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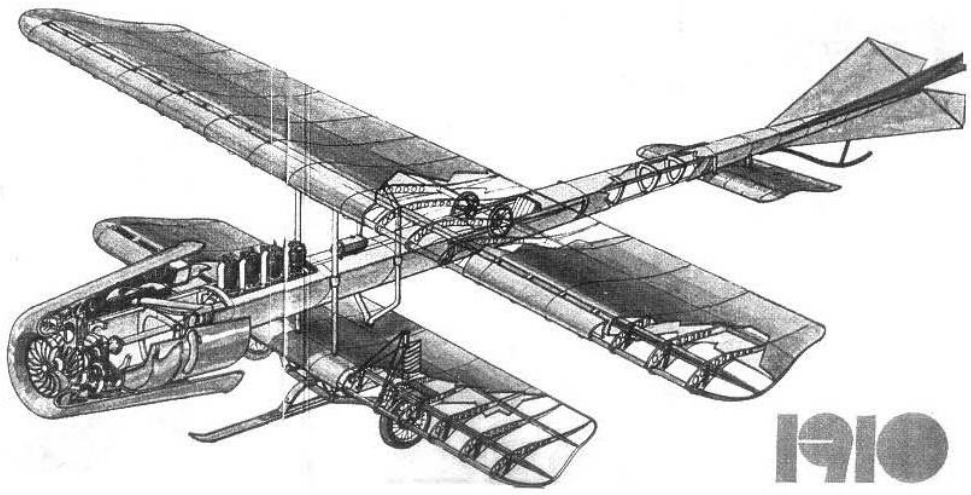

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C O N T E N T S

NUMERICAL 3D TRANSONIC FLOW SIMULATION OVER A WING

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Abstract: *This scientific paper presents performed numerical 3D transonic flow simulation over a wing. It is developed a suitable numerical model of the wing and it is created a three-dimensional mesh around the wing using the available techniques in ANSYS software. Also, it is obtained iterative convergence by using recommended solver settings. The performed numerical 3D transonic flow simulation over a wing give the opportunity to visualize 3D flow characteristics to gain physical insights. The main goal is to determine whether the numerical flow simulations over the wing performed by computational tools provide appropriate approaches for calculations of the complex 3D transonic flow characteristics. The main value of the paper is that the obtained results with the realized numerical flow simulation are compared with the experimental data and NASA CFD results using the source [1].*

Keywords: *aerodynamics, wing, ANSYS, lift and drag coefficients, transonic flow*

1. INTRODUCTION

Using the approach developed by Cornell University, [1] it is performed a 3D transonic turbulent CFD Simulation using ANSYS 15 and the solver is Fluent. For the properly investigation of the flow around the wing it has been created a three-dimensional mesh using the available techniques in ANSYS software. The performed numerical 3D transonic flow simulation over a wing give the opportunity to visualize 3D flow characteristics to gain physical insights. The main goal is to determine whether the numerical flow simulations over the wing performed by computational tools provide appropriate approaches for calculations of the complex 3D transonic flow characteristics. The main value of the paper is that the obtained results with the realized numerical flow simulation are compared with the experimental data and NASA CFD results using the source [1].

2. PROBLEM SPECIFICATION

Using the approach in source [1] the performed numerical 3D transonic flow simulation over the wing is trying to obtained the results obtained by NASA using the wind, and this is verified by comparison of the numerical results with the experimental data, [2].

Citied source [5] the Onera M6 wing is a classic CFD validation case for external flows because of its simple geometry combined with complexities of transonic flow (i.e. local supersonic flow, shocks, and turbulent boundary layers separation).

Flow over the Onera M6 wing is transonic and compressible. Quoting [6] conventional CFD methods are applicable in this case because they required a calculation for the entire three-dimensional field about the body.

The wing flow experiences supersonic conditions, a shock and boundary layer separation. The wing has no twist. There is no side-slip in the simulation. The flow conditions are given below at Table 1:

Table 1 Flow Conditions, [1]

Mach	Reynolds Number	Angle of Attack (degrees)	Angle of Side-slip (degrees)
.8395	11.72E6	3.06	0

2.1. Mathematical Model

The performed numerical simulation is governed by the continuity, Navier-Stokes (momentum conservation) and energy equations. But the flow is turbulent, that's why it was used Reynolds Average version of their equations. Therefore it was used Spalart-Allmaras turbulence model. In the beginning, it has six variables to solve for: 3 components of velocity, pressure, temperature, and kinematic eddy viscosity. The equations are:

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x_i}(\rho u_i) = 0 \tag{1}$$

$$\rho\left(\frac{\partial U_i}{\partial t} + \frac{\partial}{\partial x_j}(U_i U_j)\right) = -\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_j}\left(2\mu S_{ij} - \overline{\rho u_i' u_j'}\right) \tag{2}$$

$$\frac{\partial}{\partial t}(\rho e_0) + \frac{\partial}{\partial x_j}\left[\rho u_j e_0 + u_j p + q_j - u_i \tau_{ij} = 0\right] \tag{3}$$

$$\overline{-u_i' u_j'} = 2\nu_T S_{ij} \tag{4}$$

Where (1) is Continuity Equation, (2) is Reynolds Averaged Navier-Stokes equations, (3) is conservation of energy equation and (4) is Spalart-Allmaras turbulence model.

Using the approach from [1] the given above equations are converted to algebraic equations. It then solves for our six variables at each of the cell centers of our mesh. This means that if we have 300 000 cells, Fluent is going to solve 1.8 million equations to solve the problem, [1].

Using the approach developed at [1] for verification of the numerical results it is need to make some hand calculations.

In this numerical simulation of the flow it is expected to see many flow features in three dimensions. The following features are of interest: *Suction peak* (low pressure zone) that forms on the wing and how the size of the *suction peak* changes spanwise.

- *Shock along the wing surface* (because of the transonic flow)
- *Trailing edge vortices* (forming downstream of the wing, due to the interaction of the high and low pressure zones)
- *Lift coefficient of the wing* - c_L
- *Drag coefficient of the wing* - c_D

In the pre-analysis section an attempt has been made to predict c_L. The purpose here is to find the *lift curve slope.* The airfoil that is used for the wing, [1] is symmetrical, hence at 0 angle of attack - α, it produces no lift. The airfoil that is used here using the algorithm of [1] is ONERA OA206 Airfoil, [3].

First it has to be known the aspect ratio - *AR* of the wing, and it is calculated using the formula:

$$AR = \frac{b^2}{S} \tag{5}$$

Where b is the span and S is the planform are of the wing. The $AR = 3.8$.
The slope of an infinite wing is calculated by the formula:

$$a_o = c_L = \frac{L}{q_\infty S} \tag{6}$$

where $q_\infty = \frac{\rho V^2}{2}$ is velocity head (dynamic pressure), and L is a lift force. The slope is $a_o = .0884$. Citing [1] then it can be calculated what lift curve slope - $a = c_L^\alpha$ for the finite wing will be using the correction for a swept wing. According to [1] it is need to use this correction for a swept wing since the free stream Mach number - M is not seen by the entire wing and instead the wing sees a lesser M, delaying the onset of a shock and increasing the critical M.

The lift curve slope is calculated by, [4]:

$$a = c_L^\alpha = \frac{a_0}{1 + \frac{a_0}{\pi AR}(1+\tau)} \tag{7}$$

Where τ is the correction for the swept wing depending on the AR and η-wing's narrowing.

After that the calculated value of a corrected slope is $a = c_L^\alpha = .0760$.

It is known that for the finite wing, lift curve will be lower than for infinite wing due to the 3D effects and this is reflected the numerical simulation in the presented study. Once the slope for the finite wing is known, it can be calculated the c_L for the wing. Since the airfoil is symmetrical, $\alpha_L = 0$. Then the lift coefficient is calculated by:

$$c_{l_0} = a(\alpha - \alpha_L) \tag{8}$$

The $c_{l_0} = .2328$. Using the approach in [1], the calculated lift coefficient is for the entire wing, but here it is used only a half for the numerical simulation of the low speed incompressible flow. This means that there is need to use a correction for the compressibility at $M = .8395$, [1]. Hence the lift coefficient is calculated using:

$$c_l = \frac{c_{l_0}}{\sqrt{1 - M_\infty^2}} \tag{9}$$

Using formula (9), $c_l = .4284$ for the entire wing for the half wing, $c_l = .2141$.

This is approximated value of c_l by handout calculation, the expectations here is Fluent will give something comparable but less than what it was predicted because of the presents of the shock on the wing surface.

3. NUMERICAL MODEL

3.1 Geometry

Quoting [5] the ONERA M6 wing is a swept, semi-span wing with no twist. It uses a symmetric airfoil using the ONERA D section. The wing geometry is a scaled down version matching the geometry from NASA rather than the experiment available at [2]. The half span dimension is 304.8 mm and from there it was calculated the scaling factor for the entire wing. The Table 2 describes some key geometry, the leading and trailing edge angles are measured from vertical.

Table 2 Key geometry parameters

Span (mm)	Taper Ratio	Mean Aerodynamic Chord (mm)	Leading Edge Angles (degrees)	Trailing Edge Angles (degrees)
304.8	.562	164.592	30	15.8

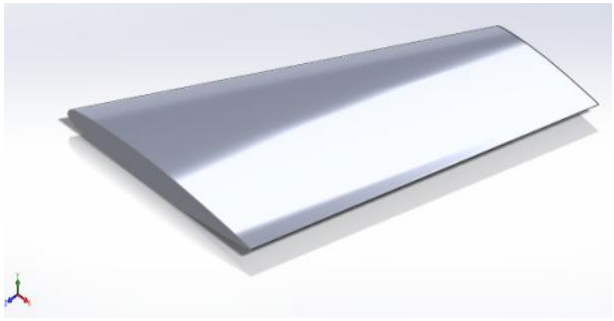

FIG.1. Wing Geometry, [1]

It is used the geometry developed in [1] and it is exported as file in ANSYS.

3.2 Boundary Conditions

Figure 2 shows the geometry and the domain around the wing in ANSYS and also the chosen boundary conditions according to [1].

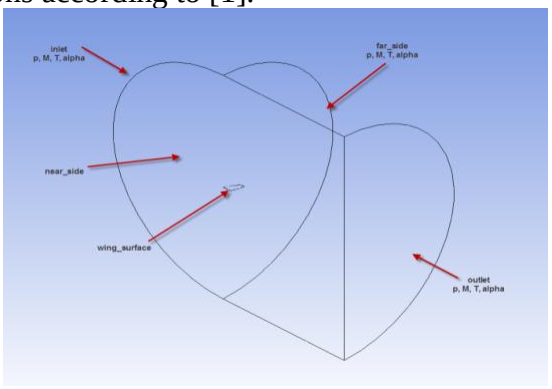

FIG.2. Geometry and fluid domain in ANSYS

Table 3 represent chosen boundary conditions and type according to [1].

Table 3 Boundary Conditions

Boundary Conditions	Boundary Type	Condition
Inlet, Far_side, outlet	pressure far-field	$p = 45.8290\,psi$ $T = 460R$ $M = .8395$ $\alpha = 3.06^0$
near_side	symmetry	symmetrical boundary
wing_surface	wall	$\nu = 0$

3.3 Mesh

Creating an accurate mesh involves a grid generation using appropriate shape cells; here the cell for the mesh is triangular. Essentially, it consists of converting the grid into a format which can be understood by the Fluent solver in order to approximate the equations of the fluid mechanics in each cell. Figure 3 shows the generate mesh around the wing and the number of cells.

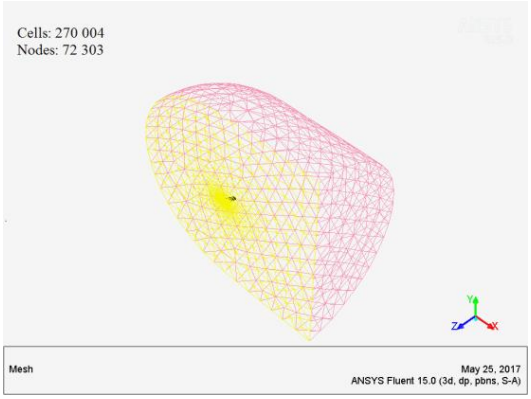

FIG.3. Mesh part in ANSYS Fluent with cells and nodes

4 NUMERICAL RESULTS

4.1 Lift and Drag coefficient

After the simulation is done, Fluent give the following values about c_l and c_d coefficients:

$$c_l = 0.11423573 \tag{10}$$

$$c_d = 0.013593919 \tag{11}$$

4.2 Pressure and Mach number distribution.

Pressure distribution

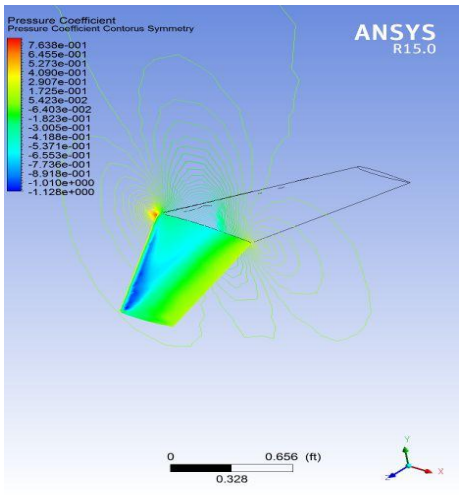

FIG.4. Pressure coefficient Contours Symmetry

Fig. 4 shows the pressure coefficient contours symmetry over the wing. It can be notice from Fig. 4 on the left side of half wing forming the shock.

After changing the view into Oxy plane, Fig. 5 it can be seen to the upper surface of the wing thin boundary layer and its thickness after the shock.

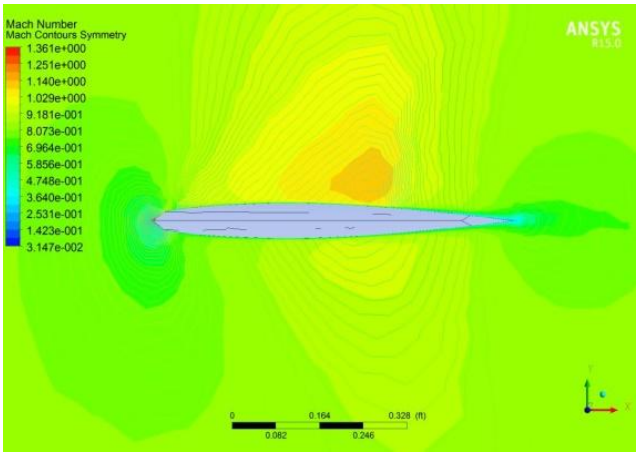

FIG.5. Forming of the boundary layer

Mach number distribution

Looking at Fig. 6 you can see where the shock was compared that to the Mach number. Quoting [8] at higher speeds, as the advancing tip Mach number approaches 1.0, its lift becomes restricted by shock-induced flow separation leading to drag.

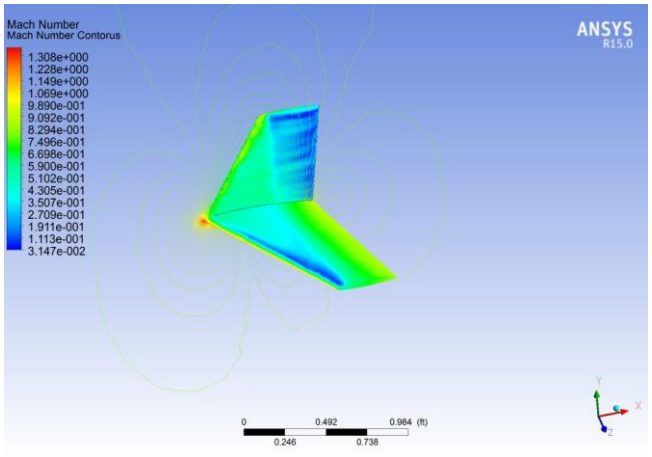

FIG.6. Mach number

4.3 Trailing Edge Vortices.

Looking at Fig. 7 it is easy to see trailing edge velocity vectors. Fig. 7 illustrated velocity vectors at the trailing edge and it can be looked along the way and the existence of trailing edge. Cities source [1] it is deduced that trailing edge vortices or lift induced vortices are a really important phenomenon when it comes to finite wings. These vortices are formed because of the finite length of the wing. The high and low pressure regions interact with one another at the wingtips and this interaction creates the vortices trailing downstream of the wing. Citied [7] the phenomenon of wake vortices is particularly dangerous in an airport because the vortices generated have a high intensity and that could lead to crashes when a plane is about to land or to take off.

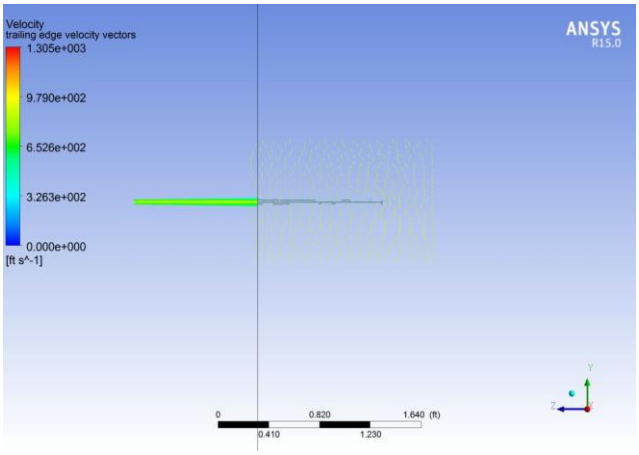

FIG.7. Trailing Edge Velocity Vectors

4.4 Plotting and Comparing the Pressure Coefficient.

Fig. 8 shows the chart of pressure coefficient - c_p and gives the results for c_p from Fluent.

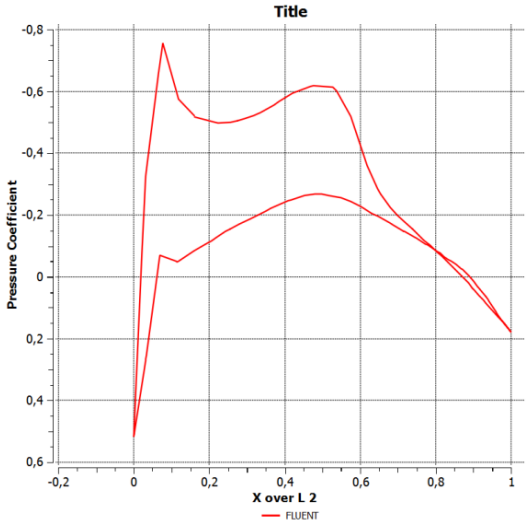

FIG.8. Chart of c_p from Fluent

Fig. 9 illustrates the comparison that was made between c_p results from Fluent and experimental data, taken from [2] citing [1].

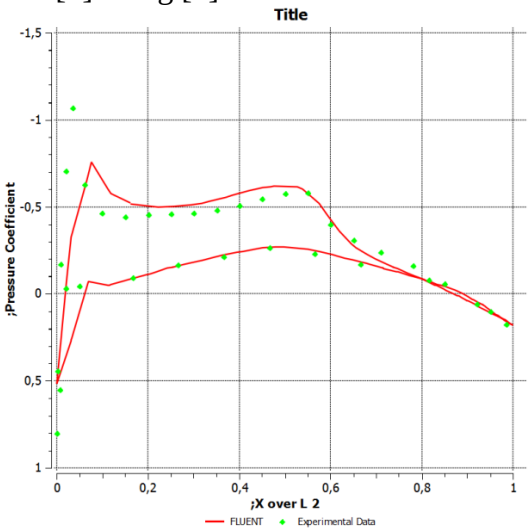

FIG.9. Comparison between c_p from Fluent and experiment

5. VERIFICATION OF OBTAINED NUMERICAL RESULTS

Citing [1] the obtained numerical results can be verified by looking at mass conservation and by comparing CFD results with those available from NASA.

At this study are used two criteria for validation and verification of the results:

1) Comparison of developed mesh for pressure parameter with both NASA and Fluent.
2) Comparison of aerodynamic coefficient of the wing c_l and c_d obtained with original mesh and NASA CFD, [2].

Fig. 10 shows the made comparison of developed mesh both with NASA and Fluent.

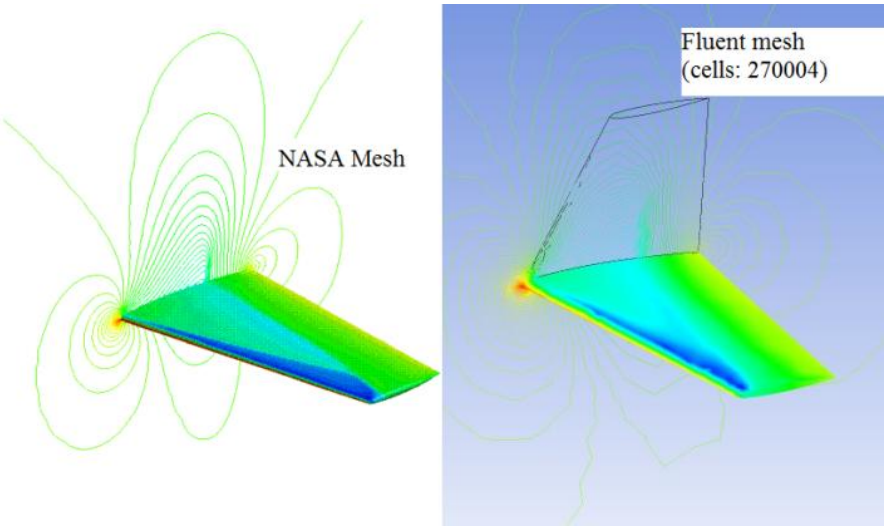

FIG.10. Mesh comparison

It can be noticed from the figure that the NASA mesh is too fine and it is clear from the streamlines in the meantime developed here Fluent mesh is consisting of 270 004 cells and it is coarse which respectively shall reflect on the results. Consequently for more accuracy it should be generated by the user more fine mesh or to use refinement techniques of Fluent.

Using the approach developed in [1] and applied it here into this study it is made a comparison of c_l and c_d obtained with original mesh and NASA CFD, [2], Table 4.

Table 4

	c_l	c_d	% difference of c_l	% difference of c_d
NASA CFD	.1410	.0088	-	-
Original mesh	0.11423573	0.013593919	23%	54%
Hand calcula-tion	.2141		46%	

6. CONCLUSION

The main conclusion that can be made onto this stage of the study is that observing the results for lift and drag coefficients shown at Table 4, the calculated percentage errors for both values are too big and it is due to the coarse mesh.

For more precision it have to be made more numerical experiments and it have to be included the technique mesh refinement.

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THE 14 JULY PARADE, OR THE MILITARY CEREMONIAL AS A POLITICAL INSTRUMENT

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1. INTRODUCTION

« *Illud autem optimum est, in quod invadi solere ab improbis et invidis audio cedant arma togae concedat laurea laudi* »[1]. This famous text by Cicero defines, once and for all, the relation that have to be set, in a democracy, between the political power - the senatorial toga - and the military force. The latter has to serve the former, so that they are able to continue their policy by other means, either to wage war, or simply "to show off muscles". In the vein of military gesticulation, there is a choice between army manoeuvres and parade; moreover the second one offers the advantage to fit into the socio-politic ceremonial by affording additional pump: by their disposal of arms, by their mass, by the quality of their uniforms and by the richness and precision of their ceremonial, the armed forces are certainly an ideal instrument to stage the political power and state strength.

In France, the most striking moment of this performance is, of course, the 14 July parade in Paris, under the presidency of the president of the republic, chief of the armed forces, and in the presence of all the constitutional bodies of the republic, as well as foreign presidents or prime ministers invited for the circumstance. The 14 July is Bastille Day, since a law of the 6 July 1880, and it implies a military march-past since the 14 July of the same year. But this national day and its military part do not appear among the symbols of the French republic as they are listed by the article 2 of the 4 October 1958 constitution, but are considered at the same level, as well as the cock, the Marianne and the Republic seal.

This institution profits of a remarkable consensus. So when Mrs Eva Joly has said, during an electoral campaign, that "it is time to suppress military march-pasts on 14 July because that corresponds to another period [attacking] this warlike France", she has found herself very isolated. Indeed, despite the tenants of this point of view, France is thought by French people as an old warlike nation, precisely, whose history is marked by a succession of victories and defeats. And it appears as evident enough that they do not wish a change.

So, it belongs to the armies to give a peculiar lustre to the Bastille Day, and it is precisely what the military ceremonial allows, majestic by nature and with an absolute precision. Until the reign of Louis XIV, it was defined by simple tradition, or even by circumstances. From that time forward, it has been defined rigorously by decree. To day the decree 2004-1101, dated 15 October 2004, "relating to military ceremonial", is the heir of this tradition.

According to its article 1, the ceremonial is split in "parades" and "military honours". It gives a foundation to the notes and particular orders of operation which precise the sequence of ceremonies.

One of these notes will be used as frame for the first part of the present study, with the objective to search the roots of the gestures with which military people pay respect to "the persons and symbols "which are entitled to them". Indeed, these gestures have a history linked to the progressive building of modern armies and they are necessarily used during the sequences of any military ceremony, from the memorial ones to authorities' funeral, to the colours ceremonies that scan the life of military units.

Even if a military ceremony may not go against the ceremonial, there exist several means to use the latter for delivering a tacit discourse: the place where it happens, the troops implied, the persons who are invited are signs that connoisseurs know how to interpret. Consequently, the second part will analyse the history of the 14 July parade in Paris, to try to show how it was used, within the frame of state's policy, whether it is simply military, or dedicated to national concord or to foreign affairs.

But before that, it imports to understand that there is a military ceremonial only if a military organization exists, with its rules, concerning ceremonies of course, but also military people's everyday life and, especially, operations managing.

If one wants to rebuild the genealogy of these instruments, it is good to use this text of Adam Smith:

"The first duty of the sovereign, that of protecting the society from the violence and invasion of other independent societies, can be performed only by means of a military force."[2]

But this military force can be build through different ways. The most immediate is the one Thucydides glorified, that is making of the citizen the last wall of the city. In case of threat, the peasant, the worker, the employee… take up arms and turn into soldiers:

"Full ten thousand heavy infantry were in the field, all Athenian citizens, (…) Then the resident aliens who joined in the incursion were at least three thousand strong".

This option is named "militia system" by Smith. But a system employing civil people can find its limits when it is not only a question of taking up arms to defend "the homeland in danger", but of maintaining watch "in any time, any circumstance and against any form of aggression"[3]. This permanence of defence action implies also a permanent presence under the colours, guarantee of absolute availability.

It is the reason why Smith is constantly praising the "standing army" system, by which the state,

" by maintaining and employing a certain number of citizens (…) it may render the trade of a soldier a particular trade, separate and distinct from all others. (…) A militia, however, in whatever manner it may be either disciplined or exercised, must always be much inferior to a well-disciplined and well-exercised standing army" [4].

In France, this system has progressively substituted for the "ost" or military service owed by a vassal to his lord. The States General of 1439, convened by Charles VII, have approved the creation of a standing army and the institution of a perpetual royal tax. This system reached its maturity under Louis XIV, what is expressed by the adoption of the uniform as a membership marker of a military corps [5].

2. THE INSTRUMENTS OF MILITARY CEREMONIAL

A parade is a sequence of manoeuvres strictly provided by the ceremonial, either "*de pied ferme*", that is to say on the spot, or in "*ordre serré*", that is in close formation. As regards to make numerous troops manoeuvre it is necessary to give precise orders and it is capital they are heard.

It is the reason why each order can be doubled by a clarion or trumpet call, for the precision of their sound [6], or by a drum roll for adding to the solemnity or for giving a precise rhythm to the troop's step [7].

2.1 ***Prise d'armes*** (taking up of arms)

Note n°…		
DEROULEMENT DE LA CEREMONIE [PRISE D'ARMES]		
Phase 1 – Mise en place		
Horaire	Autorité ou manœuvre	Ordre
9h	Mise en place terminée aux ordres des commandants de promotions	

"The *prise d'armes* (rising-up in arms) constitutes undeniably for the medieval period a gesture eminently politic, meaning that it is considered by communities as un fundamental right - the one of self defence against foreign aggressions - constituent of their very existence (…)" [8]

So it is a transgression of the interdiction of having and, a fortiori, of carrying arms. The "free men", that is the Francs, carried arms as a proof of their freedom and placed them in their tribe's service. The progressive constitution of the state has created a system where freedom has largely been abandoned, for an economic or military organization, based on the obligation, either in kind, at the beginning - fatigue or ost - or in cash later - taxes. Nevertheless the free man accepts only reluctantly to lose this eminent freedom to defend himself "*en prenant les armes*" (rising up in arms), when his security is no longer guaranteed by the armed forces and a fortiori when these forces are the cause of insecurity. If the *prise d'armes* is then understandable it remains illegal, so that the sovereign has to choose between repression and legitimation. In 1439, Charles VII had to edict a decree « *pour obvier aux pilleries et vexations des gens de guerre* » (for staving off pillages and humiliation of warriors), promising immunity to those who would have risen-up in arms and killed looters[9].

Of course the interdiction has no reason to apply to "men-at-arms", and especially to this peculiar caste that is the old nobility, for whose carrying arms in all circumstances is a privilege almost without exception:

« Ouy sur ce le Procureur Général du Roy, a été arresté que ledit suppliant Conseiller ceans, & Connestable de France , sera receu au *Serment de Pair* à cause dudit Duché de Montmorency, sans que lors dudit Serment luy soit besoin laisser son épée de Connestable. »

Nevertheless these ones also can sometimes commit a *prise d'armes*:

« L'Auteur [Louis de Gonzague, Duc de Nevers] y justifie Henri III de toutes les calomnies dont tous les Ligueurs tachoient de noircir sa réputation, & il y désabuse ceux qui s'étoient engagés à *prendre les armes* contre le Roi, sous prétexte de défendre la Religion »

If the *prise d'armes*, in this meaning has always existed, the word itself was coined only at the end of 17th century and would have taken the meaning of "parade" one century and a half later. The reason of that is simple: if the old nobility carried arms late enough, soldiers had no reason to carry a gun in all circumstances, especially because it was a cumbersome weapon, heavy and potentially dangerous. They had to take up arms in an armoury or on the rack of their barracks only in response to the call "to arms", for an exercise or, precisely, for a ceremony: « Le régiment des Vaisseaux qui, par hasard, *prenait les armes* pour une revue, fut le premier en action et souffrit beaucoup. [10] » It is evidently still the case today.

1.2. *Garde à vous !* (Attention!)

Phase 2 – Inspection des troupes		
Horaire	Autorité ou manœuvre	Ordre
9h05	Commandant en second des troupes (CT2)	« Garde à vous ! »

The command "garde à vous" appears in 1683 in the *Exercice que le Roy a réglé pour toute son infanterie* [11]*:* « Prenez garde à vous, pour rompre le Bataillon ». Logically, it is found then in the following edicts *pour régler l'exercice de l'infanterie.* For instance in 1764 :

« Lorsqu'un bataillon étant en bataille sur trois rangs serrés, on voudra les faire ouvrir, on fera les commandemens suivans :

I - *Prenez garde à vous* pour ouvrir les rangs en avant.

2 - Marche.

Le premier commandemens ne servira que d'avertissement » [12].

It is then understandable that « *prenez garde à vous* » is equivalent to « *Attention* ». Twelve years later a new edict makes the meaning of this expression to evolve:

« On accoutumera le Soldat à l'immobilité, il la prendra aussitôt qu'on lui fera le commandement : Garde=à vous. Il la conservera jusqu'à l'avertissement : Repos » [13].

But the text does not precise what position takes the one who is *immobile* (motionless). This is confirmed by the detailed analysis of the orders for the arms inspection:

« I Garde--à vous ; 2 Inspection--des armes (temps I ; mouvement I) »[13].

So it is clear that the order *garde à vous*, for which no time nor movement are provided, remains a simple call to attention with a requirement of stillness.

Having kept this meaning until now, this order appears as a first mean to pay respects; it is aimed at all the military people present, including those who do not carry arms for the ceremony.

2.3. *Présentez armes !* (Present arms!)

9h05	CT2	« Garde à vous ! » « Présentez armes ! »
	Arrivée du commandant des troupes (CT) et inspection	

This new command, more than the precedent one, is clearly today a mean to pay respects. A proof is find in the fact that when decorations are presented, only the recipients of *Légion d'honneur*, the first order of French Republic, are entitled to this position of troops.

It could be possible to imagine that, at the origin, the command "*présentez armes*" concerned the inspection of the weapon by a superior. In fact it is not the case, as it appears in the edicts already mentioned, because the only preparing commands are "*garde à vous*"; "*inspection des armes*"; possibly "*baïonnette au canon*".

On the other hand, this famous command is present in the exercise regulations since 1683 at least. But the function of this command is unclear as in this example:

« Après quoi, si l'on veut poser les armes, on dira.

Demi tour à droit.

Présentez vos armes.

Marche.

Les Tambours battent le Drapeau, & l'on pose les armes aux faisceaux. » [12]

In the edict of 1776, which "*ne devoit comprendre que ce qui doit se faire et s'exécuter à la guerre ; (...) retrancher tout ce qui est de parade* », one finds this order among the three one marking the end of a shooting sequence, after the setting of the cock "*en son repos*" (secured) and between two "Portez vos armes" (carry your arms):

« Second mouvement.

Achever de tourner l'arme avec la main droite pour l'apporter à-plomb vis-à-vis l'œil gauche au milieu du corps, la baguette en avant, le chien à hauteur du dernier bouton de la veste, la main droite empoignant l'arme au dessous & contre la fougarde ; l'empoigner en même temps brusquement avec la main gauche (…) »[14]

Nevertheless this position is already an instrument for payng respects, either to the flag or to a person « who is entitled to be saluted » :

« Lorsque la personne qu'on devra recevoir se sera approchée, & qu'elle se présentera pour parcourir le front du régiment, si elle doit être saluée, les Tambours battront, les Soldats présenteront leurs armes… »[14]

In France like eslsewhere, the movements responding to « *présentez armes* » have changed with the evolution of the weapons caracteristics : a contemporaneous assault rifle is not presented like a semi-automatic rifle of the 50s, and a fortiori like a musket of the 17th century.

2.4. *Revue des troupes* (troops review)

Phase 3 – Honneurs au drapeau		
Phase 4 – Arrivée des autorités et revue		
9h15	CT	« Garde à vous ! » « Présentez armes ! »
	Arrivée des autorités : Le CT va à leur rencontre et les salue à 6 pas, puis se place à droite, légèrement en arrière.	
	Arrivée des autorités : Le CT va à leur rencontre et les salue à 6 pas, puis se place à droite, légèrement en arrière.	
	Les hautes autorités militaires saluent le drapeau	Hymne national
	Le chef d'état-major et le commandant de l'école accompagnés par le CT passent les troupes en revue en commençant par la musique de l'air.	La musique joue la Marche des soldats de Robert Bruce.

The review of the troops has for origin the counting and inspection of the military people having to receive their pay. This function was effected by the "*commissaires aux montres et revues*". They had to verify periodically the strength of the units under their control, that is men, horses and equipment. They drew up the unit's muster roll so that the global pay of the unit could be confided to the commander on condition of distributing to the men according to their ranks.

To do that the *commissaires* convoked *montres* during which the troops where ranked fully equipped and *montrées* (shown). So it was possible to verify the identity of the present men, their ability and their equipment:

« Nous François Lucas, chevalier, seigneur de la Rochecesson, conseiller et chambellean, et Jehan de la Primaudaye, notère et secrétère du roy notre sire, commissaires dessus nommés, certiffions aux gens des comptes dudit sire et autres à qui il appartiendra avoir vu et visiité par forme de *monstre et revue* les 232 gens de guerre à pié dessus nommés et escripts par nom et prénom estant soubz la charge et conduite dudit Jehan Pigasse, escuier, leur cappitaine, sa personne en ce comprise : lesquels nous avons trouvés en bon et suffisant estat et habillement de guerre, cappables d'avoir et prendre chacun d'eulx la somme de 15 sous tournois à eulx ordonnés par ledit sire pour leurs gaiges et souldes de 15 jours entre commençant ledit 26ème jour de juillet. En tesmoing d'eulx nous avons signé ce présent rolle de nos noms, les jour et an dessusdits : (the exhaustive list follows). »[15]

But if he feared a falsification, the commissaire could want to see again the same troop [16]. It is the reason of the word "*revue*" (review), with the meaning that the same troop was going to be "passed in review". And for that the *commissaire* may ask that the troop *défile* (march-past), to detect the lames, unfit for war. It is the reason why *revue* (review or parade) and défilé (parade or march-past) are synonymous.

2.5 *Ouvrez le ban; fermez le ban* (open with clarion call (?)

Phase 5 – Remise de décorations		
9h20		« Garde à vous ! »
	Les récipiendaires sortent des rangs et se placent face au CEMAA à 10 pas du drapeau.	« Récipiendaires, sortez des rangs »
		« Portez armes »
		« Ouvrez le ban »
	Le CEMAA procède à la remise…	« Fermez le ban »

These two commands very esoteric mark the particular ritual by which the principal military authority of the ceremony proclaims an order of the day (for instance anniversary of the creation of the Ecole de l'air), a solemn declaration (for instance reading of the Appeal of the 18 June of general de Gaulle) or, like here, the presentation of decorations.
The ceremony of *ban* was practiced during the Early Middle Ages, by the Frankish tribes. During this, the tribe's men decided about war. The word itself is known by the *Histoire des Francs* of Grégoire de Tours, under the low-Latin form "bannus" with the meaning of fine:

Ensuite le roi Chilpéric ordonna que les pauvres et les serviteurs de l'Église payassent l'*amende* pour n'avoir pas marché avec l'armée. Ce n'était pourtant pas la coutume qu'ils fussent soumis à aucune fonction publique.[17]

"For not having marched with the army" means they have not respected the ost, that is the mandatory armed service owed by the vassal to his lord. So the king's army was made of the circle of his first vassals and, through them, of their own vassals, or *arrière-vassaux*. These two groups are respectively named *ban* and *arrière-ban*. This meaning has been used until the 19th century, for designating the men able to be called to the armed service, by order of growing age: 1st, 2nd, 3rd… bans. But it is with a meaning derived by extension, that this word is used today in the French armed services:

« Nous vous mandons, commandons et très expressément enjoignons, incontinent la présente reçue, que vous ayez à faire publier à son de trompe et cri public, par tous les lieux et endroits de votre ressort et juridiction accoutumés à faire cri et proclamation. Que tous Nobles, vassaux et autres sujets à notredit ban et arrière-ban (…) aient à se trouver en la principale ville de votre ressort au dernier jour du mois de Mai prochain, montés, armés et en tel équipage qu'il est porté par nos Ordonnances, pour marcher et nous faire le service requis, quand il leur sera par nous mandé et ordonné »[18]

So the *ban* could be the most ancient element of the French military ceremonial.

2.6. *Mise en place pour le défilé* (deployment for the march-past)

Phase 6 – Lecture de la citation de l'Ecole de l'air		
Phase 7 – lecture de l'ordre du jour		
Phase 8 – Défilé		
		« Garde à vous »
		« Mise en place pour le défilé »

All parades do not end by a march-past, but when it exists, it is most often the highlight of the ceremony. It is especially the case for the 14 July parade in Paris.

3. POLITICAL USE OF THE MILITARY CEREMONIAL

Curiously the 14 July has become Bastille Day during the spring of 1880 almost by default. There had been precedents: *Fête de la Fédération* in 1790 and 1792; military ceremonies of the *Directoire* between 1795 and 1799, but the 1st and 2nd Empires and the Restoration had deliberately forgotten them.

On the other hand, in 1879, the Third Republic, finally consolidated, needed symbols all the more because it wanted to be lay; only the republicans could want a national holiday on the 14 July; they needed a military celebration for marking the coming back into favour of the armed services and the sealing of their new link with the nation and their acceptation of the republic. After a difficult debate, as the issue was important and the possibilities numerous, the private bill of the deputy Benjamin Raspail is voted by the *Assemblée nationale* on the 8 June 1880 and by the *Sénat* on the 29, the law is promulgated on the 6 July. The same day a decree institutes the principle of a parade as one of the constitutive elements of the holiday.

In itself, the parade escapes policy, since determined once and for all by the military ceremonial. It is what could be called "the intangibles". On the other hand, the political power keeps a hand upon some elements of great importance: the parade's place, the choice of nature and number of the troops having to participate, including foreign troops; the identity of chiefs of state and prime ministers invited for the ceremony. It is evident that the decisions on these topics are political gestures.

3.1. The intangibles of a parade

Bastille day or not, the 14 July in Paris respects scrupulously the military ceremonial: deployment of the troops; inspection by the respective commanders; authorities' arrival; salute to the colours; review of the troops; march-past in front of the authorities.

About the march-past, it is important to know its own genealogy. It is purely a manoeuvre "*en ordre serré*" (close order) for a troop of infantry or even of cavalry. During the second half of the 18th century, this question has been a subject of debates, sometimes violent, between the supporters of "*ordre profond*" (deep order) and those of "*ordre mince*" (thin order). The former was the mean to resist to the clash of the cavalry; the latter reduced the vulnerability to artillery battering. Anyway the battle order is permanently maintained and the whole troop manoeuvre together, according to a technique learnt for long and repeated incessantly:

« Les Sergens de Grenadiers et de piquet, qui fermeront la droite ou la gauche du régiment ou du bataillon, feront à droite & à gauche, quand les Officiers feront demi-tour à droite ; & marcheront de même quand on appellera, pour se placer à douze pas des flancs du régiment ou du bataillon ».[19]

This codification is one of the elements explaining the expression "*troupe réglée*" (standing army), since for these troops there exists manoeuvre regulations for cavalry as well as infantry.

The passing from *ordre serré* to *défilé* (march-past) is the result of a tactical necessity, that is make a troop pass through a *défilé* (gorge). The *Exercice* of 1683 is too brief to treat in detail of troops movements. It is different for the edict of 1750 which explains how a marching troop has to approach a gorge and fall into line again:

« Lorsque le régiment étant en marche, il aura à passer quelque défilé qui l'obligera *de rompre ses rangs, la droite du premier rang passera la première*, la gauche ensuite, & ainsi des autres rangs ; & le Commandant, de même que le Major, auront attention de faire reformer les rangs à la sortie du défilé, ralentissant la marche pour donner le temps à la queue de joindre. » (p.16)

The edict of 1776 is the only one to treat the march-past as an instrument of the ceremonial and it shows well that the tactical manoeuvre as helped to organize the honour march-past:

Lorsque le régiment devra défiler, il se *rompra à droite par division ou par peloton*, les Officiers gardant les mêmes places qu'ils occupent dans les colonnes. (…) On observera que les têtes soient tournées, & les files des ailes alignées sur le côté où sera la personne devant laquelle on devra défiler. » (p.364)

These intangibles being known, the march-past design permits a lot of variations acquiring, evidently, a political meaning.

3.2. Where to march-past?

This question can appear as unimportant, only linked to the practical aspects of a ceremony mobilizing a lot of people. That would be forgetting the Parisian geography is profoundly marked by history but also, instantaneously, by socio-economical determinants: in terms of political meaning, the *place de la République* is not the *place de la Concorde*, and the 7th district is not the 19th. In these conditions, the choice cannot, volens nolens, be cleared of any suspicion of political motives.

The *Fêtes de la Fédération* in 1790 and 1792 took place on the *Champ de Mars*, between the *Ecole militaire* and the river Seine. Of course the *Champ de Mars* was by definition a field of manoeuvre, but the decision was commanded essentially by practical reasons: how to gather several hundred thousand people not for a march-past, but for a civic cult (in the centre, Talleyrand will celebrate a mass with 300 priests)?

March-pasts of the Directoire have not, it seems, left any trace, so that one has to go to the 14 July 1880 for seeing the beginning of the tradition. One more time, the place was chosen for practical reasons. It was impossible to return to the *Champ de Mars* because all the facilities built in 1790 had been razed during the Second Empire. And the organizers needed a vast space able to accommodate numerous troops and as many spectators as possible, and they needed it quickly: "*We will find a mean to replace the Champ de Mars. A people always find a mean to express what they have in heart and mind!*" Consequently they chose the racecourse of Longchamp for the military part of the festivities of the *Troisième République* first Bastille Day. So, until the 14 July 1914, the Parisians, at least, will be able to say and sing:

« Gais et contents
Nous marchions triomphants
En allant à Longchamp
Le cœur à l'aise
Sans hésiter
Car nous allions fêter
Voir et complimenter
L'armée française. »[20]

The 14 July 1919, Victory Day, needed a more imposing production, at the level of the sacrifices consented. Nevertheless it was not evident that the victory ought to be celebrated this very day, since the different parties were not in agreement: socialists wished to associate the victory to the commemoration of Jean Jaurès' murder, on the 31 July, and catholics wanted that the Victory Day coincide with the Sacré Coeur church consecration, between the 16 and the 19 October. Eventually, Clémenceau's government chose the more significant date for the whole French nation, the 14 July.

It remained to choose a precise scene. For celebrating a victory and the most prestigious victors - three field marshals of France - why not the Roman tradition of triumph, with a march-past on a prestigious course passing under an arch of triumph? It is certainly why the course *Porte Maillot-Place de la République,* through the *Champs Elysées* and the *Arc de Triomphe de l'Etoile*, was chosen. Anyway, the course through the *Champs Elysées* has become traditional until now, so that the political gestures in this field consist only in hour changes, adding of civil march-pasts or military displays and, exceptionally, in rerouting.

In this way, on the 14 July 1940, the "official" march-past was transferred to London, on Buckingham road, and under general de Gaulle's presidency. Even if the Free French had technically no alternative, the simple fact that a French military march-past took place in the London's streets, under the applause of Britannic people, took indisputably a strong political meaning.

The Second World War will cease early enough during the year 1945, for the Bastille Day to be of the same vintage. One more time the ceremony had to be grandiose for France to find again its pride scorned by the 1940 debacle. Consequently the same itinerary as the one of 1919 was used but with a considerable lengthening, at least for the mechanized troops: from the *Arc de Triomphe de l'Etoile*, to the *Place de la Nation*, that is six times longer, with an official stand on the Place de la Bastille, a highly symbolic scene.

Finally, if new scenes were chosen, it was by Mr Giscard d'Estaing. Pretending to rejuvenate France in every domain and give to it a less starchy image, the youngest president of the 5th Republic has shifted the march-past four times in relation to the traditional axis: from the *Place de la Bastille* to the *Place de la République* in 1974; the reverse in 1979; *Cours de Vincennes* in 1975; and *Avenue de la Motte-Piquet* in 1977. These choices appear as signals to the "people" of Paris, nay to the "Left wing people", since the triangle *République-Bastille-Nation* is the golden triangle of the republican idea in Paris. And if the avenue *de la Motte-Piquet* belongs to the "good" 7th district, it borders also the *Champs de Mars*, where the *Fête de la Fédération* took place in 1790 and 1792. Unless it appears as a provocation, the armed services marching upon the same roads as the demonstrators supposedly "left-wingers".

3.3. What arrangements for the march-past?

The arrangements of the parade concern first the number of the troops on foot and the one of rolling or flying vehicles. Their number and their modernity are determinant elements of the "muscles show-off" mentioned above. And their presentation is a magnificent window of the French know-how supporting the arms export policy.

The arrangements of the 1880 parade imported much to the republican government, which wanted substitute a lay ceremonial for the religious one. But they had another reason to look after this ceremonial, since, celebrating the nation, they wanted also to get closer to an army of which the officers where predominantly royalists… and catholics. This particular ceremony carried the bringing closer of the nation and its army thanks to a symbolic gesture: the presentation to the army of the flags replacing those abandoned as a tribute to the Prussian army in 1870 and 1871. It was the role of the President of the Republic, Jules Grévy, to make this presentation since he "disposes of the armed forces" by the article 3 of the 1875 constitution. The particular stagecraft of the ceremony described by the famous painting by Edouard Detaille, was a consequence of that.

For both Victory parades, it was important to do "great". In 1919 the theme was the respect to the dead and injured (one thousand crippled at the head of the columns) and to show off the strength of French armed forces, territorial or colonial - battle tanks included. In 1945 it mattered to show that all the equipment was not all American:

« Nous eûmes pourtant la joie d'admirer, en queue du défilé, un matériel neuf important de fabrication française, vivant témoignage du début de notre renaissance industrielle »[21].

The march-pasts of 1936 and 1981 were awaited since they implicated left-wing governments, after a long unbroken period of right-wing majorities. Those who predicted a pacifist tendency have been disappointed: in both cases the parade has been traditional. If the *Front populaire* had added a civil march-past in Paris, the Union de la gauche preferred a meeting of military and civil people on the Reuilly lawn[22].

In 1959, the first parade of the 5th Republic, presided by general de Gaulle like the one of 1945, has been the opportunity to affirm France's military strength: not less than 14 000 soldiers have marched on the Champs Elysées. They were 10 000 for the accession of Georges Pompidou. It was the times of "big battalions". There was only 3 500 soldiers in 2015, simply because the conscripts had disappeared, the French armed services had been severely slimed down - public debt *oblige* - and they were engaged in overseas operations.

In 1974 there was only a march-past on foot, probably by solidarity with the people affected by the "oil clash".

In 1959, the march-past showed a French army "between atomic bomb and bayonet"[23], meaning that their equipment was still largely inherited from the Second World War. General de Gaulle has done what was necessary and his successors have assumed the legacy: every now and then the successive presidents recall that France is a nuclear power: 12 Mirage IV and 6 tankers in 1965; a carrier truck for SSB missiles in 1971; armoured carrier vehicles for Pluton missiles in 1981; Mirage 2000 N in 2015…

2.4. March-past with whom and in front of whom?

The diplomacy has known how to use le 14 July tool for giving proofs of France's "good will" for allies and partners. Normally the invitations of foreign troops or of chiefs of states or chiefs of governments appear natural, commanded only by some anniversary or other. But it happens that the intelligentsia or the people are hostile to such an invitation: in this case policy has to find a compromise.

It would not have been conceivable in 1919, not to associate the Allies to the march-past: so foreign delegations were drawn up at the head of the troops in alphabetic order. In 1945 other allies had the place of honour: those of French "possessions", which had accepted to combat at the side of the colonial power; on the official stand were seated, around the general de Gaulle, not only the Lord Mayor of London, but also the Bey of Tunis, installed by the Free French in 1943.

It is only in 1994 when foreign soldiers marched-past one more time on the Champs Elysées: they were German soldiers and it was 54 years after the defeat, but these ones belonged to the Eurocorps and celebrated the French-German reconciliation. In fact it is in 1999 that the first autonomous foreign detachment has been seen: Moroccan soldiers have marched-past in front of president Chirac and king Hassan II, to mark a cultural event: "*Le temps du Maroc*". Brazil has had its "year" in 2005 and several Brazilian units have been inserted in the parade. In 2002 it was cadets of West Point academy. In 2004 British soldiers have come to celebrate the "*Entente cordiale*" centenary. And they have come back in 2007 with 26 other European delegations to celebrate the 50th anniversary of the treatise instituting the Common market. In 2014, 77 national flag parties participated to the celebration of the First World War centenary.

But the presence of foreign military people or chiefs of states is not always approved by the public opinion. The first invitation for Morocco in 1990 had to be cancelled because of numerous critics formulated against Hassan II by journalists or other opinion leaders [24]. In 2014 the presence of Vietnamese and Algerian troops among the Allies for the 70th anniversary of the Liberation provoked veterans' anger. The presence of Bachar el Assad in 2008 and of Enrique Peña Nieto in 2015 has raised a lot of questions in the press, in relation to breaches of public liberties in both countries. But diplomacy has its constraints and priorities, ignoring the sensitivity of a part of the public opinion or the media.

4. CONCLUSION

The 14 July parade in Paris is a military ceremony strictly regulated by a ceremonial having its roots very far in France's military history. It is different of other parades only by the number of soldiers mobilized, by their membership to all military corps, what is possible only under the presidency of the chief of the armies, the president of the republic himself. Seen by millions of people throughout the world, this parade is an ideal instrument to transmit political signals.

Of course it is possible to use the march-past to communicate with the people of Paris, knowing the part they take in the history of the whole country. For that it is enough to reroute at least a part of the celebration toward one district or another.

The principal signals are in the field of France's military policy. The march-past is not only an intangible ritual, with the cadets of military academies, the firemen of Paris and the Foreign legion's band. It is also a window showing the troops engaged in overseas operations, new armaments given to the armed services, as a support to arms exports. This military policy is one of the basis of foreign policy, helping to settle conflicts, especially when the use of force is needed.

But the parade can only be a mean to honour friends, allies and the different partners of the country, and it is all the more so that the march-past is more imposing and better regulated. It is the function of military ceremonial.

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INFLUENCE OF THE NUMBER OF VORTEX ELEMENTS ON THE STABILITY AND ACCURACY OF THE NUMERICAL SIMULATION FOR A ROTOR IN HOVER

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Abstract: *Numerical simulations based on vortex models are very sensible from both the number of vortex elements and the initial conditions. The aim of this study is to evaluate the influence of the number of the vortex elements, modelling the wake, on the stability and accuracy of the numerical solution for the performance of a rotor in hover. For each computational case the number of the vortex elements varies from the number of blades per rotor and from the number of the emitted vortices per blade, which are taken into account. It was observed that larger series of vortex rings provide more accurate results, while a quicker convergence of the numerical solution is achieved with a smaller number of vortex elements. The use of time-stepping predictor-corrector scheme of second order, contributed for an increased stability of the simulation of the convection and propagation of the free-wake in the computational domain. The numerical results are compared against previously obtained experimental data for a model rotor.*

Keywords: *rotor; hover; rotor wake; flow-field; induced velocity; vortex ring; vortex cylinder;*

1. INTRODUCTION AND STATE OF THE ART

Unmanned air vehicles (UAVs) have recently become increasingly popular amongst civilians, scientists and the military. Regardless of their size and utility, those are mainly divided into two major groups: fixed-wing and rotary-wing vehicles. The main difference between the two types of air vehicles is the way they produce lift and their aims of directional control.

The main advantage of the rotary wing UAVs is the possibility to perform hover. Widespread are the multi-rotor flying platforms, especially the multicopter (one of which is the quadcopter), which have one rotor at each corner. This configuration became very popular due to the possibility to achieve easy balance and control of the flying platform.

Whatever the purpose of a rotary wing UAV, whether it is a main-rotor/tail-rotor configuration or it is a multi-rotor configuration, there are two possible approaches for the control of their propulsion systems: to vary the rotational speed of a rotor with a fixed geometry or to change the pitch angle of the blades of the rotor, which operates at a constant rotational speed. Both control approaches produce the same result, as any increase in the rotational speed of the rotor or the pitch angle of the blades increases the produced thrust, while any decrease in both control inputs decreases it.

Regardless of the applied control method for the thrust production of all major rotary-wing based UAVs, their rotors operate in unsteady conditions due to the fact they are rarely performing long lasting hovers in zero wind conditions.

The typical flight utility of the rotary-wing vehicles is such that they are constantly maneuvering or performing thrust adjustments, in order to maintain stable flight or hover, while compensating for atmospheric disturbances. Thus of great interest is the rotor performance during transient and unsteady operating regimes, which are produced by rapid changes in the rotational speed of the rotor or by significant sudden changes of the pitch angle of the blades of the rotor.

As shown by Leishman in [1], the blade element momentum theory allows for the rapid computation of the forces acting on the blades of a rotor, thus allowing for the rapid evaluation of the overall rotor performance. However, in order for a BEM model to provide accurate estimations, the exact radial distribution of the induced speed must be known and the appropriate tip-loss corrections must be applied.

As shown in [2, 3, 4 and 5], the application of the vortex theory allows for the computations of the induced velocity field in all the computational domain around the rotor, including for the plane of the rotor. This provides accurate data for the radial distribution of the induced velocity, which is then used by the BEM model.

In [6, 7 and 8], demonstrated is the ability of the vortex models to compute the exact geometry of the rotor wake. In [9 and 10], shown are the positive effects from the use of predictor-corrector algorithms on the stability and accuracy of the numerical solutions for the wake geometry of rotors in hover.

Thus, by coupling a BEM model with a vortex model and with the introduction of a time-step marching algorithm, it is possible to obtain a valuable numerical tool, which allows the possibility to study the rotor performance in unsteady flow conditions, resulting from the transition from one operating regime to another or from phenomenons, such as the tip vortex aperiodicity of a hovering rotor [11]. In [12] is shown the capability of such a coupled BEM-vortex numerical model to adequately predict the airload of the blades of the rotor both in hover and in forward flight.

2. NUMERICAL MODEL

Modelling the wake of a hovering rotor with a combination of different types of vortex elements for different segments of the wake is demonstrated in [2-12]. The comparison study is performed with the vortex model proposed by Miller et al. in [12]. In the remainder part of the article it will be referred as the Miller model.

The wake of the Miller model consists of two parts: a near wake composed of 20 circular vortex rings arranged in series downstream of the rotor; and a far wake modelled by a single semi-infinite vortex cylinder, placed behind the last vortex ring of the near wake. Thus the model consists of only 21 vortex elements to be accounted for the computation of the entire flow-field around the rotor.

The semi-infinite vortex cylinder allows the model to compensate for the velocity deficit formed downstream of a wake when modelled with a series of vortex rings. It allows to stabilize the numerical computation and ensures that the induced velocities in the far wake double those induced in the rotor plane, such as per the theory for the hovering rotor.

Key for the degree of accuracy and the adequate operation of the model is the proper setup of the parameters d_0 and d_1, shown on Fig. 1.

The distance d_0, at which the first vortex ring is placed behind the rotor, has a key role for the distribution of the induced velocities along the blade. It is referred in [12] as the first blade-vortex encounter position, which represents the distance between the vortex ring emitted by the preceding blade and the following blade.

This parameter can be varied, in order to study its influence on the induced velocity distribution on the blades and in the near wake downstream of the rotor.

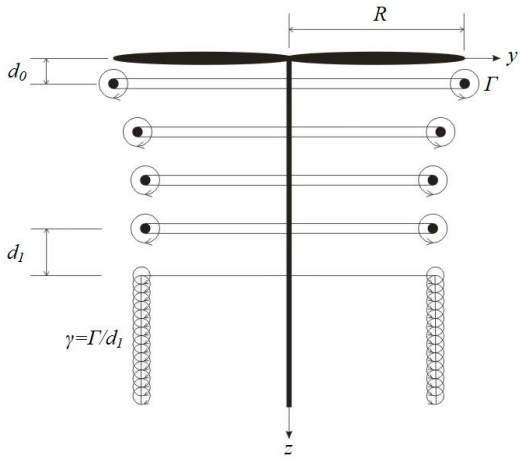

FIG. 1. T Schematic representation of the arrangement of the vortex elements for the Miller model.

The distance d_1 is the spacing between the last vortex ring of the near wake and the semi-infinite vortex cylinder, which models the far wake. The optimal values of the parameters d_0 and d_1 are estimated in a comparison between numerical and experimental data for multiple operational regimes of the rotor.

The Miller model offers the potential for rapid computation of the velocity flow-field around a rotor, when compared to CFD models, due to the necessity to perform significantly smaller amount of computations by solving only few thousand simple elliptical integrals, instead of few hundred thousand Navier-Stokes equations. An additional reduction of the volume of numerical computations is possible for hover and vertical flight regimes due to the presence of axis-symmetric flow condition for the rotor.

3. NUMERICAL STUDIES

The performed numerical study aims to evaluate the stability and accuracy of the free wake model with regards to the different number vortex rings, used to .

Computed are the mutually induced and the self-induced velocities between the vortex elements modelling the wake. The induced velocities on each vortex element are then used to compute its new position in the wake for the next computational time step Δt. Thus, the vortex rings propagate in the numerical domain and take the necessary geometry arrangement, in order to adapt to the latest flow conditions.

Once the solution has converged and the equilibrium arrangement of the vortex elements is obtained, then the distribution of the induced velocity V_z along the blades is computed. Thus, by knowing the angular velocity of the rotor Ω and the pitch angle of the blades θ, it is possible to determine the aerodynamic forces acting on the blades. Those forces are used for the computation of the net trust T produced by the rotor and the required mechanical power P for the rotor to perform hover. This computational cycle repeats itself for each time step Δt of the simulated time-period. The described algorithm is shown on Fig. 2.

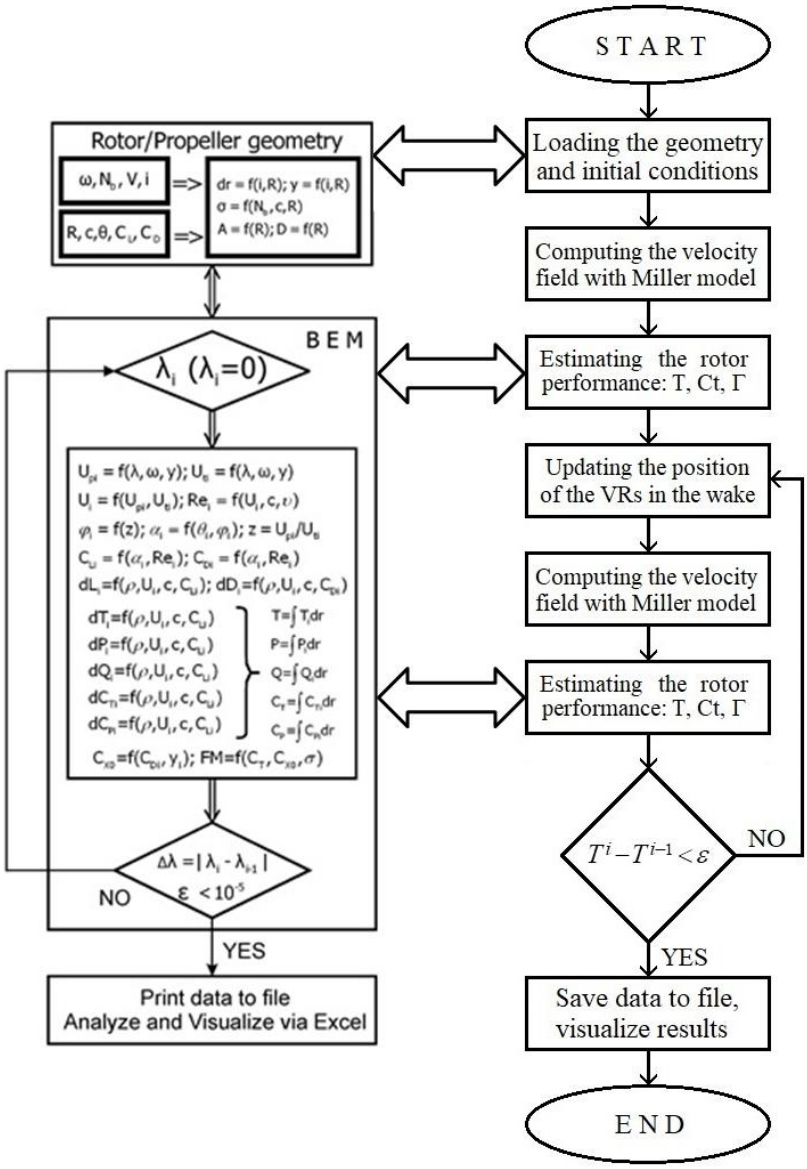

FIG. 2. Algorithm of the coupled BEM-vortex model.

By keeping constant the values of both the angular velocity of the rotor Ω and the pitch angle of the blades θ, the numerical model is evaluating the rotor parameters in hover flight. However, the presented program module is also capable of studying the rotor performance in smooth transition from one operational regime to another, as well as for an abrupt step-change of the pitch angle of the blades θ.

For this present study assumed is a stable hover, which is a hover performed in zero wind conditions. The results from this study are presented in section 5 "Results from the numerical study".

The model rotor, which is used as reference geometry in those studies, has two rectangular untwisted blades of NACA0012 profile. The tip radius R of the blades is 288mm, the root radius at the hub mounting r_0 is 65mm and the chord length c is 25mm. The pitch angle of the blades θ is adjustable and thus can be varied between wind tunnel experiments.

Shown on Fig. 3 is the velocity triangle in a typical cross-section of the blade. The velocity of the axial flow through the plane of rotation, resulting from the work of the rotor, is denoted with V_z.

In the literature it is referred as the axial induced velocity and is a function of the operational parameters of the rotor, namely the angular velocity Ω and the pitch angle of the blade θ. The speed of rotation of the section in the plane of the rotor is denoted with $U = \Omega y$, where y is the blade station radius, which varies from r_0 to R. For the tip of the blade $y = R$ and $U = \Omega R = V_{tip}$. The relative air speed for the cross-section of the blade W is computed with (1):

$$W = \sqrt{U^2 + V_z^2} \,. \tag{1}$$

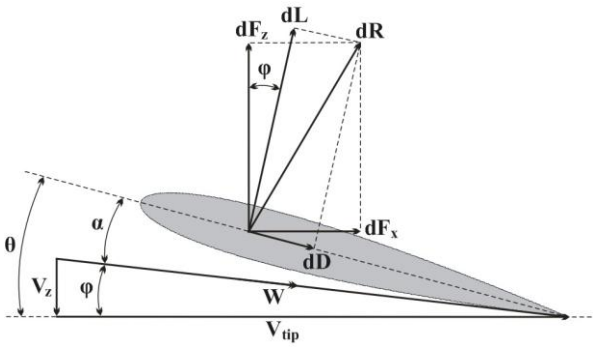

FIG. 3. Triangle of velocities in the cross-section of the rotor

3.1 Numerical approach

According to [11], by assuming uniform bound circulation and a single tip-trailing vortex per blade, the vortex strength can be computed with:

$$\Gamma = \frac{2T}{\rho N_b R V_{tip}} \,, \tag{2}$$

where T is the total thrust produced by the model rotor at a fixed angular velocity Ω and pitch angle of the blades θ. R is the tip radius of the blades, $V_{tip} = \Omega R$ is the velocity at the tip of the blades, N_b is the number of blades of the rotor and ρ is the density of the air.

For every change in either the angular velocity Ω or the pitch angle of the blades θ, the total thrust of the rotor T and the bound circulation Γ are also changed. Equation (2) is used for the computation of the bound circulation Γ.

In [1] the coefficient of thrust C_T is defined as:

$$C_T = \frac{T}{\rho A \Omega^2 R^2} \,, \tag{3}$$

where T is the total thrust produced by the rotor; ρ is the density of the air; Ω is the angular velocity of the rotor; R is the radius of the rotor and $A = \pi R^2$ is the area of the rotor disc. Equation (4) is used for the computation of the coefficient of thrust C_T.

From Fig. 2 it can be observed that for an increase of the axial induced velocity V_z there is a decrease of the angle of attack α. The smaller is the angle of attack of the cross-sectional airfoil, the smaller is the local thrust increment ΔF_z. Thus the total thrust of the rotor T reduces and with it reduces the coefficient of thrust C_T.

On Fig. 4 are shown the key dimensions, used in the computation of the induced velocity in a point of the flow-field. The dimensions y_m, y_n, z_m and z_n are universal for both the cylindrical and contracting wake models. Those are the coordinates of two points, namely M and N. It is considered that the induction happens in point M by a vortex element, situated at point N.

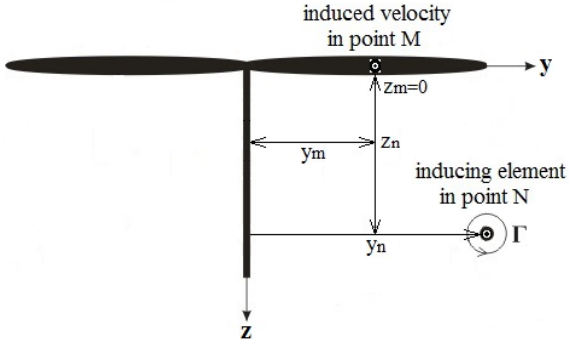

FIG. 4. Dimensions used in the computation of the induced velocity field of the rotor

Lewis [13] introduces the dimensionless parameters *y* and *z* with (4) and (5):

$$z = \frac{z_m - z_n}{y_n}, \tag{4}$$

$$y = \frac{y_m}{y_n}. \tag{5}$$

Those are used for the derivation of the equations for the axial V_z and radial V_y induced velocities. For the case of the semi-infinite vortex cylinder, the axial velocity is computed with (6) and for the case of $y = 1$, (7) is used:

$$V_{z,cyl} = \frac{\Gamma}{4\pi}\left\{B + \frac{z}{\sqrt{z^2 + (y+1)^2}}\left[K\left(k^2\right) - \frac{y-1}{y+1}\Pi\left(n,k^2\right)\right]\right\}, \tag{6}$$

$$V_{z,cyl_{(y=1)}} = \Gamma\left(\frac{1}{4} + \frac{z\,K\left(k^2\right)}{2\pi\sqrt{z^2+4}}\right). \tag{7}$$

For the case of a semi-infinite vortex cylinder, the radial induced velocity is computed with (8):

$$V_{y,cyl} = \frac{2\Gamma}{\pi k^2\sqrt{z^2 + (y+1)^2}}\left[E\left(k^2\right) - \left(1 - \frac{k^2}{2}\right)K\left(k^2\right)\right]. \tag{8}$$

The constant *B* in (6) depends from the ratio between the outer radius of the vortex cylinder and the radius of the rotor. For the case of $y = 1$ it is:

$$\mathrm{B}_{(y=1)} = \frac{\pi}{2}. \tag{9}$$

For the case of the system of vortex rings, the axial induced velocity is computed with (10) and for the radial induced velocity (11) is used:

$$V_{z,ring} = \frac{\Gamma}{2\pi y_n\sqrt{z^2 + (y+1)^2}}\left\{K\left(k^2\right) - \left[1 + \frac{2(y-1)}{z^2 + (y-1)^2}\right]E\left(k^2\right)\right\}, \tag{10}$$

$$V_{y,ring} = \frac{\Gamma z}{2\pi y y_n \sqrt{z^2 + (y+1)^2}} \left\{ K\left(k^2\right) - \left[1 + \frac{2y}{z^2 + (y-1)^2} \right] E\left(k^2\right) \right\}. \quad (11)$$

Equations (6), (7), (8), (10) and (11) contain complete elliptic integrals of the first $E(k^2)$, second $K(k^2)$ and third kind $\Pi(n,k^2)$. The elliptic parameters n and k are introduced with (12) and (13).

$$k = \sqrt{\frac{4y}{z^2 + (y+1)^2}}, \quad (12)$$

$$n = \frac{4y}{(y+1)^2}. \quad (13)$$

Equations (14) and (15) are used for the application of second-order Adams-Bashforth predictor:

$$y_i^P = y_i^n + \frac{\Delta t}{2}\left[3V_{iy}\left(y_i^n, z_i^n\right) - V_{iy}\left(y_i^{n-1}, z_i^{n-1}\right) \right]. \quad (14)$$

$$z_i^P = z_i^n + \frac{\Delta t}{2}\left[3V_{iz}\left(y_i^n, z_i^n\right) - V_{iz}\left(y_i^{n-1}, z_i^{n-1}\right) \right]. \quad (15)$$

Equations (16) and (17) are used in the corrector step.

$$y_i^{n+1} = y_i^n + \frac{\Delta t}{2}\left[V_{iy}\left(y_i^P, z_i^P\right) + V_{iy}\left(y_i^n, z_i^n\right) \right], \quad (16)$$

$$z_i^{n+1} = z_i^n + \frac{\Delta t}{2}\left[V_{iz}\left(y_i^P, z_i^P\right) + V_{iz}\left(y_i^n, z_i^n\right) \right], \quad (17)$$

The model updates the coordinates y and z with an Adams-Bashforth predictor step, followed by a corrector step. It is referred as the Adams-Bashforth predictor-corrector scheme of second order.

Numerical instability issues are observed if the vortex rings in the near wake are not being initially slightly contracted. Thus, a simple arrangement with linear contraction higher than 10% is found to be enough to assure stable computation.

4. RESULTS AND DISCUSSIONS

On Fig. 5 are shown three computational cases for the flow-field of the rotor in hover, computed with the Miller model for a rotor configuration with four blades and five emitted vortex rings per blade. The numerical computations are performed for 2000 RPM and θ=10deg for three different values of the parameter d_1, namely 0.25p for case a); 0.5p for case b) and 0.75p for case c), where p is the average spacing between the vortex rings in the near wake. In all three cases d_0 is set to 0.1p.

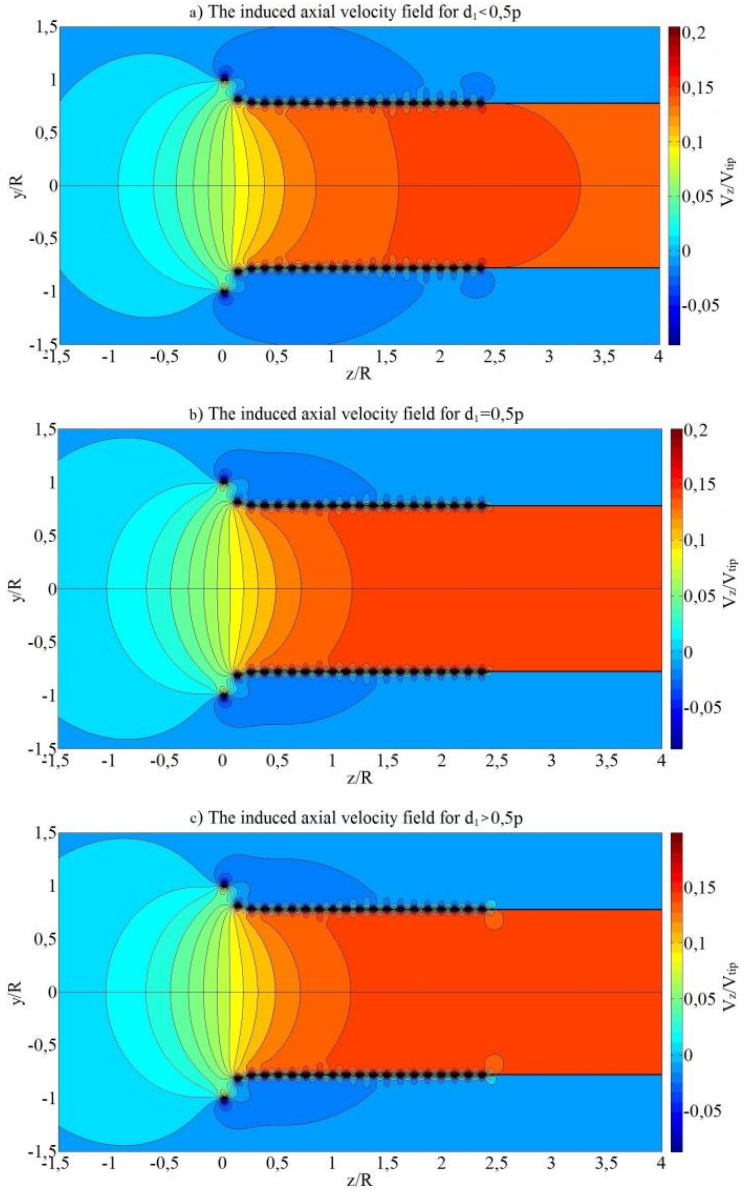

FIG. 5. The flow-field of the rotor for 2000 RPM and θ=10deg, computed with the BEM-vortex model with the second-order predictor-corrector scheme.

From the numerical results for the flow-field, presented on Fig. 5, it becomes apparent that the optimal value for the placement of the semi-infinite vortex cylinder behind the last vortex ring d_1, is the same as the average spacing of the vortex rings in the near wake d_1=0.5p. This is due to the fact that the most uniform velocity field is formed for this spacing and also it is the only setting, for which the average computed value of the axial induced velocity V_z in the plane of the rotor z/R = 0 double its value in the far wake beyond z/R = 4, such as predicted by the theory for a rotor in hover.

In Table 1 are compared the coefficient of thrust C_T, the percentage error $|\Delta|$ and the required computational time t_{comp} for the simulations performed with a rotor configuration with four blades, where two, three or five vortex rings are emitted per blade. The spacing parameters for all computations are set as follows: d_0=0.1p and d_1=0.5p.

Table 1. Comparison of the results obtained for four blade rotor configuration for two, three, five and ten vortex rings per blade against the wind tunnel experiment data

Models	***4 blade rotor 2 VRs per blade***	***4 blade rotor 3 VRs per blade***	***4 blade rotor 5 VRs per blade***	***4 blade rotor 10 VRs per blade***	***4 blade rotor experiment***
C_T $[10^{-3}]$	2.939	2.861	2.684	2.742	2.569
$\|\Delta\|$ [%]	14.4	11.4	4.47	6.73	-
t_{comp} [s]	0.19	0.23	0.37	0.63	-

From the results presented in Table 1, it can be seen that initially the percentage error decreases with the increase of the number of the emitted vortex rings per blade being taken into account for the modelling of the near wake. However, the additional increase of the number of emitted vortex rings per blade, is not only increasing the required computational time t_{comp} but it is also increasing the percentage error.

CONCLUSION

The presented approach for the numerical simulation of the performance of a rotor in hover, showed good computational stability and adequate accuracy of the obtained results, when compared with the experimental data. Although the added complexity from the integration of a time-stepping predictor-corrector scheme, the coupled BEM-vortex model retains its computational rapidity, which can be explained with good convergence of the numerical solution.

In order to obtain adequate rotor performance estimation figures with the presented numerical approach, it is recommended to use between 5 and 10 emitted vortex rings per blade, regardless of the rotor configuration.

The existing percentage error between the computational results and the experimental data is acceptable. Therefore, the proposed model can be used for preliminary studies and simulations of the expected thrust and overall performance of newly designed rotors.

FUTURE WORK

The results from the conducted study, presented in this paper, encourage the authors to use the coupled BEM-vortex model with time-stepping predictor-corrector scheme, in order to study the thrust of small rotors in unsteady operational condition. The intent is to perform a series of studies on the rotor performance during transient operational regimes, produced by both big and small rates of change in the angular velocity of the rotor Ω; and for both positive and negative rates of change.

Of special interest is to study the changes in the thrust, resulting from a rapid change of the pitch angle of the blades θ for a constant angular velocity of the rotor Ω. Such a study will provide greater insights into the rotor performance during the transition period, in which the flow-field is adjusting to the new operating conditions of the rotor.

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INTEGRATING A BASIC EMULATING NETWORK WITH MOBILE COMMUNICATION INFRASTRUCTURE

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Abstract: *The continued technological advancement in the telecommunications sector and the continuing need to improve the services provided to subscribers have led to ongoing research to meet the growing demands. For these reasons, in this paper we implemented the testing procedures so as to take into account the feasibility studies in the field. Using both real-world networking equipment and laboratory equipment with advanced emulation and simulation capabilities, the versatility and timeliness of a 2G network have been highlighted. This is possible by integrating and interconnecting the available hardware, which through a firmware approach allowed us to make advanced scenarios that highlight the complexity of such a network. The University Laboratory outperforms the network of a telephone operator in terms of architectural complexity, due to its presence in the architecture of the Tektronix K1297, which provides testing, emulation, and network management features.*

Keywords: *GSM, location update, K1297, emulation, MSC, BSC*

1. INTRODUCTION

In the present paper, the central point will be cellular communication systems, the study being conducted over a Global System for Mobile Communications (GSM) network.

To highlight the impact that various parameters have on the GSM network there has been implemented a location update scenario at the level of the A interface. By implementing this procedure, we made both hardware and software links between the K1297-G20 and the real GSM infrastructure of the laboratory. Since the interface A is between the Base Station Controller (BSC) and the Mobile Switching Center (MSC), which is not available in the lab, the first step in building the location update procedure was to emulate this communication node.

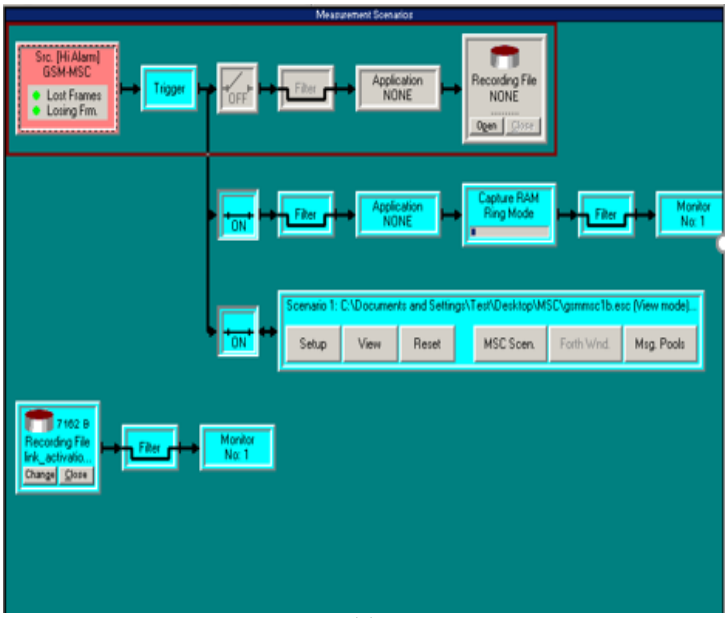
The emulation procedure in the field of telecommunications is a technique that integrates a hardware, software, netware suite to imitate the behavior of the replaced element. The emulated system must behave identically to the replaced node and comply with all the rules that are required for the exchange of information between real equipment and the emulated equipment. In the present paper, the MSC has been emulated at the interface A. At this interface, information is provided to allocate channels, time frames, and handover, location update, paging procedures [5].

2. LOCATION UPDATE PROCEDURE DESCRIPTION

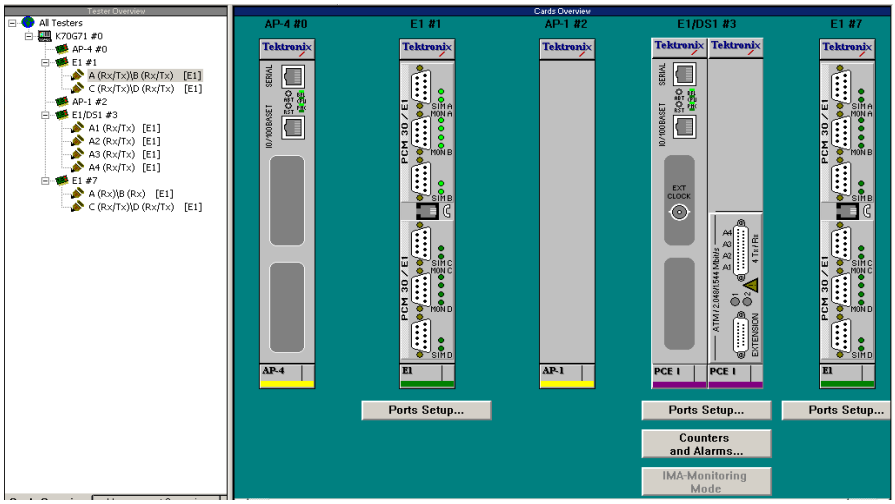
The location update procedure is the starting point of procedures that take place within the GSM network such as Mobile Originating Call or Mobile Terminating Call, as the network must always know the position of the mobile terminal within the network. For this purpose, the mobile station periodically reports its location using the location update procedure.

The location update procedure is done in three distinct situations: when the mobile station is being switched on and wants to become active; when the mobile station is active, but not involved in a telephone conversation and wants to move from one location to another; after a fixed time [4].

The figure bellow is a general overview of the data flow in the K1297-G20 protocol analyzer regarding the implementation of the location update procedure. The structure of the scenario consists of 3 branches with clearly defined roles in the way data is being presented:



(a)



(b)

FIG. 1. (a) General overview of data flow in the emulated MSC (b) Port structure for PRIME E1 card

• *Recording Branch*: At this level, we have the icon where the source of the "Src GSM-MSC" scenario is located from where the SS7 stack can be parameterized in depth, starting at the MTP (Media Transfer Protocol) level 2. In addition, at the level of this branch are presented the options for recording the procedure for future use;

• *Real-time monitoring branch*: This section shows the settings that show the succession of the real-time procedures; Here, the user can filter the messages according to the parameters of interest for each situation;

• *Emulation*: Under this section, a summary of the Mobile Station Controller emulation is presented, from where the user can access the parameters related to MTP Layer 1 going up to the highest levels of the SS7 (Signaling System no. 7) stack, reset the scenario and other options.

The construction of the scenario started from the physical level, as can be seen in Figure 1(b), where we determined which ports to use from the PRIME E1 board of the emulator. For emulation, we opted for the use of port B, which, as specified, is dedicated to emulation procedures within a communications network. To make the connection with the physical BSC, we used a twisted pair cable with 120 Ω impedance, which allows bidirectional data transmission and reception. This link is in fact, an E1 connection.

The step preceding the establishment of the port used was to set up the parameters related to it in accordance with industry standards and recommendations. The type of frame used is CRC-4, in the structure of which the first bit is the one that stores the check sum. This bit specifies whether there is one or more error bits in the last block of incoming data, a block consists of 8 frames.

Since the location update procedure is implemented at signaling level, the scenario has been built based on the 16th channel within the E1 carrier.

Tektronix K1297-G20 provides a set of protocols from which the user can choose. For the scenario in case, we have opted for a stack of protocols built specifically for the A interface, according to GSM Release 97 specifications.

The protocol on which the decoding stack has been built is the BSS (Base Station Subsystem) Application Part (BSSAP), which is a protocol within the SS7 stack used to exchange signaling messages between MSC and BSC, signaling that is compatible with MTP and SCCP (Signaling Connection Control Part) levels [2].

3. CONTROL CENTER CHART AND ACTIONS AVAILABLE AT MTP LAYER 2 LEVEL

Tektronix K1297-G20 provides the user with a representation in the form of an emulation control center diagram where the link between the physical layer LDS Placeholder and the top levels is presented in a layered form.

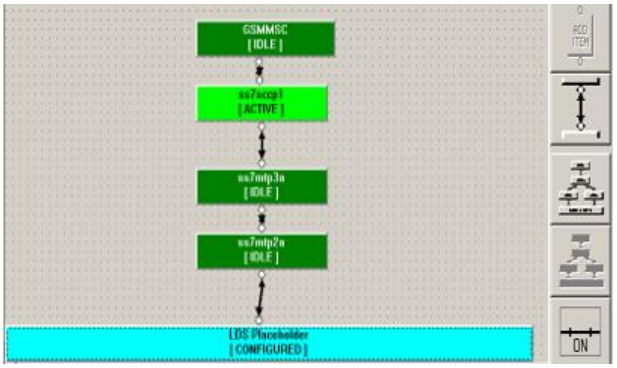


FIG.2. Emulation Control Center and the buttons responsible for activation and deactivation of the scenario

When all these levels are green, the test scenario is loaded in the system and functional, as it can be seen in the figure above.

The equivalent of this diagram is the window view of the scenario parameters, showing both the values of each parameter as well as the actions available for each SS7 stack level, starting from the MTP Layer 2 level.

In the Fig. 3, there are the steps to initiate the simulation at the logical level of the SS7 stack. The steps to be followed are “binding” through which the emulation begins, followed by “connect” which serves as alignment.

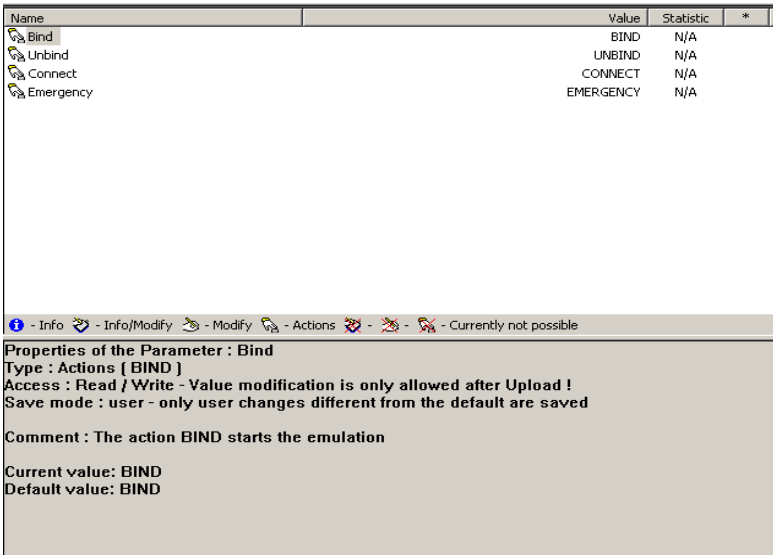


Fig. 3. Emulation initialization at MTP layer 2 level

4. CONFIGURING THE EMULATED MSC WITH MTP LAYER 3 LEVEL PARAMETERS

Another important step in building the location update scenario is to configure the emulated MSC at the MTP Layer 3 level. Values with the highest importance are the variables called "point codes" because they can identify the two network nodes involved in the testing process. In this case, the emulated MSC is identified by the "point code" with a value of 512, while the BSC in the lab is 256. The length of these codes is in line with the ITU specifications, in this case 14 bits. Within the capture files, these point codes are presented in 4-3-4-3 format, so the MSC will appear with 0-4-0-0, while the BSC will have "point code " 0-2-0-0. In Fig. 4 the configuration table for the emulated MSC it is presented, where the following information is present:

- within the scenario, a single link is used, its identifier is 1 and the MSC Point Code is 512;
- the number of test messages which have to be sent is 2, “Number SLTM”;
- having a single link, the priority of the message does not affect the functionality of the message;
- the Service Switching Function (SSF) parameter plays an important role in the routing of messages; it is important to have the same value at the BSC, as the equipment may have more point codes, the decision to send the message being taken based on the SSF;
- there can be seen two routes, one “inbound” and one “outbound” in order to clarify the direction on the messages within the capture files.

Name	Value	Statistic	*
Linkset ID	1	N/A	
DPC	512	N/A	
Link priority	0	N/A	
Max message length	272	N/A	
Link type	CCITT	N/A	
SPC length	14Bit	N/A	
Number SLTM	2	N/A	
Management and Test priority	3	N/A	
Emergency connection	TRUE	N/A	
Test SLC	13	N/A	
Test pattern length	4	N/A	
Test pattern	ff0055aa47656e6572616c00000000	N/A	
SSF	International	N/A	

- Info - Info/Modify - Modify - Actions - - - Currently not possible

FIG. 4. MTP layer 3 parameters for the emulated MSC

5. BUILDING UP THE MESSAGE FLOW

The next step in designing the location update scenario is to model the exchange of messages that takes place between the emulated MSC and the BSC. The messages involved
in this procedure comply with the ITU-T requirements. Fig. 5 shows the succession of messages between "Component Test", which in this case is MSC and "Interface Under Test" represented by BSC seen from the perspective of interface A.

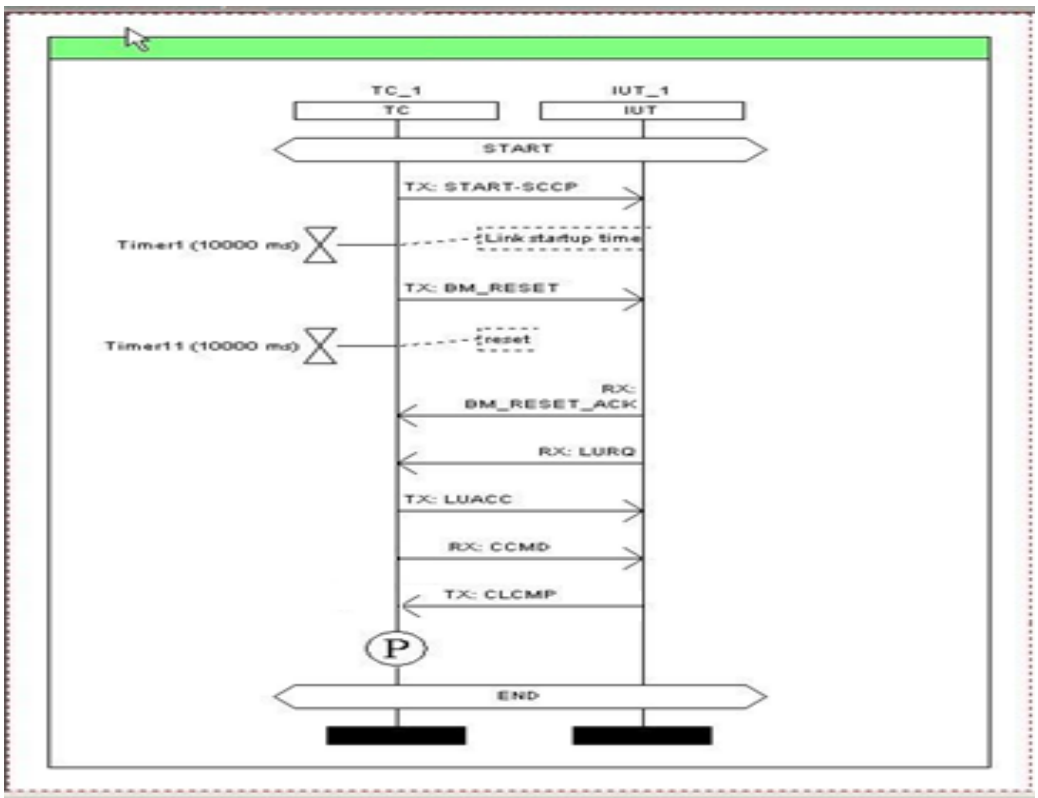


FIG. 5. Message flow between MSC and BSC

a) Since location update is a connection-oriented procedure, the message that initiates the exchange of signaling data between MSC and BSC is "Start SCCP" where MTP Layer 2, MTP Layer 3 and SCCP levels are initialized and a dedicated channel is allocated for the exchange of signaling messages. Also, with this message, the connection between the two network nodes is established.

b) By sending the Tx_BM_Reset message to the MSC, a BSSAP subsystem initialization request identified by ID 254 according to 3GPP specifications is sent, a message that was not included in the message collection available on K1297. For these reasons, the message had to be created using MBS, a proprietary software.

c) Confirmation of receipt of the link reset message is made via the BM_RESET_ACK message that is sent to MSC from BSS, a message that was not included in the message collection available on K1297. Just like in the case of Tx_BM_Reset, the acknowledge message had to be created via MBS.

d) The actual location update request message is sent from BSC to MSC. This message includes data about the subscriber who initiates the procedure as well as information about the current location of the mobile station. The message building principle lays on the actual function where the mandatory parameters are presented as well as its primitive which establishes the length and the name of the parameters. These details can be seen in Fig. 6, where the primitive is shown, also in Fig. 7, where the proper function can be observed.

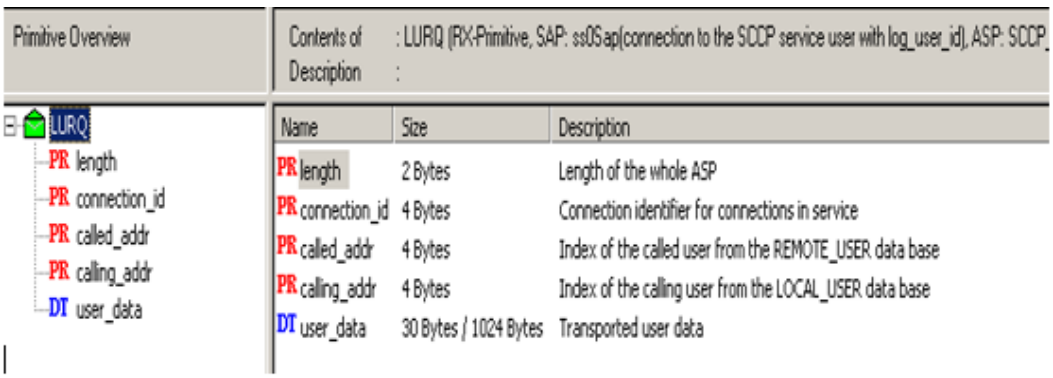


FIG. 6. Structure of the primitive for the location update procedure

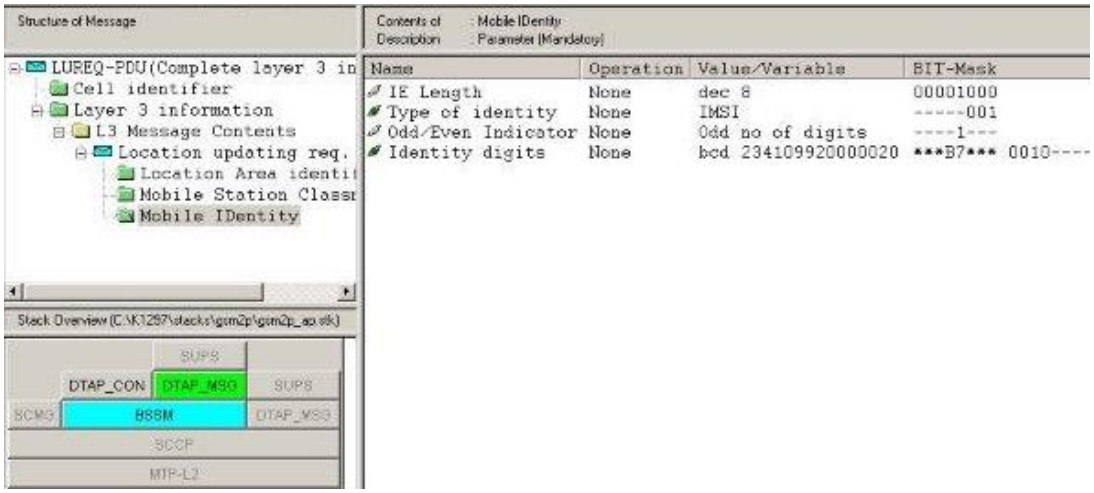


FIG. 7. The structure for the function responsible for the location update

e) The emulated MSC is the one that sends the request acceptance message that includes data such as: mobile identity and parameters related to the new location of the mobile station, as it can be seen in Fig. 8.

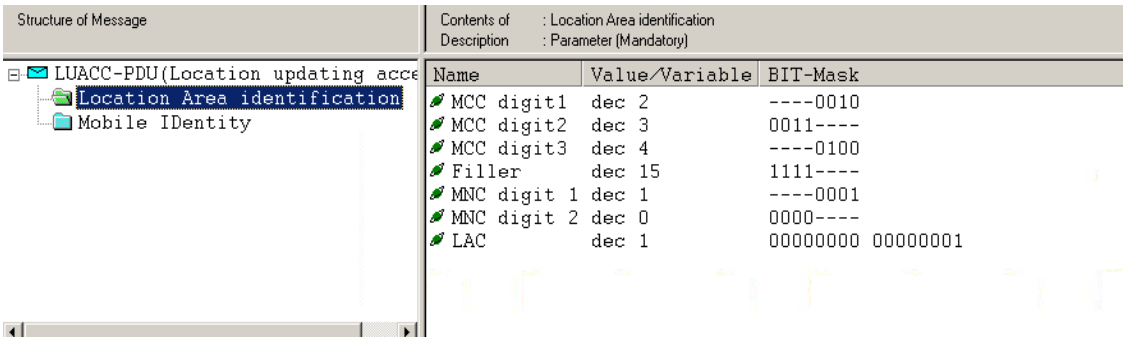


FIG. 8. The parameters passed in the update request acceptance message

f) The message "Release command RX: CCMD" is sent by the MSC to the BSC requesting the release of the channel on which the signaling messages have been exchanged

g) The last message in the location update procedure is the channel release confirmation message

6. PROTOCOL ANALYSIS. RESULT INTERPRETATION FROM THE CAPTURE FILE

As far as the interpretation of the results is concerned, the manner adopted to pursue this task will follow the methodology used in designing the message exchange between MSC and BSC.

In this regard, once the connection between the two nodes involved in the location update procedure has been established, the request to initiate the SCCP connection is received. The message is split into two parts, one for MSC “Called Party” and the other for BSC “Calling Party”. Each component is identified by MTP Layer 3: calling SPC and called SPC, which are equivalent to "Originating Point Code" and "Destination Point Code" in 4-3-4-3 format.

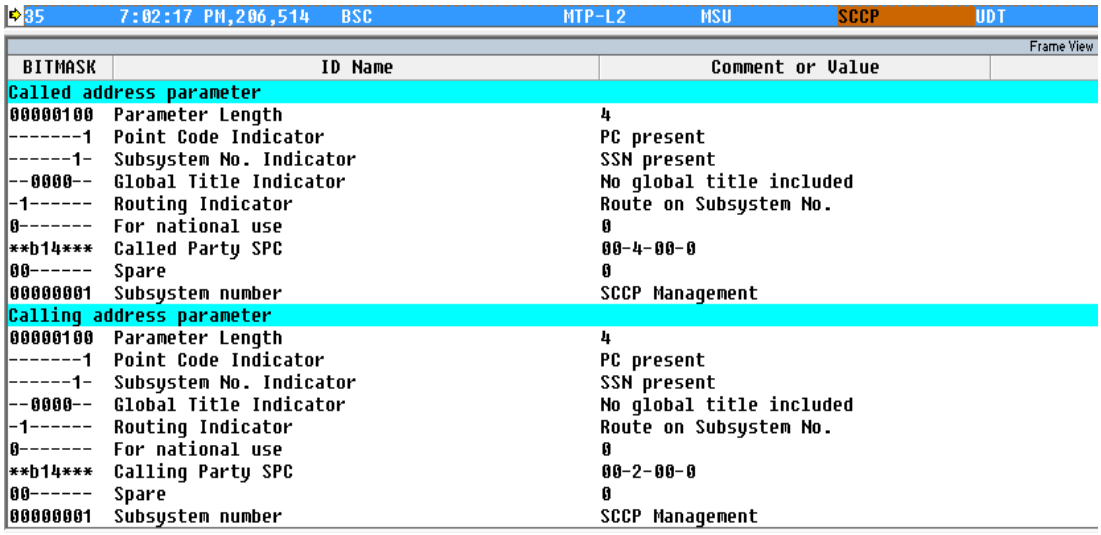


FIG. 9. SCCP message from the capture

Following the "SCCP" initialization message is the link reset request message which initiates the BSSAP subsystem. In the figure below, there can be seen the BSSAP identifier that is compliant with 3GPP specifications.

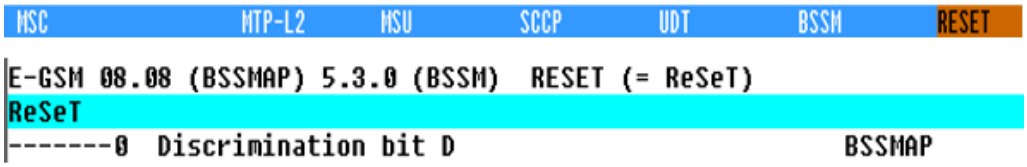


FIG. 10. BSSAP subsystem identifier

The following message of interest is the location update request where the following parameters can be seen with their values: Country Code of the country of origin (Mobile Country Code) equal to 226, specific for Romania; Mobile Network Code equal to 05, assigned to the Digi Mobil Network; Identifier for subscriber's origin area with the value of 701; The TMSI associated with the mobile station 503b382fH; The channel on which the request is received is “Standalone Dedicated Control Channel”.

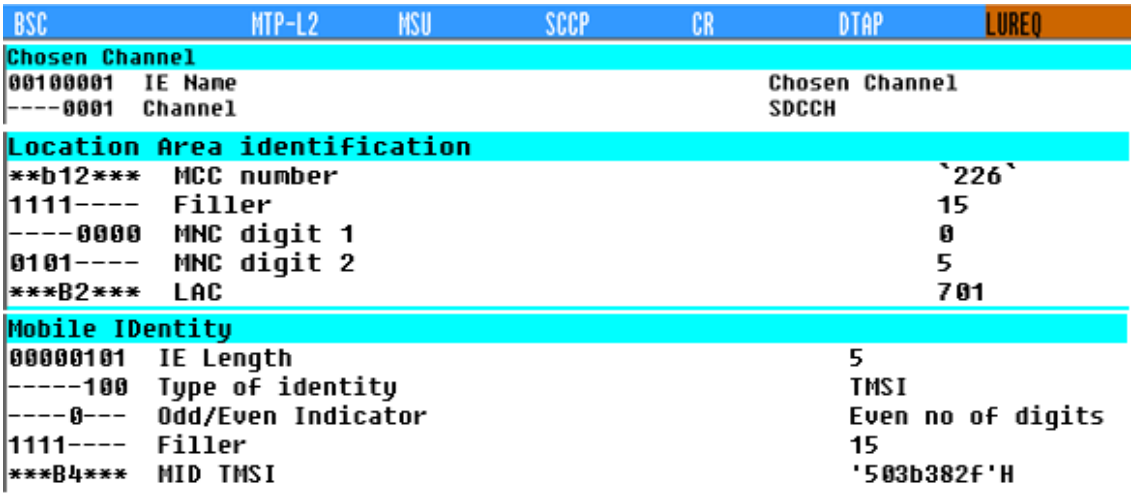


FIG. 11. Subscriber data and information about the source location are

Other values (Fig. 12): The country code where the mobile station is to be authenticated equals to 262, which is the German code, because the database loaded in the laboratory BTS is specific to the Vodafone operator; The operator code in which the subscriber enters the network, namely 02, the code associated with the Vodafone D2 network; "Location Area Code" of the area where the subscriber is to enter, its value is 8704, value assigned to the BSC in our laboratory; The cell identifier in which the MS tries to authenticate the "CI" (Cell Identifier) equal to 20000.

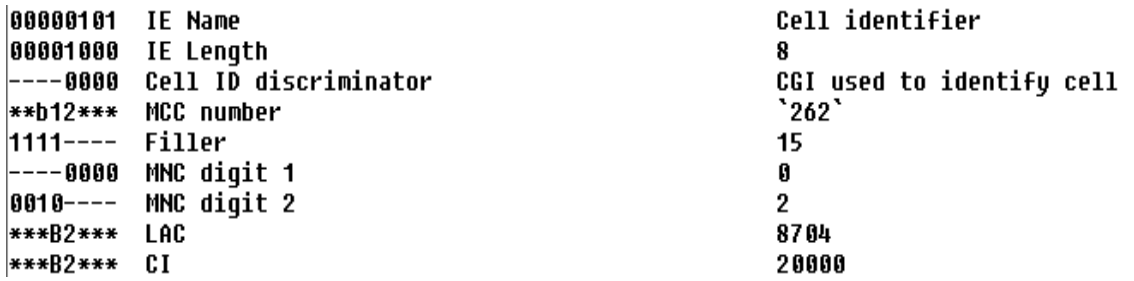


FIG. 12. The data of the new network and the location where the subscriber is about to authenticate

As it has been established in the design of the emulation, it can be noticed the fact that the message for accepting the location update request comes from the MSC. In the response message, there are several data available, among the most important are: IMSI of the subscriber: 226050082245364; the channel via which the messages are being sent SDCCH; Mobile Country Code 262; Mobile Network Code 02; Location Area Code 8704.

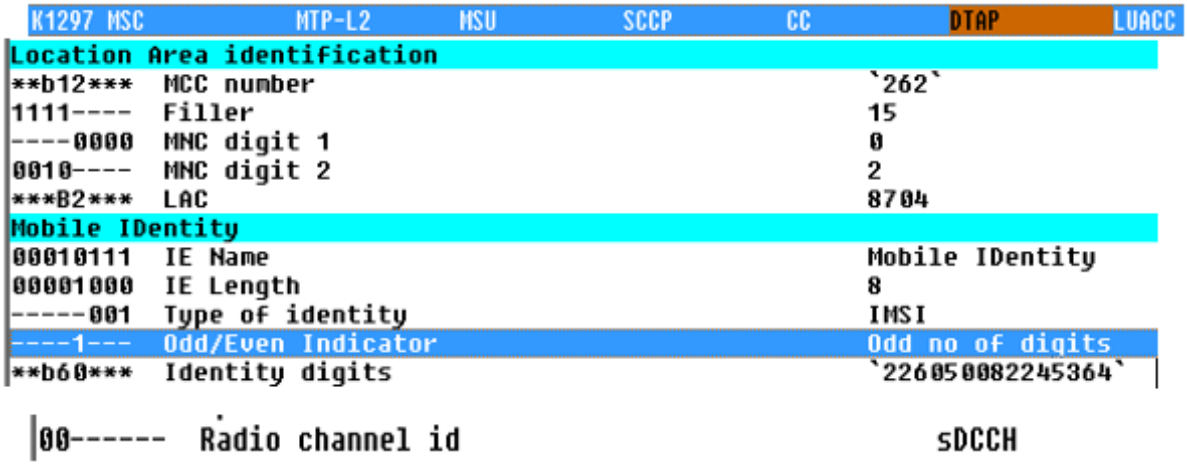


FIG. 13. Data available in the acknowledge message SCCP

Once the location update request acceptance message has been received, the MSC asks the BSC to release the SDCCH channel through the RLSD message. To determine the direction of the message, we can follow the MTP 3 level parameters, where we can see that the "Originating Point Code" belongs to the MSC, while the "Destination Point Code" is the SPC of the BSC.

FIG. 14. Data contained in the request for realizing the SDCCH channel

Confirmation of channel release marks the completion of the location update scenario and comes from the BSC, which contains the signaling "point codes" of the MSC and BSC network nodes.

6. CONCLUSIONS

In this paper, we have integrated the mobile communications network available in the laboratory with the emulated core network consisting of the protocol emulator K1297-G20, which is a very high complexity equipment at the upper limit, where the test-emulation function blends with the management level functions. The placement of the emulator and simulator within the communication network is at the level of the Maintenance Administration Operations Center, a level at which we have highlighted the versatility of the equipment by merging the communication process between real-life and emulated equipment.

The main pillar we followed in the development of communication within the GSM network was that of the Signaling System number 7, which dictates the requirements of the testing and emulation process from the lower level, the physical one, climbing to the higher levels, the Mobile Application Part level, at which we designed the location update procedure.

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MATHEMATICAL MODEL AND NUMERICAL SIMULATIONS FOR PHOTOVOLTAIC PANELS

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Abstract: *This paper presents some problems concerning efficient using of photovoltaic cells in present energetic systems. An important aspect in now days is modeling and numerical simulation for systems with photovoltaic cells. For this reason one used a mathematical model in literature to implement a simulation scheme in MATLAB/SIMPOWERSYS for photovoltaic panels. One start from a simplified mathematical model for a photovoltaic cell and next one extends this model to a photovoltaic panel with mxn cells. Implemented model in MATLAB/SIMPOWERSYS is then used for numerical simulation of the panel with a fixed load and variable irradiation and for simulation of a hybrid system with photovoltaic panel and battery.*

Keywords: *photovoltaic panels, mathematical model, numerical simulation, numerical simulations*

1. INTRODUCTION

Politico-economic conditions in last few years at global level concerning energetic resources are characterized by two pressing problems which direct the entire world to replace other forms of energy with electric energy. By one hand greenhouse gases generated using fossil combustibles and by other hand the narrow fossil combustibles depletion leads to intense research in alternative energy sources domain at global level, especially in electric energy alternative sources. Use of wind power, tidal and wave energy and photovoltaic energy mark visible progresses in the last period.

Important progresses are obtained also in electric power storage. Li-Ion and Li-Polymer batteries with very high capacities permitted together with photovoltaic energy sources to complete a flight around the earth, using only electric energy [see Solar Impulse]. Such a performance would not be possible with technology 10 years ago.

Towards replacement of fossil combustibles with electric energy one observes increasing the weight of electrical energy used by household consumers provided by wind turbines or photovoltaic panels of relative small power, which can ensure the energy for housework. In the maximum production period of these small power plants they can uphold even national energetic systems of some countries which widely use such systems (Germany, Italy, Japan, USA).

A second big domain which is a huge consumer of fossil combustibles is transportation. One remarks also in this field apparition of hybrid cars with over 600 km autonomy or even complete electric cars with autonomy of hundreds km. The urban transportation aims to use electrical busses, implemented already in some cities like Turin or some university campuses like Oxford.

Aeronautic transportation is by excellence a huge consumer of fossil combustibles. Here also appeared in last few years researches to replace fossil combustibles with electric energy. It is a long way to obtain an electric airliner but UAV of smaller or bigger dimensions, drones, last generation surveillance systems use more and more electric energy stored in last generation Li-Ion batteries. Airbus concern already built a light aircraft, one person on board, one hour autonomy, powered only by electric energy. It already passed the famous limit of English Channel overflight [1]-[5].

2. STRUCTURE OF AN ELECTRIC SYSTEM WITH PHOTOVOLTAIC PANELS

In order to use the photovoltaic energy, the basic element which generates this energy - the photovoltaic cell – has to be placed in a system capable to use this energy. Such a system is presented in fig.1.

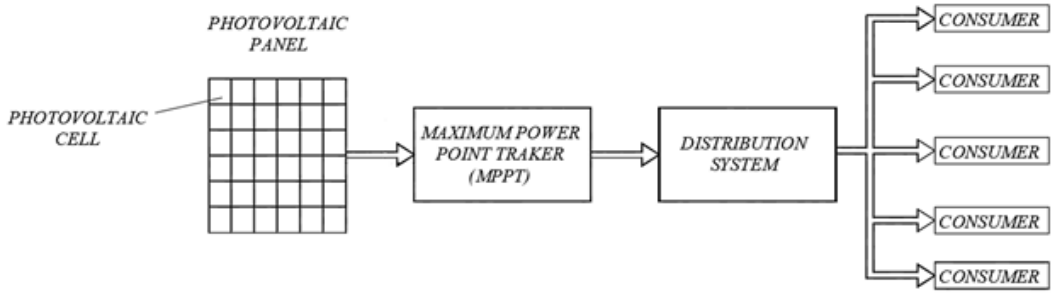

FIG. 1. Component elements of a system with photovoltaic panels

Photovoltaic cell

Basic elements of photovoltaic panels are the solar (photovoltaic) cells. Majority of solar cells are manufactured of silicon, but also other materials are used. Solar cell is based on photoelectric effect that means the ability of some semiconductors to transform electromagnetic radiations in electric current.

A solar cell is in fact a p-n junction with two different silicon layers with two types of impurities. N layer is unpurified with atoms with more than one valence electrons – donor atoms, and p layer contains less valence electrons – acceptor atoms. When these two layers are put together, near the separation surface, valence electrons from n layers spread in p layer, leaving behind, a positive charged zone of donors. Holes from p layer spread in n layer, leaving behind, a negative charged of acceptors. By this way an electric field appears between these two layers, representing a potential barrier for the supplementary fields. When the electrons and holes can't anymore pass through this barrier, a balance appears. Electric field pushes the electrons and holes in opposite directions, so that the electric current can flow only in one direction. Electrons can move from p layer to n layer and holes in inverse direction.

Both ends are joined metallic contacts to collect electrons and holes so the electric current can flow. N layer is exposed to the solar radiation. Contacts are manufactured of many metallic strips, permitting light to reach the solar cell. These are known as fingers.

Functioning principle of the photovoltaic cell can be described as follows: solar radiation photons blow the solar cell. Three situations can appear: non-reflected photons reach the substrate. Those with less energy pass through solar cell with no effect. Only photons with sufficient energy, over the band zone of silicon, can produce an electron-hole pair. These pairs are generated in both halves of p-n junction.

Electrons from p layer and holes from n layer pass through the junction and are transmitted in opposite directions by the electric field. This is the light generated current. This current depends on the irradiation: if the irradiation is intense, contains many photons with enough energy to generate electron-holes pairs, so the solar cell generates more electric current.

For solar cells manufacturing in most cases silicon is used. Although other techniques are developed, silicon is preferred in more than 80% of situations. It is a widespread material in the earth, can be found as silicon dioxide and is not toxic.

In literature, two silicon solar cells types are known: mono-crystalline and polycrystalline. There is a third type – amorphous silicon, but their efficiency in less than first two types.

Other solar cells are manufactured of Cooper – Indium – Gallium – Selenium (CIGS) or Cadmium Telluride (CdTe). A great research effort is involved to find new photovoltaic materials, but at this time, there are no commercial substitutes for the solar cells presented above.

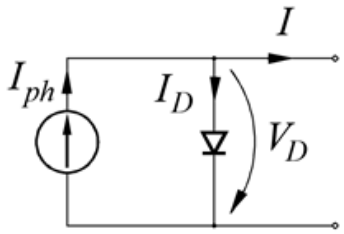

FIG.2. Simplified model of a solar cell

Electric equivalent scheme of a solar cell is presented in fig. 2. Electric current through the solar cell I described by the equation [6]-[10]

$$I = I_{ph} - I_S\left(e^{\frac{V}{m\cdot V_t}} - 1\right), \tag{1}$$

where I – current through the solar cell; Is – inverse saturation current of the diode; Iph – photovoltaic generated current; V – voltage applied to the diode; V_t – thermal voltage; m – diode ideal factor, $m = 1 \div 5.$

Thermal voltage is determined by the relation

$$V_t = \frac{K \cdot T}{e}, \tag{2}$$

where K – Boltzmann constant $1.38 \cdot 10^{-23}$ J/K , T – absolute temperature [K]; and e– charge of the electron.

A PV panel is composed from many solar cells, connected in series and/or in parallel in order to obtain output voltages and currents compatible with the electric load.

Irradiation and temperature are two important parameters affecting the photovoltaic panel characteristics. As it was mentioned before, photovoltaic current is proportional with the irradiation level, so an irradiation increase produce a bigger photovoltaic current.

More, the short-circuit current is proportional with the photovoltaic current, so the short-circuit current is proportional with the irradiation level. By other hand, the effect of the irradiation upon the open-circuit voltage is small, as the dependence of the light generated current is logarithmic, like in equation (1).

In practice, voltage dependence of irradiation is negligible. Because the irradiation effect upon the current and voltage is positive, both raise, so the irradiation effect upon the generated power is also positive – more irradiation, more power.

By other hand, temperature influences the voltage. Open circuit voltage depends linear by temperature. Photovoltaic cells producers presents in catalogue papers, specific technical parameters: open circuit voltage, short-circuit current and maximum power, when temperature varies.

One has to mention that temperature and irradiation depend on atmospheric conditions that are not constant in a day and in a year.

Photovoltaic cells produced in present have a very small power, around 4 W maximum and the voltage at the photovoltaic cell terminals is about the opening voltage of a diode, that means 0.6 V.

In order to obtain enough energy for an application it is necessary to use many solar cells linked in series or in parallel. By this way, the superior element appears – the photovoltaic panel. Depending the connection between solar cells one obtain a certain open circuit voltage and a certain short-circuit current. Voltage-current characteristic of the photovoltaic panel will reproduce on the scale the characteristic of a solar cell, depending the number of solar cells disposed in series or in parallel. In order to obtain a higher voltage one has to connect cells in series till one obtains the desired voltage. In order to obtain a higher current one connects the solar cells in parallel till obtains the desired current. Theoretically, connecting solar cells one can obtain any output current and voltage, but one has to take in account that in fact any solar cell is a diode. If one of them is interrupted, it will shut down all the cells connected in series with it. So it is preferable to manufacture photovoltaic panels for smaller voltages and higher currents following to obtain higher voltages through power converters.

Characteristics of one solar cell is presented in fig. 3.

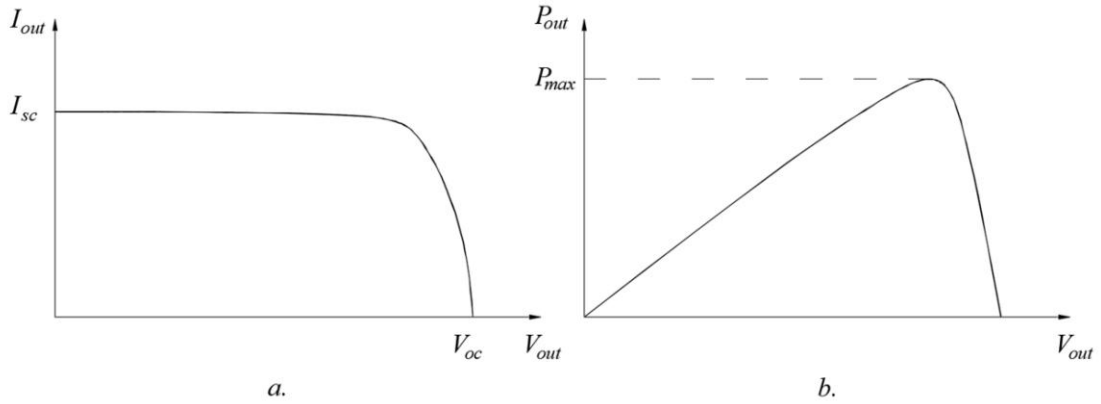

FIG.3. Characteristics of a solar cell: a. – voltage-current dependence; b. – power-voltage dependence

In fig. 3 one can observe a very disadvantageous behavior of the solar cell and by consequence of the photovoltaic panel. Beginning from a certain consumer power, the current drops very fast and also the output power decrease to zero. In order to be used efficiently in a system, photovoltaic panels, which reproduce in scale the characteristics of a cell, are provided with an electronic block named Maximum Power Point Tracker (MPPT).

This block maintains an impedance to the input bigger or equal with that produce the maximum power of the photovoltaic panel. By this way one prevents the current drop to the input and implicit the premature decrease of the output power. If the external load increase in power, MPPT will provide to the output only the maximum power the panel can produce at that irradiation. MPPT block can contain also a power converter to bring the panel output voltage to the consumers input voltage.

Control algorithms used in MPPT construction are many types in present. The most used algorithms are hill-climbing type which follow to modify the functioning point of the panels in the increasing power direction till the maximum output power is achieved. Other algorithm are based on fuzzy logic or neural networks.

3. SIMPOWERSYS IMPLEMENTATION OF A SOLAR CELL MODEL

In view to implement the mathematical model of a photovoltaic cell in SIMPOWERSYS one started from equation (1), where I_{ph} is equal to the short-circuit output current of the photovoltaic cell.

Relation (1) can be write in the form:

$$V = m \cdot V_t \ln\left(\frac{I_{ph} - I + I_S}{I_S}\right), \tag{3}$$

Knowing I_{ph} from cataloque data and the open circuit voltage of the solar cell, at the standard irradiation of 1000 W/m^2, in equation (3) one can impose I=0 for the open circuit situation and one obtain

$$V_{0C} = m \cdot V_t \cdot \ln\left(\frac{I_{ph} + I_S}{I_S}\right), \tag{4}$$

And further

$$m = \frac{V_{oc}}{V_t \cdot \ln\left(\frac{I_{ph} + Is}{Is}\right)}, \tag{5}$$

Based on relations (1) and (5) one built the model in SIMPOPWERSYS presented in figure 4, where the solar cell has a variable resistive load.

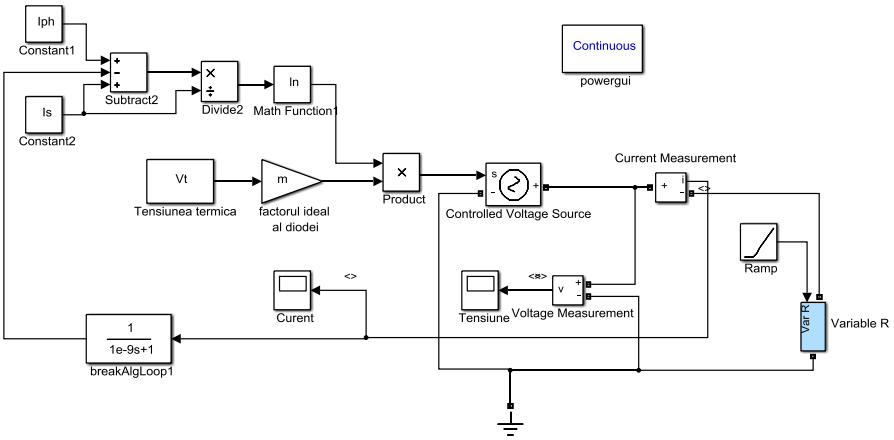

FIG.4. SIMPOWRSYS model of a solar cell

In order to develop the solar cell model, one could use a commanded current source unlike the commanded voltage source used in this model, but in this case SIMPOWERSYS does not accept to connect in series the models of a solar cells, to obtain a photovoltaic panel model. In consequence, it is more advantageous the model with voltage source from the SIMPOWERSYS using point of view and to connect with other devices like DC/DC power converters.

A photovoltaic panel which contains n_p blocks in parallel composed by n_s cells in series, can be equate with a solar cell with a certain open circuit voltage and short-circuit current.

As numerical example, one used first for a solar cell simulation the parameters of the SUNPPOWER C60 solar cell which has the open circuit voltage 0.682 V and short-circuit current 6.24 A at the standard irradiation and temperature 25^{o}C. From relation (5) results m=2.11. One obtained voltage-current characteristic in figure 5, which is a good concordance with the catalog characteristic of this solar cell.

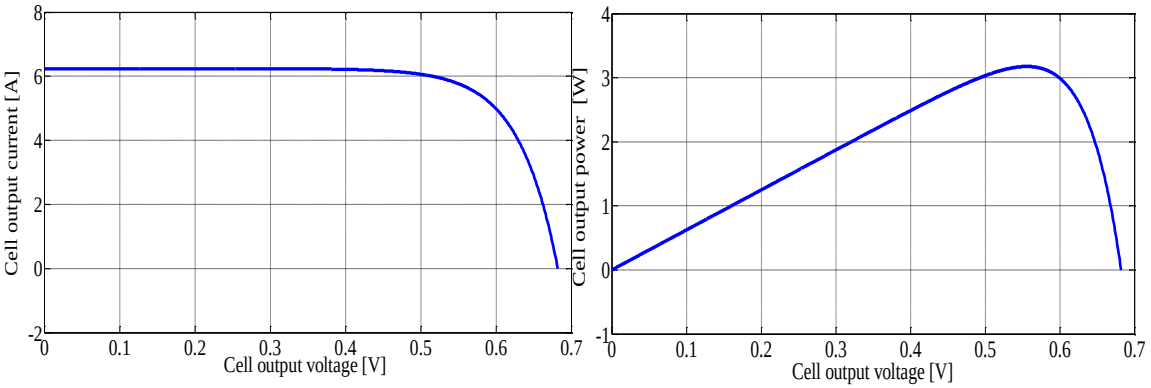

FIG.5. Obtained characteristics for SUNPOWER C60 solar cell; a. – voltage-current characteristic; b. – power-voltage characteristic

After that one followed to develop a photovoltaic panel with the open circuit voltage 24 V and the short-circuit current 31.2 A. For this panel results n_s=36 and n_p=5. So, the photovoltaic panel should contain 36x5=180 solar cells. In view to simulate the panel functioning in SIMPOWERYS is totally inadequate to connect 180 cells like that in fig.4.

More appropriate is to use one single solar cell with equivalent parameters of the panel, so there will be I_{ph}=31.2 A and open circuit voltage 24 V. From equation (5) results m=67.99 . Using the circuit with variable load in figure 4 one draw characteristics of the equivalent solar cell in fig. 6.

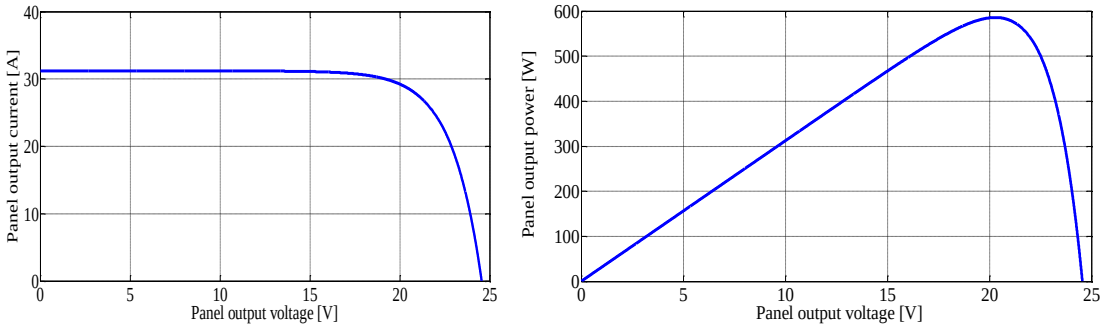

FIG.6. Photovoltaic panel characteristics: a. – Voltage-current characteristic; b. Power-voltage characteristic

For testing this model one built a complete system in figure 7. In this figure it is a solar cell (in fact an equivalent solar cell for the photovoltaic panel as one considered above), with a variable irradiation, followed by a constant load of 10 Ω (fig.7). Irradiation was composed by a medium value of 700 W/m^2 and the absolute value of a sinusoidal variation was superimposed to this medium value. The sinusoid was considered with the amplitude of 300 W/m^2 and pulsation 0.01 rad/s. In these conditions one obtained the load current variation in fig. 8.

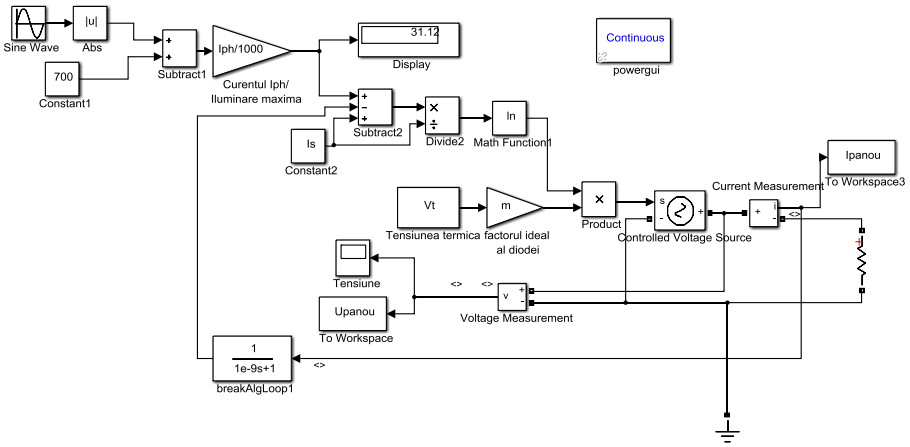

FIG.7. Photovoltaic panel model with variable irradiation and constant load

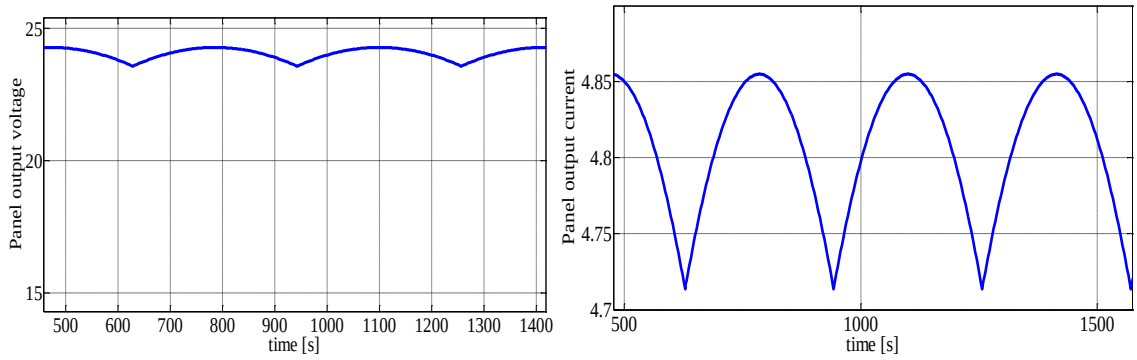

FIG.8. Output voltage and current of the photovoltaic panel with variable irradiation

To test further the photovoltaic panel model one conceived a hybrid system composed from a photovoltaic panel, a double voltage DC/DC boost converter, and a battery in parallel with the converter output. Photovoltaic panel is the same used in the previous simulations and the battery was considered Li-Ion type with nominal voltage 43 V, capacity 10 Ah, initial state of charge 100 % with voltage 50 V, internal resistance 0.043 Ω (figure 9). One considered a relative small value for the battery capacity in view to surprise in a relative short time of simulation the commutation between battery and photovoltaic panel. One considered also a 5 Ω resistive load. Irradiation variation was considered the same as in figure 7. Simulation results are presented in figure 10.

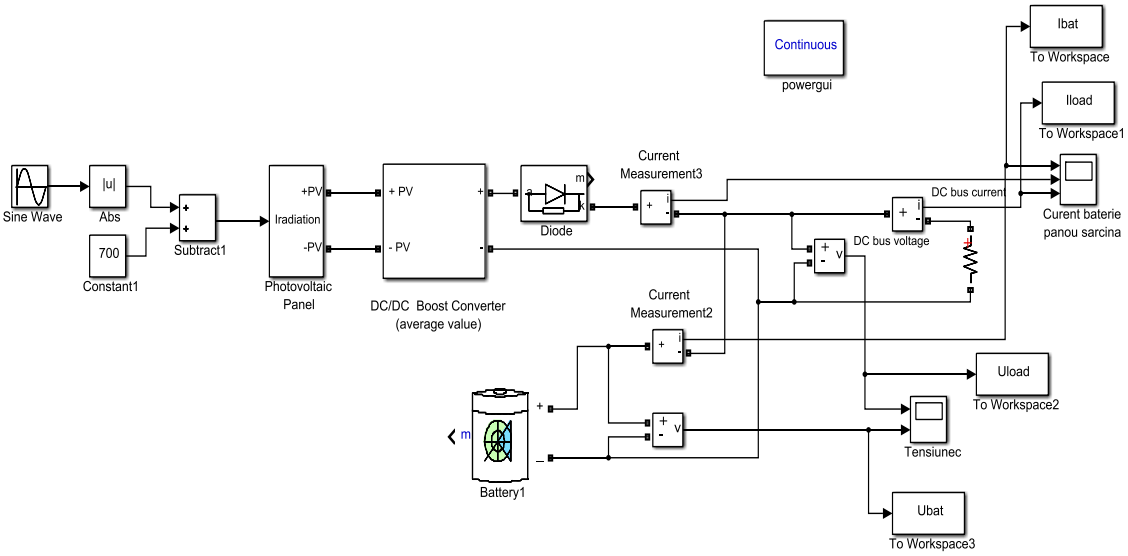

FIG.9. Hybrid system composed form a photovoltaic panel, converter, battery and load

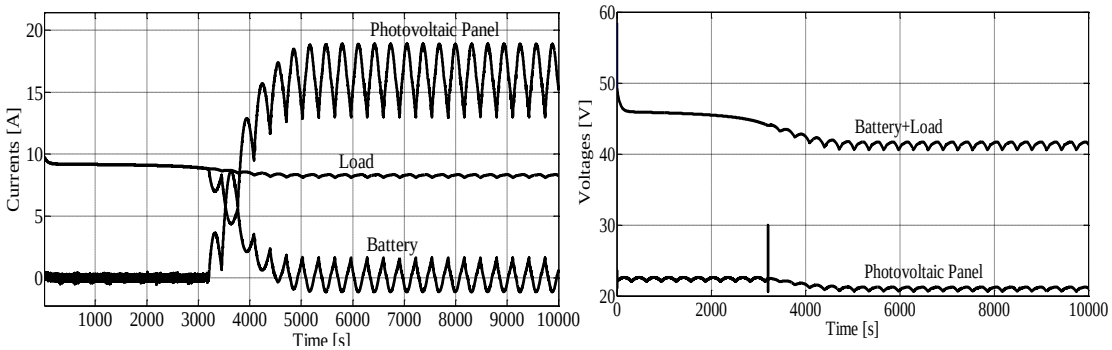

FIG.10. Currents and voltages in photovoltaic panel – battery – load system

One observes that till 3200 s load receives power from battery, photovoltaic panel current is zero. After 3200 s battery current decreases enough, the load receive power also from photovoltaic panel. After 5000 s functioning stabilizes, in the maximum irradiation periods the photovoltaic panel feeds the load and a part of its energy charges the battery. In minimum irradiation periods panel energy decrease and the battery push current in system sustaining the load feeding. After 5000s one stabilizes the current medium value through load. In the period 0 – 3200 s load current decreases constantly.

Concerning the voltages, the battery and the load are connected in parallel, so the battery and load voltages are equal. Up to 3200 s battery voltage decreases constantly and the photovoltaic panel voltage is not enough to push energy on the load.

In the period 3200 – 5000 s is a transition period, when due to battery voltage decrease, photovoltaic panel begins to push energy in the system. Now, the panel voltage presents a slightly decrease and after 5000 s the functioning regime stabilizes and the medium value of the panel voltage rests constant and upon it is superposed the pulsations due to the variable irradiation.

One has to remark that in figures 10 a. and 10 b. appears panel voltages and currents, before the converter.

One tested the possibility to connect directly the panel in parallel with the battery, but due to the sharp decrease of the photovoltaic panel voltage with respect the current (see figure 6.a) the system presents fast oscillations and simulation speed drops drastic. In this condition the model is not useful anymore for long time simulations like in figure 10. Converter input characteristic avoids the panel output voltage to drop and the simulations can be performed with increased speed and the model is useful for long time simulations. Converter output characteristic is compatible with that of the battery so the transition from positive to negative current through battery, in dependence with the energy produced by the panel, is made without oscillations and simulation speed is very high.

This aspect is in concordance with practice, because on the photovoltaic panel output one uses a MPPT block which keeps the panel in the maximum power point, even if the load requested power increases and could drive the panels in the region of fast voltage dropping. By this way, panel pushes at one moment in the system only the maximum power produced by the irradiation in that moment, without a total voltage drop to output. One can say the boost converter behaves as a MPPT, even it is not a MPPT.

CONCLUSIONS

Using the literature formulae which describe the simplified functioning of a photovoltaic cell one obtained a simulation model in MATLAB/SIMPOWERSYS which behaves very good, describing exact enough the functioning of a solar cell.

Aiming to simplify the simulation of photovoltaic panel systems which contains many solar cells, one replaced a panel with n_s cells in series and n_p cells in parallel with one single solar cell with the short-circuit current n_p times bigger than that of one cell and the open circuit voltage n_s times bigger than that of one cell. One drawn the panel characteristics in this hypothesis and one performed simulations in SIMPOWERSYS. By simulations one tested the model to a variable irradiation, obtaining realistic results. One can say the obtained model is useful in hybrid systems simulation with photovoltaic panels, fuel cell and batteries.

Aiming photovoltaic panel use in hybrid system with a battery, one need to use a DC/DC boost converter to play MPPT role and to stabilize system functioning and keep simulation at high speed, compatible with long time simulations.

As future researches, in order to complete the instrument set for numerical simulations of photovoltaic panel systems it is necessary also the development and implementation of a mathematical model for a MPPT.

AKNOWLEDGMENT

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ANALYTICAL APPROACHES OF DETONATION WAVES

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Abstract: *This paper presents some aspects regarding the gas-dynamic model of the detonation wave starting from the basic equations of mass, momentum and energy. The combustion wave speed was obtained from given initial conditions and the graphics were made for different values of energy released in the combustion process. The existence of a solution to the steady conservation laws depended on the compatibility of the solution with the dynamics of the combustion behind the wave.*

Keywords: *combustion, gas-dynamics of detonation, deflagration.*

1. INTRODUCTION

As a result of the energy release, in a combustion process can appear two types of self-propagating waves: deflagration and detonation. Deflagration waves propagate at subsonic velocities and depend not only on the initial state of the combustion mixture but also, on the boundary conditions behind the waves. Being a diffusion wave, deflagration has a velocity, proportional to the square root of the reaction rate and in stationary conditions it is defined as a flame. A detonation wave has a supersonic velocity and it can be considered as a reacting shock wave where the reactants (which are situated ahead of it) are not disturbed prior to the arrival of the detonation, remaining at their initial state. The detonation front has a transient two-dimensional structure and the flow field generated by the ignition source is responsible for the detonation formation process. Behind a strong detonation wave the flow is subsonic and the wave penetrates the reaction zone attenuating the detonation, so, a freely propagating detonation has a sonic or supersonic condition behind it.

The classical method of investigating the stability of a steady solution for self-propagating detonation wave consists of imposing small propagating multidimensional perturbations on the solution and observe if the amplitude of the perturbations grows. This assumption (of small perturbations) permits the system of equations to be linearized and integrated in order to find the unstable modes. Another method is to start with the time-dependent nonlinear equations and then integrate numerically for given initial conditions in order to see if the solution is achieved asymptotically at large time [1]. Linear stability analyses are valid only for the initial growth of the perturbations and cannot describe results far from the stability limits. The most important parameters that govern the stability of a steady detonation structure are the activation energy, E_a, the ratio of specific heats, γ, the degree of overdrive, D/D_{CJ} and the chemical heat release, Q. The detonation is unstable for high values of E_a, because small temperature perturbations result in large fluctuations in the reaction rate.

The degree of overdrive, also influences the stability of the detonation because a high degree of overdrive increases the shock temperature, T_s, having the effect of lowering the temperature sensitivity of the reaction because the exponential temperature dependence of the reaction rate depends on the ratio of activation energy and the shock temperature. Also, an increase in the heat of reaction, Q, renders the detonation more unstable, because the physical effects of the perturbations are enhanced for higher value of the heat of reaction. The possible variation of the leading shock pressure of the detonation wave as a function of time for increasing values of the activation energy is analyzed [2]. The shock pressure is normalized with respect to its value corresponding to the steady Chapman-Jouguet detonation. For a low value of the activation energy, the shock front pressure is steady.

2. BASIC EQUATIONS

For a coordinate system fixed to the wave, the basic conservation equations of mass, momentum and energy for one dimensional steady flow across a combustion wave are given by:

$$\begin{aligned} &\rho_0 u_0 = \rho_1 u_1 \\ &p_0 + \rho_0 u_0^2 = p_1 + \rho_1 u_1^2 \\ &h_0 + q + \frac{u_0^2}{2} = h_1 + \frac{u_1^2}{2} \end{aligned} \tag{1}$$

where ρ, u, p, h and q are the density, velocity, pressure, the sensible enthalpy and q is the difference between the enthalpies of formation of reactants and the products. The subscripts 0 and 1 denote the reactant and product states and the sensible enthalpy of the mixture is given by

$$h = \int_{298}^{T} c_p dT \tag{2}$$

where c_p is the specific heat of the mixture.

The existence of a steady detonation front depends on the possibility of being able to match the conditions behind a steady detonation wave to the non-steady flow in the products of chemical reaction. Planar detonation can be matched to the non-steady expansion fan behind it, being compatible with the non-steady flow of detonation products.

Starting from the caloric equation of state for the sensible enthalpy one can get the Rayleigh line and Hugoniot curve for the transition from state $(1,1)$ to state (x, y) across the combustion wave. Defining the ratios of densities and pressures as $x = \rho_0 / \rho_1 = v_1 / v_0$ and $y = p_1 / p_0$ one can write the Rayleigh line

$$y = \left(1 + \gamma_0 M_0^2\right) - \left(\gamma_0 M_0^2\right) x \tag{3}$$

and Hugoniot curve

$$y=\frac{\frac{\gamma_0+1}{\gamma_0-1}-x-2\frac{q}{p_0v_0}}{\frac{\gamma_1+1}{\gamma_1-1}x-1} \tag{4}$$

where $\gamma=c_p/c_v$ is the ratio of specific heats. The Hugoniot curve can be expressed in another form, namely

$$(y+\alpha)(x-\alpha)=\beta \tag{5}$$

where

$$\begin{aligned}\alpha&=\frac{\gamma_1-1}{\gamma_1+1}\\ \beta&=\frac{\gamma_1-1}{\gamma_1+1}\left(\frac{\gamma_0+1}{\gamma_0-1}-\frac{\gamma_1-1}{\gamma_1+1}+2\frac{q}{p_0v_0}\right)\end{aligned} \tag{6}$$

From Rayleigh line equation we note that the velocity of the combustion wave is proportional to the square root of the slope of this line,

$$\frac{dy}{dx}=-\gamma_0M_0^2=-\frac{y-1}{1-x} \tag{7}$$

and also, the slope of the Hugoniot curve is

$$\frac{dy}{dx}=-\frac{y+\alpha}{x-\alpha} \tag{8}$$

The variation of entropy along the Hugoniot curve, in a nondimensional form $(\bar{s}=s/R)$ can be expressed as follows

$$\frac{\gamma_1+1}{\gamma_1}\left(\frac{d\bar{s}}{dx}\right)_{\substack{Hugoniot\\curve}}\left(\frac{\frac{\gamma_1-1}{\gamma_1+1}-x}{1-x}\right)x=1-M_1^2 \tag{9}$$

Depending on whether the flow behind the combustion wave is supersonic or subsonic, the downstream boundary conditions may or may not have an influence on the wave propagation speed, namely, for a subsonic flow behind the wave the back boundary condition must be satisfied by the solution of the conservation laws across the wave, but if the wave speed is also subsonic, then perturbations can propagate upstream of the wave and the upstream conditions will be altered.

According to the equation (9), if the value of x is in interval $\left(\frac{\gamma_1-1}{\gamma_1+1},1\right)$, the expression $1-M_1^2$ has the opposite sign to the entropy derivative along the Hugoniot curve. For a strong detonation, where $(d\bar{s}/dx)_{Hugoniot}<0$, it follows that $M_1<1$, that is, the downstream flow is subsonic relative to the combustion wave. When $(d\bar{s}/dx)_{Hugoniot}>0$ then $M_1>1$ and the downstream flow is supersonic, so, strong detonation and weak deflagration depend on the downstream boundary condition, but for the weak detonations and strong deflagrations (where the flow is supersonic behind the wave), the propagation of the wave cannot be influenced by the downstream boundary conditions [3, 4].

Figure 1 shows the graphics of the Rayleigh line and Hugoniot curve. The shock Hugoniot curve $(q=0)$ passes through the initial state $(1,1)$ and for finite values of q this curve lies above the shock Hugoniot curve and doesn't intersect the initial state. The intersection of the line $x=1$ and $y=1$ with the Hugoniot curve give the solutions for constant volume and constant pressure combustion. For $x\to(\gamma_1-1)/(\gamma_1+1)$ or $\rho_1/\rho_0\to(\gamma_1+1)/(\gamma_1-1)$ the denominator of the ratio (9) is zero and $y\to\infty$, that means the line of equation $x=(\gamma_1-1)/(\gamma_1+1)$ is an asymptotic line of the Hugoniot curve. The slope of the Rayleigh line can be expressed by

$$\left(\frac{dy}{dx}\right)_{\substack{Rayleigh\\line}}=-\frac{u_1^2}{p_0v_0x^2} \tag{10}$$

therefore $u_1^*=c_1^*$, that is the flow Mach number downstream of a Chapman-Jouguet detonation or deflagration, is equal to unity.

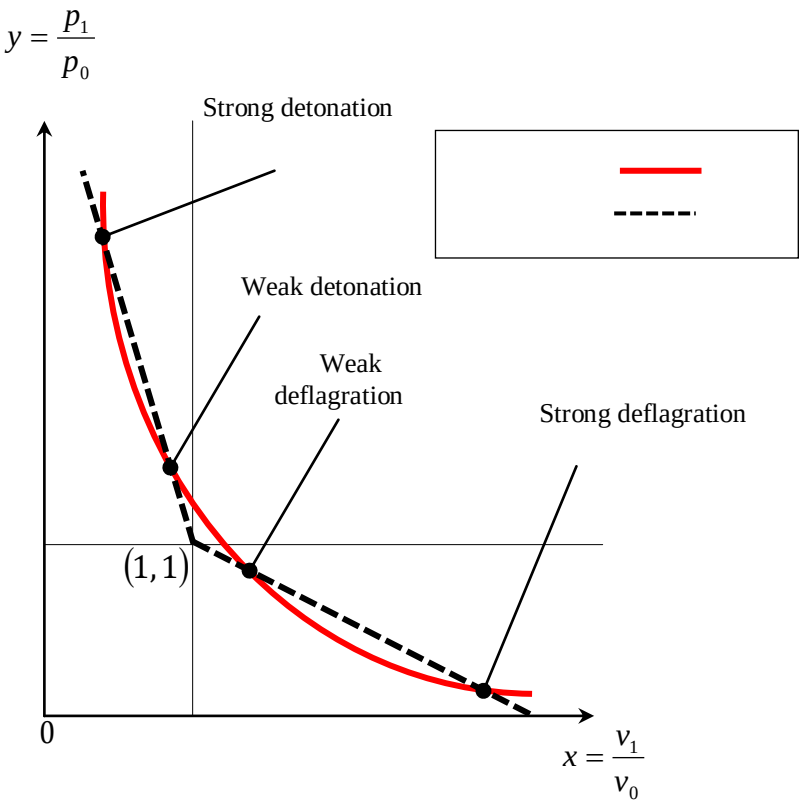


FIG. 1. The weak and strong detonation points

3. THE TANGENCY RAYLEIGH LINE AND HUGONIOT CURVE COORDINATES

For a constant chemical energy release and perfect gas assumptions it is possible to obtain the algebraic expressions relating the downstream state $(M_1, T_1, \rho_1, p_1)$to the upstream state (M_0, T_0, ρ_0, p_0).

For given initial and boundary conditions, the combustion wave speed can not be determined only from the system of conservation equations together with the equation of state, being necessary an additional relationship, which can be obtained from the Chapman-Jouguet criterion. In the point of tangency between Rayleigh line and Hugoniot curve (fig. 2) the detonation velocity is minimum and there are no solutions to the conservation equations for velocities less than this minimum value. Also, the sonic flow or minimum entropy requirement can provide a criterion for the conservation laws solution [5, 6].

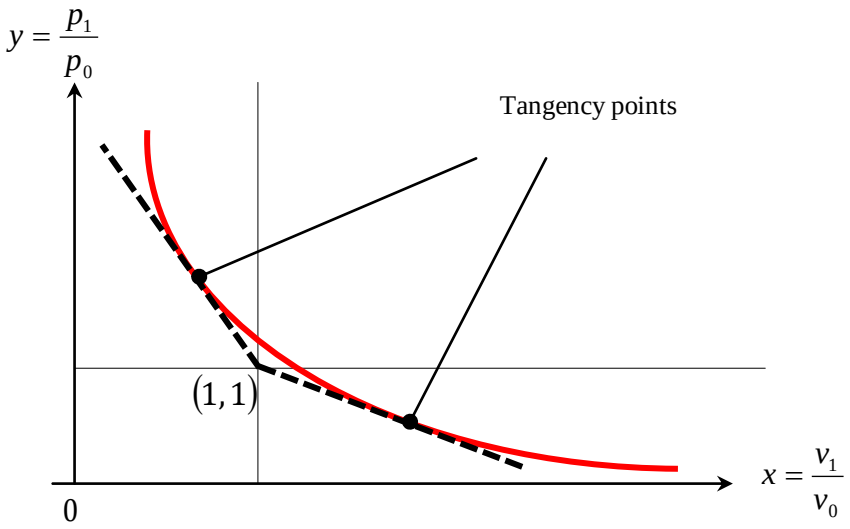


FIG. 2. The tangency solutions

Combining the equations (3) and (4) we get a quadratic equation for the specific volume ratio, $x = v_1 / v_0$,

$$x^2 - 2\frac{\gamma_1\left(\gamma_0 + \frac{1}{M_0^2}\right)}{\gamma_0(\gamma_1 + 1)}x + \frac{\gamma_1 - 1}{\gamma_1 + 1}\left[1 + 2\frac{1}{M_0^2}\left(\frac{1}{\gamma_0 - 1} + \frac{q}{c_0^2}\right)\right] = 0 \tag{11}$$

The discriminant of the above equation is

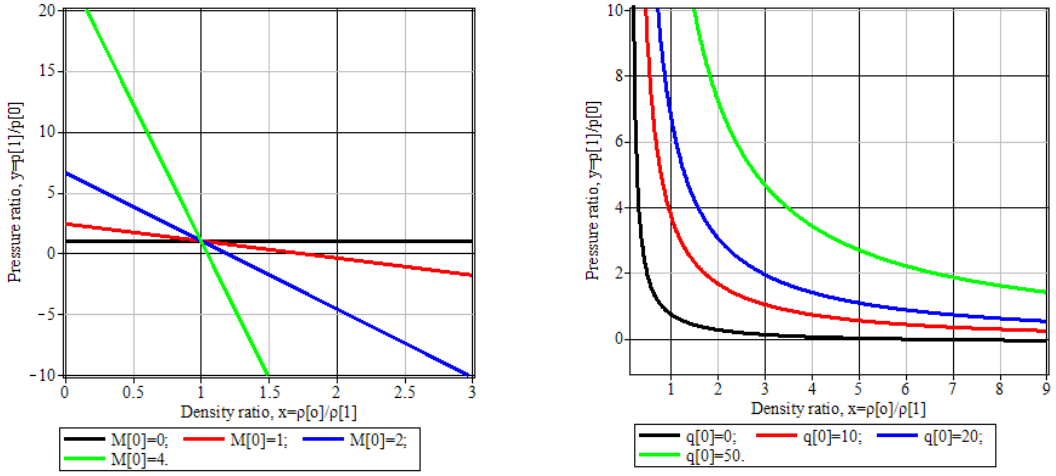
$$\Delta = \left[\frac{\gamma_1\left(\gamma_0 + \frac{1}{M_0^2}\right)}{\gamma_0(\gamma_1 + 1)}\right]^2 - \frac{\gamma_1 - 1}{\gamma_1 + 1}\left[1 + 2\frac{1}{M_0^2}\left(\frac{1}{\gamma_0 - 1} + \frac{q}{c_0^2}\right)\right] \tag{12}$$

and the solutions x_1 and x_2 can be expressed as follow

$$x_{1,2} = \left(\frac{v_1}{v_2}\right)_{1,2} = \left(\frac{\rho_0}{\rho_1}\right)_{1,2} = -\frac{\gamma_1\left(\gamma_0 + \frac{1}{M_0^2}\right)}{\gamma_0(\gamma_1 + 1)} \pm \sqrt{\Delta} \tag{13}$$

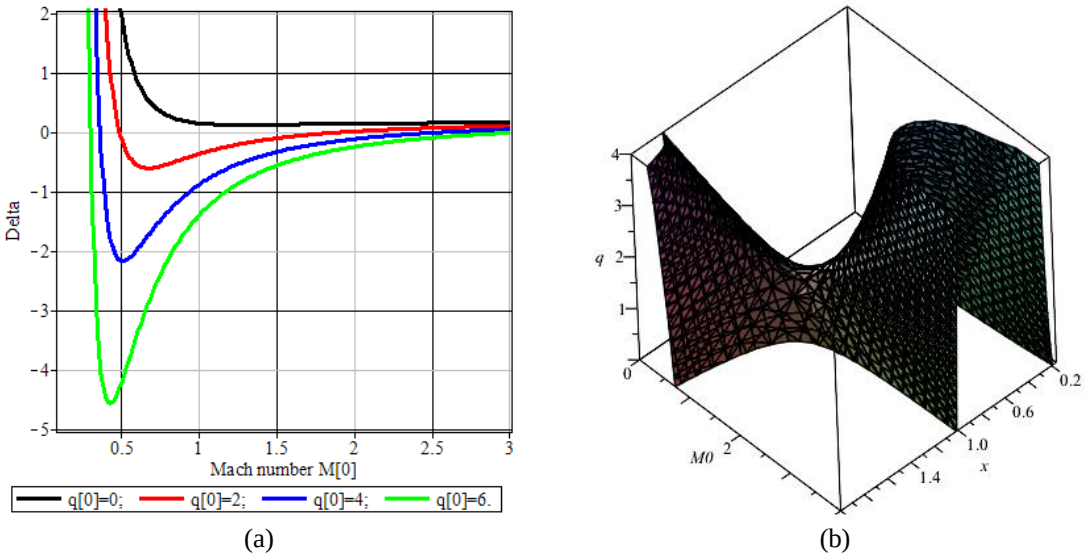
The positive sign corresponds to a weak detonation whereas the negative sign refers to a strong detonation. When the two roots coincide, we obtain the tangency solutions, which are the Chapman-Jouguet criterion. In the following picture are presented some curves for different Mach number M_0 values and for a detonable mixture corresponding to $\gamma_0 = 1.4$ and $\gamma_1 = 1.2$.

Figure 3 shows the Rayleigh lines and Hugoniot curves shapes for different values of Mach numbes M_0 and heat of reaction. Also, fig. 4 shows the discriminant function for the tangency points and the shape of solutions domain.



(a) (b)

FIG. 3. The Rayleigh lines for different values of Mach number (a) and the Hugoniot curves for different values of reaction heat



(a) (b)

FIG. 4. The discriminant of equation for tangency point solutions (a) and the domain of all possible solutions (b)

4. CONCLUSIONS

The basic theoretical aspects presented in this article permit the detonation velocity to be determined without boundary condition considerations for rear wave domain, even if their existence requires that a solution for the non-steady flow of the products match the steady boundary condition behind the Chapman-Jouguet criterion. For the planar case, the solution is continuous and the Rimann solution satisfies the sonic condition at the rear frontier of detonation, while for the cylindrical and spherical detonation there are singularities due to the infinite expansion gradient. The mathematical criterion for the sonic singularity becomes an important requirement for the choice of the correct solution from the conservation laws.

Detonation and deflagration can be analyzed using the conservation equations across the front wave and these do not require the mechanism for this transition, being necessary a model for the structure of the detonation wave, which specifies the physical and chemical processes for transforming the initial to final states.

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IoT WEB-SHARED VARIABLES – PUBLISH, COLLECT AND ANALYSIS IN THE CLOUD

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Abstract: *In a world where human activity tends to be the input data of IoT (Internet of Things) objects, AI (Artificial Intelligence) provides powerful tools for behavioral patterns with applications in wide domain areas. The approach described in this paper takes benefits of REST (Representational State Transfer) web-services to publish and get data to/from the Cloud, received from the IoT sensing elements. Based on the National Instruments web-shared variables server, the data is monitored and published. A Cloud-based IoT specific tool (Node-RED) is responsible for data retrieval using HTTP requests and extraction of the relevant values. Furthermore, these values are analyzed in order to create an AI service.*

Keywords: *IOT, AI, Cloud, ESP8266, Node-RED, REST services*

1. INTRODUCTION

Internet of Things has nowadays become a hot topic, not only as a research field, but as a growing industry, considering that more and more companies are developing businesses towards it: IBM, Google, Microsoft etc.

As technology develops in such an alert trend (in accordance to Moore's law), the number of devices with "intelligent" capabilities have increased: network connectivity, small scaled devices, even wearable technology, environment surveillance and interaction led to migration towards the Internet of Things. For example, sensor nodes can be connected to network and provide an environmental monitoring application: smart heating system, optimization of energy consumption etc. [1]

The communication between different "things" connected needs lightweight protocols, and some of the most well-known are MQTT and CoAP. Our demonstrator takes aid from REST services; as Web is implemented using RESTful principles, it would be common sense to utilize this method as means of communication. [2]

Furthermore, the Web Shared Variables server used in this demonstrator allocates resources dynamically and makes use of RESTful services, as seen above.

2. DATA TRANSMISSION AND COLLECTING ON SERVER

The scenario we have decided to implement in our demonstrator is a temperature monitoring solution, based on low-cost hardware elements that could benefit from the Cloud processing in the decision process for adapting the ambient temperature.

Similar, commercial products are already on the market (e.g. the Google Nest thermostat) but for exemplification purposes we have considered this to be a valid scenario, that could be enhanced with a more dense and accurate sensor network.

To transmit the acquired data from the temperature sensor we have chosen ESP8266.This is one of the cheapest Wi-Fi modules available on the market and can be implemented with the Arduino syntax. The ESP8266 processor from Espressif is an 80 MHz microcontroller with a full Wi-Fi front-end and TCP/IP stack. [3]

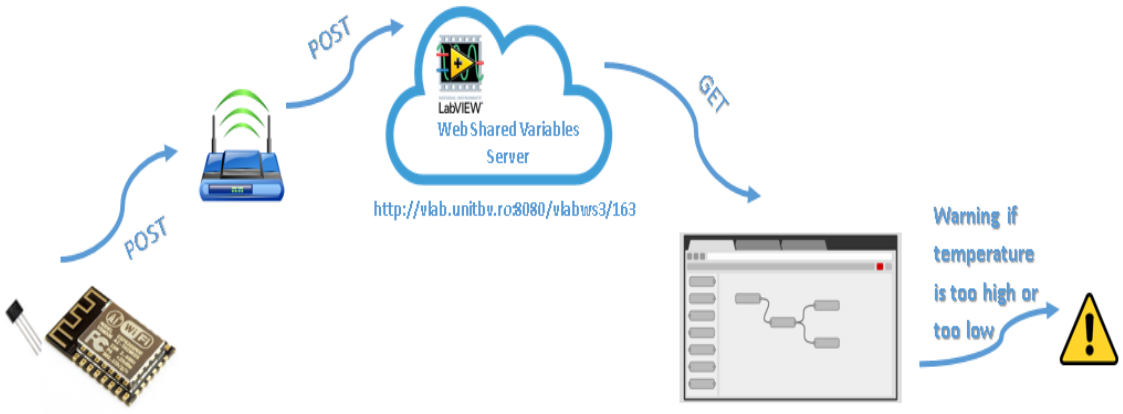

FIG. 1 Data transmission principle

Another used device that is connected to the development board is a LM35 temperature sensor. This is a device with a linear voltage to temperature in Celsius readout. It has a temperature range of -40 ° C up to 150 ° C and an output range from 0.1 V (-40 ° C) to 2.0 V (150 ° C). The development environment used to write the source code is the Arduino IDE program. This is an open source software that makes it easy to write a code and load it on the board.

The data acquisition made from the temperature sensor was sent to a shared variable server. The Shared Variable Server is an effective way to transmit data between multiple computers using simple encoding techniques and is installed with each version of LabView from version 8.0 upwards.

The Shared Variable Engine is where a variable is located on a local client. It is responsible for network communication, link management, and allows users to monitor the status of locally-implemented and real-time variables. Furthermore, since the server acts as a “man in the middle”, it can be considered as an IoT Gateway: it sits on the edge of the IoT ecosystem to provide data and connectivity throughout the communication. [4]

A communication process in LabView TCP / IP involves opening a connection, reading and / or writing information, and then closing the developed connection.

3. NODE-RED AS WORKING ENVIRONMENT

Probably one of the most specific software programs for IoT, Node-RED is a browser stream orchestrator that allows the connection / interconnection of IoT devices. Different services, APIs etc. can be applied to the resulting streams from these devices to create an entire system. [5]

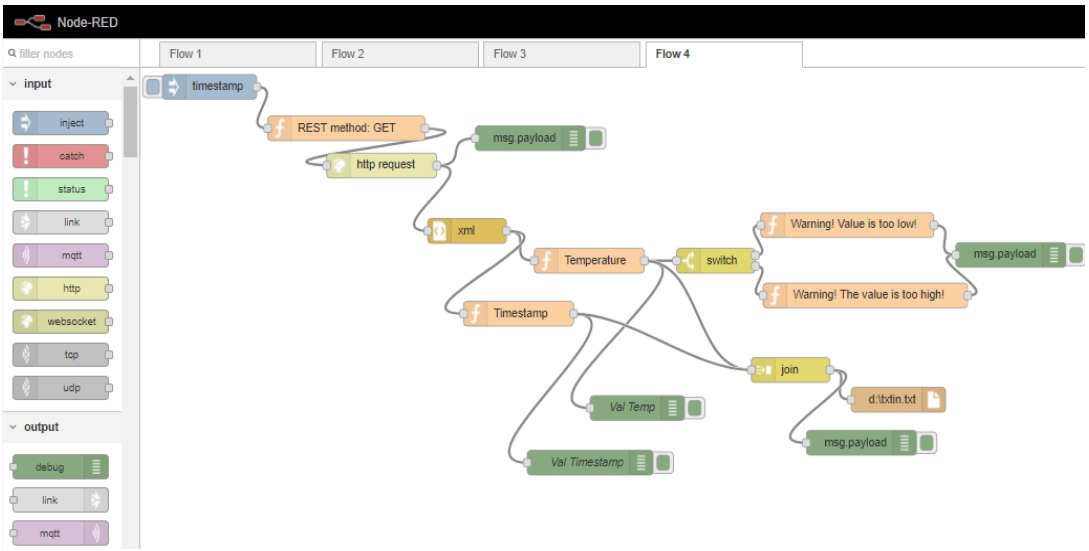

FIG. 2 Flow architecture in Node-RED

While REST stands for Representational State Transfer, which is an architectural style for networked hypermedia applications, it is primarily used to build Web services that are lightweight, maintainable, and scalable. A service based on REST is called a RESTful service. REST is not dependent on any protocol, but almost every RESTful service uses HTTP as its underlying protocol. Some might question our preference of using REST instead of IoT specific protocols like MQTT or CoAP, but as our application does not require at this point security barriers and because of the similarity of REST and MQTT werbs (POST – PUBLISH, GET - SUBSCRIBE) we have chosen REST web service. [6]

What is more, Node-RED can be successfully used to import "node" models to develop Artificial Intelligence services such as: machine learning, deep learning etc. for IoT.

4. DATA ANALYSIS

Retrieving data in Node-RED from the server is done using an HTTP request using a GET method. This method interrogates data from the server address: http://vlab.unitbv.ro:8080/vlabws3/163. The data is then displayed using a Debug Node:

```
<Response>
  <Terminal>
    <Name>Temperature</Name>
    <Value>24.4</Value>
  </Terminal>
  <Terminal>
    <Name>Device Time</Name>
    <Value>11/19/2017 7:38 PM</Value>
  </Terminal>
</Response>
```

The Inject node (timestamp) allows to inject messages into a flow, either by clicking the button on the node, or setting a time interval between injects (the repeat interval is at every 15 minutes).

As URL is used to identify resources over the Internet and HTTP as a service interface, an IoT "object" can thus connect to a certain service, located at the address pointed out by URL and send HTTP calls. The format used in this experiment is XML, by which the payload data is exchanged using GET, POST, PUT etc. verbs.

Because the data retrieved from the HTTP request is in string format, it must then be converted for easier processing in XML format using an XML node. To extract the temperature value from the data block, is used the following function: "msg.payload = msg.payload.Response.Terminal[0].Value[0]; return msg;". Then it is displayed, by using a Debug Node.

For temperature processing, is used a switch function, that route messages based on their property values: if temperature is less than 22 degrees, then will be displayed a warning that contains the following message: "Small Value"; if temperature is greater than 23 degrees, will be displayed the following message: "Exceeded Value".

Also, the value of timestamp is extracted from the data block, using the following function: "msg.payload = msg.payload.Response.Terminal[1].Value[0]; return msg;".

The value of timestamp and temperature are joined together in a file, that could potentially be further needed in a machine learning service as described in conclusions paragraph.

5. CLOUD - EDGE PARADIGM IN DATA ANALYSIS

Recent years, Cloud Computing has been on a rising trend for, not only storage, but for data processing. IoT had nevertheless took advantage of Cloud by providing MQTT brokers, for example. Node-RED described above can be classified as a Cloud solution for IoT stream orchestrator. [7]

However, if the incident data has critical, real-time characteristics, then the Cloud architecture impacts on both accuracy of data and speed of delivery, such it imposes an Edge approach.

Node-RED, as a lightweight platform can also be used as an Edge processor: if the IoT object is an SBC (Single Board Computer), it can process the time critical data itself.

6. CONCLUSIONS AND FURTHER DEVELOPMENT

In the above presented scenario we were able to demonstrate the easy methods to integrate sensing data into REST-based IoT processing flows, that can further become complex services. The advantage of the presented system is the cost (by using a low-cost processor) and the easy integration with other applications based on web services. We have proved the efficiency of Node-RED that could also be an excellent inter-protocol mediator for different IoT protocols (e.g. MQTT interconnection with REST/HTTP), acting as a broker: can implement himself some of the decisions, but can also pass values to standard Cloud platforms from Amazon, Microsoft or IBM.

Our implementation has potential to develop machine learning services from the incoming data from the server. One potential scenario could involve AAL (Active Assisted Living) services: sensors that monitors day-to-day activity of elderly people and "learn" habits to prevent any anomaly that could be a sign of illness or disease. [8]

The flow below can be considered as a starting point as a future development.

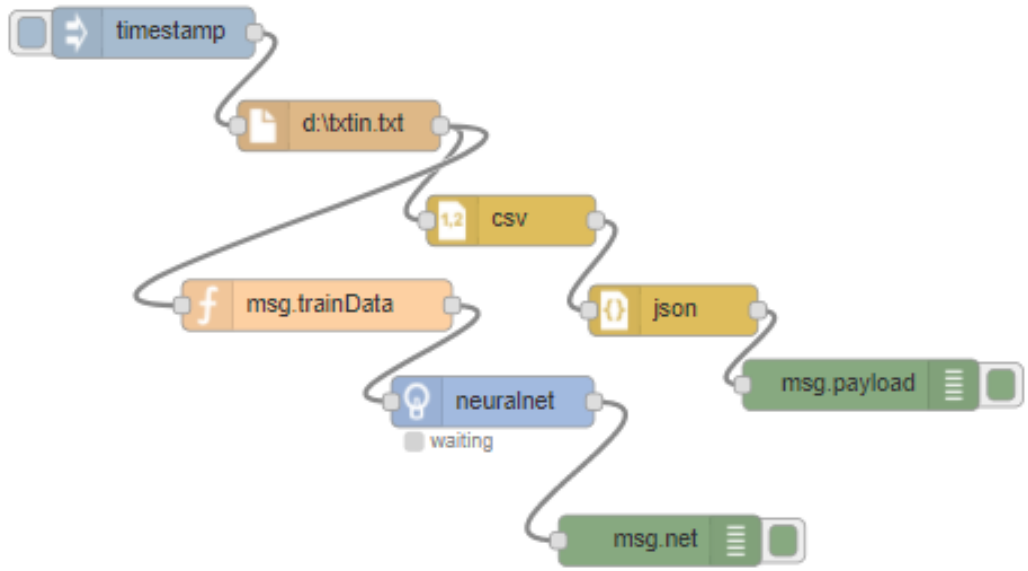

FIG. 3 Flow architecture for further development

Cloud industry provides more and more tools and services in this direction, a future development could take into consideration IBM Watson services or Azure IoT Hub logic connectivity programming.

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SS7 SIGNALLING OVER ETHERNET USING IPSL IN A MOBILE COMMUNICATIONS TESTING LABORATORY

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Abstract: *The practical approach to signaling in mobile communications benefits greatly from the special solution presented through this paper, namely the replacement of the MTP-1, MTP-2 inferior levels of the Message Transfer Protocol through Ethernet and IP (Internet Protocols). SS7 over Ethernet signaling in a test laboratory has provided a series of solutions in Adaptation Layer (AL / Middleware) related to virtualization techniques – "cleavage" in the OSI stack means independence from lower levels (keeping any services, programs, protocols, tests, generally any procedures or network plans at higher levels). This paper contributes to the concept of mixed equipment (real infrastructure combined with the emulated one without affecting controllability, testability) using IPSL – Independent protocol simulator language as a chosen solution.*

Keywords: *Middleware, IPSL, signaling*

1. INTRODUCTION

One of the most important part of the GSM network is signaling, provided by the SS7 (Signaling System number 7) protocol suite. Operators are deploying SS7 services over a dedicated 56 kbps or 64 kbps bandwidth using Time Division Multiplex (TDM) technology, or high speed T1 (1.5 Mbps) or E1 (2.048 Mbps) streams.

With the introduction of SIGTRAN in GSM network opened up a new perspective in the concept of signaling. SIGTRAN (SIGnalling TRANsport) is a standardized IP protocol developed by the IETF (Internet Engineering Task Force) working group that allows the transport of signaling using the IP protocol. This protocol has been developed to address the SS7 overload problem due to the 16 channel limitation for TDM technology.

Using SIGTRAN protocol IPSL can be "inserted" almost everywhere in the GSM architecture successfully emulating the rest of the network without affecting the overall functionality. This approach can be either used for learning the behavior of a specific equipment in various scenarios or debugging it. One of the easiest ways of learning is the "black box" approach where the functionality of the equipment is totally neglected, the main focus being the input and especially the output.

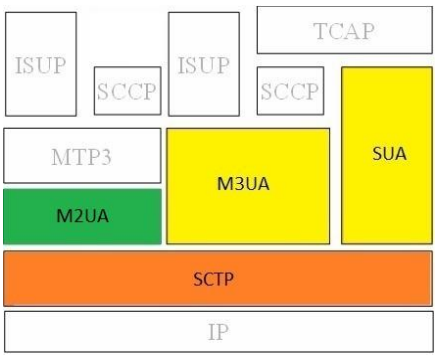


FIG. 1. SIGTRAN protocol stack

2. IPSL CONCEPT AND WORKFLOW

IPSL is a high level language developed in order to facilitate creations of numerous test suites which verify interoperability cross vendor and the behavior of the network in different scenarios. It is independent of the protocol tested, and the language does not contain specific protocol elements.

All elements, such as message type codes, protocol-specific messages, or message parameters are defined separately and transmitted transparently by the IPSL script to the simulator. IPSL allows multiple scripts or instances of the same script (possibly with different parameters) to run in parallel. An entity of the simulator, which can run a instance of a scenario in terms of IPSL, is a resource (sometimes called port).

A resource also includes a set of data to store all the information needed to direct incoming messages to the correct instance. The required information depends on the protocol used. A context-change between two running scripts is done only at the WaitFor statement or after the script has ended. This can be called a cooperative multitasking.

The function "WaitFor" always specifies which message is expected as the next event. If a different event than expected occurs, it can be interpreted in two ways: as an unexpected event or an asynchronous one. A perfect illustration of the IPSL workflow is presented in Fig. 2.

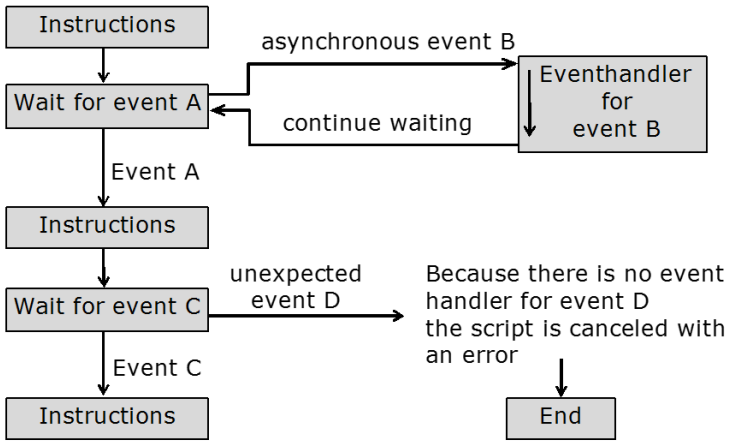


FIG. 2. IPSL standard workflow

The internal architecture is defined around two main files: the script and the control file; the first is a sequence of user defined messages which are injected in the network on the interface where IPSL is connected.

The second contains the loop invoking scripts (usually called TestBlock). These loops can expire by time range or by reaching a configurable number of passings.

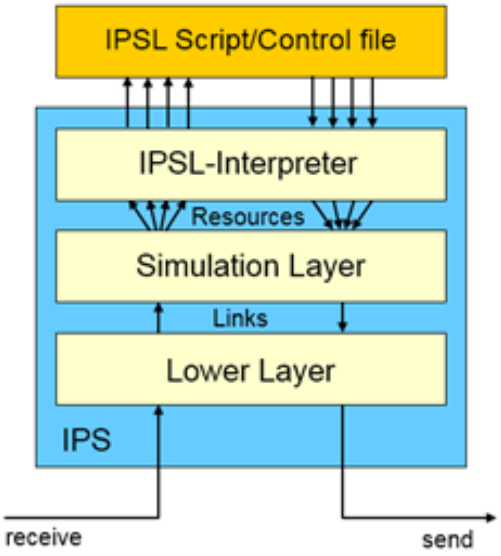


FIG. 3. Bottom-up perspective of IPSL functionality

The simulator offers a series of predefined messages grouped in a collection. In the script, a message can be retrieved from that collection via Pool() function. Now the selected message can either be sent with the default values or modified in order to adapt to the networks demands.

There are specific functions which grant access to almost every parameter of a message thus allowing the user either to set the desired value or even not sending the parameter at all. To simplify the IPSL message type model, these are treated as strings. This implies that messages can be stored in variables and can be defined as "string" constants.

3. PRACTICAL APPROACH. EMULATION APPLIED IN LOCATION UPDATE SCENARIO

The components used to implement the experiment were the BTS (Base Transceiver System) and BSC (Base Station Controller) representing the access network, these being the real elements of the system. The emulated hardware is made up of the Dialogic® TX 4000 PCI board with the role of interconnecting the computer with the GSM architecture.

The software behind the Dialogic® TX 4000 is IPSL which provides and controls the specific message flow needed by the BSC in order to successfully complete a Location Update scenario.

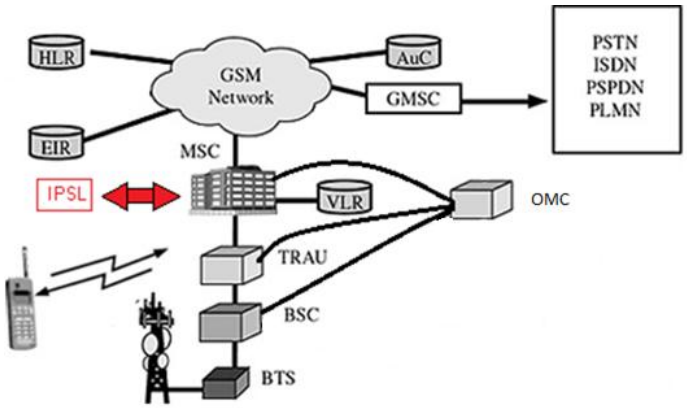


FIG. 4. The GSM architecture used in the tested scenario

The results are shown in a graphical user interface which provides the user with the following features: Standard Windows Application; Separate state viewer for each layer; Trace viewer showing messages for each protocol layer; permanent view to the main simulation state (actual count, load and errors).

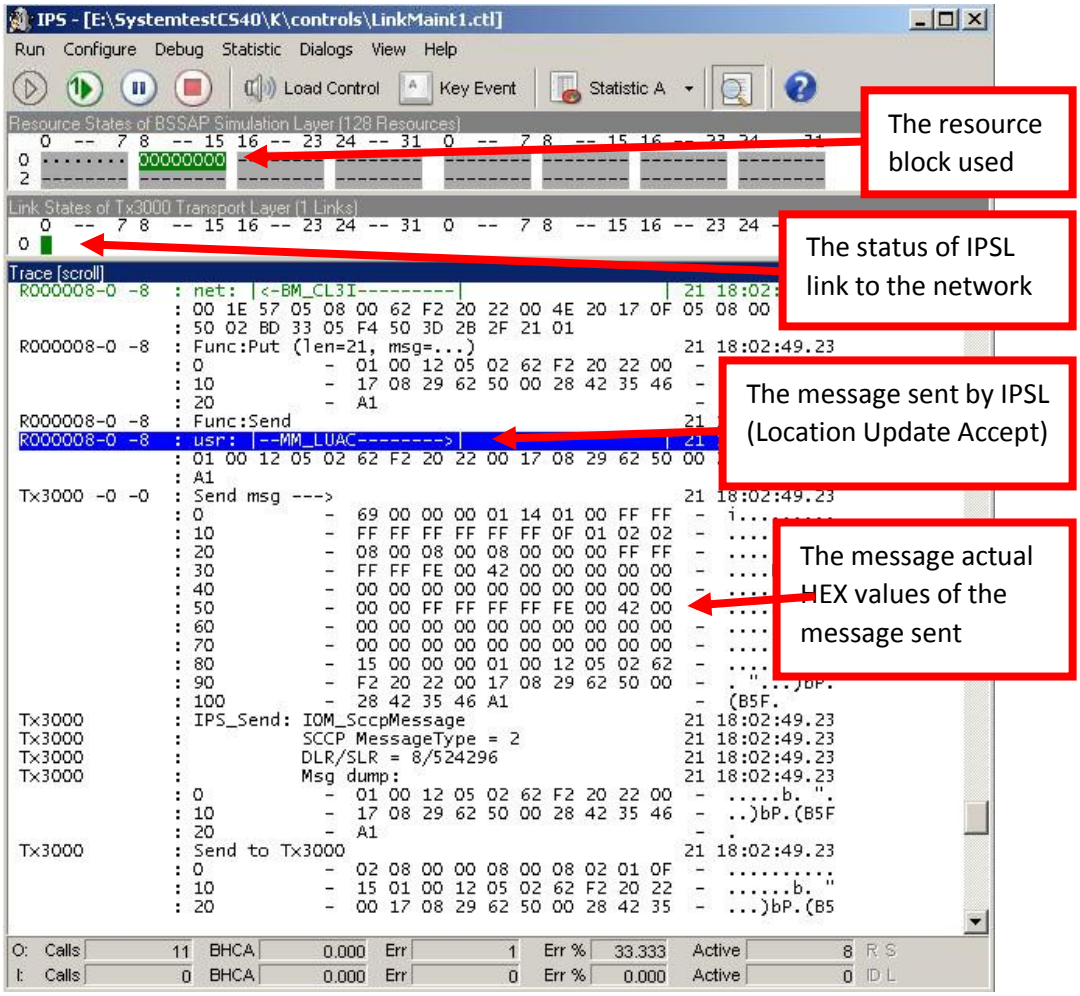


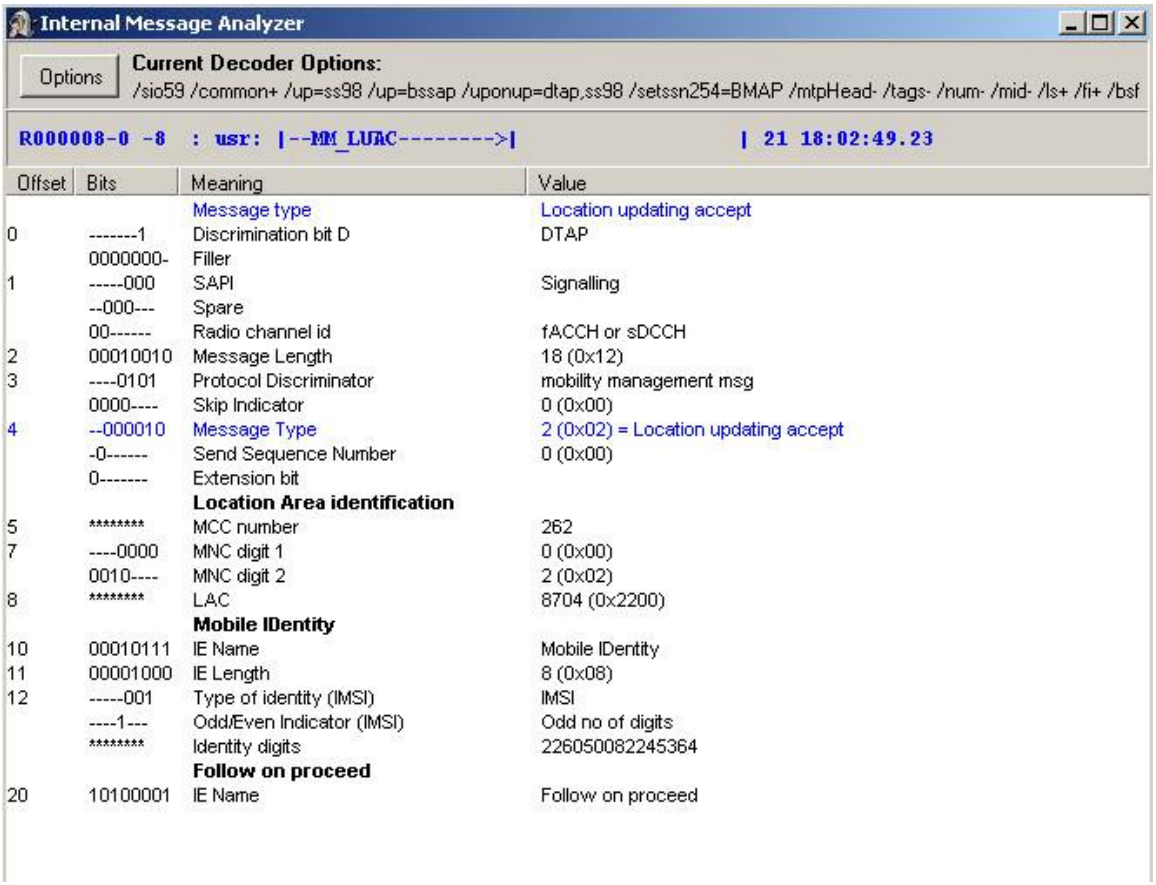
FIG. 5. IPSL GUI in live scenario

Every message from the GUI (Graphic User Interface) can be further analyzed using the Internal Message Analyzer; this tool provides the user with: online decoding of sent or received messages; decoding of messages on different protocol layers; discovering of wrongly structured messages.

The Internal Message Analyzer decodes the HEX values sent in a user interpretable manner. The messages name use the following format: <GSM_function>_<Message_Abreviation>. In Fig.. 6 is presented the actual "MM_LUAC" – (Mobility Management Location Update Accept) used in the tested scenario. Every HEX value presented in Fig. 5 is translated into a pair meaning – value.

These values were set in the IPSL script in order to match the Location Update request thus granting the BSC the needed parameters in order to authorize the whole process. With real-world equipment, the response would have been built at the MSC level by successive interrogations on the VLR and HLR databases.

Using IPSL requires prior knowledge of the parameters expected by the BSC to successfully accomplish the emulation of the MSC response such as MCC (Mobile Country Code), MNC (Mobile Network Code), LAC (Location Area Code) etc.


Internal Message Analyzer

Options

Current Decoder Options:
/sio59 /common+ /up=ss98 /up=bssap /uponup=dtap,ss98 /setssn254=BMAP /mtpHead- /tags- /num- /mid- /ls+ /fi+ /bsf

R000008-0 -8 : usr: |--MM_LUAC-------->| | 21 18:02:49.23

Offset	Bits	Meaning	Value
		Message type	Location updating accept
0	-------1	Discrimination bit D	DTAP
	0000000-	Filler	
1	-----000	SAPI	Signalling
	--000---	Spare	
	00------	Radio channel id	fACCH or sDCCH
2	00010010	Message Length	18 (0x12)
3	----0101	Protocol Discriminator	mobility management msg
	0000----	Skip Indicator	0 (0x00)
4	--000010	Message Type	2 (0x02) = Location updating accept
	-0------	Send Sequence Number	0 (0x00)
	0-------	Extension bit	
		Location Area identification	
5	********	MCC number	262
7	----0000	MNC digit 1	0 (0x00)
	0010----	MNC digit 2	2 (0x02)
8	********	LAC	8704 (0x2200)
		Mobile IDentity	
10	00010111	IE Name	Mobile IDentity
11	00001000	IE Length	8 (0x08)
12	-----001	Type of identity (IMSI)	IMSI
	----1---	Odd/Even Indicator (IMSI)	Odd no of digits
	********	Identity digits	226050082245364
		Follow on proceed	
20	10100001	IE Name	Follow on proceed

FIG. 6. Analysis of Location Update Accept message

5. CONCLUSION

Based on the practical results obtained in this paper, by integrating high-complex equipment with the possibility of emulating any equipment in the GSM architecture, we have been able to implement the mixed reality concept without affecting the functions of the access network. The scenario developed in the IPSL environment has been designed to meet the test standards.

Based on the protocols used, SS7 and SIGTRAN the used messages have standard template. Their correct parameterization was obtained by repeated tests, the results being collected on the basis of the response of the tested equipment. This has demonstrated the effect of parameterisation of messages on the access network. This kind of software can have a major economic impact because now any equipment can be tested wihtout having the whole architecture at your disposal.

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A PROBABILISTIC ASSESSMENT OF THE RELIABILITY OF AVIATION SYSTEMS

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Abstract: *The technological risk which involves running of actions/processes in operation, leads to exposing and compromising systems operations developed by advanced technologies. The application of risk analyzes in conjunction with probability theory becomes the framework for reliability studies based on the classical structural theory described by Freudenthal and others, considering that the probabilistic and statistical calculation is a solid pillar for the risk assessment methods used in the reliability theory.*

Keywords: *reliability, risk, probabilistic assessment, cumulative probability, RPAS*

1. INTRODUCTION

Aviation was a precursor for reliability analyzes since it managed to outline an average of operating failures, statistics revealing that in the 1940's, a period located at the boundary of the technical era and the human factor era, corresponding to the evolution of the flight accident analysis methods, the fault ratio traduced into an accident at 10^5 flight hours [5].

Probabilistic perception of reliability treats failures as random events, but fitting within certain limits and patterns is useful for highlighting different classes of unexpected/sudden failure or with a progressive evolution [1].

As a probability element, reporting to a fault previously produced establishes classes of failures, connections and chaining of events, since the probability of failure depends on the stability and dependence of the systems, as defects may be influenced by variations and previous states of the system. In this respect, the failures will be classified into: dependent and independent faults, thus determining their causes and influences [8].

The classical approach to the probabilistic evaluation of a failure takes into account the failure rate of a component λ, the exposure time T and the repair time τ. This is also used in the analysis of a fault tree (FTA), a frequently used technique for reliability and safety analysis, which considers the primary events of the arboreal structure as faults whose probabilities are used further to calculate the next probabilities of the events in the upper part of the intermediate structure and afterwards, the top event.

$$P = \begin{cases} 1 - e^{-\lambda T} \\ \lambda\tau / (1 + \lambda\tau) \\ c \end{cases} \quad (1)$$

c - constant probability

Error modeling based on a reliability theory approach makes a classification based on the stages or phases in which they can occur, the importance and the consequences attributed [10]. Impairment of the system's reliability affects safety as a response, hence, a reactive analysis of previous accidents and a predictive approach by anticipating errors and uniformity of operations are essential to maintaining a high level of safety.

Despite the need for an overall approach to a remotely piloted aircraft system that will be analyzed below, it must be considered that at the level of any constituent component, a relative independence should be established in respect to the rest of the elements.

2. A CUMULATIVE PROBABILITY APPROACH FOR RELYABILITY

In the probabilistic hypothesis, the expression of reliability notion specifies the probability that the fixed parameters of a system maintain their set values within the range of $[0,t)$; this probability characteristic to operational safety being framed by the values 0 and 1.

$$0 \le P(t) \le 1 \tag{2}$$

The $\langle E_i, p_i, X_i \rangle$ trio designates the probabilistic computational framework of a risk, therefore it can be seen as an interpretation of the degree of realization of E_i events [1]. If an event (malfunction) noted E_i occurs with the probability p_i, it will have consequences X_i (losses) with different nature and will verify the relations:

$$i = 1 \ldots n \tag{3}$$
$$X_i = (X_1, X_2, \ldots, X_n)$$

Assuming that:

$$X_1 \le X_2 \le \ldots \le X_n \tag{4}$$

If the events are identified, then the sum of the probabilities attached has a unitary result.

$$p_1 + p_2 + \ldots + p_n = 1 \tag{5}$$

Thus, the cumulative probabilities (which can be ascending or descending cumulative probabilities), whose form is (for an event E_i):

$$P_i = p_i + \ldots + p_n \tag{6}$$

Cumulative probability takes into account events in a sequence and represents the probability that a random variable's value is considered within a specified range [4].

So, the cumulative probability:

$$Cumulative\,\Pr = \begin{cases} P_1 = p_1 + \ldots + p_n \\ P_i = p_i + \ldots + p_n \\ P_n = p_n \end{cases} \tag{7}$$

Considering the before noted relations $p_1 + p_2 + \ldots + p_n = 1$, the probability P_1 becomes $P_1 = p_1 + p_2 + \ldots + p_n = 1$, so the cumulative probability transforms into:

$$Cumulative\,\Pr = \begin{cases} 1 \\ P_i = p_i + \ldots + p_n \\ P_n = p_n \end{cases} \tag{8}$$

For example, considering an inspection for one of the remotely piloted aircraft system developed by NASA and used for government surveillance interests, the most common malfunctions revealed at routine check could be: damage of lithium batteries produced by overheating, normally caused by solar radiation and a short circuit of the hydrogen cells.

The considered aircraft was a Helios prototype developed as part of an evolutionary series of solar electric and fuel-cell-system-powered unmanned aerial vehicles, designed to operate at high altitudes for long duration flight. It was a long-term, high-altitude aircraft made by NASA in order to perform different research tasks [2].

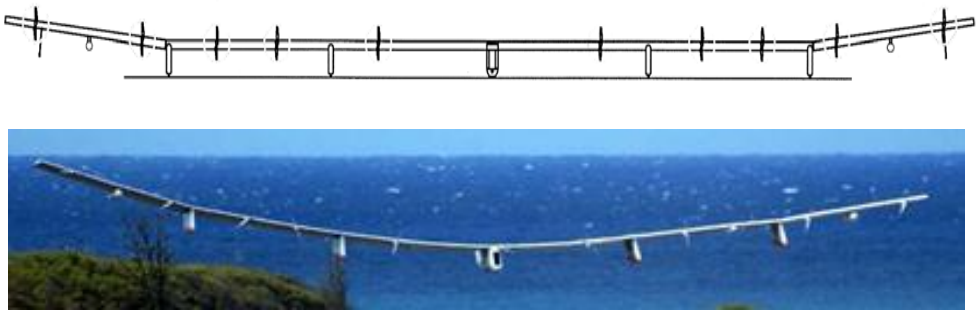

FIG. 1. Description of remotely piloted aircraft system developed by NASA

In structural failures, eighty to ninety percent of the occurrences [11], [12] are caused by human error [13]; so, the analysis of the likelihood of a failure will have to take into account both the rate or frequency of production and the contribution of the human factor and possible implications.

Problems generated by the human factor refer to the human-machine-environment trio, which is often only seen by the first two components, the latter being treated as a framework for producing the accident scenario. However, the following studies will not take into consideration human errors, but the malfunctions (i.e. damage of the lithium batteries, short circuit of the hydrogen cells, a defective piece of the hydrogen tank placed in the center of the wing) of the particular structure of a complex unmanned aerial vehicle (a propeller-driven aircraft flying under guidance of ground-based controllers [2]), produced by NASA in the early 2000.

If considering two successive inspections, it can be analyzed what is the probability that the damage of the lithium batteries caused by overheating would not produce or will produce one or two times.

Using cumulative probabilities, the result will be the sum of the probability of the event not producing and the probabilities that the damage of the lithium batteries will produce once and two times.

Table 1. Probabilities and cumulative probabilities of considered case

Number of events	Probability	Cumulative Probability
0	$2.5 \cdot 10^{-1}$	$2.5 \cdot 10^{-1}$
1	$5 \cdot 10^{-1}$	$7.5 \cdot 10^{-1}$
2	$2.5 \cdot 10^{-1}$	1

In this case, the probabilities of the consequences are calculated as the sum of the probabilities values that appear before the targeted element (inclusive), being a cumulative probability.

$$P(X \le 1) = P(X = 0) + P(X = 1) \tag{9}$$

$$P(X \le 1) = 2.5 \cdot 10^{-1} + 5 \cdot 10^{-1} = 7.5 \cdot 10^{-1}$$

$$P(X \le 2) = P(X = 0) + P(X = 1) + P(X = 2) \tag{10}$$

$$P(X \le 2) = 2.5 \cdot 10^{-1} + 5 \cdot 10^{-1} + 2.5 \cdot 10^{-1} = 1$$

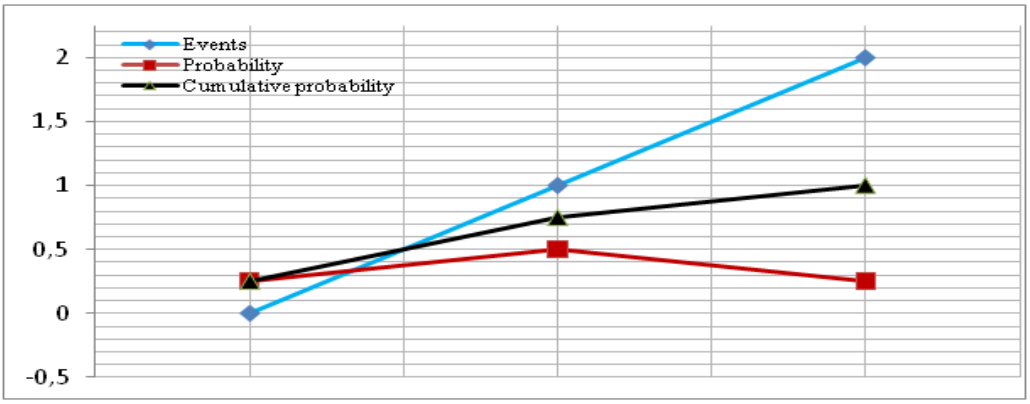

FIG. 2. Events, probabilities and cumulative probabilities of considered case

In this manner, the cumulative ascending frequency function can also be established (represented by the sum of all values that occur up to and including X).

$$F(X) = \sum_{X_i \le X} f(X_i) \tag{11}$$

The experiments described in the probabilistic studies are random, and if an event E has been produced m times from n possible times, the relative frequency oscillates around the probability of E:

$$0 \le m \le n \tag{12}$$

$$\forall n, 0 \le \alpha \le n$$

α -absolute frequency

$$\forall n, 0 \le f_n \le n \tag{13}$$

$$f_n(E) = \frac{\alpha}{n}$$

f_n - relative frequency

Table 2. Evaluation of probability and consequences by frequency and the probability of failure

Criterion	Probability evaluation	Consequence evaluation
Frequency	Per time interval	Components/equipment with defects/malfunction
Probability	Per solicitation	Length of unavailability

Statistical data on reliability that were processed over time have become necessary for a good definition and understanding of the phenomena treated by reliability laws and also for the comprehension of system behavior and evolution in order to make accurate predictions for failures [1].

Mathematical models for reliability analyzes are applied to multiple interconnections between elements/components of the system. Since system's interactions mirrors in the possible states of operation, the accuracy of reliability calculations implies uncertainty modeling which starts by eliminating incorrect/poor knowledge of different conditions.

Throughout this paper, risk and reliability analyzes are considered a framework for risk management, for identifying weaknesses in the remotely piloted aircraft system. Yet, for modeling uncertainty, probabilistic methods, statistics and complex mathematical operations are used.

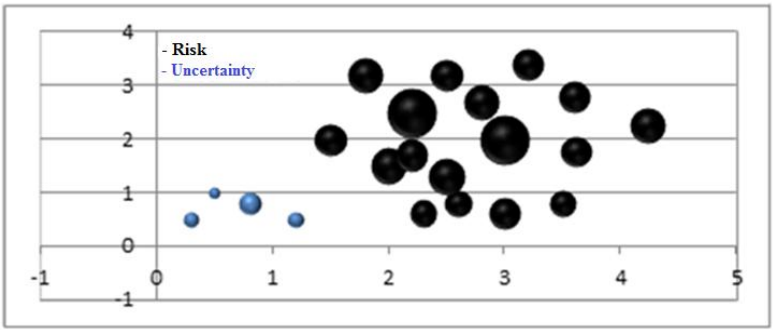

FIG. 3. Level of information regarding risk evaluation

In this case, the probability of a failure is modeled with risk and reliability studies outlined by reasoning and judgments that suppresses/annuls unclear evidence or analyzes, so the level of uncertainty and clarity regarding risk assessment tools will be framed by existing information [1].

3. A CASESTUDY ON A RPAS DEVELOPED BY NASA

Taking into account the dynamic nature of the system analyzed, since the designed levels may differ from those achieved, in a reliability/non-reliability study is necessary to consider the characteristics and performance of the remotely piloted aircraft system and the compliance with the specifications in order to be able to achieve a clear understanding of the evolution and the level of malfunctions.

The continuity in operation is not necessarily an attribute of reliable systems, but is related to service life; in spite of the malfunctions, a system may run for a period of time (treated as a random event) indicated by the "medium repair time". This is considered true if the parameters do not exceed certain imposed limits and/or the system retains its operational features [9].

Maintainability is aimed at easily keeping (or rehabilitating, if necessary) a system, this is a concept mirrored in future maintenance activities [6].

$$M(t_r) = P(t_r \le T_r) = 1 - \exp[-\int_0^{t_r} \mu_r(t_r) dt_r] \quad (14)$$

$M(t_r)$ - maintainability function

t_r - restoration time (re-commissioning)

T_r - the limit imposed for the re-commissioning time

$\mu_r(t_r)$ - rate of repair

The average repair time is MTR.

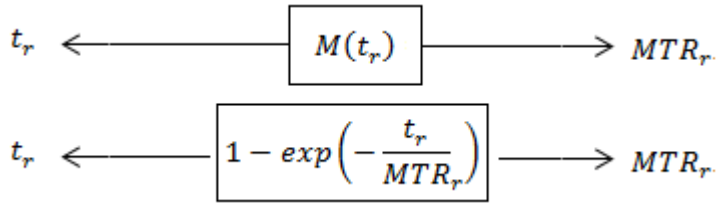

FIG. 4. The relationship between the maintenance function, the restoration time and the average repair time

Re-commissioning a system with cascade faults or failures (caused by various combinations of malfunctions depending on their nature) will be achieved with greater difficulty, as the loss of control is at an alert pace.

As known, fault manifestations depends on the following factors: the failure mode, the location of the fault, the nature/type of failure, the intensity of the fault, the moment of failure producing and the type of equipment considered [14].

Case study:

In the case of the RPAS mentioned above, a piece of the hydrogen tank placed in the center of the wings, which has been established at the last inspection to be defective, must be replaced.

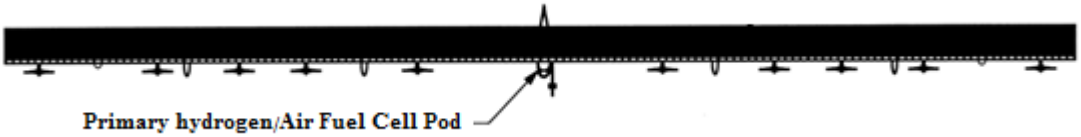

FIG. 5. RPAS configuration

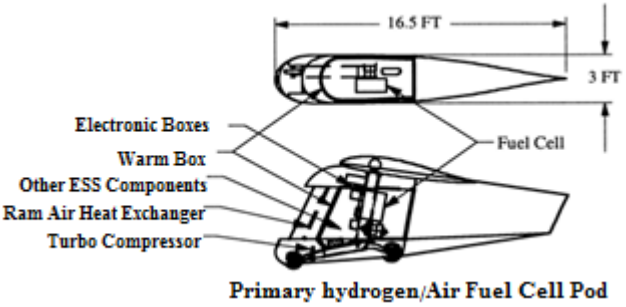

FIG. 6. RPAS primary hydrogen tank configuration

As the temperature sensor is located outside the tank, it does not require the tank to be purged in order to extract the sensor (i.e. there is no risk of leakage), so the time for changing the piece is low [1].

Although in the maintenance manual was specified that that considered piece could be replaced in $0.8h$ ($MTR = 0.8h$), supposing the time available in hangar for the replacement must be lower, for example, between $0.6h - 0.7h$, $t_r = 0.6h$ or $t_r = 0.7h$ [1].

Since the rate of repair (μ_r) is (generally) constant and equal to MTR^{-1} if MTR is given according to an exponential distribution law, the following formulas will be applied:

$$\mu_r(t_r) = \mu_r(ct) \tag{15}$$

$$\mu_r(t_r) = MTR^{-1} = ct$$

$$M(t_r) = 1 - \exp(-\frac{t_r}{MTR}) \tag{16}$$

Therefore, for the next cases:

Case 1:

$t_r = 0.6h \quad MTR = 0.8h$

$M(0.6) = 1 - \exp(-\frac{0.6}{0.8}) = 1 - 0.472366553 = 0.527633$

$M(0.6) = 0.527633 \cong 0.53$

Case 2:

$t_r = 0.7h \quad MTR = 0.8h$

$M(0.7) = 1 - \exp(-\frac{0.7}{0.8}) = 1 - 0.416862 = 0.583138$

$M(0.6) = 0.5831383 \cong 0.58$

The obtained results indicate that in the first case, the situation prior the malfunction can be fully restored in 53% of the cases ($M(0.6) = 0.5831383 \cong 0.58$) by replacing the component, and in the second case in 58% ($M(0.6) = 0.5831383 \cong 0.58$) of the cases.

Surely, the technical parameters must show a good relationship between the designed (required) characteristics and the resulting ones; the functional technical properties must have values in accordance with the technical standards and documentation [7].

Knowing the system's particularities, in this case the specific features of an unmanned aerial vehicle with the hydrogen tank placed in the center of the wing, understanding the premises of producing a fault and identifying the causes by observing/analyzing thoroughly, will result in imposing corrective measures to limit/avoid system malfunction.

The causes and occurrences of the malfunctions are not the only issues of interest in the reliability studies performed; the analysis of the failure mechanisms and ultimately, combating them creates a safety loop in the treated remotely piloted aircraft system.

CONCLUSIONS

The performance of remotely piloted aircraft system has been designed to provide acceptable levels of safety. In this context, aspects relating to the performance of equipment and, in particular, structural elements were necessary to be highlighted in order to determine the fault-generation framework.

In-service/operation safety analyzes include control methods and risk identification, involve modalities to allocate the resources needed to manage risks; and reliability analyzes, resistance calculations, evaluation of reliability parameters and maintainability studies complements them. Consequently, reliability studies are an important element in making safety policy decisions.

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ASPECTS REGARDING THE ELECTRIC PROPULSION OF THE UAV MULTICOPTER

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Abstract: *The UAVs is, by definition, the technical system which includes a lightweight frame and a number of on-board equipment. Equipment features make a major contribution to determining global air vector capabilities (C2, performance) and mission accomplishment.*

The article aims to simulate the characteristics and performance of multi-copters in terms of electrical equipment by using freeware tools that can lead to optimization in the pre-design phase of a multicopter used in transport missions.

Keywords: *multicopter, brushless, Drive Calculator, software analysis.*

Acronims

C2	*-command and control*	*ISR*	*-Intelligence, surveillance and reconnaissance*
EO-IR	*-electro-optic-infrared*	*Rx/Tx*	*-receiver/transmitter*
ESC	*-electronic speed control*	*UGV*	*-unmanned ground vehicle*
USV	*-unmanned surface vehicle*	*n*	*- rotation*
v_h	*-air speed*	τ	*-torque*
I	*-amperage*	ρ	*-air density*
P	*-power*	ω	*-angular speed*
K	*- proportionality constant*	*V*	*-voltage*
F	*-traction*	*A*	*-surface*

1. INTRODUCTION

The UAVs represent, by definition, the technical system comprising a lightweight frame and a number of on-board equipment. Equipment features make a major contribution to determining global air vector capabilities (C2, performance) and mission accomplishment. The standard electronic equipment required for any type of UAV is: propulsion systems (engine, speed regulator and propeller), automatic stabilizer / autopilot, power system and C2 system (TX transmitter and RX receiver). A UAV multicopter is an aircraft similar to a traditional helicopter but with at least two lifting rotors, see Fig.1, [1].

a b

FIG. 1 UAV helicopter, a. tandem, b. multi-rotor (quad-copter), [1]

1.1. History and evolution

According to [2] the first multicopter project belonged to George Cayley designed in 1843, the air carriage was propelled by a steam engine, see Figure 2a. In 1907, Paul Cornu developed a functional flying machine capable of vertical flight (with 2 rotors), see Figure 2b.
In 1907, Flight Jaques and Louis Breguet were flown in association with Charles Richet with a quad rotor Gyroplan 1 platform, see Figure 3a, a year later, trying Gyroplane No. 2, [3].

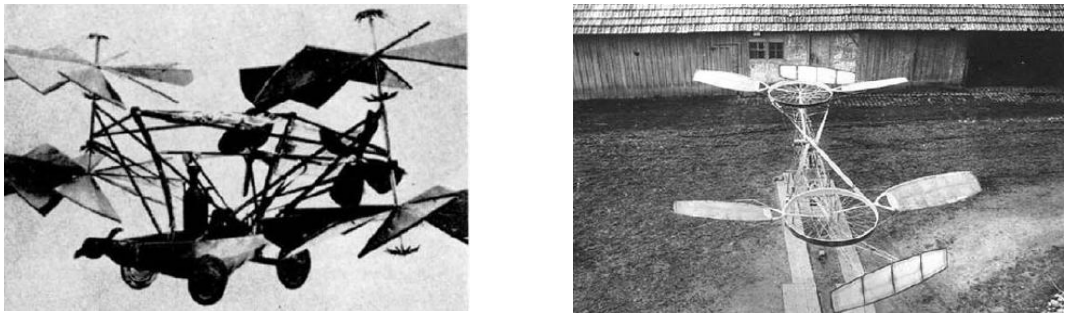
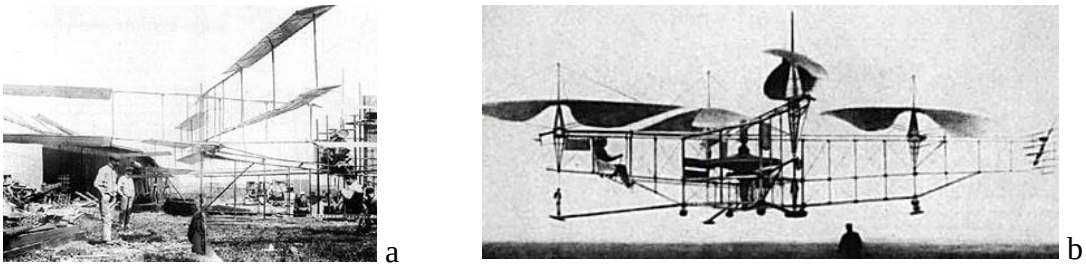


FIG. 2 Rotary wings machines, a. George Cayley – 1843; b. Paul Cornu – 1907, [2, 12]

French engineer Etienne Oehmichen in 1920 built the Oehmichen quadcopter no. 2, this platform set a new world flight record at that time, flew 360 m and stay in the air for 7 minutes and 40 seconds, see Figure 3b. Also in the same period, George de Bothezat, born in Basarabia, made the first quad-copter for the US Army [3]; and in 1936 Juan de la Cierva developed a helicopter model with tandem rotors [1].



a b

FIG. 3 Multi-copters, a. Gyro-plan no.1-1907, b. Oehmichen no. 2 [2, 3]

1.2 Classification and missions of the multi-copters

After several investigations in the UAV field, numerous classifications have been made depending on various factors, thus starting from a general classification that include all the existing UAV forms, the subsequent classification is focused on multicopter aircraft.

The most important criteria for classifying of the multi-copters are: after the number of rotors (tri-copter, quad-copter, hex-copter), see Fig.4; by flight mode (with simple GPS stabilization); according to the materials used (wood, plastic, carbon fiber, aluminum); after autonomy (small - under 10 minutes, average - between 10 and 30 minutes, high - over 30 minutes); by weight (class: micro - under 1 kg, mild between 1 and 5 kg, average between 5 and 25 kg and weight over 25 kg); after altitude (low - below 100 m, high - over 100 m).

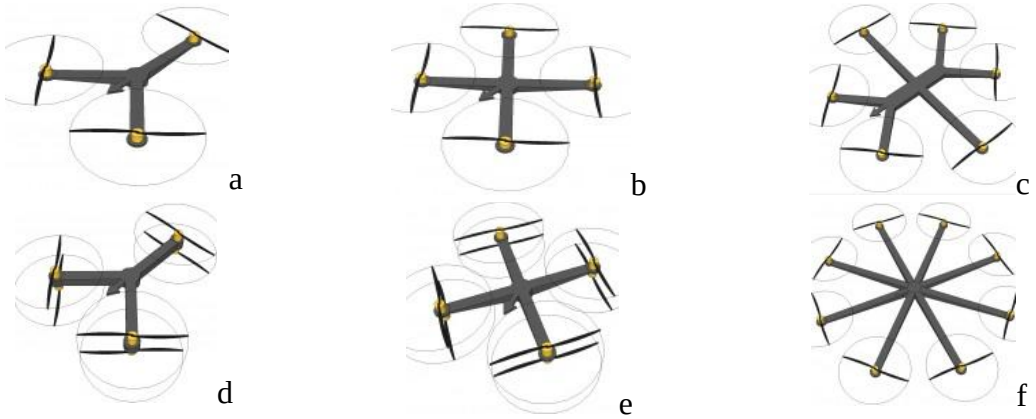


FIG. 4. Multicopter frames, a. tri-copter, b. quad-copter, c. hex-copter, d. tri-copter Y6, e. quad-copter X8, f. octopter, [12]

The most important categories of the missions that can be accomplished with multi-copters are: data acquisition (EO-IR), R&D, and transport; they can have applications in the military (ISR) and civil (industrial, agricultural, tourism), [4].

1.3. UAV multicopter capabilities

According to the literature [5, 6, 7], multi-copter air vectors possess both a set of requirements (design / fabrication, flight safety, operation / maintenance and economic) but also capabilities, including the ability to follow the map, assess the environment in which it operates, accurate navigation; mission speed (vector velocity, information processing speed, transfer, processing, centralization and dissemination); minimal radar, thermal, acoustical and magnetic mark, ability to operate in hostile areas where human factor is exposed to high risk, well-developed power system able to support the consumption of propulsion systems and secondary sensors existing on the proper vector (onboard computer, imaging equipment, sensors for processing various information, communication systems); reliability of systems in hostile environments, easy transport, launch and recovery.

2. THEORETICAL

To make a multicopter used for transport is considered to optimize the take-off mass, what includes the structural elements, the propulsion system and the radio-electronic equipment, versus the power developed by the electric motors [9], Fig.5.

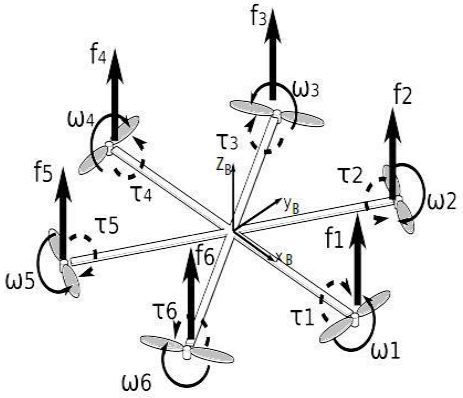


FIG. 5 Hexacopter frame, [9]

2.1. Electric motors

Generally, brushless motors are used, where the torque is:

$$\tau = K_t \cdot (I - I_0) \tag{1}$$

Where τ*- torque electric motor,*
I *–amperage intake,*
I_0 *–initial amperage in motor*
K_t *– proportionality constant torque.*

The voltage at the motor terminals is the sum of the counter-electric motor voltage (induced voltage in motor windings) and some resistive losses:

$$V = I \cdot R_m + K_\upsilon \cdot \omega \tag{2}$$

Where V *– the voltage across the motor,*
R_m *– resistance of the motor,*
ω *– Angular speed,*
K_υ *– proportionality constant, (constructive parameter of the motor).*

This motor description is used for calculate the power that the motor consumes. Power is:

$$P = I \cdot V = \frac{(\tau + K_t \cdot I_0) \cdot (K_t \cdot I_0 \cdot R_m + \tau \cdot R_m + K_t \cdot K_\upsilon \cdot \omega)}{K_t^2} \tag{3}$$

For this simple model motor resistance can be considered negligible, so the power becomes proportional to the angular velocity:

$$P \approx \frac{(\tau + K_t \cdot I_0) \cdot K_\upsilon \cdot \omega}{K_t} \tag{4}$$

To simplify it can be considered $K_tI_0 << \tau$, since I_0 is the initial motor current, therefore quite small, but this is not quite rational. But in practice this approximation is quite stable. This gives a simplified final power equation:

$$P \approx \frac{K_\upsilon}{K_t} \cdot \tau \cdot \omega \tag{5}$$

2.2. Forces and aerodynamic loads

Power is used to keep the multicopter in the air. By conserving energy, engine power consumed over a certain period of time is equal to the mechanical work done by the propeller:

$$P = F \cdot \frac{dx}{dt} \tag{6}$$

Or power is equal to the product of traction force and air velocity.

$$P = F \cdot v_h \tag{7}$$

The v_h is considered to be the air velocity while the multicopter maintains its position in the air at a stable point. It is also considered that the air velocity, v_∞, from the buffer is equal to zero. The impulse theory expresses the air velocity in the planning action of the multicopter as a traction function:

$$v_h = \sqrt{\frac{F}{2 \cdot \rho \cdot A}} \tag{8}$$

Where ρ – air density

A –propeller action area (surface).

By simplifying the equation, power is equal to:

$$P = \frac{K_\upsilon}{K_t} \cdot \tau \cdot \omega = \frac{K_\upsilon \cdot K_\tau}{K_t} \cdot F \cdot \omega = \frac{F^{\frac{3}{2}}}{\sqrt{2 \cdot \rho \cdot A}}. \tag{9}$$

In the general case $\tau = \bar{r} \times \overline{F}$, but in this case the torque is proportional to the force F by a constant rate K_t determined by the propeller blade configuration and its parameters. Simplifying the equation we obtain:

$$F = \left(\frac{K_\upsilon \cdot K_\tau \cdot \sqrt{2 \cdot \rho \cdot A}}{K_t} \cdot \omega \right)^2 = k \cdot \omega^2 \tag{10}$$

Where k – almost constant dimension.

By summing the traction forces of all the engines, the total pulling force of the multicopter results:

$$F_B = \sum_{i=1}^{n} T_i = k \begin{bmatrix} 0 \\ 0 \\ \sum \omega_i^2 \end{bmatrix} \tag{11}$$

3. SIMULATION OF THE PERFORMANCE OF AN ELECTRIC MOTOR

The hex-copter vector used (see Figure 5) in transport missions has the characteristics and performance in Table 1.

FIG. 5 Hexacopter, [10]

Table1. Hex-copter features and performances [10, 13]

Features	Value	Features	Value
Frame dimensiond	650 mm	Empty weight	1380 g
Motors	Tip 4015	Battery weight	265 g
Propeller	9x5 inch	Total weight	3000 g
ESC	40A	Used weight	1800 g
Battery 4S	4000 mA	Autonomy	15 min

In the case of a hexacopter, the optimum choice of the propulsion system takes into account both the performance of the electric motor and the battery used. We present a simulated propulsion case with a freeware Drive Calculator 3.4, [8] and analysis conditions in Table 2.

Table2. Analysis conditions

Condition	Value	Condition	Value
Constant voltage	14.8 V	Gearbox	direct drive
Altitude	0÷300 m	Max weight for test	3000 g

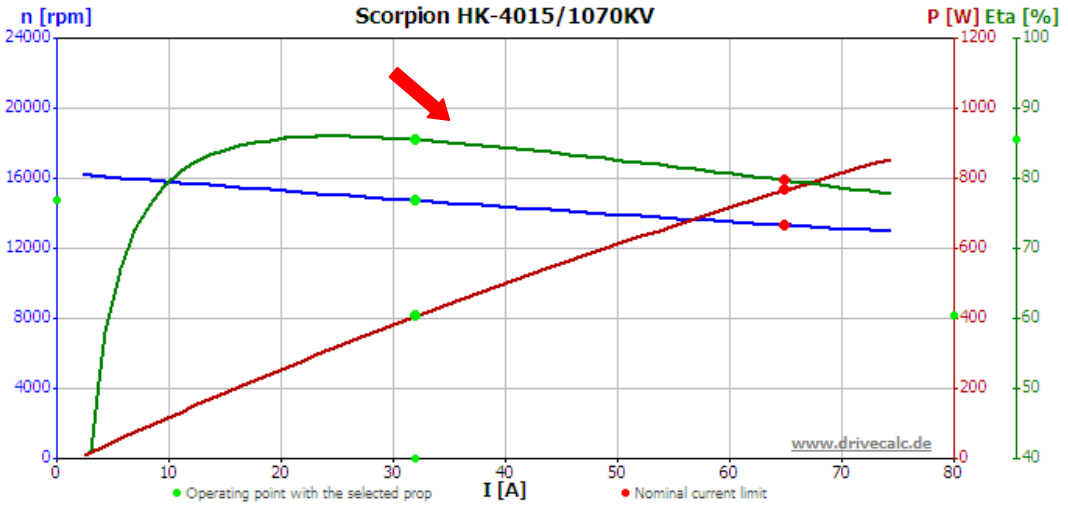


FIG. 6 Features of the 4015 electric motor at constant voltage

Fig. 6 shows the decrease in angular speed (n) but an increase in power depending on the current intensity (maximum 65 A), with a maximum efficiency between 20 and 30 A. Table 3 shows the results of the simulation of the engine operation at four altitude values. Observes an increase of the angular speed (n) with the altitude increase (14709 rot/0 m to 14740 rot/300 m) but there is a decrease of the static traction with the altitude increase (2111g /0 m at 2080/300 m).

Table3. Features of the electric motor for the altitude (constant voltage)

0 m				100 m			
Prop speed	**14719 rpm**	Current	**32.0 A**	Prop speed	**14726 rpm**	Current	**31.9 A**
Static thrust	**2111 g**	Power in	**474.1 W**	Static thrust	**2101 g**	Power in	**471.5 W**
Vpitch	**112 km/h**	Power out	**405.3 W**	Vpitch	**112 km/h**	Power out	**403.2 W**
Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.5%**	Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.5%**
200 m				300 m			
Prop speed	**14734 rpm**	Current	**31.7 A**	Prop speed	**14740 rpm**	Current	**31.6 A**
Static thrust	**2090 g**	Power in	**469.0 W**	Static thrust	**2080 g**	Power in	**467.0 W**
Vpitch	**112 km/h**	Power out	**401.2 W**	Vpitch	**112 km/h**	Power out	**399.5 W**
Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.5%**	Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.5%**

Fig. 7 shows a repositioning of the operating point corresponding to the currents used (about 28 A current versus 33A at constant current).

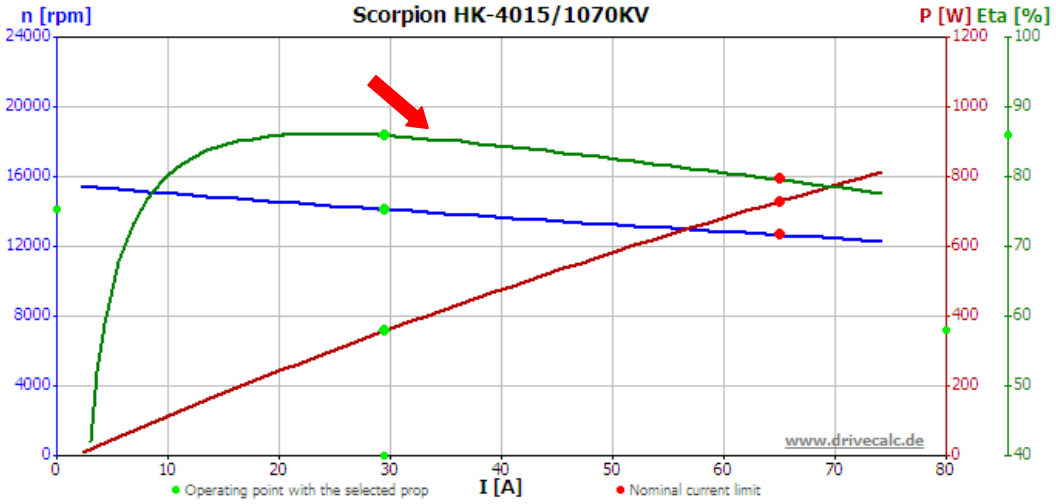


FIG. 7 Features of the 4015 electric motor at the variable voltage

Table 4 shows an increase in angular speed (n) with increasing flight altitude, but also a decrease in power consumption and effective static power (1931 g/ 0 m at 1904 g/ 300 m).

Table 4. Features of the electric motor for the altitude (variable voltage)

0 m				100 m			
Prop speed	**14110 rpm**	Current	**29.5 A**	Prop speed	**14120 rpm**	Current	**29.4 A**
Static thrust	**1931 g**	Power in	**415.9 W**	Static thrust	**1922 g**	Power in	**414.1 W**
Vpitch	**108 km/h**	Power out	**357.0 W**	Vpitch	**108 km/h**	Power out	**355.5 W**
Thrust efficiency	**4.6 g/W**	Drive efficiency	**85.9%**	Thrust efficiency	**4.6 g/W**	Drive efficiency	**85.9%**
200 m				**300 m**			
Prop speed	**14129 rpm**	Current	**29.2 A**	Prop speed	**14139 rpm**	Current	**29.1 A**
Static thrust	**1913 g**	Power in	**412.2 W**	Static thrust	**1904 g**	Power in	**410.4 W**
Vpitch	**108 km/h**	Power out	**354.0 W**	Vpitch	**108 km/h**	Power out	**352.5 W**
Thrust efficiency	**4.6 g/W**	Drive efficiency	**85.9%**	Thrust efficiency	**4.6 g/W**	Drive efficiency	**85.9%**

Table 5 shows the variation in operating characteristics at 0 m depending on the ambient temperature. The speed characteristic increases with temperature increase (14610 rpm / -10^o at 14814 rpm / 40^o) and static traction decreases as the temperature rises (2275g / -10^o at 1969g / 40^o).

Table5. Features of the electric motor for the temperature (variable voltage at 0 m)

-10^o				0^o			
Prop speed	**14610 rpm**	Current	**34.4 A**	Prop speed	**14656 rpm**	Current	**33.4 A**
Static thrust	**2275 g**	Power in	**509.3 W**	Static thrust	**2207 g**	Power in	**494.2 W**
Vpitch	**111 km/h**	Power out	**434.0 W**	Vpitch	**112 km/h**	Power out	**421.8 W**
Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.2%**	Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.3%**
10^o				**20^o**			
Prop speed	**14700 rpm**	Current	**32.4 A**	Prop speed	**14740 rpm**	Current	**31.6 A**
Static thrust	**2142 g**	Power in	**480.1 W**	Static thrust	**2081 g**	Power in	**467.0 W**
Vpitch	**112 km/h**	Power out	**410.2 W**	Vpitch	**112 km/h**	Power out	**399.5 W**
Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.5%**	Thrust efficiency	**4.5 g/W**	Drive efficiency	**85.5%**
30^o				**40^o**			
Prop speed	**14778 rpm**	Current	**30.7 A**	Prop speed	**14814 rpm**	Current	**30.0 A**
Static thrust	**2023 g**	Power in	**454.9 W**	Static thrust	**1969 g**	Power in	**443.3 W**
Vpitch	**113 km/h**	Power out	**389.5 W**	Vpitch	**113 km/h**	Power out	**379.9 W**
Thrust efficiency	**4.4 g/W**	Drive efficiency	**85.6%**	Thrust efficiency	**4.4 g/W**	Drive efficiency	**85.7%**

Fig. 8 and Table 6 show an increase in operating time depending on the current supplied by the battery and battery mass.

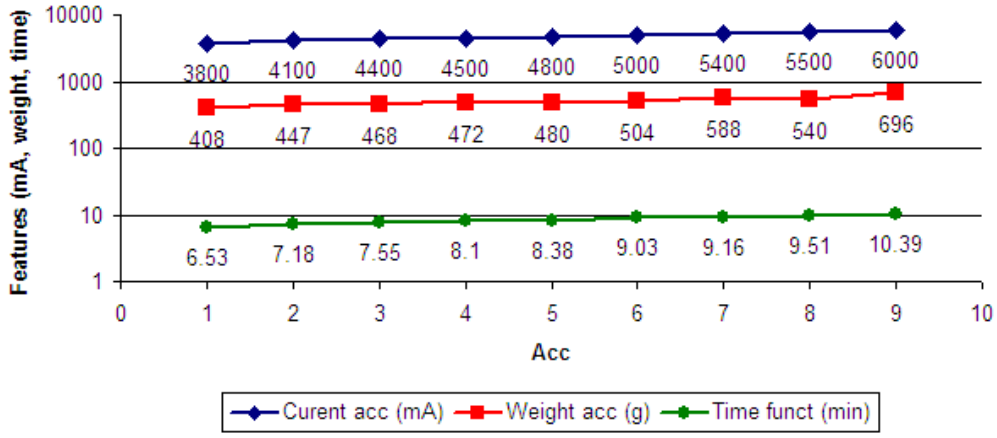


FIG. 8 Autonomy versus battery amperage

Tabelul 6. Flight autonomy simulation

Nr. crt.	Amperage battery (mA)	Battery weight (g)	Time (min)	Nr. crt	Amperage battery (mA)	Battery weight (g)	Time (min)
1	3800	408	6.53	6	5000	504	9.03
2	4100	447	7.18	7	5400	588	9.16
3	4400	468	7.55	8	5500	540	9.51
4	4500	472	8.10	9	6000	696	10.39
5	4800	480	8.38				

4. CONCLUSIONS

The propulsion equipment used in the operation of a multicopter will have a major impact on the payload and the maximum flight mass, which the multicopter type UAV can have with direct implications for total autonomy. The use of multicopter operation simulations used in transport missions during the pre-project phase can provide a picture of how to capture useful tasks with direct implications for flight stability and mission success. Due to the miniaturization of the radio-electronics and propulsion equipment on board multi-copters, we can also talk about a reduction in total drive power consumption and an increase in flight autonomy as we approach a multi-level multilevel constructive concept (two conjugated engines).

The approach to innovative constructive concepts (morphing, multiagent, UAV-UGV-USV hybrid vectors) can generate significant increases in flight characteristics and performance (autonomy, stability / maneuverability).

ACKNOWLEDGEMENT

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NUMERICAL ANALISYS OF IMPACT PHENOMENON BETWEEN A FRANGIBLE PROJECTILE AND THIN METALLIC PLATES USED IN AIRCRAFT STRUCTURES

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Abstract: *This paper shows simulation results whose purpose is to study the impact occurrence between an anti-hijack pistol projectile and a thin metallic plate. The plate is made of aluminium alloy used in aeronautical structures. Laboratory tests permitted to analyse the mechanical behavior of the projectile's material. The shootings experiments have confirmed the expected impact behavior at given velocity. The model and simulation works were developped under AUTODYN/ANSYS. The simulation results are well proven by the experimental outcomes.*

Keywords: *terminal ballistics, FEM, frangible bullet, antihijack projectile, experiment*

1. INTRODUCTION

The projectile – target impact phenomenon is complex and is summed up in the study of involved materials submitted at a specific deformation ratio. The impact conditions may vary within a wide range and are a function of impact velocity, incident angle, projectile and target type [1]. The continuous developping trend in ammunition design and the needs for specialized ammunition bring in front new projectiles, made of new materials, with complex impact behavior. For these reasons we are dealing with a variety of terminal ballistics cases. Last period we faced a move from classical ammo to frangible ammunition, especially for training purposes, in order to reduce the risk. So that not only the ricochets are avoided but the toxicity of projectiles made of copper powder is less significant than the lead core bullets show [9].

This is the context of issuing on the market the anti-hijack ammo. The bullets are made on the basis of copper powder and polymeric binder. The mixture allows a dual behavior, with respect to target's nature: the impact with thin metallic plates produces a bullet smash, in a very short time and without target damage, while a penetration in soft targets (e.g. ballistic gelatin) occurs. In this paper we are focused on impact analysis between this kind of projectile and aircraft structure (aluminium thin deformable plates). Some experimental and laboratory data were used for buiding the simulation cases and for validating the results.

2. LABORATOY TESTS

The material used for anti-hijack bullets is a composite of copper powder in a polymeric matrix and has the property of being frangible due to a mixture of phases with weak adhesion properties [10]. For this reason, besides compression tests (for Young's modulus and yield stress determination) additional tensile tests were made (based on Brazilian disk test).

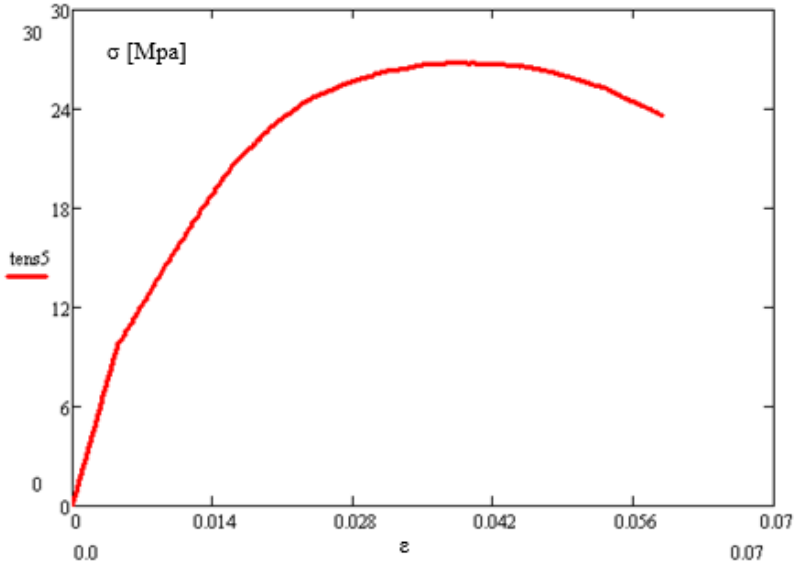

FIG. 1 Mechanical behavior of composite copper-polymer material

The experimental results show an elasto-plastic behavior. There are instantaneous deformations remaining after loading removal. Under the elasticity limit, only elastic deformations occur. A special case is the elasto-plastic model with a perfect plastic behavior. If the elasticity limit is reached, the material tension remains at elasticity limit level. This model can be well represented by a serial connection of a spring and a friction sleeve (Saint-Venant model).

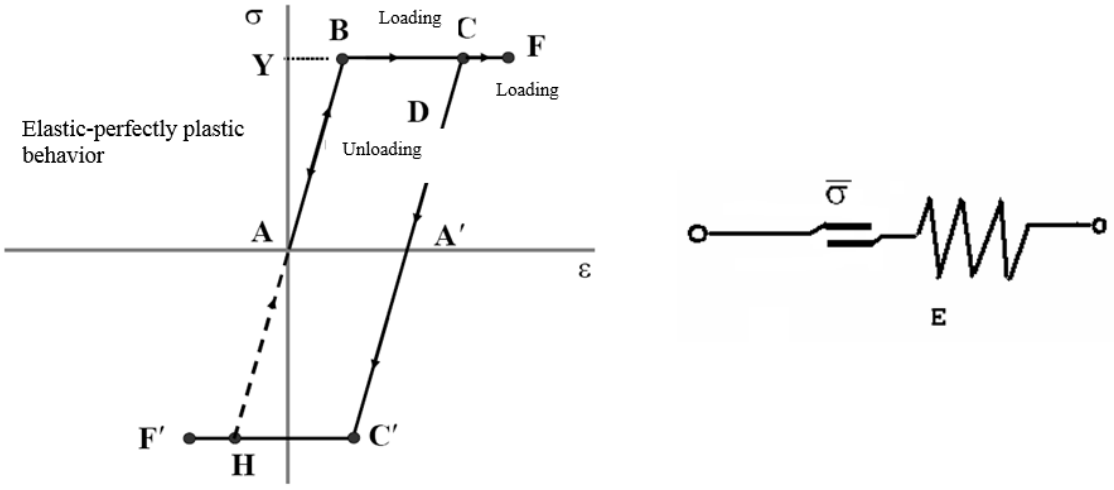

FIG. 2 Loading scheme of an elastic-perfectly plastic material and Saint-Venant model

Based on experimental results, the mechanical properties according to Saint-Venant model were defined, as in Table 1.

These data and the Saint-Venant model were used in the part dedicated to numerical calculus and impact simulations between anti-hijack projectiles and the metallic plates [11].

Table 1 Mechanical properties of tested material

Properties	Projectile material
Young modulus [GPa]	2,11
Yield stress [MPa]	26,58
Poisson coefficient	0,3
Tensile strenght [MPa]	6,20
Density [g/cm^3]	4,8

3. SHOOTINGS EXPERIMENTS

The composite projectiles were tested in real shootings against aluminium plates of 1,5 mm thickness. At nominal velocity, the bullets have proven their *nonpenetrating* behavior, as in Figure 3.

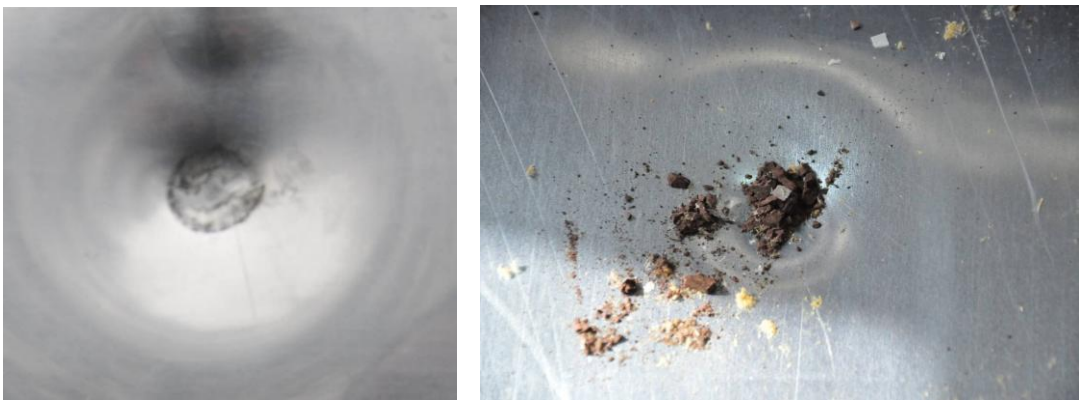

FIG. 3 Aluminium plate's shape after impact. The projectile breakage model

For comparation purposes and validation of simulation results, a cross-sectional view of an impacted aluminium plate (1,5 mm thickness) were measured. The center shows a displacement of 8,11 mm and the plate thickness at the greatest deformation plate is 1,25 mm. Figure 4 shows the profile of impacted plate.

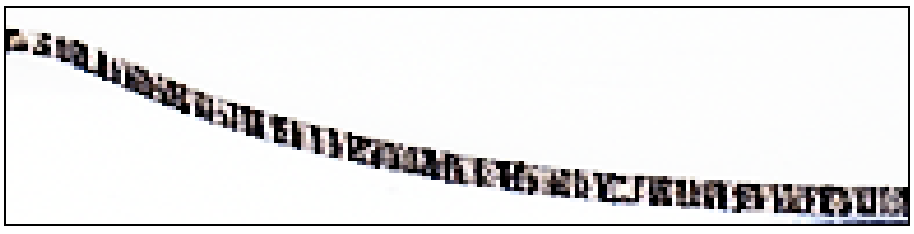

FIG. 4 Real profile of an impacted aluminium plate of 1,5 mm thickness

A profile function was found by measuring the displacements at several distances from the center. Using mathematical regression algorithms, the profile function that includes the measured points was found as follow:

$$f(x) = 8{,}11 \cdot e^{-0{,}028 \cdot x^{1,5}} \quad (1)$$

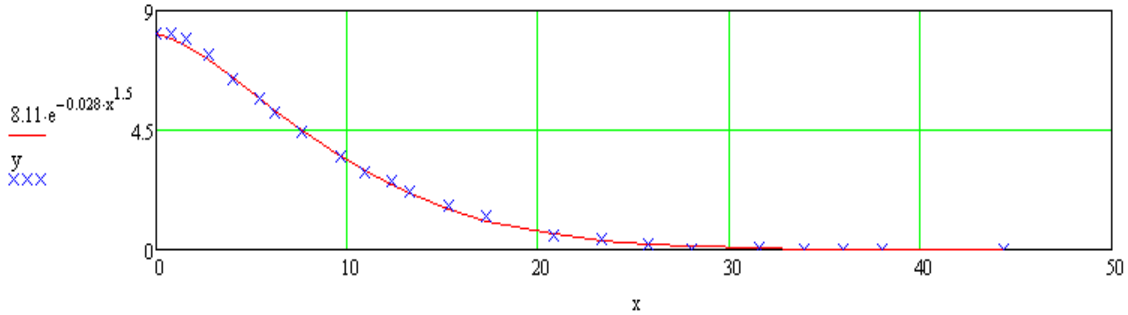

FIG. 5 The impacted profile's approximation function and measured points on the profile. The maximum value of the function is 8,11 mm – the impact center displacemet

4. NUMERICAL MODEL

The model was built under Autodyn, considering a 3D nonlinear formulation. All involved materials have nonlinear behavior.

The code allows the use of the three solvers: Lagrange, Euler and SPH. Due to specific behavior of the materials and the characteristics of impact phenomenon, we decided to use the Lagrange solver for the impacted structure. For the projectile deformation, we have used both Lagrange and SPH solvers. The numerical studies considered the similar case as in real shootings, i.e. anti-hijack projectile impact with aluminium plates of 1,5 mm thickness. Table 2 comprises the model configuration.

Tabelul 2 Model configuration

Configuration	Type	Material	Solver	Innitial conditions
1	Projectile	Anti-hijack	Copper powder in polymeric matrix	Lagrange	V0 = 330 m/s
	Target	Al plate 1,5 mm	Al 2024 T3	Lagrange	Shell; V0 = 0 m/s
2	Projectile	Anti-hijack	Copper powder in polymeric matrix	SPH	V0 = 330 m/s
	Target	Al plate 1,5 mm	Al 2024 T3	Lagrange	Shell; V0 = 0 m/s

For the projectile we have used an elastic – perfectly plastic material model. The characteristics are given in Table 3. For the aircraft structure material we have used a material model which allows shell elements discretization (uniform stress and strain in plate's depth) for reducing the solving time. The chosen model was completed with the characteristics of aluminium 2024, T3, according to French standard 9048 AIR - Conditions de controle des produits lamines en alliages d'aluminium utilises dans les constructions aerospatiales).

Tabel 3 Johnson-Cook constitutive constants for aluminium 2024-T3

Material	Density (kg/m^3)	Specific heat (J/kgK)	Melting temperature (K)	A (MPa)	B (MPa)	N	C	M
Aluminium 2024-T3	2770	875	775	265	426	0,34	0,015	1,00

The decission of using SPH solver for the projectile arised as a necessity in this kind of impact. The deformation and, eventually, penetration of the plate are dependent on the amount of transferred momentum and energy, as well as being dependent on the way in this transfer occurs.

The SPH solver does not require and erosion algorithm (as the Lagrange does). The fragmentation is accomplished by particles separation and without mass losses. The projectile discretization is shown in Figure 6. The chosen values have been obtained after a number of tests for checking the solving time and results quality.

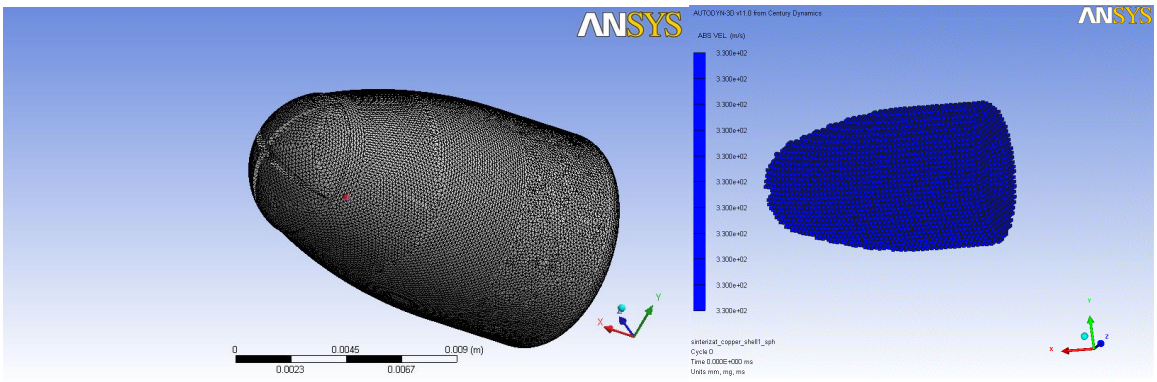

Fig. 6 Discretization of projectile: 235000 nodes for Lagrange solver; 78000 elements for SPH solver

For the plate model we have used shell elements of 1,5 mm thickness.

After solving the problem, we can obtain images and graphics related to deformed state, velocities and deformations fields, kinetic energy distribution etc.

5. SIMULATION RESULTS ANALYSIS

For a better understanding of the results we will present instantaneous pictures both for the projectile and for the plate. Regarding the plate, we are interested in deformation evolution, looking for penetration/nonpenetration events. Also, the way in which the projectile is fragmented, the shape and size of the fragments are of interest.

The simulated projectile behavior coresponds to the real one. The Lagrange approach with erosion option catches its breakable character and the fragmentation. However, the fragments are affected by erosion algorithm, being totally consumed. In real tests we obtained several fragments of different sizes.

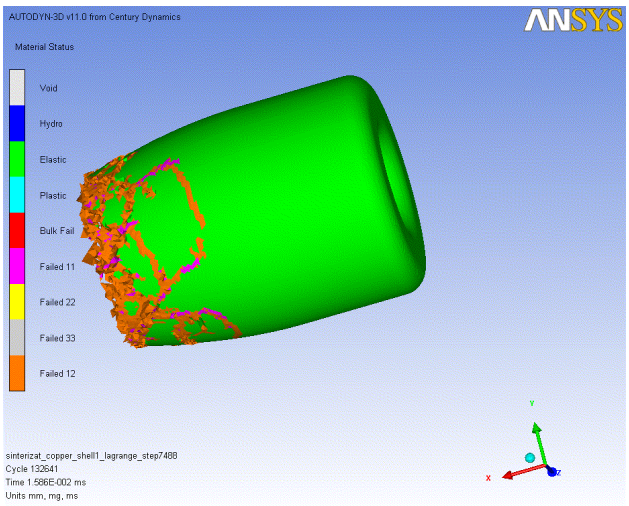

FIG. 7 Projectile's nose fragmentation. Side view

The impact phenomenon lasts 0,1 ms. Thus, at 0,15 ms the bullet is eliminated from the simulation. A critical analysis of the energy transfer between the bullet and the plate is needful.

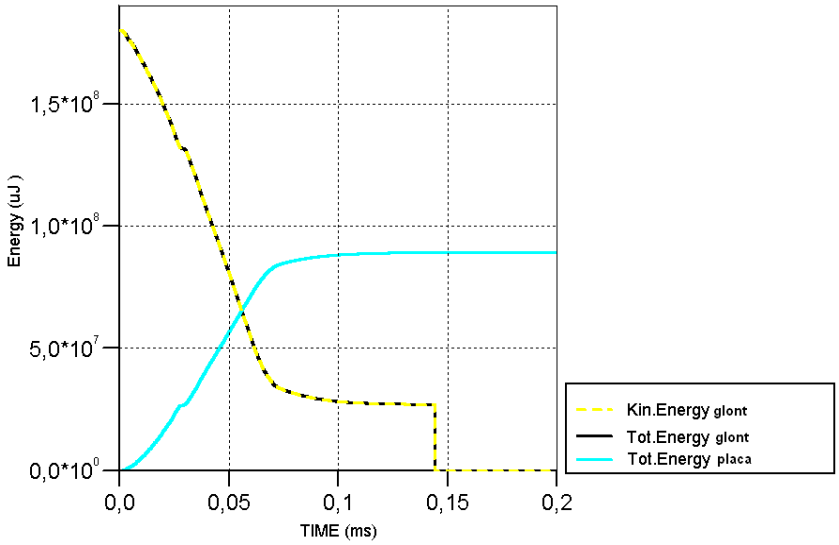

FIG. 8 Energy transfer at impact in Lagrange approach

First, we observe that the total energy of the bullet is similar with its kinetic energy evolution, so that the bullet material doesn't faces a deformation work or an elastic energy. This is because of the rapid erosion of the nodes. This is a condition imposed by the breakable nature of the material. Also, we meet an elimination from the model of the associated energy, excepting the kinetic energy of the nodes. So that, even if the model is functional, it doesn't respect the principle of energy conservation. In Figure 9 the *free* nodes evolution at a given moment can be observed as having inertia. As they are released from the network, some of them go beyond the aluminium plate and quickly disperses. However, this unrealistic event comes with a momentum transfer to the plate. As we already noted, the energy transfer is finished at 0,1 ms, even the simulation shows that the projectile is fully consumed by erosion at 0,64 ms. As a conclusion, the Lagrange approach leads to an incomplete energy transfer from the free nodes to the plate and even unrealistic, as the plate does not break, nor crack.

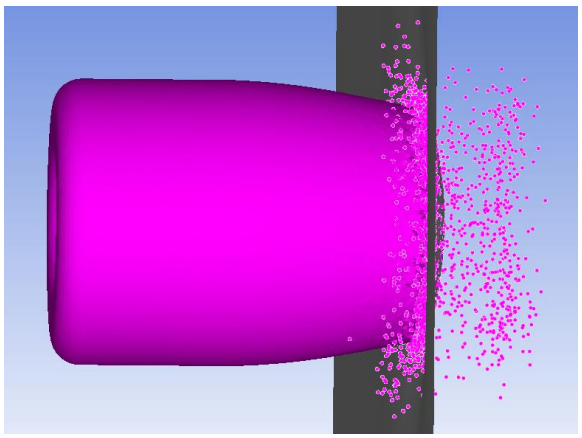

FIG. 9 Free nodes behavior within impact phenomenon. Lagrange approach

The results shows a maximum displacement of 9,47 mm in the impact center, at 0,176 ms.

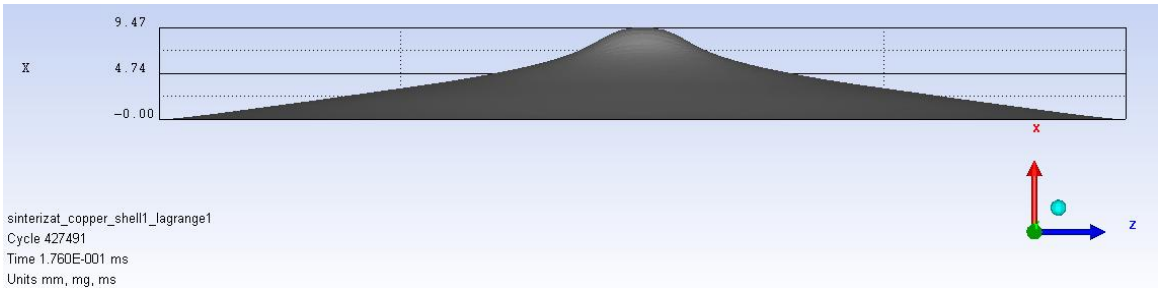

FIG. 10 Plate profile after maximum displacemet of impact center occurs

For getting the final profile of the plate, the artificial amortization of the movement is used (an Autodyn built-in option). So that the nodes velocities are reduced gradually to zero. Solving the problem with the option of artificial amortization allows us to estimate the final form of the plate and the impact point displacement.

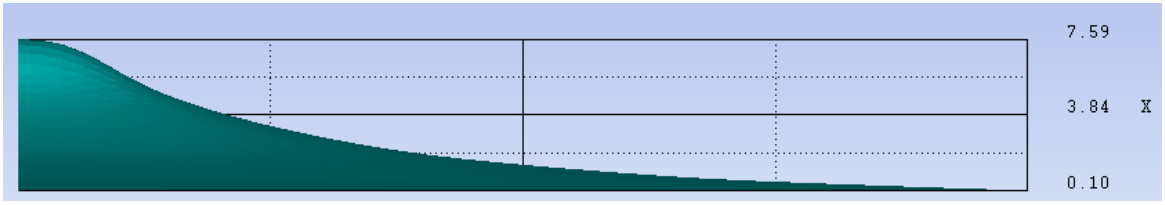

FIG. 11 Final plate profile. Lagrange approach

So, the total displacement in impact center is 7,59 mm, with a plastic deformation of 0,32 and a remained thickness of 1,17 mm. An interpretation based on strenght limit of the material, allows to conclude that the impact will not provoque cracks.

When simulating of the same phenomenon with SPH solver, we were especially focused on bullet behavior at impact. The images succession the cracks in projectile can be seen, simultaneously with fragments occurrence. Some fragments are projected in radial directions, while the remaining go ahead, on the impact direction. The same excessive fragmentation happened. In this case, this is because the solver cannot handle big size fragments. Because the bullet material doesn't face any erosion, we can observe an increasing of the impact surface, up to 1,45 times the bullet caliber. This has correspondence in reality, while in Lagrange approach the impact surface remained restricted to the bullet caliber.

From the projectile velocity evolution (the projectile not being anymore a true bullet, but a cloud of dust, as it was transformed in fragments), we can see that the interaction time with the plate lasts up to 0,22 ms. From this point on, no change in velocity happened. The final velocity value is negative, due to a forward movement of the plate after maximum deformation. The plate starts an oscillatory movement. The same fact can be observed in energy evolution diagram of the plate and projectile. All these let us note that the energy conservation principle is respected this time.

For the deformation shape evolution we have used again a virtual displacement transducer placed in impact center. The results show that a maximum displacement in impact center occurs, up to 10,23 mm, at 0,17 ms.

Using the same amortization algorithm as in previous case, the final displacement of the impact point is at 8,5 mm, with a plastic deformation of 0,18 and a thickness of 1,28 mm. again, the strength limit is not reached and no cracks occur.

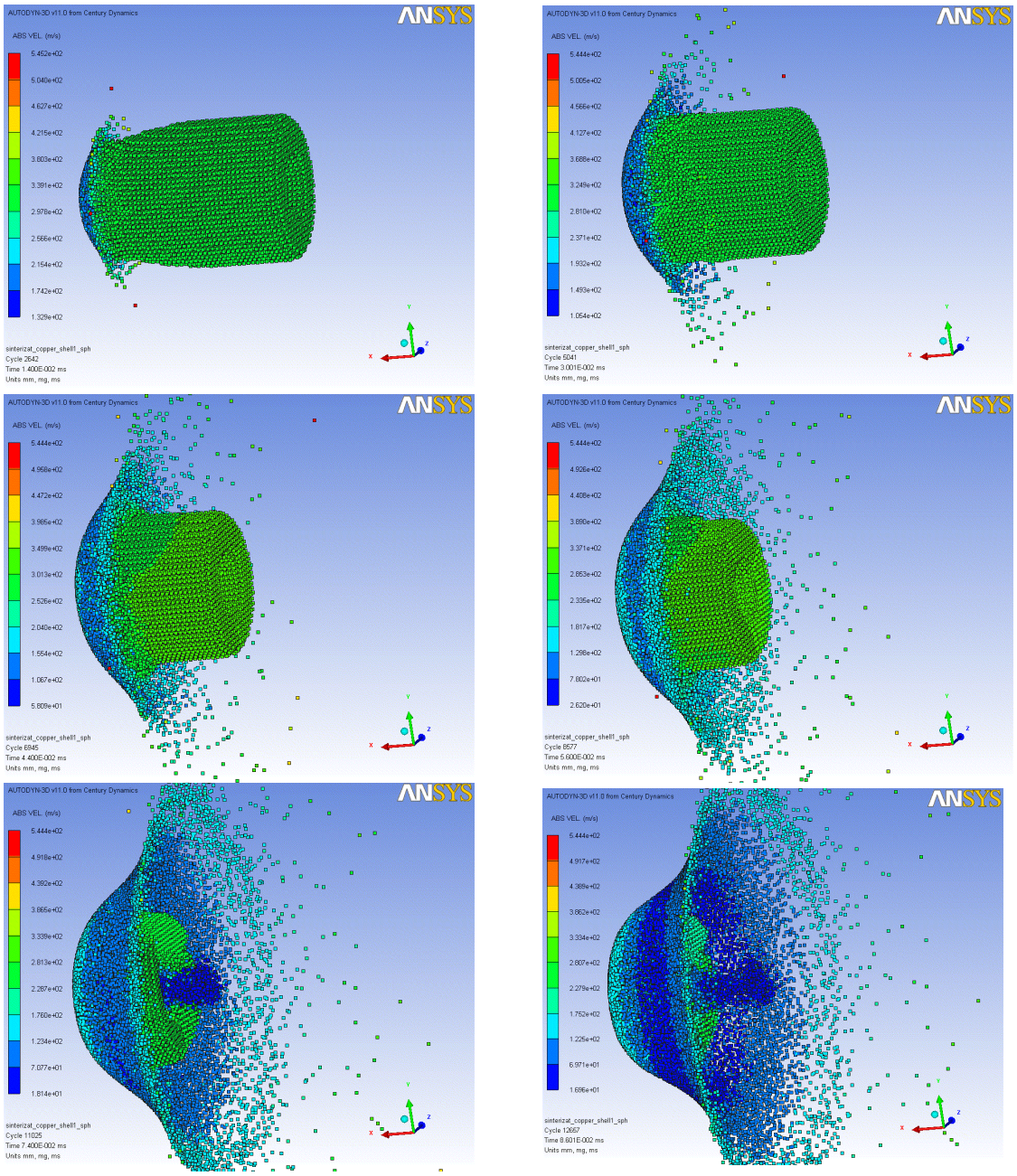

FIG. 12 Projectile fragmentation at impact. Gradual instants

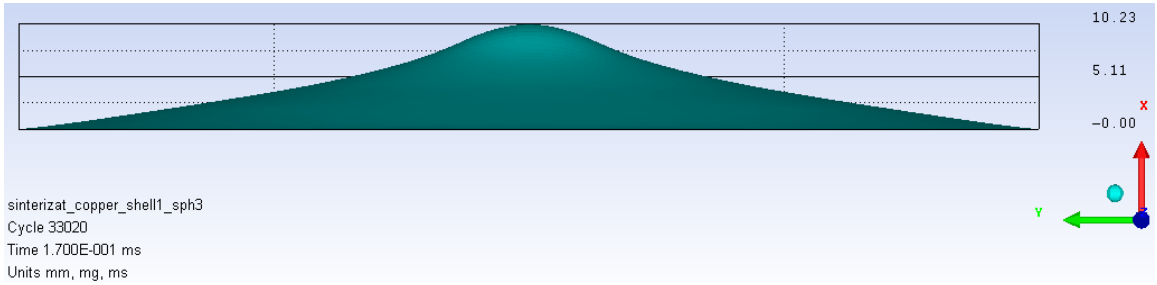

FIG. 13 Plate's profile at maximum displacement of the impact center

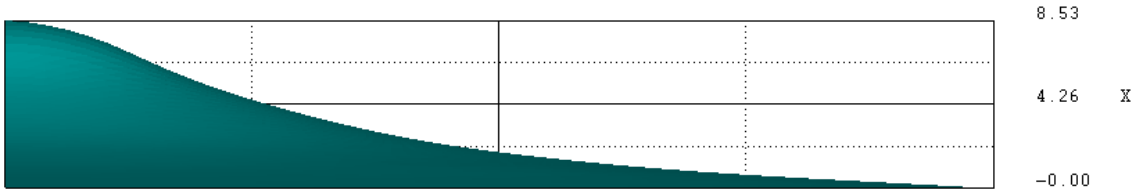

FIG. 14 Plate's final profile. SPH approach

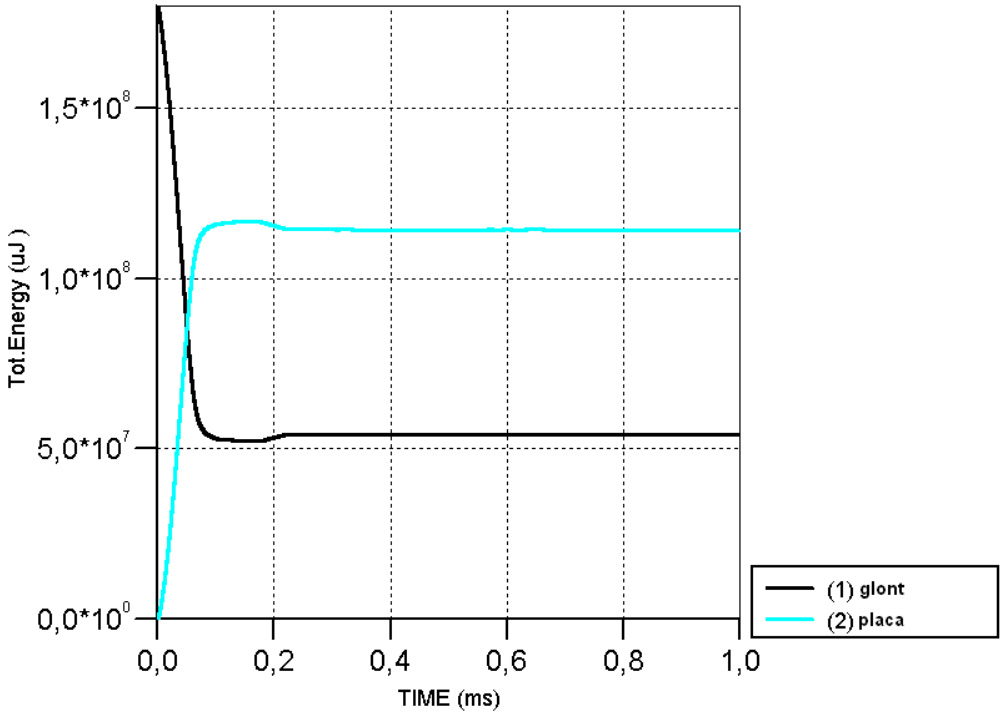

FIG. 15 Total energy transfer; bullet (black) and plate (green)

A greater displacement in SPH approach then the Lagrange case can be explained by a greater amount of energy transferred to the plate: 115 J in SPH approach versus 89 J in Lagrange approach. However, in the impact center the deformation is smaller in the SPH case then in Lagrange one. This is only an apparent contradiction. The fact is explained by the greater impact surface using SPH, so an even distribution of energy whose effect is less bending of the plate. So that, in SPH case we have greater deformation but less effort on the impact center.

FIG. 16 Final plate's profile: Lagrange (left) vs SPH (right)

The measured data of maximum displacement and plate thickness are within the range delimited by the simulation results in the two cases. The significant differences between the two approaches are in plate's profile shapes. Regarding this, the SPH case has a better match with experimental results.

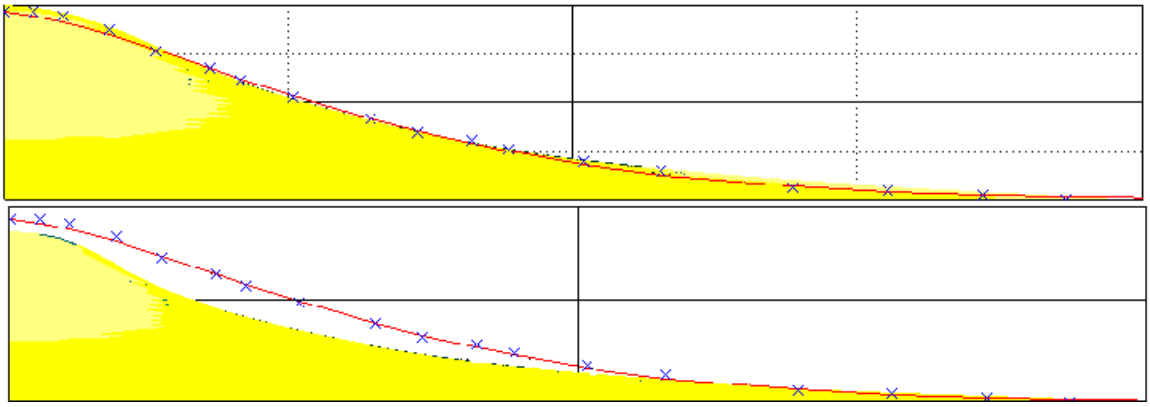

FIG. 16 Final plate's profile. Match level of real test with simulation. SPH (up) vs Lagrange (down)

5. CONCLUSIONS

The two numerical methods used in our study offers the advantage of a good model for impact analysis between a frangible projectile and an aluminium plate. The simulation results are close to experimental results. However, for a very good analysis, additional data are required: material real characteristics, constitutive models and appropriate solver for each material. Laboratory tests have proven the breakable (frangible) behavior of copper powder mixed with polymeric binder. The data were processed for finding the material model as being elastic-perfectly plastic, with tensile limit lower than yield limit. The SPH model was find better than Lagrange model in the case of projectile, because of inaccuracy of the last one in accurate reproduction of the impact steps and material's behavior.

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UNMANNED AERIAL VEHICLE FUTURE DEVELOPMENT TRENDS

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Abstract: *Unmanned aerial vehicles can be equated with multisystem entities that require transdisciplinary knowledge, concepts and technologies (for example: aerodynamics, electronics, informatics, materials) that train a range of resources across the entire technology chain (design, manufacturing, testing, operation). The use of a UAV in a hostile environment leads to a considerable reduction in the risk of human losses and allows the use of smart weapons outside the range of forces and means of the opponent.*

The article wants a descriptive presentation of UAV missions and future development trends in this area.

Keywords: *UAV, sensors, hybrid systems, UAV missions.*

Acronyms and symbols

IFR	Instrumental Flight Rules	IMINT	IMagery INTelligence
DDD	Dirty, Dull & Dangerous	EO-IR	Electroptic-infrared
SAR	Synthetic Aperture Radar	TESAR	Tactical Endurance Synthetic Aperture Radar
SMA	Shape Memory Alloy	UGV	Unmanned Ground Vehicles
USV	Unmanned Surface Vehicles	VTOL	Vertical Takeoff and Landing

1. INTRODUCTION

The use of unmanned aerial vehicles in modern airspace generates new challenges with leverage over aircraft operation and airspace management supported by legislation that needs to be adapted to new realities. Lack of coherence in addressing new concepts of aeronautical management (airport, logistics) may give rise to security implications sometimes with notable consequences.

It is important to highlight both the technological maturity of unmanned aerial vehicles and their concepts of operation and maintenance, both of which have implications for human resources using such technical systems. Unmanned aerial vehicles can be equated with multisystem entities that require transdisciplinary knowledge, concepts and technologies (example: aerodynamics, electronics, informatics, materials) that train a range of resources across the entire technology chain (design, manufacturing, testing, operation). Failure to know or knowledge of unmanned airplanes in terms of their mode of operation and requirements, limits and performances [1, 2, and 3] may have negative implications for airspace security.

1.1. Advantages and disadvantages of uav's

After analyzes, according to [1, 3] we can summarize a number of advantages and disadvantages regarding the use of unmanned aircraft. The advantages of UAV are mainly transposed into operational aspects (operation, maintenance), the most significant being: ease of launching and recovering, requiring no pretentious ground infrastructure, heavy overloads; has IFR flight capabilities from the outset, increased autonomy through lower fuel consumption, can carry out a wide range of dangerous DDD (Dirty & Dangerous) missions; reducing pilot training versus flight time eliminating the risk of losing lives.

Technological and manufacturing advantages are: the dimensions can be considerably reduced for the same range of missions; a greater payload on average of almost 25% compared to a conventional airplane (reduction of the mass resulting from the removal of the cabin, the catapult, the life-maintenance facilities, the equipment and the dashboard); considerably lower manufacturing costs.

Disadvantages: Field of view of the ground operator is limited which can lead to high collision risk (for vectors without sense and avoid); is prone to loss of radio link that often has destructive effects; the operator's delay caused by the radio wave gap; the need for broadband for data transfer; increased risk of jamming; the automatic pilot cannot act properly in the event of limit situations; lower loads for cargo transportation; dependence on unfavorable weather factors; lack of refueling capacity in the air.

1.2. Mission of uav

According to the specialist references [3, 4, 5], the current UAVs can carry out a wide range of missions such as: identification, attack, radio transmission and communication, observation, surveillance; air support of military actions; evaluation of the effects of the actions or blows; acquisition and laser targeting. The use of a UAV in a hostile environment leads to a considerable reduction in the risk of human losses and allows the use of smart weapons outside the range of forces and means of the opponent.

Engagement in direct air support missions can be extended to what USAF specialists call a closed loop precision procedure that includes surveillance, target acquisition, attack, impact assessment, and cycle resumption, if necessary, all in one very short time.

The images transmitted from the UAV are, as a rule, almost real time, and the results are communicated over encrypted data transmission channels. For the efficiency of the activity, the distribution of the images is made in real time both to the ground control station and to the command structure that requested it, the images being processed both during and after the mission [6].

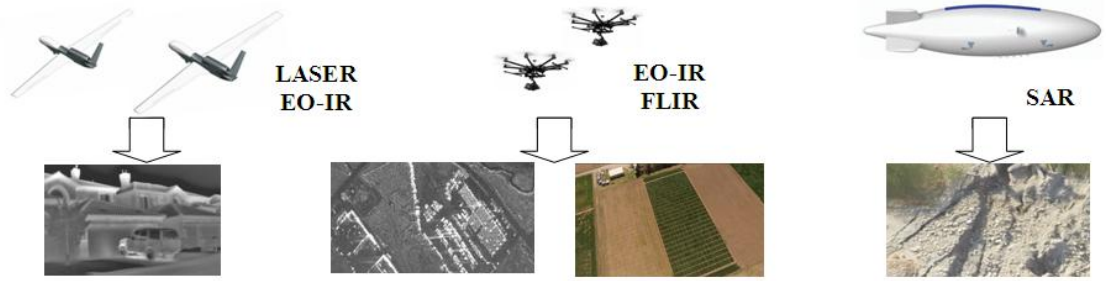


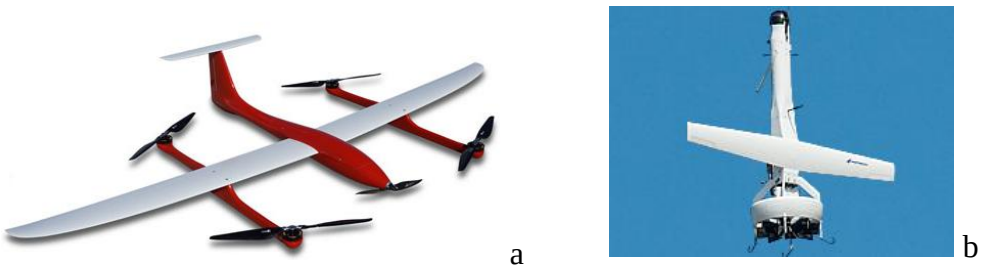
FIG. 1 Sensor data fusion UAV

The availability of a UAV is determined by the usefulness and quality of the payload, with most existing vehicles being represented by different types of sensors and concepts of use (data fusion, TESAR system), see Fig. 1 [8].

The transported sensors differ in type and performance according to the role of the UAV and mission requirements. To eliminate the influence of platform motion on UAV images, sensors can be fitted with a gyroscopic stabilization system. The significant increase in the computing power of the onboard computers, coupled with the reduction in size, weight and power requirements of sensors and their control systems, also leads to a continued increase in UAV usage. All useful IMIT (Imagery INTELLIGENCE) fieldwork tasks are characterized by the sensitivity they have in the construction and ultimately expressed through image quality, more precisely by resolution, [4].

2. FUTURE DEVELOPMENT TRENDS

Innovative concepts, methods, technologies and materials will have a major impact in the field of UAVs used in military operations and in civilian missions, which are based on advances in information technology, nanotechnology and miniaturization. The adoption of innovative aerodynamic concepts is an important research direction for the optimization of unpolluted systems both in terms of flight autonomy and range of action and versatility of the system (example: VTOL concept), see Fig. 2.



a b

Fig. 2 VTOL concept, a. Tempest DL (VTOL), b. VBAT martin UAV, [17, 18]

Increased data processing power provides the ability to process in-vehicle sensor information in real-time and the ability to perform complex autonomous operations.

Most of the bandwidth is used to send raw data to the ground station for processing, so this leads to a decrease in the mass, the aural load, and implicitly the cost of manufacturing, maintenance and operation.

Miniaturization reduces costs, increases reliability, and increases the functionality and capability of UAVs. The inclusion of micro-electro-mechanical systems and other technologies (nanotechnology, morphing, intelligent materials) for sensors and data acquisition systems allows the miniaturization of complex systems and platforms see Fig. 3.

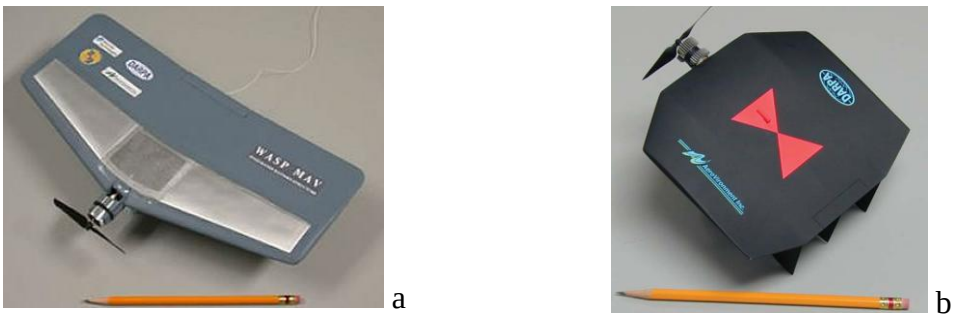


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FIG. 3 Miniaturized systems, a. WASP microUAV, b. Black Widdow miroUAV, [9]

The use of ***intelligent materials*** in the realization of UAVs has direct influences on concepts of design, manufacturing, maintenance and operation. From this category we can mention: piezoelectric and ferroelectric materials, electro-structural materials, magneto-strictive materials, shape memory alloys (SMA), optical fibers, see Fig. 4.

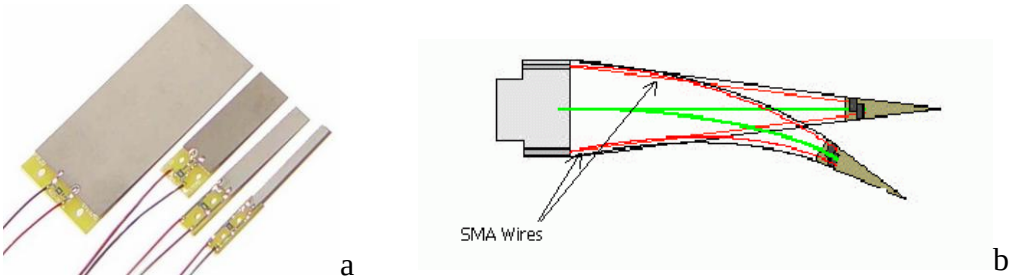

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FIG. 4 Smart materials, a. piezoelectric sensors, b. memory shape alloys (SMA), [10]

The use of the ***morphing concept*** has led to a renewed interest in making substantial changes to the UAV shape and geometry, to the controlled change of the wing surface and curvature of its profile. Rapid and controlled modeling of the aperture and wing geometry can also be used to actively control some undesirable phenomena such as airplane detachments at low attack angles, or the occurrence of wing-induced aero-elastic loads, see Figure 5. Changing the shape and profile of a wing for different types of mission has been the subject of extensive studies reported in the literature [11, 12, 13, 14].

FIG. 5 The concept of morphing, [15]

Use of ***UAV-UAV, UAV-UGV, UAV-USV hybrid*** air systems to increase the range and total operating time (operating in different environments).

UGVs are somewhat deficient in completing a more complex mission because the field of vision obtained by both on-board cameras and sensors is limited to 2D. A UGV can carry additional loads and sensors beyond the weight and power limits of an unmanned air vehicle and can easily carry out missions of longer duration. A possible solution could be to adopt a UAV that would overhang the ground vertically to the UGV, so the visual range would increase considerably. To minimize the intervention of operators, the autonomous capabilities of the platforms involved will be improved. The UAV-UGV hybrid system is used in surveillance missions, cooperative mapping and mine detection and disposal [16], see Fig. 6.

FIG. 6 Unlisted hybrid systems (UGV-UAV), [16]

Implementing artificial intelligence

Current research efforts aim to operate UAVs under full ownership as a function of mission pre-programming. Increasing the autonomy of an unmanned aerial vehicle requires the implementation of a program complex in the UAV's onboard computer before the mission. A completely autonomous system is the system capable of operating in the environment, without any form of external control, for long periods of time. By autonomy is meant the use of artificial intelligence, reaction in the shortest possible time and accumulated experience, in order to overcome an unplanned situation by the airborne individual.

The study of artificial intelligence has experienced an explosive development, in a manner similar to that of UAS development. For the development of artificial intelligence, two approaches were considered. One is a bottom-up approach that attempts to develop some neural networks similar to those necessary for the functioning of a human brain. Another approach, which comes in contradictory terms and is known as top-down, involves the use of high-speed algorithms to simulate the performance of a human brain.

Li-Ion/Li-Po intelligent battery

Most air vehicles are propelled by electric motors, so most times that the battery is the component with the largest weight of the platform. To limit this inconvenience, but also to improve the performance of a UAV, to increase the range of action and flight autonomy, a battery concept based on lithium-ion (Li-Ion) has been developed. These batteries have a relatively high density of energy compared to other types of batteries. This energy density is due to the fact that lithium is the most electropositive (standard electrode potential = -3.04 V) but also the lightest metal (equivalent mass = 6.94 g/mole). Li-Ion batteries have a low discharge rate, a wide range of operating temperatures, and a long-life cycle. The advantages offered by this type of batteries mainly used by UAVs are: high energy density; low maintenance costs; low self-discharge properties; the flexible battery housing allows a design freedom in terms of profile thickness; their operation over a thousand load cycles. A disadvantage of these batteries is *the short-circuit* and overload vulnerability, see Fig.7.

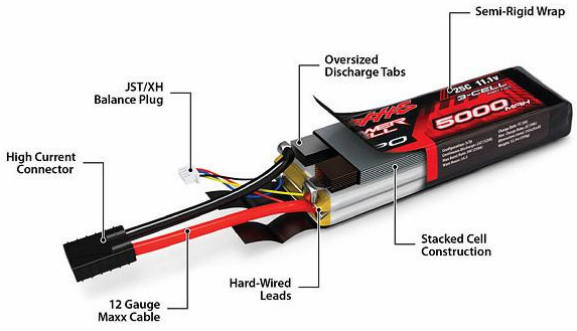

FIG. 7 LiPo batteries

Use of multispectral / hyperspectral sensors

For the development of unmanned airborne vector ISR / ISTAR capabilities, specialists' concerns have focused on the use of sensors used to acquire data constituting both the actual mission and the acquisition of data necessary for navigation and trajectory control. An important category of sensors is those used to acquire image data (hyperspectral), used to enhance the optoelectronic image for providing stereoscopic and spatial data.

The raw data provided by the multispectral sensors are refined with specialized software tools that process pre-calibrated databases and provide optic finite information including radiometric, spectral, textural and contextual data [19, 20].

3. CONCLUSIONS

Modern warfare requirements are more and more varied and complex, and the UAVs have taken over for the most part, with a great success rate and operating expenses considerably lower. In the context of the current armed conflict requirements, more and more UAV missions are being given. This type of mission requires the design of the new aerial vectors, considering the reduced size with a high maneuverability, smallest radar and noise footprint, and last but not least with a good transport capacity. The simultaneous fulfillment of these conditions greatly increases air superiority in combat.

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DEFENCE ARCHITECTURE BASED ON INFORMATION AGE OODA LOOP

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Abstract: *The paper analyzes the OODA loop from the Information Age point of view to find if is possible to use it without any changes. According with the results of this analyze the loop was created based on a kinetic confrontation and must be updated to be used in Information Age. On the other side if we want to use the loop at a strategic level to design a military organization the loop must be changed from OODA to OODPA loop. This original approach shows the direction of development of a military organization, to invest in information domain to increase the speed of the loop. But this source of power must very well protected because can grip the loop in case of an attack.*

Keywords: *: Information Age, OODA loop, military organization, information domain*

1. INTRODUCTION

Despite the fact the Defense organizations exist for more than 5000 years the hierarchical structure remained almost the same during the time. This structure gave the possibility to commanders to control large mases of soldiers sometimes more than 200.000. At the beginning because the communication lines were based on primitive tools like drums, trumpets, letters the battlefields was located on a plain terrain to coordinate all soldiers involved into battle. Later when communications like telegraph and telephone using wire and radio waves appeared the dimensions of the battlefield increased, and the vertical dimension was added. The commandants could coordinate considerable number of soldiers around the globe like in World War II. Even in this condition the hierarchical structure of the army survived because could sustain the existed quantities of information which was used.

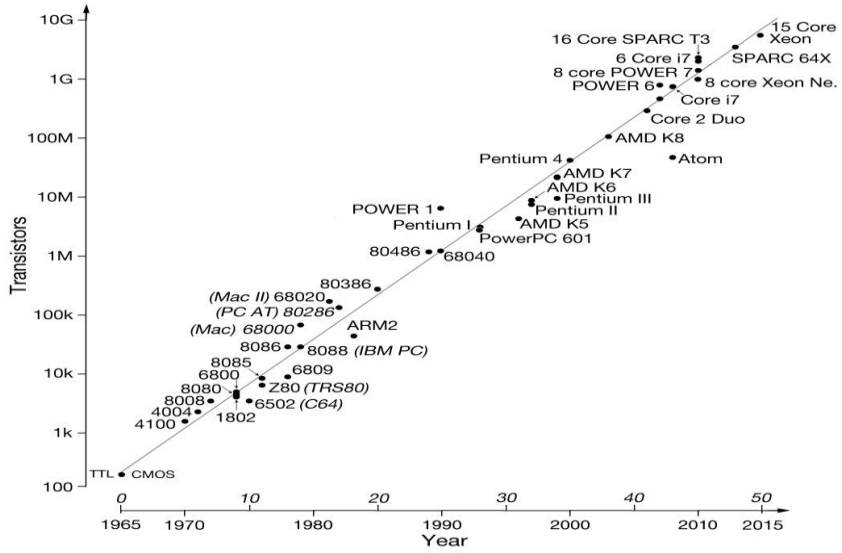

FIG. 1 Moor's law during the last 50 years

In the second half of XX centuries the digital revolution had started, and the quantity of information start to increase exponentially. First the Moore's law explains haw the physical tools was developed with exponential speed. In 1965, GORDON MOORE noticed that the number of transistors in an integrated circuit doubles approximatively every second year. Based on this observation, he predicted that this development trend will continue. This prediction is now known as the MOORE's law. The MOORE's law can also be applied to such digital systems performance as: calculating speed, information storage capacity, transport capacity of networks, etc.

This unprecedented development in digital technologies caused major changes in the society. These transformations affected military organizations as well, which were, thus, forced to switch from concepts specific to the Industrial Era to approaches characteristic of the Information Age. The hierarchical organization of military started to show their limits in dealing with enormous quantities of information and the increased speed of evolution of actions.

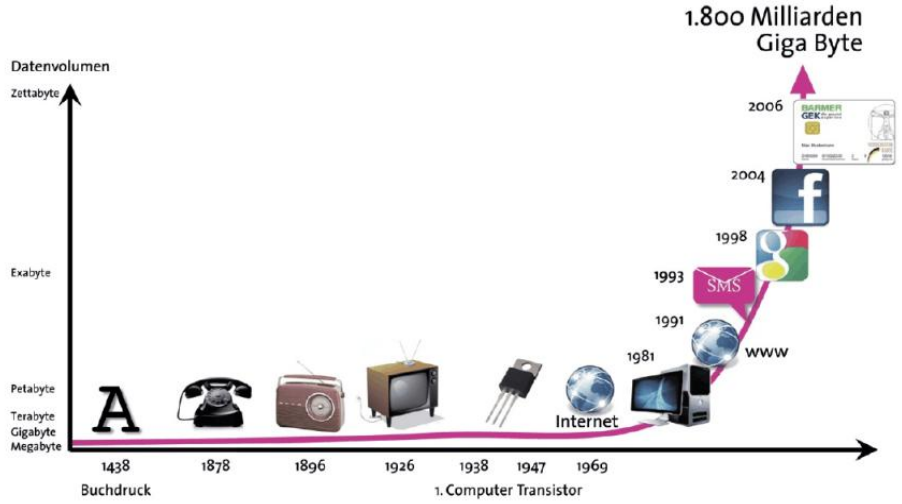

FIG. 2 Possible causes for big data according to Bitkom [1]

In fig.2 is presented the evolution of total amount of information in the world according with Bitkom research. If this graph is not related with the limit of a hierarchical structure to handle a certain amount of data, the following assumptions can be made:

a) The amount of data in the world will affect each organization also military organizations;

b) The amount of data able to be handled by a hierarchical organization is limited;

c) The amount of data in the world had increased exponentially and will continue to increase;

A military hierarchical organization can survive in this new environment if it takes the following measures:

1) The amount of data flowing in organization is limited to be efficient and effective. This approach can be used only if the military organization keep the hierarchical organization only at lowest level where the quantity of information is not yet too high. At high level of military organization, a new structure must be created. According with the assumption number 3 this approach will solve the problem only for a certain period and many hierarchical units will work in a non-hierarchical structure.

2) The structure of a military organization will be changed to a non-hierarchical structure to allow an effective and efficient flow of information inside and outside organization.

Unfortunately for both directions of development a new kind of structure must be created, and we do not have in our history a similar example. The best approach is to use the civil organization experience and to adapt their structures to military organization. But this is not enough because a military organization will be tested in a very dynamic environment during military confrontation. The new structure must allow large amount of information to flow efficient and effective but also must react with high speed to new changes in battlefield and to new threats. The new military structure must be very agile.

To create this new structure a various tool can be used but at the end the new structure will be checked using OODA loop model.

2. OODA LOOP MODEL

The OODA cycle (Observe, Orient, Decide and Act) was created by JOHN BOYD and it is applicable to all military conflicts, from individuals to organizations. The four phases of the cycle allow for the sequential analysis of an armed confrontation. Initially, this cycle has allowed in the case of the combats during the war in Korea to account for the reason why American pilots obtained more numerous victories. By dividing the fight into the four phases of the OODA cycle, one can better see from where the combat advantage and, ultimately, the victory were gained in military confrontations. The first phase of the cycle, **observe** referred to detecting enemy plane. In the second phase, **orient,** the pilot chose the position in relation to the enemy plane, so he could move to the third phase, **decide**. In this stage, the pilot decided what he was going to do next (to shoot down enemy plane). In the fourth phase, **act**, the previously taken decision was put into practice.

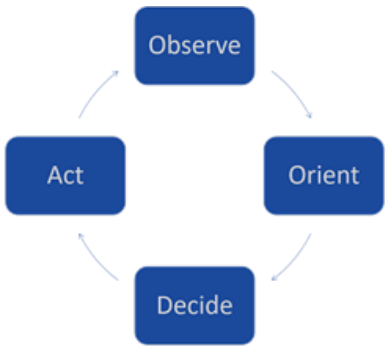

FIG. 3 OODA loop

After this last phase, the cycle was resumed after a new evaluation of the situation. By applying this analysis, BOYD noticed that the American pilots and their F-86 *SABRE JET* planes were superior to their enemies' in all the four phases of the OODA cycle. As the American pilots went through the OODA cycle at a higher speed, they acted during the enemy's cycle, thus winning the air combat. This high speed was possible because during the observation phase, the information was more rapidly acquired by observing the physical environment, considering the position of the plane during the orient phase, while the decision to shoot down the enemy plane was being taken by the pilot. As both planes had similar speeds, the decision was put into practice at a relatively equal speed.

At this level the OODA loop is very simple and cannot be used as an efficient tool to create a new structure. We should take into consideration the OODA loop was created before the Information Age and to understand how the loop can be used in this age we should analyze the loop from Information Age point of view.

From the Information Age point of view, we have the following domains of action for military operations:

a) **Physical domain**: is the place where those situations that the military try to influence exist. It is the domain where attacks, protection, and maneuvers occur, be it on the ground, by sea, in space or electromagnetic spectrum. It is the domain where physical platforms and the communications networks that connect them are located. Comparatively, the elements of this domain are the easiest to quantify, which is why, traditionally, the fighting power has been measured particularly in this domain. There are quite a few analyses and models, in which the physical domain is characterized as reality or fundamental truth. Important indicators used to assess the fighting power in this domain include mortality and survival rates.

b) **Information domain:** is the space where information exists. It is the domain where information is created, manipulated, and transmitted. It is the domain that allows for information to be communicated among fighters. It is the domain where the command and control of the armed forces is exerted. The information that exists in the Information domain may or may not reflect the reality. For instance, a sensor that observes the real world produces data that exist in the Information domain. Except for the direct observation of the sensor, all the information about the world travels through and is affected by the interaction with the Information domain. It is only through the Information domain that communication with the others is possible. Consequently, to allow a force to generate fighting power in response to offensive actions carried out by an adversary, it is becoming increasingly important to protect and defend the Information domain. In all fights relevant to achieving information superiority, the Information domain is the most important.

c) **Cognitive domain**: is formed in the participants' mind. This is the place that allows for decisions to be taken, where perceptions, awareness, understanding, beliefs and values coexist. This is the domain where, at present, numerous battles and wars are lost or won. This is the domain of the attributes can create an untouchable army: the leadership, morale, unit cohesion, level of training and experience, situational awareness, and public opinion. It is the domain where doctrines, tactics, the understanding of a commandant's intentions, techniques and procedures exist. The attributes of this domain are extremely difficult to quantify, and every sub-domain (every individual mind) is unique. All the components of the cognitive domain travel through a filter or a lens which is characteristic of human perception. This filter comprises an individual's perception of the world, the level of personal knowledge with which a person contributes to a situation, the experience, training, values and individual abilities (intelligence, personal style, perceptive abilities, etc.). Since these lenses which represent human perception are unique for every individual, then it means that individual cognition is also unique.

FIG. 4 Domains of action for military operations [2]

If we analyze the OODA loop from the Information age perspective, we will find the limitation of this simplest model. First, we should take into consideration the fact this loop was created using an air dog fight. The Observation phase was in physical domain but was executed by the pilot visual. The Orientation and Decision phases took place in the pilot mind, in cognitive domain. The Action phase was also in physical domain and was based on airplane possibilities. At the end the entire loop was between pilot and airplane and the information domain had only a small influence.

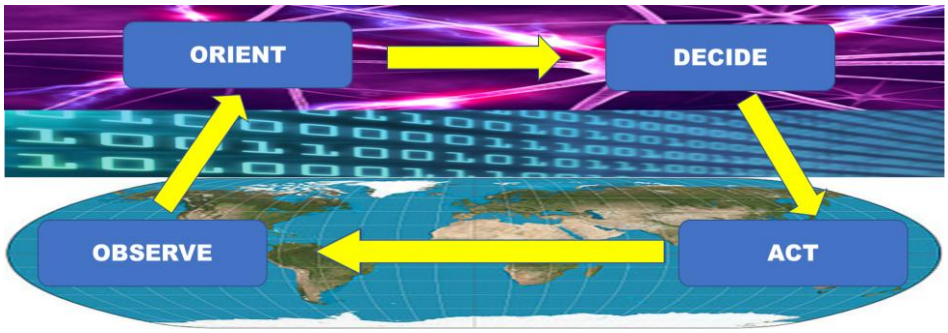

Fig. 5 OODA loop from Information Age perspective

To use OODA loop model for an organization should be developed from tactical level to strategic level. If during air combats in the Korean war, the information was transmitted between the airplane systems and the pilot (and the American pilots were better trained), in the case of a military organization's components situated at large distances in space, the increase in the speed at which information travels is given by the existence of some high performance digital technologies. Given the fact that a military confrontation can take place even between two military organizations, the same analysis method can be applied, except that the cycle has a more complex form, as shown by Boyd in 2001. It has, therefore, been demonstrated that in the case of some military systems with similar physical characteristics, victory can be achieved when the OODA cycle's speed is higher, which allows for "getting inside the enemy's OODA loop".

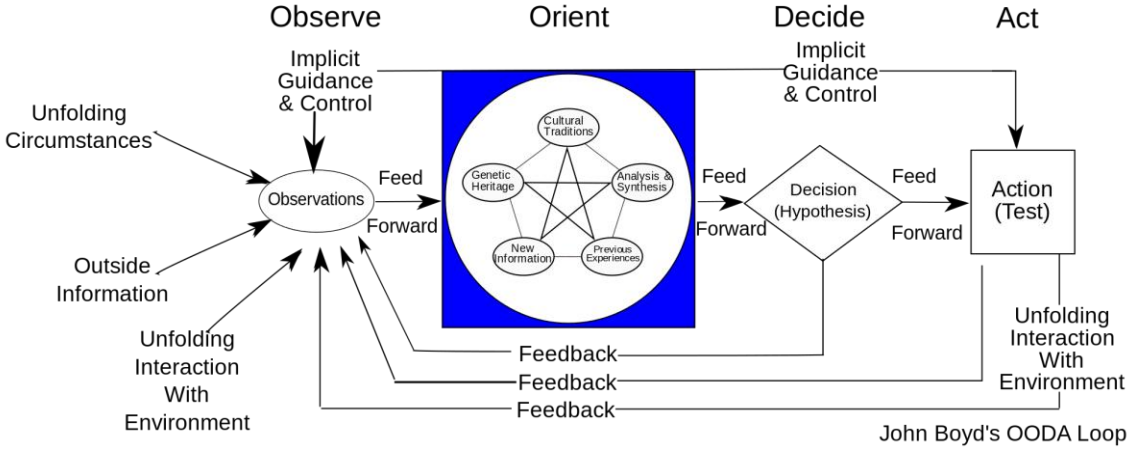

FIG. 6 John Boyd's OODA Loop 2001

But even this complex form of OODA loop is not well adapted to Information Age. According with this model the Orient and Decide phase still took place in cognitive domain. Because the OODA loop model is still valid the loop should be updated to take into consideration the Information Age environment. First, we should identify this new challenges.

Speed in the information domain can secure victory in the physical domain. The Information Age gives military organizations precisely those tools through which the speed in the information domain can be increased. When reaching this point, something unprecedented occurs within military organizations. This thing questions a military organization's fundamental principles, such as hierarchy and relations between individuals, structures, and processes.

The hierarchy and the relations within a military organization have been created, tested and improved throughout the history considering a certain speed in the information domain. And by speed in the information age, I mean the speed for acquiring, storing, processing, multiplying and transmitting the information. As previously shown, in the Information Age there is an explosion of speed increase. The information age's tools allow for speed to be increased within the military organizations, yet the traditional structure of hierarchy becomes an obstacle in using the power of information at its fullest.

Decades of efforts have led to an increase in the interoperability of the communications systems. These processes have become faster owing to the changing digital technologies. The huge progress in terms of storage, processing power, and bandwidth has allowed for a higher distribution of data, information, and images. Modernized sensors, new platforms, (from satellites to UAVs) and improved fusion algorithms, novel approaches possible thanks to a bigger processing power, have caused an increased awareness of the combat area and a reduction in the level of uncertainty in several contexts. Tools such as videoconferencing or extended bandwidth to distribute a larger volume of information, if only as PowerPoint files, have boosted the level of understanding, thus allowing for more varied decisions to be taken.

Similarly, decision processes are now faster and have resulted in a mutual understanding of what needs to be done, and an improved quality of combat management. Perhaps the most difficult aspect regarding C2 in the Information Age is the way in which C2 organizations are modified. Military culture is deeply rooted in a structure that, functionally speaking, is divided into smaller parts in terms of combat components (responsibility divisions such as armored vehicles, ground, air, sea and underwater artillery in naval wars) and in terms of group elements (personnel, operations, etc.). These divisions are confirmed by traditions, armament, and experience. They represent an essential component of the military culture. Therefore, they will resist change.

Anyhow, the present organizational divisions are the product of the information technologies and capabilities before Information Age. For instance, the arm platforms had, for generations, their own sensors or depended upon the five senses of the operators in service.

In the Information Age, sensors can be disconnected from the weapon platforms and, quite frequently, even from the platforms with people on-board. Thus, the sensors can be placed in a dangerous place, while people are safe.

Organizationally speaking, the information from the sensors can become available to potential shooters, in safe positions. Under such circumstances, and especially when the need for a rapid reaction is crucial (the ever-increasing mobile targets, the more accessible arms with terminals, etc.), the artificial distinction between the quality of intelligence (sensors) and the quality of operation (shooters) is pointless.

Since priorities have been established, and the criterion for aiming the weapons at targets is understood (including the quality of the information available according to which only correct targets are dealt with, and collateral damage is taken into consideration), the fewer the organizational barriers to collaborative planning and synchronizing of activities, the better. The changes within the C2 organizations are crucial for acquiring the benefits available in the Information Age. This is to be expected, owing the cultural obstacles, and the excessive costs resulting from wrong approaches.

The great difficulty in testing new methods of organization (identifying commanders and personnel that can undertake experimental approaches without creating problems regarding their current training and level of skills, identifying the facilities that can withstand such tests, etc.) has already emerged has a practical issue.

Finally, in any case, the full impact of concepts and technologies in the Information Age cannot be acquired without adequate changes within the C2 organizations and the collections of empirical data as part of structured war games, exercises and experiences.

As previously argued, human behavior is, simply, too complex to be shaped or dealt with by means of assumptions. The military organizations' solution to the challenges of the Information Age is the network centric warfare.

3. OODA LOOP MODEL UPDATED TO INFORMATION AGE

As we already presented in the introduction of this paper the amount of information has increased nowadays to an unprecedent level. To use the same scale as we used when we analyzed the OODA loop the physical, information and cognitive domains should appear like in fig.7.

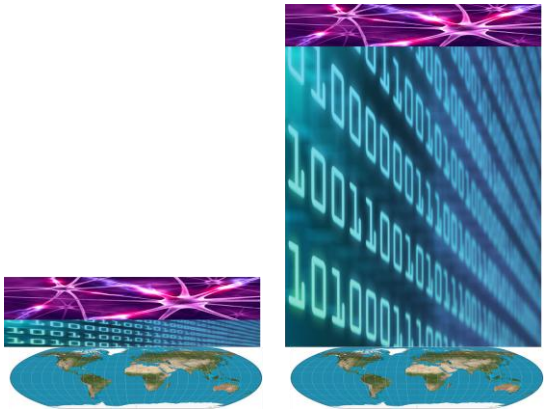

FIG. 7 The evolution of Information domain

The following graph represent the OODA loop according with new reality and at strategic level. The observe phase of the loop cover both physical and information domains because now an electronic sensor can be used as a surveillances tool. For instance, the airspace is scanned with networked digital radars. In this case if airplanes are in physical domain the recognized air picture is in information domain. The next phase, orient cover both information and cognitive domains because to analyze increased amount of data in a short time powerful computer with complex software must be used but humans conduct this analysis. Nowadays the complex software evolves in artificial intelligence.

Decision phase still occur in cognitive domain but to automate the process and to increase the reaction speed a software can take the decision to act. For instance, a modern integrated surface to air missile system like Patriot PAC 3 can decide automatically which target must be engage first but all the time the human operator can intervene in the process.

Because this model should be used also at strategic level the plan phase must be implemented before action phase. This phase occurs both in cognitive and information domains. In case of an organization the humans will create the plan using information domain tools, but in case of a system like Patriot PAC 3 the system will calculate the path of missile to hit the designated target. The act phase can occur in information domain if is a security system for a data network like intrusion detector or firewall, but also can occur in physical domain if is about a kinetic war.

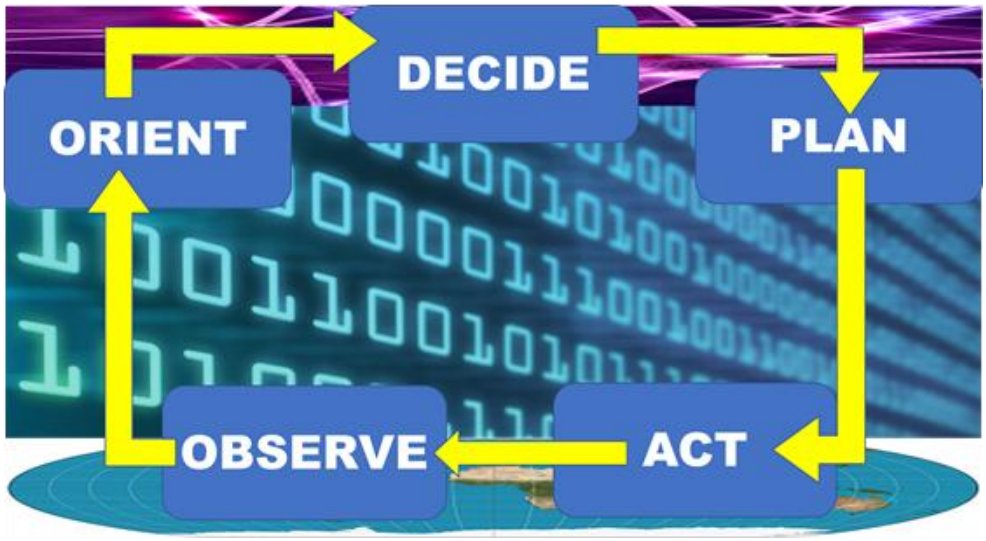

FIG. 8 The updated OODPA loop

CONCLUSION

The OODA loop is a powerful model used to analyze a military confrontation. Because John Boyd created this tool based on a kinetic confrontation the information domain was not so important at that time. This conclusion is proved also by the updated loop presented by Boyd in 2001. Also in this updated loop the orient and decision phase occur in cognitive domain. Nowadays the information domain has increased at an unprecedent level and continue to grow faster. If we take into consideration the main outcome of OODA tool is how to increase the speed of the loop, the information domain can increase this speed.

From this point of view the new Information Age OODPA loop show us the way to increase the speed of the loop at an incredible speed because a system can be designed to work only in information domain. If we analyze a military organization, we cannot obtain an increase speed of OODPA loop without to create a strong data network between elements of organization.

This tool also shows us the weakness point of our system or organization, the information domain. If an attack occurs in this domain, the entire loop can be blocked with disastrous consequences.

From this analyze the information domain can be the strongest but also the weakness points and must be very well protected.

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TRENDS IN PILOTS TRAINING

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Abstract: *This paper presents the trends for distance learning used for pilots training nowadays. It provides a briefing regarding the distance learning in aviation training according to the international/national rules and regulations. The study has revealed the fact that this method offers an efficient Learning Management System used to monitor the progress of the student, for administer the records and also for communication.*

The distance learning needs to be completed with a traditional face-to-face training. According to the legal framework the face-to-face training should be at least 10% from the total number of theoretical knowledge hours.

The distance learning system is accepted by EASA only for modular courses and ATOs have lately introduced this type of training due the high demand of the market. This new training method was implemented in the last years by ATOs as an aviation market requirement.

The study has concluded that the high demand of the airlines for pilots in the last years has determined the increase of number of trainees.

Keywords: *distance learning, pilots training, theoretical knowledge*

1. INTRODUCTION

The internet and new technologies have significantly influenced peoples' live, the vision of companies for presenting, communicating and disseminating their massage. One of the key competitive advantages in an information society could be achievement of the high level of acquisition and management of knowledge.

Many Approved Training Organizations have introduced in the last years the distance learning system[1,3] with respect to PART-ORA:AMC 1 ORA.ATO.300.

In order to achieve the necessary SKAs required by EU No.1178/2011 the trainee should complete the distance learning module, the face-to-face module and he has to obtain at the end of the course at least 75% for each exam.

The training material and systems should include the following:

- A complete set of books covering the entire syllabus EASA compliant; optionally the electronic version of the books could be included;
- Computer Based Training and/or Web Based Training;
- An online question bank;
- Access to a Learning Management System (LMS) for all communication, administration and for monitoring the progress of the students;
- Study guides for all subjects;
- Self-assessment tests, progress tests & retests and school exams;
- Exam reference material available online;
- Jeppesen Student Chart Manual, optionally.

The distance learning system represents nowadays an alternative to the traditional training. This type of training has a set of advantages the main one being that it gives the trainee the freedom to choose when and where to study, it cost often less than a face-to-face course. Also this system is a modality of training better suited for a certain type of learners, it offers a great flexibility and it encourages a great virtual interaction between the trainee and instructor or classmates. The e-learning system ensures equal access to education and allows the internationalization of learning opportunities.

The main disadvantage of this type of training is the fact that it is suitable only for self-motivated, disciplined learners and for flexible instructors. It may create a lug between student input and feedback. It also demands technological infrastructure.

2. BUSSINESS ANALYSIS AND ENVIRONMENT

In order to introduce the distance learning each Approved Training Organization should conduct a detailed analysis. For the traditional pilot training schools it is usually easy to introduce e-learning courses, because they already have the standardized programs and manuals and they also have the human capital[5]. The study has revealed that the strength of the studied ATO is the human capital. Due the fact that the goal of each ATO is to increase the number of students, almost each school has decided to introduce this type of method for training the future pilots. Around the world are Approved Training Organizations that use only distance learning training. The market offers e-learning platforms and professional book for each mandatory subject according to EASA syllabus. The face to face training represents only 10% of the total course number of hours, meaning at least 65 class hours for ATPL from PPL Modular Course. Those 65 class hours are usually done by experienced Theoretical Knowledge Instructors, who may teach in other Approved Training Organizations too.

In the last years most of the traditional Approved Training Organizations have decided to introduce the distance learning for pilots training due the high demand[3,6] on the market. Most of the traditional schools are overloaded and in this light they have introduced the distance learning in order to succeed in training a higher number of students in order to increase the revenue. Lately there is a high demand on the aviation market not only for trained pilots, but for theoretical knowledge instructors and flight instructors too.

The fiscal value of the aviation training schools has increased and therefore the activity of training has become a profitable business. The trends shows a continuous increasing of the students number and implicit for the fiscal values of the aviation training schools. The Fig. 1 illustrates the evolution of the students number between the year 2000 and the year 2017. It has revealed the fact that the number of trainees had a gradually increase between 2000 and 2008. The graph also shows that between 2008 and 2014 the number of trainees has significantly decreased, but starting with 2014 the number of trainees has increased.

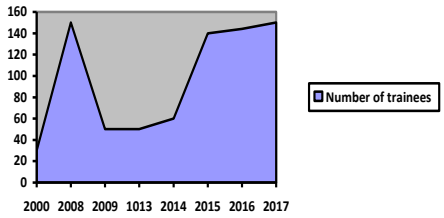

FIG. 1. The evolution of students number between 2000-2017

All these variations are strongly related with the economic, political and aviation industry events.

The global crisis which started in 2008 was the root cause of the students number decreasing. In the last two – three years all airlines started to hire pilots and this can be the reason for the increasing showed in the right part of the graph.

The trends for the next years indicated a continuous growth of number of future trainees.

The trends for aviation industry are hardly predictable, but overall there are four scenarios (Fig. 2) in the next 20 years, highly influenced by the increasing number of passengers, new technologies and markets. Other factors that may be considered are the environment, economy, geopolitics, security and borders, privacy and trust.

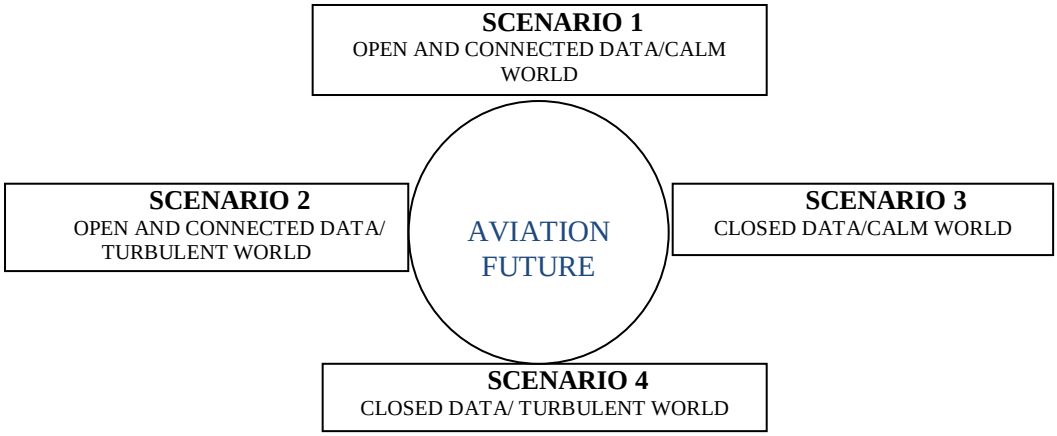

FIG. 2. Scenarios for aviation industry

3. LEGAL CONTEXT OF DISTANCE LEARNING

The legal context[3] of distance learning for pilots training is set up by EASA through EU No. 1178/2011, PART-FCL, PART-ORA.

In order to complete an Modular ATPL form PPL Course a trainee shall study at least 15 hours per week. The course documentation[5] should include a study guide in order to give the student a clear indication about what it means 15 study hours and a flexible course structure. In order to verify the students' progress it is recommended a test after each 15 study hours. The tests should be kept by the ATO for 5 years. I order to obtain very good results for the theoretical training the students should have access to self-assessment test after 5-10 study hours. The ATO has to ensure communications channels via telephone, mail, internet or fax between the students and the theoretical ground instructors. When an ATO provides the distance learning[5,6] by help of IT solutions (e.g. internet), the theoretical knowledge instructors has to monitor students' progress by appropriate means. The theoretical knowledge instructor may add on the platform additional materials and questions for each subject.

The following pre-requisites[3,4,5] should be fulfil before acceptance at a modular ATPL distance learning course:

- Hold a PPL(A) issued by a state ICAO member.
- Hold a class 1 medical certificate obtained before starting the course.
- ICAO Level 4 Language Proficiency or a knowledge of English language proficiency, in accordance with EASA Regulation (Part-FCL 055) .
- Sufficient knowledge of mathematics and science.

After completing the on-line part of the course the student shall attend at least 10% (at least 65 hours) face-to-face hours from the total number of the course hours (at least 650 hours).

ATO shall decide if the final exams for each subject exist on-line or not.

4. DISTANCE LEARNING PACKAGE CONTENT

Nowadays are used distinct platforms for pilots training. This type of platforms should include a complete set of books and/or e-books covering the entire EASA syllabus for each subject[1,2,5], CBTs, Web Based Training, animations, links to relevant web sites and study guides. Each platform should include a Learning Management System which will enable the ATO through the theoretical ground instructors to keep track on student progress and to generate information[4,6] to the ATO management[1,2,5].

The distance learning package should consists for the evaluation part self-assessment test, progress tests, reference material, school exams.

In order to complain[3] with PART-ORA: AMC 1 ORA.ATO.300 the platforms shall fulfill the following requirements contained in table 1:

Table 1. Requirement-compliance of platforms

Requirement	Compliance
A student will study for at least 15 hours per week	According to the training plan a student should study at least 15 hours a week
An indication throughout the course material of what constitutes a week's study	The training manual will indicate what constitutes a week's study
A recommended course structure and order of teaching	This is up to the ATO to decide, but once the course structure and order of teaching is established, this will be presented via the LMS
One progress test for each subject for every 15 hours of study, which should be submitted to the ATO for assessment	It is mandatory for the students to take an online progress test for every 15 hours of study in each subject.
Additional self-assessed progress tests should be completed at intervals of five to 10 study hours	Self-assessed progress tests is scheduled at intervals of 3-4 hours of study in each subject
Appropriate contact times throughout the course when a student can have access to an instructor by telephone, fax, email or the internet	This is up to the ATO to decide, but the LMS allows for a student to contact an instructor by email
Measurement criteria to determine whether a student has satisfactorily completed the appropriate elements of the course to a standard that, in the judgment of the HT, or CTKI, will enable them to be entered for the PART-FCL theoretical examinations with a good prospect of success	The LMS will tell the status of all assignments in a course, i.e. If a student has failed a progress test – a retest will be required. Upon completion of a subject, the student has to pass a school exam which is a timed test with the same number of questions as in the official exam.
If the ATO provides the distance learning by help of it solutions, for example the internet, instructors should monitor students' progress by appropriate means	Instructors will have access to numerous reports that contain information about student progress

5. DISTANCE LEARNING MARKET TRACK EVOLUTION

In the last years the number of student of distance learning had a significantly increasing as it is revealed in fig.3.

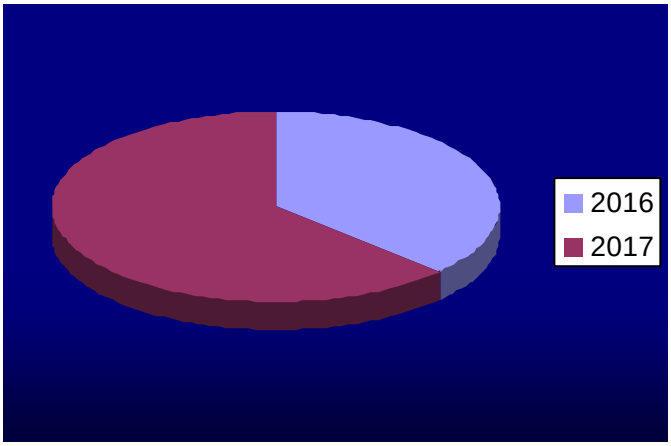

FIG. 3. Market evolution for distance learning training

The fig.3. indicates the fact that in 2017 the number of students had a significant increasing. The students number that have decided to study[4,6] on-line for a modular ATPL course was almost double in 2017 (62.96%) comparing with 2016 (37.03%).

The number of students who manage to finish this on-line training has not the same trend as the one mentioned above.

Only 10% of the students manage to complete the theoretical training for a modular ATPL course within the minimum specified period, minimum 6 months.

70% of the students need a period between 6-18 months to complete this type of course. 1% of them decide to withdraw after 1-2 study months. For this category becomes clearly that they cannot complete the course using this method which is mainly based on self-study. Part of them decide to continue the training in order to become a pilot using traditional type of courses.

The study has revealed the fact that the students who succeed in completing on time the distance learning training have an extensive flight experience or they have a technical background.

CONCLUSIONS

Distance learning represents a new method for pilots training used by ATOs. The trends are favorable for this type of training. It seems to be preferred by students because it offers them a flexible program, it gives them the opportunity to be employed in the same time. The main disadvantage of this type of training is the one that it is inappropriate for all learners. Due this disadvantage the training period in this case is much higher comparing with the period of traditional training. Only 10% of the students manage to complete the course in 6 month. The rest of them need 6-8 months to complete the course.

During 2017 the number of the students who started distance learning training is almost double comparing with 2016 for the studied ATO.

Distance learning is an alternative method and it has a favorable trend at least for the next years.

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THE EVOLUTION OF UNMANNED AERIAL VEHICLES

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Abstract: *Unmmaned aerial vehicles offer the advantage of flexibility and modularity of constructive and use concepts in the context of modern airspace and specific regulations inadequately adapted to reality. Operational requirements and limitations cover the UAV's technological path from design to entry into service, taking into account both manufacturing technologies, costs and materials as well as flight safety and maintenance aspects. The article offers an overview of the evolution of unmanned aircraft with aspects regarding the Romanian civil and military market.*

Keywords: *Kattering Bug, D-21- ShunkWorks, RQ-1 Predator, Shadow 600*

Abbreviations

SAM	*- surface to air*	*BRAA*	*-Air Defense Recognition Bureau*
UCAV	*- unmanned combat aerial vehicles*	*UGV*	*-unamnned ground vehicles*
USV	*- unmanned surface vehicles*		

1. THE EVOLUTION OF UNMMANED AERIAL VEHICLES

1.1.First projects

The first UAV projects came up with the pilot flying. Using the radio waves, the so-called "Aerial Target," a model speculated as a Zeppelin reaction weapon, was manufactured in the UK. Subsequently, the remote piloting technique began to develop, so that Hewitt Sperry's automatic aircraft, nicknamed the "flying bomb", became representative due to the fact that its gyroscope was used in its control system (1917), [1, 2, 3]. The first unmanned aerial aircraft on board were used as "air torpedoes" during and immediately after World War I. Americans talk about inventor Charles Kettering with his invention of the "aerial torpedo" called the Kettering Bug (1918), see table 1. Being a premiere at the time, this unmanned airplane onboard was able to launch a bomb, see Figure 1, [2, 4, 5].

The construction of the British-based "Queen Bee" ended many unsuccessful attempts during the First World War. This version is an unmanned version of the De Havilland DH 82-th Tiger Moth (mainly used as a target aircraft). Radio-controlled, it was modernized, between 1934-1943 by the British Royal Navy [7], see figure 2.

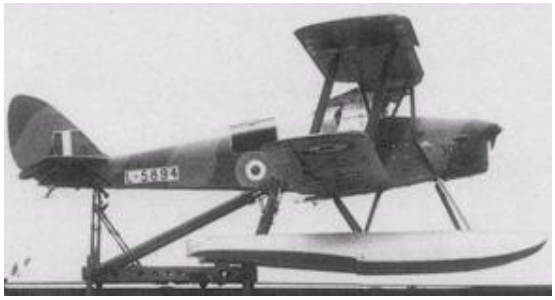
Also around this time, British actor Reginald Denny was the owner of a UAVs factory called "Radioplanes." This factory also produced unmanned airplanes for use as targets for troop training.

The OQ2 was equipped with two opposite-rotation propellers (to defeat the torque). Command control was done through radio waves, and the launch was done with a catapult, [2, 8]

Table 1. Kettering Bug, technical data, [27]

Data	Value	Data	Value
Span / Length / Height	4,5 / 3,8 / 2,3 m	Range	121 km
Cruise speed	80 km/h	Weight	240 kg
Powerplant 1x V4 piston engine		40 HP	

Fig. 1 The Kettering Bug



Fig, 2 De Havilland DH-82B [6]

German engineers from the Second World War worked intensively on this segment. They designed and developed the V-1 "Buzz Bomb" and V-2 (Figure 3). These systems used electronic equipment for the first time, being mainly used in theaters of operations in the UK with more psychological impact [7]. However, their operational results have prompted Allies to implement a large-scale air defense system. In addition, the Henschel HS 293, Fritz X and the *Enzian* missile were also used. The last two have been used very effectively in combat, especially in the Mediterranean theater of operations, see figure 4 and table 2.

Table 2. Henschel HS 293, technical data, [28]

Data	Value	Data	Value
Length	3,82 m	Range	2,2 …8,5 km
Speed	936 km/h	Weight	1045 kg
Power plant	Rocket engine	5,9 kN	

Fig. 3 V1 „Buzz Bomb", [7]

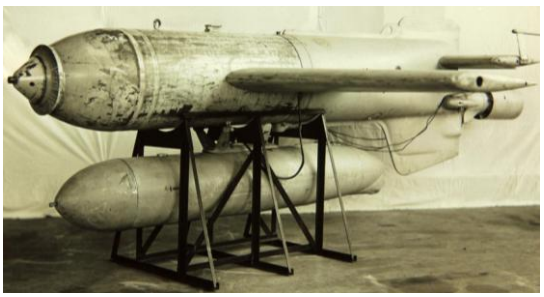


Fig. 4 Henschel HS 293 bomb, [14]

1.2. UAV evolution in postwar period

After the war, the Americans took over the project and developed it, imitating the "enemy targets", used both to prepare pilots for hunting and to prepare soldiers in antiaircraft artillery. Initially, in the Vietnam War, aerial research was carried out with the help of pilot airplanes on board.

They went after bombers and hunting aviation, many of them being shot down by Soviet-ground SAM missiles. As a result of these losses, the unmanned aircraft solution was imposed on board. Thus, on October 6, 1968, SB-12 flew to North Vietnam in reconnaissance missions. Thanks to the success, the range of missions made with this new model has increased, being used not only as a target, but also as a research aircraft. The airplane was powered, radio waves, with a rudimentary navigation system, with a first-generation onboard computer (controlling the camera). The airplane's recovery system was primitive (a pilot plane took the UAV from the flight at the time of parachute, and was then transported by air to an airbase using a helicopter). Due to lack of processing equipment, the film was sent to the US for development. This film trail, from the moment of the photos were executed and until they reached the table of the Pentagon commanders, lasted a few days, when the situation on the ground changed most of the time. This required the use of cameras and television systems. The monitoring point was in the C-130 plane fuselage (fly near the target to be monitored). The Ryan Firebee model was successful, resulting in the Ryan Model 147 Lightning Bug. And later on carried out research missions over North Vietnam, China and North Korea during 1960-1970, see Figure 5. The war in Vietnam has opened a new stage in the use of these systems. There have been 3.435 missions over enemy territory, shooting missions, electronic reconnaissance, passive jamming, communications and launching of manifests. With their help, the SA-2 missile routing signals were received and passive and active protection measures could be taken.

Fig. 5 Lighning Bug

Fig. 6 D-21- ShunkWorks, [10]

Technological advances in these devices declined after the withdrawal of US troops from Vietnam for nearly a decade, even if the espionage missions of the following years occurred in Russian and Cuban airspace. Thus, the CIA has boosted the field study by inviting Lockheed Martin to produce new types of research systems. The technological experience gained from the use of the SR-71 aircraft has led to the design and development of the D-21 "ShunkWorks" unpiloted model. Launched from the SR-71 platform, it has greatly enhanced technical-tactical performance. The model was used in espionage missions over China, (see Figure 6), and table 3.

Table 3. D-21- ShunkWorks, technical data, [29]

Data	Value	Data	Value
Span / Length / Height	5,79 / 12,8 / 2,14 m	Range	5550 km
Speed	3,35 mach	Service ceiling	29000 m
Engine	Marquardt RJ43-MA-20S4 ramjet		6,67 kN

Electronic image transmission technology was not developed at the time, so data was not transmitted in real time. The photo film followed the same awkward tracking and recovery route used in Vietnam.

As a result, the accuracy of recovery of the collected information material was deficient, which caused many problems in the planning and execution of the missions. Moreover, D-21's navigation system did not provide accurate data. Due to these conditions and accidents occurred in July of 1966 (when the UAV collided with a SR-71 in flight), the entire development program was canceled.

"The concepts of use have evolved both in terms of operating techniques and technological development (propulsion mode, flight duration and height, on-board research or on-board electronic warfare technology, navigation systems, transmission ground or satellite data, invisible structure by radar and / or IR, launch and recovery mode)"[9].

Due to the conflict, the Middle East area has been the area where acceleration has been accelerated. Israel's decision-makers have very well understood the role of UAVs in air operations in missions prior to piloted aviation. UAVs were mainly used to inform the battlefield, focusing on target recognition and evaluation of the results of the attacks. This fact was also recognized by Americans.

In early 1970, Israel used the American model "BQM-74" as”bait" (simulating combat aircraft flight) for Arab rocket troops (see Figure 7). Some UAVs have been knocked down, but the Israeli hunting-bombing aircraft has succeeded, with the support of these systems, to annihilate the launch ramps of the enemy pretty soon. The tactic was later used in the first Gulf conflict, more precisely at the Kuwait border with Saudi Arabia.

The UAV battle technique has been concentrated in groups of three flight vectors. Launched at short intervals, many lives and a lot of destruction techniques were saved in the initial hostile triggering phase.

Fig, 7 BQM-74, [15]

With all initial mistrust, Pioneer airplanes have provided real-time video images to senior allied commanders (over 700 hours in the pre-flight period and over 1,000 hours during the conflict). This tactical advantage triggered a change in the optician's use of these systems, ultimately in the thinking of military strategists. With the help of the Pioneer system, shipbuilding craft corrections were made in the US Naval Fleet, resulting in very effective target accuracy and, moreover, a novel fact "was the first time in history when the man surrendered to a machine ... the Iraqi they waved white flags when they noticed a UAV ".

We can assert with certainty that the Pioneer system has psychologically influenced the Iraqi army by the fact that, upon its appearance or only the noise produced by it, the soldiers gave up fighting; knowing very well that following the flight there will be intense shooting of artillery or allied missiles in the deployment area, [19, 20].

"The lessons learned from this conflict have generated the major directions that will be taken into account in the design of future UAV models" [9]. The development program continued after the first Gulf conflict when General Atomics Aeronautical Corporation designed the Predator at El Mirage, California.

The new generation UAV has a much broader range of radios, delivering real-time video from virtually anywhere in the world. Given the complexity of the system, the initial production was one copy per month.

The model was exploited in combat missions in the Yugoslav conflict as part of the IFOR (NATO) component of the Air Force Commands.

The notoriety of this system has led the US to establish the first UAV squadron "Squadron 11 Scouts". The Photographic Recognition Section of the US Pentagon and Department of Defense was named the Air Defense Recognition Bureau (BRAA). Gender. Maj. Kenneth R. Israel - USAir Force said in a film interview that BRAA's main theme was extensive recognition so that it could provide the military with "clear, timely, timely information when the fighter requested it at any time of the day, at all times.

"The Predator system was also used in non-military missions, but the focus was mainly on military missions. Two appliances were lost in Bosnia, but social implications were non-existent (cost: 1/6 of the price of an F-16).

1.3. The evolution of UAV's in modern age

The real battle UAVs only came to their end at the end of the 20th century and the beginning of the 21st century, when for the first time on the world, on 16.02.2002, a rocket launched from a UAV (RQ- 1 Predator), see figure 8. As Eric Adams also said "then it was the unmanned combat air vehicle" (UCAV). After the campaign it became clear that unmanned aerial vehicles on board are the weapon of the future.

The experience of the conflict in Bosnia and Afghanistan has not been limited here, so the famed Global Hawk product of Teledyne Ryan has been designed. This model uses the most advanced technology in the industry. This also led to an astronomical increase in the delivery price (a full US $ 35 to $ 50 million), thus achieving "equality" in terms of delivery prices for human-on-board airplanes. The model was later perfected by Americans and Europeans, resulting in the "EUROHAWK" model.

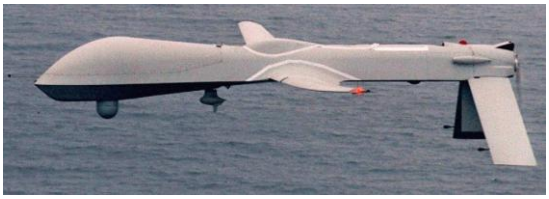


Fig. 8 RQ-1 Predator, [11]

Fig. 9 Air Target [12]

2. ASPECTS REGARDING THE DEVELOPMENT OF UAV'S IN ROMANIA

According to [12], the first uses of unmanned aircraft are dated from 1981 as aerial targets (Figure 9), and table 4, being equipped with only a remote radio control system, and between 1986 and 1997 a VR- 3 Reis, Soviet production, see Figure 9.

Table 4. ATM 1, technical data, [30].

Data	Value	Data	Value
Span / Length / Height	2,6 / 1,75 / 0,58 m	Range	3000 m
Min / max speed	35 / 190 km/h	Service ceiling	2800 m
Weight	8 kg	Automomy	0,75 h
Power engine	26 cmc	1,7 HP	

The first concrete actions on modern, unmanned aircraft in Romania were undertaken in 1997 when negotiations on the acquisition of Shadow 600 (see Figure 10), worth USD 20 million, were negotiated. There are currently systems in place, replacing URSS-type VR-3 models [12], see Figures 10 and 11.

Fig. 10 VR-3 Reis, [13]

Fig. 11 Shadow 600 [16]

Although no official data has been published, some analysts believe that UAV- was used during the events of December 1989 in Romania. According to [17], the evolution of the number of unmanned aircraft is highlighted in the chart in Figure 12, Romania being advanced and experienced in the use of UAVs and making efforts to align national legislation with the European one.

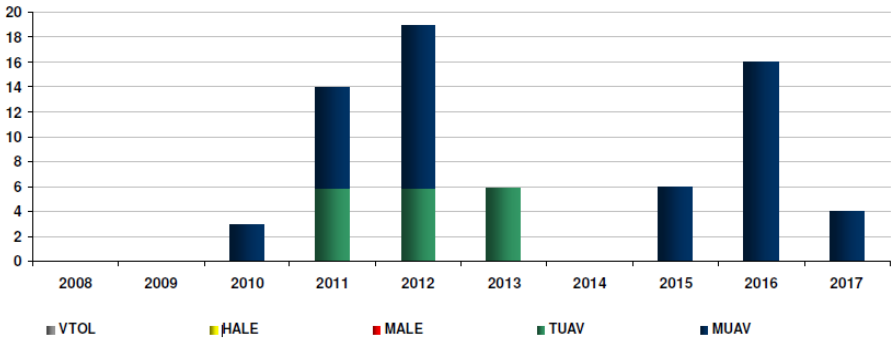


Fig. 12 Romanian UAV market evolution, [17]

Currently, the civilian market still offers moderate opportunities for UAV use, although concerns can be noted in the research area and uses for monitoring areas and events of interest, mainly using multicopter drones, see Figure 13, and table 5, [21, 22].

a

b

Fig.13 Comercial multi-copter type: a. DJI Phantom 4 Pro [21], b. DJI Inspire 2 [22]

Table 5. DJI Inspire 2, technical data, [31].

Data	Value	Data	Value
Max speed	108 km/h	Service ceiling	2500 m
Weight	4 kg	Power	4 x electrical
Misions	Image aquisitions	Autonomy	0,5 h

Unscheduled aircraft research projects are finalized or under way at civilian and military research institutes such as: INCAS Bucharest [24, 33], see figure 14a and table 6, IMSAR Bucharest, ACTTM Bucharest or civilian and military higher education institutions: *Politehnica* University of Bucharest [26] see Figure 14b, The *Henri Coandă* Air Force Academy in Braşov [23], these institutions having the role of coordinator or partner in projects.

Table 6. IAR+T, technical data, [32, 33]

Data	**Value**	**Data**	**Value**
Max speed	180 km/h	Range	10 km
Weight	20 kg	Power engine	4,1 HP
Autonomy	0,5 h		
Misions	Image aquisitions, airborne laboratory, military training		

a

b

Fig.14. a. IAR-T (INCAS), [24, 33], b.UAV-DUAV (Poltehnica Bucureşti), [26].

3. CONCLUSIONS AND FUTURE DEVELOPMENT DIRECTIONS

Future development directions for unmanned aircraft are marked both by a number of operational requirements and limitations, as well as by national and European legislative coherence [17]. Operational requirements and limitations cover the UAV's technological path from design to entry into service, taking into account both manufacturing technologies, costs and materials as well as flight safety and maintenance aspects [18]. According to [20], unmanned aircraft have a number of attributes (persistence, penetrability, versatility) that give them far more exploited advantages, which is why we can notice a series of trends in the development of unmanned aircraft, the most important being: (UAV-UAV, UGV-UAV, USV-UAV) with the concept of *"smart sensor"* and *"sense and avoid"*.

We can conclude that unmanned aircraft offer the advantages of the flexibility and modularity of constructive and use concepts in modern airspace and specific regulations not sufficiently adapted to reality.

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METHOD OF EVALUATING THE RELIABILITY OF DEMOUNTABLE ASSEMBLIES WITH CATCHING DEVICES

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Abstract: *The present paper proposes a method of evaluating the reliability of demountable assemblies with catching devices. After there have been identified the random variables that intervened in the sizing calculation, reliability of this type of assembly is being determined.*

Keywords: *reliability, demountable assemblies, catching devices, contact pressure*

1. INTRODUCTION

Assemblies with catching devices, which belong to the category of assemblies based on friction forces, are used for the construction of fine mechanics devices, in fixing and mounting rotating elements on crankshafts.

These variants of assemblies have the advantage of uniform loading; they do not modify the crankshaft section and they can be moved along the rotation axis.

In assemblies with catching devices, the radial force necessary for transmitting the torsion moment is achieved by means of fastening screws. In order to assure a constant fastening pressure, it is necessary for a correct assembly standardized adjustment of the catching device of the crankshaft, a good surface quality and an accurate mounting.

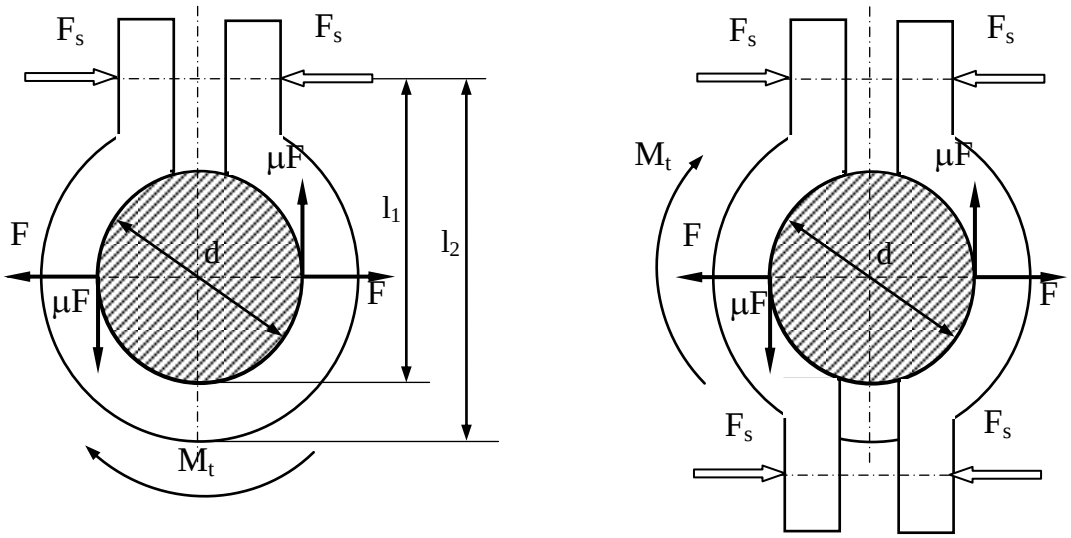

FIG.1 Assemblies with catching devices

The moment of friction M_f can be determined through the following relation [5]:

$$M_f = \frac{\pi d^2}{2} lp\mu K_{fm} K_f \quad (1)$$

where:
d – the nominal diameter of the assembly (crankshaft);
l – contact length;
p – contact pressure;
μ – friction coefficient;
K_{fm} – friction modeling coefficient;
K_{fm} - bending coefficient;

The equation below shows the contact pressure, resulting from relation (1):

$$p = \frac{2M_f}{\pi d^2 l \mu K_{fm} K_f} \quad (2)$$

where the friction moment is:

$$M_f = \mu F d \quad (3)$$

and F standing for the interaction force between the crankshaft and the catching device. Thus, the contact pressure can be determined through the relation:

$$p = \frac{2F}{\pi d l K_{fm} K_f} \quad (4)$$

The screw tightening force F_s (figure 1 and figure 2) [1]) takes the form of:

$$F_s = \frac{F l_1}{z l_2} \quad (5)$$

Result:

$$F = \frac{F_s z l_2}{l_1} \quad (6)$$

where:
z – the total number of catching screws;
l_1, l_2 – construction sizes of the catching device.

Taking into account relation (5), the contact pressure relation becomes:

$$p = \frac{2F_s z l_2}{\pi d l l_1 K_{fm} K_f} \quad (7)$$

2. METHOD OF EVALUATING THE RELIABILITY

In relation (7) sizes that can be considered constant and those that are variable during functioning are identified. Thus, we note:

$$k = \frac{2z}{\pi K_{fm} K_f} \tag{8}$$

Resulting:

$$p = k \frac{F_s l_2}{d l_1} \tag{9}$$

The average of the contact pressure is expressed as:

$$m_p = \frac{m_{F_s}}{m_l} \frac{m_{l_2}}{m_{l_1}} \tag{10}$$

where, m_{F_s} represents the average value of force upon a tightening screw of the assembly, and m_l the average contact length.

The standard deviation of the contact pressure is determined by relation [3]:

$$\sigma_p = \sqrt{\frac{\partial p}{\partial F_s}\sigma_{F_s}^2 + \frac{\partial p}{\partial l}\sigma_l^2 + \frac{\partial p}{\partial l_2}\sigma_{l_2}^2 + \frac{\partial p}{\partial l_1}\sigma_{l_1}^2} \tag{11}$$

The admitted pressure, expressed by p_a is given as a random variable defined through average and standard deviation:

$$p_a\left(m_{p_a}, \sigma_{p_a}\right)$$

The reliability of assemblies with catching pieces is expressed as [4]:

$$R(t) = P(p_a > p) = P(p_a - p > 0) = P(Y > 0) \tag{12}$$

$$R(t) = \frac{1}{\sigma_y} \int_0^{\infty} e^{-\frac{(y-m_y)^2}{2\sigma_y^2}} dy \tag{13}$$

The replacement of the variable is applied:

$$t = \frac{y - m_y}{\sigma_y^2} \tag{14}$$

resulting:

$$R(t) = P(p_a > p) = P(p_a - p > 0) = \frac{1}{\sqrt{2\pi}} \int_{t_0}^{\infty} e^{-\frac{t^2}{2}} dt \tag{15}$$

where it was noted:

$$t_0 = \frac{m_{p_a} - m_p}{\sqrt{\sigma_{p_a}^2 + \sigma_p^2}} \tag{16}$$

Thus, after calculation of relation (14), the reliability of an assembly with catching devices, irrespective of the construction variant that has been adopted.

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MARITIME SECURITY THREATS IN THE BLACK SEA REGION

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***Abstract**: Unfortunately, the end of the Cold War did not bring the desired peace and stability to the regions neighboring the Black Sea. Moreover, for the past few years, there has been an increase of tensions, both at state level and at interstate level, thus causing political dissensions, placement of embargos and even posing military threats.*

Risks and threats that may affect the maritime interests of Romania are mainly in connection with the violation of the maritime borders and the carrying out of certain actions displaying a diversionist character, meant to destabilize the internal political background, as well as the expansion of terrorist nets and activities in the direction of or from the sea, transnational organized crime (economic-financial crime, trans-border illegal human trafficking, drug, radio-active and strategic materials, weapons and ammunition smuggling etc.).

***Keywords**: maritime security, threats, migration, Black Sea region.*

1. INTRODUCTION

Romania's geographic position constituted a military interest both for Russia as well as for the historical alliances that perceived the territory situated to the East of the Carpathians Mountains as a buffer zone or transit of some campaigns toward a new world order.

The two European hot zones: the Caucasians and the Balkans, play a direct influence on the maritime security of the Black Sea regions, hence the numerous potential, existent and future military threats in the region.

Moreover, apart from the permanent desire for expansion and territorial influence, the conflict is also economically augmented by the energy resources existent in the region and by the fact that the Black Sea represents the necessary link toward the strategic resources and materials from Central Asia and Middle East, as well as toward these markets, now in their full development and ascension.

To these frozen conflicts, numerous asymmetrical risks in the area are added, which leads us to the conclusion that the Black Sea region represents a challenging background at the NATO's European Union's Eastern border.

2. THREATS TO MARITIME SECURITY

From the military perspective, the interest gains new dimensions, in the context of asymmetric risks and threats amplifying and diversifying. Due to the existence of certain vulnerabilities in the Black Sea region, despite evolutions favorable to international relaxation and cooperation, military and non-military threats and challenges continue to take place, endangering security and stability of the whole region.

According to the International Maritime Organization (IMO), the six threats to maritime security, which affect each port and each ship to a certain extent include: merchandise robbery, drugs smuggling – IMO Resolution A.872 (20) – Guidelines for the prevention and suppression of the smuggling of drugs, psychotropic substances and precursor chemicals on ships engaged in international maritime traffic, illegal migrants and transfugees – IMO Resolution A, 871 (20) - Guidelines on the Allocation of Responsibilities to Seek the Successful Resolution of Stowaway Cases, piracy (UNCLOS Art. 101) and armed attack against the ship, sabotage and terrorism [3]. Some of the above mentioned manifestations have existed since Homer until now. For the Black Sea region we may also add:

- political, economic and social instability within the newly appeared states after the disintegration of the USSR;
- bitter economic competition launched by the necessity of exploiting and transporting oil from the Caspian Sea region – this fact contributing paradoxically to both initiation of some forms of cooperation and to the appearance of tensions in some of the regional states, based on their national interests;
- manifestation of aspects related to organized crime, armament trade, nuclear materials and narcotics trade, as well as human trafficking;
- existence of risks of ecological nature, more and more acute in the Black Sea and Danube River regions;
- existence of zones of permanent ethnic-separatist conflict, such as the centrifugal movements of some forces meant to constitute independent state entities ;
- export of instability, through promotion of the Islamic fundamentalism as well as political, military and economic interests of Islamic states directed to the south-eastern Europe, through the existence of some entities of Islamic religion and of compact ethnic groups.

We can argue that for almost all the risks presented, each state of the region, perceived as recognized authority, may take action both militarily, using armed force and diplomatically, through dialogue, techniques and legal procedures, in accordance with the type of threat.

FIG. 1. The Black Sea region ([6])

The past events that occurred in Ukraine, annexation of Crimea by Russia and Russia's involvement in the Eastern Ukraine's conflict are, equally, a warning signal and food for thought for military strategists. These events, in the context of the massive cybernetic attacks of 2007 against Estonia and of the invasion of Georgia in 2008 [4], denote an ampler strategic plan that threatens the NATO and, implicitly, the Balkan states situated at the Western border of the NATO alliance, all of which take place on the background of some relaxation with regard to threat disappearance once the Cold War had come to an end [2].

The Black Sea region constitutes an interface between the Euro-Atlantic community and the Middle East (see Fig. 1), this region being today at the epicenter of the western efforts to design stability in a broadened European space and even beyond its boundaries[1].

Military analysts have considered that the migrant flux that troubles Western Europe is conducted by Russia. After the closure of the Balkan route, via Greece and Macedonia, the migrant flux might be deviated through an alternative route, namely through Romania, fact that would threaten, in a specific manner, the maritime security at the Eastern border of the NATO and the European Union.

FIG. 2. The future directions of the migrant fluxes in the Balkan region ([5])

Although the Black Sea is not a friendly sea from the meteorological perspective, and the religious differences could receive certain reactions from the local populations, when thousand of migrants wait daily at one country's border, diplomatic and moral approaches which a state should apply are not able to face the situation or they cannot be applied. Consequently, the only available method for a state is to act in cohesion with their desire to transit a national territory only to reach the promised land, as a result of a well designed and applied plan that is almost impossible to counterattack.

Recently, Russia has made a map public (see Fig. 2), showing the future directions of the migrant fluxes in the Balkan region. On this map, Romania is crossed by a flux of migrants coming from Turkey on the Black Sea, passing through Dobruja, and then crossing Romania through the central area, to finally exit it to Hungary. The infograph is published by the Russian propaganda agency, Sputnik News.

The route transiting Romania is called "alternative route", whereas the route via Greece, Macedonia and Serbia is named "Balkan route" [5]. It is less probable for such events to take place, they being more of a series of fake news, released by Russia in order to consolidate its influence in the Black Sea region and to send a new scorn at the EU's helplessness in front of the migrant crisis.

Migration, as a form of threat to maritime security, is considered an increased vulnerability for a state to which, apart from its internal problems of any nature that might occur, the appearance of new cultures and values that need to be integrated does not imply only financial resources, but also something that is probably the hardest thing to happen – integration of migrants within the democratic society and convincing the local people to accept migrants while each individual has to respect and tolerate the values and ideologies of the Other culture. History has proven that the preservation of latent instability spots, generated by separatist ethnic movements or by territorial litigations may change, when needed, the force rapport in key moments of a conflict.

We can invoke an attempt to destabilize the European Union, by adding trouble to what was already vulnerable: free circulation, democracy and religion. Nevertheless, isn't this, in fact, only a pretext for weakening the Orient and not for the weakening of Europe, taken the entire amount of assumed risk to infiltrate terrorists? For the EU, this is not but a pretext for increasing control and limiting the free circulation.

What is going to happen in these regions after it is considered that all of those who refused to fight or those who were against terror and chose the old continent for a better, democratic life left? There will be a purification war and all of those who have remained will be considered terrorists and will live the consequences. And after that, the territories will be populated with those who contributed to purification and will taste the great existent resources, being able to control the dependent parties, in the absence of less orthodox modalities.

For the past two years, immediately after the annexation of Crimea, Russia has started to consolidate its naval position at the Black Sea. The new batteries and long-range missile installations located in Crimea, confer Russia a significant coverage of the Black Sea, including the Romanian sea coast, while the Black Sea Fleet – as it is nicknamed by Russia -, has received new equipment and ships.

"If there were a conflict with Russia, especially a conflict of high intensity, at the Black Sea, then Romania would be dependent, to a great extent, on its allies in the NATO, for help, especially that it lacks an efficient defense against the sea-aviation and thus, it could be vulnerable to Russian aircraft equipped with anti-ship missiles", declared for the HotNews.ro Omar Lamrani, a military analyst at Stratford, an American agency specialized in military and geostrategic analyses.

Nevertheless, international rules of access to the Black Sea limit a lot the presence of American ships, the United States being Romania's most important military ally, on whom it would depend largely in any possible conflict [6].

3. CONCLUSIONS

Romania, just as any of the European Union's and NATO's member states, holds and will continue to hold responsibilities in the area of counterattacking security threats to maritime region and it will have to contribute with its own force, means and resources to the common defense effort. In order to do so, it is necessary for Romania to maintain the interoperability of its forces and the expeditionary capacity to be ready to meet the challenges of the twenty-first century.

The EU and NATO's interests with regard to maritime security consist of protecting their member states and citizens against the whole array of risks and threats in the maritime area, including those connected to illegal migration. Legal migration has already been approached through a comprehensive set of laws issued by the EU, including cooperation with EUROSUR, for the purpose of improving the situation, raising awareness and increasing reaction capacity at the external borders to detect, prevent and combat illegal migration and to save migrants' lives.

Regarding the influence of the changing threats to security in the Black Sea region, I estimate that Romania's, Bulgaria's and Turkey's adjustment to the new geo-political status required a relatively long interval of time, the first two countries passing through a neutrality transition from their belonging to the Warsaw Treaty Organization to joining the NATO (2004) and the EU (2007). Adherence to the North-Atlantic defense structures has meant, for the two countries, a replacement of ideologies, doctrines and procedures, which proved to be long-termed and costly.

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PARTICULARITIES ON MODIFICATION OF THE MILITARY POWER BALANCE IN RUSSIAN-UKRAINIAN SPACE

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Abstract: *Taking into account the changes in the balance of military power in the Russian-Ukrainian space, promoted by state actors with nuclear capabilities (Iran, North Korea, and Russia), the Alliance reaffirms its commitment to work in tandem with international humanitarian law and moves towards the gradual development of defense programs against hybrid threats, international terrorism, the promotion of the cyber war and the extension of the nuclear program to the East European area. In this article we will detail the particularities of the change of the military power balance in the Russian-Ukrainian area as a result of the Russian Federation's territorial expansion and energy blackmail policy addressed to the European countries, as well as NATO's position on the flagrant violations and the imperialist, undemocratic attitude of the Russian federal leadership.*

Keywords: *military power, military power projection, power factors, military potential, power balance, military power instruments, fighting capacity, Russian-Ukrainian space, missile shield*

1. CONCEPTUAL MILESTONES ON MILITARY POWER AND MILITARY POWER PROJECTION

In the evolution of geopolitical events, *power* is important. The concept of *power* is particularly complex and represents the ability of some actors to produce, construct or destroy various goods of particular or general interest, and "*great power is a state capable, under certain circumstances, to alter the will of individuals or groups, through effective use of force, going up to war*"[1]. From a sociological point of view (if we refer to social processes and situations), power means "*someone's ability to impose their will in social relationships despite any resistance encountered and regardless of the factors that determine this capacity*"[2]. It manifests itself through authority and force, and those who hold power can maintain it by legitimacy or coercion.

As an extremely complex phenomenon, power has its own *features* that regulate social relations, establish and rank the power centers, establish relations between the subjects (who leads and who executes) on the basis of *global power factors* (political, military, economic, technological, communication, etc.). All these elements are criteria that have highlighted the types of power (niche, secondary, regional and global), the struggle for power remaining the essence of the institutional policy by which "*states aim at reaching their own interests using the instruments of the military power*"[3], in order to maintain superiority and hegemony in areas of strategic interest.

Military power is a special form of power, based on the state's armed respond capacity. It is based on actionable vectors (armed forces, military potential and military reputation) and military-specific regulations.

The legitimacy of the military power (*the only and true determinant of the power of a state*)[4] provides the basis for the possibility of recourse to the military force by using instruments of the coercive dimension of political power. According to other sources, "*military power is the military's ability to act by its military potential"*[5] (personnel, budget, infrastructure, logistics, armaments, research-development institutions, defense industry, etc.) in order to achieve its strategic objectives, to ensure the security of allies and national interests.

The configuration of the military power system must be stable and based on the following elements of support: Armed forces, quality and diversity of infrastructure elements; The quality of the command act, the size and structure of the budget allocated to the defense, the level of training; The contribution of military technology and intelligence, the cohesion and morale of troops, the level of spiritual and material satisfaction of staff [6], etc. The quality of these system elements influences the capacity of any state to use its military potential, in relation to its national interests and defense policy.

The projection of military power is an important component of the projection of power, which includes a complex of diplomatic, political, financial, economic and military activities organized to exert influence within a system of relations as an expression of the mode of imposing the sovereign will, a last alternative usable when most of the power elements failed or failed to deliver the expected results. Both the projection of power and the projection of force have become very complex areas because they bring to the foreground states and international organizations (governmental or non-governmental), and the decision-making process on issues or events of major interest is always collective. Concluding on the two concepts (military power projection and force projection), we believe that the first concept belongs to the strategic environment, and the second concept belongs to the tactical or operational environment.

The projection of components of military power (belonging to an alliance, coalition, or state) can be made according to the interests, needs, possibilities and resources available to exert influence in an area of strategic interest, by imposing the act of will on defusing crises, eradicating conflicts, creating a climate of stability and security, all of which are associated with historical motivation, tradition, strategic vision, image, morality, etc. From this perspective, the projection of military power can be influenced by the following factors: International regulations; Political will; The model established by international diplomacy; Collective motivation; Strategic vision; Competitive Intelligence; Purposes, finalities, and objectives; Armed forces; Economic and financial support; The degree of air, land and sea space control; Post-conflict strategy, etc. All these factors are indispensable for the planning of military power design, but the degree of complexity of these factors justifies the cause for which, at the beginning of this century, no important international or national actor has managed to unilaterally design its military power in area of strategic interest.

In the contemporary operational environment, the projection of military power or force (at strategic or tactical-operative level) as a form of global power projection depends, in our opinion, on the following characteristics: International credibility; Major purposes of stabilizing conflict zones; Comprehensive analysis of situations; Preventive character; Flexibility of forces; Operative capacity to intervene in military, humanitarian and civil emergencies; Persuasive character; Preventive and active intelligence; Multilateral logistics capacity; High ability to execute preventive strikes, etc. In view of these characteristics, we appreciate that each type of operation implies a specific way of designing force, not being confused with an aggression of the past, but with a credible and operative tool to defuse conflicts, crises, or achieve stability and security at global and regional level.

In conclusion, military power influences the behavior of processes and phenomena in the operational environment, may impose certain options on partners, certain institutionalized cooperation relations, willingly or necessarily accepted. New elements such as: network warfare, expeditionary forces, super specialized means, information supremacy and technological advantage have already been of major importance in the characterization of the military power system of this 21st century.

2. ATTITUDES OF THE RUSSIAN FEDERATION THAT HAVE LED TO THE DESTABILIZATION OF THE BALANCE OF POWER WITHIN THE RUSSIAN-UKRAINIAN OPERATIONAL ENVIRONMENT AND NATO'S POSITION ON ALLEVIATING THE SITUATION IN THE AREA

For nearly twenty years, Russia's energy blackmail and military activities have affected security and stability in the Russian-Ukrainian operational environment, have changed the operational environment, and have increased the state of unpredictability. While NATO member states have honored their international commitments, the Russian Federation has violated the values, commitments, and principles that grounded the NATO-Russia relationship, disregarded most of the principles that underpinned the Euro-Atlantic global security architecture and deceived trust on which cooperation between the two sides was built.

Russia continued to strengthen its military presence in the eastern part of Europe, intensify its military activities, displace new structures of forces with high-performance capabilities, seriously destabilizing the balance of regional power, especially at the border with Ukraine. These developments have amplified hybrid risks and threats in the area, favored the rise of unpredictability, and the Alliance's response is to continue closely monitoring the situation in the region and to continue working on the situation and developing common approaches of European states to hostile challenges Russia, in a continuous evolution.

Destabilizing policies and targeted actions by Russia to change the balance of power in Eastern Europe included: The illegitimate and illegal annexation of the Crimea (which NATO member states will never recognize); The use of force to violate the borders of Eastern European sovereign states; Aggression and deliberate destabilization of the eastern part of the state of Ukraine; Numerous and unexpected exercises (as opposed to the provisions of the Vienna documents) and provocative military actions at the borders of NATO states, including continental waters of the Baltic Sea, Black Sea and Mediterranean Sea; Enhancing hybrid threats in aggressive and irresponsible ways (of nuclear, bacteriological, and informational type), as well as The frequent violations of the airspace of some Alliance countries. Moreover, the significant military presence in the Black Sea, the intervention of the Russian Army and the military support of the Syrian regime, as well as the projection of military power in the Eastern Mediterranean, pose asymmetric risks and additional challenges to allied security.

NATO has responded to the measures taken by Russia to modify the Eastern European security environment by strengthening the Eastern European defense alignment (including the construction of the East European missile shield), by intensifying the ground forces exercises and maneuvers, and by stopping the whole military and civilian cooperation between Russia and NATO, remaining open to political dialogue with Russia. In fact, talks with Russia have been permanently agreed by NATO, which has very explicitly stated its position on the Russian hybrid war in the region of Ukraine. NATO will also remain open to regular dialogue with Russia on the basis of reciprocity, in order to avoid misunderstandings, involuntary escalations, miscalculation and to increase predictability and transparency, and to reduce gaps that do not facilitate military transparency.

The Alliance will not seek confrontation and will not be a direct threat to the Russian Federation, but it will not allow any deviation from the Alliance's established principles, being firm, predictable and transparent, as set out at the 2014 Wales Summit, which means the continuation of strategic talks with Russia on the basis of respect, in line with international commitments and legislation. Continuing NATO's relations with Russia and returning to normality will depend on a clear and constructive change in Russia's position on respect for international law, obligations and responsibilities.

NATO strongly condemned the Russian Federation's aggressive hybrid actions against the Ukrainian state and continued non-compliance with international rights and obligations, with Russia bearing full responsibility for the serious deterioration of the Crimean peninsula, especially for discrimination against the Tatar population and other local communities. To regulate these issues, NATO calls on the Russian authorities to take firm measures to ensure the freedoms and rights of the people living in the peninsula, and to respect international structures that monitor and support essential human rights protection activities in the conflict zone. NATO also condemns the excessive militarization of the peninsula and the increase of Russian military devices in the Black Sea region.

The Russian Federation, signing the Minsk Agreements, has a major responsibility for the situation in the area. However, Russia persists in its actions of destabilizing the eastern part of Ukraine, with repeated violations of international law. Moreover, Russia continued to provide equipment and weapons to the rebels, to provide financial assistance and to intervene military in conflict. To alleviate the situation in the Eastern Ukraine region, NATO calls on the Russian authorities to stop aggressive actions, use its influence on rebels to meet commitments, fire stop, disarmament and confidence-building measures.

An independent, sovereign and stable Ukrainian state, firmly committed to the rule of law and democracy, will be the key to Euro-Atlantic security. Moreover, the Alliance will remain firm in providing Ukraine with support to restore its sovereign status within its internationally recognized borders, as well as its right to take decision on its future and the way forward on its foreign policy, without external interference, as set out in Warsaw (30 September 2016), in the Final Act of the NATO Summit.

NATO has supported any peaceful solution to stop the conflict (through which more than 10,000 lives have been lost), to reintegrate areas of the Luhansk and Donetsk regions controlled by the Russia-backed rebel fighters. For this, Minsk agreements must be implemented, starting with the cease-fire agreement and ending with the unilateral withdrawal of armaments. NATO also strongly supported the OSCE's monitoring mission, although Russia-backed rebels are obstructing monitoring, violating the provisions of the Minsk Accords. Also in those areas, the EU-supported consultative mission is being assisted, assisting the Ukrainian state in implementing reforms in the civil, police, police, and rule of law sectors.

In order to balance the security balance, the Black Sea countries have undergone important regional efforts, strengthened dialogue and cooperation with Ukraine, Georgia, Armenia, Azerbaijan and the Republic of Moldova, supported their territorial integrity, independence and sovereignty, continued to uphold the democratic right of partners to fight for sovereign and independent choices, to promote their own foreign or domestic policy without external constraints or pressures. Also based on the principles and international norms of law, the Final Act issued in Helsinki and the UN Charter, they continued to support the efforts to peacefully resolve conflicts in the South Caucasus and those of the Republic Moldova and Transnistria.

Moreover, as part of the overall democratic dialogue promoted by the Alliance with regard to ensuring the security of NATO populations and territories, the package of deterrence measures has been accompanied by an open dialogue and a strong commitment to Russia to reduce risks and increase transparency mutual. These efforts, to ensure a territorial balance, will be made at the same time as taking credible deterrent and defense measures.

On the territory of the south-eastern part of Europe, the Alliance will adopt an advanced presence with appropriate measures adapted to the Black Sea shore, by promoting Romania's deployment initiative in the area of a multinational tactical unity framework that will ensure integrated training of Allied units in the South-East Multinational Division. Thus, through these decisions, the Alliance will step up defensive deterrent measures, better know Russia's intentions in the Black Sea basin, show NATO's intention to operate in the area without constraints, provide a signal of regional security support, and an assessment of the options for a future enhanced presence in the Black Sea air and maritime environment.

In the spirit of meeting collective defense tasks, the NATO Summit in Lisbon (2010) decided to develop a NATO ballistic missile defense (BMD) capability to fully cover and protect the European Union population, territory and forces against threats stemming from the proliferation of ballistic missiles in the Eastern European operational environment. This plan is based on the principles of NATO's solidarity and the indivisibility of Allies security, reasonable challenge, fair distribution of tasks and risks, with increasing threats, availability and technical feasibility. If international efforts diminish the possibilities of proliferation and use of ballistic missiles, then NATO's missile-defense capabilities will adapt accordingly.

NATO's missile defense shield implementation program has had a rapid evolution, these achievements being made public at the Chicago Summit (2012), the Wales Summit (2014) and the Warsaw Summit (2016). Thus, the alignment of the anti-missile ballistic shield was implemented with technical and informational elements through the advanced deployment of Aegis ships with BMD capabilities at Rota (Spain), Aegis Ashore Complex from Deveselu (Romania), advanced remote detection radar of BMD deployed at Kürecik (Turkey) and Aegis Ashore Complex which will be deployed at the military base at Redzikowo (Poland). The allied states involved in this program understood the importance of implementing the ballistic shield and provided important voluntary, additional national contributions.

The US missile defense system (the Shield) is not aimed at Russian objectives and has no missions to undermine the strategic deterrent capabilities of Russian territory. Therefore, any offensive statement that threatens allied states because of the US missile defense shield is considered unacceptable, leaving NATO open to talks with Russia on this issue. However, the Russian cyber-attacks, as well as the nuclear/ballistic threats from North Korea and Iran, remain clear challenges to the security of NATO states. In Warsaw, the Alliance reaffirmed NATO's defensive attitude and admitted that cyberspace has become an operational environment in which the Alliance must organize defense as professionally as in the air, at sea or on the ground. This will enhance NATO's ability to deploy operations in cyberspace and provide an opportunity for efficient resource management and operational capabilities.

3. CONCLUSIONS

* The diversity of hybrid threats (international terrorism, proliferation of weapons of mass destruction, authoritarian regimes, unresolved conflicts, "failed states", global crime, internal corruption, uncontrolled migration, etc.), in consensus with the issues and the physiognomy of hybrid conflicts (information, bacteriological and nuclear warfare, guerrilla warfare, ethnic disputes, counterinsurgency, low intensity conflicts, etc.) have led to real changes in the organization and operation of the structure of forces, the projection of military power (or forces), the mission planning in the operational environment, as well as the use of performing technologies, whose dynamics have produced essential mutations on the entire military system;

* A new consequence of technological development will be the expansion of the conflict in the cosmic space and in the information environment, the East European world moving from the three-dimensional (terrestrial, air and maritime) space to the five-dimensional conflict space. This new perspective will cause the actors (manufacturers and suppliers) to compete in increasingly sophisticated and costly weaponry and equipment systems.

This issue will attract many specialists, will concern international security actors as the future evolution of this process will be upward and of a global scale;

* Under the unprecedented expansion of the operational confrontational environment, the aerospace component of the military power favored the rapid multiplication of the space military actors, thus becoming an important factor of the future hybrid conflict, the new military equipment and technologies being an amplifying factor for the consolidation of an credible military power, capable of counteracting hybrid threats to the security of democratic states;

* The rapid operation of the 21st century will have a wider sphere than the classic contemporary defense/offensive operation. It will involve a complex system of actions because no country with a strong military potential will allow itself to permanently maintain at peace an army with complete structures ready for war, because they are inefficient and very expensive. Today, states are making efforts to operationalize military structures that, in a very short time, are able to reach war structures and capabilities. Many countries have deployed rapid action forces (reaction, intervention), the value of operative or tactical units, able to rapidly plan and conduct either peacekeeping or war operations;

* The modern battlefield, as a three-dimensional space of confrontation between the belligerents, recorded a rapid evolution, determined by the development of theories and general concepts of warfare. The essential parameters of the theater of operations will be determined by human and technological factors, as technological superiority will be necessary, but not always sufficient to achieve success, which will require a permanent analysis of the doctrinal-human-technical relationship. Moreover, the concepts of automated warfare, cyber-battlefield and digitized battlefield will decisively influence the operations of the forces, creating new dimensions of the battle space;

* At the current historical moment, the Russian Federation should continue its good strategic partnership relations with the EU and the US, develop proper relations with other European states (not energy blackmail), fight for the non-proliferation of weapons of mass destruction, trafficking of strategic materials (nuclear, radioactive, chemical, bacteriological, etc.), and manifest itself globally as a basic pillar of the fight against international terrorism, but neither as a force of violent political pressure as an instrument of the underworld and mafia clans, nor as the leader of non-compliance with international agreements on state borders.

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LEADERSHIP – ESSENTIAL QUALITY OF AN EFFICIENT MANAGER

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Abstract: *Managers placed on various management positions in the organizational structure communicate with subordinates, partners representing the interests of communication tool that any manager has on hand to motivate and influence behavior. Only through a certain type of communication on an emotional level, the manager is able to understand the subordinate personality, needs and aspirations of its particular system of values.*

In time, it was formulated the idea that leaders are born, not be trained. The truth is that real leaders have innate abilities, which ennobled by education, contribute to the perfecting of this entire process. Good leaders turn their talents into action, they shape their personal experiences and successes and failures.

Keywords: organizational management, persuasion, professional goals, social phenomenon

1. INTRODUCTION

Leadership emerged in the nineteenth century as a consequence of the industrial revolution, and later evolved over the twentieth century. The first significant theorizations belong to Kurt Lewin, Ralph White and Ronald Lippitt, from 1938 to 1952, their attempts to highlight aspects of effective leadership. The three analyzed democratic, autocratic and laissez-faire [1] styles in groups of children in charge of adult monitors. On the basis of these experiments in which some indicators of personality, performance, level of aggression, organization were studied, they noticed that there are various advantages and disadvantages for each type of leadership. These researches were carried on during the Second World War on various samples of the US Army in an attempt to establish the main attributions of those who had an ascendant over the others. One of the conclusions of the studies was that the ascendant is given by intelligence, initiative and self-confidence.

It is far easier to show the opposite of leadership than what it literally means, and there are many controversies between researchers about its definition. However, trying to define a leadership, we can say that it is but a "mutual process in which a person has the prerogative to exert influence on others, motivate them to achieve their group goals, thus succeeding in inducing group satisfaction." This definition highlights some key features, namely: leadership is a mutual relationship, which includes, on one hand, the leader - who has the role of determining, conducting and facilitating the behavior of the group, and subordinates, on the other hand, consider the proposals from the leader.

2. THE ART OF LEADERSHIP

The success of an institution depends on many factors, but no less important is the impact of leadership. A polisemantic term, untranslatable in Romanian, in a single word that encompasses the true meanings of the notion, leadership still makes a career in managerial literature. When talking about the attribute of management or management coordination, inevitably reference is made to leadership. When it comes to communication strategies in the institution, again the notion of leadership is mentioned. The development of agreeable interpersonal relationships based on cooperation and trust is related to leadership, and the starting point in formulating differentiated motivation policies for subordinates. Leadership can be understood as an attribute of a hierarchical position in the institution, a person's characteristic, a mobilization process or a category of behavior. At the same time, leadership is influenced by the requirements of changing work tasks, by the labour group itself, and by individual members, being exercised and determined by particular circumstances and by the organizational context. Consequently, leadership does not belong to one person, but is distributed differently among group members depending on the situation. However, studies conducted over the last thirty years lead to the conclusion that there are four crucial variables for leadership analysis, namely the leader's qualities, the nature of the group, the nature of the workload and the organizational culture.

The art of leadership, therefore, is defined by leadership - a complex process that refers to participation obtained through non-coercive means, having as a goal the achievement of objectives. The basic feature is that leadership is the ability to inspire and stimulate group members that success is worthwhile. As a participation, leadership is done through delegation of authority, action committees, sharing goals, actions that offer advantages such as: improving decisions, facilitating change, identifying with the leader, and achieving a high level of success. It is not, however, enough for leaders to train subordinates to simply accomplish their goals through motivational "temptations," but it is more than necessary for at least part of the group to engage in this activity personally. Those who manage to do this are called leaders.

Over time, the idea has been formulated that leaders are born, unable to be trained, the truth being that leaders have innate abilities but have been ennobled through education. Good leaders start in action with their talents, which they shape according to the successes and failures of their experiences. This is confirmed by one of the most important authors in leadership theories, Noel M. Ticky, who presents a seemingly very simple thesis: "successful firms are distinguished by having good leaders who, in their turn, are capable of forming new leaders for all the hierarchical levels of the firm [2]." Therefore, the ultimate test for a leader lies in the ability to prepare other leaders. Consequently, the behavioral view exceeds the traditional model of the leader based on innate qualities, as practice demonstrates that the fulfillment of the objectives is strongly conditioned by the training and the formation, in time, of the leadership competencies. Given that it is commonly said that the world's poorest resource is leadership talent and the leadership crisis has become a problem in our society.

Psychologists D. Katz and R. Khan show that regardless of whether the organizations are well structured and have clearly established goals, leadership is needed because [3]:

- it ensures the dynamics of the organization;
- it allows greater flexibility and responsiveness to environmental changes;
- it offers the opportunity to coordinate the efforts of the various groups within the organization;
- it facilitates coordination of the efforts of various groups within the organization.

We can appreciate that leadership is a social phenomenon that requires total participation in the life of the group, leadership is causing change and is, in turn, an extremely labile process because, over time, the requirements and needs of the group are changing. Leadership is also conquered and maintained through the power of the interactions that are born within the collective. This idea allows us to formulate a first distinction between what leadership means and the influence exerted by management. While leadership is not required from an outside group, being a result of the group's internal life, management acts through the force of hierarchical authority, and can also be called outside the organization.

As an act of conception, design and control, for all the sequences of social action, leadership represents the functional side of the institutionalized power, that is, it includes only those axiologically motivated action models validated as effective as the concretely determined activities.[4]

Leadership involves influencing the behaviour of subordinates by means of psychosocial instruments so that they carry out certain tasks, taking into account organizational goals; if it is a harmonious blend of position and style, leadership becomes an effective art, capable of directing energies towards the long-term achievement of goals. Leadership is more than mere authority or power, assuming some voluntary support from the individuals who are in the lead group. In human resources management, the issue of leadership examines the people involved in this activity. The first studies focus exclusively on the determination of the ideal characteristics of the individual invested as the leader of an institution, the second theoretical study focusing, in particular, on the most effective attitudes and modalities that could be established and put into practice by to these special statuses, so that the last category of theories, the most complex and most expressive, at the same time, to distract pragmatically from the previous attempts of sketching, either of the portrait or of the ideal leadership behaviour towards which all tend, those who want to occupy such a position, indicating flexibility as the main feature of management. A definition that illustrates in a synthetic way what management is supposed to belong to is Gerald A. Cole, who appreciates leadership as a "dynamic process in a group in which an individual determines others to contribute voluntarily to carry out group tasks in a given situation[5]." Leadership is a "dynamic form of behaviour [6]", which involves the capitalization of four basic dimensions, namely: the characteristics of the leader, the attitudes, needs, behaviours, and other personal attributes of the subordinates.

Managers have a leading role in sizing the performances of that institution, and this quality must be closely related to the particular importance of a decision taken by the manager. The connection between the manager and the institution he manages is a complex one, considering that the manager is the one who has a major influence on the system and, on the other hand, the effectiveness of the manager's activity is closely related to the value of the system in which he operates.

As Warren Bennis says, "large-scale leadership combines, as a rule, as harmoniously as possible, the two attributes: native talent and competence gained through study, through work, and through experience [7]."

3. INFLUENCING WILLINGNESS

Human capital is unique in terms of growth and development potential, people's ability to know and overcome their own limits, to meet new challenges or current and prospective exigencies. Human resources are precious, rare, difficult to imitate, and relatively irreplaceable. People have the potential to create material and spiritual goods that meet new requirements or better meet some of the old requirements. People shape and produce goods and services, regulate quality, allocate resources, make decisions, and determine or formulate goals and strategies. Human resource management decisions interconnect individual organizational and situational factors, differ from one country to another, from one organization to another, from one organizational subdivision to another, because the relative importance of functions or activities in the field of human resource management is not identical in all cases. Respect for the person, mutual respect, procedural fairness, transparency, honest communication, fair treatment, honest competition, special consideration, responsibility towards the organization, respect for the law, respect for the personality of the people must be the pillars on which to stabilize the process of implementing a managerial decision in the field of human resources. Subordinate managers must regularly rely on respect for human dignity. As worthy human beings, people have the right to be treated honorably, and their personal needs cannot be met without the support of an appropriate human resource management. Subordinates perceive the managerial style of bosses as the one who defines their long-term activity, leaving aside casual deviations from the usual conduct. Whether a driver changes his or her leadership style over the medium or long term, his perception has long stabilized as the one that people have adopted with regard to the previous managerial style.

However, we cannot fail to notice that the main problem faced by today's institutions is that of adaptation, so that permanent changes in society, clientele, technology require institutions to create new strategies and to know new ways to act. In the majority of cases, the most difficult task for a leader in face of change is mobilizing individuals in a particular institution to adjust to new working conditions.

In Heifetz and Laurie's conception, "mobilizing an organization to adapt its course to the new business environment is fundamental, it is the very motive of leadership in a competitive world [8]."

Through the experience gained as a result of the research of managers around the world, the authors cited above elaborate six principles in order to systematize adaptive work, namely: balcony panorama, identifying the adaptation challenge, stress relieving, disciplined attention, repositioning people in work and support for leaders at all levels.[8]

According to the balcony panorama, leaders need to be able to make a full vision of things, and they are not recommended to become the main actors in the field of action, and leaders must, in fact, direct the context of change in a beneficial way to subordinates.

Leaders must be able to induce a strong sense of the importance of the institution, highlighting its good parts and, last but not least, insist on the importance of subordinates in shaping the future.

If we report, instead, when identifying the problem of adaptation, things are quite obvious, in the sense that, when the organization cannot learn to adapt to new references, it inevitably tends to its extinction. Thus, in order to be able to overcome the difficulties of adaptation, leaders must finally forget the preconceived ideas that the leader orders, and the subordinates execute.

A leader in the true sense of the word, regardless of the hierarchical position he occupies, will have to support his own subordinates in the various problems they face, in changing perspectives and in facing the new challenges that may appear.

Leaders must be the promoters of change, have a philosophical vision of their own, have the ability to predict, be original and dynamic, and to some extent inspire subordinates, the need for well-done work, proving confidence in the creative potential of them. Contemporary adaptation needs are directed towards leaders who take a certain responsibility, without being passive, and waiting for the impetus of revelation or explicit request.

CONCLUSIONS

Managers have a leading role in sizing the performances of that institution, and this quality must be closely related to the particular importance of a decision taken by the manager.

The connection between the manager and the institution he manages is a complex one, considering that the manager is the one who has a major influence on the system and, on the other hand, the effectiveness of the manager's activity is closely related to the value of the system in which he operates.

Over time, has been formulated the idea that leaders are born, unable to be trained. The truth is that leaders have innate abilities but have been ennobled through education. Good leaders start in action with their talents, which they shape according to the successes and failures of their experiences.

We can appreciate that leadership is a social phenomenon that requires total participation in the life of the group. Leadership is causing change and is, in turn, an extremely labile process because the requirements and needs of the group are in constant change.

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E-LEARNING – CHALLENGES AND OPPORTUNITIES

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Abstract: *Distance learning (e-learning) has experienced a huge development at a very rapid pace in recent years and educational institutions are more and more interested in developing and offering a higher number of online learning programs in an effort to satisfy the demand for permanent development. Thus, e-learning has ceased to be just a buzz word people or institutions use when they want to put up a modern and innovative face, it has become a common educational situation within the educational environment which offers many promises and opportunities. In practice, however, the combination between educational process and technology does not always function properly. Some of the shortcomings are caused by technology, administrative issues, instructional methods and even students.*

Despite the promises and the evident benefits of distance learning, the issues mentioned above need to be addressed, otherwise they will affect the quality of education, will incur hidden costs, will bring about misuse of technology and even improper attitude on the part of instructors, students and administration. Most of the times, these issues are interrelated and for this reason they should all be given the same importance when tackled. Unfortunately, it is impossible to solve all the problems and to keep up with the rapid rhythm the issues and changes that occur. Nevertheless, we should not lose faith and give up because distance learning is an educational product which continues to be attractive and viable. The increasing number of students of all ages and backgrounds enrolling in distance learning courses prove its attractivity and usefulness.

Keywords: *E-learning, traditional learning, challenges, opportunities.*

1. INTRODUCTION

Online education has evolved from distance education and Isaac Pitman, a British, is attributed the pioneering the concept of "distance education" when he started teaching shorthand via correspondence in 1840. The technological advancements have helped in improving the teaching process and the IT&C development contributed to the appearance of a new method of learning, online learning or e-learning. E-learning has experienced a huge development and expansion in the recent years, if at the beginning of 2000s online courses were just a sporadic presence in the offers presented by the educational institutions, nowadays almost every university has developed e-learning programs. Although this growth is impressive it does not come without problems and there some challenges that need to be taken into consideration if we want the results of these learning programs to be above average.

Educational institutions have increased their learning programs with online course in response to social changes and student demand. More and more people want to continue their education, but work and family obligations or some financial restrictions prevent them from doing it. E-learning has made education more convenient and accessible for a large number of people, the development of technology made learning activities able to take place anytime and anyplace.

2. OPPORTUNITIES

According to different reports and surveys the number of students attending online educational programs continues to grow annually and there is no apparent reason for this growth to stop. The Babson report from 2011 presents the results of an analysis of the online education status in the U.S. The report states that "the number of students taking at least one online course has increased at a rate far in excess of the growth for the overall higher-education student body" [1] as you can see in fig. 1.

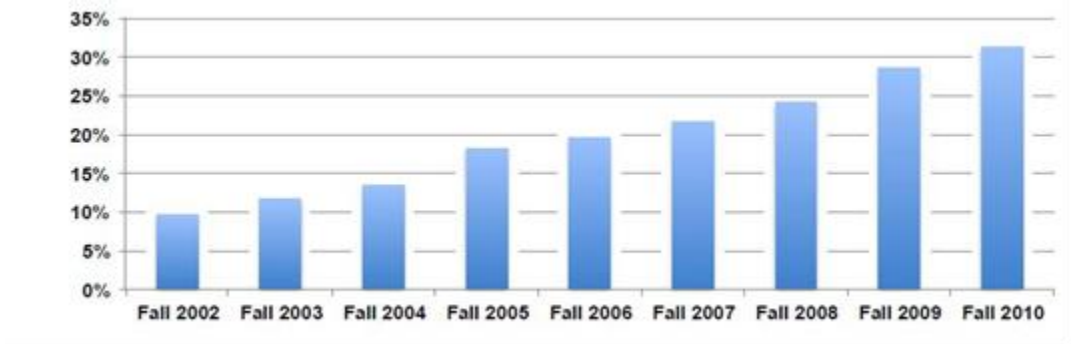


FIG. 1 Online enrollment as a percent of total enrollment - Autumn 2002 through autumn 2010 [2]

The facts presented above are the result of the U.S. strategy to encourage distance learning. They have invested heavily in this domain in order to face the challenges of modern society: unlimited accessibility, flexibility.

The Distance Education Enrollment Report released in 2017 by Babson Survey Research Group [3] presents the evolution of online education in the USA on between the years on 2012-2015. The findings come to support the results from earlier years (see figure 1) and show that distance education growth maintained its momentum.

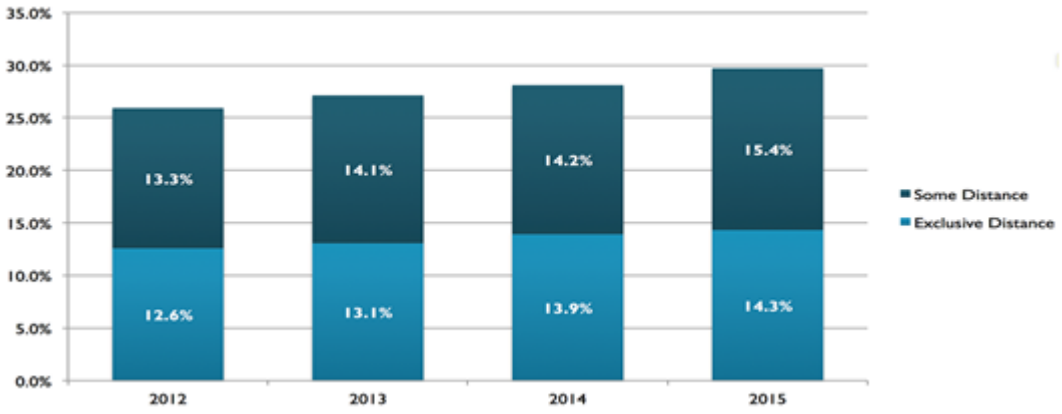
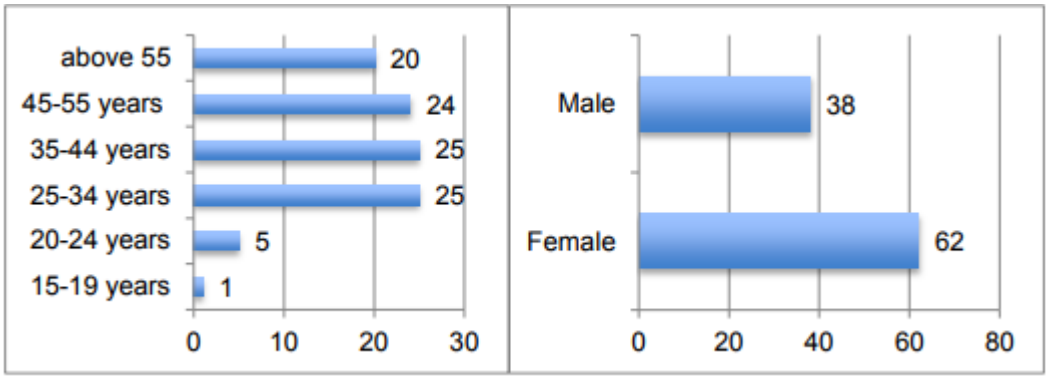


FIG. 2 Percentage of students taking distance courses 2012-2015

Even if there is a gap between Europe and U.S., Europe now goes in the same direction and the new program of the European Commission "Erasmus for all" which focuses on improving people's skills and their personal development through lifelong learning, will help the funding for e-learning in Europe.

Also, the opinion of the academic world has changed and the advantages of distance learning have become visible and have been recognized. Piet Henderikx, Secretary General of the European Association of Distance Teaching Universities (EADTU), stated that it "has become an important answer to the current educational challenges and will significantly impact our educational landscape" [4]. Originally, EADTU had eleven founding members in ten European nations and now the number rose to 15 institutions and 14 national associations across 25 nations. The membership covers over 200 universities and around 3 million students [5].

A report by the IDEAL project (Impact of Distance Education on Adult Learning) covering the period between October 2013 and September 2015 offers information about the situation in the European Union and the results of the EU strategy concerning equitable and inclusive quality education and lifelong learning for all, focusing on people enrolled in distance education programs. From fig. 3 presented below, we can see that there are two predominant age groups 25-34 and 35-44-year-olds in distance education and according to the gender more women than men are enrolled in distance education.



(a) (b)

FIG. 3 Percentage of students enrolled in distance education according to age and gender [6]

This impressive growth that is visible in the European Union and the United States is due to its principal characteristic and advantage: convenience. Why is it convenient? Well, one very important aspect is the budget. For both sides, the educational institutions and the students, online learning offers the possibility of providing and taking courses without the burden of a high cost. Here we can mention the teaching staff cost, utilities, consumables for the educational institutions and for the students the cost of tuition, lodging, travelling, educational materials and why not, the impossibility of earning an income while attending a full time education program.

Another aspect is that of time and schedule flexibility. A person engaged in a full time work activity will not be able to attend traditional education programs; there are people who prefer to learn and research at their own pace, spending more time on a specific topic and less on others. Also, students enrolled in this educational process can attend courses from different universities located in other countries, with different time zones.

Diversity and opportunity are two other criteria taken into consideration. For example, one can choose a course on a specific topic, which is delivered by a university from another country without the necessity of relocating there or, one person can attend two educational programs at the same time without overlaps in schedule also, such programs offer access to education even to people having disabilities.

Adaptability to new. Whenever there is a new trend and learners are asking for it the online platforms can adapt quicker than the traditional programs. This is not an impediment. You just need to develop a new module on the training platform and instantly get all the benefits to all your learners. Gamification which represents the process of adding games or gamelike elements to something (such as a task) so as to encourage participation can be a good example.

To conclude, we can say that the fact that this kind of education does not require for the student to be in a certain location for the classes, the only mandatory aspects is access to a PC with an internet connection makes it very attractive. These basic two requests trigger other effects like reduced tuition costs and the possibility to accommodate the learning process to the work schedule or to family constraints. In a service-oriented economy, education is perceived as a service so, the student as a consumer, looks for the most advantageous and diverse offers.

Online education has become more and more competitive, not only from a material point of view, but also from an academic perspective. Online programs offer new learning opportunities in a variety of formats and manners and people from the most remote regions can have access to education. An online course can comprise more information than a traditional class of 50 or 100 minutes. The delivery and structure of the course will not be altered by interruptions and all the misunderstandings can be clarified without taking up from the delivery time, using written communication. And last, but not the least the programs offered can cover almost every domain (with some exceptions, thus universities can enlarge their curricula without any modification to their physical spaces.

Taking into considerations all the above mentioned aspects, we can say that e-learning offers great educational opportunities in an ever-changing world, broadening the scope and reach of education farther than ever before and at the same time being a valuable and cost-effective method of continuous education.

3. CHALLENGES

As it often happens, there is also a downside of this situation, along with making education available to greater number of people arises the challenge of making this diversity of people work in concert and avoid the discrepancies that arise from lack of direct (face to face) communication.

Many of the promises of distance learning and maybe the most appealing are of a financial nature. Universities, as well as students, aim at saving money by offering and enrolling in online courses. Universities can increase the class size without any change in the overhead or without having to worry about the lack of physical space (classrooms, laboratories etc.). All these seem very good, but there are some hidden dangers if we only look for financial benefits. Universities welcome those who want to enroll, but the more they are, the bigger the administrative, technical and instructional challenges.

From the administrative point of view enrolling many people means keeping a lot of records, staying in contact and trying to keep organized large groups of people. Sometimes this can be a very tedious activity and the administrative department might not have the necessary personnel for such an amount of work. This is a problem that occurs for the faculty staff, also. The need for instructors surpasses the personnel of the faculties due to the increased number of new courses that appear every academic year. The challenge is the how to fill in the gaps, as the classes cannot be postponed or cancelled and hiring new instructors is not always possible and the shortage of instructors will influence the quality of the educational process.

The quality of instruction depends on the attitude of the administration and of the instructors. People who are dissatisfied with their activity will not do their best.

Due to the shortage of staff and the multitude of tasks to be accomplished some of the assignments will be superficially effectuated. In order to avoid misunderstandings it is very important that the schedules the deadlines should be very clear, as well as the academic requirements. All the materials should be posted in time and the answers to the students' questions must be prompt. Some students tend to neglect their responsibilities and it is advisable to post some of the most important issues or deadlines on the main page of the site to remind them. Online learning requires students to be more disciplined and determined, they have to manage their time wisely, the fact that their learning schedule is flexible could make them postpone or even omit completely to accomplish their tasks. For this reason online education is not appropriate for young or dependent students who need a lot of supervision and guidance.

Communication is another issue and lack of face to face communication makes the educational process more difficult. The instructor needs to be interactive and to provide quick and clear response to the students' inquiries. The teachers should be deeply involved in their activity, they should find a way to supply the lack of face to face contact by creating a participative environment fostering the sense of a learning community in order to achieve maximum participation. Online courses are generally characterized by lack of interaction. In this case, where direct contact is almost absent and communication is sequential, some problems and especially misperceptions may occur. Also, taking away all forms of interactions with other people might be a demotivating factor for some users, boredom occurs as well as lack of focus.

Some students lack to ability to measure their own progress and need to see the flow of the class in order to feel like progress is being made. Such students are used to the traditional face-to-face instruction and have a difficult time in adapting to the environment, most likely they will show disinterest, will respond with absenteeism and will not finish the learning program.

Learning as a collaborative process is essential when students and instructors are separated by distance. A research by Palloff and Pratt shows that "collaborative activities can alleviate feelings of isolation by purposefully connecting learners with one another through various learning activities and promoting interdependence" [7] and "assists students to achieve deeper levels of knowledge generation through the creation of shared goals, shared exploration, and a shared process of meaning making" [8]. The instructor can shape the distance learning environment and encourage collaborative learning thus creating the sense of community among the students and attaining effectiveness. The instructor has the difficult task to overcome the limits of the technology and impediments caused by distance and lack of interaction and to involve the students and facilitate discussions.

Technology is another challenge. Technology in itself cannot improve the quality of the courses. High technology does not guarantee nor produce effective distance education. Technology can facilitate the educational process as long as both instructors and students are familiar with it. There is the possibility of not using it at its full capacity and potential because of lack of knowledge in the area or because of some technical incompatibilities between the programs and the platforms on which the courses are hosted and the personal computers of the students. Technology must be user friendly, any equipment malfunctions can affect the effectiveness of a class and if they happen too often they affect the entire course. Technology will challenge the instructors not only to learn how to use it but also to learn to reorganize their materials to adapt their lessons to the e- learning requirements.

4. CONCLUSIONS

Online **s**tudents come from all walks of life**,** they are younger, older, men, women, from cities or villages, but they all want to develop their skills and education. This variety of participants proves the potential of distance education to meet the needs of adult learners**.** From the point of view of institution it is also a good element to capitalize on, since it offers solutions for financial, material and personnel problems. The goal of online education is to provide learning programmes to large amounts of people, especially those who otherwise could not enroll in a traditional form of education. E-learning should offer to students an experience as close as possible to the traditional, face-to-face instruction, from the point of view of quality, but as Bates (1995) said, instead of using technology to replicate traditional methods, we should use it to improve instruction [9]. Such programs offer solutions to actual challenges like continuous change in the social environment, larger classes, more diverse students, demands from government and employers who want more implication and responsibility in the instruction process of students who should be ready and able to enter the workforce when they graduate and to keep up with all the quick social and technological developments.

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MATHEMATICAL MODEL FOR AN AIRCRAFT TURBOSHAFT-TYPE AUXILIARY POWER UNIT

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Abstract: *In this paper the author has studied an aircraft auxiliary power unit (APU), identified as controlled object, referring to the specific case of a TG-16M unit (consisting of a gas turbine turbo-shaft which spins up an electrical 28 V DC generator, treated as an embedded system). From APU's behavior point of view, the author has identified embedded system's non-linear motion equations, then, using the finite difference method, the equation system was brought to a linear, then to an adimensional form, which is more appropriate for further studies. System's coefficients were experimentally established or calculated and/or estimated during several ground lab tests of the TG-16M unit, using the facilities of Aerospace Engineering Laboratory (at the University of Craiova). Based on system's determined mathematical model and transfer function, the author has also performed some studies concerning its stability and quality, studies realized using Matlab® Simulink simulations and some conclusions were expressed.*

Keywords: *APU, fuel, rotational speed, gas turbine, electrical power, generator, control.*

1. INTRODUCTION

From aircrafts point of view, an auxiliary power unit (APU) is a small gas turbine engine, which can provide a certain power (electrical power and/or compressed air power) to on-board consumers; it allows them an autonomous operation, without reliance on specific ground support equipment (such as electrical power units/batteries/generators, external air-conditioning units, or any other auxiliary ground equipment) [14].

APU's main goal is to provide power to almost all airplane's essential consumers while it is on the ground (on the runway or platform); in most of cases, APU cannot offer supplementary propulsion, but its generated power is used to: a) start the main propulsion engine(s); b) provide another form(s) of energy for several systems (pressurized air for environmental control system, or electrical power for on-board equipments, avionics, lighting system(s), or else). Additionally, an APU can provide during the flight backup and emergency power (such as supplementary power for deicing system) [3].

An APU may be used as a starter for aircraft's main engines, which needs to be accelerated to rotate at an extremely high speed and kept spinning, in order to assure sufficient air compression.

Depending on its destination, the APU is designed to be able to provide electric, hydraulic, or pneumatic power (even all three of them). The APU connection to a hydraulic pump allows a safe back-up operation of hydraulic equipment (such as the flight controls, aerodynamic brakes or flaps), even if an engine failure occurs. Other APUs are designed only for ground use (engine start, air conditioning), but if certified for use in flight, an APU is also useful for supplementary electrical power (if an engine driven generator fails), or as a source of bleed air for air conditioning.

The APU is normally left off in flight, but, when necessary, it may be turned on as an extra precaution, especially for transoceanic flights, severe conditions flights and/or the icing hazard is present.

APU's are positioned on different locations on the airplane (aircraft). Often them are mounted in the tail (in the rear fuselage, as Fig. 1 shows), or in the rear of engines' nacelles (for example on An-24 or Il-18), as well as in the landing gear bay. As a precaution, the APU is installed in the far aft tail-cone section; it realizes APU's safe isolation from other critical systems (in the unlikely event of a fire, or failure). Consequently, it is compulsory that APUs are installed behind secure firewalls (as aircraft main engines are) and they also need their own fire detection and extinguishing system [3,8].

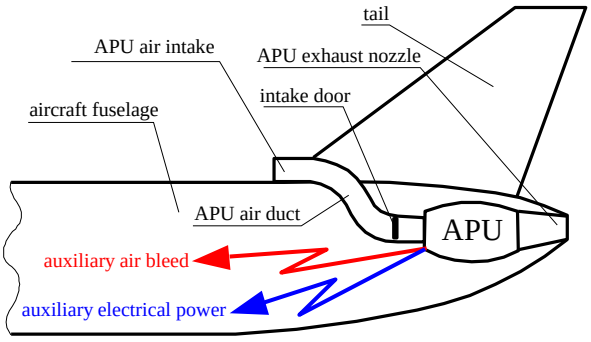

FIG. 1. APU's positioning on aircraft

2. DESCRIPTION OF APU'S ARCHITECTURE AND OPERATION[14]

The TG-16M APU, studied in [14] and [15], is a turboshaft-type (very similar to a turboprop engine, but, instead a propeller, it spins up a dedicated 28 V DC electrical generator). A planetary or a conventional gear is used to reduce the engine's turbine speed to an appropriate value for the generator. It operates as auxiliary electrical power source for an airplane (such as An-24T short-haul passenger airplane, or the old Il-18 medium-haul passenger airplane); it is positioned in the rear of starboard AI-24 engine's nacelle.

The studied APU consists of three main sections, depicted in Fig.2: a) the power main section (the turbo-engine, or the gas generator); b) the planetary or classical gearbox; c) the electrical DC generator. The power section consists of the gas generator portion of the engine and produces all the power for the entire APU (engine's compressor, reduction gear and electrical generator).

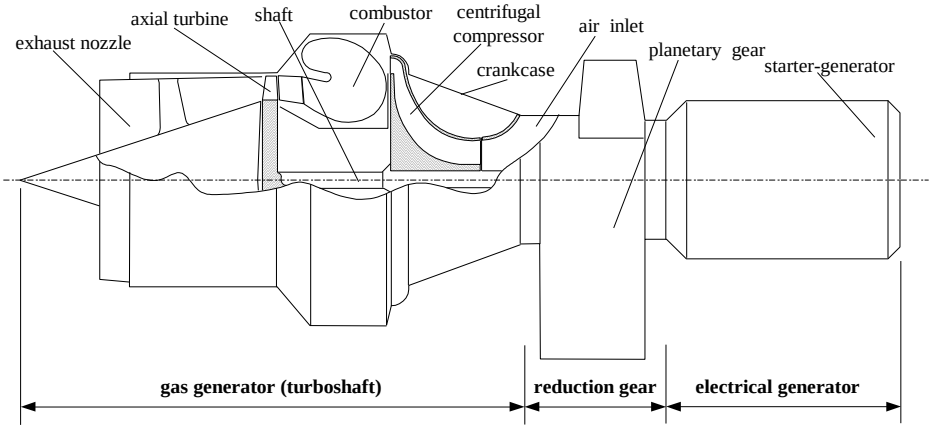

FIG. 2. Schematics of a TG-16M-type APU with its main parts

As Fig. 2 shows, APU's main shaft is driven by a single stage axial turbine, which is the only mechanical work producer. So, it spins up both engine's centrifugal compressor and the electrical generator (via the reduction gear). The engine (the gas generator) has a compact combustor (with inverted flow), where the injected fuel is intimately mixed with the compressed air (which s delivered by the compressor). Burning process transform them into hot gases, which are, firstly, expanded in the engine's turbine (producing mechanical work), then discharged through the exhaust nozzle. Turbine's mechanical work should cover the necessary work of several parts, such as the compressor, the reduction gear and the electrical generator ([4], [7], [8]).

3. EMBEDDED SYSTEM'S NON-LINEAR MOTION EQUATIONS

Non-linear mathematical model, as determined in [14], consists of APU-system main parts' non-linear equations. System main parts, as shown in Fig. 2, are: a) APU's main shaft'; b) rotational speed transducer; c) fuel pump and fuel control system. In Fig. 3 APU's fuel system's technical schematic is depicted.

Shaft motion equation involves a few torques ([1], [12]), as follows:

$$M_T - M_C - M_g - M_{fr} - M_{EG} = \frac{\pi J}{30}\frac{\mathrm{d}n}{\mathrm{d}t}, \tag{1}$$

where M_T is turbine's torque, M_C – compressor's, M_g – gear, M_{fr} – friction, M_{EG} – electrical generator torques, J is spool's axial moment of inertia and n – shaft rotational speed.

APU's fuel system motion equations are:

$$Q_i = Q_p - Q_C, \tag{2}$$

$$Q_C = \mu_d \frac{\pi d_1^2}{4}\sqrt{\frac{2}{\rho}}\sqrt{p_a - p_C}, \tag{3}$$

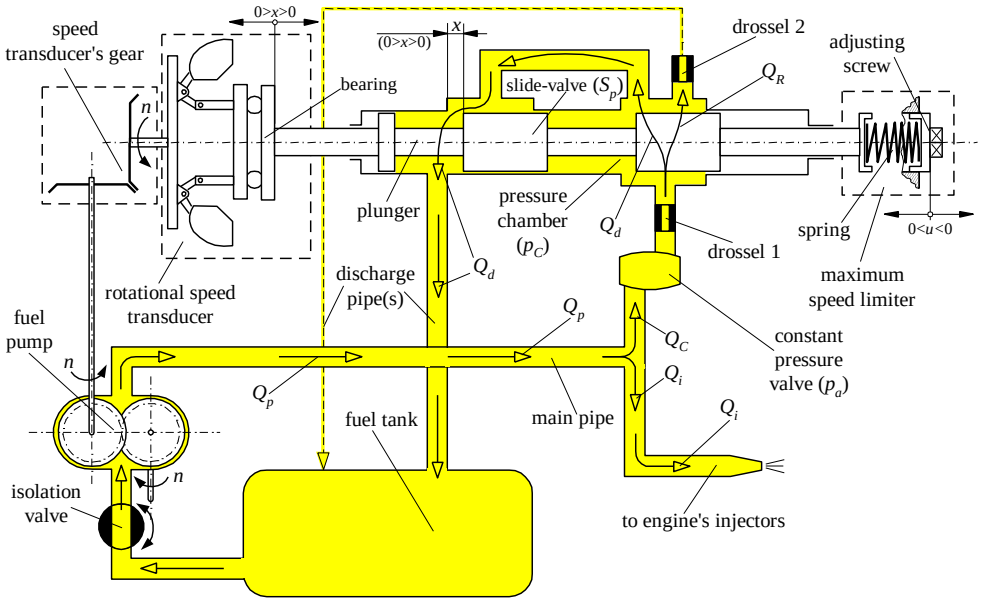

FIG. 3. APU's fuel system constructive and operational diagram

$$Q_R = \mu_d \frac{\pi d_2^2}{4} \sqrt{\frac{2}{\rho}} \sqrt{p_C - p_{dc}}\,, \tag{4}$$

$$Q_d = \mu b x \sqrt{\frac{2}{\rho}} \sqrt{p_C - p_{dc}}\,, \tag{5}$$

$$Q_C - Q_R - Q_d = S_p \frac{\mathrm{d}x}{\mathrm{d}t} + \beta_f V_C \frac{\mathrm{d}p_C}{\mathrm{d}t}, \tag{6}$$

where p_a is the fuel supplying pressure (assumed as constant), p_C – command pressure, p_{dc} – discharge pipes fuel pressure (negligible because its very low value), μ, μ_d – flow coefficients, β_f – fuel's compressibility coefficient (assumed as null), S_p – slide-valve plunger's surface area, b – slide-valve's discharge slot width, V_C – pressure chamber's volume, Q_i – injection fuel flow rate (which supplies engine's combustor and it is established as the difference between pump's flow rate Q_p and control flow rate Q_C, recycled and sent back to the fuel tank). In the slide valve's pressure chamber the control flow rate is split into two streams: Q_R – through the second drossel and Q_d – through the variable slot of plunger's slide valve and further through the discharge pipe back into the fuel tank. Consequently, discharged flow rate Q_d depends on the plunger's displacement *x*, which results from engine's effective speed *n* and from preset speed value n_p (given by the adjusting screw's displacement *u*).

4. EMBEDDED SYSTEM'S MATHEMATICAL MODEL AND TRANSFER FUNCTION

Assuming the small perturbation hypothesis, one has used the finite difference method ([12], [13]) in order to bring non–linear equations to a linear form. Thus, any variable or parameter X should be formally considered as $X = X_0 + \Delta X$ (where X_0 is X parameter's steady state value, ΔX – parameter's deviation, while $\overline{X} = \frac{\Delta X}{X_0}$ the non-dimensional deviation). Using some appropriate chosen amplifying terms, linearised equations can be transformed into non-dimensional forms; after applying the Laplace transformation, one obtains system's linear non-dimensional mathematical model, as follows:

$$(\tau_m \mathrm{s} + 1)\overline{n} = k_f \overline{Q}_i - k_{cg} \overline{I}_{cg}, \tag{7}$$

$$\overline{Q}_i = \overline{Q}_p - \overline{Q}_C, \tag{8}$$

$$\overline{Q}_C = -k_{QC} \overline{p}_C, \tag{9}$$

$$(\tau_x s+1)\bar{x}=\frac{1}{k_{xC}}\bar{p}_C\,, \tag{10}$$

where $k_{mR}=\left(\frac{\partial M_C}{\partial n}\right)_0+\left(\frac{\partial M_{EG}}{\partial n}\right)_0-\left(\frac{\partial M_T}{\partial n}\right)_0$, $\tau_m=\frac{\pi J}{30k_{mR}}$, $k_f=\frac{1}{k_{mR}}\frac{Q_{i0}}{n_0}\left(\frac{\partial M_T}{\partial Q_i}\right)_0$, $\tau_x=\frac{S_p}{k_{dx}}$, $k_{cg}=\frac{1}{k_{mR}}\frac{Q_{i0}}{I_{cg0}}\left(\frac{\partial M_{EG}}{\partial I_{cg}}\right)_0$; $k_{QC}=k_{CC}\frac{Q_{C0}}{p_{C0}}$, $k_{xC}=\frac{x_0}{(k_{CC}-k_{RC}-k_{dC})p_{C0}}$.

One has to consider also fuel pump's and transducer's equations (keeping their own annotations, given by [12]):

$$\bar{Q}_p=k_{pn}\bar{n}\,, \tag{11}$$

$$\bar{x}=k_{es}\bar{n}-k_u\bar{u}\,. \tag{12}$$

As far as adjustments of maximum speed are made during ground tests, the term(s) containing $\bar{u}$ can be excluded. Using above determined Eqs. (7) to (12), system's block diagram with transfer functions was built, as depicted in Fig. 4.

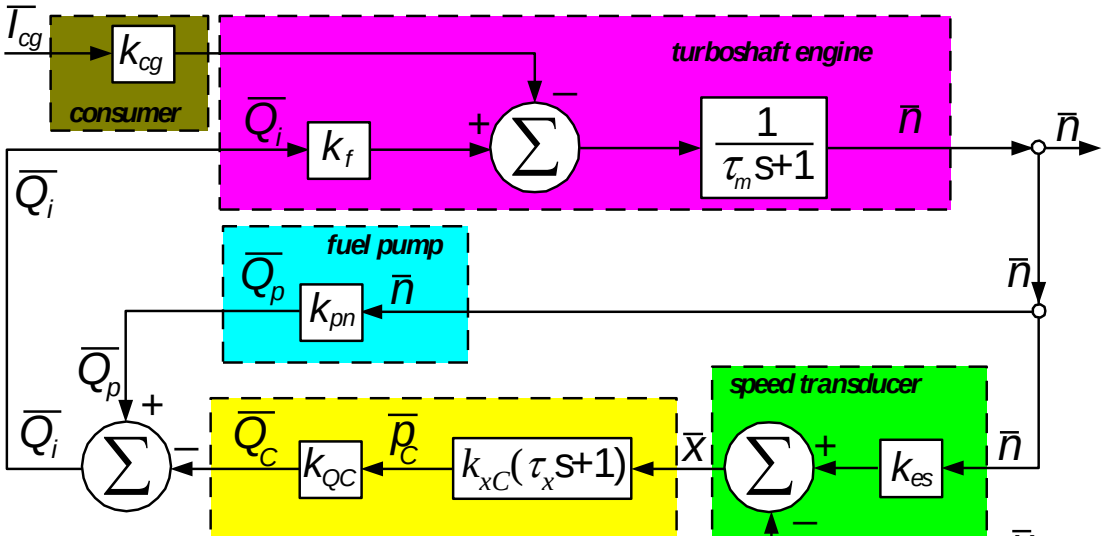

FIG. 4. APU system's block diagram with transfer functions

Furthermore, from Eqs. (7) to (12), a much simpler single equation may be obtained, equation which expresses the dependence $\bar{n}=f(\bar{I}_{cg})$ and will give the expression for system's transfer function, as follows:

$$\left[(\tau_m-a\tau_x)s+1-k_f k_{pn}+a\right]\cdot\bar{n}=-k_{cg}\bar{I}_{cg}\,, \tag{13}$$

equivalent to

$$\bar{n}=-\frac{k_{cg}}{(\tau_m-a\tau_x)s+1-k_f k_{pn}+a}\bar{I}_{cg}\,, \tag{14}$$

where the term a has the expression $a = k_{QC}k_{xC}k_{es}$. Thus, system's transfer function expression becomes

$$H_n(s) = -\frac{k_{cg}}{(\tau_m - a\tau_x)s + 1 - k_f k_{pn} + a}. \tag{15}$$

When mounted on the ground test facility (see Fig. 5), APU's fuel system operates a little different, because of the secondary discharge pipe cancellation; obviously, the mathematical model form modifies (as presented in [15]). The most important consequence is that the fuel flow rate Q_R, given by Eq. (4), becomes null, so Eq. (6) has a new form, as follows:

$$Q_C - Q_d = S_p \frac{dx}{dt} + \beta_f V_C \frac{dp_C}{dt}. \tag{16}$$

Furthermore, k_{RC} – coefficient becomes also null, which implies both k_{xC} and a coefficients values modifying:

$$k'_{xC} = \frac{x_0}{(k_{CC} - k_{dC})p_{C0}};\ a' = k_{QC}k'_{xC}k_{es}. \tag{17}$$

As presented in [15], system's time constant $(\tau_m - a'\tau_x)$ is also affected, becoming smaller; meanwhile, the term $1 - k_f k_{pn} + a'$ becomes bigger, but system transfer function keeps the same form:

$$H_n(s) = -\frac{k_{cg}}{(\tau_m - a'\tau_x)s + 1 - k_f k_{pn} + a'}. \tag{18}$$

5. STUDIES CONCERNING SYSTEM'S STABILITY AND QUALITY

In both of above-presented situations (see Eqs. (15) or (18)) system's transfer function is a first order one. In order to assure system's stability, it is compulsory that its characteristic polynomial coefficients should have the same sign. Consequently, system's stability condition shall be expressed as:

$$(\tau_m - a\tau_x)(1 - k_f k_{pn} + a) > 0. \tag{19}$$

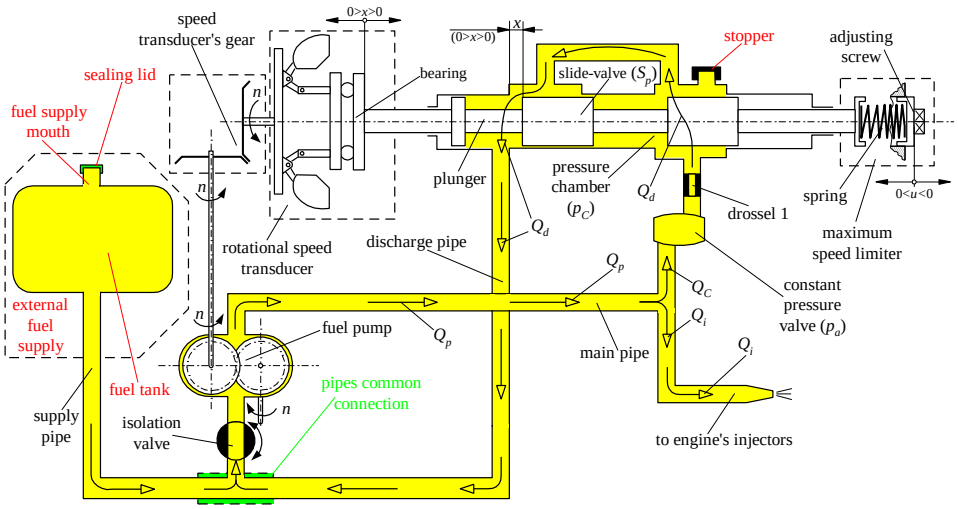

FIG. 5. APU mounted on test facility (fuel system with external supply and different discharges)

Because of its definition formula(s), the term a is strictly positive. Meanwhile, from [11] and [12] it results that the term $1-k_f k_{pn}$ must be strictly positive, in order to assure the stability of the engine-fuel pump connection. Consequently, from Eq. (19) it remains that only the first term $\tau_m - a\tau_x$ has to be discussed, so $\tau_m - a\tau_x > 0$, which gives (considering formulas for a and τ_m):

$$S_p < \frac{k_{dx}}{k_{QC}k_{xC}k_{es}}\tau_m . \tag{20}$$

If $1-k_f k_{pn} < 0$, the engine-fuel pump connection becomes unstable, which means that, in order to keep the same condition (20), a supplementary condition is required. Consequently, for $1-k_f k_{pn} + a > 0$, this supplementary condition has the form:

$$a > \left|1-k_f k_{pn}\right|, \tag{21}$$

otherwise the term $\tau_m - a\tau_x$ should become negative, and the (20)-condition becomes

$$S_p > \frac{k_{dx}}{k_{QC}k_{xC}k_{es}}\tau_m . \tag{22}$$

System's co-efficient $\tau_u = \frac{\tau_m - a\tau_x}{k_{cg}}$ (APU's time constant) and $\rho_u = \frac{1-k_f k_{pn} + a}{k_{cg}}$ (APU's stability co-efficient) were experimentally determined using the test facility for ground operation $(H=0, V=0)$ and analytically estimated for other flight regimes $(H\neq 0, V\neq 0)$, having as sources mathematical expressions of the involved coefficients $(k_f, k_{pn}, k_{cg}, ...)$ and their variations with respect to the flight regime (as presented in [12], [13] and [10]).

The obtained results are graphically presented in Fig. 6, for a range of 10000 m of altitude and 600 km/h of speed; one can observe that τ_u is always positive, but grows for more intense flight regimes; it means that the engine becomes slower in action, its responses at acceleration and/or decelerations becoming longer. The stability coefficient ρ_u has a different behavior, decreasing for more intense flight regimes; it becomes negative at high altitudes and flight speeds (altitudes bigger than 8000 m and speeds bigger than 520 km/h), which leads to an unstable APU behavior.

System's quality was studied for two situations: a) idling engine (without generator's load); b) step input of the electrical load $\bar{I}_{cg}$. Results (step responses of the main output – the engine's speed n, as well as of a secondary output – injection fuel flow rate Q_i) are presented in Fig. 7 and were calculated using Matlab-Simulink simulations, based on system's block diagram with transfer functions (depicted in Fig. 4) and on graph-analytical determined coefficient values (depicted in Fig 6).

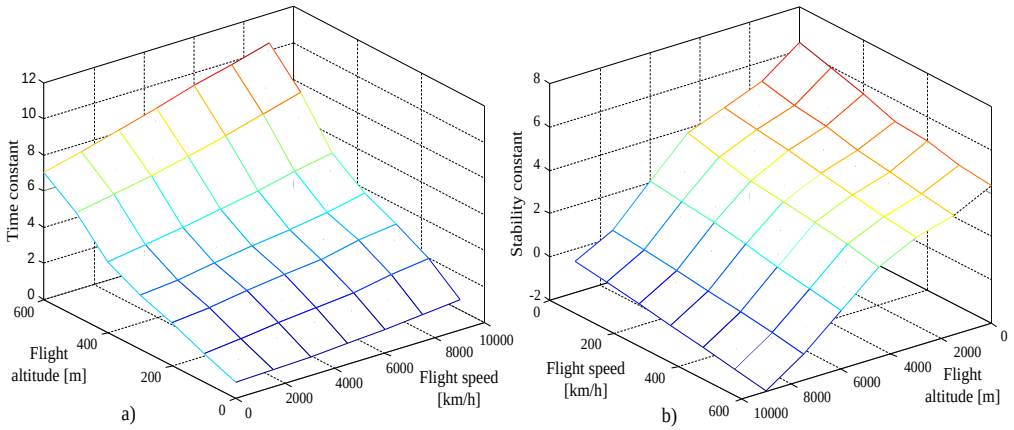

FIG. 6. System's co-efficient values with respect to the flight regime (altitude *H* and flight speed *V*)

Engine speed parameter's behavior is presented in Fig. 7.a), for different flight regimes for both situations: with continuous line – for idling engine, while with dash-dot line for the embedded system. Engine's behavior proves an aperiodic stabile system, with growing static error and stabilization time, the more intense the flight regime is. For the idling engine static errors are positive, while for the embedded engine+generator system static errors are negative and 2…3 times bigger as absolute values. At high altitudes (over 5000 m) the static error, as well as the stabilization time, become prohibitive (because they grow much over the acceptable values), while over 8000 m the system becomes unstable and needs to be assisted by another type of controller.

Figure 7.b) shows the secondary output parameter (fuel flow rate $\overline{Q}_i$) step response, for both above-mentioned situations. Same observations can be made, concerning the aperiodic stability, excepting the fact that static errors for the idling engine is a negative one too.

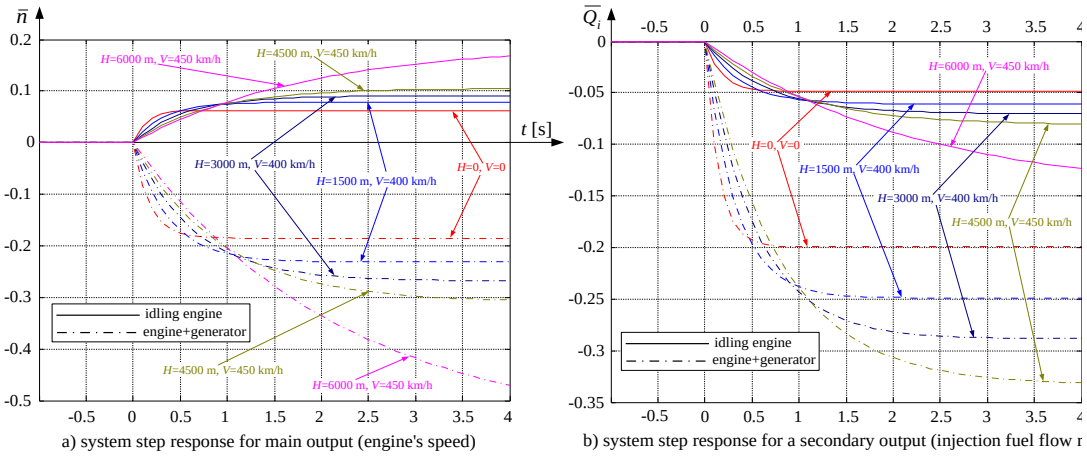

FIG. 7. System's quality: speed and injection fuel flow rate parameters' step response for APU's ground test configuration comparing to APU's airplane configuration

CONCLUSIONS

The paper has studied an APU system as controlled object and has determined his simplified mathematical model, useful for studies. The APU consists of a single shaft turbo-engine, which spins up a dedicated DC electrical generator through a reduction gear. From its non-linear motion equations, using the finite difference method and the Laplace transformation, one has determined the linear non-dimensional mathematical model, as well as its transfer function model, as well as its transfer function.

It has result a first order system (see Eqs. (15) and (18)), its transfer function having a first-degree characteristic polynomial. Consequently, its stability studies were significantly simplified; a simple condition for the stability was obtained, giving information about how to choose the plunger's slide valve frontal surface area S_p with respect to the gas turbine engine time constant τ_m and to the gas turbine engine's fuel system geometry (effective diameters), as well as to flow rate coefficients values.

System's quality studies results, presented in Fig. 7, show stabile aperiodic behavior for both the idling engine and the embedded system engine+generator. However, the system is affected of static errors (positive for idling engine, negative otherwise), especially when the generator supplies external consumers, the bigger the consumers' electrical power are. The system becomes unstable for high altitudes and speeds, so it can be used as it is only for low speed turboprop airplanes, or, with some other fuel/speed controller and/or settings, for high altitude and speed airplanes (such as medium- or long-haul passenger airplanes with turbofan engines).

This study was realized for experimental ground test operation and analytically estimated for several flight regimes (flight speeds and altitudes), but it may be extended for other APUs, using same method and approach.

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VISUAL LITERATURE. AVANT-GARDE AND EXPERIMENT

Review of the volume *Literatura vizuală. Avangardă și experiment* by Daniela Nagy, Cluj-Napoca, Casa Cărții de Știință Printing House, 2017

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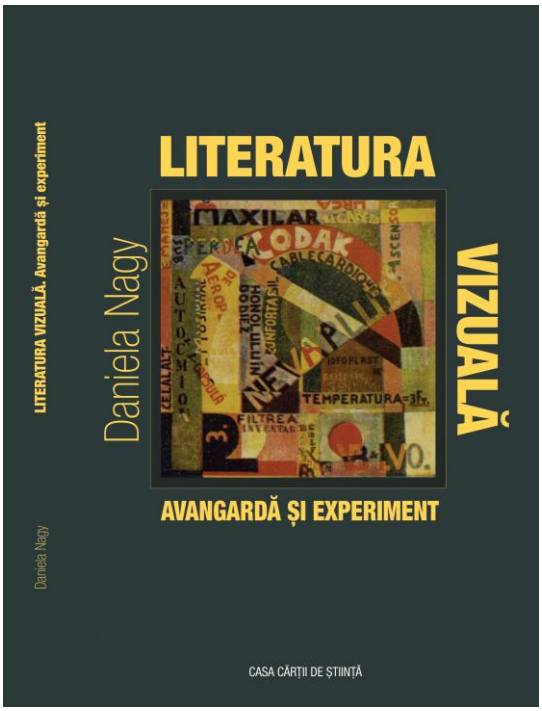

FIG.1 Daniela Nagy, Literatura vizuală. Avangardă și experiment. Front cover.

Visual Literature. Avant-garde and Experiment, by Daniela Nagy is a daring work of literary criticism that approaches a topic long avoided by the Romanian critics. Whereas the latter part of the twentieth century was being marked by the appearance of some important schools of visual literature overseas, in the United States of America, and especially in Latin America: Brazil, Argentina, Uruguay, Europe was gradually abandoning its appetency for the verbal-icon assembly that had emerged at the same pace with the literary avant-gardes. Contaminated by the challenges of multiple-combination possibilities between the very graphical sign and the visual context of its occurrence, the Romanian literary avant-gardes explore the extra-verbal elocution, employing, in the image-text interaction, trans-semiotic and meta-semiotic sign systems which they assume and hire iconic and verbal elements in interaction.

Regrettably, the classical image of Victor Brauner and Ilarie Voronca's pictopoem has become an icon of the Romanian literary avant-garde, in the absence of a reliable exploitation of the semiotic valences of this hybrid work.

Daniela Nagy, nevertheless, fosters, throughout her book, a complex, dynamic and trans-disciplinary approach in which the text is not perceived as a final unique and immutable product, but in agreement with the challenge of Umberto Eco's unlimited semiosis (*semiosi illimitata*):

> (…) the quasi-infinite possibility of the verbal-iconic sign to define and interpret itself through other signs, thus offering the chance of understanding the text functionality as an auto-generative, autopoietic structure. The approach is complex from a double perspective:
> - on the one side, due to the (a) postmodern and (b) post-postmodern (trans-modern) focus, consisting of (a) multiple, fragmentary lecture, without any claim of exhaustiveness or imposition of perspective and of (b) holistic, functionalist intention of unifying perspectives in order to describe the auto-generative verbal-iconic textual structure;
> - on the other side, due to the dynamic approach to literary semiotics, whose study subject is the semiosic act, dynamic in itself and permanently enriched by the semiotic act that intervenes over the semiosic structure. (p.6)

The analysis from the perspective of the text's autopoiesis (verbal-iconic, in this case) is quite atypical for the Romanian literary criticism. Apart from Ion Manolescu, interested in the auto-productive structure of image (in *Videologia*: *o teorie tehno-culturală a imaginii globale*, published in 2003), the literary criticism preferred to focus on the study of divisions and alterations produced by the literary avant-gardes and to preserve multi-art experiments of some classics (Ion Barbu, Nichita Stănescu) outside the mainstream, while considering them pastimes unworthy of their authors.

Daniela Nagy's book stands out as a remarkable synthesis of verbal-iconic movements and trends in the Romanian literature of the past century, and mainly as a reliable theoretical synthesis and a singular interpretation (also holding a corrective role) of some confusions created in the field of literary avant-gardes' interpretation by the Romanian criticism. The confusions were generated by the superposition of Angelo Guglielmi's taxonomy (that entered specialized literature in Romania due to Marin Mincu), which distinguishes between avant-garde/ avant-gardism and experimentalism, over Peter Bürger's classical taxonomy, which identifies a stage of historical avant-garde and a post-avant-garde. Daniela Nagy discovers that the two classifications rely on the same ideology, evident, in case of the (historical) avant-garde, and almost inexistent, in case of post-avant-garde or experimentalism. Therefore, the author proposes the understanding and surpassing of Mincu's confusion, the critic who attached the ideological touch of Guglielmi's *–ism* (in reference to, in the host-literature, experimental literary groups of the 1960s, *Grupo 63* or *Novissimi*) to some singular creators, such as Emil Brumaru or Șerban Foarță. Moreover, the author fosters an interpretative scheme, defining individual experiment, experimentalism or neo-avant-garde and historical avant-garde in relation with two axes: individual/collective, respectively, constructivist/destructivist ideological support. Her viewpoint is not singular in the Romanian literary criticism, yet, some remark on behalf of Laurențiu Ulici, in an article of 1987, 'Text as an experiment' (in Romanian, *Textul ca experiment*), published by *Contemporanul* magazine, which could have brought to a halt Mincu's erroneous interpretations, was disregarded: "To 'post-avant-gardism', the literary critic [author's note: Marin Mincu] takes over the term 'experimentalism' from the Italian criticism, a term that has been in circulation before, in our literary criticism of the '60s, in connection with the echoes of the 'new novel' in fiction and structuralism, in literary analysis".

Accordingly, Daniela Nagy does not only propose a chronological analysis of more or less active forms of the Romanian visual literature, but also takes a critical attitude toward a theoretical apparatus that is slightly altered because of the need of promoting an interpretative uniqueness.

Thus, analysis of the Romanian literary avant-garde's place within the similar European movement, the survey of the Romanian waves of historical avant-garde, identification of dominant avant-garde movement in the Romanian cultural space: constructivist-integralist from *Contimporanul* magazine and its satellite magazines, *75 H.P.*, *Punct* and *Integral* (including futurist and Dadaist echoes of the integralist melting-pot) and surrealist (from *unu*, *Urmuz* and from magazines of the minor mimetism) are but simple steps of a methodical, original and steady enterprise. The most articulate example of complex understanding of manifesting peculiarities of the national avant-gardism is the one related to the strange synthesis of the avant-garde and tradition with Voronca, which implied a four decade-anticipation of what was to become the dissolution of the historical avant-garde into post-avant-gardism:

> This is the expression of maximum closeness of the avant-garde art to a tradition holding an amazing potential of manifestation, renewing, cyclically, a form of preceding. Moreover, *Integral* becomes a form of capitalizing of the aesthetically unindoctrinated culture, manifested in its pure form, consonant with the art practiced by Brâncuși, opposing the degenerative borrowings, respectively a tradition of the cult creation that slipped away into imitation and mannerism. Through this positioning, integralism stands against Dadaism, a movement that begins demolition at the deep layers of culture. Within the Romanian culture, integralism becomes reference for the whole literary avant-garde, characterizing it and placing itself, beyond this, in the 'avant-garde' of the European experimentalism. (p.56)

Each of the avant-garde movements (the author prefers the phrase 'waves of the avant-garde') that occurred in Romania, but also each of the forms of experimental expression, benefit from analyses that prove a superior understanding of the phenomenon. The research is rigorously projected and is set around the main objective, "*the rigorous analysis of the natural continuity in the verbal-iconic assembly present in the Romanian literature"*, through a multi-disciplinary approach, focused on the perspectives of semiotics and literary theory and analysis" (p.77). The semiotic interpretation of the verbal –iconic creations of the Romanian literature included works belonging to Urmuz, Tristan Tzara, Ion Vinea, Ilarie Voronca, Mihail Cosma, Geo Bogza, Saşa Pană, Gelu Naum, Virgil Teodorescu, Isisore Isou a.o. (in parallel with the avant-gardist literature of the manifestos), literary experiments of Ion Barbu, Nichita Stănescu, Şerban Foarţă, of the authors belonging to the 1980s - Mircea Cărtărescu, Romulus Bucur, Daniel Pişcu, Florin Iaru, Traian T. Coşovei a.o., paradoxist poems, visual literature of *Aisberg* mural magazine and that of *Infinitezimal* magazine, as well as other multiart occurrences of recent time. The literary analysis, perceived in its dynamics, in the autopoietic intention declared from the very beginning, is a fine mapping of the verbal-iconic occurrences in the Romanian literature.

It underlines the "undermining of literature by the letter", specific to the visual poetry of the avant-garde, the liberation of speech from convention and marriage of the text to the iconic assembly (through the appearance of pictopoem), derails toward "typography" and calligrammes, the experimental valences of the Barbian poetry, to which speech becomes insufficient to itself, sliding toward the geometry of rhythm, toward symbolic geometrism, the semiotic incapacity of the Stanescian word, reverberations of a concretism unknown to the Romanian cultural space, expressed with a certain postponement, verbal-iconic manifestations of the 1980s: typographic poems, calligrammes and anti-calligrammes, as well as visual experiments of the past two decades. The result is an excellent work, unique in what regards the approach (until now!) within the national literary criticism, through which the author, Daniela Nagy, claims the very "necessity of a solid critical engagement in the area of Romanian visual literature".

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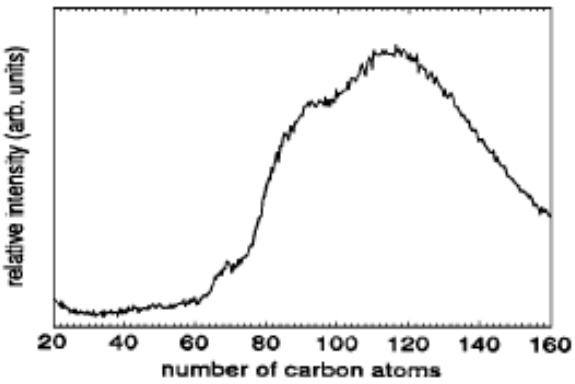

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