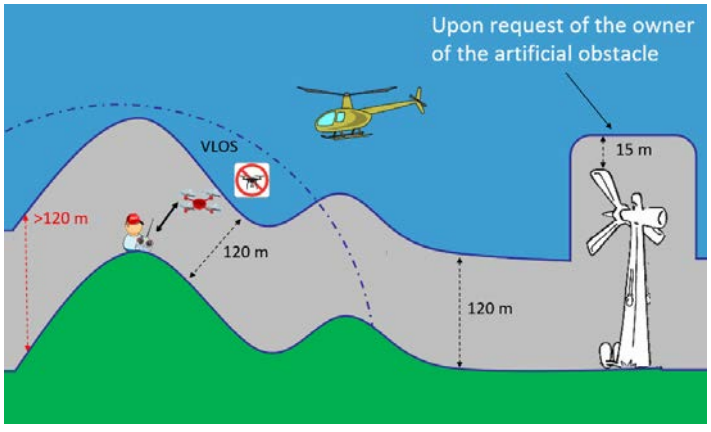


FIG. 4 The UAV semi urban flight in limited flight envelop [1].

In [1] a requirement of keeping 15 m distance to artificial obstacles required by owners of facilities is shown. In Figure 4 it is easy to see that the aircraft flight path ensuring flight above a given obstacle generates difficulties in path planning and design.

3. MULTIROTOR UAV FLIGHTS IN MILITARY OPERATIONS

The multirotor UAV is a promising tool to strengthen force protection (FP) skills of the military units, mostly serving as forward operation base (FOB). Figure 5 shows a 3D animation of the future military FOB camp.

FIG. 5 Military FOB facilities 3D animation

The FOB, as a rule, has very limited physical size. In desert war theatre with hilly places with fragmented relief it is a great strategic challenge to select an appropriate site for the construction of a FOB. After a decision making, a FOB is constructed (Fig.6)

FIG. 6 Construction of the war theatre military FOB between FP T-Walls

The FOB is designed with FP elements (Fig. 6). In Fig. 6 there can be seen some mechanical elements of the FP. It is easy to understand that to strengthen military unit FP capability located inside the walls with UAV recce capabilities, only the multirotor small UAV can be considered for application. If the military base is located at large open places (i.e. at airports etc.), the fixed wing UAVs also can be applied for improving FP capabilities.

4. MULTIROTOR UAV FLIGHT PATHS PLANNING FOR SAFE TAKE-OFF AND LANDING

In UAV flight automation there are several point of view how to design and plan flight paths. The first method is to use open source autopilots like Paparazzi and to give the UAV operator the opportunity to create the more feasible UAV mission flight paths. The advantage one can gain here is the freedom in path planning, and opportunity to develop flight paths toolbox for several UAV applications.

The drawback of the method is that it requires high level of knowledge and programming skills, which limits access and demand to those UAVs using this principle. The method competing this and eliminating difficulties with path planning is to have a reach toolbox of pre-programmed possible flight paths, and the UAV operator task is a simple selection of appropriate flight paths from a toolbox.

4.1. Flight path planning for multirotor UAV aggressive take-offs. The multirotor UAV take-off is supposed to be executed in very tight area like in military FOBs. It is supposed that UAV air space use is thoroughly regulated, and for UAV take-off the segmented and designated area is dedicated in the form of a rectangular cuboid with given sides.

For UAV flight path planning we considered a box with sizes of $10m * 10m * 20m$, and it is supposed that at height $H = 20\ m$ the UAV take-off flight phase will be finished. From among those infinite number of possible UAV flight paths, the unique one and chosen is fitted to the cylindrical surface with radius of $5\ m$ placed inside the cuboid.

The 3D path of multirotor UAV can be derived with the following set of equations:

$$x = X \cdot \sin(\omega x) \tag{1}$$

$$y = Y \cdot cos(\omega x) \tag{2}$$

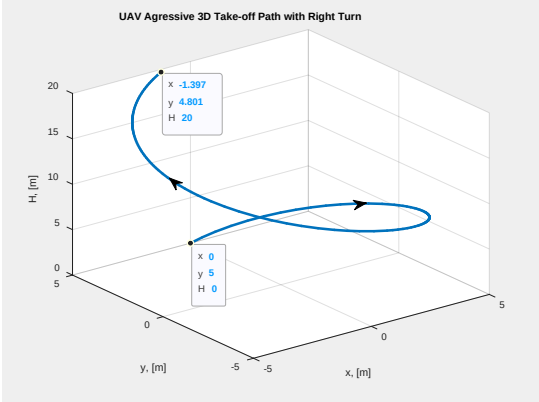
$$z = H_o + a * H \tag{3}$$

Using equations (1)-(3), the multirotor UAV 3D take-off paths can be designed using following parameters:

$$X = 5\ m; Y = 5\ m;\ H_o = 0\ m;\ a = 1 \tag{4}$$

Depending on the need or on the pre-requirements, the multirotor UAV take-off can be executed both with left and right turns. Such situations depicted in Fig. 7 [11, 12].

From Fig. 7 it is easy to see that varying angular frequency ω the UAV flight might have aggressive feature. To washout this, the angular frequency must be increased until it reaches the proper UAV behavior. The angular frequency is a design parameter able to serve in designing toolbox of flight paths segments. It is worth mentioning that this kind of flight paths designed might serve also in collision avoidance missions of the UAV, and , in changing flight altitude flight phases, too. The design parameter of a in equation (3) can be used for manipulation of the slope of the take-off path along the vertical axis. Varying initial data of the flight path wide variety of the possible geometry can be selected and used after for the UAV reference path to be followed.



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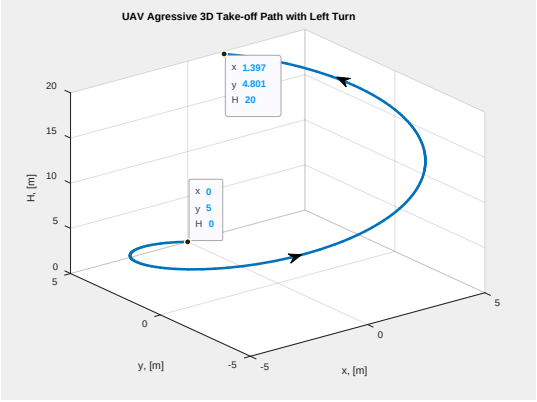
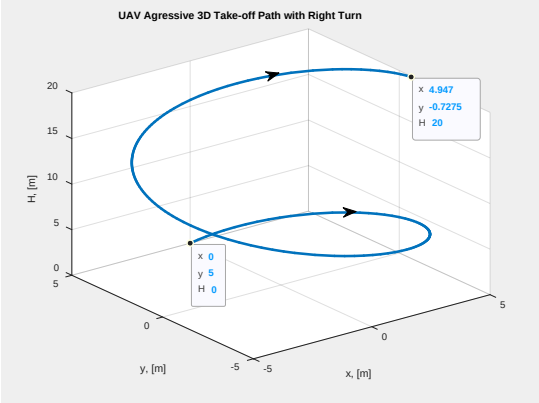
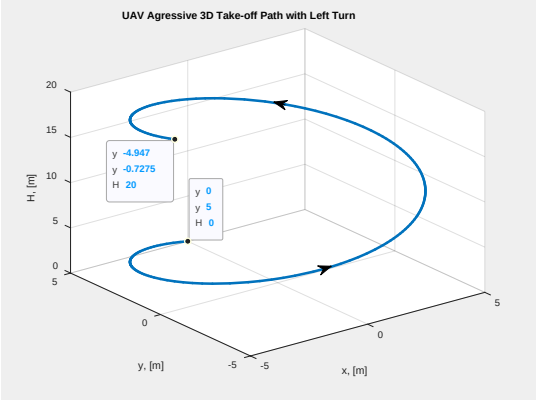


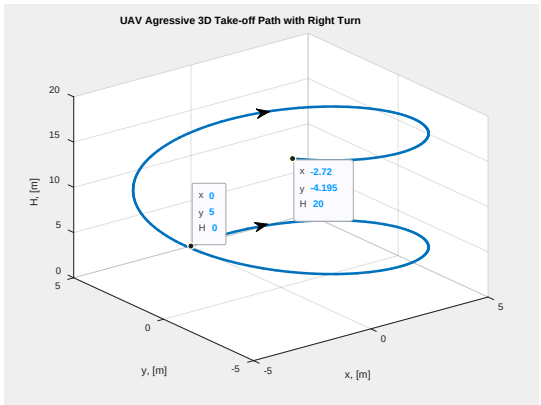
(b) $\omega = 0{,}3\ ^{\circ}/s$



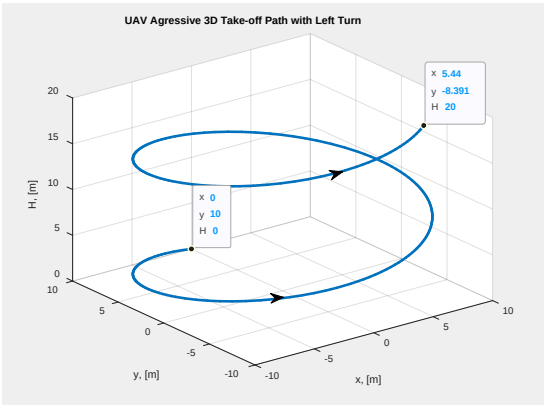
(c) $\omega = 0{,}4\ ^{\circ}/s$



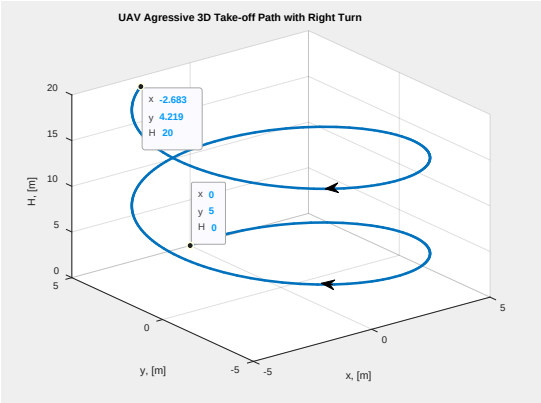
(d) $\omega = 0{,}4\ ^{\circ}/s$



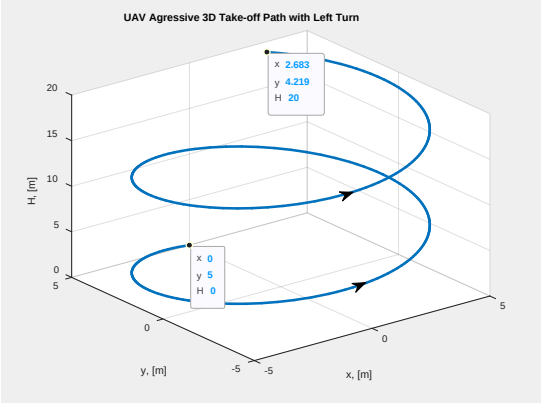
(e) $\omega = 0{,}5\ ^{\circ}/s$



(f) $\omega = 0{,}5\ ^{\circ}/s$



(g) $\omega = 0{,}6\ ^{\circ}/s$



(h) $\omega = 0{,}6\ ^{\circ}/s$

FIG. 7 The UAV take-off paths planned with left and with right turns.

4.2. Flight path planning for multirotor UAV aggressive landing. The safe UAV landing is a basic criterion to eliminate damage, losses, and to be able to take part after in several flight missions. The landing must be pre-planned ending the UAV flight, and it can be a non-planned emergency one in case of necessity like in bad weather conditions, or in case of loss of thrust. The 3D landing path of multirotor UAV can be derived with the following set of equations:

$$x = X \cdot \sin(\omega x) \tag{5}$$

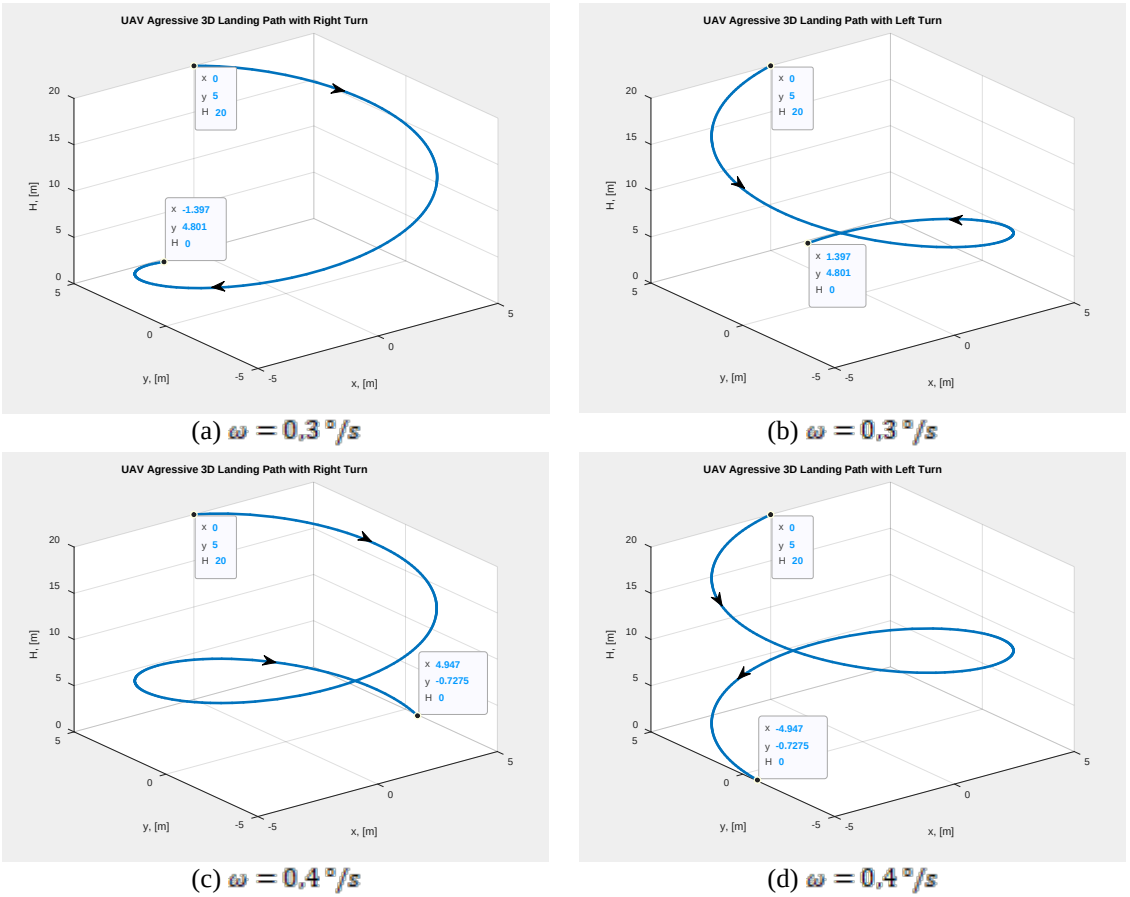
$$y = Y \cdot cos(\omega x) \tag{6}$$

$$z = H_o - a * H \tag{7}$$

Using equations (5)-(7), the multirotor UAV 3D landing paths can be designed using following initial parameters:

$$X = 5\ m; Y = 5\ m;\ H_o = 20\ m;\ a = 1 \tag{8}$$

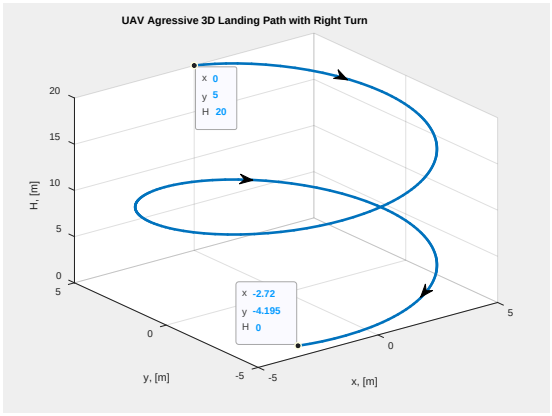
Depending on the need or on the pre-requirements, the multirotor UAV landing can be executed both with left and right turns, and such paths can be seen in Figure 8 [11, 12].



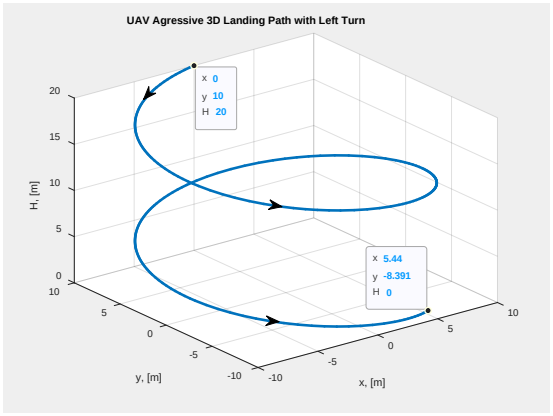
(a) $\omega = 0{,}3\ °/s$ (b) $\omega = 0{,}3\ °/s$

(c) $\omega = 0{,}4\ °/s$ (d) $\omega = 0{,}4\ °/s$

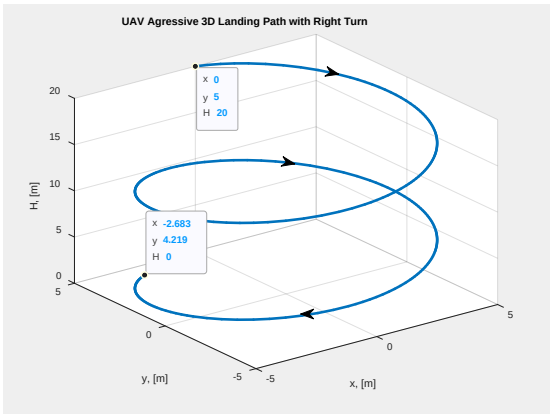
FIG. 8 The UAV landing paths planned with left and with right turns.



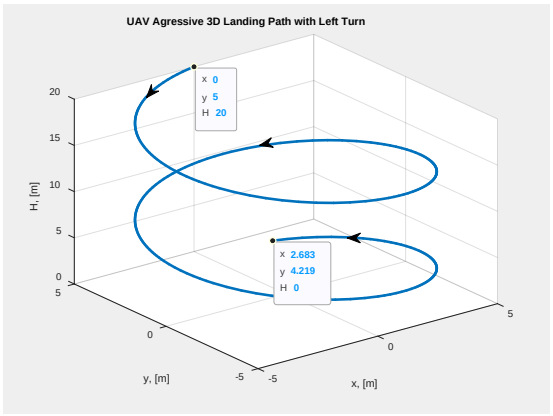
(e) $\omega = 0{,}5\,°/s$



(f) $\omega = 0{,}5\,°/s$



(g) $\omega = 0{,}6\,°/s$



(h) $\omega = 0{,}6\,°/s$

FIG. 8 The UAV landing paths planned with left and with right turns (Continued).

From Fig. 8 it is easy to see that varying angular frequency ω the UAV flight might have aggressive feature. To eliminate aggressive behavior of the UAV landing paths the angular frequency must be increased until it reaches the proper and expected pre-planned UAV behavior. The angular frequency is a design parameter able to serve in designing toolbox of flight paths segments. It must be emphasized that such kind of UAV landing flight paths designed might serve also in collision avoidance missions of the UAV, and, in changing flight altitude flight phases, too. The design parameter of a in equation (7) can be used for manipulation of the slope of the landing path along the vertical axis *oH*.

4.3. Exponential flight path planning for multirotor UAV landing. The basic idea of using exponential flight landing paths is well-known from manned aviation. However, the exponential reference flight path, which is standardized and fixed for traditional aviation can be used very effectively in flight automation of the UAVs. Having no pilots or passengers aboard, more intensive and although the aggressive maneuvers of the UAV can be planned. If the exponential flare flight path of the UAV is an option for its landing, the set of proper exponential function can be set up. In this case, the flight path equations are as follows below:

$$x = L_o + L \tag{9}$$

$$y = Z_o + b * L_{max} \tag{10}$$

$$z = H_o * e^{-t/T}. \tag{11}$$

Using equations (9)-(11), the multirotor UAV 3D landing paths can be designed using the following initial parameters:

$$L_o = 0\ m;\ L_{max} = 80\ m;\ Z_o = 0\ m;\ \Delta Z \leq 0{,}2\ m;\ z_o = H_o = 10\ m;\ H|_{L=80\ m} \leq 0{,}5\ m;\ \ b = 0{,}0001 \tag{12}$$

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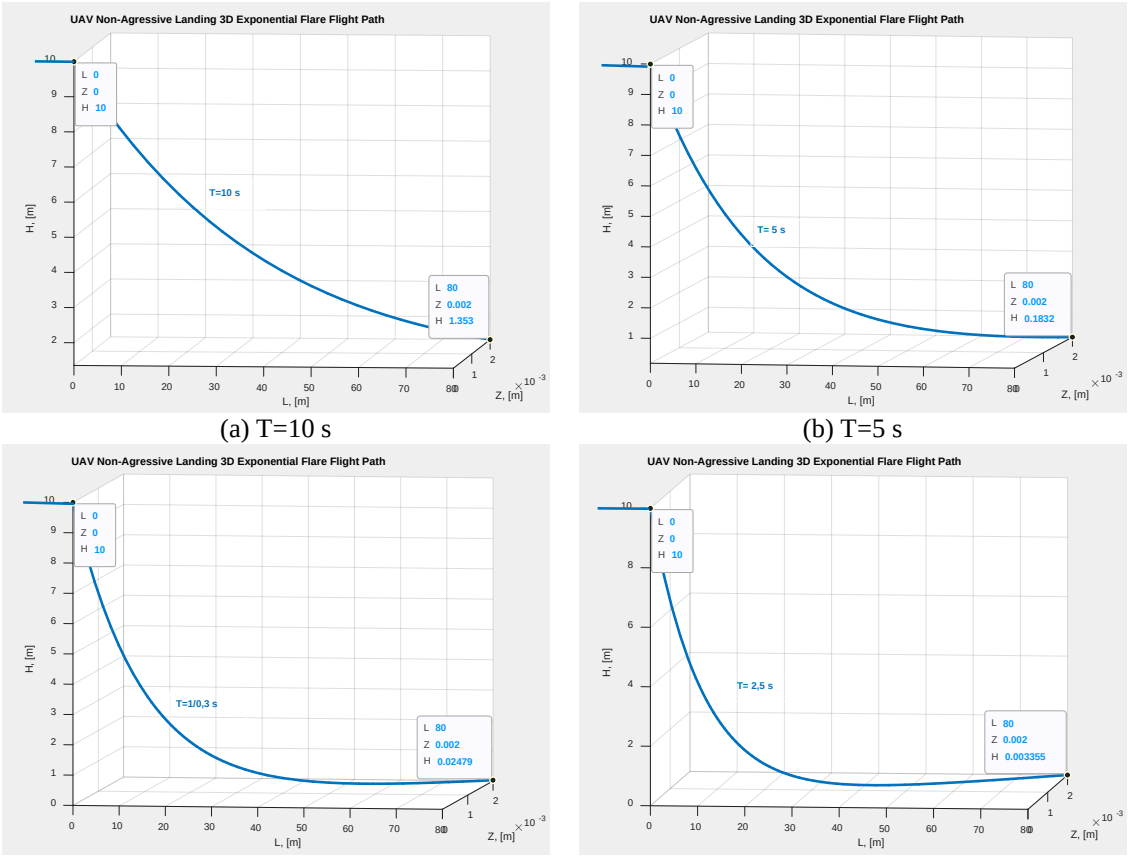
Using initial data given by equation (12) for a given set of time constant of T traditional flare exponential functions were generated and tested for the UAV landing. Results of the computer simulation can be seen in Fig, 9 [11, 12].



(a) T=10 s (b) T=5 s

(a) T=1/0,3 s (b) T=2,5 s

FIG. 9 The UAV exponential landing paths.

From Fig. 9 it can be seen that the case of $T = 10\ s$ will give a very smooth landing path, however, at the end of the landing phase the height is $H = 1{,}35\ m$ (Figure 9., (a)), which is larger, than the pre-set criteria of $\Delta \leq 0{,}5\ m$. The case of $T = 5\ s$ (Figure 9., (b)) will ensure the prescribed performances whilst a landing path is still smooth enough to land safely the UAV, and the height deviation is $\Delta = 18\ cm$. The case of $T \cong 3{,}3\ s$ is a path famous for very intensive change of the slope of the exponential, which might be achieved with very intensive speed deceleration of the UAV, however, at the end of the exponential the height deviation is $\Delta \cong 2{,}5\ cm$. For all cases shown in Figure 9. the lateral displacement measured from the *oL* axis is $\Delta Z = 2\ cm$, which is in the range of the pre-defined tolerance field of ΔZ. It is easy to see that varying initial data a toolbox of possible standard exponential flare landing paths can be generated and can be used after as the landing path reference.

4.3. Exponential flight path planning for multirotor UAV aggressive landing. There are several reasons for planning unconventional landing paths for the UAV. Firstly, the urban area (Fig. 3) can generate the need of the existence of the pre-planned landing paths for the multirotor UAV selecting proper landing path from a pre-defined toolbox of the possible paths. For those cases requiring intensive maneuver of the UAV landing via exponential path but conducting left turns during landing, the following set of the equations is proposed to be used to generate flight paths:

$$x = L_o + L \tag{13}$$

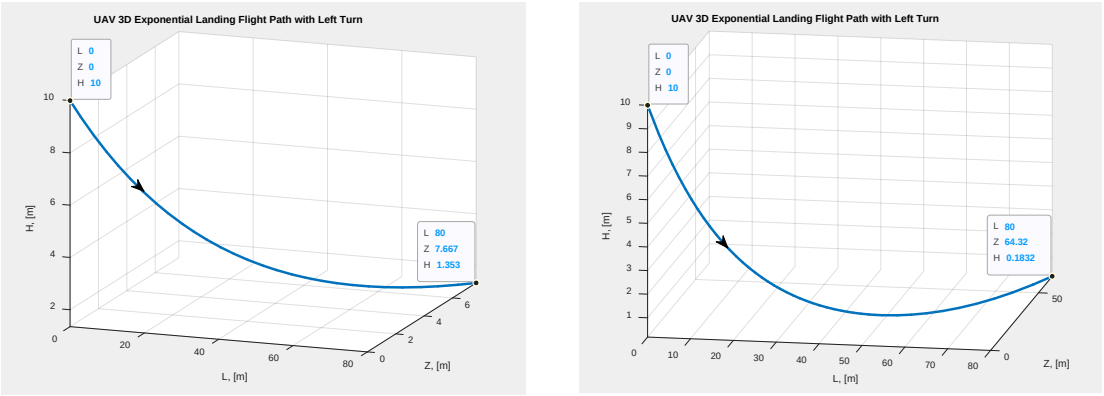
$$y = -1{,}2 + 1{,}2 * e^{t/T} \tag{14}$$

$$z = H_o * e^{-t/T}. \tag{15}$$

Using equations (13)-(15), the multirotor UAV 3D exponential landing paths with intensive left turns can be designed using the following initial parameters:

$$L_o = 0\ m;\ L_{max} = 80\ m;\ Z_o = 0\ m;\ z_o = H_o = 10\ m;\ H|_{L=80\ m} \leq 0{,}5\ m \tag{16}$$

Using the initial data given by equation (16) for a given set of time constants the non-traditional flare exponential functions were generated and tested for UAV safe intensive landing. The results of the computer simulation can be seen in Fig. 10 [11, 12].



(a) T=10 s (b) T=5 s

FIG. 10 The UAV exponential landing paths with aggressive left turns.

From Fig. 10 it is evident that the lateral displacement Z depends on the exponential time constant of T. If it is larger, then the lateral displacement is larger, too. This kind of maneuver can be conducted not only for landing purposes, but for collision avoidance missions if there is a sudden emergence of any obstacle on the UAV path, and the collision with obstacle on the right is avoided with aggressive turn to left. The case shown in Figure 10. (a) will not meet pre-defined criteria for the height deviance, and case of $T = 5\ s$ will ensure the accurate height deviation of $H \cong 18\ cm$.

If the left turn is a non-achievable behavior, and the right turn of the UAV will serve effectively the collision, the following set of equations deriving 3D UAV can be applied:

$$x = L_o + L \tag{17}$$

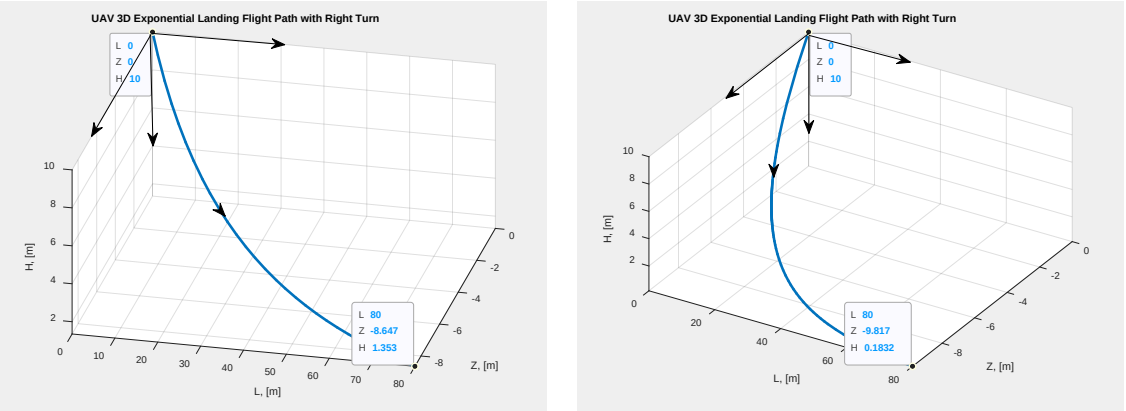
$$y = -10 + 10 * e^{-t/T} \tag{18}$$

$$z = y = 10 * e^{-t/T}. \tag{19}$$

Using equations (17)-(19), the multirotor UAV 3D exponential landing paths with intensive right turns can be designed using the following parameters:

$$L_o = 0\ m;\ L_{max} = 80\ m;\ Z_o = 0\ m;\ z_o = H_o = 10\ m;\ H|_{L=80\ m} \leq 0{,}5\ m \tag{20}$$

Relying on the initial data given by equation (20) for a given set of time constants the non-traditional flare exponential functions were generated and tested for the UAV's safe intensive landing. The results of the computer simulation can be seen in Figure 11 [11, 12].



(a) T=10 s (b) T=5 s

FIG. 11 The UAV exponential landing paths with aggressive right turns.

From Fig. 11 it is easily seen that the change of the lateral displacement Z depends on the common time constant T of the exponential functions. As T is increasing the lateral coordinate will increase, too, and steady-state value of the height of the flight will be decreased.

It is evident that such flight path can be used in collision avoidance missions when the left turn is a non-achievable one, and to avoid collision with any kind of obstacle it is necessary to conduct aggressive right turns. Moreover, the flight paths shown in Fig. 10 and Fig. 11 can be used for collision avoidance missions in such cases when at UAV low altitudes further descend of the UAV due to ground proximity is not allowed. In these cases the ascend paths must be used. Having a robust set of pre-planned flight paths of the UAV basic flight missions can be automated, or, in case of emergency with proper landing zone selection the UAV might be landed automatically very safe way.

CONCLUSIONS

In contemporary days, the UAV flight automation is an up-to-date issue of modern control engineering. In this framework, the dynamical systems' reference test inputs are very important for closed loop automatic flight control system preliminary design, which is a computer assisted one.

The UAV flight automation is still an option, however is some countries this is a requirement for UAVs.

Both governmental and non-governmental UAV applications may meet a need of onboard autopilot supporting operators in standard and in non-standard situations they trained for. There is an opportunity to use open-source autopilots like Paparazzi to automate UAV's flight phases leaning on standard procedures based upon the toolbox of pre-programmed flight path geometry.

The author has shown a set of 3D paths planned to be followed in standard UAV flight management. These flight paths can serve as reference flight paths although in emergency flight situations. The mathematical models of the multirotor UAV 3D paths introduced and proposed to be used by the author are the first ones and varying initial parameters their number can be magnified creating a proper toolbox for the UAV operators.

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USE OF AUTONOMOUS SYSTEMS IN THE PERFORMANCE OF SECURITY MISSIONS

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Abstract: *New types of threats to global security affect the entire infrastructure for production and transportation, storage of material, equipment, resources and energy. The number and size of these facilities prevent the use of conventional protection means and require a large number of well-trained personnel. To these high costs are added. For this reason, autonomous systems with increased remote sensing, monitoring and even equipment with lethal armament offer a promising means of extending protection with limited human resources. This article presents some possibilities for the use of autonomous systems: protection of military bases, protection and automation of air bases and use of autonomous convoys.*

Keywords: *UGV (Unmanned Ground Vehicle); UAV (Unmanned Aerial Vehicle)' USV (Unmanned Surface Vehicle); Security mission.*

1. INTRODUCTION

Within the new types of conflicts (asymmetric, unconventional, hybrid wars) their autonomous systems have an important place. Military theoreticians imagine a new face of war with autonomous systems, drones, robots, sensors. To avoid the image of soldiers returning home in metal coffins dressed in flags, instead of grief-stricken families, autonomous robots that can make decisions, such as shooting at a target, can be used. In the future, the tacticians want to carry out missions without human intervention, to be able to replace the human soldier from a growing range of dangerous missions such as carrying out missions in caves, in search of terrorists, securing streets in locations exposed to sniper fire, air and naval cover, FDI road and waterway cleaners, overseeing damage from biochemical weapons, permanent guarding of borders and buildings of strategic importance, to control potentially hostile crowds and even infantry-specific combat missions. These robots would be "smart" enough to make decisions that only humans can now make; and as conflicts increase in pace and require much faster processing of information and responses, robots have a distinct advantage over limited and failing human cognitive capabilities. Autonomous systems bring a significant multiplication effect to the battlefield and lead to the disappearance of some human medical phenomena (distress, fatigue, low morale, perceptual and communication challenges in conditions of war etc., lack of emotions, adrenaline and stress) that cause the soldiers to exaggerate or deliberately go beyond humanitarian laws and commit atrocities, war crimes (illegal actions that have a significant political cost) [1].

According to Unmanned Systems Roadmap 2007-2032 US (Unmanned System - Autonomous System) is a "system whose components include the equipment, network and personnel required to control an unmanned aircraft". And a vehicle without a crew is defined as a motor vehicle that does not carry a human operator, can be operated autonomously or remotely, can be consumable or recoverable and can carry a lethal or non-lethal load [2].

2. USE OF AUTONOMOUS SYSTEMS IN THE SURVEILLANCE AND PROTECTION OF MILITARY BASES

It is known that human alertness begins to decline after approximately 30 minutes of sensor monitoring, and monitoring all video cameras and sensor streams required to protect a large surface 24 hours / 7 days requires extensive and costly human resources. This has led to increased demand for the use of autonomous systems within security systems. Advanced sensors can provide assistance for all aspects of the security task, including finding, evaluating, tracking or targeting intruders. The autonomous platforms equipped with sensors can take over the boring, dirty and dangerous aspects of the surveillance and security of some objectives and installations, reducing the operator overload.

Currently, the concept of I-IBD (Interim Integrated Base Defense) for the protection of military bases has emerged. The integrated base defense program is designed to improve the integration and interoperability of existing basic defense systems, leading to the improvement of basic operations. These enhancements include automatically displaying threat data, merging and correlating basic defense information through a graphical interface, evaluating and disseminating threat information, and reducing task / band ratio and training requirements. The effectiveness of the basic defense operations will be achieved by reducing duplicate capacities and assistance requirements [3].

The combination of C^4/I^2 systems with UGV, UAV, USV systems provides integrated protection from the base control center. These autonomous systems are targeted as force projection units. The useful tasks of these systems and physical sensors provide situational awareness, but also a physical response capacity to possible threats. Within this concept, the following autonomous systems can be used.

-UGV (Unmanned Ground Vehicle): within the base security missions this autonomous system is equipped with useful tasks for intrusion detection and evaluation, and physical response possibilities [4]. Its capabilities include autonomous navigation, obstacle avoidance, motion detection, day and night images, barrier access control by automatically evaluating access cards and even using lethal weapons against potential physical threats.

- AutoScan Under Vehicle Inspection System: The access area can be equipped with UVIS. These automatic scanning systems improve the security of the bases, providing a reliable threat detection capability at the check points. As the vehicles cross the automatic scanning platform, the system operator receives a real-time image of the vehicle ready for inspection. From a security position, the operator can then zoom in on any part of the image for closer inspection with more detailed magnifying levels. In addition, unlike manual inspection methods, the automatic scanning system produces images that can be stored for future comparison and analysis[5].

- USV is an autonomous naval vehicle used for protection against suicide boats, being equipped with on board ammunition (explosives, weapons), designed to investigate a suspicious boat, warn and attack if necessary [6].

- UAV is an autonomous air vehicle, which can perform the same missions as UGV but much faster and over a longer distance [7].

- Semi-autonomous weapon tower for security service on the defensive lines: optical, laser and thermal sensor, voice recognition, automatic weapons, grenade launcher, gas grenade launcher of different types of gas tanks. These towers can perform autonomous detection of human targets, target shooting autonomously or with human control [8].

In Fig. 1 a typical I-IBD configuration is presented. The towers, air balloon and UAV sensors offer wide coverage of the area near the protected area. Ground-based sensors can detect intrusions in the outer perimeter of a protected area and signal violations. Ground sensors offer a rough location and a type of target. Further information must be obtained from the nearest sensor, with the ability to more accurately measure location, title and speed and to make a more positive identification of the target type. Other sensors may be needed to positively identify the target as friendly or enemy and to continuously track the target Visible / IR cameras and radar sensors are used to identify and track intrusions. Human patrols and UGV / UAV systems intervene in the protected area. Finally, weapon systems may be needed to deter or neutralize the threat.

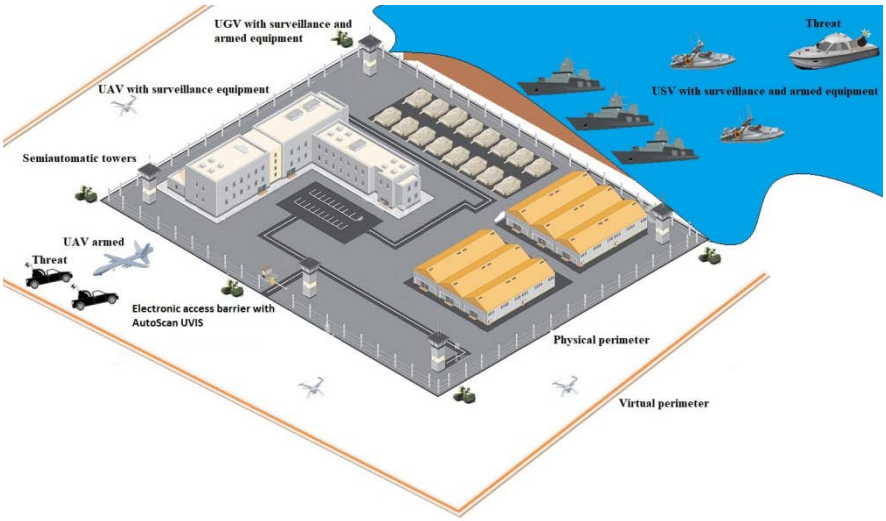

FIG. 1 The use of autonomous systems in the integrated defense of the bases [9]

2. SECURITY OF AIR BASES

Related to the security of air bases (the physical security of the air bases as well as the security of the flight), in order to improve the effectiveness and the efficiency, the air forces have developed the concept of SAB (Smart Air Base) that takes advantage of technologies such as robotics, artificial intelligence and automatic data analysis. They will perform the following functions:

1. The awareness of the situation of the upper air base: The basic control base will be better connected to all systems of the air base. Decision Support Systems (DSS) based on data analysis and using artificial intelligence systems will recommend further action, allowing faster decision making for more complex air operations.

2. Automated Aircraft Inspection: Hangars with sensors and UGVs will check whether aircraft are suitable for flight. This reduces aircraft return time.

3. Proactive Maintenance: A network of cameras in the aircraft hangar that will feed images of the aircraft's surface onto a computer running specialized software.

Using specific algorithms, the software will identify areas of the aircraft that require further human rectification or intervention. With data analysis, the intelligent fleet management system will provide information on aircraft performance and proactively recommend maintenance actions.

4. Evaluation and repairs of tread and track damage: if at present the inspection of the tracks and the treads and the problem solving is done manually by the human personnel, to reduce the labor force and the necessary time the autonomous systems will be used (Aerial drones will check quickly and transmit the exact location of the problem areas and the terrestrial ones will quickly remedy the situation regardless of time or weather). DSS will prioritize track repair operations and the choice of running tracks to minimize launch and recovery interruptions.

5. Improved Air Base Security: Using advanced sensors and video analysis by means of artificial intelligence systems will increase the capabilities of current systems used to improve air base security. UAVs can be used to catch "stray" drones [10]

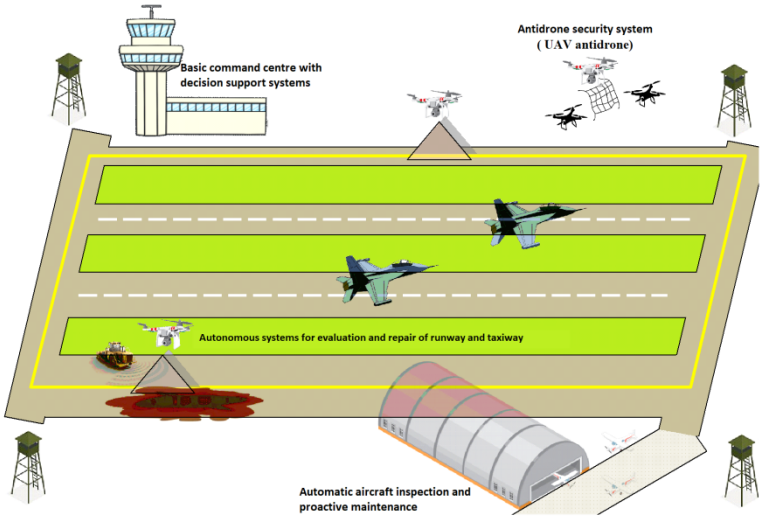

FIG. 2 Use of autonomous systems within the concept of intelligent air base [11]

3. SECURITY OF CONVOYS AND INDEPENDENT CONVOYS

The military relies on convoys to move people and supplies, usually on large and sometimes unpredictable grounds. Improvised explosive devices (IED) are one of the biggest threats to today's ground forces carrying out logistics missions in hostile environments. While tactical vehicle armor has been effective in reducing casualties, the fighter remains in danger due to increased quantities of explosives used for IEDs. Obstacles, enemy fighters, even bad weather can pose challenges that can prevent a successful convoy moving. In the event of an attack on a convoy, the drivers are targeted and cannot defend themselves. For this reason the armed forces are studying the ways in which operations with ground vehicles can be made safer and more efficient by integrating autonomous solutions[12]. The purpose of this use of autonomous systems thing is to completely remove the soldier from the cabins of military trucks that make supply convoys transporting food, water, ammunition, fuel, etc., in war zones, where the troops need them. Not only does this release more soldiers that can be used to effectively fight, but it avoids exposing them to the risk of being blown up by bombs or mines, or exposing enemy fire in ambushes.

To increase the efficiency of a reduced force structure, UGVs will serve as force multipliers, allowing a fighter in a protected vehicle to oversee the coordinated operation of multiple UGVs from a safe distance. These UGVs will be able to operate for long periods of time, during the day and at night, and through dust and adverse weather conditions, without fatigue or loss of consciousness[13].

The protection of military convoys becomes a critical issue for military operational planners facing modern war threats. The armed UGV and UAV will protect the supply convoy. The typical protection systems of the logistic convoy are autonomous vehicles with mobile firefighting system, equipped with audio and video detection equipment of enemy shooters and coupled to weapons operated autonomously or by remote control. This integrated sensor system can instantly turn fire in the direction of the enemy, on the move. These vehicles are also equipped with electronic countermeasures to block radio controlled improvised explosive devices (IEDs). These locks are designed to pre-activate IEDs (by mimicking the command signal) or to disrupt the communications channel when the convoy passes nearby. Enemy activity along the road or in certain locations suspected of being ambush points, also monitored from the air, by unmanned vehicles. While tactical UAVs are primarily tasked with collecting information and are rarely available for such missions, mini UAVs (MAVs) are currently optimized for such missions. By applying moving control systems, such MAVs can function as the vanguard, providing an area of several kilometers up to several hundred meters before the first element of the convoy. Sensors engaged by these MAVs can be programmed to detect recent field changes that indicate an IED or ambush on the roadside. Armed tactical UAVs patrolling the area can be used to eliminate possible threats [14].

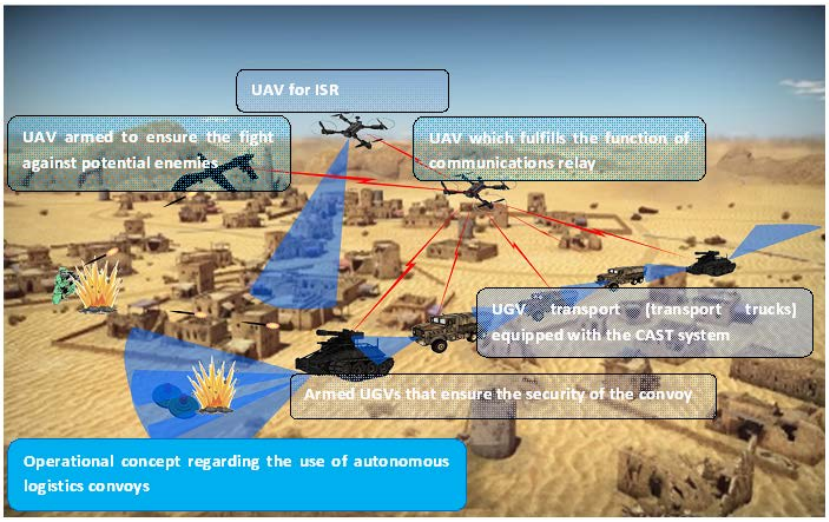

FIG. 3 Use of autonomous systems within a logistics convoy

It is quite simple to configure a vehicle with a GPS navigation system to follow a route independently, but it appears the probability of hitting other vehicles in the columns, crossing over pedestrians, colliding with unforeseen objects on the road, etc.15. This is why the concept of Convoy Active Safety Technology (CAST) has emerged. Thus, not only a GPS guidance unit is applied to the cars in the convoy, but also a LIDAR scanner.

This can detect things like cars, pedestrians, inopportune objects, etc. and the software can then command to stop and wait, drive or do anything else that needs to be done. The vehicles can be connected electronically with each other [15].

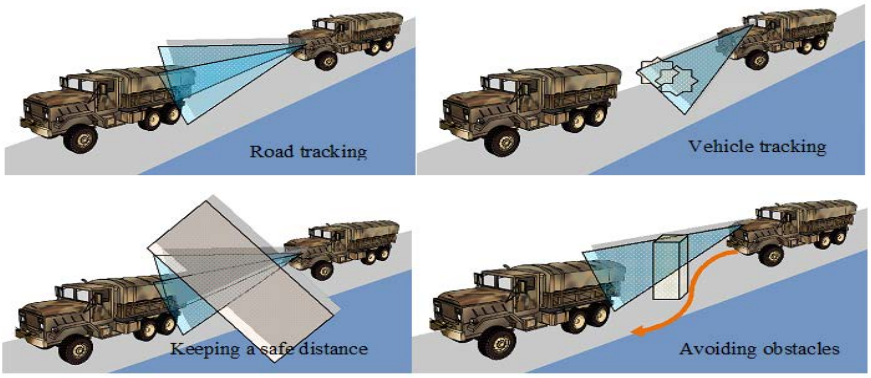

FIG. 4 CAST system capabilities [16]

CONCLUSIONS

The autonomous systems used to protect the military bases represent a viable improvement of this mission. These will be used to greatly reduce the risks of responding to high threat incidents and to offset the costs associated with the labor force used to perform routine repetitive tasks.

- In the use of sensors and autonomous systems within the protection of military bases such problems can occur: multiple simultaneous intrusions from different directions make the scenario even more complex, because the sensors have to coordinate between several competing tasks with different priorities. At some point, they can be overloaded and in this context the calculation algorithms used must perform the identification, tracking and engagement of the most critical targets.

- Troops can exit the field with autonomous supply vehicles following them. When supplies are depleted, vehicles can return to the base and take over much of what the ground troops need. This saves time and costs by not having to use personnel back and forth on potentially dangerous supply lines, allowing them to continue their mission.

- Autonomous logistics convoys offer a significant advantage of force protection - the removal of personnel from the vehicles concerned, the protection against IED and the use of a small number of operators necessary to simultaneously supervise more activity.

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EVOLUTIONS AND TRENDS IN INFORMATION SYSTEMS ASSISTING MANAGERIAL DECISION-MAKING. STUDY ON ERP SYSTEMS

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***Abstract**: The aim of this paper is to describe the evolution of information systems used in managerial decision-making, as well as their transformation under the current economic conditions. The main phases underwent by ERP (Enterprise Resource Planning) information systems are described, as well as the current perspectives in their development and the opportunities brought about by these systems in the era of globalization. Furthermore, the present paper aims to carry out an analysis, using fuzzy sets, to identify the optimal system, on the basis of multiple criteria of varying importance.*

***Keywords:** ERP, decision support, ERP evolution, fuzzy sets.*

1. INTRODUCTION

An information system is that system which is capable of performing data ***acquisition*** through either manual or automatic procedures, data ***storage***, ***processing***, and perhaps the most important function, ***conversion*** of data into information.

The resulted information may take various shapes, however, it's ultimate aim is to facilitate the decisional process, in order to ensure an enterprise's sustainable growth. The main components of an information system are: the computer (terminal), computer networks, servers, the database, software resources, and last but not least, the users. An alternative approach to the information system is that it may be considered a language which supports decision-making, and facilitates the actions undertaken by employees.

Currently, along with the globalization of the economy, the decision-making process has become increasingly complex, forcing managers to adapt, by adopting dedicated software in order to come to optimized, clear and precise decisions. ERP systems are a prime example, given that they contain model libraries, intended for the optimization of the decision-making process, and which can be tailored for each enterprise, regardless of their size, purpose or geographical position [1].

As the formalities associated with international trade are increasingly simplified, and with the expansion of online commerce, a company may have branches in multiple countries, may separate the production and managerial activities, and may operate on more than one market, in order to enlarge its customer base.

Under these conditions, in order to maintain high standards and to optimize processes, real-time communication is an absolute necessity. This necessity can only be fulfilled by having a finely tuned information system, focused on the requirements of the company in question.

Finally, an information system needs to ensure complete data security, a vital aspect in the case of network use (either internal and/or the Internet), given the added risk of unauthorized access to data or even fraud [2].

2. INFORMATION SYSTEMS CLASSIFICATION

Over the years, various authors have contributed to the design of a theoretical framework regarding information systems, based on conventional company hierarchy. Laudon & Laudon (2012) characterize the information system as being composed of the elements that collect, process, store and distribute information which is intended to support decision-making and control over organizations. Thus, information systems include three distinct aspects: organization, technology and human resources. These can be classified according to the level at which the decision is made, as illustrated in figure 1 [3].

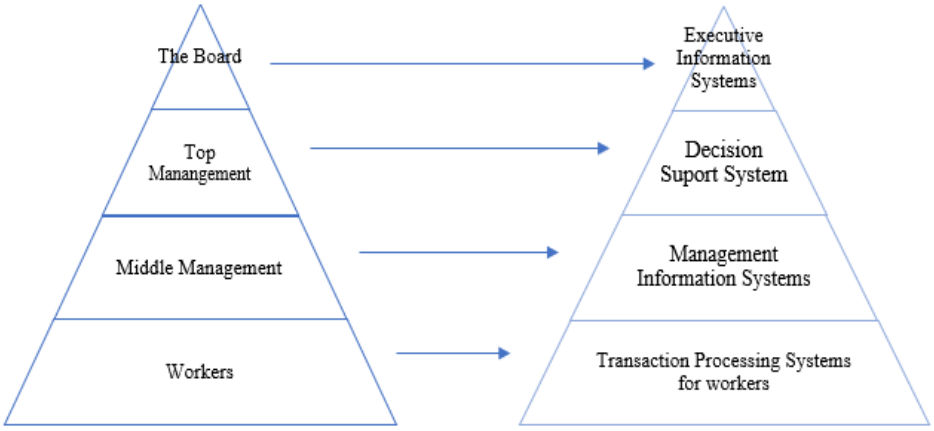

FIG. 1 The information system pyramid – adapted from *Four level pyramid model of information systems* (O´Brien & Marakas, 2010)

At the level of operative employees, information systems need to support the control and supervision of basic activities of the company's transactions, which has led to these systems being termed *transaction processing systems.*

Information systems employed in management and decision-making systems collect data from the transaction processing systems and transform them into information that managerial decision will be based on. These can process a vast quantity of data in real-time and include analysis instruments and predictions that are vital for the optimization of the enterprise's processes.

Executive informatic systems are employed in devising strategic medium to long-term decisions. These analyze both internal and external data in order to anticipate fluctuations which could affect the competitiveness of the enterprise [4].

In the book Decision Support Systems: A Knowledge-Based Approach (1996), the characteristics of a decision-support information system are described as follows:

- Its design should reflect a solid knowledge base pertaining to the domain approached by the decision process;
- It allows for the acquirement of descriptive knowledge or the inference of procedures and rules;
- Offers the opportunity of presenting information on the spot or for the periodic generation of a detailed report;
- It facilitates the selection of certain knowledge sets which may be studied or included in the decision-making process;
- It is meant to ensure constant interactivity between the system and the deciding department of the organization [5].

Despite the pyramid model remaining theoretically useful, at the practical level a number of innovative technologies have been introduced, and novel categories of information systems have been developed. These do not fall under the previously described pyramid model.

The following are among the most significant examples:

- Data warehouse;
- BI Model;
- ERP (Enterprise Resource Planning) software.

A data repository is a database with a unique data structure which allows for the quick and efficient extraction of information from a large quantity of data [6]. At the same time, this system is employed in data analysis and report and is considered a significant part of the BI Model (Business Intelligence Model). Data repositories store current and historical data, which is used for the creation of analytic reports that concern all the employees of the company [7]. The data repository constitutes an alternative to traditional databases.

The BI Model (Business Intelligence Model) advances the possibility of obtaining key information regarding day-to-day activities, but can also generate an analysis of medium to long-term opportunities and risks. The market for this particular model has increased significantly in recent times; there are more and more companies investing considerable capital in BI Models [8]. However, the majority of BI systems are directly correlated with the data structure that they linked to, generating exhaustive statistics which can be hard to comprehend regarding the general business strategy. A recent study concerning BI users indicates that one of the system's drawbacks is its low flexibility [9].

The ERP (Enterprise Resource Planning) is a software package that ensures the integration of the entirety of information pertaining to an organization into a single platform. The purpose of ERP systems is to ensure the transparency of data in an organization and to facilitate access to any kind of information that may be instrumental to the organization's goals. ERP systems analyze cash-flow fluctuations, material and raw material resources, production capacity, the status of business commitments (the purchase and sale process) and the human resources. This system is modular and is built on the basis of data collected from multiple departments such as: manufacturing, the purchase department, the sales department, accounting etc. [10].

Concurrently, ERP systems improve the flow of information between all business functions and manage the connections with interested parties (shareholders, state institutions, clients, potential investors) [11].

3. THE EVOLUTION OF ERP SYSTEMS

ERP systems have undergone continuous improvement since the advent of their precursors, being constantly upgraded in order to respond to economic market changes and technological development. The earliest proposal of an enterprise resource-planning system emerged 60 years ago with the development of Inventory Control Packages (IP), developed as frameworks, written in one of the following programming languages: COBOL, ALGOL and FORTRAN.

Seeing that any system can benefit from an upgrade, new modules are being tested, which will be integrated into the system of future ERP generations. The expected outcome is the enhancement of the decision-making process and the generation of more reliable predictions. In addition, ERP systems are becoming increasingly flexible, customized, with both local and cloud storage capabilities, modularized into multiple interconnected applications which can be changed individually. These are known as postmodern ERP systems [12].

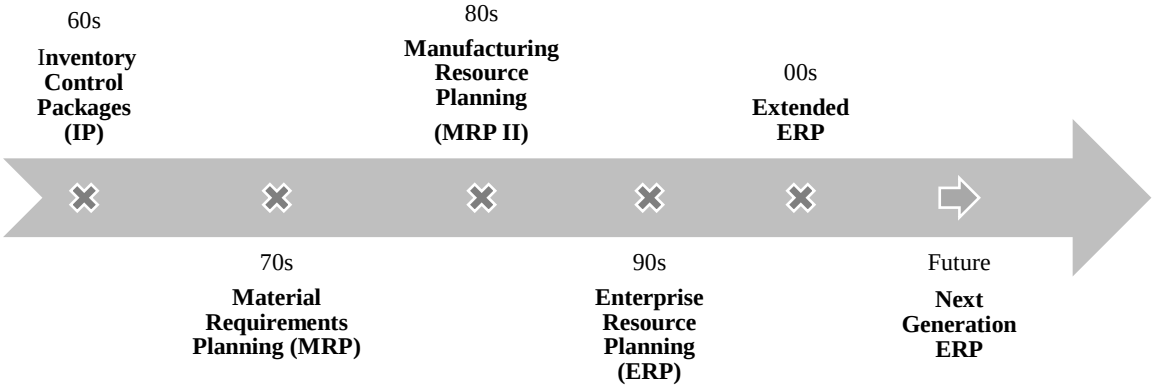

FIG. 2 The evolution of ERP – adapted from Kasem, Ramy & El-Bakry, Hazem & Saleh, Ahmed. (2017). *Surveying Systems of Enterprise Resource Planning. International Journal of Advanced Research in Computer Science & Technology.*

Inventory Control Packages – provide accurate real-time analysis, optimization and prediction procedures, aimed at solving complex supply management issues [13]. The most important functions of an inventory control system are:

- The function of controlling and predicting inventory, using multiple algorithms to identify anomalies and potential issues;
- The function of inventory optimization;
- The purchase and inventory dimensioning function, using inventory calculations;
- The function of calculating emergency inventory and working capital;
- The function of managing inventory-associated costs (storage, transportation, etc.);
- The function of determining the duration of an inventory-cycle;
- The function of logistic support and of multiple locations;
- The function of inventory object management [14].

Specialty literature describes two inventory control methods: a periodic control system (typically the end of an accounting year) and a perpetual control system which thoroughly monitors all stock movements.

The perpetual control system has the advantages of more detailed control, as well as decreased storage cost of products, materials and raw materials. However, its setup requires more time and financial resources.

Material Requirements Planning, abbreviated as MRP is a production planning system by means of inventory control and detailed planning of fabrication processes. The novelty brought by these MRP systems compared to inventory control packages is that they solve three major problems:

- They ensure the availability of supplies for production and of products that are to be delivered to clients;
- They plan the production processes, delivery deadlines and material purchasing processes;
- They maintain low storage costs for materials and products.

In 1983, Oliver Wight develops MRP into **Manufacturing Resource Planning**, abbreviated MRP II [15]. The MRP II system improved upon previous systems by the integration of all the aspects of the fabrication process, including materials, finances and human resources. One similarity to present-day ERP systems is the centralized storage and processing data, by means of a centralized database. 1980's technology (hardware, software and relational databases) were insufficiently developed to be able to provide real-time information [16], and the costs of those systems proved prohibitive for the majority of enterprises. Together with technological improvements and the trend set by the MRP II systems in data processing, the foundation was laid out for the integrated systems and more accessible software presently used by businesses [17].

Enterprise Resource Planning is a software product that integrates the entirety of an organization's information into a single platform. The purpose of this system is to ensure the organization's data transparency and to facilitate the access to potentially useful data. ERP provides an integrated, continuously updated assessment of the basic business processes, using common databases, maintained by a database management system. ERP systems monitor business resources – cash, raw material, production capacity – and the status of business arrangements: orders, purchases and salaries. The applications of which the system is made up share data from multiple departments (production, purchases, sales, accounting etc.) [1]. ERP facilitates the flow of information between all functions of a business and manages links with interested external parties.

4. THE CRITERIA FOR SELECTING AN ERP SYSTEM

Understanding the environment in which the information system is to function is the first step of the analysis phase. The study of the internal environment of the economic entity which will make use of the information system comprises the following activities: identification of general information pertaining to the organization, awareness of the entity's activities, consideration of its management characteristics, as well as knowledge of all technical means at its disposal [5].

In order to generate a detailed analysis, this paper aims to make use of fuzzy sets, that allow for the breakdown of insufficiently clarified phenomena, since for each element of said sets there are multiple intermediary degrees of membership, from full membership to non-membership [1].

Modelling the managerial decision using fuzzy methods requires the modelling of imprecise, subjective, linguistical data that occur in the real-life situations of the decisional process.

According to Tom Miller, some key criteria that are useful for choosing an ERP system are:

- Decision-making support provided to upper management – labeled **C1**;
- Product support provided to the users by the producing company – labeled **C2;**
- Integration with existing systems – labeled **C3**;
- Monthly maintenance and update cost – labeled **C4**;
- Employed technology and potential capabilities – labeled **C5**;
- The prospect of customization according to the organization's requirements – labeled **C6** [18].

These six criteria have been weighted distinctly. Thus, C1 is 20%, given that in the calculation of system performance this criterion occupies the first positions; C2 is 25% given the importance that is carried by a sound implementation and utilization of the system by the employees; C3 is worth 15% because system modification is a lengthy and costly process; C4 is weighted 20% since the running costs of the system, as well as its support and maintenance result in considerable expenses; C5 is weighted 15%, the ability of using the system on all available devices and the ability to use cloud technology are essential; C6 is worth 15%, given the potential competitive advantage generated by a system's conformity to the specific characteristics of a business.

Criteria C1, C2, C3, C5 and C6 were graded on a scale from 1 to 10, where 10 is the maximum grade a system can receive. In addition, the C4 criterion's values are written in a fuzzy triangle, where the first value is the minimum, the second value is the mean of the expenses and the last value is the maximum expense.

ERP information systems were randomly selected from the paper „Top ERP Software Comparison" [19], and were labeled E1 to E5, omitting the name in order to avoid advertising.

Table 1. Outcome matrix. "Maximum" indicates "the higher the better" criteria, „minimum" indicates "the lower the better" criteria.

	C1 (maxim)	**C2 (maxim)**	**C3 (maxim)**	**C4 –$ thous. (minimum)**	**C5 (maxim)**	**C6 (maxim)**
E1	7	7	9	(2, 4, 5)	9	8
E2	7	8	8	(1, 3, 6)	9	7
E3	8,5	9	6	(6, 7, 9)	10	8
E4	10	8	10	(13, 17, 27)	10	8
E5	9	9	8.5	(14, 19, 26)	10	8
Weight %	**20%**	**15%**	**15%**	**20%**	**15%**	**15%**

In order to convert each fuzzy triangle to a single value, the following formula was used:

$$X = \frac{1}{4} * (x_1 + 2*x_2 + x_3)$$

Table 2. Outcome matrix after calculation of the fuzzy triangle

	C1 (max)	**C2 (max)**	**C3 (max)**	**C4 – $ thous. (min)**	**C5 (max)**	**C6 (max)**
E1	7	7	9	3,75	8	8
E2	7	8	8	3,25	9	7
E3	8,5	9	6	7,25	10	8
E4	10	8	10	18,5	10	8
E5	9	9	8.5	19,5	10	8
Weight %	**20%**	**15%**	**15%**	**20%**	**15%**	**15%**

In order to determine the degree of membership for each criterion, the aspiration level and the margin of error were taken into account.

Table 3. Aspiration level and margin of error for each criterion

	C1	C2	C3	C4	C5	C6
Aspiration level (S_E)	9	8	9	7	9	9
Margin of error (δ_j)	1	2	3	5	2	2

The degree of membership takes values from 0 to 1, where 0 means that the value is larger than the aspiration level plus margin of error (for "the lower the better" criteria) or is below the aspiration level after subtracting the margin of error. In order to calculate the degree of membership, the following formulas were used:

- For "the higher the better" criteria:

$$X = \begin{cases} 1, & x_i \geq S_j \\ 1 - \frac{S_j - x_i}{\delta_j}, & S_j - \delta_j < x_i < S_j \\ 0, & x_i \leq S_j - \delta_j \end{cases}$$

- For "the lower the better" criteria:

$$X = \begin{cases} 1, & x_i \leq S_j \\ 1 - \frac{x_i - S_j}{\delta_j}, & S_j < x_i < S_j + \delta_j \\ 0, & x_i \geq S_j + \delta_j \end{cases}$$

where:

E = the cases included in the calculation;
x = value taken by one criterion in one case;
s_j = the level of aspiration for that criterion;
δ_j = the margin of error for that criterion.

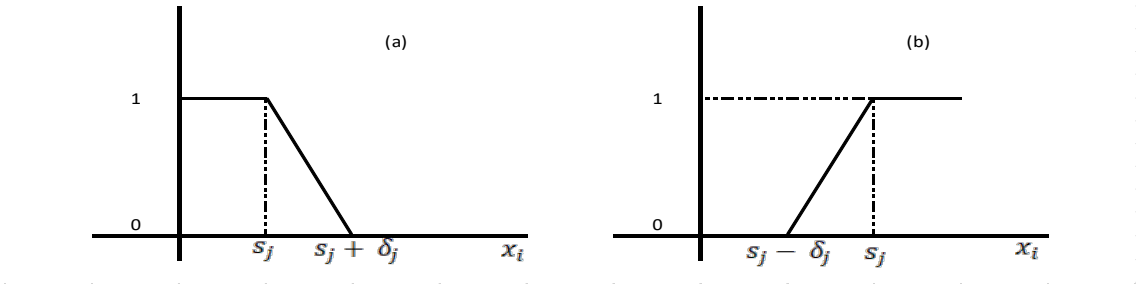

FIG. 3 Membership function: (a) "the higher the better" criteria, (b) "the lower the better" criteria
Source: Adapted from Lixăndroiu D. *Modelarea deciziei economice*, Ed. Economică, Bucharest 2014, p. 187, figure 5.10.

Following the application of formulas in all the cases, the outcome matrix was rebuilt, containing values in the [0,1] interval, which stand for the degree of membership for each of the criteria of every information system.

Table 4. Outcome matrix

	C1 (max)	C2 (max)	C3 (max)	C4 – $ thous. (min)	C5 (max)	C6 (max)
E1	0	0.5	1	1	0.5	0.5
E2	0	1	0.67	1	1	0
E3	0.5	1	0	0.95	1	0.5
E4	1	1	1	0	1	0.5
E5	1	1	0,84	0	1	0.5
Weight %	**20%**	**15%**	**15%**	**20%**	**15%**	**15%**

The final step in the analysis was the calculation of the weighted mean for each ERP system, taking into consideration the weight of each criterion.

Table 5. Outcome matrix

	C1 (max)	C2 (max)	C3 (max)	C4 – $ thous. (min)	C5 (max)	C6 (max)	Weighted mean (φ)
E1	0	0.5	1	1	0.5	0.5	0,575
E2	0	1	0.67	1	1	0	0,6
E3	0.5	1	0	0.95	1	0.5	0,665
E4	1	1	1	0	1	0.5	0,725
E5	1	1	0,84	0	1	0.5	0,7
Weight %	**20%**	**15%**	**15%**	**20%**	**15%**	**15%**	**100%**

The optimal decision will by determined as such:

$$E_{optim} = \{ E_i \mid \max \varphi(E_i),\ E_i \in \mathrm{E} \} = \mathrm{E4}$$

Following the analysis, it was concluded that the most advantageous ERP information system was the system designated **E4**, which had the highest weighted mean of the membership degrees, 0,725 to be exact.

Thus, it can be surmised that the E4 system has a compliance to the imposed criteria of 72.5%, therefore being the optimal choice. Not far behind is the **E5** system, obtaining a score of 0.7, signifying a 70% accordance with the imposed criteria. At the opposite end is the **E1** system, with a score of 0.575 and a compliance degree of 57.5%.

5. SWOT ANALYSIS OF ERP SYSTEM IMPLEMENTATION

A SWOT analysis is a technique used in a business environment to reveal the **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats. Strengths and weaknesses are attributes of an economical entity's internal activity, whereas opportunities and threats refer to market influences over the organization. Concerning the opportunities, the company may choose to take advantage, while in the case of threats it may protect itself, but cannot alter them.

Table 6 SWOT analysis of ERP system implementation

	Helpful to achieving the objective	**Harmful to achieving the objective**
Internal origin (attributes of the organization)	**Strengths ↓**	**Weaknesses ↓**
	• Enhances the decision-making process; • Optimizes the purchases and sales processes; • Improves relations with the clients; • Improves communication between departments; • Decreases manual processes and increases automation; • Utilizes a business model; • Enhances process control.	• High monthly cost; • Product support is in English– employees need to speak English; • Employees may be hesitant to change; • Inadequate understanding and use of the system; • Prolonged employee training time to avoid errors; • Insufficiently developed technology; • Lengthy system implementation.
External origin (attributes of the environment)	**Opportunities ↓**	**Threats ↓**
	• Competitive advantage over those who did not implement ERP systems; • Development of existing technology and control methods; • Emergence of new business models; • The process of globalization and the necessity for real-time knowledge of the data; • The increase of market-value of the ERP system providers; • The European legislative context; • Artificial intelligence.	• Low proficiency of the workforce in utilizing an ERP system; • The rise of support and maintenance costs; • System security and the risk of information leaks; • Technological upgrade; • The high cost of changing the ERP system and the dependence on one ERP system provider • Limitations in the management process; • Market saturation.

6. FUTURE TRENDS IN ERP SYSTEMS

Currently, technology is being developed at a rapid pace, which forces the ERP system providers to adapt to the technological progress. Market saturation, online commerce and the emergence of artificial intelligence are a few of the problems that must be addressed in order to create a high-performance ERP system. Changes to ERP systems will drastically impact any companies that employ such systems.

ERP systems are intended for high-turnover companies, both because of the high cost, as well as the large amount of data typically used.

Given the market saturation, integrated information system producers are driven to new markets, which require price reduction strategies in order to make the product financially viable. Additionally, the implementation and configuration system is constantly improved, so that system changes are not stressful for the employees.

Artificial intelligence and the increasingly efficient sharing of data inside these systems has improved data collection and analysis and has led to the simplification of all processes. Further development of artificial intelligence will lead to the automation and optimization of all processes, which may contribute to improved production cost prediction for all products that are to be sold. Additional information generated by ERP systems will help managers implement increasingly well-informed decisions, by using data processed using advanced analyses.

Additionally, management may improve efficiency and productivity by using this information to select the most beneficial updates for various business processes [20].

Another step in the evolution of ERP system is the development of iERP (intelligent Enterprise Resource Planning) systems, which use machine learning technology and advanced analysis procedures, which is a welcome upgrade to the existing capabilities of traditional ERP systems. Another improvement brought about by intelligent ERP is that this system is capable of learning exceptions, constantly evolving and adapting to market challenges. Additionally, iERP can reuse information and previous responses whenever a more complex analysis is necessary.

iERP systems will incorporate social media modules, facilitating internal communication, as well as communication with business partners. Additionally, increasingly prompt responses to both employees and consumers, will be a considerable improvement brought about by social media upgrades to ERP systems.

CONCLUSIONS

Selecting an appropriate ERP system is a challenging task, given that it generates significant monthly costs, and requires a prior, detailed analysis. Since no system is perfectly compliant to the requirements of an organization, this paper presents a comprehensive, multiple-criteria analysis, using fuzzy sets, in order to assist users in selecting the most appropriate package for their needs.

Following the analysis, it was concluded that the ERP system that had the highest weighted mean of the degrees of membership to the criteria had accumulated 0.725 points, signifying a 72.5 % compliance to the imposed criteria, and thus being the optimal solution.

ERP systems are undergoing constant development, ever since their precursors in the 60's, their current characteristics being susceptible to improvement. In the future, these systems will include artificial intelligence technologies, which will optimize production and management processes and reduce their cost.

In addition, artificial intelligence and machine learning technology will be capable of utilizing increasingly complex databases and greater quantities of data, which will facilitate the decision-making process by generating more precise predictions.

Furthermore, ERP systems will undergo considerable upgrades. By fusing with various other technologies, these platforms will offer additional information to enterprises, which may contribute to improved financial decisions.

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STUDY OF THE MIXED FLOWS TURBOFAN THRUST FOCUSED ON THERMODYNAMIC PARAMETERS AND ENGINE OPERATING REGIMES

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Abstract: *The study presented in this paper is focused on highlighting how the thrust as the main performance of the mixed flows turbofan engine is influenced by the airspeed, flight altitude and engine operation speed regime variation. Based on the performances (thrust, specific thrust and fuel specific consumption) of the mixed flow turbofan engine, the Engine Maps (Altitude Map, Velocity Map and Speed Map) can be expressed. The mathematical model describing the operation of the mixed flows turbofan engine is based on the assumptions of fixed geometry engine, fluid flow consisting of perfect gas, with the consideration of different species (i.e. air as cold stream, fuel and a mixture of burned gas as hot stream), Brayton cycle described by isentropic, adiabatic thermodynamic evolutions, including losses that generate an increase in entropy. For further developments, the mathematical model of the engine can be expanded with the variable geometry hypothesis. From the numerical simulations based on the mathematical model of the mixed flows turbofan engine, the correlations of thrust with flight Mach number and engine operation speed regime conclude the study that describes the behavior of the engine from the standpoint of thermodynamics, flight and engine operating regimes.*

Keywords: *mixed flows turbofan engine, performances, thrust, flight regimes, engine operating regimes, Mach number, mathematical modeling, numerical simulations.*

1. INTRODUCTION

The turbofan engines are widely used in civil and military aircraft. With respect to the turbojet engines, the turbofan engines prove significant advantages that contribute to increased safety in operation, Cumpsty [1], Fowler [2], Mattingly [3-4], Farokhi [5].

For the entire flight envelope, the turbofan engines, due to the multiple spool architecture, the operating line of the engine is shifted at a significant safer distance from the surge line, by the means of the advanced engine control systems [9-12], [22-24].

The most used multiple spool solutions are twin -spool and then triple-spool. For more than four spools, the designed construction of the engine supposes higher costs due to the enlargement of the cross section and significant increase of the global weight, and it also requires intricate engine control systems.

The turbofan engines, which are also referred as high bypass ratio or large bypass ratio are widely used for commercial flights, for civil and military aircrafts. The reasons are the improved fuel economy (in cruise) and noise reduction, [13-14].

2. DESIGN OF ACTUAL TURBOFAN ENGINES

The design of actual turbofan engines includes optimizations on the overall engine efficiency, mitigation of noise and emissions levels [5-8].

The most relevant aspects of engine design and construction are summarized as follows:

Figure 1 illustrates the construction of a modern twin spool turbofan, highlighting its main parts. The core flow passes through the fan (which acts as a Low Pressure Compressor), High Pressure Compressor, Combustion Chamber, High Pressure Turbine, Low Pressure Turbine and Core Nozzle. The Bypass Flow crosses the fan and the Bypass Nozzle. The use of the reverse-flow combustion chamber, as shown in Fig. 1, enables a significant reduction of the engine's weight, by shortening its length.

For military applications there are used the high-bypass turbofans, which are also known as mixed flows turbofan engines.

The reasons are consequences of different priority setting for the military applications focused on combat aircraft, such as:

1. The thrust requirements change rapidly during combat and the response of the low-bypass turbofans to throttle adjustments is faster compared to the high-bypass turbofans; the inertia is less and less air mass is involved (for increasing the velocity).

2. The low-bypass turbofans have less frontal area, thus reducing the drag produced. For aircraft expected to fly at supersonic speeds, however briefly, this is important.

3. Better thrust to weight ratio, e.g. 9:1 for F119 low-bypass ratio (used in F-22 Raptor) versus 6:1 for Trent 1000 high-bypass ratio. Even if the actual thrust produced by the low-bypass turbofans is lesser, they produce more thrust per kg of engine, which means that the engine can be more compact in size.

4. The low-bypass turbofans are more efficient at higher speeds compared to the high-bypass turbofans.

5. The reduced cross section size of the low-bypass turbofans mean that the aircraft can be made stealthier by embedding the engines inside the fuselage, which in case of high-bypass turbofans cannot be achieved.

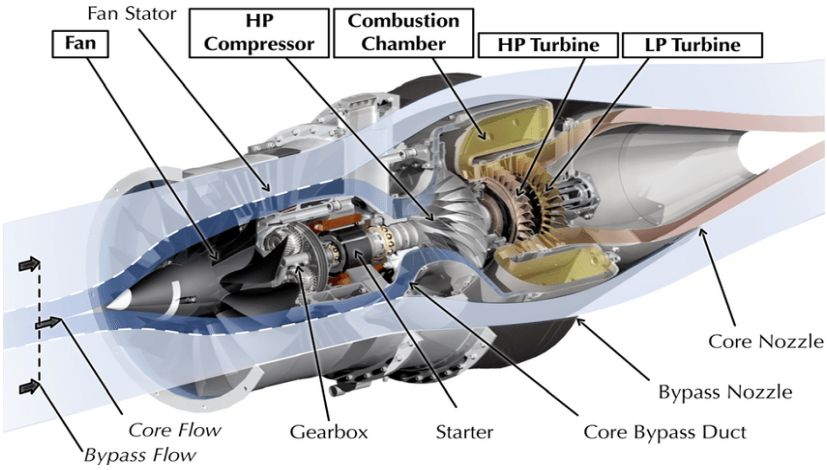


FIG. 1 – Turbofan Engine Parts [6-8]

Figure 2 presents a multiple-spool turbofan construction, with the visualization of the fluid flow path and streamline. For such type of engines, the axial component of the velocity (in core flow as well as in bypass flow) is significantly higher than the radial and tangent components of the velocity, thus resulting lower turbulence levels and consequently reduced noise levels, which demonstrates the environmental friendly feature.

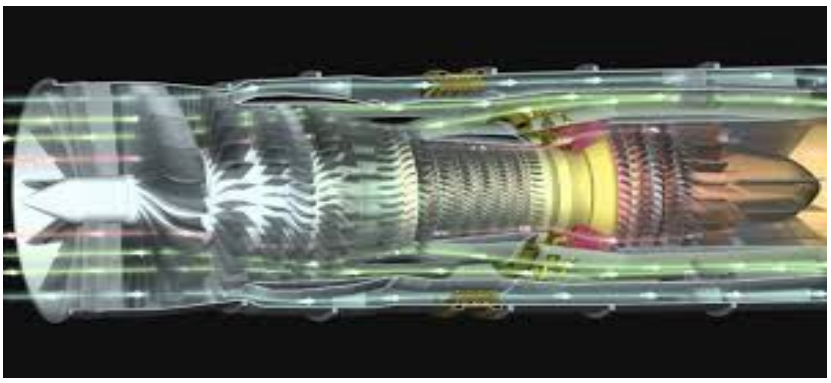
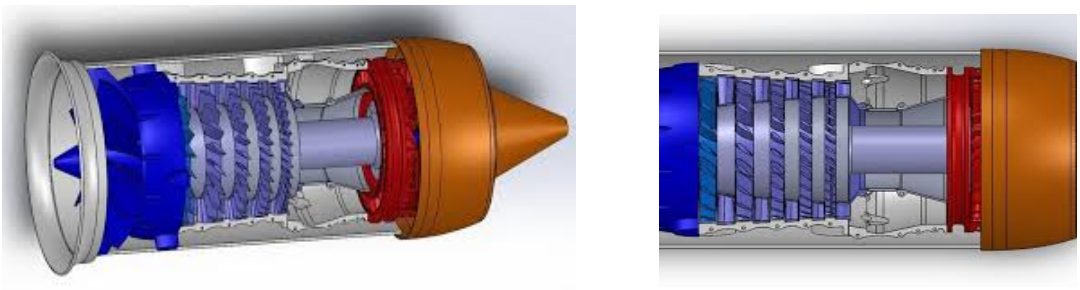


FIG. 2 – Multiple-Spool Turbofan Engine – View of Fluid Flow Path, Streamlines [6-8]

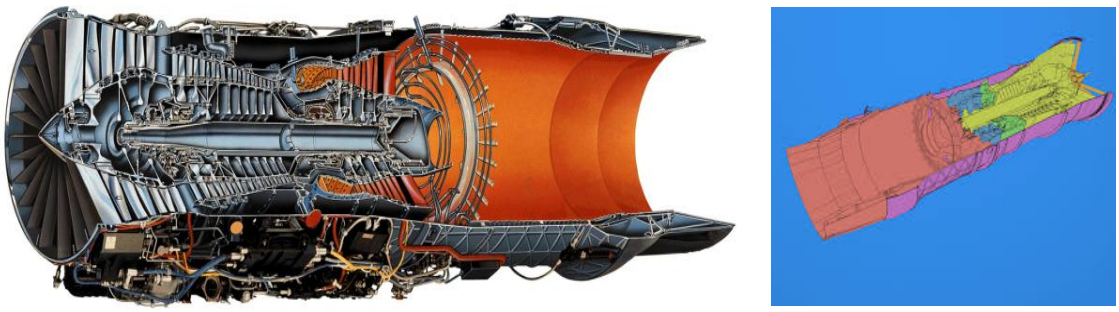
From Fig. 1 and Fig. 2 one can remark that the construction of the combustion chamber determines the axial length of the engine; the direct-flow construction (as indicated in Fig. 2) produces an increase of the engine's axial length, while the reverse-flow construction (as shown in Fig. 1) enables a reduction of the axial length.



Low- and High-Pressure Compressor-Turbine Group: (left) 3D cut view; (right) cut view

FIG. 3 – Twin-Spool Mixed Flows Turbofan Engine – Schematic Diagrams [6-8]

In Fig. 3 the Low- and High-Pressure Compressor-Turbine Group for a twin-spool construction of Mixed Flows Turbofan Engine are high-lighted.



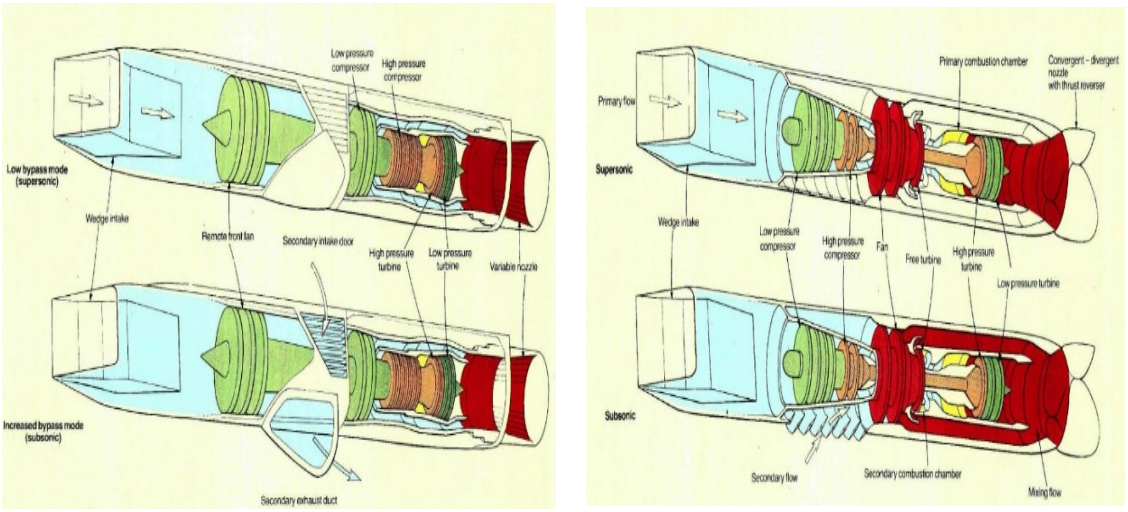
(a) F100 PW 220 Reheated Mixed Flows Turbofan Engine (b) Schematic Diagram

FIG. 4 – Reheated Mixed Flows Turbofan Engine [6-8]

The use of the reheat is a powerful means aimed to augment the thrust of the turbojet and turbofan engines. Referring to the F16 Fighting Falcon, which is currently serving the Romanian Air Force, the propulsion system is the F100 PW 220 Reheated Mixed Flows Turbofan Engine, as shown in Fig. 4.a.

For the supersonic propulsion of the aircraft, mixed flows turbofan engines can be successfully used. For achieving such purpose, the geometry of the aircraft must be adjusted; the main modifications refer to the supersonic inlet and the variable geometry exit nozzle, for both dedicated engine control systems being required.

Figure 5 presents the architectures of supersonic Mixed Flows Turbofan Engine MFTE, designed and manufactured by Rolls Royce and SNECMA.



(a) Rolls Royce Architecture (b) SNECMA Architecture

FIG. 5 – Supersonic Mixed Flows Turbofan Engine Architectures [6-8]

3. THEORETICAL CONSIDERATIONS

The purpose of the thermodynamic analysis of the jet engines is to determine the Design and Off-Design Engine Performances, where the accuracy of the predicted performances depends on the mathematical model and the assumptions considered within.

The objectives of the analysis of the mixed flows turbofan MFTF engine are represented by modeling and simulation, so as to obtain the predicted engine performances, for different flight regimes and various operating regimes. In principle, the calculations are carried out distinctly for the core flow, bypass flow, mixing area and integrating the results in the overall performances, [1-5], [9-14].

The mathematical model of the mixed flows turbofan includes the mathematical model of a turbojet engine, since the core flow calculations describe perfectly the turbojet engine calculations, from the stand point of the fluid flow thermo-dynamical processes, [19-21].

In case of the mixed flows turbofan engine, the mathematical model describing its behavior as close to reality as regards the engine operation and analysis from the thermodynamic standpoint, is based on the following assumptions:

1/ fixed geometry engine,

2/ the work fluid is considered perfect gas,

3/ different species are considered for the work fluid:

a/ air as cold stream within engine intake and compressor,

b/ fuel,

c/ mixture of burned gas as hot stream within combustor, turbine and exhaust unit,

4/ Fuel Specific Energy FSE [kJ/kg] = P_{CI} = 43500 [kJ/kg] at design point, from a range of 40000 [kJ/kg] up to 45000 [kJ/kg],

5/ Brayton cycle is described by isentropic, adiabatic thermodynamic evolutions,

6/ losses are included, which generate an increase in entropy within the Brayton cycle,

7/ the properties of the work fluid: ratio of specific heat k, constant pressure specific heat C_p, gas constant R, as listed in Table 1; the relation between R and C_p is (1).

Other parameters (expressed as non-dimensional coefficients) required for calculating the performances of the engine are:

1/ pressure ratio (i.e. compressor pressure ratio): π_c^*

2/ fan pressure ratio: π_v^*

3/ turbine inlet temperature T_3^* or stagnation specific enthalpy at turbine inlet: i_3^*

4/ air intake pressure loss, σ_{da}^*

5/ adiabatic efficiency on compression for compressor η_c^* and fan η_v^*,

6/ combustion chamber pressure loss, σ_{ca}^*

7/ efficiency of the combustion process, ξ_{ca}^*

8/ adiabatic efficiency on turbine expansion, η_t^*

9/ velocity loss within nozzle exit, φ_{ar}

10/ mechanical efficiency η_m (i.e. shaft transmission efficiency),

11/ bypass ratio: K.

For further developments, the mathematical model of the engine can be expanded with the hypothesis of variable geometry, e.g. in case of engine exit nozzle.

Table 1. Properties of the work fluids

Fluid Type	$k = \frac{C_p}{C_v}$	$C_p\ [\frac{kJ}{kgK}]$	$R\ [\frac{J}{kgK}]$
Air	1.4	1.005	287.3
Burned Gas	1.33	1.165	288.4

$$C_p = R \cdot \frac{k}{k-1} \tag{1}$$

The thermodynamic analysis of the jet engines and mixed flows turbofan engine as well, supposes the calculation of the performances (thrust F [N], specific thrust F_{sp} [Ns/kg] and specific fuel consumption C_{sp} [kg/Nh], TSFC, for the flight envelope of the aircraft and global range of engine speed regimes $\bar{n}$; such process is also referred as design and off-design performance prediction, [9-14].

$$\bar{n} = \frac{n}{n_{Design}} \tag{2}$$

The mathematical model allows the design and off-design performance prediction of the mixed flows turbofan engine MFTFE, for all the flight regimes that are included within flight envelope and for all the engine operating regimes $\bar{n}$.

The most representative engine operating regimes are:

- Design: $\bar{n}$ =100 %,
- Cruising: $\bar{n}$ = 90%,

- Cruising lowered: $\bar{n} = 85\%$,
- Idle ground: $\bar{n} = 40\%$ and
- Max starting: $\bar{n} = 105\%$.

The results of the performance prediction computations can be summarized in the engine maps, as follows: Altitude Map, Velocity Map and Speed Map. The analysis of the engine maps supposes the consideration of the influence of altitude, flight velocity and engine speed $\bar{n}$ on mechanical work on compression l_c^* (compressor) and l_v^* (fan), pressure ratio π_c^* (compressor) and π_v^* (fan), overall airflow ratio $\dot{M}_{am}$, core flow airflow ratio $\dot{M}_{a1}$, bypass airflow ratio $\dot{M}_{a2}$ and bypass ratio K.

The specificity of the mixed flows turbofan consists in the mixing of the two streams (Core Flow and Bypass Flow, as detailed in Figure 1), resulting the mixture of burned gas from Core Flow and the compressed air from Bypass Flow.

The thermodynamic parameters and the specific thrust are distinctly calculated for Core Flow and Bypass Flow. In addition, for the mixed flows turbofan engine it is required the determination of the fluid parameters (static and stagnation pressure, static and stagnation temperature, velocity) inside the mixing chamber, [15-18] and the combustor fuel – air mixture ratio. The parameters at fan exit and turbine exit are important for calculating the overall engine thrust; the parameters in question are: turbine exit stagnation pressure and stagnation temperature, fan air exit stagnation pressure and stagnation temperature, [1-5], [9-13].

Computation of performances on mixed flows turbofan engine Core Flow

The core flow performances are expressed by the specific thrust F_{sp1} (3), core thrust F_1 (4) and specific fuel consumption C_{sp1} (5).

$$F_{sp1} = m_g \cdot c_{5am} - V, \left[\frac{Ns}{kg}\right] \tag{3}$$

$$F_1 = F_{sp} \cdot \dot{M}_{a1}, [N] \tag{4}$$

$$C_{sp1} = \frac{3600 \cdot m_c}{F_{sp}}, \left[\frac{kg}{Nh}\right] \tag{5}$$

The velocity of the expelled gas c_{5am} (6) comes out after computing the thermodynamic parameters in the mixing area.

$$c_{5am} = \varphi_{ar} \cdot \sqrt{2 \cdot \left\{\left[i_3^* \cdot \left(1 - \pi_d^* \cdot \sigma_{da}^* \cdot \pi_c^* \cdot \sigma_{ca}^*\right)^{-\left(\frac{kg-1}{kg}\right)}\right] - i_1^* \cdot \left[\frac{(\pi_c^*)^{\frac{k-1}{k}} - 1}{\eta_c^* \cdot \eta_t^* \cdot \eta_m}\right]\right\}} \tag{6}$$

Based on the fuel flow ratio $\dot{M}_c$ and core airflow ratio $\dot{M}_{a1}$ result the flow coefficients: a/ fuel flow coefficient m_c (7) and b/ gas flow coefficient m_g (8):

$$m_c = \frac{\dot{M}_c}{\dot{M}_{a1}} \tag{7}$$

$$m_g = \frac{\dot{M}_g}{\dot{M}_{a1}} \tag{8}$$

Computation of performances on mixed flows turbofan engine Bypass Flow

The bypass flow performances are expressed by the specific thrust F_{sp2} (9) and bypass thrust F_2 (10).

$$F_{sp2} = c_{5am} - V, \left[\frac{Ns}{kg}\right] \quad (9)$$

$$F_2 = F_{sp2} \cdot \dot{M}_{a2}, [N] \quad (10)$$

Computation of overall performances for mixed flows turbofan engine

The overall performances are given by overall specific thrust F_{sp} (11), overall specific fuel consumption C_{sp} (12), overall thrust F (13) and overall air flow $\dot{M}_{am}$ (14):

$$F_{sp} = (1+K)(c_{5am} - V), \left[\frac{Ns}{kg}\right] \quad (11)$$

$$C_{sp} = 3600 \frac{m_c}{(1+K)(c_{5am} - V)}, \left[\frac{kg}{Nh}\right] \quad (12)$$

$$F = F_1 + F_2 = \dot{M}_{am}(1+K)(c_{5am} - V), [N] \quad (13)$$

$$\dot{M}_{am} = \dot{M}_{a1} + \dot{M}_{a2} = (1+K)\dot{M}_{a1}, \left[\frac{kg}{s}\right] \quad (14)$$

Assessing the influence of the engine speed $\bar{n}$ on mechanical work on compression l_c^* (compressor) and l_v^* (fan)

The equation expressing the work balance in case of the mixed flows turbofan engine is (15). The variation of mechanical work of the compressor l_c^* (16) and fan l_v^* (17) with the engine rotor speed $\bar{n}$ (2) is quadratic.

$$l_T^* = l_C^* + K \cdot l_V^* \quad (15)$$

$$l_c^* = l_{c_0}^* \cdot \bar{n}^2 \quad (16)$$

$$l_v^* = l_{v_0}^* \cdot \bar{n}^2 \quad (17)$$

Assessing the influence of the aircraft flight regimes (altitude, Velocity or Mach number) and the engine's operating speed regimes $\bar{n}$

The influence of the aircraft flight regimes (altitude, Velocity or Mach number) and the engine's operating regimes (i.e. engine speed regimes) is expressed by variation of the dynamic pressure ratio π_d^* (18), compressor pressure ratio π_c^* (19), fan pressure ratio π_v^* (20), core airflow ratio $\dot{M}_{a1}$ (21), bypass airflow ratio $\dot{M}_{a2}$ (22) and bypass ratio K (23).

$$\pi_d^* = \frac{p_H^*}{p_H} = \left(\frac{T_H^*}{T_H}\right)^{\left(\frac{k-1}{k}\right)} = \left(1 + \frac{(k-1)}{2} \cdot Mach^2\right)^{\left(\frac{k-1}{k}\right)} = \left(\Theta(Mach)\right)^{\left(\frac{k-1}{k}\right)} \quad (18)$$

$$\pi_c^* = \left[1 + \left(\left(\pi_{c_0}^*\right)^{\frac{k-1}{k}} - 1\right) \cdot \frac{i_0}{i_H^*} \cdot \bar{n}^2 \cdot \frac{\eta_c^*}{\eta_{c_0}^*}\right]^{\left(\frac{k}{k-1}\right)} \quad (19)$$

$$\pi_v^* = \left[1 + \left(\left(\pi_{v_0}^*\right)^{\frac{k-1}{k}} - 1\right) \cdot \frac{i_0}{i_H^*} \cdot \bar{n}^2 \cdot \frac{\eta_v^*}{\eta_{v_0}^*}\right]^{\left(\frac{k}{k-1}\right)} \quad (20)$$

$$\dot{M}_{a1} = \dot{M}_{a1_0} \cdot \frac{\pi_c^*}{\pi_{c_0}^*} \cdot \pi_d^* \cdot \frac{p_H}{p_0} \quad (21)$$

$$\dot{M}_{a2} = \dot{M}_{a_{20}} \cdot \frac{\pi_v^*}{\pi_{v_0}^*} \cdot \pi_d^* \cdot \frac{p_H}{p_0} \quad (22)$$

$$K = K_0 \left(\frac{\pi_v^*}{\pi_{v_0}^*}\right)\left(\frac{\pi_{c0}^*}{\pi_c^*}\right) q(\bar{\lambda}_{52}) \sqrt{\frac{(i_0 + l_{v_0}^*)}{(i_1^* + l_{v_0}^*)}} \quad (23)$$

The mixing area – specificity feature of the mixed flows turbofan engine

Prior to calculate the velocity of the expelled gas c_{5am} (6), the thermodynamic parameters of flow (e.g. field distributions of velocity, static pressure, static temperature, static enthalpy and entropy, stagnation pressure, stagnation temperature, stagnation enthalpy and entropy, gas fluid flow rate) in the mixing area must be completely determined.

Based on the thermodynamic flow function $q(\lambda)$ (24), expressed with the Chaplygin's number λ (25) as variable, a new non-dimensional function $q(\bar{\lambda}_{52})$ (26) can be introduced, where its variable $\bar{\lambda}_{52}$ is the ratio of the values of the flow functions appraised in the mixing section, for the current operating regime $q(\lambda_{52})$ versus the design regime $q(\lambda_{52\_0})$.

Unlike the definition of Mach number (27), the Chaplygin's number is introduced as in relation (26).

$$q(\lambda) = \lambda\left[\frac{k+1}{2}\left(1-\left(\frac{k-1}{k+1}\right)\lambda^2\right)\right]^{\frac{1}{k-1}} \tag{24}$$

$$q(\bar{\lambda}_{52}) = \frac{q(\lambda_{52})}{q(\lambda_{52\_0})} \tag{25}$$

$$\lambda = \frac{object\_speed}{local\_critical\_speed} \tag{26}$$

$$Mach = \frac{object\_speed}{speed\_of\_sound} \tag{27}$$

Description of computational algorithm

Design and Off-Design Performance Prediction (also referred as Performance Analysis) in case of Mixed Flows Turbofan Engine supposes the completion of three phases, [1-5]:

 # Phase 1/ - the determination of the overall engine's performances: overall specific thrust F_{sp} (11), overall specific fuel consumption C_{sp} (12), overall thrust F (13) and Brayton cycle, for the design speed regime $\bar{n}$, at SLS, ISA conditions (28), i.e. static pressure, static temperature and static specific enthalpy, for flight velocity or Mach number = 0, [9-13].

$$p_0 = 1.01325\ [bar] \qquad T_0 = 288\ [K] \qquad i_0 = C_p \cdot T_0\ \ [kJ/kg] \tag{28}$$

 # Phase 2/ - the determination of the overall engine's performances: overall specific thrust F_{sp} (11), overall specific fuel consumption C_{sp} (12), overall thrust F (13) at different flight regimes (i.e. altitude H ranging from 0 up to 12 [km] and flight Mach number) and engine rotor speed $\bar{n}$, which usually are expressed by Altitude Map, Velocity Map, Speed Map which define the Engine's Operating Maps, [9-14], [19-21], [22-24].

 # Phase 3/ - is dedicated to refining the investigation, by focusing on the influence of the exit unit parameters such as the exit nozzle velocity loss coefficient φ_{ar} and compressor efficiency η_c^*, as well as the influence of the flight regimes and engine operating speed regimes $\bar{n}$ on the overall thrust overall thrust F (13), as the main performance of the mixed flows turbofan MFTF engine.

The mathematical model is of versatile use, since the numerical simulations can be done in a similar way, but in purpose to highlight the influence of other thermodynamic parameters (such as turbine inlet temperature, efficiency on compression within fan, Low Pressure Compressor LPC and High Pressure Compressor HPC) on the overall thrust.

4. NUMERICAL SIMULATIONS AND RESULTS

The study case is a mixed flows turbofan, as indicated in Fig. 3, defined by the main design parameters of the mixed flows turbofan engine, listed in Table 2: overall pressure ratio π_c^*, bypass ratio K, overall airflow rate $\dot{M}_a$ [kg/s] are given in jet engine catalogue, while the core airflow rate $\dot{M}_{a1}$ [kg/s], bypass airflow rate $\dot{M}_{a2}$ [kg/s] and the fan pressure ratio π_v^* results from calculations based on the engine's design data.

Table 2. Main parameters of the mixed flows turbofan engine

Parameter		Units
Overall Pressure Ratio	$\pi_c^* = 22$	[---]
Bypass Ratio	$K = 2.9$	[---]
Overall Airflow Rate	$\dot{M}_a = 65.772$	[kg/s]
Core Airflow Rate	$\dot{M}_{a1} = 37.18$	[kg/s]
Bypass Airflow Rate	$\dot{M}_{a2} = 107.82$	[kg/s]
Fan Pressure Ratio	$\pi_v^* = 1.77$	[---]

Based on the computational algorithm described above, the authors have developed an in-house code purposed to determine the variation of the mixed flows turbofan engine overall performances: overall specific thrust F_{sp} (11) [Ns/kg], overall specific fuel consumption C_{sp} (12) [kg/Nh], overall thrust F (13) [N], with flight Mach number, flight altitude and engine operational regimes $\bar{n}$: Design, Cruising and Ground Idling, presented in Table 3.

Table 3. Flight regimes and engine operational regimes

Flight regimes		Units
Altitude	$H \in \{0, 2, 4, 6, 8, 10\}$	$[km]$
Mach number	Mach $\in \{0; 0{,}2; 0{,}4; 0{,}6; 0{,}8; 1{,}0\}$	[---]
Engine operational regimes $\bar{n}$		[% *engine-design-speed*]
Design	$\bar{n}$ =100 %	[% *engine-design-speed*]
Cruising	$\bar{n}$ = 90%	[% *engine-design-speed*]
Ground Idling	$\bar{n}$ = 40%	[% *engine-design-speed*]

The current analysis is focused on highlighting the influence of the exit nozzle velocity loss coefficient φ_{ar} and compressor efficiency η_c^* (see the values listed in Table 4), as the most significant parameters of the mixed flows turbofan engine, on the overall thrust.

Table 4. Investigation Variable parameters

Parameter		Units
Compressor efficiency	$\eta_c^* = 0.82; 0.84; 0.86$	[---]
Exit Nozzle Velocity Loss Coefficient	$\varphi_{ar} = 0.85; 0.90; 0.95$	[---]

In case of the mixed flows turbofan engine, due to its military applicability, the overall thrust is the most important engine performance and therefore it is monitored and controlled with priority.

The results from the simulation the Mixed Flows Turbofan Engine are summarized and presented graphically, in Fig. 6 – Fig. 8.

In Fig. 6 – Fig. 8 there are presented the variation of overall thrust $F[N]$ for flight Mach number ranging from 0 up to 1 and the flight altitude $H \in \{0, 2, 4, 6, 8, 10\}$ $[km]$.

In Fig. 6 there is expressed the variation of overall thrust $F[N]$ in case of the 100% Design Regime, compressor efficiency $\eta_c^* = 0.84$ and exit nozzle velocity loss coefficient ranging $\varphi_{ar} = 0.85; 0.90; 0.95$.

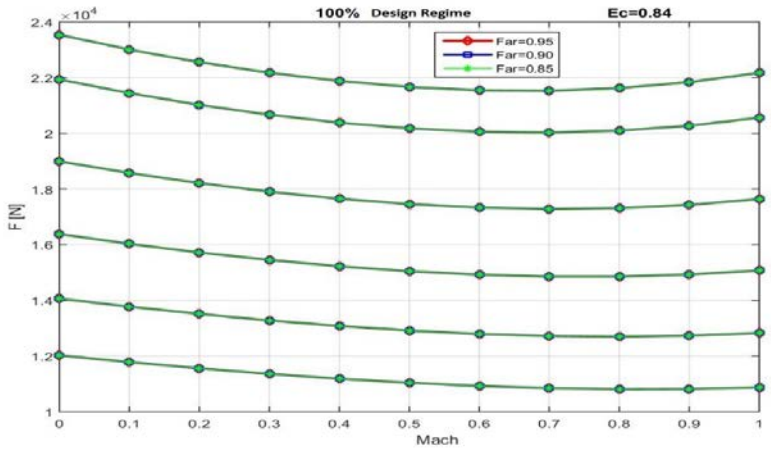


FIG. 6 – Variation of Thrust [N] versus Mach number; Engine Regime = Design

In Fig. 7 there is expressed the variation of overall thrust $F[N]$ in case of the 90% Cruise Regime, compressor efficiency $\eta_c^* = 0.84$ and exit nozzle velocity loss coefficient ranging $\varphi_{ar} = 0.85; 0.90; 0.95$.

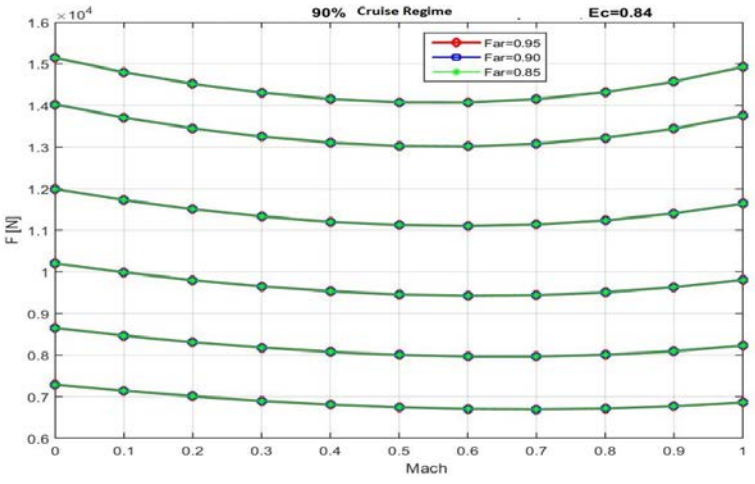


FIG. 7 – Variation of Thrust [N] versus Mach number; Engine Regime = Cruise

Figure 8 expresses the variation of overall thrust $F[N]$ in case of the 40% Ground Idling Regime, compressor efficiency $\eta_c^* = 0.84$ and exit nozzle velocity loss coefficient ranging $\varphi_{ar} = 0.85; 0.90; 0.95$.

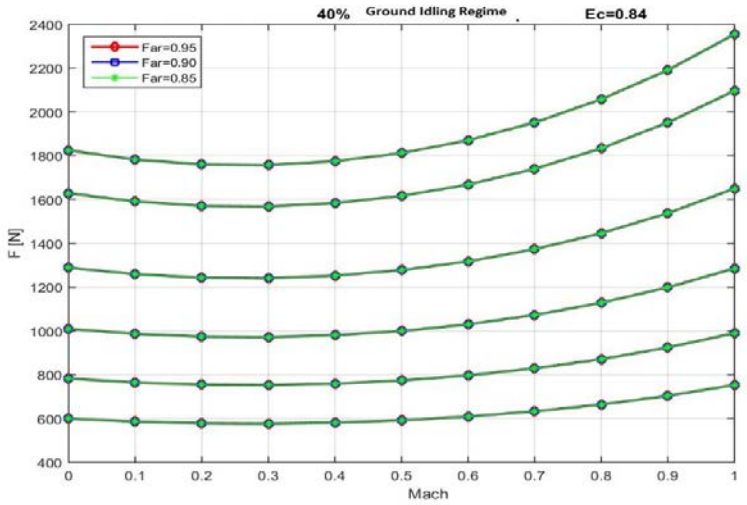


FIG.8 – Variation of Thrust [N] versus Mach number; Engine Regime = Ground Idling

5. FINAL CONCLUSIONS

The investigation presented in this paper is focused on the variation of the overall thrust $F[N]$ of the mixed flows turbojet engine due to the variations ranging for flight Mach number $\in \{0;0{,}2;0{,}4;0{,}6;0{,}8;1{,}0\}$, flight altitude $H \in \{0,2,4,6,8,10\}\ [km]$ and engine operational regimes $\bar{n}$: Design 100 %, Cruising = 90%, and Ground Idling = 40%.

The objective of this study is to highlight the variation of engine's thrust for given perturbations of the compressor efficiency $\eta_c^* = 0.84$ and exit nozzle velocity loss coefficient ranging $\varphi_{ar} = 0.85; 0.90; 0.95$.

The results of the numerical simulations for performance prediction of the mixed flows turbofan engine, focused on the overall thrust, are concluded in Fig. 6 ÷ Fig. 8.

The graphical results can be interpreted such that the effect of small perturbations in the exit nozzle velocity loss coefficient ranging φ_{ar} do not affect the overall thrust, in case of constant compressor efficiency η_c^*.

For the flight altitude 10 [km], from Fig.6 there results that the overall thrust is minimum for the Mach number = 0.7, at Design regime 100%, while from Fig. 7 there results the overall thrust as minimum for the Mach number = 0.6, at Cruise regime 90%, in comparison with Fig. 9 that indicates the overall thrust as minimum for the Mach number = 0.3, at Ground Idling regime 40%. As a matter of fact, the Ground Idling regime takes place for SLS, ISA conditions, indicating the flight altitude 10 [km], so therefore, from Fig. 9, one can consider that the overall thrust is minimum for the Mach number $\in [0{,}2 - 0{,}3]$.

The potential future developments of this study can be guided to the complete determination of the Engine Maps (1/ Altitude Map. 2/ Velocity Map, 3/ Speed Map), Engine Universal Map, which can be represented in non-dimensional coordinates.

The importance of this study consists of providing reliable input data for further expansions of the study towards the mixed flows turbofan engine automat control and the design and optimization of mixed flows turbofan engine automatic control system.

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CONSIDERATIONS REGARDING THE USE OF PHOTOVOLTAIC CELLS TO PRODUCE ELECTRICITY ON THE BOARD THE AIRCRAFT

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Abstract: *Technological progress involves a continuous process of identifying and developing new sources of unconventional energy. It guides us towards ideal perspectives and different outlooks regarding photovoltaic technology. Based on the in-depth studies and experiments performed ever since the discovery of the photovoltaic effect, new contributions can be made in order to obtain a coherent, consensual concept and modern applications, to be used in the aerospace industry, all these efforts resulting eventually in an autonomous system concept.*

Keywords: *unconventional energy, photovoltaic technique, photovoltaic effect, aerospace, photovoltaic cells.*

1. INTRODUCTION

The term "photovoltaic" comes from the combination of the Greek word "photos", meaning light and "volt", the unit of voltage. Thus, photovoltaic technology describes the process of generating electricity using light.

In 1839, during the Industrial Revolution, Alexandr Edmond Becquerel, the father of Nobel Laureate Henri Becquerel, discovered the photovoltaic effect, showing how electricity can be generated by sunlight. He proved that "exposing an electrode immersed in a conductive solution creates an electric current". Despite extensive research, after this discovery, photovoltaic conversion continued to be inefficient.

Photovoltaic cells were mainly used for measuring light intensity. The first memoir on photovoltaic or photoelectric effect (as it was called at the time), was created by Cambridge scientists W. Adams and R. Day in 1877, and it described the changes that took place when a selenium plate was exposed to light. In 1887, Heinrich Hertz noticed in his experiments, that a zinc plate is positively charged if exposed to ultraviolet radiation. The phenomenon is due to the same photoelectric effect: under the action of ultraviolet rays, electrons are removed from the metal and consequently, the metal is positively charged.

The first PV cell using a selenium base was built by the American electrician Charles Fritts in 1883 and it was patented in 1884. The construction of the cell was very similar to today's cells, but its efficiency was less than 1% and could not be used industrially.

About a century after the effect's first discovery, Albert Einstein received the Nobel Prize in Physics, in 1921, for explaining the photoelectric effect, which enabled the practical use of photovoltaic cells. In 1946, Russell Ohl invented the solar cell, followed by the invention of the transistor in 1947. In the middle of the twentieth century, scientists and engineers returned to the study of the photovoltaic effect in semiconductors. In 1953, the engineering team at Telephone Laboratories (Bell Labs), represented by D. Chapin, C. Fuller and G. Pearson, discovered that silicon PV cell is much more efficient than the selenium cell.

The following year, the same team builds a silicon cell with a yield of 6%. At the same time, the first consumers of photovoltaic energy appear - artificial satellites. In 1957, PV cells were installed on the earth's first artificial satellite "Sputnic 3", and in 1958 PV cells were installed aboard the American satellite "Vanguard 1", and were used to power a radio transmitter.

To date, PV cells are generally recommended as energy source for space technology. In the 60s, a spectacular progress was made in the field of satellite power supplies, being separated the rigid dependence of decentralised energy from the tradional sources: generators, baterries or storage batteries. By using the photovoltaic effect, the direct conversion of sunlight into electricity took place. Direct conversion technology excludes intermediate transformations: solar radiation into thermal energy, thermal energy into mechanical energy, mechanical energy into alternating current electricity. The direct conversion is obtained by using the PV effect produced in semiconductor materials, using the photovoltaic effect. Unlike the electromechanical generator, the photovoltaic generator, the so-called photovoltaic cell, produces electricity directly.

The exclusion of intermediate transformations from the technological chain, the absence of motion, noise or vibration, the modular construction, and the over 25 years operating life expectancy; these are arguments to saying that the future of decentralized energy belongs to photovoltaic technology.

2. PHYSICAL PHENOMENA. TYPES OF PHOTOVOLTAIC CELLS USED IN THE AEROSPACE INDUSTRY

On the whole, in the unconventional energy development industry, photovoltaic cells are named after the semiconductor material from which they are made, especially selected so they can absorb photons carried by solar energy. Some of these structures are intended to be used in terrestrial space, mounted on different types of equipment, or to be used in space.

In the manufacturing process, photovoltaic cells can be designed with a single layer of absorbent material (single junction), with several layers of the same material, or different materials (multiple junctions), the last two being more advantageous as they can absorb different light spectrum and also can connect to a charging mechanism.

Solar cells are sorted into classies by generations of production, following the evolution of technological process, such as first generation PV, second generation PV and third generation PV. First generation cells, also called traditional or conventional photovoltaic cells, use materials such as polycrystalline and monocrystalline silicon and are predominantly of commercial production.

The next generation comes with a thin film of amorphous silicon, cadmium tellurium and gallium arsenide, beeing used in complex electricity production systems, in aeronautical applications.

The third generation is represented by photovoltaic cells that are still in the design stage. The materials used are of organic nature, composite materials, with a wide range of usage, especially in environments where an elastic characteristic is required. Manufacturing costs are differentiated according to the materials required and the production technology.

Photovoltaic technology using the crystalline form of silicon can be applyed on a multitude of systems, starting with the common pocket computer and reaching the complex systems of producing unconventional electricity from satellites and aircraft with or without a pilot.

The developed manufacturing technique consists in placing a thin layer of silicon (Si), with the thickness of approximately one micron on a material such as glass or metal.

The thermal field of operation has little limitations regarding the application (-40° C up to 60° C). During the process, the silicon layer undergoes a reduction coefficient of 15 to 35% (in use).

Experimental tests made to this type of photovoltaic cells indicated that placing a layer as thin as possible, produces a bigger electrical current along the length of the material.

Technological evolution tends towards using multiple layers of amorphous silicon. In 2019, a performance was obtained by testing a three-layer photovoltaic cell. The pioneers of the new manufacturing technology are Uni-Solar, a company that has performed multiple tests, recorded functional parameters and innovated the photovoltaic field.

Concluding the above, amorphous silicon photovoltaic cells are the most common unconventional electricity production systems, being the system with the lowest production cost.

In the manufacturer industry of photovoltaic structures, for the cells that use groups III to V elements, GaAs is the most commonly used element, with increased performance.

According to studies, photovoltaic cells, which use GaAs as a raw material, benefit from a maximum conversion factor of up to 31.6%, a value recognized by the National Renewable Energy Research Laboratory (NREL), USA. In the last scientific conference in May 2019, was discussed the possibility of evolution in this field, more precisely, the intention to increase the development and research to 38% in 2020 and 42% by 2025.

When it comes to efficiency in the field of photovoltaic cells, the following criteria is taken into account: manufacturing technology and mass production. The greatest advantage that these contextures have, is the hight efficiency, its coefficient being almost double than the ones using crystalline silicon PV.

Unlike other types of photovoltaic cells, cells made of GaAs have also the advantage of flexibility, color adjustment as needed, the diversity of shape in which they can be manufactured and the low weight. These advantages are applicable in many fields, the most commonly used being in the aerospace industry.

The thermal factor is not a decisive one for this type of photovoltaic cells. Unlike the structures made of Silicon, which at a temperature of 200°C , no longer produce electricity, GaAs, at a temperature of 250°C, operates in nominal parameters. However, used in an environment where humidity predominates, the external factor (water droplets) reduces the photon absorption surface, the efficiency is diminished and the electric current produced has lower values.

The only disadvantage of GaAs photovoltaic cells is the high price of the manufacturing process, surpassing many other similar structures. Nevertheless, the performance and the multitude of areas in which they can be applied tilts the balance in a favorable way.

The wafer has 4-6 inches in diameter, compared to the silicon wafer, which has 10-12 inches. The harmful characteristics of arsenides require additional safety methods during the production, leading to additional costs.

Regarding the energy calculation, for example, a cell that is part of a photovoltaic structure assembly, having 150W, will have 100W energy power. On the other hand, the fragility detected during the production process is a major disadvantage compared to silicon photovoltaic cells.

Production techniques require high-performance automated equipment, capable of manufacturing a large number of proper cells, concurrent to the number of scraps resulting from a batch. Currently, GaAs solar cells have shown good performance in the efficiency of solar energy conversion, compared to other known types of similar structures.

The most commonly used material in the manufacturing technology of thin-film photovoltaic cells is Cadmium tellurium (CdTe). In the early 1980s, in the beginnings of using sollar structures, the efficiency was about 10%, percentage shown in applications. By implementing new improvements, like using a glass layer with better transparency, increasing the transparency level of the oxide layer, using a high-resistance and transparent film with CdS junction, raising the temperature used in applications and at the same time, by implementing new doping and treatment technologies, this type of energy producing structure has proven to be up 16% more efficient in the 2000s.

Cadmium tellurium is looked up in the photovoltaic production industry, despite the disadvantages of limited life cycles, radioactive emissions from heavy metals used in the manufacturing process. This technology is limited by the ability of tellurium to form chemical compounds, feature needed to obtain photovoltaic cells. However, it has its benefits, such as the lack of carbon emissions and the possibility of using electronic equipment in systems that cannot be connected to a power supply.

Cheap large-area placing methods can be developed to produce high-efficiency devices, and monolithic integration methods would reduce the cost of module manufacturing.

Achieving many of these upgrades, CdTe, is today the most successful structure used globally, about 5-6% of the total market. CdTe photovoltaic cells have a valence band of 1.5V and a high absorption coefficient. For three decades, R&D researchers worked on a cell of this type, whose efficiency increased up to 10%, by using a thin printed film, reducing the immediate space and by applying the electrodeposition technique.

A technical team of NASA's Research Department focused on developing an independent system, satellites being their starting point. In this regard, they planned to use the satellites' energy consumption and provide it with a photovoltaic cell.

CONCLUSION

As we now know, by using photovoltaic structures and conducting countless tests, scientists concluded that GaAs and CdTe photovoltaic cells were efficient for future applications.

Taking into account the aerodynamics of an aircraft, the wing (the largest surface of an aircraft exposed to sunlight) must have certain characteristics, including elasticity, in order to achieve a load-bearing structure.

Considering the aspects shown before, the main features of CdTe and GaAs cells, that support their use in aero-space applications, are elasticity, low weight and high efficiency, offering the possibility of full assembly on the entire surface of the wing, thus resulting its considerable performance.

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THE AUTOMATION OF THE PRODUCTION LINES

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Abstract: *The overall objective of the project is to develop an intelligent system for monitoring the components of the production line in real time and to help the operator to assemble the equipment by indicating their number and order in the production flow. The development of monitoring systems is a very important topic both domestically and internationally.*

Simultaneously with the emergence and specialization of monitoring systems, the barriers between human operators and the control system, between the world of computers and programmable automata, between technology and the automation system were removed. In this paper I want to describe a topic of great interest due to the tendency of companies to gain control over the resources they use in order to reduce the costs generated by the excessive consumption of components and the incorrect assembly of equipment. Due to the employees' lack of focus or fatigue, various errors can occur in the production flow, leading to a significant loss in terms of time, profitability and quality.

Keywords: *electric, components, systems, automation, equipment, production flow*

1. INTRODUCTION

The electronic products industry is characterized by a fast pace and maximum competitiveness, being essential the ability to combine high standards of quality and constant precision with high productivity, low production costs and fast process times. Offering immense flexibility in a wide range of manufacturing processes, automated solutions make it relatively easy to obtain this synthesis.[1]

Lean manufacturing is today one of the most successful strategies for improving the competitiveness of organizations. Lean is based on the philosophy, concepts and tools of the Toyota Production System (TPS), but it all started in 1913 with Henry Ford and the streamlined assembly line of the famous T model.[2]

A recent study by the National Institute of Standards and Technology - Manufacturing Extension Partnership in the United States concluded that a correct implementation of Lean Manufacturing techniques and methods can generate important benefits: • Reducing unfinished production by up to 90% • Reducing process cycles by up to at 95% • Increase productivity by 10-40% • Increase quality by 25-75% Lean is an integrated approach to using human, material and financial resources to produce exactly what is required, when required and in the required quantity, using the minimum of materials, equipment, work and space.

A first list of classic wastes was sent to us by the Japanese, the 7 "muda" (muda = wasted), which we are now trying to enlarge. The seven classic wastes, identified by the initiators of the Lean methodology are: overproduction, stocks, defects, over processing, transportation, waiting, movement, people.

In the manufacturing process, on the production lines, the lack of an overview of the ongoing stages and processes can lead to significant losses. Moving components, structural elements, raw materials are constantly changing in the manufacturing process. Human error is a real factor that must be taken into account. The quantity of scrap, or returned product is inversely proportional to the quality level of the production system and production supervision.[3]

2. THE NOVELTY OF THE PROJECT

The novelty of this project is characterized by:

• the implementation of the system on a model consisting of boxes of independently monitored components;

• the introduction of RFID mode for traceability of electronic equipment;

• a much lower cost than in the case of current systems.

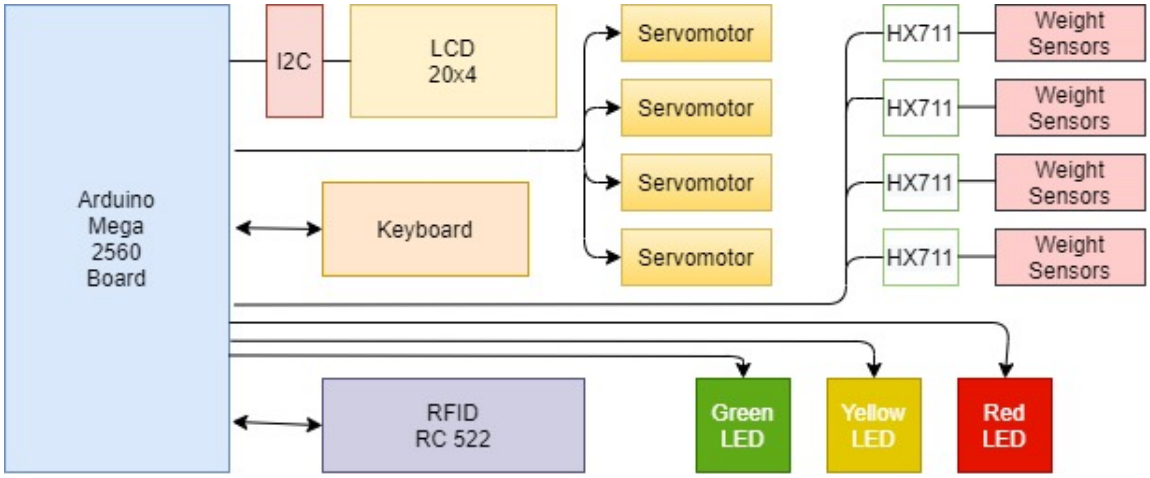

FIG. 1 Electronic circuit diagram

Traceability means in the very strict sense of the word, the ability to review the path taken by a product on manufacturing processes and technological flow based on the "traces" left behind. Traceability is a solution for consumer protection, but it is also a control tool and delimitation of liability. If a product or a larger quantity of electronic products has failed, the manufacturer through a traceability system has the ability to verify whether the reason is a general one related to the whole batch or a batch. Or it is a well-defined specific situation and the cause of this incident must be investigated at the distributor: the way of storage and handling, the way and circumstances of presentation, exposure, etc.

The objective of traceability is to obtain total control over the products by individual and group identification (batch or batch) in order to be able to intervene if after the manufacture a defect or inconvenience of the product is found.

Through a traceability system related to the product or goods we receive answers to the following questions:

1. when? where? from what? how much was produced? by whom? who worked and at what stage of production on that product?

2. when? where ?, what quantity? by whom was it stored? how long did that product stay in the warehouse?

3. when? where? by whom? what? What quantity was delivered?

For the practical achievement of traceability, a common language is needed to ensure continuity and unity on the distribution chain, beyond the limits set by the information systems specific to each company. All traceability items must be identified by either labeling or marking. Each item must have a unique, global identifier. Then follows the step of aligning the basic information, in which each factor must obtain the unique global identifier.[4]

In the traceability information recording stage, it is determined how to allocate, apply and capture the identifiers of the items included in the traceability process and how to select, collect, share and store traceability information during the physical flow. This is the stage in which the identifiers are effectively allocated and applied, as the physical flow of processes is achieved, and the information contained in them is captured.

3. SENSORS

The recent development of electronics and integrated circuits offers new possibilities for many practical applications and leads to new discoveries in the field of sensors. The sensor can be generally defined as a sensitive device that detects a certain phenomenon. The sensor is a device that detects a phenomenon. The term sensor is widely used and is associated with that electronic component that allows the measurement of a physical quantity. In fact, the sensor senses a certain phenomenon, receives and responds to a physical stimulus. It is the device at the input of the measuring system.

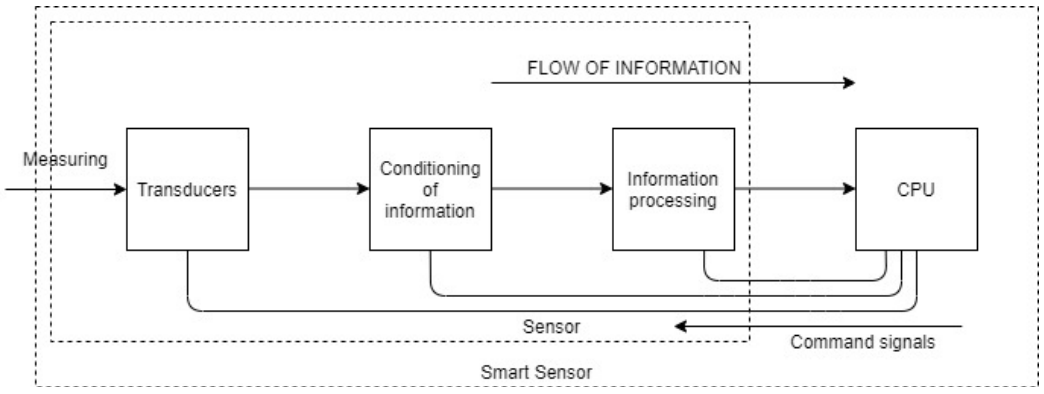

FIG. 2 Structures of sensory systems

The most requested and important sensory function is the visual one, which ensures the preponderant amount of information, having the highest transfer speed (cc.3.106 bits/s). Sight facilitates man almost all actions to investigate the environment - identifying objects and their configuration, position and orientation, appreciating distances.

Devices Used

1. Weight sensor
2. Module HX711
3. Display LCD 20X4
4. Module I2C
5. Sevomotors
6. Keypad 4X4
7. Module RFID RC522
8. Leds
9. ARDUINO MEGA 2560 [5]

4. ELECTONIC CIRCUIT DIAGRAMS

Electronic Diagram of the Circuit

The electronic diagram of the circuit, Fig. 3, shows the diagram of the electronic circuit of the monitoring system of the components on the assembly line. The power supply of the circuit is made from a 9V battery or a 5V direct current source through the Arduino Mega 2560 development board.

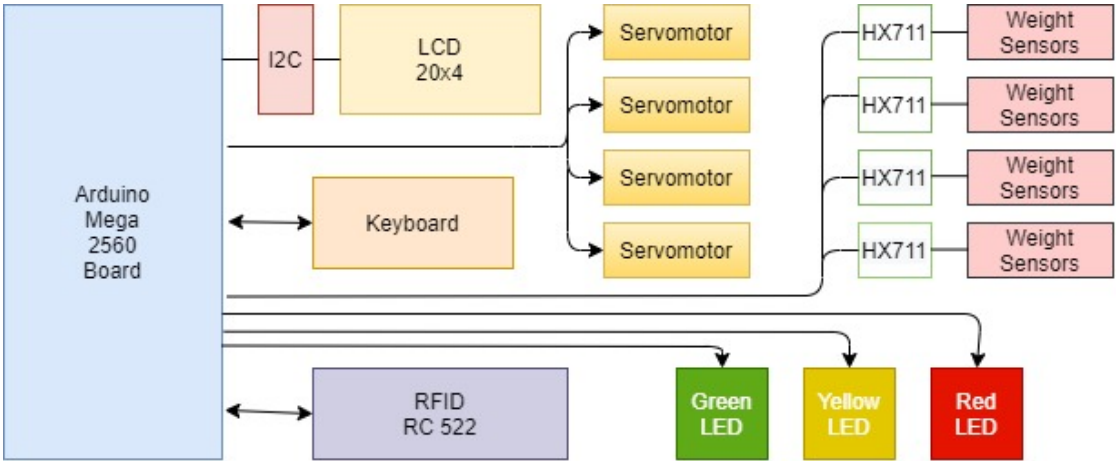

FIG. 3 Electronic diagram of the circuit

To make the circuit we used an Arduino Mega 2560 development board to which we connected four weight sensors connected separately to the Arduino through the HX711 mode which converts the analog signals transmitted by the sensor into digital signals for a much higher reading accuracy. For the display I used a 20x4 LCD connected via I2C and three LEDs of different colors. On the data entry / reading side I used a 4x4 matrix keyboard and an RFID RC522 module, and to help the operator in the assembly flow and the exact indication of the component to be assembled I used a servomotor.

Block Diagram of the Weight Sensor

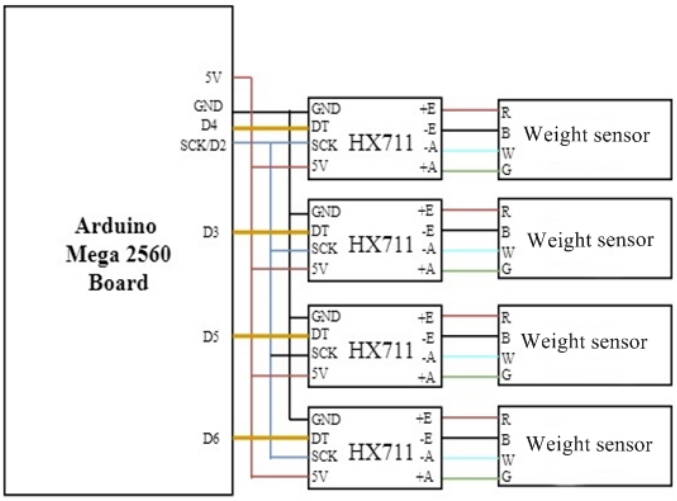

FIG. 4 Block diagram of the weight sensor

To identify and monitor the number of components we used a weight sensor for each box. The weight sensors are connected to the arduino via the HX711 module. It helps to increase the measurement sensitivity due to the conversion of analog signals into digital signals at a resolution of 24 bits. The HX711 modules are powered by a 5V voltage from the Arduino, and the sensors in the module. The data pins are different for each module, sharing only the SCK, because there must be the same clock signal on the entire circuit. The red wire from the weight sensor connects to the + E pin on the module, the black wire to -E, the white wire to -, and the green wire to + A.

Block Diagram of Servo Motors

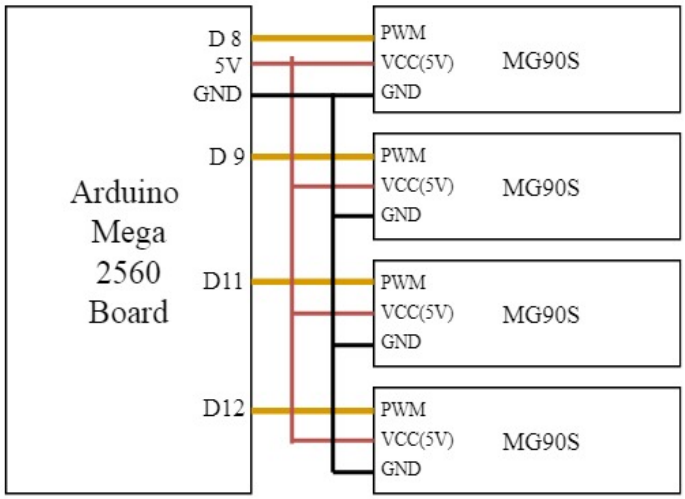

FIG. 5 Block diagram of servo motors

In the application were selected as execution elements of the process of lifting the lids of component boxes. For the connection of the servomotors, they have three wires of different colors. They usually represent: • brown = GND • red = VCC (5V here) • orange = servo signal (PWM) MG90S toretically has a range of position variation of 180º in both directions, 90º on one side and 90º on the other hand, but the tests performed and the information provided by the product talk page indicate that it cannot rotate more than 160º. To obtain the maximum range of variation it is necessary to introduce a servo controller which, in the case of this paper, was not included because it involved additional costs.

Block Diagram for LCD

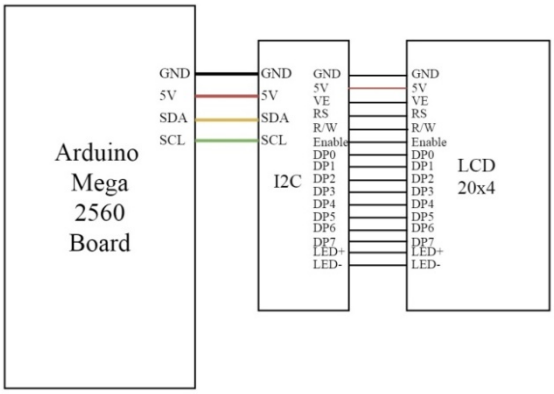

FIG. 6 Block diagram for LCD

Figure 6 shows the wiring diagram of the connection between the Arduino and a 20x4 LCD. The LCD is used to present to the operator at the assembly table the number of components in each box. It is connected via I2C because it is a simple mode of communication, in the sense that it requires only two wires of communication, and allows the connection of as many devices (with different addresses). Each I2C device has an address that may or may not change. For the Arduino Mega, digital pin 20 is SDA pin and digital pin 21 is SCL pin.

Block Diagram for RFID

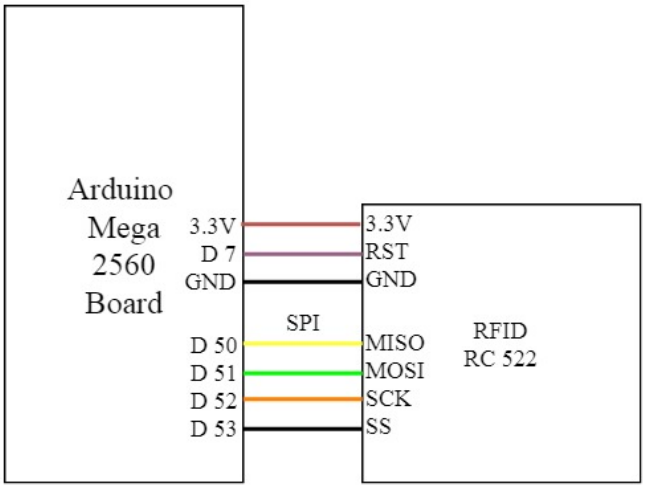

FIG. 7 Block diagram for RFID

For an easier and faster use of the system I chose to connect an RFID module through which to read certain commands with the help of cards. It is connected to Arduino via SPI. SPI is a way to communicate with master-slave devices. One device is master, usually Arduino and the other devices are Slavic. SPI communication is done using four channels: • MISO - the wire through which the slave devices send data to the master • MOSI - the wire through which the master device sends data to the slave • SCK - the wire through which the clock is transmitted • SS - this channel is specific SPI, and it's interesting.

Keyboard Block Diagram

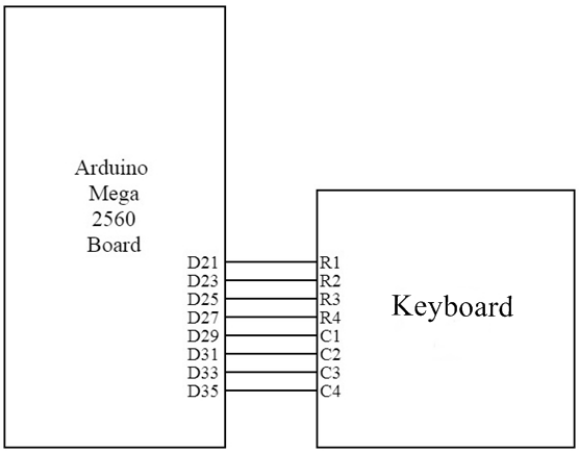

FIG 7 Keyboard block diagram

Figure 7 shows the connection of a 4x4 matrix keyboard to the Arduino. With the help of the keyboard you can enter the commands necessary for the operation of the system. The keyboard consists of four columns and four rows, so every time a button is pressed, the column and row of that button are shorted, and the processor realizes what character it should display. For example, the second and second rows are short-circuited for the "5" key.

Block Diagram for LEDs

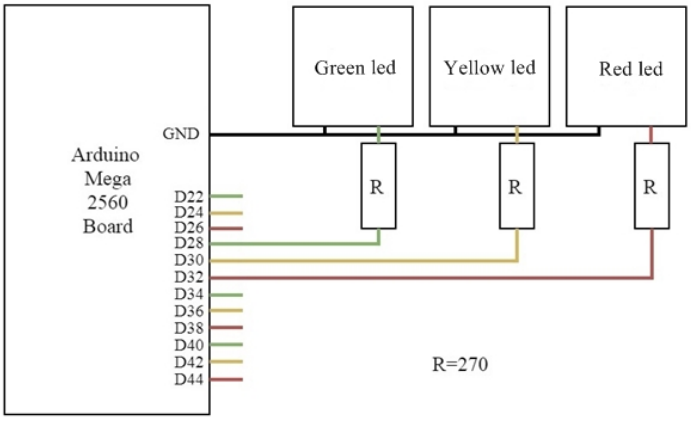

FIG. 8 Block diagram for LEDs

For a more suggestive indication of the number of components in each box we used three LEDs of different colors, green, yellow and red. I connected them to the digital pins of the Arduino using a 270 ohm resistor and defined them as output voltages.

Through this project I want to implement a system for monitoring components on the production line and indicating the next step in assembling electronic equipment. Each box will be prepared for a type of components, because with the help of the weight sensor I will identify the number of components. To avoid mixing components in boxes, each type of component is accompanied by a unique identification code. Entering this code on the keyboard will open the box specific to that component.

5. CONCLUSIONS

The purpose of the project was to develop a monitoring system for components in the assembly line to facilitate the production flow. In addition to this monitoring system, a way has been implemented in which the operator is helped to assemble the electronic equipment correctly. When scanning an order, it appears on the monitor which components must plant and the respective order. The following graph shows a situation of the number of incorrect assembly defects before the implementation of the system for a period of 15 weeks. After the installation of the system in week 16, following some analyzes on the production line a value that tends to 0.

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EXPECTATIONS IN THE MILITARY ENVIRONMENT REGARDING THE APPROACH OF PERSONNEL STRATEGIES ACCORDING TO THE PRINCIPLES OF E-MARKETING

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Abstract: *The recruitment of personnel for the needs of the military is an issue of great interest today in the theory and practice of human resources management in defense, given the new security environment havin taken shape after the end of the Cold War and the revision of national defense issues. Human resources represent one of the most important investments of an organization, the results of which become increasingly evident over time. From this perspective, the analysis and redesign of the candidates' recruitment and selection for the military profession, according to the principles of e-marketing, is a priority step in the succession of necessary stages towards a human resources reform in the Romanian Armed Forces.*

Keywords: *marketing, management, performance, company*

1. INTRODUCTION

Motto: *"The army is made for war and all its special studies must consider warfare and almost only warfare. Warfare manifests at a material level through a multiple series of operations, starting with the gathering of the elements constituting a force and up to the final act, the battle. All these operations have as essential elements: the PERSONNEL, the materiel, the land". Marshall Alexandru Averescu*

The more important the human resource is for an organization (numerically and qualitatively), the more obvious and necessary it is to approach the recruitment activity as a marketing campaign, at the center of all marketing efforts being the promotion of the military profession.

Although the military institution is highly appreciated by the Romanian population (as the opinion polls conducted at national level show), the military profession remains listed at an average level in a hierarchy of preferences.

The promotion is considered the set of marketing techniques or practices, or marketing action, or form of communication that aims to exceed a level of sales by capturing the attention and attracting potential buyers, by points of sale, information, persuasion, training and maintaining a customer attracted by the product and the manufacturing company.

2. ONLINE APPROACH TO HUMAN RESOURCE MARKETING

When every day is a challenge to attract the best, the employer brand weighs a lot. 64% of respondents who recently participated in an eJobs survey said that a company's reputation is one of the most important criteria according to which they decide to submit their CV for employment.

According to the study "Relevance of brands. What really matters to consumers", the favorite sources of information for Romanians are TV and social networks, followed by news sites, company sites, family, friends or colleagues (word of mouth).

The presence in the online environment therefore becomes a ***must have***, and a well-trained marketing team, through marketing courses, can work wonders. And yes, it can actively make a simple site, launched, but not synchronized with what the public likes. And as recruiting people is not as simple as a few years ago when by displaying an ad they expressed their desire to participate in the contest, hundreds of candidates, now, more than ever are needed, principles, tools and notions of marketing to attract the best!

What Does Marketing Mean and How Can HR Help?

Marketing means creating positive and compelling experiences for the public. The first step is to identify a target audience and create a strategy to entice them to buy products or services. The same thing is wanted in recruitment - reaching the right candidates and having the right strategy to persuade them to join the organization. For this, one can be inspired by the language of marketing people, by their creative campaigns made for clients (potential employees), which can be adapted for candidates.

Why Do We Need Employer Branding?

Marketers are responsible for building a strong brand for the organization's products or services. Unfortunately, it will not convince anyone to work or stay in it. The same branding strategy must be implemented when it comes to communicating the values and culture of the institution. An employer brand means the organization's reputation as a job, as well as employees' perceptions of it. The more it is invested in the employer brand, the easier it is to attract and retain talent***. 86% of candidates would not apply to an organization that has a bad reputation in relation to the former employees or to the public. (Randstad USA study)***

Organizational Culture Is Important for a Good Mix Bun between HR and Marketing

The first step in building an employer branding strategy is to encourage collaboration between departments, to create common workspaces where specialized HR staff can work closely with marketers. Basically, it is no longer about the success or results of a single team, but about how we learn to think like the colleagues from other structures and about the exchange of skills. Thus, there are more chances to create campaigns to the liking of the public.

Harvard Business Review BB writes that success in HR depends on marketing, HR professionals should at least think like marketers.

Here's why it's important for an HR person to think like a marketer:

Dona Scarola*, head of digital strategy for talent development la Johnson & Johnson,* says that HR has a lot to learn from marketers when it comes to communicating with employees and creating a pleasant work environment.

One of the biggest problems is that HR does not take the human factor into account when communicating with employees, and language is not of impact.

The Importance of Natural Language, Borrowed from Marketing

To attract candidates more easily you need a simple, natural language. Dona Scarola gives the example of the clothing brand Outdoor Voices whose slogan is quite vague: *Doing Things*. One should make sure that the message gets the attention of the candidates. Communication can be simplified by the use of meaningful words and images.

What Should Be Borrowed from Marketing Strategy in Employer Branding

In order to attract talent, you need a solid employer brand. Attracting talent is no different from attracting customers and here marketers play a key role in building brand *awareness* and attracting *leaders*.

The 4P

- **The products** are the jobs of the institution. Job responsibilities, benefits, salary help shape this product.
- **The price:** it is a bit abstract when it comes to jobs, but one can think about the prestige of the job. How coveted is it? How many candidates do one usually gather?
- **Promotion:** as in marketing, promotion refers to the methods and channels one usse to promote professions.
- **Place:** Let's think about where professions are "offered" - career sites, social media, recruitment company sites, employee recommendations, etc. Each job has its own specifics and fits a certain channel.

SWOT Analysis

One of the most important aspects of a good employer brand is authenticity. No one wants new employees to come in the door with certain expectations and not leave after a long time because they have been misled. A SWOT analysis, just like in marketing, provides a clear picture of the aspects that need to be highlighted for potential employees.

Strenghts: Why is the institution a pleasant place to work? One should find that Employer Value Proposition (EVP) that sets him apart from competitors.

Weaknesses: It is important to know them, to mention them (maybe the job requires overtime hours), but to specify what you offer in return.

Opportunities: are those directions in which one wants to develop.

Threats: are external factors, that cannot be controlled, but which endanger the recruitment process. If you know what problems you may face, you can make a defensive strategy.

Positioning: just like in Marketing

Just as other brands are positioned according to quality or price, so are employer brands positioned according to benefits, work environment, culture, development opportunities. It's a good exercise to know what strengths to highlight in messages.

Make Friends with Influencers

Nowaodays, candidates have become much more selective with information. They like to receive information from personalities they trust. Why not use personalities in the recruitment process as well? All that matters is to choose them carefully, to be related to what the institution does, to identify with it.

The line between the consumer brand and the employer brand, between customers and candidates is becoming shorter and shorter. And it's good news that they are supporting each other, but that requires joint efforts from the HR team and the marketing team.

3. THE MILITARY- A BRAND THAT ATTRACKS

Motto*:"A brand is not what we tell consumers it is - it's what consumers tell each other it is". (Scott Cook)*

It is well known that the Ministry of National Defense is one of the most important employers in Romania and from this perspective it must act according to the principles of marketing on the labor market, to be a recognized brand, with a trademark and a distinct visual identity.

According to the American Marketing Association (AMA), a trademark is a "name, term, sign, symbol or design or a combination thereof, intended to identify the goods and services of a seller or group of sellers and differentiate them from those of other sellers."

Although the trademark and the brand are considered to be one and the same, in reality, the trademark is a symbol (name, logo, slogan, etc.), and the brand is more than that, it is the image, prestige, value, influence of the trademark among the public (clients).

As proof, we can register as many visual symbols (graphics and / or text) at the State Office for Inventions and Trademarks (Romanian OSIM), but if they are not recognized, if no one knows what and who they represent, they are not associated with a product or a quality service; it is nothing to those who see them.

In other words, the trademark indicates the source of the product or service, the supplier, and the brand represents the reputation associated with the trademark, by the public (customers). Therefore, the creation of a brand (or branding) aims to determine the target audience to see in the product or service offered the best solution to their problem. A brand is a set of distinctive perceptions, ideas and feelings that people have about the company / product / service offered, which differentiates them from alternatives.

To create a strong brand, it is necessary to understand the needs and desires of the target audience. A brand is not only a symbolic representation, but also the image and the impression that consumers have towards that product, service or organization.

The brand is very important in marketing communication, and the definition of the brand is very important in the process of building the brand, which involves time, creativity, promotion and, last but not least, offering a product or service of consistently superior quality.

Branding is the process of forming the perceptions that consumers have about the company / product or service provided.

The first people who carry the company's image in the world and send messages on its behalf are its employees and loyal customers, those who have become brand ambassadors.

Things are no different when it comes to the military institution or the military profession. A favorable image and a good reputation mean more support and respect from the population and more candidates for military training programs.

It is indisputable that when under arms, the military personnel is proud of its membership in the brand called the Romanian Army and contributes, in one form or another, to increasing its reputation, but few of them, once they no longer have this quality, resort paradoxically, to criticisms and denigrations of the system from which they left, launched mainly in the online environment that ensures their anonymity.

These negative reactions, probably generated by personal frustrations or professional failures of former employees, have existed in any organization / institution and probably will exist, but we must be aware that, now, in the age of the Internet, information circulates very quickly and remains posted over time against the background of the lack of a strategy of continuous brand consolidation.

Young people like the brands they can identify with, be those institutions, professions or people.

Everyone knows what the Romanian Army does, but few really know how diverse the activities and occupations specific to this institution are, for example.

A system of elements such as: logo with design by colors, text, symbol, slogan, clothing (uniforms), personalized documents (diaries, folders, pens, letterheads), newsletter, vehicles, buildings and other visual elements that have as The main role is the recognition of an organization or a brand and is also an essential part of the communication strategy. Visual identity can convey a lot in a very short time, which is why it must be given maximum attention.

A well-made, original logo will enter the public memory and, being recognized, will become familiar and immediately associated with the army, will inspire confidence whenever it appears on a product to promote the military profession.

In order to achieve its goal, the recruitment logo must contain, not only the drawing itself, but also words, but not initials.

Along with the logo, through the message it focuses, the slogan can serve very well the objectives of promoting the military profession, especially those aimed at ensuring a sufficient number of suitable and motivated candidates for military career.

For this, the slogan must be memorable, incorporate / suggest a feature or keyword for the brand, be easily used in promotional campaigns, on any medium, be clear, credible, induce positive feelings and, not lastly, to be original.

In summary, we can say that a slogan must meet the following requirements: to be memorable, to recall the brand name, to include a key advantage / quality, to differentiate the brand, to arouse positive feelings towards the brand, to reflect the brand personality, to be strategic, be usable in promotional campaigns, be competitive, original, simple, clear, credible and help the brand.

Here are some examples of the many possible slogans that were analyzed in 2015, when the current slogan of recruitment in the Romanian Army was chosen:

1. THE ARMY – A WAY OF LIFE!
2. STRENGTH AND PROFESSIONALISM!
3. ORDER YOUR FUTURE
4. MORE THAN YOU THINK!
5. TRY SOMETHING DIFFERENT. TRY THE ARMY!
6. KEEP UP!
7. FOR THOSE WHO WANT MORE!
8. EXCEED YOUR LIMITS!
9. AIM UP, BE THE BEST!
10. EXPLORE, ACT, SIGN UP!
11. TOGETHER, BETTER!
12. IT'S TIME FOR PROFESSIONALS!

Finally, most of the votes of the communication and recruitment specialists, who were involved in the process of "(re) branding" the military recruitment process, also went to the old slogan, used between 2002 and 2006, "AIM UP, BE THE BEST! "

Both the slogan and the logo are registered trademarks, owned by the Ministry of National Defense.

The brand has a vital role in gaining the respect of the public, because it means promise. For example, the current brand of recruitment suggests the idea of career, of evolution, the fact that those who join the army are among the best, the best of their generation.

But for attracting people who aspire to work in the army, for attracting talent, just an inspired brand is not enough. We have to work hard, sustained, by constantly sharing best practices, culture, perspectives of personal and professional evolution, through all possible channels of communication. Only through this serious and constant effort can trust, loyalty and respect be built.

It would be a big mistake to rely only on the very good reputation of the army. It has been proven (including through sociological research conducted by the army in the last 20 years) that the army is a brand, and the military profession, another brand, even if it feeds on the notoriety of the former. Everyone loves and respects the military institution, what it symbolizes, but not everyone would like to embrace the military profession, although it is a profession respected by most.

Every military man can and must support the building of public confidence in the army, in the human and professional quality of the military, in the uniqueness and solidity of any brand that belongs to the army. And recruitment must become a brand of trust, as respected as the Romanian Army.

3. PROMOTING AND RECRUITING CANDIDATES ONLINE, OPPORTUNITY OR NECESSITY

Technology plays an essential role in the life of the current generation of young people, among the most important, because it is an integral part of them, as well as other generations were books, television or radio. This generation does not know life without the internet and without technology.

The differences between the generations are due to the different realities in which they have reached maturity. Today's children have more freedom of expression. They are highly influenced by marketing and advertising campaigns and become the targets of campaigns that try to sell their products.

These marketing strategies take advantage of young people's concern for image and social comparisons and can draw their attention and cause them to spend their time and money on irrelevant things.

What does this mean for recruiters? That they will have to come up with innovative ways to attract and retain them. Because they are the generation that before "buying" anything, will turn to the "holy internet" for opinions, just as it does before buying something online. And this means that the institution will have to pay more attention to the image in the online environment. Equally important for recruiters is that the tools used keep up with the moment and the technology. From applications to social platforms, they will have to tailor their own custom recipe to recruit and attract this generation.

Recruiters must have the ability to easily adapt, be able to predict, identify and adopt trends, given that in the digital age we live in, what is on the wave today may not be in a few months. so attractive. The closest example is the popularity of social platforms.

First it was fashionable Facebook, then Instagram, then Snapchat, but the reign of the latter will not be long because this generation gets bored quickly.

At international level, employers have already started to react at the moment, to go after young people instead of waiting for them to come to the company, because they have realized that the second option will not happen. This led to the use of Snapchat for recruitment.

Here are some of the results of a study conducted by the SmartDreamers Recruitment Marketing platform in Romania. Almost 44% of the survey respondents are active on social networks between 1 and 3 hours a day. The next category belongs to those who spend less than an hour a day on Facebook, Instagram or LinkedIn - over 22%. It is followed by young people who are online between 3-6 hours a day (by 21.5%) and those who have a presence on Social Media of more than 6 hours a day, by 12.4 percents. As for the environment in which young people want to know about new jobs, Social Media is in an open battle with the classic job sites. 44.6% of those who participated in the study want to know about new jobs on alternative recruitment channels, such as Facebook, Instagram, YouTube or the online communities they frequent. The recruitment process will have to keep pace with technological developments. It will have to contain fewer words and bureaucratic components and more applications, video content and virtual reality.

No one doubts today about the need to promote products. The more flexible and innovative the promotional activity, the greater its impact on a market saturated with advertising messages.

4. CONCLUSIONS

The success of an institution is determined both by the quality of human resources and by the procedures used to attract and retain the most suitable people to perform the most difficult tasks with the same enthusiasm as the light ones.

Providing human resources involves analyzing the interference between recruitment and the marketing mix in this area.

The main components of the mix that the institution can use are the candidate, the offer, the promotion of the offer (hereinafter referred to as promotion) and the selection. These components are means that the institution can use profitably to achieve its objectives, depending on the characteristics of the microenvironment and the macroenvironment in which it operates.

The complexity of the relationships between recruitment and the components of the marketing mix is amplified by the inter-relationships between those components. The marketing mix emphasizes the association of its structural elements, on the multiplier effect of the harmony between the components.

The components of the marketing mix do not only interact with each other, but also with other variables, such as: financing promotion and recruitment activities, training recruiters, etc.

The Relationships between Recruitment and Offer

The interconditioning between the offer and the recruitment is apparently limited to the design of the recruitment process depending on the type of products offered by the institution.

The particularities of the offer influence, for example, the type of means used, the duration, the recruitment and selection criteria, etc.

Also, the characteristics of the offer indicate the way in which the selection will be made later and the other training needs of the recruited candidates.

The Relationships between Recruitment and Candidate

Recruitment of candidates can be done from internal sources, ie from existing staff or from external sources. The decision on the sources of candidates must be taken early in the recruitment process. Despite the priority given to internal sources of recruitment, it must be borne in mind that an exclusive or even predominant recruitment policy within the institution may also have disadvantages.

Institutions must also pay special attention to the conditions offered to future employees, as candidates, in turn, select professions / jobs. The staff is not only attracted by a high salary. There are other methods of motivation that must be considered, in addition to the monetary reward, and that can bring a sufficient quantity and quality of candidates.

The Relationships between Recruitment and Promotion

Another component of the marketing mix, which involves the collaboration of recruiters and marketers, is promotion. Collaborative relationships must be permanent throughout the process.

At first glance, recruitment and promotion are two completely different areas of the institution's activity. While one includes, among others, the preparation of the candidate file and the verification of the fulfillment of the job requirements, the other aims at cognitive, affective and behavioral objectives at the level of current and potential candidates, stimulating the demand, creating and developing the institution's image and offer. In the recruitment stages, as well as their predecessors, the most important component of the marketing mix is promotion.

The Relationships between Recruitment and Selection

Along with the candidate, offer and promotion, selection is a major component of the marketing mix. Once the offer of candidates obtained following the recruitment process is available, the institution makes their selection by choosing, according to certain criteria, those that best correspond to the requirements for which the recruitment was made.

Institutions are generally concerned with making the best possible selection of staff, as this activity can become very costly when hiring people who prove to be inadequate to the requirements of the job.

The selection requires an objective analysis of the concordance between the professional characteristics of a position and the physical, mental and informational possibilities that the candidates present. At the same time, it is designed based on the diversity of the candidates' offer and distribution.

Also, a certain relationship between recruitment and selection is that of succession, the selection following as a natural continuation of the first.

In these circumstances, it can be argued that *recruitment does not guarantee that the best candidates will be selected, however it provides candidates from where the best employees can be selected.*

The capacity of the institution to have as many eligible candidates as possible depends on the functionality of the recruitment and selection system.

It can be said that the improvement of the cooperation between recruitment and marketing is not conditioned by an organizational restructuring. The harmonization between recruitment and marketing is also facilitated by the advances in the field of information technology, by the possibility of specialists from different functional areas to share in common the information system of the institution. However, the development of cooperation is not long as long as recruitment managers and marketing managers do not have a strategic vision on their own activity.

In conclusion, the objectives and directions of action for providing human resources are inextricably linked to those of recruitment and marketing in terms of meeting the needs and expectations of the institution.

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THE IMPORTANCE OF FLUENCY AND SELF-CONFIDENCE IN THE FIELD OF LEADERSHIP

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Abstract: *The essential behaviours that directly affect the impression a leader makes on other people are considered to be an issue of vital importance. The manner in which fluency, self-confidence, presence, authenticity, courage, passion and attitude are shaped and expressed represents the basis of leadership training and the infrastructure of efficiency when it comes to creating the desired impression as the leader interacts with his/her peers.*

Keywords: *leader/leadership/charisma/self-analysis/intuition*

1. INTRODUCTION. PERSONAL IMPACT

People perceive leadership unconsciously, as they perceive a leader's natural ability to make a powerful impression. Personal impact does not always coincide with the notion of "good". Positive leadership is one and the same with the idea of "good" and the leaders who have managed to consolidate in other people the desire for freedom, the respect for life, the love of their peers and the compassion for people in pain are significant examples in this respect. Among such authentic leaders, we can name Ghandi, Nelson Mandela and Maria Theresa. At the opposite pole of the idea of "good" is negative leadership, which is represented by leaders such as Hitler, Stalin or Mao, who have led people towards destructive outcomes.

Regardless of whether it is positive or negative, leadership seems to involve mysterious innate properties combined with qualities that rely on the ability to create interhuman relations. Celebrities from the world of entertainment, great religious and spiritual leaders, renowned politicians and military geniuses are just a few examples of leadership that have influenced important areas of mankind. This kind of influence can, for the most part, be learned (Fig. 1).

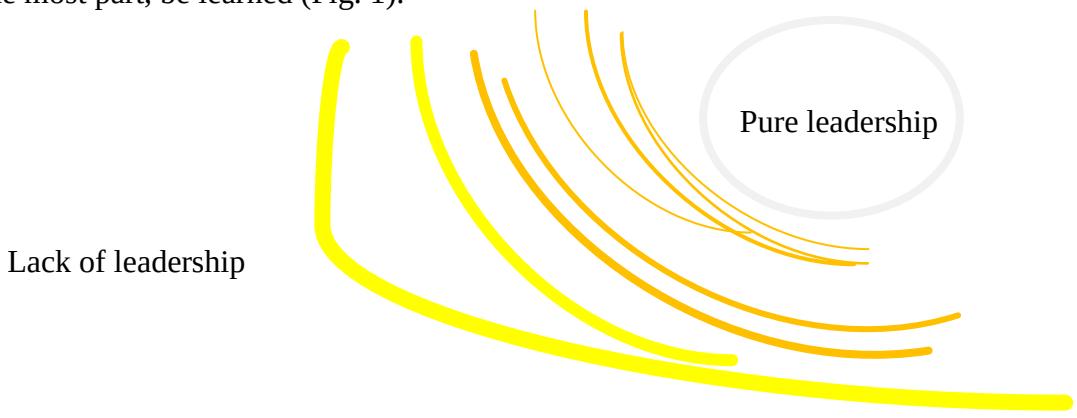

FIG. 1 The charismatic effect of leadership

It is a matter of how one can use the area of one's own leadership (defined by the personal views, integrity, realism and courage) in solving life problems, by attracting attention and using one's own energy to remain fully present, with a view to making oneself understood and mobilising one's peers by gaining their approval, trust, commitment and admiration, thus creating affinities, influencing and creating emotional, intellectual and maybe even spiritual bonds. Therefore, the charismatic effect of leadership represents the ability to use all of one's qualities to generate a powerful and memorable impact on your peers, by influencing them at an emotional, physical and intellectual level, including their thoughts, attitudes and behaviour.

Traditionally, the extreme version of innate charisma is the unusual ability to influence people and to generate devotion. Nevertheless, the charismatic effect could be created from knowing and exercising the ingredients of increasing personal impact, which leads to antisocial, quiet, reserved, even shy leaders, i.e. a paradoxical combination of personal humility and professional wilfulness that reminds us of Socrates rather than Caesar (J. Collins, Good to Greit, Random House, 2001).

In general, the interactions between us and other people represent a normal part of our daily lives, regardless of whether they take place during meetings, when you greet your boss in the hallway, when you have a dialogue with a client, during a job interview, when you make a phone call or when you are part of a team. What all of these people think of us is important even if we are fans of technology, recluse, infatuated specialists or preoccupied managers, because this affects the manner in which they react to our demands. The process by means of which leaders enter into contact with other people making themselves heard, saying things that are worth remembering by the interlocutors, being perceived as an authority in their professional field, being asked for their opinion and answering the requests of their peers without disappointing them involves 3 key elements, as shown in Fig. 2.

FIG. 2 The process of personal impact

The aim of managers could be to motivate, to arise consciousness or to trigger actions from their subordinates. An important and difficult part of their personal attraction is represented by the type of relationship that they have with target people. The more explicit the aim of communication (clear, achievable, necessary, desirable), the easier it is to eliminate the obstacles and to obtain more precise results:

- To convince people to trust you;
- To determine people to commit to a certain action;
- To determine people to approve of your ideas;
- To inspire your enthusiasm in other people;
- To make people listen to you with respect;
- To attract new volunteers;
- To reach an agreement on a new meeting for the following month;
- To obtain a warm smile and a handshake at the end.

Trying to achieve all these results involves the risk of failure. Therefore, it is crucial to set priorities based on the classification of multiple aims from 1 to 4:

1. having a high impact on the boss;
2. improving one's position within the team;
3. building a relationship with the client;
4. obtaining the approval of a colleague for a new project.

Increasing self-consciousness is absolutely necessary when the aim is to increase one's personal impact on other people, because only this way strengths are emphasised and weaknesses are minimised. There is not wrong in wishing to improve the impression one makes on other people.

2. THE ROLE OF FLUENCY IN CONSOLIDATING LEADERSHIP

What we communicate, our message must be received by the interlocutor. Communication is clear if the receiver absorbs the speaker's message. If nothing has been heard, it means that nothing has been communicated.

Being fluent means:

- To speak easily;
- To explain complicated ideas in a simple manner;
- To communicate convincingly;
- To give life to your words;
- To speak clearly in order to be heard;
- To use pauses properly and powerfully.

Fluency is a mixture of: 7% verbal communication (only words), 38% voice (tone, pitch, speed and intonation) and the remaining 55% non-verbal communication (body language, gestures, expression and posture).

Having a vast vocabulary is amazing. Still, it is less important than being able to devise a message that people believe is worth listening to. Here are some ways of improving one's fluency:

- eliminating verbal delay tactics, such as repetition and hesitation;
- updating one's vocabulary by:
    - checking one's vocabulary;
    - learning a new word every day using a dictionary of neologisms;
    - doing crossword puzzles;
    - reading;
- exploiting subjects such as art, music, theatre, literature, foreign languages, psychology etc.;
- practicing the active listening of the interlocutors;
- practicing stimulating conversation as a form of training of the mind.

The simplification of the message increases personal impact and involves the elimination of jargon and even professional language, even if they represent useful shortcuts among professionals in the field.

Being convincing is little dependent on the position one holds or the professional role one plays, but it is very much related to the purpose of communication, the non-verbal language, the power/passion behind the actual message and the capacity to give people the most relevant information from the beginning. The verbal content of the message can also increase the speaker's credibility, provided that there are sufficient real aspects supporting the case, that the message is transmitted in a logical and easy-to-follow manner and that it is short enough to be received clearly, without any ambiguities.

Conceptual ideas and complex notions must be presented in an accessible manner, using creative sentences, memorable visual images, metaphors and analogies. Persuasion begins from the transformation of conceptual images into plastic images, using the verbal symbolism to describe something as if it were something else.

The aspects related to the musicality of the speaker's own voice are also very important in attracting the public's attention:

- diction (for a clear pronunciation of the words it is recommended to speak slowly and to look closely at the interlocutor);
- the pitch of the voice tone (it is recommended to avoid monotone speaking, by using the breathing and relaxation technique, "stressing the important words and sentences", investing emotion in the speech and emphasising the end of the assertions/questions);
- volume (speaking too loudly or too softly can undermine the effort to catch attention; determining the volume required to attract attention starts with deep breath and regular speech that does not use up all the air in one sentence);
- tone (a pleasant tone involves using the diaphragm, the vocal cords and the sound that resonates in the throat, mouth and head and that has the effect of what the voice is transmitting: joy, friendliness, anger, patience, poise);
- rhythm (speaking more rarely, using techniques such as adding pauses to give the interlocutor time to think, varying the rhythm of the speech by increasing or decreasing the speed of the speech, minimizing the use of energy for an efficient speech so that the words can be uttered slowly and less intermittently, all of which shall increase the level of attention).

3. THE ROLE OF SELF-CONFIDENCE IN BUILDING LEADERSHIP

Self-confidence is, along with correct self-assessment and emotional self-knowledge, one of the competencies of self-knowledge, one of the dimensions of emotional intelligence.

There is a difference between the internal and external confidence that leaders transmit to other people and a powerful link between internal confidence and the external results interpreted by others as self-confidence.

Basically, self-confidence is built through practice and it leads to the shaping of certain skills that shall support, in their turn, more self-confidence (figure no. 3).

Here are some of the things that show the external self-confidence:

- Being relaxed rather than stiff;
- Being flexible in voice tonality, attempting to cover a wide range of tones and gestures;
- Controlling one's movements in order not to tremble and seem clumsy;
- Using open-ended questions in order to involve other people and to avoid "Yes/No" answers;
- Using the informal 2nd person singular when addressing the interlocutor directly, which shows a direct and friendly approach;
- Being proactive and taking the initiative in the conversational process;
- Looking the interlocutor in the eye and maintaining visual contact for enough time in order to send a clear message, for example: "Trust me, you interest me."
- Making one's intent clear.

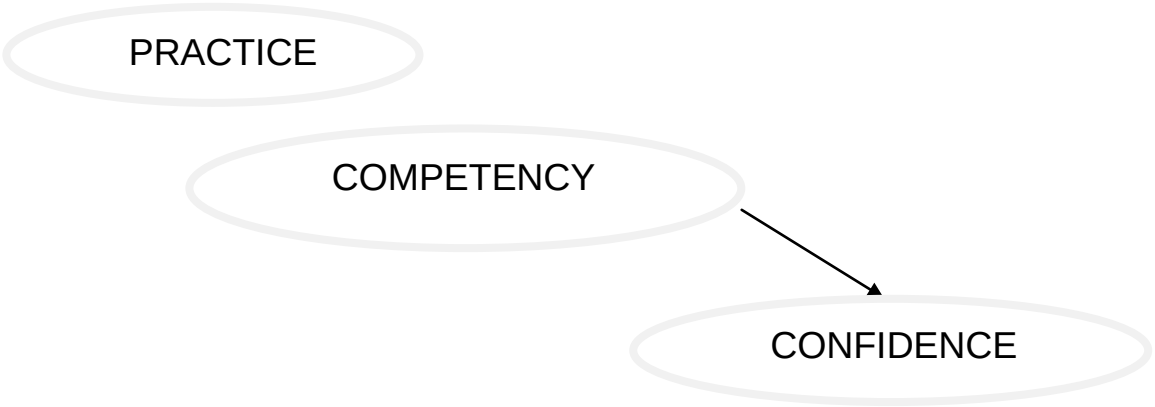

FIG. 3 Steps in achieving inner self-confidence

The simple fact of having inner self-confidence shall significantly reduce the fears that might become overwhelming when:

- entering into a room full of strangers;
- giving a speech;
- supporting one's own point of view in a team meeting.

Exterior self-confidence involves rejecting one's doubts, by adopting a normal demeanour, which shall increase the chances of one's own progress through behaviours that target the desired premises as an already incontestable reality, i.e.:

- behaving as if the others are happy to see you;
- behaving as if other people are eager to listen to what you have to say;
- acting as if your peers like, respect and admire you.

People shall have the same assumptions about leaders as they do about themselves. Leadership is based on the leader's attitudes that echo back from the others. People tend to reflect the emotional state of their leaders, i.e. their interest for their peers shall be transmitted and converted in the interest that people have for the leader. The expectations related to the manner in which peers behave shall affect their behaviour significantly. This has nothing to do with telepathy, but rather with the tacit messages sent by the leader's poise, facial expression, gestures and body language.

For example, the challenges of delivering a public speech at an event involve the fears related to speaking in public and to the interaction with strangers, which leaders, as people with self-confidence, shall cope with by using the technique of imagining the 3 series of sequences (scenarios) and by preparing strategic solutions to get out of such situations, as described below:

1. the scenario in which the leaders shall behave as the host of their own party (the solution imagined for the challenge of speaking in public at a conference: leaders shall behave with all the people they meet at the event as if they were their guests, paying close attention to each and every one of them before moving on to the next stage);

2. the scenario in which the leaders shall manifest their curiosity (the solution imagined for the challenge of speaking in public at a conference: leaders shall focus on a target of their curiosity that shall become the aim of their focus, such as curiosity to identify the reason why people have chosen to attent the conference);

3. the scenario in which the leaders assumes the role of an emissary, or the bearer of a message (the solution imagined for the challenge of speaking in public at a conference: leaders shall approach the people atending the conference by talking to them as if they benefited from a unique opportunity to find out what they have to say and they were eager to listen to their messages).

3.1 The role of emotional intelligence in developing self-confidence

Emotional intelligence means being aware of what is happening to other people at an emotional level. Decreased emotional intelligence is the equivalent of not feeling/understanding/anticipating or not caring about the fact that one makes the people around feel belittled, inadequate, intimidated, angry, frustrated or guilty. Machiavellian people have decreased emotional intelligence. Leaders have above-average emotional intelligence, which translates into:

- their ability to detect social dynamics, i.e. what happens during an interaction between people;
- their capacity to get involved more from a social point of view;
- their capacity to correctly interpret behaviours, intentions, emotional states and their willingness to relate to their peers.

The increase of emotional intelligence is based on the development of situational consciousness by knowing and using the appropriate tools to properly identify/perceive a situation (Andrew Leigh, 2010):

- Space (identifying who is staying where and why; for example if the most experienced person is sitting at the head of the table; identifying whether the set-up of the environment highlights the power of the person occupying it, whether it encourages intimacy, whether it promotes communication or it blocks it);
- behaviours (body posture, movements, gestures, face expression, voice tone, who is touching who, who enters the room first or last);
- Advanced sensorial activity (superficial or deep breathing of the people, face pallor, flushing might indicate anger, opposition or shyness or simply the fact that that person is in trouble; the signals of shifting energy levels can be decrypted from multiple sources, such as one's body posture, visual contact, hand or foot movements etc.)
- Words and symbols (the meaning of words and symbols can vary from one person to another depending on their social status, which is identifiable from: language, slang, figures of speech, the use or avoidance of insulting expressions, the use of specialised vocabulary, such as jargon);

4. CONCLUSION: THE INTERACTIONAL LEADERSHIP TYPE

Fluency and self-confidence are indisputable traits of leadership, together with a wide range of characteristics, behaviour and personality features that make some people more efficient in achieving their goals. Undoubtedly, leadership is also a process based on power sources that are directed towards influencing the members of a group into the direction of a common objective. In reality, the definition of leadership is somewhere between a sum of traits and a process used to influence a group. As it cannot occur in isolation, any leadership action shall take place within a context.

Therefore, a leader's fluency and self-confidence and all their personal qualities must be confirmed/supported by the particularities of the situation/context in which the leader performs.

Some leadership situations are simply not suitable for certain people or certain situations and the interface between a leader, his/her people and a situation makes

leadership hard to define and apply and it also makes leaders valuable and necessary individuals for the society.

A more realistic incorporation of fluency and self-confidence in the leadership equation is provided in figure no. 4 (Manfred Kets de Vries, CODEX Publishing House, 2001, page 246).

The leadership style is determined by the fact that, in real life, the following elements meet and match in a fortunate manner:

- The leader's fluency, self-confidence, conceptual thinking, type of character, values, position, experience;
- The group's type of character, values, cohesion;
- The organisation's type of activity and life stage, the organisational variables, the culture, the social, political and economic environment;

Unfortunately, most of the times, these elements meet, but they do not match, as shown by the following situations:

- the group has a much higher level of emotional intelligence than the leader;
- the leader has the required self-confidence, fluency, position and experience, but he/she lacks the conceptual thinking and character, which has disastrous consequences for the group that follows the leader trustingly;
- the leader has self-confidence, fluency, conceptual thinking and character, but he/she lacks the position and experience required to make the group to follow him/her;
- the nature of the activity, the social, political and economic environment or the culture of the organisation might not put the leader's quality in the best light.

FIG. 4 Leadership field

The company follows its leaders, who are people that are ahead of their times and who assume the role of implementing a collective sense of importance by:

- building a clear personal vision for the future and creating the feeling that the group is headed towards an AIM;
- planting the feeling of SELF-DETERMINATION by inspiring his/her peers to feel that they are in control of their own lives;
- building the feeling of IMPACT among his/her peers, letting people convince themselves that their actions matter to the people around them;
- planting the feeling of COMPETENCY among people, by finding the means of expression of the creativity required for their need to explore;

- knowing and successfully applying the values of the organisation, i.e. focusing on teamwork, honesty, employee empowerment, respect for the individual, customer orientation, entrepreneurial attitude, pleasant atmosphere, assuming common responsibility, lifelong learning, trust, openness to change.

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THE VIRTUAL ENVIRONMENT DURING "THE STATE OF EMERGENCY"

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Abstract: *The line between respecting and violating fundamental rights, in the context of a state of emergency, becomes rather thin due to ignorance and/or the incorrect enactment of European Union and national policies. This article summarizes two of the essential rights of European citizens, which were constantly violated during the COVID 19 pandemic.*

Keywords: *COVID-19, human rights, European Court of Human Rights, misinformation, conspiracy.*

1. INTRODUCTION

The normal life and daily routines of each of us took a break or underwent radical changes, with the emergence of the pandemic virus known as "COVID-19"/"SARS-CoV2"/ "CORONA VIRUS". This virus is believed to have appeared first in the most populous city in central China, Wuhan, the capital of Hubei Province, and it soon spread around the World.

There are several hypotheses regarding its origin: that the virus reached the human body through food, or that it is of animal origin and the animal was bought from a fish market in this city and consumed, but the fact that the most modern institute of virology in central China is only 30 kilometers away from the market leads many to believe that the virus was accidentally or even intentionally released from the laboratory where the most dangerous and infectious diseases are researched.

However, and surprisingly in large numbers, there are also people who are absolutely convinced that this virus does not exist and that everything is nothing more than a global manipulation in order to gain world supremacy. There are still not enough factual data to establish with certainty how the virus appeared, but what we all know and feel is that it really exists and is making more and more victims around the World every day.

In Europe, in order to limit the spread and to eliminate the virus, a number of extreme measures have been taken which have proved to be effective, but which have also undermined fundamental human rights, including the right to free movement, as a result of the general rules on social distancing, and the right to free speech. In such circumstances, as the many people who do not believe in the virus could influence others and nullify the doctors' effort against the virus, or could affect the right to the protection of personal information, the authorities are using all possible means to monitor the population and keep under control a climate of public order and safety during this period.

The aim of this essay is to present contemporary human rights issues in the context of the current Covid-19 pandemic, the first part highlighting general notions concerning human rights, European policies on the right to express opinions and the right to the protection of personal information, followed by current examples of infringements of these rights and, finally, by the conclusions reached after analyzing all the issues presented.

2. EU HUMAN RIGHTS POLICIES

Theoretical considerations on human rights

General human rights notions. The concept of "Human Rights" came into being when the Persian king Cyrus II the Great, after the conquest of Babylon in 539 BC, freed slaves and gave people the freedom to choose their religion. All these ideas were contained in the "Cylinder of Cyrus" (a code of laws that included the said human rights). His ideas spread rapidly in India, Greece, and later in the Roman Empire, influencing modern philosophers who noticed that human beings were inclined to follow certain rules – what we call today "Natural law" – but which were always diminished by those in power. It took thousands of years before the "Magna Carta" was adopted in England in 1215 (the document stipulates that nothing and no one, including rules and rulers, should burden human rights).

Another major document on human rights was the "British Petition for Right" adopted in 1628, which reaffirmed the idea that English citizens should be entitled to their rights. Between 1776 and 1778, the "The United States Declaration of Independence" has been adopted, which stipulated the recognition of equality between people, and in 1789, the French Revolution developed the concept of human rights and insisted that our rights must be invented. Between 1800 and 1814, Napoleon destroyed the fragile French Democratic System, but European countries were defeated and the idea of human rights became a central topic for debate after the Napoleonic Wars, even if it remained a local topic in Europe.

The rest of the World did not enjoy these rights, but the Europeans conquered and invaded the World, turning these vast territories into empires. The year 1915 brings Mahatma Gandhi about, who considered this local viewpoint on human rights to be unjust and led the protests in India against the British Empire. Gandhi believed that all people have rights, which also influenced Europeans. These events were not enough, the whole World was shaken by two World Wars, and Hitler enacted his racial ideology which resulted in millions of people being killed. This also seemed to lead to the disappearance of the very idea ofhuman rights. Fortunately, at the end of World War II, in 1945, the countries of the World cooperated to form the United Nations (UN), an institution that aimed to defend World peace and reaffirm the idea of human rights in their full dignity and value. The year 1948 marks a crucial moment in the evolution of human rights, as the UN adopted the "Universal Declaration of Human Rights”, a document which contains 30 articles, promoting the most important human rights that can be applied to all, regardless of geographical area or cultural and personal difference.

In 1949, the "Council of Europe" has been established, with the aim of defending human rights, democracy and the rule of law in Europe. These states have adopted the European Convention on Human Rights, laying the foundations for a single system that provides for a mandatory oversight mechanism. Thus, the "European Court of Human Rights" was created in 1959.

The court expresses the desire of states to never again experience the atrocities committed in the mid XX th Century. At first, the Convention was signed by twelve states, and now there are almost 50 signatory states.

The court is located in Strasbourg and is composed of judges (one for each member state of the Council of Europe). Elected by the Parliamentary Assembly, the judges are completely independent and do not represent any National Interest. They are to be assisted by qualified staff from all Member States to deal with the application of their decisions. The Court receives hundreds of letters and phone calls every day.

When the requests arrive in Court, they are forwarded to one of the clerk units who prepare the cases for the judges. They shall meet in full by a single judge, in a committee of three judges, in a chamber of seven or in a grand chamber of 17 judges for the most important cases. The procedure is written, but in exceptional cases, the Court meets in public hearings, all video recorded and broadcasted on the Internet. The Court receives a considerable number of applications each year; however, the vast majority is rejected at the admissibility stage, as the conditions for being able to apply to the Court are not met. For example, this is the case for claims in which the applicants did not apply to the National Courts before coming to the European Court. For this reason, the Court decides only in a small number of cases compared to the large number of applications it receives. It shall then decide whether there has been a violation of the Convention or not and may award financial compensation. The Convention protects a number of rights, the most important being the right in front of the road. The death penalty is no longer applicable in any Member State in Europe. The rights and freedoms enshrined in the Convention are formulated in a general way and the Court must interpret them in the context of today's societies, in order to avoid the conventional transformation of a text, i.e. in the context of modern concerns. Thus, it has ruled on subjects unimaginable at the time of conventional adoption, such as, for example, the cases concerning the technological legacy of the new generations. In one such situation, Turkey was convicted for blocking citizen’s access to the "Google" site. The Court found that this is a restriction on internet access and affects people’s freedom of expression.

The Committee of Ministers is the executive body of the Council of Europe that ensures compliance with decisions and is composed of the ministers of foreign affairs of the Member States of the Council or of the Permanent Representatives of those states. The Committee meets regularly to monitor the execution of the Court’s verdicts. The examination of each case is concluded only when the Court is satisfied with the measures taken by the convicted State, and the governments must take steps to ensure compliance with the Convention in their country. During all this time and for more than half a century, the European Court of Human Rights has been the bastion of human rights in Europe, the ultimate defense court for millions of people.

During the Nice council, the European Commission, the European Parliament and the Council of the European Union proclaimed on the seventh of December 2020 the "Charter of Fundamental Rights of the EU", a document set to acquire in 2007 the value of primary law of the EU. The Union institutions and the Member States are compelled to guarantee these rights. The purpose of the document is to recognize and develop rules on human rights, rights that are also found in the common international obligations of the Member States, such as the European Convention on Human Rights. Compared to the Convention, which is limited to civil and political rights, the Charter is intended to cover other areas as well, thus being used by the European Court of Human Rights for the modern interpretation of the provisions of the European Convention on Human Rights, and by this, extending the scope of the Convention.

The provisions of the Charter take precedence over National Law, except in cases where domestic provisions are more favorable.

The difference between "Human Rights" and "Fundamental Rights"

The main difference is territorial. Human rights are universal, without any limitations. Instead, a fundamental right exists in a specific legal system, with the limitations that the law grants. Therefore, the concept of fundamental rights predominates in state laws. A fundamental right is, above all, a right that the Constitution creates. For this reason, the pre-existence of a right must be taken into account in order to form a fundamental right. Human rights function in a much broader context than fundamental rights. The distinction between human rights and fundamental rights is important because not all human rights have been recognized as fundamental rights. Thus, we see that in the internal ordinances of the state, and especially in the Constitutional Doctrine, there is a distinction between fundamental rights and human rights. Therefore, this distinction has a number of consequences for the internal regulation of states.

Examples of rights contained in the EU Charter of Fundamental Rights:

- The right to life;
- The right to the integrity of the person;
- Prohibition of torture;
- Respect for private and family life;
- The right to marriage;
- The right to family;
- Freedom of thought, religion and conscience with all subsequent components:
  - Freedom of speech;
  - The right to education;
  - The right to work;
  - The principle of equality and non-discrimination;
  - The preservation of various cultural, religious and linguistic activities;
  - The right to social security;
  - Consumer's protection;
  - Environment protection;
  - The right to defense;
  - The right to a fair trial.

All human rights are, in principle, seen as unconditionally due to every person, but there are also situations in which a large part of these rights can be suspended, except for the right to life, the right not to be subjected to torture and ill-treatment, the right not to be subjected to slavery and forced labor and the right not to be subjected to a punishment not provided for by law. For cases of emergency, **Article 15 of the European Convention on Rights Derogation** stipulates that:

"1. In the event of war or other public danger threatening the life of the Nation, the Contracting Party may, in any case, take measures to ensure that the obligations are waived when agreed, in strict compliance with the situation or immunity and its conditions taking action may run counter to other obligations under international scrutiny.

2. The preceding provision shall not permit derogation from Article 2, except in the case of acts resulting from the lawful act of war, nor from Article 3 (1) and (7).

3. Any High Contracting Party exercising this right of derogation shall be informed of the exceedance by the Secretary-General for all European Parties of the measures taken and of the reasons therefore.

Determination - It is also necessary to inform the Secretary-General in order to make them available to Europe and of the date on which the measures are to be taken into account and to be uploaded in force, and to make it available to the Convention for new applications".[10]

Contemporary issues related to EU human rights policies in the context of the current Covid-19 pandemic

EU policies on the right to freedom of opinion

Freedom of opinion and expression is a complex right that includes the right to seek, receive and share information and ideas of all kinds, regardless of the environment and without the imposition of sanctions or censorship. When a person's right to express his/her ideas and transmit information is violated, another person's right to receive information is implicitly violated as well. These are indispensable rights to dignity and individual development and are at the foundations of democracy.

The media would not have the capability of objectivity without this right; therefore, the veracity of the information would be questionable and would cause more uncertainty than security. The EU guarantees, within its borders, the defense, observance and promotion of this right and aims to address and prevent its violation in a timely manner. The International Covenant on Civil and Political Rights (ICCPR) emphasizes that no one should suffer because of his or her views. Personal opinion can be expressed through any means such as newspapers or books and through any form of audio, visual or internet expression. However, through the information provided and the ideas presented, the person concerned is not allowed to harm the dignity of others or endanger the integrity of the body or health of others by developing false information that could adversely affect others. The law also prohibits any incitement to religious, racial or national hatred or inciting discrimination, violence or hostility.

Article 10 in the "Human Rights Act" stipulates the following as far as the freedom of expression is concerned:

"1. Everyone has the right to freedom of expression. This right includes freedom to hold opinions and to receive and impart information and ideas without interference by public authority and regardless of frontiers. This Article shall not prevent States from subjecting broadcasting, cinematographic or television undertakings to an authorization regime.

2. The exercise of these freedoms involving duties and responsibilities may be subject to formalities, conditions, restrictions or sanctions provided by law, which, in a democratic society, constitute measures necessary for national security, territorial integrity or public safety, the defense of order and the prevention of crime, the protection of the health, morals, reputation or rights of others, to prevent the disclosure of confidential information or to guarantee the authority and impartiality of the judiciary." [11]

EU policies on the right to the protection of personal information

The right to the protection of personal data is a right recognized by the "Charter of Fundamental Rights of the European Union", which provides in Article 8 that:

"1. Everyone has the right to the protection of personal data concerning them.

2. Such data must be processed correctly, for the purposes specified and based on the consent of the person concerned or based on another legitimate reason provided by law. Everyone has the right of access to data collected concerning him or her and the right to obtain rectification thereof.

3. Compliance with these rules shall be subject to control by an independent authority. "[12]

At the same time, this right is closely linked to Article 8 of the “European Convention on Human Rights”, which states that:

"1. Everyone has the right to respect for his private and family life, his home and his correspondence.

2. The interference of a public authority in the exercise of this right shall be admissible only in so far as it is provided for by law and constitutes, in a democratic society, a measure necessary for national security, public security, the economic well-being of the country, defense of order and the prevention of criminal acts, the protection of the health, morals, rights and freedoms of others”. [12]

The right to the protection of personal information can also be violated in the virtual environment; therefore, it was necessary to create a set of rules on the storage of personal data online. The EU argues that the personal data of every EU citizen are protected whenever it is necessary to use them (online shopping, CVs for employment, etc.), and these rules apply to both public and private companies, inside and outside and outside the EU. All these aspects are included in the General EU Data Protection Regulation (RGPD) and describe the possible situations in which the collection or reuse of personal information is allowed, including the following conditions:

- The existence of a contract between the company providing the service and the person concerned.
- When there is an obligation on the company to store personal data.
- When the processing of personal data is a vital action for that person.
- The existence of a legitimate interest.

Apart from these situations, the company is obliged to request the user's consent for the collection of personal data, the expression of the agreement being made through a very clear action, such as checking a "YES" or "NO" answer. The company also has the obligation to present the following information in a clear and accessible way:

- The reason for collecting personal data.
- Details of the company that will process the personal data, which includes the contact details of the data protection officer, if any.
- Period of storage of personal data.
- Information about a possible other company that will take possession of the data.
- Information regarding the right to delete, modify or withdraw consent.
- The user has the right to request access at any time to his personal data held by a company and may request a copy of the data, the company being obliged to respond to the request within one month and make known how the data was used.

Examples of violations, in the virtual environment, of the rights to opinion and the protection of personal information, following the onset of the state of emergency in the EU

In response to the SARS-Cov2 pandemic (Covid-19), some governments have improved surveillance, increased censorship, and restricted the free flow of information. As everyone’s lives have shifted from the public to the digital realm, many freedoms have also been suspended, while the burden of liability for violations has fallen on citizens, as governments have imposed restrictions that in many cases have violated normal human rights standards.

Given that, after the establishment of the State of Emergency, the predominant activity of people shifted towards the online environment. As simply limiting the movement and contact between people was no longer enough to stabilize the situation created by the pandemic, the affected states had to adopt strict rules on the activities carried out in the virtual environment, in order to avoid the misinformation of the population.

However, the imposition of these rules consequently entails the violation of fundamental human rights, such as the right to free expression of opinion and the right to the protection of personal information.

One of the clearest examples of violations of these rights is the case of one the most controversial figures of the moment, a person the authorities are constantly paying attention to: namely Brian Rose, the founder of the live channel "London Real", which mainly aims to present interviews with various influential people. Following the publication of an interview that featured David Icke, the authorities permanently blocked all his accounts, channels and websites. David Icke is a journalist, writer, conspiracy theorist and vaccine activist. For a long time, many people thought he was neither a reliable source or a reasonable person, but there were enough people who supported him, as well. Following the outbreak of the Covid19 pandemic, he made his own ideas public through a video recording posted via "YouTube" and attracted tens of thousands of views, but the site's administrators immediately deleted the content. Journalist Brian Rose took advantage of the situation and published a 2-hour interview in which he presented David Icke's conspiracy theories – this video being also deleted a few tens of minutes later. Subsequently, he tried to publish the interview online again, this time obtaining a record numbers of views, but the video had the same quick outcome from the authorities. Currently, Brian Rose is raising funds to create a new platform to provide uncensored information to all users.

In Romania, there were and there are actions to restrict the right to express opinions by blocking sites such as "genocid.ro", "r.news-romania24.xyz" or "news-romania24.xyz" by the Romanian Authorities, as they consider that false information has been presented which could endanger the safety of citizens. In addition, in Romania, the publication of false information regarding Covid-19, claiming its non-existence, blocked the news site "romania-veche". The information was redistributed over 170,000 times on the social networking site "Facebook" before the site was blocked.

Another site in Romania that came to the attention of the authorities is "ortodoxinfo.ro", which was blocked due to the support and promotion of information discouraging the due national protection measures against Covid19. Conspiracy theories related to the pandemic were exposed in Romania through the site "bpnews.ro", which was permanently closed due to the persistence of published information related to this topic.

"Reporters without borders" claims that states have used the context of the pandemic to limit the press, thus violating the rights to disclose real information related to the global spread of the pandemic, and, consequently, people's lives are put at risk.

Bulgarian politician Volen Siderov was detained after inciting citizens to disobey the authorities' recommendations, and another arrest case comes from Hungary, where a citizen was arrested for claiming online that the corona virus epidemic did not exist and that the whole situation is just a cover for a secret entity's taking control of the world.

The rights to the protection of personal information are violated by the actions of states monitoring the population by means of drones or applications installed in the mobile phone system, through which State Authorities have the opportunity to obtain not only the personal data of users, but also their exact location in real time, in order to detect the violation of the norms of social distancing or quarantine, this subject being a hot one in Croatia since the beginning of the pandemic.

3. CONCLUSION

As expected, following the onset of the State of Emergency, to limit the spread of infections caused by the virus "SARS-CoV2" among the population, certain rules and restrictions have been implemented that have led to the restriction of fundamental human rights, such as the right to free movement, to the protection of personal information or even the right to the free expression of one's opinions.

Not all these rules can be characterized as abusive, as they were adopted during a State of Emergency, thus being protected by Article 10 of the European Convention on Human Rights.

But despite the fact that there are well-meaning people who have suffered because of these restrictions upon human rights, the steps taken by states in this regard, in such a period, are necessary to come out well of the difficult moments brought by the pandemic – and as quickly as possible.

In the absence of a response from the State Authorities to the false information leaked online about the non-existence of the virus, the misinformation created could expose the entire population to a general state of uncertainty and chaos. Therefore, although the entire planet is in a period of severe physical and mental trial which affects each and every individual, the best option is to listen to the advice of doctors and authorities and not to promote and believe in conspiracy theories.

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