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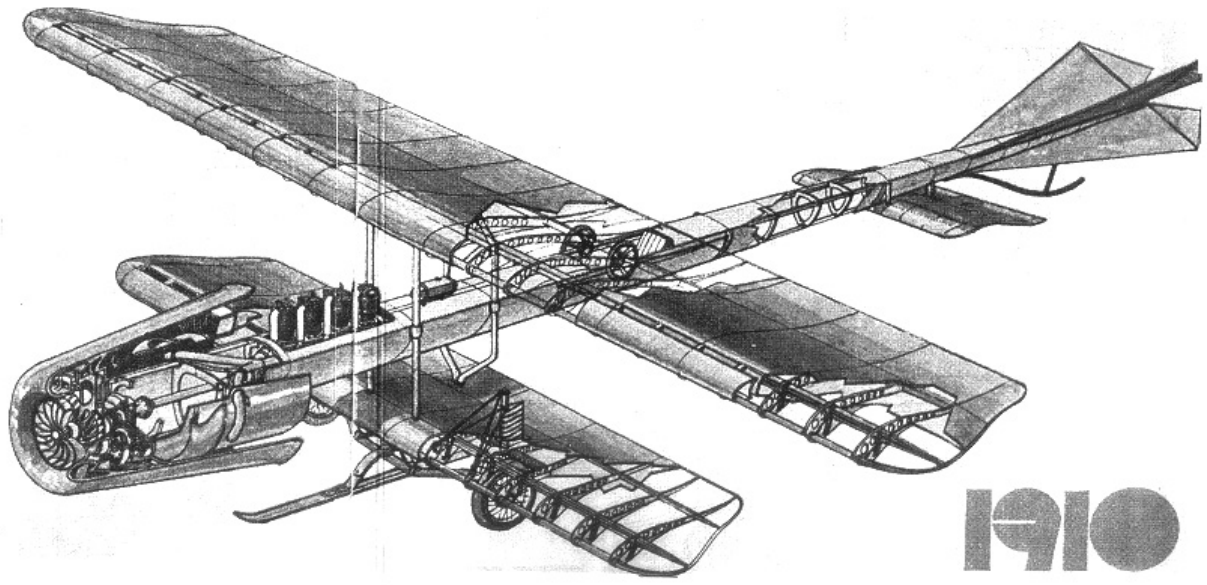

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C O N T E N T S

THE WAR FOR THE SOUL OF THE NATION

Grzegorz ROSŁAN
Air Force Academy of Dęblin, Poland
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Abstract: *The rebirth of Russian statehood constitutes both an interesting and a difficult topic for consideration. Currently Russia is going through another groundbreaking moment in its troubled history, the moment which coincides with radical changes in international relations, the reevaluation of threats and possible causes of their origin, as well as with the process of shaping a new statehood. After the collapse of the Soviet giant in 1991, Russia faced the necessity to answer a number of fundamental questions, which were, inter alia, concerned with its future as a country and the world power, the prospects for its social and economic development, and finally, its attitude towards former allies from Eastern and Central Europe. For the Russian Federation the way to achieve the goals which have been referred to above and to strengthen idiosyncratic supremacy in the world, inherited from the Soviet Union, consisted not only in the policy adopted by the state but also in determined action. The conflict over Crimea and Eastern Ukraine shows that when it comes to Russia the West possesses no suitable instrument of pressure; Lack of any coherent policy towards Russia on both the U.S.' and EU' part, resulted in the occupation of Crimea.*
Keywords: *Russian Federation, the conflict over Crimea, the soul of the nation*

1. INTRODUCTION

The Soviet Union, accompanied by its allies, won *the hot war*, fought in years 1941–1945, but lost the *cold war*, which started in 1947[1] and lasted, varying in its intensity, until the collapse of the Soviet empire. The debris of the Soviet Union led the foundations for numerous independent countries, the largest of which was the Russian Federation, which took the function of the former USSR's successor.

The rebirth of Russian statehood constitutes both an interesting and a difficult topic for consideration. Currently Russia[2] is going through another groundbreaking moment in its troubled history, the moment which coincides with radical changes in international relations, the reevaluation of threats and possible causes of their origin, as well as with the process of shaping a new statehood.

After the collapse of the Soviet giant in 1991, Russia faced the necessity to answer a number of fundamental questions, which were, inter alia, concerned with its future as a country and the world power, the prospects for its social and economic development, and finally, its attitude towards former allies from Eastern and Central Europe[3]. In the first decade of the young country's functioning, Russia had to struggle with its difficult heritage in order to be able to make up for the time it had lost and to catch up with other countries in terms of development.

It is in this period that the *Declaration of State Sovereignty of the Russian Federation* of 12th June 1990 and *Constitution of the Russian Federation* of 12th December 1993 were adopted. Those were the documents which, in the course of the process of building its own identity, defined national goals, interests and priorities in both domestic and foreign policy.

For the Russian Federation the way to achieve the goals which have been referred to above and to strengthen idiosyncratic supremacy in the world, inherited from the Soviet Union, consisted not only in the policy adopted by the state but also in determined action[4].

1 B. Potyrała, H. Szczegóła, *Russian Army after the USSR's collapse* (*Armia rosyjska po upadku ZSRR) (1992 – 2000),* Higher School of Pedagogy, Zielona Góra 2000, p. 4.

2 Nowadays the term 'Russia' is often used as the correlate of term 'The Russian Federation', whereas in the USSR's time this name was only used in its historical sense, since officially only the Soviet Union existed.

3 Comp. *Studies on Russia (Szkice o Rosji)*, eds: A. Stępień-Kuczyńska, J. Adamowski, Łódź-Warsaw 2000.

4 P. Wieczorek, *The United States towards the changes in Russia's military potential,* in: *Eastern Politics*

The component that played a special role in this process was Russian military potential, particularly, the nuclear one, whose main goal was to, broadly speaking, deters a potential opponent[5].

In this period, having regard to the goal mentioned above, the Russian Federation wished to gain exclusive access to nuclear power created by the former USSR, which was reflected, for example, in Budapest Memorandum[6]. Moscow achieved this aim[7] and currently Russian nuclear arsenal, apart from fulfilling its basic role that is to guarantee the safety of the country, also plays a particularly significant role in the Russian Federation's global and vital interests. The man that was the face behind these changes was Boris Yeltsin, the first president in the country's history.

At that time Russia resigned from the rhetoric of confrontation while interacting with other powers. It considered itself the part of the West, as a result, contributing to the abolition of divisions created during the cold war. Unfortunately, the process of shaping a new identity, by following the example of the western countries, overwhelmed the Russian society. The lack of positive outcomes resulted in Russia's turning its back on the system's patterns followed in the West and as a consequence, led to Boris Yeltsin's crew resignation. In the period of Yeltsin's presidency Russia also used its weakened war machinery to defend the citizens of the former Soviet Union. Such a situation took place in Trans-Dniester, South Ossetia and Abkhazia in Nagorno-Karabakh. Furthermore, it intervened by supplying heavy tank equipment for Armenia, which does not border with the Russian Federation.

The groundbreaking moment in the history of the Russian Federation occurred when, in December 1990, Boris Nikolayevich Yeltsin who was stepping down, pointed his successor – Vladimir Vladimirovich Putin.

How come that Putin succeeded where others had failed, becoming in 2000 the President of the Russian Federation? From the perspective of time one can see that it was a thoroughly prepared propaganda operation, planned in the tiniest details and conducted with surgical precision[8]. It was the final tool of the internal battle for power, which for years had been fought by Russia's political elites.

When Yeltsin started the First Chechen War, he had two goals: to put an end to political destabilization in the region and to guarantee his reelection. The latter goal was about taking over the entire power. The winner took it all.

Yeltsin lost the first war, mainly in the media. Consequently, he had to step down. The second war, just like a number of other endeavors which were connected with it, became the beginning of Putin's visible activity. The war was planned in the last months of Yeltsin's presidency[9] and it became the gateway for the new authorities to take over, and until this day Vladimir Vladimirovich Putin continues to be their leader. It is worth mentioning that Vladimir Putin gained power thanks to the fact that during his first election campaign he referred to popular patriotic slogans and promised the Russians that he *would kill terrorists*. It happened during the second war in Chechnya[10].

The second Chechen war was even more brutal and cruel than the first one. On the Russian side one could clearly sense the need for revenge. The need to punish the Chechens for humiliating Russians.

It was the first military confrontation of *Putin's crew.* It was also the first example of using the Russian propaganda machine in the form of the central media to the benefit of new Putin's crew. It aimed at shaping the public opinion to be favorable for the authorities. This machine, in its perfected form, continues to function until this day. That war also turned out to be Putin's first *war for the souls of the nations* – Vladimir Vladimirovich Putin's first victory. He was the actual winner.

5 H. Malon, *Post-Soviet nuclear weapon*, Warsaw1995.

6 Budapest Memorandum on Safety Warrants – an international agreement without the status of treaty signed in December 1994 in Budapest, by the power of which the US, Russia and Great Britain obliged themselves to respect Ukraine's sovereignty and territorial integrity and to withhold any threats of using force against its independence and territorial integrity, and Ukraine was obliged to pass strategic nuclear weapon on to Russia and join the Nuclear Non-Proliferation Treaty.

7 Comp: H. Malon, *Post-Soviet Nuclear Weapon*, Warsaw: 1995.

8 M. H. van Herpen, *Putin's Wars. Chechnya, Georgia, Ukraine 2014*, Pruszyński i S-ka, Warsaw: 2014.

9 On Friday, 31st Dec. 1999, B. Yeltsin waived the function of The Russian Federation's President. Acting President, until the announcement of the election, was Vladimir Władimirovich Putin.

10 The second Chechen War – a military conflict fought from 11th Oct.1999 until 16th April 2009 between the Russian Federation and Chechen separatists.

One should point out the fact that the second Chechen war broke out on 22nd September 1999 and the pretext for starting it was terrorist attacks in residential buildings in Buynasksk, Moscow and Volgodonsk.

Approximately 300 people were killed in these bombings. It is worth mentioning that at that time Federal Security Service (FSB[11]), which is Russian secret service, was led by a promising officer, V. Putin[12].

2. MAIN PART

In the book entitled *Blowing up Russia: Terror from within*[13] written by Alexander Litvinienko and Yuri Felshtinsky its authors prove that terrorist attacks were conducted by FSB officers and constituted *casus belli*[14], which was supposed to justify a military pacification in Chechnya.

It is FSB agents who reputedly set bombs under residential buildings to provoke the outbreak of the second Chechen war, since the first one was lost by the Russians.

Putin's next war for *the souls of the nations* was the conflict around South Ossetia, the conflict which started at the time of USSR's collapse. As early as November 1989 first clear tensions between Georgians and Ossetians occurred. After a bloody, but short, war which broke out at the beginning of the nineties, Ossetians and Georgians signed a truce which froze the conflict for a few years.

Throughout the nineties both sides were reluctant to change the situation in the region. Georgians, due to lack of power and actual economic and political dependency on Moscow, did not dare pacify the separatists, whereas the insurgents from Tskhinvali were satisfied with their *quasi* state status.

The situation was not the same when the authorities changed and when Georgia made an effort to integrate with the West[15]. Today at our disposal we have knowledge from which it results that this conflict was not provoked in a day, but it was preceded by many months of skillfully masked actions, from which the following ones should be referred to:

- cybernetic attacks conducted from Russian servers targeting servers which supported the websites of the Georgian government,
- military maneuvers: *Caucasus 2008*, which started the day before the conflict at the Georgian border,
- presence of the journalists from the leading Russian media in the area where the conflict originated,
- presence of regular Russian troops in the area in question.

The catalyst for the Georgian-Russian conflict in 2008 was the referendum held in January, in which over 60% of the Georgian society supported the accession to NATO structures. After military action had started, Russian propaganda machine was launched and the local inhabitants were affected by Russians' ruthlessness, perfidy and cruelty.

Russian actions, both propaganda and military ones, resulted in the support of the experts favorable to Kremlin.

They were mainly the participants of the Valdai International Discussion Club[16], which is often referred to as the club of *Putin's worshippers*.

On the 21st November 2011, Dmitry Medvedev, who was the President of the Russian Federation at that time, made a speech, during his visit to Vladikavkaz, in which Moscow's official standpoint from 2008 – which was concerned with a humanitarian intervention aiming at the protection of South Ossetia's population – was replaced by the need to hinder Tbilisi's ambitions of entering NATO.

11 FSB, the Federal Security Service of the Russian Federation (Russian: Федеральная служба безопасности Российской Федерации, ФСБ) – since 1995 Russia's special service. It is the direct successor of KGB (mainly II, III and V Boards). After Putin gained power, its competences have been significantly expanded.

12 25th July 1999 V. Putin became the Director of FSB.

13 Comp.: A. Litvinienko, Y. Felshtinsky, *Blowing up Russia*, Rebis, Poznań 2007.

14 Lat. *casus* – case, occurrence; *cadere* - occur; *belli* – Genitive of *bellum* – war – the reason or pretext for the declaration of war.

15 A. Micek, Georgian-Russian War of 2008 (*Wojna gruzińsko-rosyjska z 2008 r),* [at:] /home/windmaker/domains/militis.pl/public_html/ plugins/content/ sexybookmarks.php, [access 7.07.2014].

16 Valdai International Discussion Club – the annual meeting of renowned experts who specialize in Russia's domestic and foreign policy. The Club was established in September 2004 by *RIA Nowosti*, The Council on Russia's Foreign and Defence Policy, *The Moscow Times* and journals *Russia in global politics and Russia Profile*.

It was the second victorious war *for the souls of the nations*. At this point it is worth mentioning that as early as in August 2007, Russia committed cybernetic attacks whose aim was to block the websites of several Estonian banks. It was the first time when a mass cyber-attack against an independent country occurred.

Russian politicians, gathered around Putin, meticulously took advantage of the situation by repeating the old pattern which had worked out before and with which not only Poles but also Lithuanians, Latvians, Estonians or Finns were familiar.

In 1939 Moscow reduced its aggression to *granting internationalist assistance* to fellow Ukrainian and Belarusians. The part of the public opinion in the West bought these both in 1939 and now. How come? The reason is that they did not know much about this part of the world. Poland and other countries located between Germany and Russia knew it all too well.

Humanitarian intervention aiming to protect the interests of the inhabitants.. is a scenario which has been present in the history of the USSR. In 1939, the year which has already been mentioned, W. Churchill referred to the Soviet Union as *the puzzle inside a riddle wrapped in an enigma*[17].

It is also worth mentioning that in 2007, as if anticipating the conflict with Georgia, President Vladimir Putin signed the special decree to suspend the execution of *Treaty on Conventional Armed Forces in Europe.* This very decision was made due to *exceptional circumstances violating the safety of Russian Federation and requiring immediate steps* – this was Kremlin's official statement. One may assume that already at that point *Putin's crew* predicted military actions in Crimea.

The five-day war with Georgia in August 2008 became the real catalyst for the reform of Russian armed forces. It may have ended with the indisputable victory of the Russian Federation, but it showed that its Armed Forces had significant difficulties in conducting military actions. Russian troops suffered losses which were disproportionate in relation to the opponent's military potential. The commanding system proved to be inefficient.

What also turned out to be a very serious problem was Russian army's poor mobility.

Moreover, the transport air forces had too few planes to secure the redeployment of the land troops and basically, it was used only for the movement of subdivisions of airborne troops[18].

The analysis of the course of the conflict shocked both political and military authorities in Russia.

The decision was taken to conduct immediate and radical reforms of Russian Federation Armed Forces, which basically embraced all the aspects of their functioning. The Russian Army was to be shaped in accordance with the requirements of the contemporary *fight space* – the so called *novyioblik* [19].

The Russian Federation's attempts to regain the position of the real power in the world also resulted in Dmitri Medvedev's signing a new *Russia's National Security Strategy* in May 2010 and *Russia's Military Doctrine* in February 2010.

The listed documents were the Russian response to the changes caused by the international situation as well as by the internal transformation of the country – inter alia, in the field of foreign policy and army.

The analysis of the content of the subject literature allows to state that the new *Strategy* constitutes a seeming attempt at re-cataloguing and organizing the challenges concerned with Russian Federation national security. Moreover, it is used to shape the views of the Russian political elites and propagate the ideology of power. The doctrine which has been referred to above explicitly defines NATO as Russia's main opponent (which is a significant constraint in comparison to the previous documents of that kind). Furthermore, the main threats for Russia's safety were unequivocally associated with the western direction and North Atlantic Treaty. Simultaneously the military part of the document consisted of general announcements concerned with creating modern armed forces. The doctrine also contained statements proving that Russia considered its military potential as a factor which helps to consolidate its influence zone in the countries of the former USSR[20].

17 E. Laurent, *Moscow in Wall Street*, published by POLONIA, Warsaw 1990, p. 5.

18 *Nowaja Armia Rossiji*, ed. Michail Barabanov, Moscow 2010, p. 23.

19 This term is usually encountered in materials referring to the reform of the Russian Armed Forces, literally it means 'new shape' (image)'.

20 *The Russian Federation's War Doctrine*, Eastern Studies Centre, Warsaw 2010.

The fundamental goal of the reform of the Russian Federation's Armed Forces was their transformation – from the traditional Soviet mass army, based on conscription and mobilization – into modern, smaller but mobile and flexible armed forces. Military and political authorities in Russia stated that under contemporary conditions numerous soldiers and a lot of equipment cannot compensate for their low quality.

The transformation of the Russian Federation's Armed Forces, which is currently executed, was divided into three main stages:

- Stage I (2008–2010) included: the essential changes in the structure of organization and vacancies, which mostly consisted in the reorganization of the commanding system, the reduction of the number of the soldiers in the Armed Forces and introduction of new ranges of responsibility of particular commanders and staffs;
- Stage II (2011–2012) included: reformation of the brigades within the Land Army and the Navy and the reorganization of naval and army aviation [21]; modification of roles an ranges of responsibility of the commanders in the Armed Forces;
- Stage III (2013–2020) includes: the correction of the changes introduced in Stages I and II, intensification of the supplies and implementation of modern armor and military equipment in order to conduct complete rearming of the Russian Federation's Armed Forces.

It is worth noticing that in terms of legal aspects and organization, the greatest endeavor was to introduce radical changes in the organizational structure of the Russian Federation's Armed Forces.

All military units were reformed into permanent combat readiness units, equipped for 'W' time (with both military equipment and human resources).

Moreover, the combat readiness maintenance system changed – in all units combat readiness was introduced which allowed taking actions in 1 to 6 hours.

Additionally, in the all of the Russian Federation's Armed Forces new and precise ranges of duties for a given position were implemented.

The modification of the organizational structure was also introduced in other types of the military.

The most significant reorganization occurred in the Russian Federation's Land Forces.

What one should also draw attention to is the fact that from 1st January 202 the Russian Federation's Ministry of Defense started to significantly raise the remuneration in the Russian army.

Hence, as a result of the raise, the platoon commander (in the lieutenant's rank) earns approximately 50 thousand rubles, whereas the battalion commander (the lieutenant colonel rank) earns around 100 thousand rubles.

Until the raise, depending on the position held, the salary for lieutenants and lieutenant colonels amounted for, correspondingly, 14 and 18 thousand rubles (approximately, depending on the vacancy held)[22].

A comprehensive analysis of the reform of the Russian Federation's Armed Forces allows us to make hypothesis that the political and military management in Russia represented the standpoint that in the current international situation the occurrence of a conventional global conflict (or a large-scale conflict) was not very likely.

Therefore, it was agreed to radically reduce the size of the Russian Army and prepare it to undertake effective actions in local conflicts. Conflicts whose aim is to win the *souls of the nations*.

The beginning of Stage III in mid-February 2013 resulted in the increased activity of the Russian Federation's Armed Forces, which expressed itself in a number of unannounced exercises and tests of military readiness, as well as presence of Russian ships in the Mediterranean Sea extending over the period of several months.

Those endeavors had not been included in the previous training applied in the Russian Army.

In terms of the forces and resources which were involved, the exercise area, the number of exercises, as well as when and in what mode they were organized, those endeavors had no precedent in Russia's contemporary history.

Last military readiness tests of that nature took place in the Russian Army in the 1980s.

21 Unlike in the majority of other armies, in the Russian Armed Forces Land Army Aviation is the part of the Air Forces.

22 Compare: P. Cieślik, G. Rosłan, *The Reform of the Russian Federation's Armed Forces 2008-2011*, Zeszyty Naukowe AON, 2012.

The activity of the Russian Federation's Armed Forces as well as all the changes which occur within them, have been and still are constantly in the field of direct interest of Russian authorities, with Vladimir Putin, the current president, in the fore-front. Already at that time one could make a probable assumption that those events heralded another *war for the souls of the nations.* The lack of effective tools hindering Russia's ambitions resulted in the third *war for the nations' souls.*

The third war, which was the most sublime one, was disguised in the slogan with which we are already familiar: *Humanitarian intervention aiming to protect the interests of the inhabitants….* It also constituted an actual upgrade of the previous wars.

Nothing heralded the events which were to take place. At night 21/22 November 2013 the proponents of European integration gathered in Maidan Independence Square in Kiev. The protesters announced that they would remain in Kiev's main square until the government changed their decision. Protests were also organized in Lutsk and Ivano-Frankivsk, as well as in Donetsk and Kharkov. Was it the moment when Putin's crew 'glued the envelope' which said 15 billion in Ukrainian treasury bonds, and 'opened' the envelope with the title *crisis in the Ukraine?*

There is no need to describe the facts which are now common knowledge. However, there is one event which stopped *little green men*[23] with Russian weapons – Putin's Winter Olympic Games in Sochi.

Winter Olympic Games in Sochi should be considered a great PR success for both Russia and its president who used his 'five minutes' in a calculated way. It was another, this time bloodless one, war for *the souls of the nations*. The Olympics showed the world that Russia can be open to cooperation.

President Vladimir Putin claimed that *the entire world saw modern and friendly Russia which is willing to cooperate*.

Kremlin's host, in his hypocrisy, said that those who earlier had been afraid of Russia should use the example of the Olympics and understand that *the Russian society has significantly changed for the better*[24].

The Olympics finished on 23th February 2014, and just three days later, a group of Russia's armed proponents in unmarked uniforms took the buildings of the Crimean government and parliament.

Almost simultaneously, Russian armored personnel carriers appeared not far from Simferopol. In the course of the days that followed armed individuals dressed in military uniforms occupied the airport in Simferopol and Sevastopol. The consequence of those events was Declaration of Independence of the Crimean Parliament and the referendum to join Crimea to Russia. The first time that Vladimir Putin admitted that Russian troops had stayed in the Crimean Peninsula both before and after the referendum was 17th April 2014. The Russian President stated *their aim was to provide the conditions to conduct the election correctly* and added that *our soldiers accompanied the local defense forces. Their conduct was correct and professional*[25].

On 18th March this year in Kremlin there was an understanding signed between the Russian Federation and Crimea's self-appointed authorities. The war for the souls of the Crimean population was over and the war for the souls of Eastern Ukraine's citizens began. The activity of *the little green men* of Russia has shown that the Russian Federation's Armed Forces have at their disposal a relatively numerous group of units of various armed forces and types of troops which in the initial period of the reforms have achieved the expected level of military readiness. Those units are able to undertake tasks in the areas situated far from their permanent redeployment, without long-lasting and visible preparations. According to Adam Rotfeld, the former Poland's Minister of Foreign Affairs, President Putin has been waging the war for his nation's soul for at least seven years[26]. This is how he gains support, adoration and enthusiasm. He continues to execute his plan in a cold-blooded way, which was referred to much earlier in various official documents, and the West is still at a loss trying to find a good solution to tame Russia's attempts to rebuild its imperial influence zone.

23 *Little Green men* – the term which has been used to describe unknown, professionally armed Russian separatists, who officially have nothing to do with Russian Armed Forces

24 *Putin: The Olympic Games showed new Russia,* http://www.bankier.pl/wiadomosc, [access: 25.02.2014].

25 *Putin: 'Little green men in Crimea is us*, http://wmeritum.pl/, access 17.04.2014.

26 *Rotfeld: Russia had been preparing for the conflict for at least seven years,* http://wyborcza.pl/, [access. 25.03.2004].

The events which have been referred to in this paper illustrate these endeavours.

The conflict over Crimea and Eastern Ukraine shows that when it comes to Russia the West possesses no suitable instrument of pressure; Lack of any coherent policy towards Russia on both the U.S.' and EU' part, resulted in the occupation of Crimea and probably in the foreseeable future, in modernization and development of Russia's Black Sea Fleet. It will also lead to next claims, for example, to Kaliningrad Oblast transit.

CONCLUSIONS

Russia is an experienced political player. However, it does not mean that it is possible for Russia to be as powerful as it was during the Soviet times. The conflict over Crimea has proved that Russia is the main playmaker in the Post-Soviet area. It has also shown the weak position of the United States in the world. It has also shown that the European Union is powerless and is not ready (fails to come up with an idea) to solve such crisis situations.

Currently, Russia has been strengthening its position in the geopolitical Post-Soviet area. Simultaneously, we have received a clear signal that if someone from the Post-Soviet area, which Moscow considers its influence zone, does not include Kremlin's opinion, it might have tragic consequences.

Fundamental changes in the balance of political forces in Eastern Europe 1990 resulted in the fact that the countries located in this region are implementing their transformation in the situation of local instability, which is the case scenario that is being written by the crew situated in Kremlin.

The recent events have proved beyond doubt that one needs to be skeptical when it comes to finding *modus vivendi*[27] between the main political players of the broadly defined West (Poland included) and Russia.

The process of guaranteeing the safety for the Russian Federation can be divided into two stages: one concerned with concepts and decisions and the other one focused on implementation.

The first stage defies the form and character of the implementation stage.

The fundamental part of this stage is its ideological layer[28].

Russia's future conduct in the international arena can be forecast inter alia on the basis of the new national security policy[29] designed by Putin's crew. From this document it results that Russia's strategic aim is to build a multi-polar world in which Russia would be one of great powers. The strategy of the authorities is also to lay the foundations for the national approval of solving Russia's main problems, which are contained in the populist slogan to rebuild a strong country[30].

The Russian Federation's national security strategy, signed in May 2009, presents the country's goals which have not changed for years; however, the document does not specify how Russia is going to achieve them.

The collapse of the USSR caused the feeling of emptiness in the Russian society, which first of all, resulted in the crisis of values. It expressed itself, inter alia, in the loss of fundamental ideological goals and presence of pessimism and negative moods in the society.

Putin's presidency is a number of Russia's successes – both economic and political ones. The years of Putin's domination have led to the increase in Russia's significance, particularly in comparison to the nineties (the decade of Yeltsin's presidency. It is worth pointing out that since the end of the nineties one has observed economic growth in Russia which directly translates into the improvement of living conditions for the population (for example, pension benefits paid on time, etc.). Moreover, since 2000 unemployment has decreased in Russia. Ever since Putin became President in 2000 the Russian nation has been more and more consolidated.

This consolidation embraces all the areas which are focused on national traditions and values. Russia's desire to hold a significant position in the world results from its historic heritage, imperial traditions and the ambitions of Kremlin's authorities.

27 *modus vivendi* - pl. modi vivendi 'way of living') – establishing an international accord on the basis of a temporary compromise.

28 See.: *Studies on Russia*, eds: A. Stępień-Kuczyńska, J. Adamowski, Łódź-Warsaw 2000.

29 D. Jankowski, *The Russian Federation's new national security strategy*, http://stosunkimiedzynarodo we.info/artykul,525,Nowa strategia bezpieczeństwa narodowego Federacji Rosyjskiej (2009-11-03).

30 S. Saradżjan, *Putin's return: back into the past (article in Polish)*, http://www.Stosunki miedzynarodowe. Info /artykul,1146,Powrot Putina szybko z powrotem do przeszłości (2011-11-03).

Moreover, it is not a coincidence that it is nowadays that this heritage is so emphasized. It inter alia expresses itself in making references to important events in Russia's history, the USSR' history included.

Currently Russia spends 3,7% of its GDP on armaments. Both strategic rocket and nuclear forces are reinforced, as well as particular segments of conventional forces. What Russian authorities have been particularly focusing on is the activity of special troops and air forces. Simultaneously the analysis of the scenarios of recent exercises clearly shows that a conflict might be triggered by the events of national grounds.

The operation 'The return of Crimea to the motherland' to was supposed to be a practical test of Russian Armed Forces' professionalism. Millions of Russians feel nostalgic about the empire they lost. In his address to the parliament Putin said that the most tragic event of the twentieth century was the collapse of the USSR. Not World War I or II, not fascism in Germany and communism in Russia, but the collapse of the USSR. In the Ukraine Russians tested a new kind of conflict towards which the West turned out to be helpless.

Neither bombers nor rockets mattered; it was the feelings of pro-Russian population that were of significance.

Since the very first day Putin's crew gained power, their activity has not been focusing on winning the public opinion in the West; on the contrary, Putin does not take this opinion into consideration at all. Putin's aim is to *win his nation's soul.*

This is how he gains support, adoration and enthusiasm. XXI World Championship in 2018 will be organized in Russia. It is the first world championship tournament that is scheduled to take place in Eastern Europe.

One can safely assume that it is going to be another great PR success for both Russia and its president, Vladimir Vladimirovich Putin. It will be another, this time bloodless one, *war for the soul of his own nation.*

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LOADS AFFECTING UGVs' TECHNICAL STATUS

Róbert SZABOLCSI, József MENYHÁRT
Óbuda University, Budapest, Hungary
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Abstract: *There are many new initiatives and scientific research on autonomous ground vehicles (AGV). New applications forecast a new era when autonomous vehicles start to take part in more complex traffic situations, i.e. they are ready to execute their mission although in pick-time, or, in military applications they are ready to execute missions autonomously in their pre-programmed missions. If to combine those two techniques of unmanned aerial vehicle (UAV) and unmanned ground vehicle (UGV) one can get benefits from integrating two platforms into one, supporting for example the border control units answering challenges of the modern epoch. The article provides an overview of the history of robots. The second chapter describes the history of UGVs. This chapter starts with the presentation of the remotely controlled vehicles from the Second World War and finishes the history with the DARPA robot, which used artificial intelligence (AI) in the 1960s. The study also contains information about the autonomous ground vehicles. Authors will derive a set of the loads of the UGVs during their use.*
Keywords: *AGV, UAV, UGV, Robot, Maintenance, Load.*

1. INTRODUCTION

Military and industrial researchers try to use more and more automatic applications in practice. They have lots of reasons why they want to use them. Few times later we can use robots in different types of jobs, and in different missions. These kinds of missions can be very dangerous, boring and/or monotonous. That means users will use robots in the air, on the land, under the water, and also in space both for governmental, and non-governmental applications and purposes.

Nowadays a lot of institutes, factories, hospitals and military facilities use different types of UGVs. These robots are not only used inside the facilities. We can meet them in different areas outside the buildings. This multi-purpose UGVs causes different and unexpected events during their operations.

This paper would like to describe why it is important to use robots in our daily work. The study also incorporates a chapter about the history of the UGVs, and describes a problem about the daily operations of the UGVs.

2. HISTORY OF ROBOTS

First of all, we have to know some information about the word 'robot'. Szabolcsi in his works [1,29] gives a new approach to find the origin of the word 'robot'.

The first robot word was used by Karel Čapek. He used it in his work titled Rossum' Universal Robots (R.U.R.) written in 1920. The word 'robot' came from the Czech word 'robota', meaning unpaid work. [1,2]

We can find the roots of the automation technology in the 18th century. That was the century of the First Industrial Revolution in England. Sir Richard Arkwright invented different types of machines like the automatic weaving and spinning machines, which he used in his own factory. The machines first used water power, and later steam engines. [3,4]

Latter in the 19th century Charles Babbage invented an analytical engine. It was the idea of the first reprogrammable computer in the world. [5,6] This machine can be seen in Figure 1.

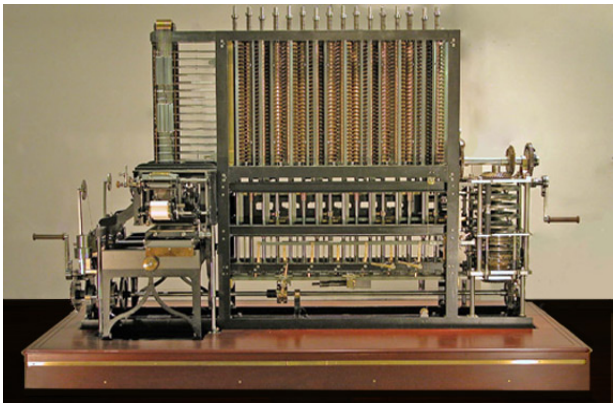

Fig. 1 „The Babbage Engine" [5]

Nikola Tesla, the Croatian-Serbian-American mechanical and electrical engineer who open new dimensions for automation of the technical processes. Tesla invented the first polyphase induction motor and the first electrical motor to run on alternating current. [7]

In the middle of the 20th century the vehicle industry put a lot of energy into robot development. A lot of robot manufacturer companies were born in this period, like FANUC, KUKA, ABB (Asea Brown Boveri). [3,8,9,10] The first robots could work on a known way that they got in their program before the first use. In the early years, robots didn't use any artificial intelligence (AI) technology. Robots were used only for highly precise and/or monotonous operations. Latter robots were used not only by car manufacturers. The developers understood advantages of the application of robot technology. Different kinds of industrial areas started to use them like logistics, or chemical industry. [3,11]

Another important thing about the robots was the costs of the production at the factories. If the companies use robots, they can produce their goods at lower prices in a better quality and, the same time to reduce the amount of losses. If to analyze industrial production supported by robots, or any other kind of activity executed by robots one also have to think about the HR (Human Resources) costs. When companies use robots in the manufacturing, or in the logistic areas one can find lower costs of hiring, training, working clothes, tools and any other personal costs.

All these costs are often called for hidden ones because they are often forgotten while calculating the return costs of robot investments. [3,12,13]

First definition of the industrial robot is available in ISO 8373 standard, accepted worldwide by users. [14]

3. SHORT HISTORY OF THE UGVS

The UGV is a vehicle which operates on the ground without human presence on its board. These kinds of robots can be used for many applications which may be D3-ones (Dirty-Dull-Dangerous) for the Human (assault, defense, minesweeper etc.). The UGVs use different types of sensors and cameras which send signals to its control stations. The new generation of UGVs uses artificial intelligence (AI) technologies during their work. Figure 2 presents a TALON UGV, which is a type of military UGVs. [15]

Fig. 2 Talon UGV [16]

The first UGVs were built in the 1930s and the early 1940s by the USSR (Soviet Union). The name of this UGV was Teletank. It was a series of wireless remotely controlled unmanned tanks. This tank was used in the Winter War during the Second World War (1939-1941). [17]

Worth mentioning that not only the Soviet Union has used remotely controlled machines. The British army used a radio controlled prototype of MATILDA II (Figure 3.) in 1941. This kind of tank got the Black Prince code name. [18]

Fig. 3 MATILDA II [18]

During the Second World War not only the allies tried to use remote controlled weapons. In 1942 the Nazis developed a new small remote controlled tank. The tank's name was GOLIATH. (Figure 4) [3,19]

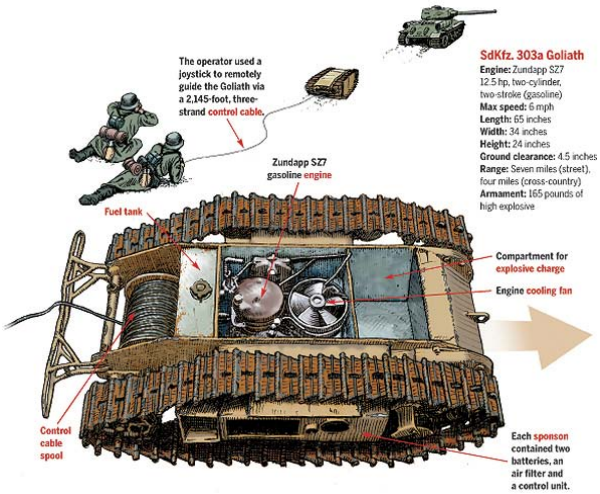

Fig. 4 GOLIATH [19]

The GOLIATH was controlled by cable and it carried approximately 60 kg explosive material. The Nazis had more weapons which are the ancestors of the modern ballistic rockets. They were the V1 and V2 rockets. [3,19]

As we can see, these kinds of robots were controlled by humans with cable or with using radio technology. The focus of mobile robotic research was moving towards the discipline of artificial intelligence (AI). The first „modern" mobile robot was SHAKEY, which was developed in the late 1960s. It was a prototype robot made by DARPA. (Figure 5) [20]

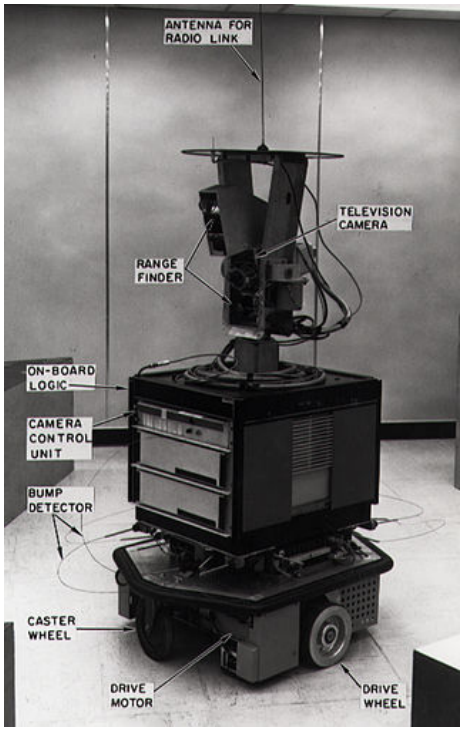

Fig. 5 SHAKEY [21]

Nowadays we can meet different types of UGVs which are operated by human control or with AI. References [22,23] and [24] describe different types of UGVs. These articles discussing high mobility robots and one can also read about big robots with diesel engines which are used for any dirty or dangerous (D3) applications.

The factories use another type of UGVs which we call – Automated/Automatic Guided Vehicle (AGV) (Figure 6). This kind of vehicle follows markers or wires on/in the floor or uses magnets or laser beams for navigation. This kind of robots is most often used in industrial environments to carry materials, finish goods or tools around the manufacturing facilities and warehouses. In the late 20th century they were given increased importance. [25,26,27]

Fig. 6 AGV in work [28]

The first AGV was made by Barrett Electronics of Northbrook, Illinois, USA in 1953. This kind of robots has a professional system management system where the user can check where the vehicles are in the facility, the status of the AGV, battery voltage etc. [25,26,27]

4. UGV GROUPS FROM MAINTENANCE SIDE

Regarding fields of the possible UGV applications they can be classified into four groups [3]:

- Reconnaissance robots;
- Prevention robots;
- Logistic robots;
- Assault robots.

These groups perfectly describe the four main categories of UGVs. But this classification and segmentation can't be used to evaluate maintenance and operations of the robots.

The basic maintenance steps at the UGVs are the same as in the maintenance of a normal machine. The large scale diversity of the UGVs allows users use robots in different situations, environments and in more and more dangerous projects (e.g. reconnaissance missions at Fukushima nuclear power plant's radiation, monitoring volcano eruptions etc.). This is the reason why one could find uncertainty in the maintenance and operation methods. There are many different types of the loads affecting robot application, and their behaviour. The most important of those loads being considered for evaluation of the robot operation could be the followings:

- high temperature loads;
- loads from changing humidity;
- surface roughness loads;
- weather conditions;
- extra loads on the UGVs chassis;
- damages of the UGVs' mechanical or electrical components.

High temperature loads can lead to irreversible degradation of the technical status of the UGV. There are many missions famous for that kind of external loads, e.g. monitoring volcano eruptions.

The climate itself can change the technical parameters of the dynamical systems, e.g. resistances and conductances are in high dependence of the temperature and humidity, as well. The surface roughness determines the quality of the robot navigation and, derives energy consumption of the electrical servo actuators applied on-board. Besides extra needs in relation of the electrical energy consumption of the robots if there is a meaningful surface roughness the robot movement itself can generate mechanical extra loads on robot frame (chassis) being considered during robot design phase.

We can call these kinds of loads external loads. They can appear both during robot operations and when robot is out of the operation. Most of these loads intensively influence the batteries' technical status applied on the board of the UGV. The battery's electrical loads can be divided into two main groups (Figure 7.)

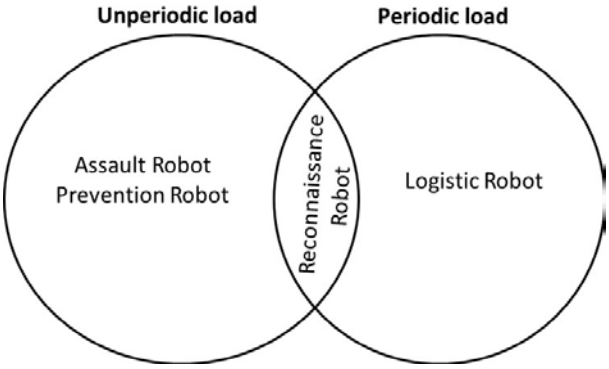

Fig. 7 Load set

Figure 7 shows two groups of loads. Logistic robots which are used mostly in the same environment with the same loads get a periodic load. Assault and Prevention robots are used in different types of environment and they always work in different missions.

Reconnaissance robots can be part of both groups. Users can use them in war theatre applications generating aperiodic loads on the robot, or they can be used in facility guarding operations generating mostly the periodic loads. The main load factors were determined and defined. The aperiodic loads of the electrical batteries can lead to failures, shortfalls in electrical energy supply system during robot operation.

The modern UGVs are mostly supplied with on-board diagnostics of the batteries responsible for management of the energy supply process.

CONCLUSION

The paper gives a short summary of the history of robots. In the second part the reader can get information about the evolution of the UGVs and AGVs. The article also describes a possible classification of UGVs. The authors used these four groups and made new sets of UGVs from the operation side. This classification helps to determine a new operations method for the UGV systems. The aperiodic loads may cause damage while the users work with the UGVs, which mean the life time of the UGVs can be worse than the previously predicted one.

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MODIFIED ADOMIAN DECOMPOSITION METHOD FOR SOLVING RICCATI DIFFERENTIAL EQUATIONS

Necdet BİLDİK, **Sinan DENİZ**
Celal Bayar University, Manisa/TURKEY
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Abstract: *In this study, we solve Riccati differential equations by modified Adomian decomposition method which is constructed by different orthogonal polynomials. Here, Chebyshev polynomials are used instead of Taylor polynomials to expand the source function. We see the benefits of using these expansions to get better results.*
Keywords: *Chebyshev polynomials, Adomian decomposition method, nonlinear differential equations.*

1. INTRODUCTION

Adomian decomposition method was found by George Adomian and has recently become a very well - known method in applied sciences.

The method does not need any linearization or smallness assumptions to solve the differential equations and this makes the method very effective among the other methods.

Many works have been examined in various different areas such as heat or mass transfer, nonlinear optics, incompressible fluid and gas dynamics phenomena etc [1-5].

Nonlinear differential equations arise from many important applications in physics, engineering, applied science such as damping laws, diffusion processes, transmission line phenomena, etc.

They have been solved by many different techniques [6-9].

Riccati differential equation is one of the most significant nonlinear differential equations.

They are generally used in the studies of optimal control problems.

Obtaining the exact solution of this equation is not always possible.

So, numerical methods are needed to get the approximate solution.

Traditional Adomian decomposition method is also used to solve Riccati differential equation in many different papers [10-12].

2. ADOMIAN DECOMPOSITION METHOD

In this section we give some brief and basic information about Adomian decomposition method. For much more information, we refer to [5,13,14].

Consider the differential equation

$$Ly + Ry + Ny = g(t) \tag{1}$$

where L is the highest-order derivative which is assumed to be invertible, R is a linear differential operator of less order than L, N is the nonlinear operator and g is the source term. If we apply the operator L^{-1} which is the inverse of the L to the equation (1), we get

$$L^{-1}(Ly) = y = L^{-1}(g) - L^{-1}(Ry) - L^{-1}(Ny). \tag{2}$$

Let us suppose the solution of the Eq.(1):

$$y(t) = \sum_{n=0}^{\infty} y_n(t). \tag{3}$$

Besides that the nonlinear terms is obtained by

$$Ny = \sum_{n=0}^{\infty} A_n \tag{4}$$

where A_n are Adomian polynomials which can be calculated from:

$$A_n = \frac{1}{n!}\frac{d^n}{d\lambda^n}\left[N\left(\sum_{i=0}^{\infty}\lambda^i t_i\right)\right]_{\lambda=0}, \quad n = 0,1,2,\ldots \tag{5}$$

Using the equations (2)-(5), we get

$$\sum_{n=0}^{\infty} y_n = f - L^{-1}\left(R\left(\sum_{n=0}^{\infty} y_n\right)\right) - L^{-1}\left(\sum_{n=0}^{\infty} A_n\right). \tag{6}$$

where f is calculated from the source term and the given condition(s) which are assumed to be prescribed. We now construct the recursive relation as :

$$\begin{aligned} y_0 &= f = \Psi_0 + L^{-1}(g(t)) \\ y_1 &= -L^{-1}R(y_0) - L^{-1}(A_0) \\ &\vdots \\ y_{k+1} &= -L^{-1}\left(R(y_k)\right) - L^{-1}\left(A_k\right), \quad k \geq 0 \end{aligned} \tag{7}$$

It can be easily said that the solution is

$$y = \lim_{m\to\infty}\left(\sum_{n=0}^{m} y_n\right) \tag{8}$$

provided that the series converges suitably.

3.MODIFIED ADOMIAN DECOMPOSITION METHOD

In this section, we give the construction of modified Adomian decomposition method by using Chebyshev polynomials. Normally, we use Taylor polynomials in calculations for Adomian decomposition method. However, as we will see that using Chebyshev polynomials yields better results than Taylor polynomials. Generally, the source term is usually written as

$$g(t) \approx \sum_{n=0}^{m} \frac{g^n(0)}{n!} t^n . \tag{9}$$

Hosseini [15] used Chebyshev polynomials to modify the ADM by expanding:

$$g(t) \approx \sum_{n=0}^{m} a_n T_n(t) \tag{10}$$

where a_n are coefficients and T_n are Chebyshev polynomials [16,17].

In fact, there are many orthogonal polynomials as Laguerre, Legendre etc. that we can use instead of Taylor polynomials. But, Tien [18] and Mahmoudi [19] showed that these modifications are not good enough as much as Chebyshev polynomials.

4. NUMERICAL EXAMPLES

In this section, we solve two Riccati equations to illustrate the phenomena. These problems are brand new and cannot be found in the literature.

Example 1) Consider the Riccati differential equation

$$y' - \frac{1}{2}y + y^2 = e^t, \; y(0) = 1 \tag{11}$$

which have the exact solution $y = e^{\frac{t}{2}}$.

Solution:

We proceed according to section 2. We have

$$L = \frac{d}{dt}, R(y) = \frac{-y}{2}, Ny = F(y) = y^2$$

and $g(t) = e^t$. (12)

Constructing Adomian polynomials according to (5), we obtain:

$$\begin{aligned} A_0 &= F(y_0) = y_0^2 \\ A_1 &= y_1 F'(y_0) = 2y_0 y_1 \\ A_2 &= y_2 F'(y_0) + \frac{1}{2!}y_1^2 F''(y_0) = 2y_0 y_1 + y_1^2 \\ &\vdots \end{aligned} \tag{13}$$

Writing the source function in Taylor series form for only 4 terms:

$$g(t) = e^t \approx 1 + t + \frac{t^2}{2} + \frac{t^3}{6} \tag{14}$$

Then we form the recursive relation as in (7):

$$y_0 = f = y(0) + L^{-1}(1 + t + \frac{t^2}{2} + \frac{t^3}{6})$$
$$y_1 = -L^{-1}R(y_0) - L^{-1}(A_0) \qquad (15)$$

yields

$$y_{k+1} = -L^{-1}\left(R(y_k)\right) - L^{-1}\left(A_k\right), \quad k \geq 0$$

$$y_0 = 1 + t + \frac{t^2}{2} + \frac{t^3}{6} + \frac{t^4}{24}$$
$$y_1 = -\frac{t}{2} - \frac{3}{4}t^2 - \frac{7}{12}t^3 - \frac{5}{16}t^4 - \frac{7}{60}t^5 + \cdots \qquad (16)$$
$$y_2 = \frac{3}{8}t^2 + \frac{17}{24}t^3 + \frac{23}{32}t^4 + \cdots$$
$$\vdots$$

After doing much more calculations, we get the solution as:

$$y_T(t) = \sum_{n=0}^{m} y_n = y_0 + y_1 + y_2 + \cdots y_m \qquad (17)$$

where $y_T(t)$ denotes the approximate solution computed by using Taylor series expansions. For $m = 4$ we obtain

$$y_T(t) = 1 + 0,5t + 0,125t^2 + 0,020833t^3 + 0,002604t^4 + 0,000520t^5 \qquad (18)$$

Now, we make the same calculations by using Chebyshev expansion which can be calculated as in [17,18]:

$$g(t) = e^t \approx \frac{382}{384} + \frac{383}{384}t + \frac{208}{384}t^2 + \frac{68}{384}t^3 + \cdots \qquad (19)$$

Again, we have now the recursive relation:

$$y_0 = 1 + 0,9947916t + 0,9973958t^2 + 0,53125t^3 + \cdots$$
$$y_1 = -0.5t - 0,746094t^2 - 1.32857t^3 - 1.19272t^4 + \cdots \qquad (20)$$
$$y_2 = -0.125t^2 - 0.207682t^3 - 0.352595t^4 + \cdots$$
$$\vdots$$

By proceeding for $m = 4$ we get

$$y_C(t) = 1 + 0.49947916t + 0.126301t^2 + 0.021991t^3 + 0.002697t^4 + 0.000601t^5 \qquad (21)$$

For larger m more accurate results we get. Figure 1 and Figure 2 displays the errors for only $m = 4$. Table 1 shows the comparisons of these errors for $m = 8$.

Example 2) Consider the Riccati differential equation

$$y' - ty + y^2 = e^{t^2}, \; y(0) = 1 \qquad (22)$$

which have the exact solution $y = e^{\frac{t^2}{2}}$.

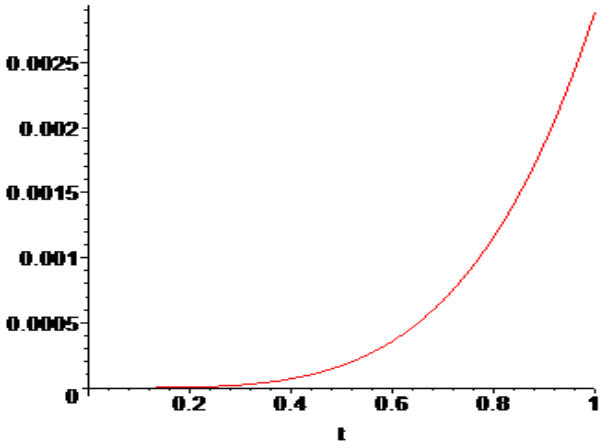

Figure 1. The errors $y - y_T$ for Example 1

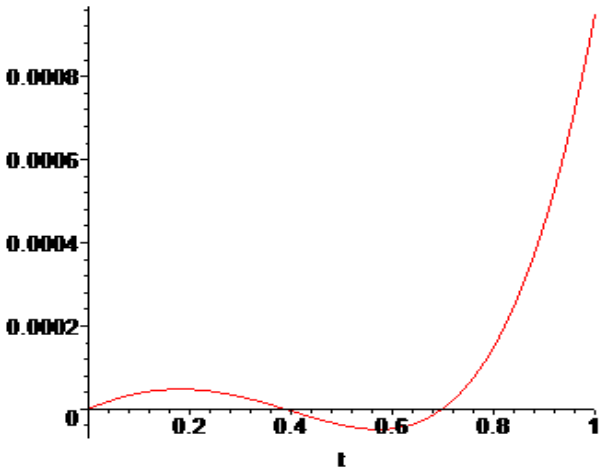

Figure 2. The errors $y - y_C$ for Example 1

Table 1: Absolute errors for $m=8$ for Example 1.

t	$y(t)$	$\lvert y-y_C\rvert$	$\lvert y-y_T\rvert$
0.2	1.1051709	8.054395E-10	6.762634E-8
0.4	1.2214028	5.043533E-8	5.595943E-6
0.6	1.3498588	3.766847E-7	1.939455E-5
0.8	1.4918247	1.504646E-6	4.543433E-4

Solution:
We here have

$$L=\frac{d}{dt}, R(y)=\frac{-t}{2}y, Ny=F(y)=y^2 \text{ and}$$

$$g(t)=e^{t^2}. \tag{23}$$

We can easily compute the Taylor and Chebyshev series expansions of the source terms we need:

$$g_T(t)=e^{t^2}\approx 1+t^2+0.5t^4+0.16666t^6 +0.04166t^8+\cdots \tag{24}$$

and

$$g_C(t)=e^{t^2}\approx 0.99997+1.0001t^2+0.49912t^4 +0.17036t^6+0.034853t^8+\cdots \tag{25}$$

Following the same procedure as in the previous example 1, we get the approximate solutions:

$$y_T(t)=1+0.5t^2+0.125t^4+0.020833t^6 +0.0026041t^8+0.0002604t^{10}+\cdots \tag{26}$$

and

$$y_C(t)=1+0.49999998t^2+0.12500037t^4+0.02083112t^6 +0.002610400t^8+0.0002514712t^{10}+\cdots$$

Figure 3 and Figure 4 displays the absolute errors for only $m=4$.

We can see the difference even for small m . Table 2 shows the comparisons of these errors for $m=8$.

CONCLUSIONS

In this study, we show that using Chebyshev polynomials is good idea to improve the effectiveness of the Adomian decomposition method.

We use Chebyshev expansions of the source term to obtain more accurate results.

Figures enable us to see that the difference between the using both two methods by graphically.

Tables are also given to show the variation of the absolute errors for larger approximation, namely for larger m .

Maple 18 is used for calculations and sketching graphs.

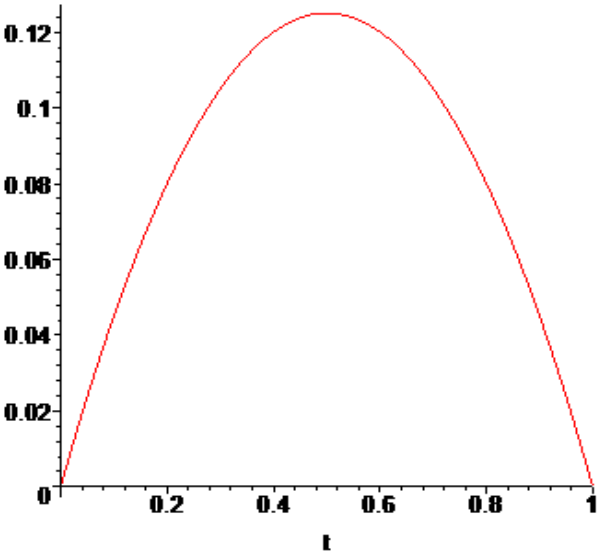

Figure 3: The errors $\lvert y-y_T\rvert$ for Example 2.

Table 2: Absolute errors for $m = 8$ for Example 2.

t	$y(t)$	$\lvert y - y_C \rvert$	$\lvert y - y_T \rvert$
0.2	1.0202013	3.053732E-12	6.039393E-11
0.4	1.0832871	5.958308E-10	1.003932E-10
0.6	1.1972174	1.958503E-9	4.900392E-7
0.8	1.3771278	2.408753E-6	7.540059E-5

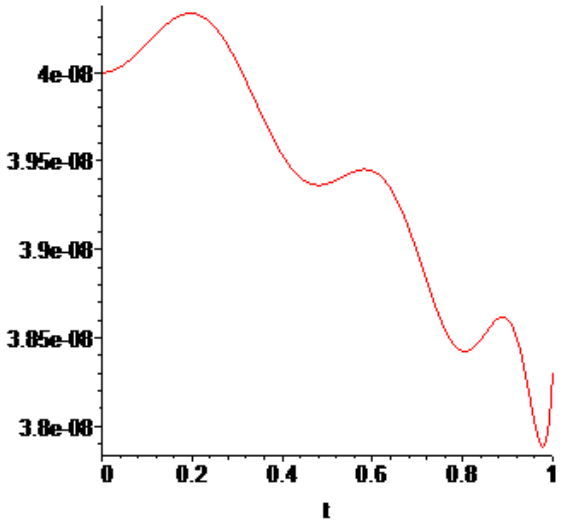

Figure 4: The errors $\lvert y - y_C \rvert$ for Example 2.

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GAS TURBINE MIXED JET FLOWS BASED ON THE COANDĂ EFFECT

Ionică CÎRCIU, Vasile PRISACARIU, Cristian George CONSTANTINESCU
"Henri Coandă" Air Force Academy, Braşov, Romania
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***Abstract**: In this paper are presented some analytical results regarding the mixing jet flow devices used in the gas turbine engines. Recent achievements in advanced ejectors, nozzles and air flow rate amplifiers are presented. Two cases of specific flows ejectors were studied: ejector with normal ejection and uniform speeds; ejector with peripheral ejection and non-uniform speeds in admission region. The analysis is based on the theoretically and experimentally characteristics of a typical axial flow engine elements. The paper deals with the theoretical quantitative and qualitative aspects of the Coandă phenomenon, in connection with the analytical Karman model.*
***Keywords:** Coandă ejector, Karman model, air amplifier, jet*

ρ = air density	A = surface	μ = coeff. of increase
H = force	V, ,V_i ,V_e = speed	α = unevenness
φ = growth factor	u = uniform speed	U = average speed
C = a constant	υ = distribution fact.	*n* = parameter

1. INTRODUCTION

The Coandă effect is a natural phenomenon. Since it occurs independently, it acts on the fluid flow in the vicinity of a divergent wall called airfoil and is characterized by strong asymmetry favored by the low pressure area in the rear of the airfoil [4]. According to specialized studies in aerospace, Coandă effect is successfully used to increase performance on lifting surfaces in morphing concept (flap, jet-slot), [7].

Henri Coandă identified an application of the effect during experiments with his Coandă-1910 aircraft. The motor-driven compressor pushed hot air rearward, and Coandă noticed that the airflow was attracted to the nearby surfaces. He discussed this matter with leading aerodynamicist Theodore von Kármán who named it the Coandă effect.

In 1934 Coandă obtained a patent in France for a "Method and apparatus for deviation of a fluid into another fluid".

The effect was described as the "Deviation of a plain jet of a fluid that penetrates another fluid in the vicinity of a convex wall" [4,9].

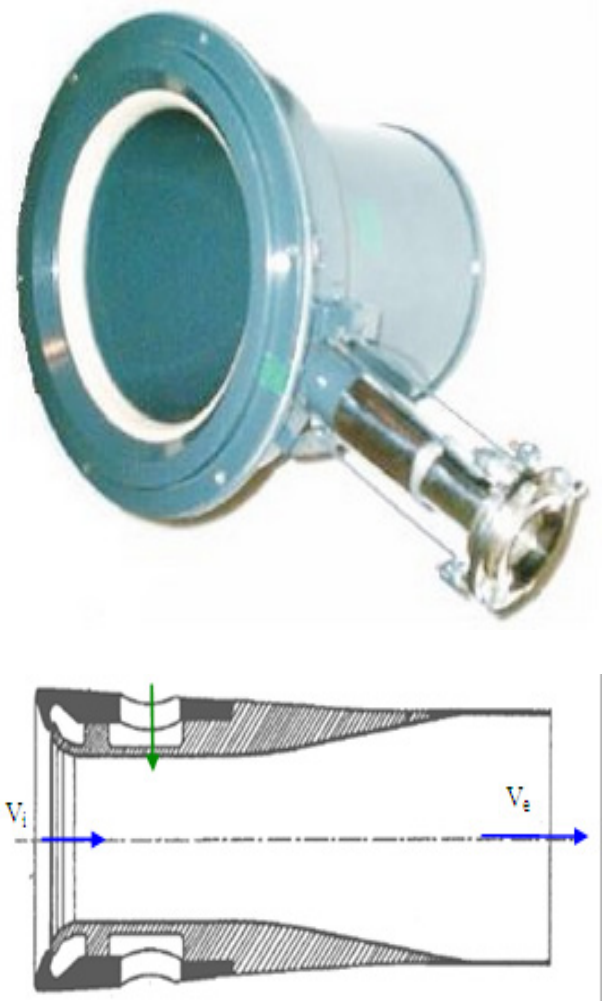


Fig.1 Coandă ejector [14]

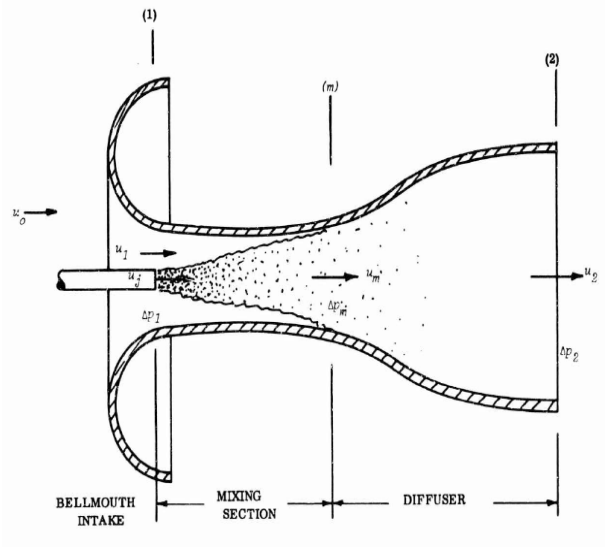


Fig.2Coandă ejector typical geometry [10]

Soon after discovering the phenomenon, the inventor Henri Coandă thought about controlling it and finding its limits through physical and mathematical calculations.

Due to its high complexity, he needed to contact other important theoreticians of the time. Theodore von Karman's model is presented below:

2. THEODORE VON KARMAN MODEL

One of the most comprehensive theories belongs to Professor Theodore von Karman who analyzed theories about the Coandă effect and theoretical implications of increased traction.

The interior ejection device was at the basis of this analysis (figure 1 and 2).

Two cases of specific flows of two ejectors were studied:

- Ejector with normal ejection and uniform speeds in the calculation sections;
- Ejector with peripheral ejection and non-uniform speeds at admission point;

The coefficient for the increase of force H is defined as the fraction:

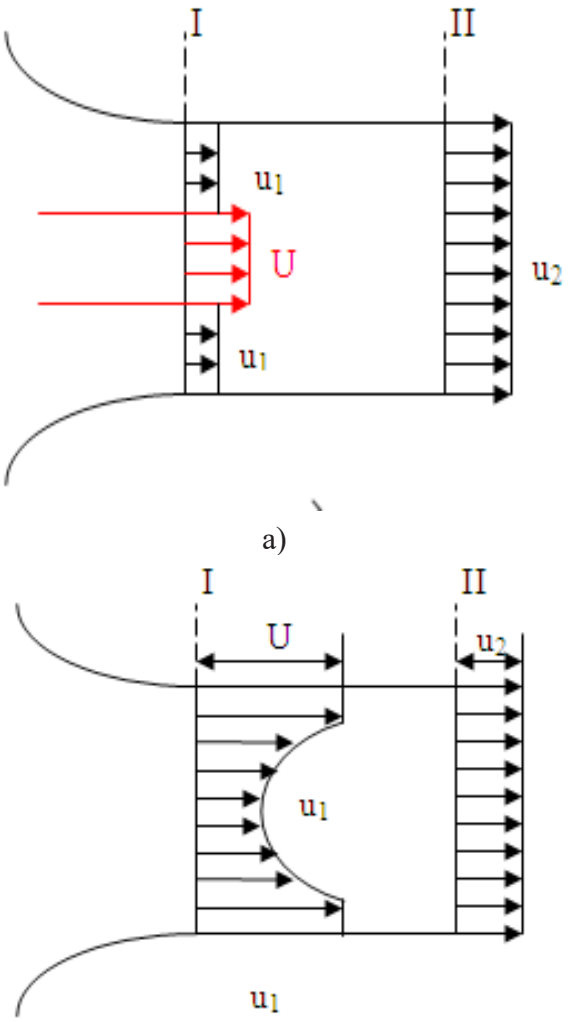


Fig. 3. Speed range in case of:
a) uniform speeds, b) non-uniform speeds
(Karman, 1949)

It is defined to increase the force coefficient φ, (fig. 4) :

$$\varphi=\left(\frac{A}{a}+1\right)\left(-\frac{a}{A}+\sqrt{\frac{a}{A}}\right)^2; \quad (2)$$

and for non-uniform speeds :

$$u_1=\text{const}\ R^n\ \lambda=\frac{(n+2)^2}{4(n+1)} \quad (3)$$

for: a<< A

In both cases, section I is for analyzing the primary flow and the secondary one respectively, while section II is the area for mixing the two flows in section I.

To conclude on his analysis, the author indicates that the maximum value of the coefficient for the generated force (traction) theoretically equals 2, but it is difficult to obtain a value higher than 1.35.

In case of non-uniform speed distribution, where for λ =1, the distribution is uniform (*n*=0).A variation of n implies a variation of the value of λ and they both define the asymmetry of the flow in the admission section [2, 5].

3. ADDITIONS TO THE THEODORE VON KARMAN MODEL

Detailed and completed formulae and conclusions that can be obtained from the Theodore von Karman model are shown below speed range-distribution:

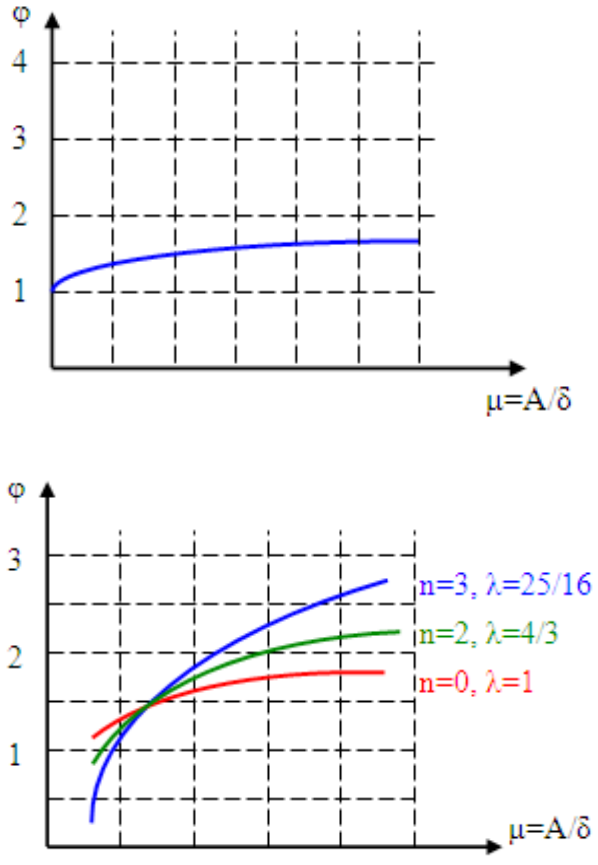


Fig. 4. Increase of force in case of distribution of: a) uniform speeds , b) non-uniform speeds (Karman,1949)

$$\frac{u_1}{U} = C\left(\beta + \eta^n\right) \text{ for } \eta = \frac{r}{h} \le 1;\ |\beta| < 1;$$
$$\frac{u_1}{U} = 1 \text{ for } r \le H \qquad (4)$$

$$\left(\overline{\frac{u_1}{U}}\right) = C\left(\beta + \frac{1}{1+\upsilon}\right);\ \upsilon = \frac{n}{\varepsilon};\ \varepsilon = \overline{1,2} \qquad (5)$$

$$\left(\overline{\frac{u_1^2}{U^2}}\right) = C^2 \left(\beta^2 + \frac{2\beta}{1+\upsilon} + \frac{1}{1+2\upsilon+\upsilon^2}\right) \qquad (6)$$

where u= *n*/e,

C being a constant and b, available parameters.

For β = 0, the speed distribution is obtained where ε = 1 and ε = 2 in the axial-symmetrical case.

If we mark by Ⱪ the combined parameter which refers to both the degree of non-uniformity and the fraction of maximum and average speeds from the secondary flow, we get the quadratic equation in u^2/U.

$$Ⱪ = \lambda - \alpha\left(\frac{u_{1h}}{\overline{(u_1)}}\right)^2;\ \left(\frac{u_2}{U}\right)^2 \qquad (7)$$

$$(2-(1+\alpha)\Omega) + 2\alpha\Omega\left(\frac{u_2}{U}\right) - \frac{\alpha(2+\alpha\Omega)}{1+\alpha} = 0$$

$$\left(\frac{u_2}{U}\right)_{1,2} = \frac{\pm\alpha(\alpha+\alpha\Omega)}{(1+\alpha)\left(\sqrt{\Delta} \pm \alpha\Omega\right)} = \frac{\sqrt{\Delta} \mp \alpha\Omega}{2-(1+\alpha)Ⱪ} \qquad (8)$$

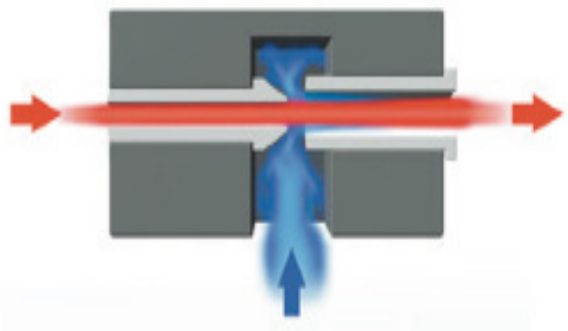
The conclusions of the author are that the jet trajectory is parabolic and the characteristics of the flow and of the forces that challenge the airfoil are influenced by the initial flow parameters as well as by the form of the airfoil [2, 5, and 11].

4. COANDĂ EFFECT APPLICATIONS

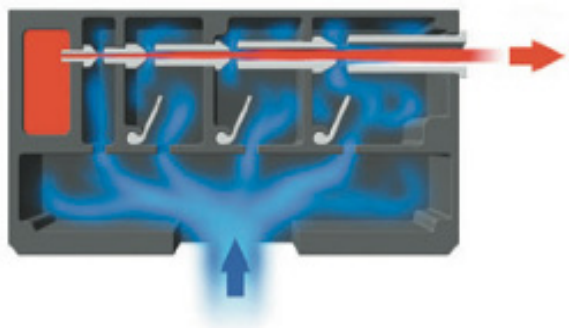
The Coandă effect due to its advantages has a number of applications such as: in aeronautics (blowing boundary layer) [8] and thrust vectoring [10];in transportation/handling, in injection molding and ventilation (vapors, smokes, and gases), silencers, and vacuum systems (loading and unloading), [3], see figure 5 and 6.

Table1. Values for ejector pumps [15]

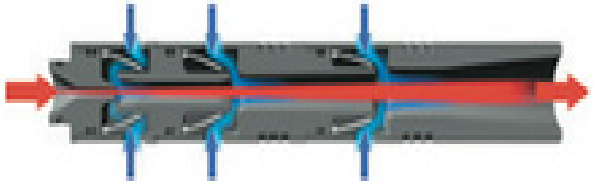
Units		*Vacuum level - Pa*					
		0	10^3	$20x10^3$	$30x10^3$	$40x10^3$	$50x10^3$
Displacement flow	l/s	10	10	10	10	10	10
	m^3/h	36	36	36	36	36	36
Free air	Nl/s	10	9	8	7	6	5
	Nm^3/h	36	32.4	28.8	25.2	21.6	18



Single stage ejector



Multistage ejector



Coaxial technology

Fig. 5 Compressed air-driven ejector pumps [7]

Table2. Features air amplifier [16]

Air supply – 80 PSI (5.5 bar)		
Input flow (Nl/min)	Output flow (Nl/min)	Velocity (m/s)
255	2124	277
142	1189	162
85	623	265

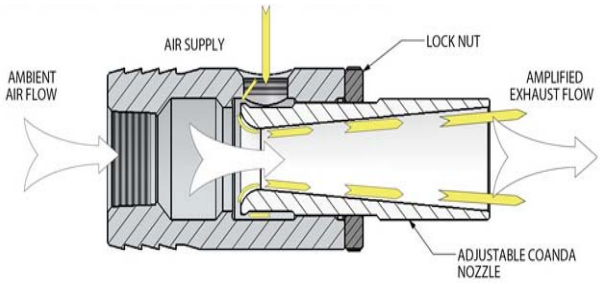
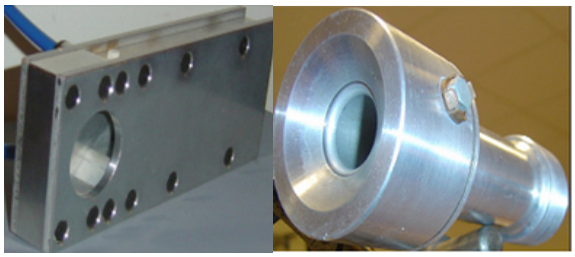


Fig.6 Air amplifier [16]



a) b)

Fig. 7a) ejector plan, b) cylindrical ejector

Such a system has recently been developed by a private Romanian company (AERODIN SRL, 2001) and obtained at $4.7x10^6$Pa, a flow rate of 2750 m^3 /h at a pressure drop of 882Pa with a coefficient of ejection 60.

The lack of moving mechanical parts allows the movement of various categories of foul air. [6, 10, 13] A number of specialized references prove that the Coandă effect can be used for flow measurement solutions (as an example flow-meters based on oscillation flow principles are simple devices with generally no moving parts.

These flow-meters are limited to 4 inch pipe for a high measurement resolution [8, 12, 14].

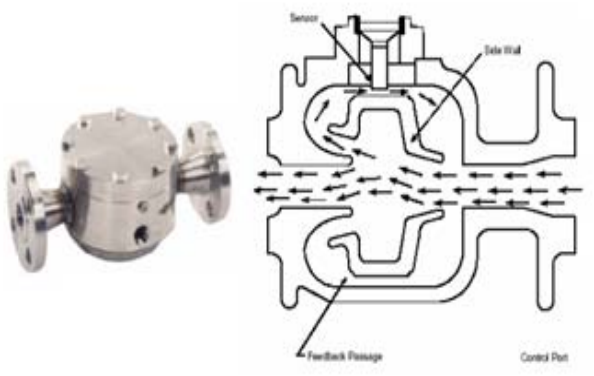


Fig. 8 Flow-meter [8]

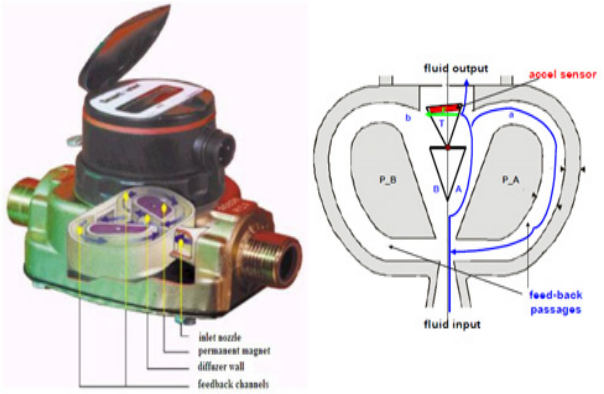


Fig. 9 Smartmeter Flow-meter [12]

CONCLUSIONS

Using the Coandă effect ejectors are able to entrain large amounts of ambient air without any moving mechanical parts.

By applying the Coandă effect, the flow that comes from a primary source (compressor, blower, fan, steam boilers, etc.) adheres to a wall of a shape specially calculated for this, determining the existence of a strong depressure drop.

Coandă nozzles are fed from a blower, compressor or fan of high pressure and low flow and were designed to amplify the primary flow 1,5-5-20-100 times depending on the geometrical configuration adopted.

Coandă nozzles geometries are diverse and vary depending on the application they are used. The diameter can vary from 20 mm to 1-2 m or even 10 m in special cases.

Coandă ejectors can reach lengths from 150mm to 120m 10-20m or in special cases.

The flows circulating in the order of 10-100-1000 m3 / h for the low and even ejectors 1,000,000 m3 / h for special cases.

The Karman model can be improved by introducing the new notation Ƙ which allows quick solving of the quadratic equation which facilitates writing the analytical solutions for the power increase in the Coandă ejector.

ACKNOWLEDGMENTS

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ASPECTS REGARDING VELOCITY DISTRIBUTION IN THE SECONDARY ZONE OF A GAS TURBINE COMBUSTOR

Constantin ROTARU, **Ionică CÎRCIU**, **Cornel ARAMĂ**,
Cristian George CONSTANTINESCU
"Henri Coandă" Air Force Academy, Braşov, Romania
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Abstract: *This paper deals with the modelling and simulation of the combustion in a turbojet engine in order to find the velocity distribution in the secondary zone of the flame tube. The Arrhenius relationship, which describes the basic dependencies of the reaction rate on pressure, temperature and concentration, has been used. Also, combustion efficiency has been defined and related to both the exhaust temperature and species concentration. Premixed laminar flames and the dependence of propagation rate on temperature and the fuel-air ratio have been highlighted. The main focus of this paper consists in a new configuration of the aircraft engine combustion chamber with an optimal distribution of gas velocity in front of the turbine. This constructive solution could allow a lower engine rotational speed, a lower temperature in front of the first stage of the turbine and the possibility to increase the turbine pressure ratio. Also, a higher thermodynamic cycle efficiency and thrust in comparison to traditional constant-pressure combustion gas turbine engines could be obtained.*
Keywords: *combustion chamber, aircraft engine, premixed combustion.*

1. INTRODUCTION

The aircraft engine combustor requires an inlet velocity which is much lower than that leaving the high-pressure compressor, so that the flow velocity must be greatly reduced between these engine components. Although the purpose of a flow diffuser is to reduce axial velocity in order to gain static pressure, this must be accomplished in a short axial distance and with a minimal loss of total pressure. The gas turbine combustor is viewed not only as the source of thermal energy required by the propulsion cycle, but also as a necessary flow path which must provide adequate flow stream to maintain the static pressure drop between the compressor bleed outlet and turbine inlet. The radial various jets support a difference in both static and total pressure across the liner, as the jets flow into a second control volume having a single radial boundary inside the liner wall [1]. The viscous dissipation of kinetic energy in all of the jets leads to an approximately uniform level of total pressure within the liner.

The effect of the perforated colander liner is to maintain a fixed level of total pressure between the upstream and downstream plenums.

Because the Mach numbers have low values within the combustor, except within jet cores, the difference between the static and total pressure is slight, and so it is convenient to consider the static pressure to be approximately constant within the liner [2].

2. TURBULENT ROUND JETS IN THE FLAME TUBE

The round jet holes in both the secondary and dilution ones must be sized to provide the correct blockage to not only support the required total pressure loss, but also to divide the air flow into the appropriate mass flow rates into the primary, secondary and dilution zones.

The combustor is required to convert the chemical energy of the fuel into thermal energy with the smallest possible pressure loss and with the least emission of undesirable chemicals.

To achieve this in a small volume it is necessary for the flow to be highly turbulent [9, 10]. Because the behavior of the burning process depends on the turbulence, while at the same time the energy release brings about large alterations in the turbulence properties, it is not possible to carry out the detailed computations for the three-dimensional flow in the combustor (fig. 1).

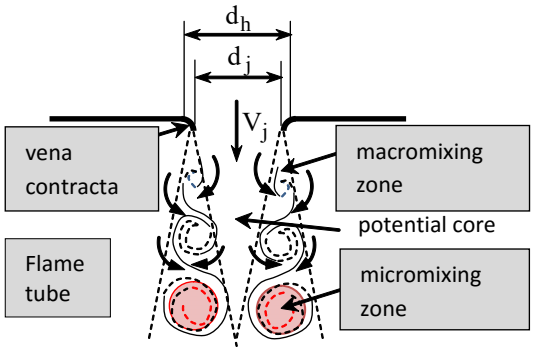

Fig. 1 Model flow in a combustor hole

If the flame tube region has a lower static pressure than the region above, the pressure difference causes a jet to flow through the hole of area $A_h = \pi d_h^2 / 4$, which reduced to $A_j = \pi d_j^2 / 4$. The vena contracta diameter d_j is approximately $(0.8 \div 0.9) d_h$. Because the flow is assumed to be isotropic, the jet velocity V_j is therefore determined by the static pressure difference. Downstream of the vena contracta all of the kinetic energy in the jet is converted to thermal energy by turbulence and subsequent viscous dissipation.

The length of the potential core varies from about $5d_j$ to $7d_j$ as the jet Reynolds number varies from 10^4 to 10^5 and the mixing transition point is about $10d_j$ downstream of the vena contracta [6, 7]. The micro mixed region occupies about one half the jet width, so that $\delta_m \cong 0.1\,y$ (fig. 2).

The combustor for a jet engine needs to be small to fit between the compressor and turbine without making the shaft unnecessarily long, since that would add to the weight and introduce problems of mechanical stiffness.

The high energy release in a small volume is made possible by the high pressure and by the very high level of turbulence created in the combustor which mixes the fuel and air [3, 4].

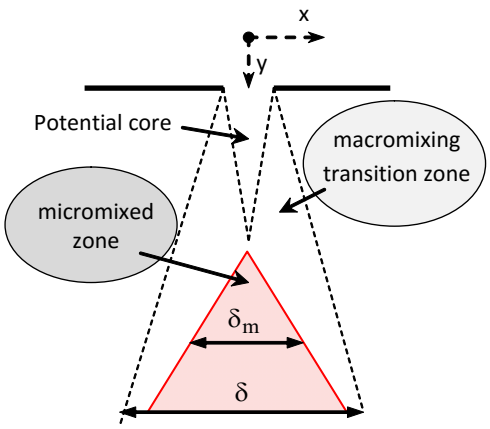

Fig. 2 Turbulent round jet

If all of the reactants are consumed in the combustion and there is no excess fuel or oxygen, the combustion is said to be stoichiometric.

A difficulty with hydrocarbon fuels is that they will not burn if the fuel-air ratio is far below stoichiometric. Fuel is injected as a fine sheet or spray and is broken up by a surrounding air blast. Most of the air from the compressor is diverted to avoid the region where the fuel is injected so that combustion starts in a relatively rich primary region with a fuel-air ratio of about 0.25 for takeoff and 0.1 at idle [8, 11]. Additional air is then fed in through holes in the combustor lining to complete the combustion process and to reduce the temperature to the level acceptable for the turbine so that after dilution, the effective overall air-fuel ratio is about 0.03. The air entering the dilution region also puts a layer of relatively cool air on the walls and modifies exit temperature radial profile to be suitable for entry into the turbine. To prevent the flame from being blown away it is necessary to set up local regions with much smaller velocity [5].

3. ENERGY RELEASE

Most frequently standard heats of formation are used to determine the chemical energy released during combustion process.

The standard heat of formation, h_f, represents the energy addition necessary for constant-pressure formation of a compound from its elements in their natural state at $25^\circ C$ and the energy required to accomplish any reaction can be calculated by algebraically summing the heat of formation contributions of the products minus the reactants

$$(\Delta h_r)_{25^\circ C} = \sum x_i (h_f)_i - \sum x_j (h_f)_j \quad (1)$$

where Δh_r represents the heat of reaction, x_i and x_j are the stoichiometric coefficients of product and reactant compounds.

The amount of heat, Δh_r, required to accomplish a reaction is a function of temperature. Heat required at temperature T_1, rather than $25^\circ C$ would be

$$(\Delta h_r)_{T_1} - (\Delta h_r)_{25^\circ C} = (h_{sp} - h_{sr})_{T_1} - (h_{sp} - h_{sr})_{25^\circ C} \quad (2)$$

where h_{sp} and h_{sr} are the product and reactant static enthalpies, respectively. For a given amount of energy release, it is apparent that the final flame temperature will increase with the initial temperature.

4. COMBUSTION PROCESS

Accurate flame temperature prediction requires consideration of the dissociation effects and variable specific heats. If the fluid in the annulus is moving from left to right at velocity U_A (fig. 3), then the fluid entering the jet carries with it its axial momentum flux in addition to the y direction momentum flux, $\rho_A V_j^2$, generated by the difference in static pressure. The entering velocity V_j is inclined at an angle θ, where $\theta = \arccos(U_A / V_j)$. An expression for the trajectory of the jet centerline is given by the equation [2]

$$\frac{y}{d_j} = 0.82 \left(\frac{\rho_A V_j^2}{\rho_L U_L^2} \right)^{0.5} \left(\frac{x}{d_j} \right)^{0.33} \quad (3)$$

The simplified relationship between the constant-pressure adiabatic flame temperature and mixture ratio is significantly altered when the detailed effects of dissociation and specific heat variations are included.

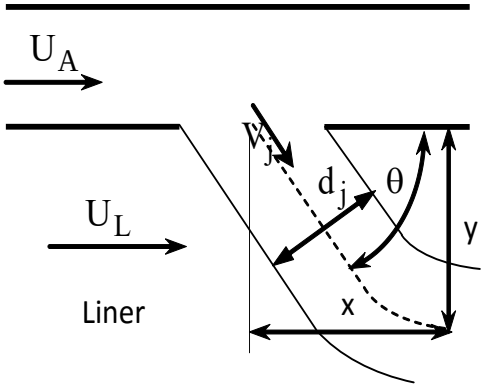

Fig. 3 Jet trajectory

The difference between the theoretical and actual flame temperatures as the mixture ratio approaches stoichiometric is due to the presence of significant O and H_2 concentrations at the higher temperatures.

The maximum combustion temperature occurs when hydrocarbon fuel molecules are mixed with just enough air so that all of the oxygen atoms are consumed, all of the hydrogen atoms form water vapor and all of the carbon atoms form carbon dioxide, this ideal mixture of fuel and air being represented by the atom-balance equation

$$C_x H_y + \left(x + \frac{y}{4} \right) \left[O_2 + \frac{79}{21} N_2 \right] \rightarrow x CO_2 + \frac{y}{2} H_2 O + \frac{79}{21} \left(x + \frac{y}{4} \right) N_2 \quad (4)$$

The stoichiometric mass-basis fuel-air ratio is given by

$$f_{st} = \frac{36x + 3y}{103(4x + y)} \quad (5)$$

A generic molecule representing jet fuels is $C_n H_{2n+2}$, which for $n = 12$ gives $f_{st} = 0.0669$ kg fuel/kg air. To quantify the off-stoichiometric mixtures of fuel and air, it is defined the fuel/air equivalence ratio, $\varphi = f / f_{st}$.

For the incomplete combustion, the atom-balance equation can be generalized as

$$C_xH_y+\left(x+\frac{y}{4}\right)\left[O_2+\frac{79}{21}N_2\right]\rightarrow\sum_{i=1}^{NS}n_iA_i \quad (6)$$

where NS represents the total number of product species, A_i represents the chemical formula of the i^{th} gas molecule appearing in the NS product gases and n_i represents the mass-specific mole number of the i^{th} species.

Methods for finding the actual composition of the post-combustion product gases, as represented by the set of mole number $\{n_i\}$, are provided by the software programs. Both the adiabatic flame temperature and heat of reaction are end-state quantities calculated on the basis of the static change from the given reactant mole numbers $\{n_i\}_R$ to the set of product mole number $\{n_i\}_P$. The product mole numbers can be calculated either from assumed complete combustion or chemical equilibrium.

Because fluid particle residence times in any subcomponent of a gas turbine engine are less than a millisecond, it is very often the case that insufficient time is available for the exothermic combustion reactions to reach chemical equilibrium.

If the two streams have different molecular identities, the shear layer is also a mixing layer and it is generated at the interface between the two streams, in which momentum is transported laterally from the faster to the slower stream (fig. 4).

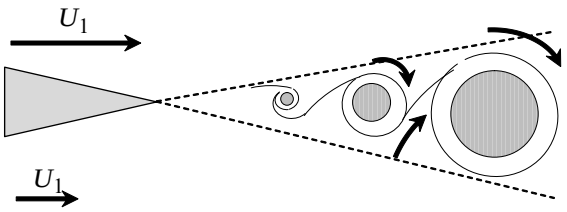

Fig. 4 Parallel streams mixing

The release of thermal energy occurs in three distinctly periods: the induction, heat release and equilibration regimes.

The induction period is the time interval immediately following some form of homogeneous bulk ignition, where the ignition occurs as a result of shock compression, but such ignition occurs only if the fuel and air are micro mixed to flammable proportions $(0.2<\phi<2.0)$.

The induction period ends when the mixture temperature begins to rapidly increase (after about 8×10^{-6} s). During the heat release period, the species equations and the energy conservation equations are strongly coupled. The heat release period ends when the reaction intermediates have all passed their peak values, at about 1×10^{-5} s. The equilibration period begins when all species mole numbers begin a decaying-exponential approach toward their respective equilibrium values. The end of the equilibration period can be defined as the time at which all of the mole numbers and the temperature are within 1% of their chemical equilibrium values, at about 5×10^{-4} s. Taking into account the combustion reaction progress variable, ε, the atom-balance equation for incomplete combustion, may be generalized as

$$\begin{aligned}&C_xH_y+\left(x+\frac{y}{4}\right)\left[O_2+\frac{79}{21}N_2\right]\rightarrow\\&\varphi(1-\varepsilon)C_xH_y+x\varphi\varepsilon CO_2+\frac{y}{2}\varphi\varepsilon H_2O+\\&+\left(x+\frac{y}{4}\right)\left[(1-\varphi\cdot\varepsilon)O_2+\frac{79}{21}N_2\right]\end{aligned} \quad (7)$$

For $\varepsilon=1$ in the above equation, the maximum value of T (the adiabatic flame temperature) is realized. The static temperature T and the reaction progress variable, ε, can be represented by the equation

$$T=T_i+\varepsilon\cdot\varphi\cdot\Delta T_{max} \quad (8)$$

where T_i is the air inlet temperature in the combustion chamber and ΔT_{max} is the maximum temperature rise when both $\varphi=1$ and $\varepsilon=1$.

The volumetric mass rate of consumption of the fuel, R_f, is expressed by the Arrhenius equation of the overall combustion reaction

$$\boldsymbol{R}_f = M_f\left(x+\frac{y}{4}\right)\varphi A e^{-\frac{T_{act}}{T}}\left(\frac{p}{RT\sum N_p}\right)(1-\varepsilon)(1-\varphi\cdot\varepsilon)$$

where M_f is the molecular weight of the fuel, A is the pre-exponential factor, T_{act} is the activation temperature of the reaction, p is the static pressure, R is the universal gas constant and $\sum N_p$ represents the sum of the product mole numbers given by the expression

$$\sum N p = \frac{100}{21}\left(x+\frac{y}{4}\right)+\varphi\left[1+\left(\frac{y}{4}-1\right)\varepsilon\right] \qquad (9)$$

On the other hand, the volumetric mass rate of consumption of the fuel can be expressed

$$\boldsymbol{R}_f = \left(\frac{\varphi\cdot f_{st}\cdot \dot{m}_A}{V}\right)\varepsilon \qquad (10)$$

where $\dot{m}_A$ is the mass feed rate of air and V is the volume of the combustor primary zone. The penetration depth of the secondary air jet trajectory is about ¼ the liner height, H_L (fig. 5).

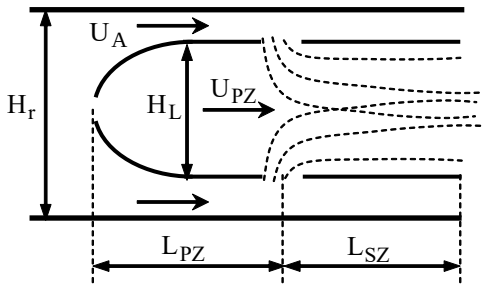

Fig. 5 Secondary zone trajectories

Because all of the secondary air must pass through round holes with jet vena contracta of diameter d_j, the number of the secondary holes is

$$N_{hSZ} = \frac{4\dot{m}_{SZ}}{\rho_r \pi d_j^2 V_j} \qquad (11)$$

The secondary air holes are spaced in a lateral line with one-half located on the upper flame tube wall and the other half, staggered and opposed, on the lower wall.

The axes of the secondary holes are located at the downstream end of the primary zone. The axial length of the secondary zone should be long enough for the inflowing jets to mix out the crossflowing primary zone effluent gases.

5. NUMERICAL RESULTS

The numerical simulations were made in Fluent software for a combustion chamber with a geometrical shape presented in the figure 6.

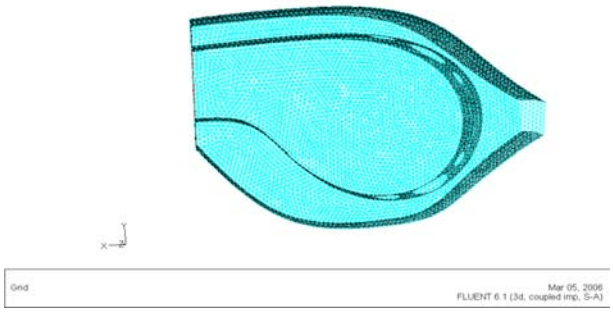

Fig. 6 Combustion chamber model

The velocity contours in the secondary zone of the flame tube and in the afterburner have the forms presented in the following pictures:

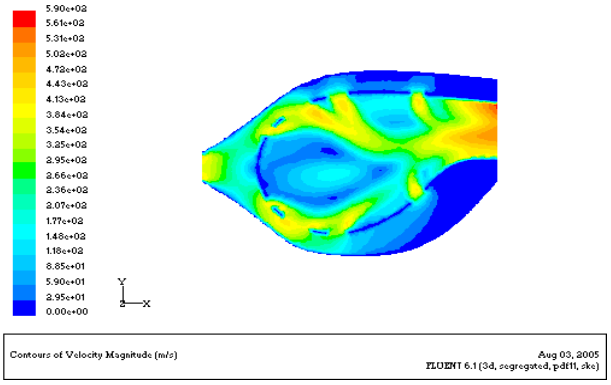

Fig. 7 Flame tube velocity contour

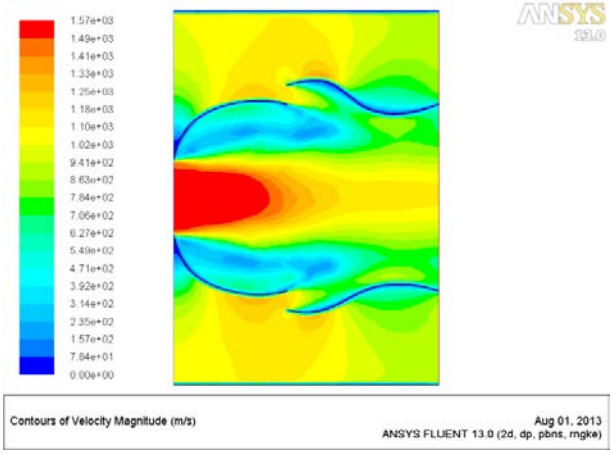

Fig. 8 Afterburner velocity contour

ACKNOWLEDGMENT

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CONCLUSIONS

Any fluctuation in the heat input rate to a gas flow produces acoustic disturbances and variations in the entropy of the flowing gas. When these entropy variations are convected through a pressure gradient, a second acoustic disturbance is produced. The interaction of the traveling waves in this process will depend on the geometry and velocity distribution in the flame tube of the combustion chamber. A low turbulence intensity environment in a fuel-air mixture flow of 50-100 m/s results in a root mean square of the turbulence fluctuation speed of 2.5-5 m/s. In a high turbulence intensity in a flow with a mean speed of 100 m/s, the turbulence contribution to flame propagation speed may be as high as 30 m/s. The combustion model presented in this paper allows the study of the optimal shape of the combustion chamber.

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STUDY OF THE INFLUENCE OF A GAP BETWEEN THE WING AND SLOTTED FLAP ON THE AERODYNAMIC CHARACTERISTICS OF ULTRA-LIGHT AIRCRAFT WING AIRFOIL

Cvetelina VELKOVA, **Michael TODOROV**
Technical University of Sofia, Bulgaria
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Abstract: *The purpose of the study is to assess what should be the optimal distance of the gap between the wing and slotted flap should be in order to improve the aerodynamic characteristics of ultra-light aircraft wing. A numerical study was performed on a NACA 23012 airfoil with a single slotted flap to examine the aerodynamic coefficients at Reynolds number of 3×10^6. The choice of the optimal distance of the gap between the wing and the slotted flap is made by comparison of its aerodynamic characteristics for two different cases in take-off stage. The numerical simulations were performed for two different lengths of slot, whose length is expressed as percentages of the airfoil chord. All calculations were made using a CFD code Fluent. Conclusions about the aerodynamic efficiency of the proposed configuration wing-single slotted flap were made.*
Keywords: *airplane wing, single slotted flap, aerodynamic characteristics, CFD, Fluent.*

1. INTRODUCTION

Aircraft wing high-lift configuration design is an important and challenging part of the whole aircraft aerodynamic configuration design, even dealing with a 2-D high-lift configuration design task which is an essential step for the 3-D high-lift configuration design [1], [2], [3], [4]. During the take-off and landing of an aircraft, the performance of high-lift devices has strong impact on the operating costs and environment around airports, such as improvements of payload, fuel consumption, and noise emission. Take-off and landing performance for very light airplanes are governed by the requirements as EASA CS-VLA [5]. The take-off and landing distances, and the important speeds as the stall speed with flaps retracted – V_S, the design maneuvering speed – V_A, the speed with flaps fully deflected – V_F, and the stall speed with flaps fully deflected – V_{SF}, depend on aerodynamic characteristics of the wing with a flaps deflected.

Nowadays, Computational Fluid Dynamics (CFD) is widely used for the prediction of the aerodynamic performance of the wing, at least in cruise flight.

The computation of the flow over a multi-element wing in high-lift configuration remains however one of the most difficult problems encountered in CFD [6]. The computations normally include a comprehensive code, coupled to Euler or Navier-Stokes solvers. The examples for a successful application of CFD are the codes FLUENT, OVERFLOW of NASA, FLOWer and TAU of Deutshes Zentrum für Luft und Raumfahr [2], [6], elsA and WAVES of ONERA [7], CFD++ [8], Star-CCM+ [9], [10], TAS of Takoku University and UPACS of Japan Institute of Space Technology and Aeronautics [10], [11].

The high-lift configurations considerably complicate the flow physics by boundary layer transition, separations and reattachments. Therefore it is very important to generate the appropriate mesh around it. The mesh can be structured, unstructured or hybrid. The structured mesh is identified by regular connectivity. The possible element choices are quadrilateral in 2D and hexahedral in 3D. The unstructured mesh is identified by irregular connectivity, [7], [12]. This grid typically employs triangles in 2D and tetrahedral in 3D.

The structured mesh has many coding advantages, but it may be difficult to conform a single block to a complicated shape. A hybrid mesh contains a mixture of structured portions and unstructured portions. It integrates the structured meshes and the unstructured meshes in an efficient manner, [2].

Another important step is the choice of a turbulent model. The turbulence is the most challenging area in fluid dynamics and the most limiting factor in accurate computer simulation of the flow. An overview of turbulence modeling is done in [13]. There are the following turbulent models, [14]:

- *Direct numerical simulation* (DNS)
- *Large eddy simulation* (LES)
- *Spalart-Allmaras model*
- k-ε *turbulent models*
- k–ω *turbulence models*

The DNS and LES practically do not have engineering applications. The other models have practical applications, and advantages and disadvantages depending on the specific tasks.

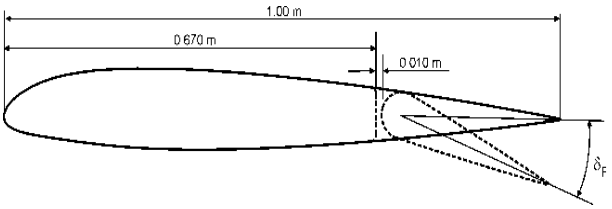

Fig. 1 NACA 23012 airfoil with single plain flap [15]

In [15], it was found the aerodynamic characteristics of an airfoil with single plain flap, as it is shown in Fig.1. For this purpose, first it was obtained numerical results for NACA 23012 airfoil which were compared with experimental wind tunnel data [16] to select density mesh and turbulent model. The aerodynamic characteristics were obtained by commercial CFD code FLUENT. It was generated structured mesh. The Spalart-Allmaras method gave the closest results to the experimental data results.

Then the aerodynamic characteristics of NACA 23012 airfoil with single plane flap (SPF) were calculated. It was generated multi-object hybrid mesh.

The calculations were made for Reynolds number of Re=3×10^6 (respectively *V*=43.81 m/s) at the sea level. The turbulent intensity and turbulent viscosity were 2.48% and 10 respectively. The flap deflection angle, δ_F, was 20º (take-off configuration).

The obtained results showed that the chosen arrangement of wing-single plain flap is not sufficiently effective from an aerodynamic point of view, although it is attractive with the simple design.

In [17], another configuration was studied: an airfoil with a single slotted flap (SSF), as it is shown in Fig.2. A NACA 23012 airfoil with a 1.00 m chord has been used in all the CFD simulations. The single slotted flap with a 0.32 m chord, corresponding to 32% chord, has been constructed in such a way as to match the geometry of the baseline airfoil.

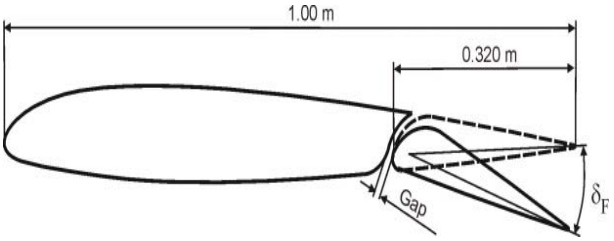

Fig. 2 NACA 23012 airfoil with single slotted flap

The multi-object hybrid mesh was generated. The calculations were made for Reynolds number of Re=3×10^6 (respectively *V*=43.81 m/s) at the sea level. The turbulent intensity and turbulent viscosity were 2.48% and 10 respectively. The flap deflection angle, δ_F, was 20º. The gap between the wing and slotted flap was 10% of chord (0.01 m).

The obtained results showed that configuration of a wing-single slotted flap is more effective than the configuration wing-single plain flap.

During the design the question of changing the gap size for improving the aerodynamic characteristics of the airfoil with single slotted flap has appeared.

2. AERODYNAMIC CHARACTERISTICS OF NACA 23102 AIRFOIL WITH A SINGLE SLOTTED FLAP AT DIFFERENT SIZES OF THE GAP

To calculate the aerodynamic characteristics of NACA 23012 airfoil with a single slotted flap at different sizes of the gap, the multi-object hybrid O-mesh is generated. The circle has a 10*c* (*c*-airfoil chord) radius. Around the airfoil, the flap and downstream are provided with a high refinement, as it is shown in Fig.3. Thus the meshes have about 420 000 nodes and 420 000 elements.

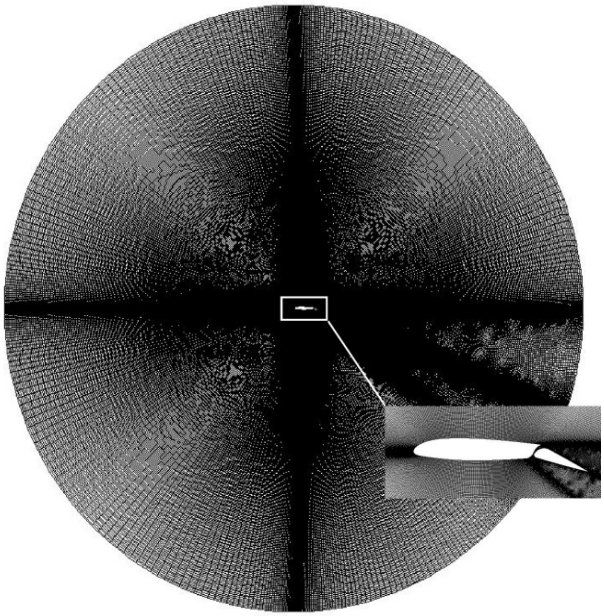

Fig. 3 View of mesh geometry of NACA 23012 airfoil with single slotted flap (gap 5%c)

The calculations are made for Reynolds number of Re=3×10^6 (respectively *V*=43.81 m/s) at the sea level. The turbulent intensity and turbulent viscosity are 2.48% and 10 respectively. The flap deflection angle, δ_F, is 20º.

Fig.4 and Fig.5 show the curves of C_L-α and C_D-α of the numerical results for a NACA 23012 airfoil, and NACA 23012 airfoil with a single slotted flap with two sizes of the gap, 5%*c* (0.005 m) and 15%*c* (0.015 m), respectively. Figs. 6, 7, and 8 show velocity fields around NACA 23012 airfoil with a single slotted flap in the range from 0º to 20º angles of attack for the two gap sizes.

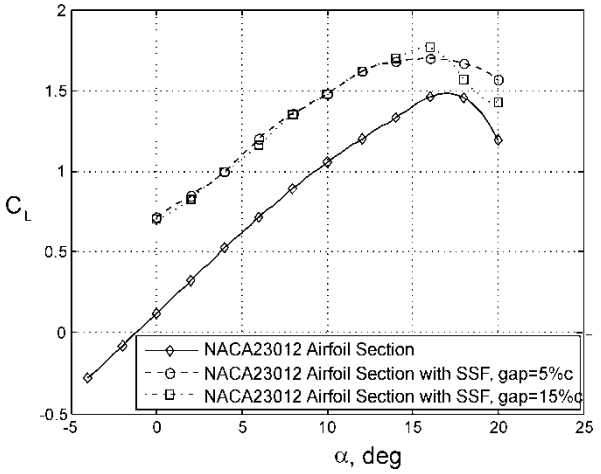

Fig. 4 Lift coefficient C_L plot over the range of angles of attack α for a NACA 23012 airfoil, and NACA 23012 airfoil with a single slotted flap, with two sizes of the gap

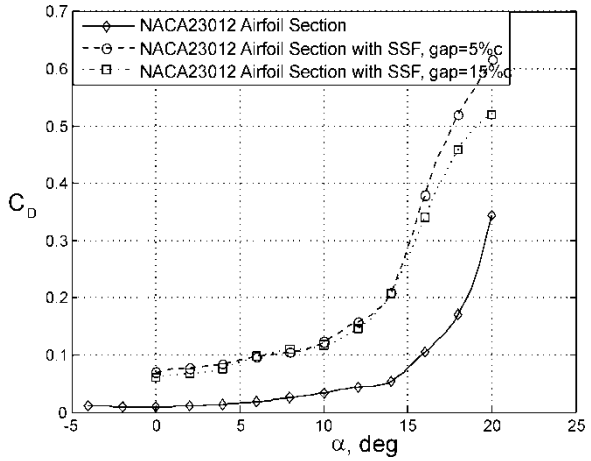

Fig. 5 Drag coefficient C_D plot over the range of angles of attack α for a NACA 23012 airfoil, and NACA 23012 airfoil with a single slotted flap, with two sizes of the gap

3. DISCUSSION

The use of configuration wing with single slotted flap (SSF) shows an increase of the lift coefficient C_L. Fig. 4 and Fig. 5 show that the lift coefficient C_L and drag coefficient C_D do not significantly differs throughout the range of angles of attack until α = 16°. There is no significant difference in velocity fields, as it is shown in Fig. 6 and Fig.7, too.

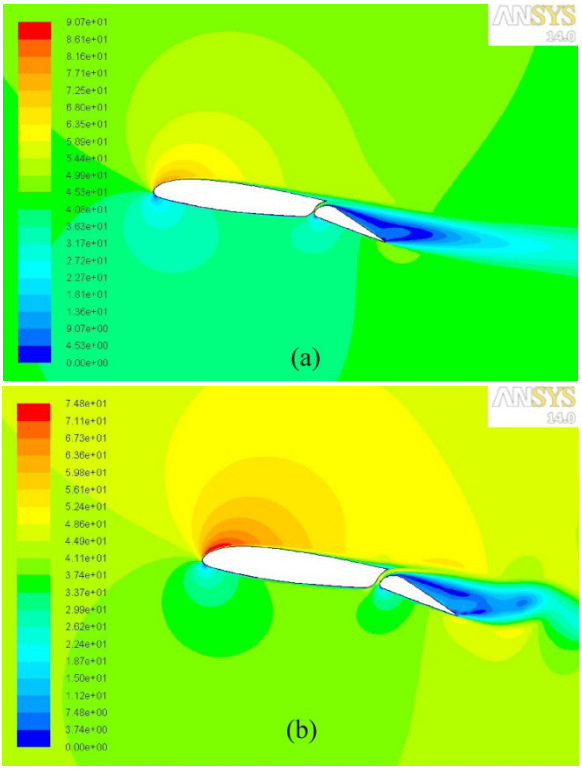

Fig. 6 Velocity field around NACA 23012 airfoil with a single slotted flap at α=6º; (a): gap size 0.005 m, and (b): gap size 0.015 m

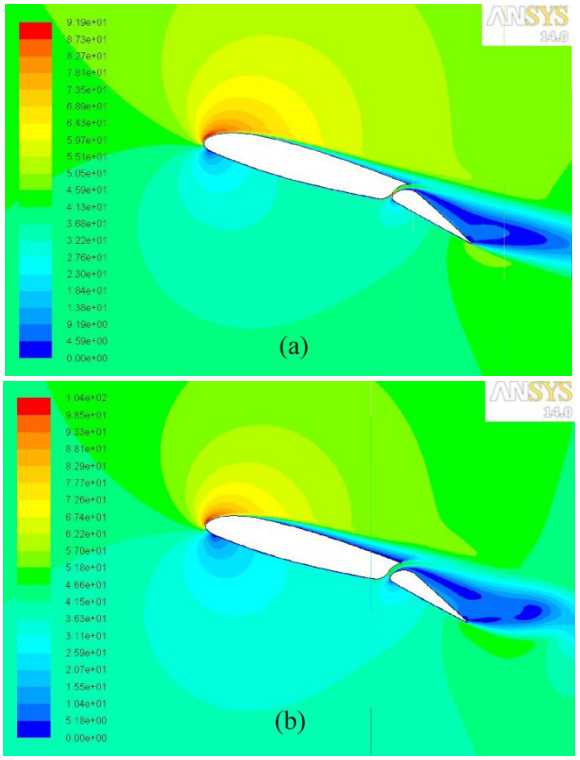

Fig. 7 Velocity field around NACA 23012 airfoil with a single slotted flap at α=14º; (a): gap size 0.005 m, and (b): gap size 0.015 m

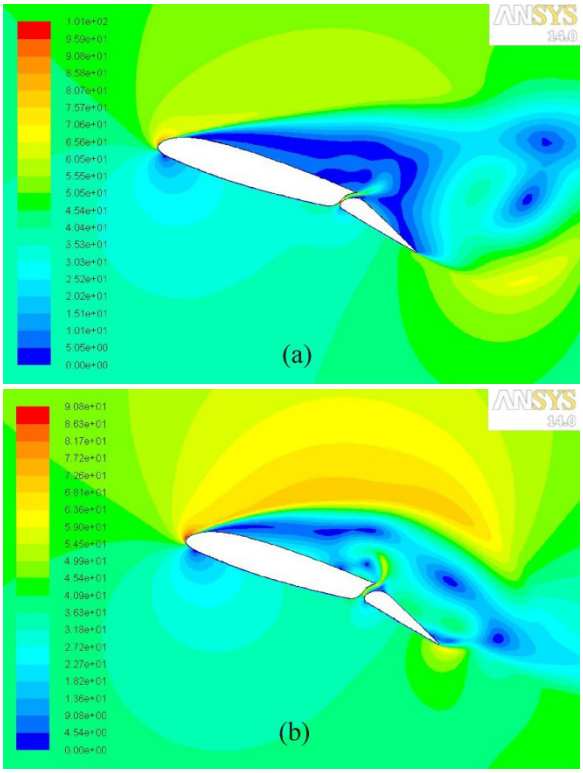

Fig. 8 Velocity field around NACA 23012 airfoil with a single slotted flap at α=16º; (a) gap size 0.005 m, and (b): gap size 0.015 m

When reaching α = 16° the lift coefficient C_L is maximum, and it is bigger at SSF with gap size 15%*c*, (see Fig.4). The last statement can be explained with the fact that the airflow has passed rapidly through the gap, and reaching the upper section of the SSF it has accelerated (Fig.8).

Therefore, the airflow velocity has increased, thereby increasing the value of lift coefficient C_L. In Fig. 4 the lift coefficient C_L decreased at SSF with gap size 5%*c* since the airflow passing through the gap has a delay.

The curves on Fig. 4 and Fig. 5 show that at α = 18° and α = 20° the value of lift coefficient C_L decreases at SSF gap size 15% c compared with the rate of C_L obtained for the SSF gap size 5%c. This is due to the fact that the flow field on the upper flap section is not optimal in these angles of attack.

The drag coefficient C_D is smaller at angles of attack bigger than 14° at SSF with gap size 15%*c*, (see Fig.4).

Therefore, a recommendation for a future work considers the question how to be shifted the single slotted flap (SSF)'s axis of rotation in order to obtain the optimal values of the aerodynamic characteristics.

Since the design scheme of an ultra-light aircraft with a tail wheel (tail dragger) was chosen, the aircraft starts the takeoff at maximum value of angle of attack $\alpha_{max,take\text{-}off}$, and in the process of takeoff the angle of attack α will decrease.

In our case the maximum designed angle of attack is 13° at the beginning of the takeoff.

Therefore observing Fig. 4 and Fig.5 it can be concluded that the SSF gap's size will have no the significant impact on the aircraft's aerodynamic characteristics in the range of angles of attack α from 6° to 13°.

Consequently, there is enough freedom of designing of the aircraft single slotted flap deflection mechanism.

CONCLUSION

A numerical analysis was performed for a NACA 23012 airfoil with a single slotted flap in take-off configuration. All calculations were performed with the Fluent code for two gap sizes 5%*c* and 15%*c*, respectively. It was used Spalart-Allmaras turbulent model.

The air domain has been modeled, meshed and solved, and post processing visualization options have been used for better understanding and investigation of the airflow. A mesh refinement near to the wing airfoil and single slotted flap has been done for more accurate results.

The analysis aimed to identify the aerodynamic forces acting on the proposed wing and flap configuration at Reynolds number $3x10^6$.

The 2D CFD model was used to examine the major features of the airflow around the proposed configuration wing-single slotted flap.

The obtained results were compared with those for NACA 23012 baseline airfoil.

The CFD results for the proposed configuration wing-single slotted flap show higher lift coefficient than NACA 23012 baseline airfoil.

The results show the gap size between the wing and single slotted flap does not have an influence on the lift coefficient for operating angles of attack in the takeoff regime.

As a future work, the influence of a changing of the position of the slotted flap (SSF)'s axis of rotation and slotted flap gap's size should be investigated simultaneously.

Thus, the values of the aerodynamic characteristics of the proposed wing and single slotted flap configuration can be improved.

Furthermore, this investigation is a base for making 3D CFD model and simulation of proposed wing-single slotted flap configuration for an ultra-light aircraft.

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TWO FLUXES MULTISTAGE INDUCTION COILGUN

Laurian GHERMAN
"Henri Coandă" Air Force Academy, Braşov, Romania
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Abstract: *This paper presents a new design of electromagnetic launcher based on induction. This design uses two magnetic fluxes to accelerate a projectile and the configuration allow multiple stages. The two fluxes multistage induction coilgun design offer multiple advantages over single flux designs. First we can control much efficient the induced current in ring and the induced coil current is kept at low values. Second the direction of magnetic field B inside the air gap is perpendicular on ring and the Lorentz force is acting on ring during entire length of magnetic circuit. Because the magnetic field B is created by a different coil we can manage to keep the magnetic circuit unsaturated for a great efficiency.*
Keywords: *Magnetic field, induction, Lorentz force, coilgun*

1. INTRODUCTION

The actual systems to accelerate projectiles based on chemical energy have achieved their limits but our demands are continuous growing. The electromagnetic launch systems (EMLS) are a possible answer to this issue.

This paper present a new design of EMLS based on induction. Before presentation of this design let analyze very short the actual designs.

Based on force used to accelerate the projectiles the EMLS are with attractive and repulsive force. The attractive force EMLS are well known like reluctance coilguns and are made by coils used to accelerate ferromagnetic projectiles.

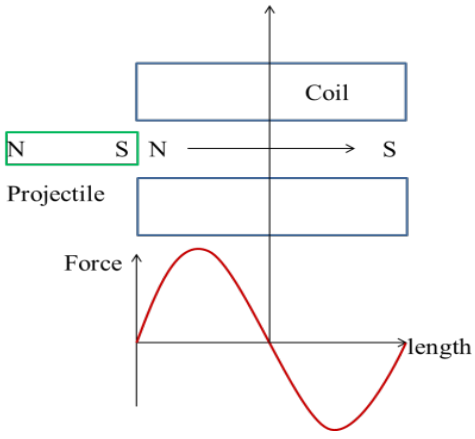

Fig. 1 Reluctance coilgun

When the coil is powered an electromagnet is created.

The flux lines created by coil intersect the ferromagnetic material of projectile and a magnet is created.

The poles between coil and projectile are different and an attractive force is acting on projectile. The projectile is accelerated inside the coil until it reaches the middle of length of coil when the force became repulsive. In that point the power of coil must be switched off in order to allow the projectile to travel further. If multiple coils are synchronized with projectile position, the projectiles can be accelerated with a multistage coilgun. At the end only half length of coils is used to accelerate the projectile. Because the projectile is made by a ferromagnetic material this design is efficient until saturation. This design use ferromagnetic materials but the accelerating force is not Lorentz force.

Other EMLS designs are based on repulsive force. This force is Lorentz force.

$$\vec{F} = I \int d\vec{l} \times \vec{B} \quad (1)$$

The well-known design based on Lorentz force is railgun design. This design consists of two conductors (rails) and an armature made by conducting materials. The armature has an electrical contact with both rails but is able to move alongside the rails. When the rails are powered by a high current the armature is accelerated by Lorentz force alongside the rails.

In this design the projectile is accelerated on the entire length of rails and is not limited by saturation.

In the railgun design (fig. 2) the current *I* can be increased with great impact on Lorentz force. The main advantage of railgun design is the possibility to increase the current inside armature at very high values due to electric contact between armature and rails.

In the same time the sliding electric contact between armature and rails represented the weakness of this design. Because of high currents used that electric contact affects the rails during lunches.

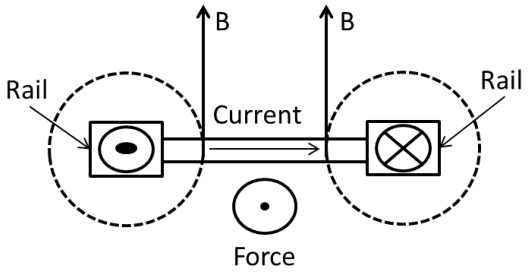

Fig. 2 Railgun

In order to decrease the current and to avoid contact between projectile and accelerator another design was created. The rails were replaced by coils and the armature was allowed to move inside or outside the coils. In this way we can obtain the same value of magnetic field density *B* with less current. In order to replace the sliding contacts the current inside armature

$u_i = -\frac{d\Phi_B}{dt}$ined by induction. (2)

$$u_i = -\frac{d}{dt}(BA\cos\theta) = -\left(\frac{dB}{dt}\right)A\cos\theta - B\left(\frac{dA}{dt}\right)\cos\theta + BA\sin\theta\left(\frac{d\theta}{dt}\right) \quad (3)$$

Where θ is the angle between $\vec{B}$ and $\vec{n}$ (normal unit of surface area A, let assume the magnetic field is uniform distributed in space)

The new design was developed based on Faraday's law of induction, named induction coilguns. In this design only the magnetic field is variable, the surface *A* and angle θ are constant.

The Faraday's law can be writhed:

$$u_i = -\left(\frac{dB}{dt}\right)A\cos\theta \quad (4)$$

One design consists of coils which allow a projectile made by aluminum to move inside them (fig3) [1]. The axial component of magnetic density $\overrightarrow{B_a}$ inside coil creates the induced current inside projectile which interact with radial component of magnetic field density $\overrightarrow{B_r}$. The induced current depends by rate of change of the axial magnetic density $\overrightarrow{B_a}$ and the radial magnetic flux density depends by amount of magnetic flux. The magnetic flux is created by coil and is only one magnetic flux which induces current in projectile and provide in the same time the radial magnetic field on induced current. It is difficult to control in the same time with one coil the rate of change of the axial magnetic density $\overrightarrow{B_a}$ and the radial magnetic flux density$\overrightarrow{B_r}$.

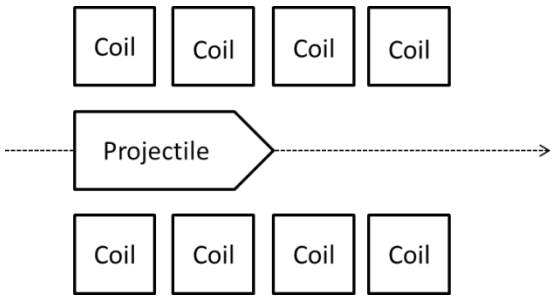

Fig. 3 Induction coilgun

These two designs railgun and coilgun are based on Lorentz force but do not take advantages of ferromagnetic materials.In order to increase the radial magnetic flux density $\overrightarrow{B_r}$ and to decrease the current inside coil a design with magnetic circuit made by ferromagnetic materials was proposed. The magnetic circuit creates also a zone where the magnetic field is radial on conductor, in our case a ring. (fig.4).

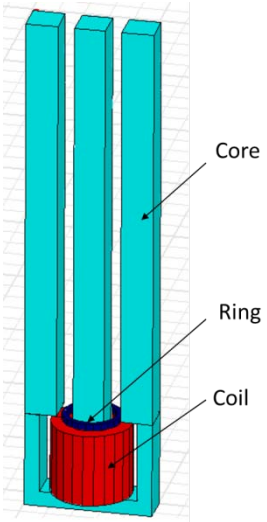

Fig. 4 E shaped coilgun [2]

The E shaped design use the ferromagnetic materials and use the Lorentz force to accelerate projectiles but that design does not allow multiple stages. We need multiple stages because if we increase the current in coil at certain value the ferromagnetic material will reach the saturation point. At this point we can identify the main aspects which should be taken into consideration when a design of an electromagnetic launch system is created. First we should use the Lorentz force to accelerate the projectile. Second we should avoid the contact between the projectile and the accelerator. This can be achieved if we use the induction. Because of this, coils should be used to induce current into projectile. In order to take advantages of ferromagnetic materials a magnetic circuit should be in place to create a strong magnetic field radial to the path of induced current in projectile.

And in order to keep the ferromagnetic material below saturation point all design should be created with multiple stages. A design which obeys all that conditions is presented in the following section.

2. TWO FLUXES MULTISTAGE INDUCTION COILGUN DESIGN

First we design an air core coil which will induce current into a ring placed outside the coil (fig.5). The coil has an air core in order to obtain a low inductance and give us the possibility to increase the current in coil without saturation problem eq.5. In this design the surface A is constant and the angle θ=0^0 and is not changing.

$$u_i = -\left(\frac{dB}{dt}\right) A \cos\theta = -\left(\frac{dB}{dt}\right) A \quad (5)$$

The power source is a direct current source (DC) because all system will work in transient mode and the time when entire system is powered is less than time constant of induction coil.

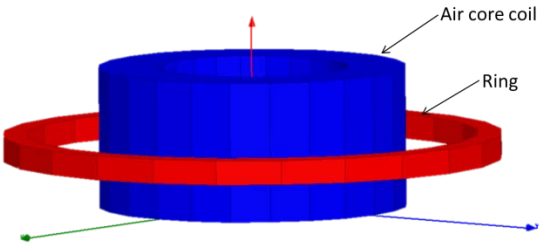

Fig. 5 The induction system

In this way the coil create only an induced current inside the ring. We need another coil which will create the radial magnetic field. Together with this coil we will design a magnetic circuit in order to control the magnetic flux. This coil is connected separately in order to control the saturation of ferromagnetic materials from magnetic circuit. The design is similar with E-shaped design but allow multiple stages of acceleration (fig.6).

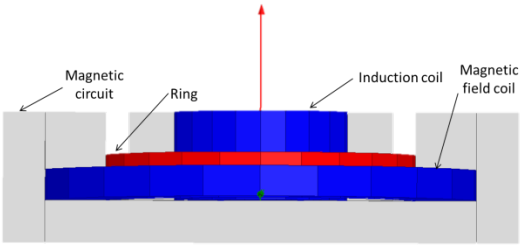

Fig. 6 First stage of two fluxes multistage induction coilgun

In order to find which dimensions should be modified to increase the Lorentz force acting on ring we made the following assumptions. All magnetic field created by induction coil is uniform distributed inside coil. All magnetic field created by magnetic field coil is uniform distributed inside magnetic circuit.

The force acting on ring is Lorentz force:

$$\vec{F} = \vec{F}_r + \vec{F}_l \quad (6)$$

where:

$\vec{F}_r$ is Lorentz force acting on right side of magnetic core; $\vec{F}_l$ is Lorentz force acting on left side of magnetic core.

$$\vec{F}_r = \vec{F}_l \quad (7)$$

$$\vec{F}_r = i_r \int \overrightarrow{dl_r} \times \overrightarrow{B_r} \quad (8)$$

where:

i_r is the induced current in ring; l_r is the arc of ring inside the air gap of right side magnetic core; B_r is the radial magnetic field density inside the air gap of right side of magnetic circuit created by magnetic field coil.

Because the l_r is constant let find i_r and B_r.

$$i_r = i_{ri} - i_{rB} \quad (9)$$

where:

i_{ri} is the induced current in ring by the induction coil; i_{rB} is the induced current in ring by the magnetic field coil.

Because the time constant of induction coil is larger than the time where the coil is powered ($\tau > t_i$) the induction coil will work on the linear part variation of current in coil (fig.7).

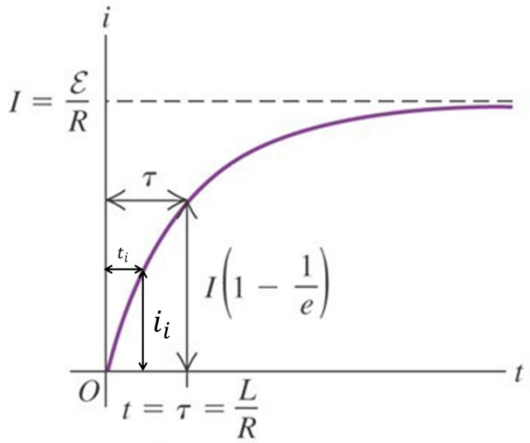

Fig. 7 t_i working time of a stage

The current is induced in ring using the same principle like in a transformer with concentrically windings. Because the ring is moving and the time spent in one stage is very short the induction coil can be powered with DC current and the variation of current is enough to induce a current in the ring.

We wrote the instantaneous currents equations for the time t_s inside the working time $0 \le t_s \le t_i$.

$$i_{rI}(t_s) = -M_{Is}\frac{dI_I/dt}{R_r} = -M_{Is}\frac{\varepsilon_{Is} - i_{Is}R_I}{L_{Is}R_r} \quad (10)$$

$$i_{rB}(t_s) = -M_{Bs}\frac{dI_B/dt}{R_r} = -M_{Bs}\frac{\varepsilon_{Bs}-i_{Bs}R_B}{L_{Bs}R_r} \quad (11)$$

$$i_r(t_s) = -\frac{1}{R_r}\left(M_{Is}\frac{\varepsilon_{Is}-i_{Is}R_I}{L_{Is}} - M_{Bs}\frac{\varepsilon_{Bs}-i_{Bs}R_B}{L_{Bs}}\right) \quad (12)$$

where:

R_r is resistance of ring inside the air gap of right side magnetic core; M_I is the mutual inductance between induction coil and ring; ε_I is DC source voltage of induction coil; i_I is current inside induction coil; R_I is resistance of induction coil; L_I is inductance of induction coil; M_B is the mutual inductance between magnetic field coil and ring; ε_B is DC source voltage of magnetic field coil; i_B is current inside magnetic field coil; R_B is resistance of magnetic field coil; L_B is inductance of magnetic field coil.

The mutual inductance between induction coil and ring M_I is constant

$$M_I = \frac{\mu_0 N_I A_I}{l_I} \quad (13)$$

The mutual inductance between magnetic field coil and ring M_B depend by the position z of the ring. When the ring is moving the mutual inductance M_B will decrease because the flux decrease when the distance z between ring and magnetic field coil increase.

$$M_B(z) = \frac{\Phi_{rB}(z)}{i_B} \quad (14)$$

As we can see the projectile is the ring made by aluminum for less resistance in order to obtain the maximum induced current. In order to increase the variation speed of magnetic field the value of inductance L_I of induction coil must be keep it at low level. The value of inductance L_B of magnetic field coil must be at high level. This also helps us to obtain a higher value of radial magnetic field B_r inside air gap.

$$B_r(t_s) = \frac{1}{2}B_B(t_s) = \frac{1}{2}L_{Bs}\frac{i_{Bs}}{N_B A_{core}} \quad (15)$$

where:

B_B is all magnetic field created by magnetic field coil; N_B is turns of magnetic field coil; A_{core} is the transversal surface of air core (we assumed all magnetic flux is inside core and cross the air gap).This design was multiplied four times resulting two fluxes multistage induction coilgun presented in fig.8.

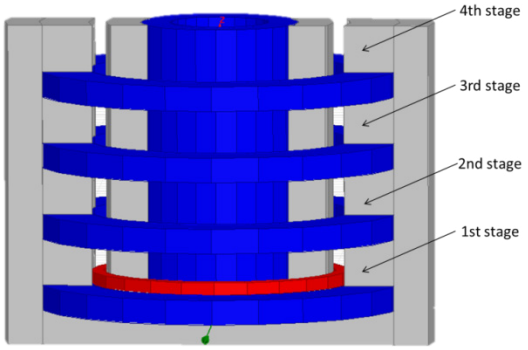

Fig. 8 4th Stages two fluxes induction coilgun

When the ring is reaching the second stage it already has an initial speed and the accelerating time will be shorter than in first stage ($t_1 > t_2$).

In order to achieve the same amount of current in the second induction coil in a shorter time we will use a higher voltage. At the end all stages will function at the same amount of current but the voltage will be increased accordingly. The magnetic field B is created by the magnetic field coil. The magnetic circuit created around this coil provides a perpendicular magnetic field on ring inside the air gap where the ring is moving. Both coils induction coil and magnetic field coil are powered at the same time. When the ring reaches next stage the power is switched off in first stage and switched on in the next stage, with increased voltage.

In order to check the validity of this design the following dimensions of this design was calculated. The dimensions were calculated for an experimental model which was built for laboratory measurements for E shape design [2] in order to obtain a great acceleration force. The mass of aluminum ring was calculated at 10 grams. We started from dimensions of device used for E shaped design and during simulation we changed dimensions in order to obtain the maximum speed of ring.

Table 1 Coil parameters

Induction coil	Inner radius	20 mm
	Outer radius	32 mm
	Length	29 mm
	Number of turns	300
Magnetic field coil	Inner radius	53 mm
	Outer radius	73 mm
	Length	10 mm
	Number of turns	300
Ring	Inner radius	47 mm
	Outer radius	52 mm
	Length	5 mm
	Number of turns	1

These dimensions will allow us to build a real model and to make measurements according to our laboratory possibilities. The Maxwell interactive software package that uses the finite element method (FEM) was used to analyze, solve 3D electromagnetic field problems, and simulate two fluxes multistage induction coilgun design. Because the presented equations give us only an image of which dimensions should be modified in order to obtain high speed of projectile we used Maxwell software to simulate the transient interaction between all parts. Through those simulations we fund the right dimensions and calculated the values of all dimensions without the simplified assumptions.

3. SIMULATION RESULTS

The coilgun with dimensions already calculated was build using 3D simulation software.

During the simulation we limited the current inside induction coils at 1600 A in order to protect the real coils. The values of voltages and duration of pulses for every stage are presented in Table 2. In this simulation both coils from the same stage were powered with the same voltage.

Table 2 Stages parameters

Stage 1	Voltage (V1)	3600V
	Time (t1)	1.7 ms
Stage 2	Voltage (V2)	5600V
	Time (t2)	1 ms
Stage 3	Voltage (V3)	9600V
	Time (t3)	0.55 ms
Stage 4	Voltage (V4)	11600V
	Time (t4)	0.4 ms

The variation of induced current inside ring is presented in fig.9.

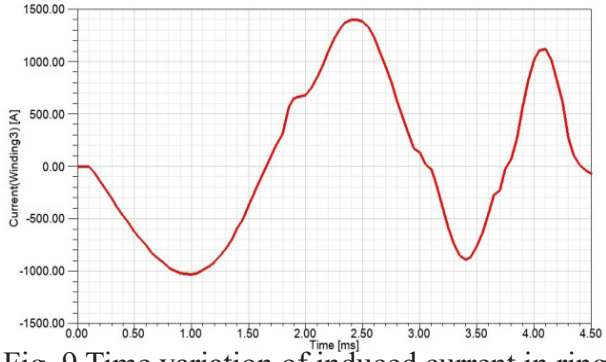

Fig. 9 Time variation of induced current in ring

In order to obtain this variation each stage was powered in opposition with previous stage. The time variation of current in accelerating coils is presented in fig.10. As we can see each stage is powered in opposition with previous stage when the ring is passing a certain position after the previous stage was switched off.

The current inside the induction coils are limited at 1600 A. The current inside the magnetic field coils reach the maximum value at 500A.

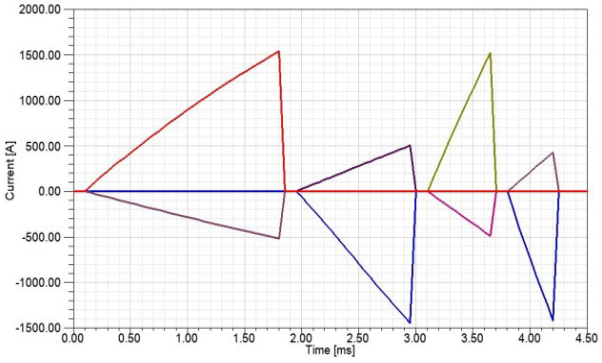

Fig. 10 Time variation of acceleration coil currents

Also the power time of each stage decrease according with values presented in table 2.From the graph in fig. 11 we can see the variation of current in induction coils is higher than variation of current in magnetic field coils.

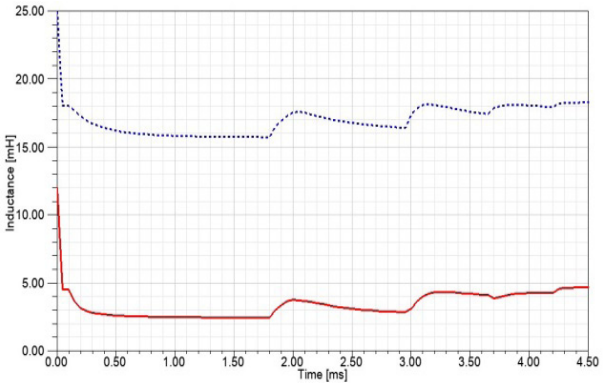

Fig. 11 Time variation of self-inductance L_B and L_I

From the fig.11 we can see the time variation of inductance for induction coil and magnetic field coil from stage 1.

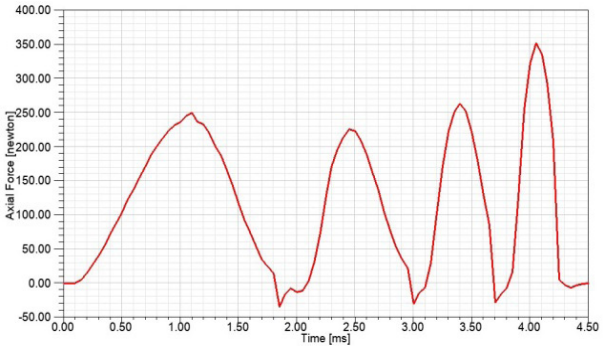

Fig. 12 Time variation of accelerating force acting on ring

From the fig.12 we can see the Lorentz force is acting on ring during entire time when the ring is inside a stage. The time when the Lorentz force is acting on ring is decreased in higher stages but the maximum value of force is around 250 N. This design creates significant forces only on axial direction for ring acceleration. The forces on radial direction are kept at low values as is shoved in fig.13. The maximum force on radial direction is 7.5 N.

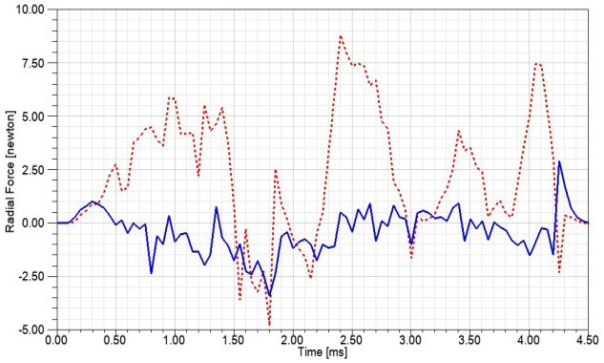

Fig. 13 Time variation of radial forces on ring

At the end the speed of ring was calculated for each stage in order to determine the muzzle velocity.

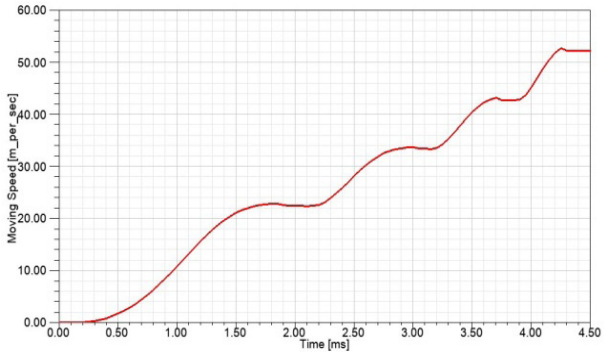

Fig. 14 Time variation of ring velocity

The ring is continuous accelerated from 0 m/s to 53 m/s in 4.3 ms. The value of muzzle velocities of ring is not very important at this time because should be validated in a practical experiment. The important thing is this design can accelerate a projectile using multiple stages without creating strong radial forces and without contact between projectile and coils.

CONCLUSION

The two fluxes multistage induction coilgun design offer multiple advantages over single flux designs. First we can control much efficient the induced current in ring and the induced coil current is kept at low values. Second the direction of magnetic field density *B* inside the air gap is radial on ring and the Lorentz force is acting on ring during entire length of magnetic circuit. Because the magnetic field density *B* is created by a different coil we can manage to keep the magnetic circuit unsaturated for a great efficiency. By using the Faraday's induction law in order to replace the physical contact between projectile and accelerator, the ferromagnetic materials for a strong magnetic field density *B* and a proper timing of switching power on/off we can create a better electromagnetic launch system able to launch a projectile at the desire velocity with less energy.

The next step is to build a laboratory model in order to prove in practice the values obtained through simulation.

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CONSIDERATIONS REGARDING THE DYNAMIC BALANCING OF COMPLEX ROTORS

Alexandru TUDORACHE, Ion FUIOREA
INCD Turbomotoare COMOTI, Bucharest, Romania
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Abstract: *Dynamic balancing of the rotor is a fundamental requirement for the smooth operation of any turbomachinery. Unbalance in a machine is recognized as one of the major factors that can lead to machinery malfunction and even catastrophic failure, and may result from its initial manufacturing process or may occur as a result of various operating factors such as machine erosion, thermal effects or unbalance buildup of process material on impellers and surfaces of the rotor. The purpose of this paper is to analyze the theory behind the dynamic balancing of rotors and to describe the process of applying it in the case of a complex rotor. The paper details the types of unbalance in rotors that have been classified, initial unbalance resulting from manufacturing or those that appear while operating, and the process of balancing of rigid rotors (two centrifugal compressor rotors) and a flexible rotor (the main assembly which contains the two centrifugal compressor rotors)..*
Keywords: *dynamic balancing, unbalance, complex rotors.*

1. INTRODUCTION

Rotor balancing is a fundamental requirement for the smooth operation of turbomachinery. Ideally, in the operation of all rotating machinery, the inertia axis of the rotor lies along the rotor spin axis, but in reality, this does not happen and centrifugal moments and forces that are being generated can be transmitted to the bearings or the supporting structure. This unbalance may lead to a motion with large amplitudes that may destroy the shaft, bearings, or the structure. This is why the unbalance of rotors is considered one of the major factors that can lead to machinery malfunction or even failure.

There are many reasons that unbalance may be present in a rotor, the most common being [1]:

a) Blow holes in castings – may be present within the material, undetectable through normal visual inspection and may represent a truly significant unbalance;

b) Eccentricity – exists when the central principal axis of a part does not coincide with its rotating centerline;

c) Addition of keys and keyways – there are few industry-wide standards regarding the addition of keys when balancing components. If two components are balanced without a key, but the two components are then assembled with a key, unbalance will result. Similarly, if both components are balanced with a full key, the assembled units would be unbalanced.

d) Distortion – although a part may be reasonably well balanced following manufacture, there are many influences which may distort or change the shape of a rotor and alter its original balance. Common causes are stress relief and thermal distortion;

e) Clearance tolerances – a common source of unbalance is the stack-up of tolerances possible in the assembly of a machine. Tolerances for the different parts accumulate and produce unbalance;

f) Corrosion and wear – many rotors, particularly fan, blower, compressor and pump rotors, are subject to corrosion, abrasion or wear, that usually do not occur uniformly, resulting in the appearance of unbalance;

g) Deposit build-up – rotors used in material handling may become unbalanced due to the unequal build-up of deposits (dirt, lime, ash, etc.) on the rotor, and the resulting gradual increase in unbalance can quickly become a serious problem;

h) Unsymmetrical configurations – many rotors are manufactured in ways that produce dissymmetry, for example rough surfaces on forgings, core shifts in castings, unsymmetrical parts such as crankshafts, etc;

i) Hydraulic or aerodynamic unbalance – oil trapped in oil galleries, oil trapped in grinding wheels, and cavitation or turbulence can sometimes produce unbalance forces.

All of the above causes of unbalance can exist to some degree in a rotor.

The vector summation of all their effects can be considered as a concentration at a point termed the "heavy spot". Balancing, then, is the technique for determining the amount of material and location of this heavy spot so that an equal amount of mass can be removed at this location or an equal amount of mass added directly opposite.

Multistage turborotors (compressors, pumps, turbines, etc.) have a residual unbalance due to the assembly of multiple components. Manufacturers usually employ procedures, to insure the initial balancing of their machinery, which generally involve balancing using commercial balancing machines based on either the soft bearing or the hard bearing support methods or using resonant machines. Dynamic balancing usually involves using two planes of correction, and can lead to very high accuracies.

After the rotor has been placed into service, unbalance may appear in the system due to many factors, best described in Table 3.1 by E. J. Gunter & C. Jackson, 1988 [2]:

a. Detectable runout on slow rotation (center of gravity runs to bottom on knife-edges) – Disk or component eccentric on shaft;

b. Measurable lack of symmetry – Dimensional inaccuracies;

c. Detectable runout – Eccentric machining or forming inaccuracies;

d. Detectable angular runout; measured with dial gauge on knife-edges – Oblique-angled component;

e. Detectable runout on slow rotation, often heavy vibration during rotation – Bent shaft; distorted assembly; stress relaxation with time;

f. Visually observable bearing vibration during operation, possible process pulsations – Section of blade or vane broken off;

g. Bearing vibration – Eccentric accumulation of process dirt on surface; Non-uniform process erosion;

h. Shaft bends and throws out center of gravity; heavy vibration – Differential thermal expansion;

i. Rotor machined concentric, bearing vibration during operation; possible process pulsations – Non-homogenous component structure; subsurface voids in casting;

j. Vibration reappears after balancing because of components angular movement; possible vibration magnitude and phase changes – Loose bolt or component slip;

k. Vibration reappears after balancing; apparent angular movement of center of gravity; possible vibration magnitude and phase changes – Trapped fluid inside rotor, possible condensing or vaporizing with process cycle;

l. Bearing vibration; eccentric orbit with possible multi-loops; frequency of vibration is 1, 2 or more per revolution – Ball-bearing wear.

2. THE METHODS

Balancing has been a subject of interest for over one hundred years. The literature in this specific field is extensive, with thousands of references regarding rigid and flexible rotor balancing written, as well as balancing standards developed by various organizations.

The methods used for this study are those set by the Romanian Research & Development Institute For Gas Turbines – COMOTI and IRD Mechanalysis, Inc., in accordance with the international standards ISO 1925 – 2001 Mechanical vibration – Balancing – Vocabulary, ISO 19499 – 2007 – Mechanical vibration – Balancing – Guidance on the use and application of balancing standards, ISO 1940-1:2003 – Mechanical vibration – balance quality requirements for rotors in a constant (rigid) state – Part 1 – Specification and verification of balance tolerances, and ISO 1940-2:1997 – Mechanical vibration – balance quality requirements for rotors in a constant (rigid) state – Part 2 – Balance errors.

2.1. Basic principles of balancing

Balancing is the process by which we determine the amount and angular location of the heavy spot so we can either add an equal amount of mass to the opposite side of the rotor or remove mass at the heavy spot. We know that the more unbalance we have, the greater the force and, thus, the greater the amplitude of vibration. For this reason when balancing in place, we use the amplitude of vibration to help us determine how much unbalance we have. In addition, we use the position of a reference mark on the part as seen by an analyzer strobe light to help us find the location of the unbalance.

2.2. Dynamic unbalance

It is perhaps the most common type of unbalance and is defined simply as unbalance where *the central principal axis and the rotating centerline do not coincide or touch*. This type of unbalance exist whenever static and couple unbalance are present, but where the static unbalance is not in direct line with either couple components. As a result, the central principal axis is both tilted and displaced from the rotating centerline. Generally, a condition of dynamic unbalance will reveal comparative phase readings which are neither the same nor directly opposite one another. This type of unbalance can only be solved by making corrections in a minimum of two planes.

2.3. Two-plane balancing techniques

The choice of balancing technique will depend on several factors such as unbalance configuration, length-to-diameter ratio, balance speed compared to operating speed, rotor flexibility and amount of cross-effect.

Two-plane balancing techniques are:

a. Separate single plane approach – used when the rotor length to diameter ratio is large;

b. Simultaneous single-plane approach – used when the rotor length to diameter ratio is large and the original unbalance vector indicates a predominantly static or dynamic unbalance configuration;

c. Force/Couple Derivation – used in overhung rotor configurations and some standard rotors;

d. Two-plane vector calculations: either a graphical method or by using an automatic balancing instrument or programmable hand calculator.

2.4. Cross-effect

Also called "correction plane interference", can be defined as the effect on the unbalance indication at one end of a rotor caused by unbalance at the opposite end. Because of cross-effect, the unbalance indications observed at each end of a rotor do not truly represent the unbalance in their respective correction planes. Instead, each indication will be the resultant of unbalance in the associated correction plane plus the cross-effect from the opposite end. At the start of a balancing problem, there is no way of knowing the amount and phase of cross-effect. In addition, the amount and phase of cross-effect will be different for different machines. For this specific study, a two-plane balancing method has been used, together with an IRD Mechanalysis Inc. balancing instrument.

Each component of the assembly has been balanced individually to reduce the final assembly residual unbalance as much as possible. The limits for the residual unbalance of each component were calculated using formulas specific to the type of rotor placement.

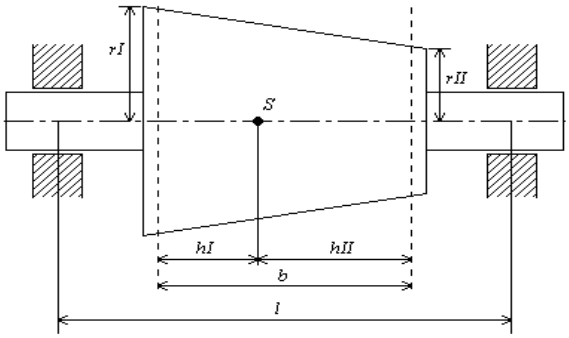

Fig. 2.4. "Long-asymmetrical" rotor placement

$$U_{lim} = \frac{9549 \cdot G \cdot m}{n} \text{ gmm} \quad (1)$$

Where: U_{lim} is the total unbalance limit G is the balance quality depending on rotor type; m is the rotor mass; n is the working speed of the rotor.

This total unbalance limit is then split in two limits, one for each bearing. This split depends on knowing the rotor center of mass (marked with "S" in Fig.2.4.), but if it is not known, an educated approximation will suffice.

$$U_{lim1} = U_{lim} \cdot \frac{h_I}{b} \text{ gmm} \quad (2)$$

$$U_{lim2} = U_{lim} \cdot \frac{h_{II}}{b} \text{ gmm} \quad (3)$$

Where: U_{lim1} / U_{lim2} are the unbalance limits for each bearing; U_{lim} is the total unbalance limit previously calculated; h_I / h_{II} are the distances between each correction plane and the center of mass; b is the distance between the correction planes (marked by the dashed lines in Fig.2.4.).

To find out the limit of the unbalance mass, we only need to divide the unbalance limit of each bearing by the radius at which the corrections are made (r_I and r_{II} in Fig.2.4.).

The dimension "l" in Fig.2.4. is not used in any calculation for this rotor placement. Its only purpose here is to accurately position the balancing machine bearings according to the rotor bearings, because it is recommended, if possible, to place the rotor exactly how it would be placed in the machinery that uses it.

It is important that the rotor is leveled, so it could spin parallel to the ground, to insure a normal distribution of unbalance to each bearing.

Then, a piece of reflective tape is placed on the rotor, thus determining the phase angle 0 position.

Next, three calibration runs are needed to calibrate the balancing instrument with the rotor being balanced.

The first run measures the amplitude of the unbalance (in μm) using two sensors (one on each of the two soft bearings on which the rotor rests).

The next two runs are needed to measure the change in amplitude when a calibration weight is added, first only to the left plane, second only to the right plane.

This is done to accurately determine the weight needed to balance the rotor by calculating how many grams are needed for each μm of amplitude. Since the reflective tape marks the 0 angle position, the angular position of the peak amplitude can easily be determined for each correction plane.

Corrections were made to two of the five components (specifically the two centrifugal compressor rotors) by placing weights opposite of the determined angular position for each heavy point of the two correction planes until the unbalance was reduced to a value below the calculated residual unbalance limits, thus confirming the position where mass must be removed to balance the rotor.

To prevent removal of too much material, the right plane of each rotor was left untouched to be able to use them as balancing planes when the final assembly would be balanced

Using the previously mentioned formulas, (1),(2) and (3), the residual unbalance limits have been calculated for the two centrifugal compressor rotors, working at 22000 RPM, with the balancing grade G2.5:

-1st stage (mass 45 kg): $U_{lim} = 48.8\ gmm$, $U_{lim1} = 18.3\ gmm$ and $U_{lim2} = 30.5\ gmm$;

-2nd stage (mass 35 kg): $U_{lim} = 38\ gmm$, $U_{lim1} = 13.3\ gmm$ and $U_{lim2} = 24.7\ gmm$.

3. RESULTS

After balancing, the residual unbalance for the first stage (balanced at 528 RPM) is 14 gmm at 161° in the left balancing plane, with 1.11 μm amplitude of vibration in the left bearing (front of rotor), meaning 23% lower than the limit, and 24 gmm at 326° in the right balancing plane, with 1.86 μm amplitude of vibration in the right bearing (back of rotor), meaning 21% lower than the limit.

The residual unbalance for the second stage (balanced at 573 RPM) is 9.1 gmm at 0° in the left balancing plane, with 0.824 μm amplitude of vibration in the left bearing (front of rotor), meaning 31% lower than the limit, and 13.2 gmm at 45° in the right balancing plane, with 0.906 μm amplitude of vibration in the right bearing (back of rotor), meaning 46% lower than the limit. As previously stated, material was removed only in the left planes.

For the main assembly the residual unbalance limits have been calculated as $U_{lim} = 166.7\ gmm$, $U_{lim1} = 96.5\ gmm$ and $U_{lim2} = 70.2\ gmm$, considering the assembly mass 105 kg, balancing grade G2.5 and working speed of 22000 RPM.

Unlike the centrifugal compressor rotors, the main assembly is flexible and has critical speeds that need to be taken into consideration. In this case, we have found the first critical speed to be between 500 RPM and 600 RPM, where the amplitude of vibration jumps to very high values (65-70 μm) and returns to more reasonable values (10-15 μm) at 700 RPM.

After balancing (at 734 RPM), the residual unbalance of the main assembly is 42 gmm at 97° in the left plane, with 0.58 μm amplitude of vibration in the left bearing (front of assembly), meaning 46% lower than the limit, and 47.2 gmm at 213° in the right plane, with 0.97 μm amplitude of vibration in the right bearing (back of assembly), meaning 32% lower than the limit.

CONCLUSIONS

In this study we have emphasized the importance of combining balancing techniques, having patience and not rushing to remove material as soon as the heavy point is found.

Individual parts of complex assemblies must be balanced but not necessarily have material removed from them.

One must always have a picture of the final assembly in mind to have a better understanding of how the parts will all be put together.

Some residual unbalances might cancel each other out, or at least decrease in magnitude, should the part placement in the final assembly be made, if possible, considering the position of the heavy point for each part.

In some cases the heavy point shifts to another angular position in the final assembly planes of correction.

This mix of procedures and techniques could be applied to many other complex assemblies like multistage axial compressor disks or multistage axial turbine disks, as well as other assemblies that require both individual part balancing and final assembly balancing.

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THE STUDY OF THE INFLUENCE OF PROPELLANT PERFORMANCES CHANGES ON THE BALLISTIC CHARACTERISTICS OF ANTI-HAIL ROCKET

Cristina MIHAILESCU, **Marius RADULESCU**
SC Electromecanica Ploiesti SA, ROMANIA
DOI: 10.19062/1842-9238.2015.13.3.9

Abstract: *The paper proposes to analyse the influence of utilising an alternant propellant with similar characteristics on ballistic performances of anti-hail rocket. For that purpose a comparative analyse of usual performances of rockets used so far will be made, giving a special attention to the safety aspects of product operation. Following these results was obtained several relevant recommendations helpful in the future development of this kind of weather modification means, and in anti-hail working procedures also.*
Keywords: *rocket, hail, propellant, trajectory*

1. INTRODUCTION

A national anti-hail system was established in our country in 1999 based on the cloud's seeding method using silver iodide. The method of seeding the clouds with ground-launched rockets was chosen according to the national strategy [1], [2].

Fig. 1 Anti-hail rocket and launch platform

The system is composed of several fighting hail units. A hail Combat Unit includes a weather station equipped with weather radar with a Doppler effect, a central control point and several local units of anti-hail rocket launch (Fig. 1).

The functioning of anti-hail rocket ensures the transport of reactive agents at the necessary altitude where the substances are spreading according to rocket's sequences presented in figure 2. For secure reasons the self-destruction must occurred at a pre-set altitude.

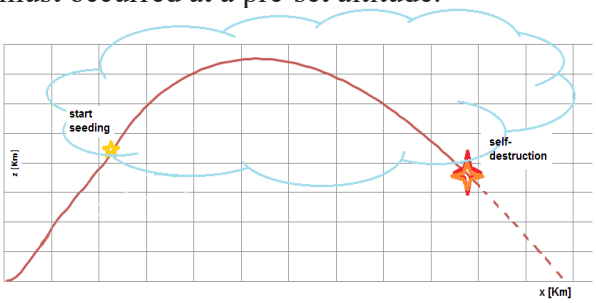

Fig. 2 Rocket's sequences

Unlikely the rocket terminology we define the active zone of the rocket's trajectory as the zone between the start seeding point and self-destruction point. The active zone of the trajectory determines some constraints in positioning of launching units. The launching units' disposal the must be designed according to radial active area resulted, so as to obtain a better coverage of the desired protected area.

The component that ensures the required propulsion power is the rocket engine, propellant playing a crucial role.

Since there are various suppliers in the market results differences in propellant's performance. The aim of this paper is to quantify the deviations due to these differences in the functional characteristics of the product and to set acceptable limits for the propellant's performance.

2. MODEL DESCRIPTION

In order to predict the trajectory of an unguided rocket, six degrees of freedom (6-DOF) mathematical model is used according to [4,8]. All aerodynamic forces and moments coefficients of the configuration are previously calculated according to [3], and they are considered as input data.

The mass properties (mass, mass centre, moments of inertia) are calculated considering the change of the rocket mass during propellant burning till the propellant burn-out (active part), then the rocket will fly the rest of its trajectory as a projectile of fixed mass (passive part) until self-destruction. The 6-DOF model assumed the rocket is ideal, where the axis of symmetry of the exterior surface coincides with the longitudinal principal axis of inertia, and the two lateral principal moments of inertia are identical.The input data for calculations and for obtaining the necessary data for simulation of rocket trajectory are (table 1): mass and geometric data, experimentally data for thrust obtained on firing bench (Fig. 3) for different temperatures and the input parameters of launching conditions: launch angle, wind speed etc.

Table 1

Input data	model (product) standard	model (product) modified	Difference %
initial mass [kg]	8.5	8.2	3.53
final mass [kg]	4.87	4.87	0.
initial mass center [mm]	750	640	1.33
final mass center [mm]	686	686	0.

For the present paper two double base propellants with little geometry differences (both existing on market) were utilized as components in propulsion system of the rocket.

This will induce differences of input data for thrust value, burning time, mass variation in time, and others that will conduct inevitable to other results for trajectory of the rocket [5,7].

The aerodynamic configurations are the same for both cases. All the deviations in rocket functioning must be evaluated. In figure 3 there are represented the thrust diagram for the standard and modified models.

The thrust data are obtained experimentally by testing the rocket engine on the firing bench based on methodology described in [6].

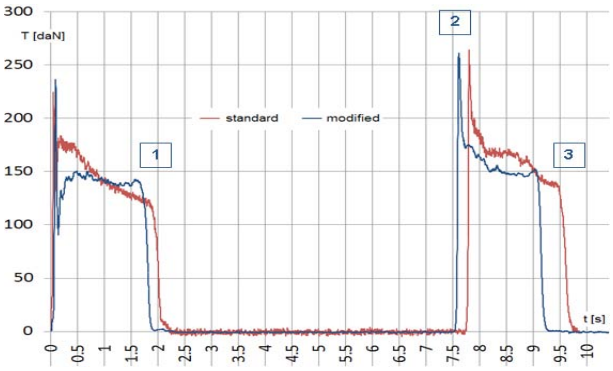

Fig. 3 Thrust diagram
(experimental bench data)

The propulsion occurs in 2 steps (corresponding to the two stages - see Fig. 3), separated by a delay time. The measurements performed for the force vs time provide necessary information to estimate the average value of thrust and specific impulse for each propellant.

Moment 1 corresponds to the final of stage1, also marking the burning time for stage1, moment 2 corresponds to the beginning of stage2 - burning and moment 3 corresponds to the final of stage 2 (Fig. 3). Knowing the experimental values *T(t)* from the thrust diagram (Fig. 3) for both rocket engines, the average value of thrust for each stage was calculated as the average value of a function:

$$T_m = \frac{\int_{t_i}^{t_j} T(t)dt}{\Delta t} \quad (1)$$

All these average values of thrust are presented in Table 2 for both models.

Table 2

Parameter	standard	modified	Difference %
Propellant mass [kg]	3.1	2.8	9.68
Average value of thrust for stage1 [daN]	132.68	132.5	0.14
Average value of thrust for stage2 [daN]	146.93	146.17	0.52
moment 1 [s]	2.15	1.85	11.63
moment 2 [s]	7.75	7.6	1.94
moment 3 [s]	9.75	9.25	5.13
self-destruction [s]	43.5	42.45	2.41

By definition, the specific impulse for each stage is:

$$I_{sp} = \frac{T_m}{\dot{m}.g_0} \quad [s] \qquad (2)$$

Where:

T_m is the average value of thrust obtained from the engine [N];

$\dot{m}$ is the mass flow rate [Kg/s];

g_0 is the acceleration at the Earth's surface [m/s^2].

Although the difference of thrust between the two propellants is not significant, however the difference of specific impulse is 4,86% for the first stage, while 5,83% is the difference for the second stage.

Because the geometric configuration is the same all the aerodynamic coefficients are unchanged.

The static stability margin is defined as the distance between the center-of-pressure *(CP)* and center-of-gravity *(CG)* locations normalized with respect to the body length *l*:

$$SM = \frac{X_{CP} - X_{CG}}{l} \qquad (3)$$

The influence of mass variation is reflected in variation of centre mass position. Since CP position is the same because the geometry is unchanged only the differences of CG position will have an influence. Analysing the variation of CG position we conclude that are less than 2% (Table 1), so the differences are too small to endanger the static stability of the rocket.

3. SIMULATION RESULTS

The results obtained refer to a number of parameters (coordinates, speed, angles, etc. vs. time) that describe the performance of the rocket during flight.

For this type of rocket will have to pay attention to:

- maximum range position and time
- maximum altitude position and time
- position and time for start-seeding
- position and time for self-destruction
- distance during seeding and duration

Analysis was performed for all the necessary launching angles, but in the present paper only results for 45^0 and 50^0 will be referred. Because it will make a comparative analysis, these trajectory diagrams will be represented compared to the standard case, as in figure 4.

For a better interpretation the time moments corresponding to the associate position in space are also represented on the diagram.

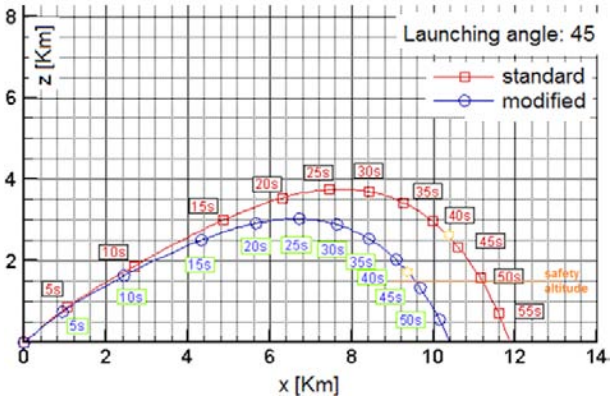

Fig. 4 The trajectories

For this case a difference in maximum altitude reached is about 25% and the maximum range decreased by about 8%. The trajectory being shorter and lower determines the total flight time to be decreased by 12%. Since the time of self-destruction must be achieved at a safe altitude of more than 1500 m, the rocket position in time must be carefully examined during flight. From figure 4 we can observe that the self-destruction (marked with yellow on the trajectories diagram) occurs lower than in standard case, so the limit of secure altitude became narrower.

CONCLUSIONS

Regarding the influence of these changes in the organization of the national system, there are two possible approaches:

i. Starting from the acceptable limits of positioning trajectories according to existing launching units and constraints of the evolution (time for seeding, time and position for self-destruction) will result limitations imposed to the propellant performances.We conclude that for the studied case a decreasing of 6% in specific impulse is the accepted lower limit for the performances of propellant. Anyway a modification of propellant, even in the accepted limits, must be studied from the point of view of all the constraints of the product functioning (trajectory via seeding time and launching angle, time and position for self-destruction, etc.)

ii. Starting from deviations that may have the propellants in the same range, just results trajectory deviations that have to be declared as acceptable and to be taken into account in future launching unit's disposal.

One particular zone of trajectory is very important. This is the active zone where the rocket performs cloud's seeding and it is important to be on the top side of trajectory on an area extended as much as possible to increase the rocket's efficiency. The area of significance (where the presence of seeding is necessary), as it is presented in figure 5, is traversed by the trajectory of standard rocket for the launching angle of 45 degrees. The length of active zone of trajectory inside the area of significance is a measure of anti-hail rocket's efficiency. We can observe that for the modified rocket the trajectory for the same launching angle is lower and the active zone inside the area of significance is shorter, therefore the efficiency of seeding is lower. A better matching for the area of significance is offered by the trajectory of 50 degrees launching angle, even though there is a noticeable horizontal shortening of the intervention.

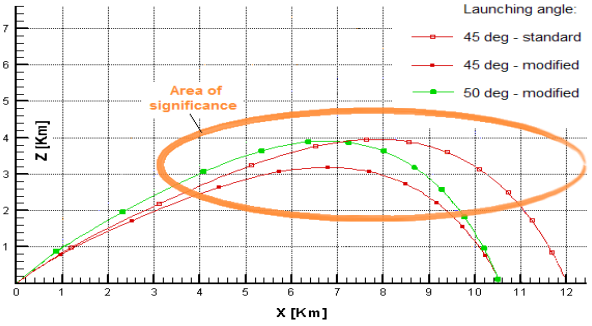

Fig 5 The seeding area

As a conclusion, the area of intervention is shorter than in standard case, and the launching angle must be increased to approach the performance from standard model. The problem have a real involvement in the operational procedures. Around the launching points, until the maximum effective range of the rocket, two zones can be distinguished (Fig. 6):

- the protection zone (near) - is the area protected 75% - 90%
- the processing zone (far) – is the area where is made the active intervention against hail (with some probability of hail falling)

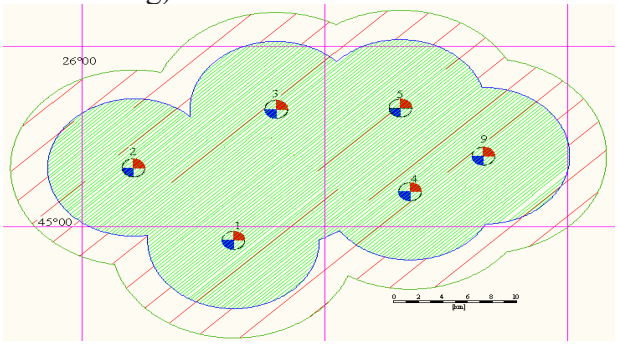

Fig. 6 The protection and processing zones

When a factor imposes to have a shorter seeding line, the processing zone became bigger and the protection zone decreases, that reduce the system efficiency.

In the case of predefined launching units inside the system will result the influence of these changes: for disposal of launching units is good to take into account such possible changes, resulting in an over coating that will allow trajectories to be within the effective area.

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CLOSED SPIRAL ANTENNA

Gheorghe MORARIU, **Mihai MIRON**
"Transilvania" University, Brasov, Romania
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Abstract: *The paper presents a model of fractal antenna having as resonance element a planar logarithmic spiral. The content highlights the resonance phenomenon analysis and technical design features accompanied by experimental results. Covering a very wide frequency band, having relatively small geometric dimensions and satisfactory gain, this antenna is recommended in mobile telephony, digital television and multiservice.*
Keywords: *antenna, fractal, resonance.*

1. INTRODUCTION

Fractal element antennas use fractal geometric structures as virtual combination of capacitors and coils (inductances). This allows the antenna to have several resonance frequencies that can be selected and corrected by fractal model chosen. In recent years it has been shown in many studies (Best, 2003), (Kumar, 2010), (Kumar, 2012), that the use of fractal elements in the construction of antennas provides superior properties and performances, validating the idea that geometry is a key issue in determining the unique electromagnetic behavior of antennas substantially independent of frequency (Lincy, 2013). The present paper is included in the cycle of works published by the authors and dedicated to the design and analysis of some fractal antenna types (e.g. Fractal Elliptical Segment Antenna; Fractal Sector Antenna with Resonators; Fractal Sector Stripline Antenna with Disks; Fractal Antenna with Hexagonal Resonators). Content of the work refers to a brief survey of the resonance phenomenon specific to the particular structure of the proposed antenna, the technical achievement and experimental results obtained in the process of testing the antenna.

2. THE RESONANCE PHENOMENA

Having as a resonant element the dipole formed from generated surfaces by logarithmic spirals, antenna in question is independent of radiant field polarization (admitting circular polarization) as described below.

Figure 1 shows the diagram of circular polarization on the border of a logarithmic spiral.

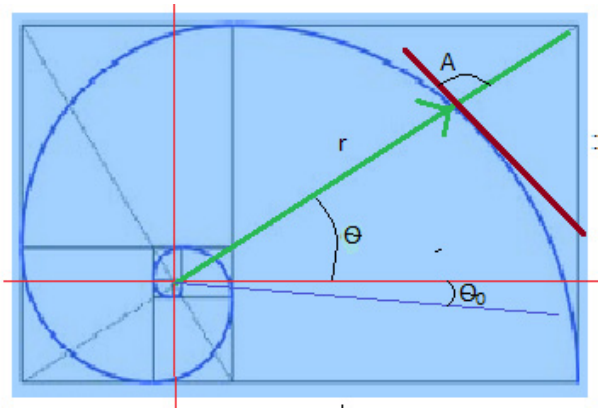


Fig. 1. The diagram of circular polarization on the border of a logarithmic spiral

$$\theta = \theta_0 + \operatorname{tg} A \cdot \ln r \quad (1)$$

where: θ_0 is the angle formed by the tangent to the spiral in origin.

$$\ln r = \frac{\theta - \theta_0}{\operatorname{tg} A} \quad (2)$$

$$r = e^{\frac{\theta - \theta_0}{tg\, A}} \quad (3)$$

If $r' = k \cdot r$, then

$$\theta' = \theta_0 + \operatorname{tg} A \cdot \ln(k \cdot r) \quad (4)$$

$$\theta' = \theta_0 + \operatorname{tg} A\, (\ln k + \ln r), \quad (5)$$

and

$$\theta' = \theta + \operatorname{tg} A \cdot \ln k\,. \quad (6)$$

It results that $\operatorname{tg} A \cdot \ln k$ is a rotation angle.

For k=1, the spiral degenerates into a circle: $\theta' = \theta$ and $r' = r$.

Frontier radiation

$$r = r_0 \cdot e^{\frac{\theta-\theta_0}{tg\ A}} \quad (7)$$

$$ctg\ A = b \quad (8)$$

$$r = r_0 \cdot e^{(\theta-\theta_0)\cdot b} \quad (9)$$

For $\theta_0 = 0$, the length of the spiral spring is

$$L_{sp} = \int_0^{\theta} \sqrt{r^2(\theta) - [dr(\theta)]^2}\ d\theta \quad (10)$$

$$L_{sp} = \frac{r_0}{b}\sqrt{1+b^2}(e^{b\cdot\theta} - 1) \quad (11)$$

The electric field intensity is:

$$E = \pm j \cdot Z_0 \cdot H_0 \cdot e^{j(\omega t - \varphi_0)} \quad (12)$$

Frontier radiant flux (Φ) for a segment corresponding to an opening of (0-θ) radians will be:

$$\varphi(E) = L_{sp} \cdot E \quad (13)$$

The radiant surface (S)

$$r = r_0 \cdot e^{\theta\cdot b} \quad (14)$$

$$r_0 = \rho \quad (15)$$

$$x = \rho \cdot e^{b\cdot\theta}\cos\theta \quad (16)$$

$$y = \rho \cdot e^{b\cdot\theta}\sin\theta \quad (17)$$

$$S = \int_0^{\rho}\int_0^{\theta}(y_1 - y_2)\,dx(\rho,\theta) \quad (18)$$

$$y_1 = \rho \cdot e^{b_1\cdot\theta}\sin\theta \quad (19)$$

$$y_2 = \rho \cdot e^{b_2\cdot\theta}\sin\theta \quad (20)$$

$$S = \rho^2\left(\frac{e^{2\cdot b\cdot\theta}}{4\cdot b}\right)\Big|_0^{\rho}\Big|_0^{\theta} \quad (21)$$

$$S = \frac{\rho^2}{4}\left(\frac{e^{2\cdot b_1\cdot\theta}-1}{b_1} - \frac{e^{2\cdot b_2\cdot\theta}-1}{b_2}\right) \quad (22)$$

3. TECHNICAL ACHIEVEMENT AND EXPERIMENTAL RESULTS

The construction of the antenna is based on a divergent fractal with square surface contour and sides divided by a factor of 2, where the logarithmic spiral dipoles are cut out (figure 2) respecting the following adaptation relationships.

$$w_0 = \frac{c}{2f_0}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (23)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1 + 12\frac{h}{w_0}\right)^{\frac{1}{2}} \quad (24)$$

$$\lambda_{c0} = 2\frac{c}{\sqrt{\varepsilon_{reff}}}\cdot\frac{1}{f_0}\cdot\frac{w_0}{L_{01}+L_{02}} \quad (25)$$

$$\lambda_{ci} = \frac{\lambda_{c0}}{2^i} \quad (26)$$

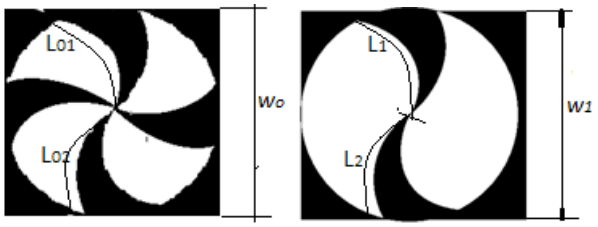


Fig. 2. The cutting of the logarithmic spiral dipoles

Take into consideration a reference frequency f_0 = 1,5Ghz and $\varepsilon_r = 2{,}25$, $\theta_1 = 34^0$, $\theta_2 = 46^0$, these values are calculated:

$w_0 = 8cm$;

$\varepsilon_{reff} = 2{,}14$;

$L_{01} = 5{,}2cm;\ L_{02} = 4{,}7cm$;

$\lambda_{C0} = 21cm$.

Corresponding to optimal wavelength λ_{ci}, i = 0 - n, for which are obtained the best antenna gain, are determined reference central frequencies of the fractal antenna.

Figure 3 and Figure 4 shows front and rear antenna architecture.

Fig. 3. The active face of the antenna

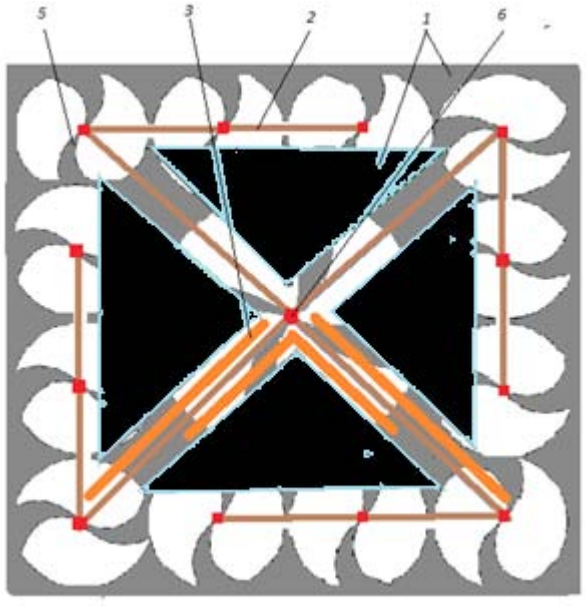


Fig. 4. Rear view of the antenna: 1- relative ground of the antenna, 2- resonator and signal collector, 3-section of line adaptation; 5- logarithmic spiral resonator; 6- signal socket

The experimental results are presented in sequential order as follows: directivity diagram, characteristic impedance variation, electric field on the central resonator, Smith charts obtained for two different frequency domains (through vector analyzer - VNA).

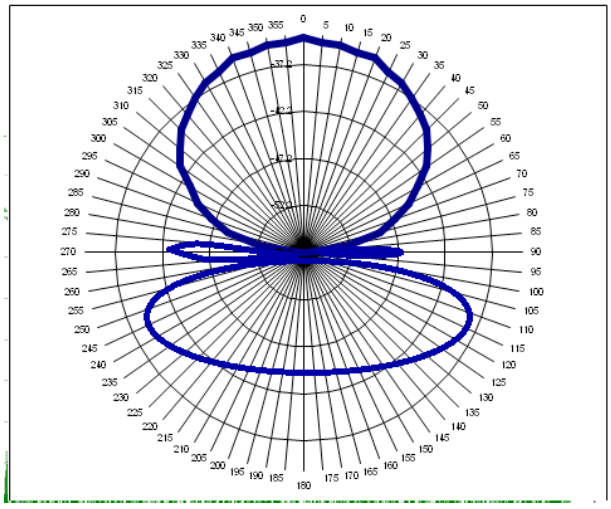


Fig. 5. Directivity diagram

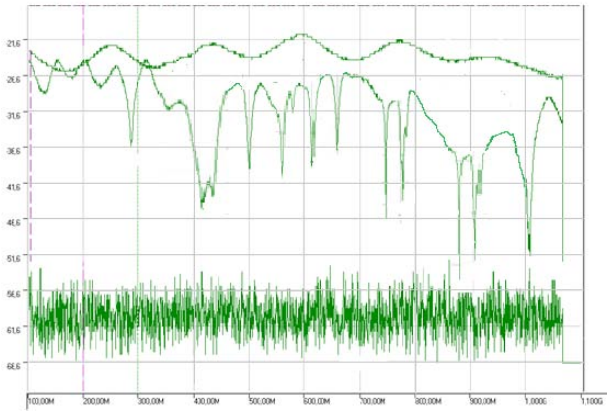


Fig. 6. VSWR for a 50Ω feeder

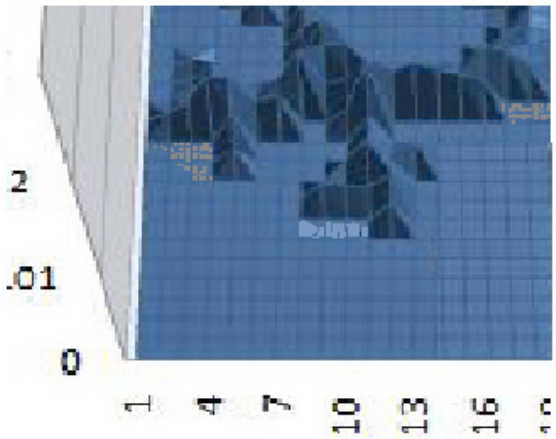
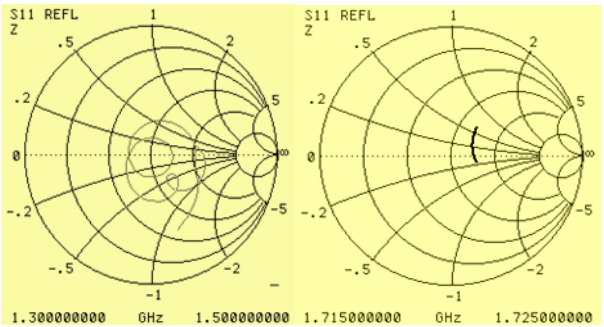


Fig. 7. Mapping of the electric field on the central resonator



a. **b.**

Fig. 8. Smith charts obtained for the frequency domains: a. 1.3-1.5GHz; b. 1.715-1.725GHz

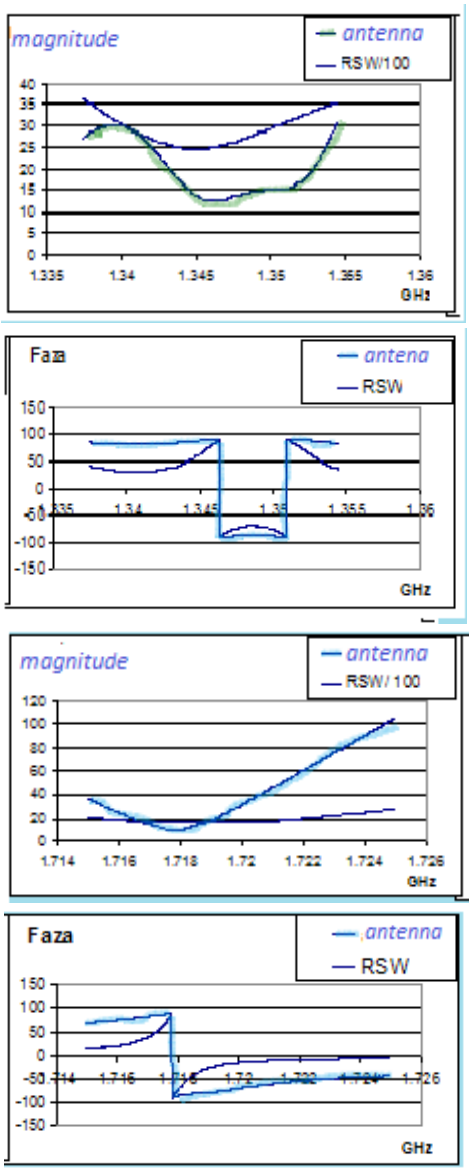


Fig. 9. VNA images for the frequency domains 1.335-1.36GHz and 1.714-1.726GHz

CONCLUSIONS

This antenna belongs to the class of fractal antennas (theoretically independent of frequency antennas) and operates in 100MHz-2.5GHz frequency band with 4-6dB gain. Through a good adaptation between fractal radiating elements and feeder it can obtain a gain of 7-8dB in a narrower frequency band.

Due to the characteristics, this antenna pattern achieved on a smaller scale can be used in digital communication; group delay can be below 2.5 periods at 2.5GHz.

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SECONDARY APPLICATIONS OF VECTOR ANALYSIS

Gheorghe MORARIU, **Otilia CROITORU**
"Transilvania" University, Brasov, Romania
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Abstract: *This paper presents an application of Vector Network Analyzer (VNA) in qualitative and quantitative spectral analysis in order to identify traces of chemical elements in a solution or complex substance. The work is based on reflectance spectrum analysis generated by a special built antenna containing the test sample, having as scientific support the different behavior of the two different elements in a field of microwave radiation. Their behavior is dependent on frequency and amplitude. The paper highlights some concrete results obtained experimentally.*
Keywords: *Vector Network Analyzer; reflection parameter; measurement.*

1. INTRODUCTION

The spectra obtained with the vector analyzer in microwaves range by transmission or reflectance, used in particular for the analysis of microwave circuits and devices, through this study, are used also to identify chemical elements or compounds.

The application describes the basic physical principle, measurement scheme and procedures to be followed to obtain the results. In the experimental part it was aimed at identifying sodium chloride NaCl concentrations of tens / hundreds of ppm in aqueous solutions.

2. APPLICATION CONTENT

2.1 Basic principle. Vector analyzer sees antenna system as impedance and measures the reflected signal from it, namely: S_{11} parameter from the Smith diagram and the reflection coefficient $\Gamma\Gamma$.

2.2 Calculation summary. The law of conservation of radiant flow $\gamma_{emitted} = \gamma_{transmitted} + \gamma_{absorbed} + \gamma_{reflected}$

$$\gamma_{emisie} = \gamma_{transmisie} + \gamma_{absorbție} + \gamma_{reflexie} \quad (1)$$

The spectral analyzer generates a power $P_{e\,dB} = 7dBm$ on a load impedance $Z_0 = 50\Omega$.

To convert the emission power in watts, is used the relationship:

$$P_{e\,dB} = 10\log_{10}\frac{P_e}{P_o} \quad (2)$$

where the power reference is:

$$P_o = 1\ mW \quad (3)$$

In this way it follows:

$$P_e = 10^{\frac{P_{dB}}{10}}\ mW = 10^{\frac{P_{dB}}{10}} \cdot 10^{-3}\ [W] \quad (4)$$

At the same time, the emission power is the sum of direct power and reflected power:

$$P_e = P_d + P_r \quad (5)$$

Depending on the reflected voltage U_r, we can write the reflected power:

$$P_r = \left|\frac{U_r^2}{2 \cdot Z_0}\right|\ [W] \quad (6)$$

The reflection coefficient is

$$\Gamma = \frac{Z_s - Z_o}{Z_s + Z_o} \quad (7)$$

and the load impedance

$$Z_s = R_s + j \cdot X_s \quad (8)$$

The emission voltage is the sum of direct and reflected voltage:

$$U_e = U_d + U_r \quad (9)$$

Knowing that

$$U_e^{\,2} = P_e \cdot Z_o = 10^{\frac{P_{dB}}{10}} \cdot 10^{-3} \cdot Z_o \Rightarrow U \frac{\sqrt{Z_o}}{10\sqrt{10}} \cdot 10^{\frac{P_{dB}}{20}}\ [V] \quad (10)$$

Direct voltage:

$$U_d = \frac{U_s}{1+\Gamma} \quad (11)$$

By processing the equation (7), for the reflection coefficient, we obtain:

$$Real(\Gamma) = \frac{R_s^2+X_s^2-Z_o^2}{(R_s+Z_o)^2+X_s^2} \quad (12)$$

$$Im(\Gamma) = \frac{2\cdot Z_o\cdot X_s}{(R_s+Z_o)^2+X_s^2} \quad (13)$$

The magnitude of the reflection coefficient:

$$|\Gamma| = \sqrt{Real(\Gamma)^2 + Im(\Gamma)^2} \quad (14)$$

The phase of the reflection coefficient:

$$\varphi_\Gamma = arctg\left(\frac{Im(\Gamma)}{Real(\Gamma)}\right)[rad] \quad (15)$$

$$\varphi_\Gamma{}^\circ = \frac{180\cdot\varphi_\Gamma}{\pi}[^\circ] \quad (16)$$

Magnitude relationship computing :

$$A_{dB} = 20\log_{10}\left(\frac{1}{Z_o}\sqrt{R_s^2+X_s^2}\right)[dB] \quad (17)$$

$$A = 10^{\frac{A_{dB}}{20}} \quad (18)$$

The reflected signal energy is calculated using the formula:

$$E = P_r\cdot\Delta t \quad (19)$$

where Δt is computed as period of time of the frequency band studied, divided by the number of samples:

$$\Delta t = \frac{t_{max}-t_{min}}{n} \quad (20)$$

Dielectric relative permittivity for water:

$$\varepsilon_r(t)_{water} = 87.740 - 0.40008t + 9.398(10^{-4})t^2 - 1.410(10^{-6})t^3,$$

$$\in_{r_{water}}(20^\circ) = 80 \quad (21)$$

2.3 The measuring scheme. The measurements were carried out using a scheme as in Fig.1, where the antenna measurement unit is shown in Fig. 2.

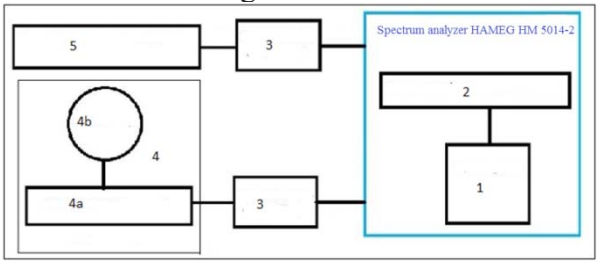

Fig. 1 The measuring scheme with the elements: 1 - VNA analyzer; 2 - processing interface; 3 - impedance adapters; 4 - antenna unit; 5 - reference antenna (witness).

Performing experiments are done at a constant temperature of 20º C and 20 ml test volume, following the procedures below:

- Preparing the reference of double-distilled water (pure water in an amount of 20 ml);
- Preparing the etalons with fixed concentration of sodium chloride in: 50 ppm NaCl; 100 ppm NaCl; 200ppm NaCl;
- Preparing the samples for examination: mineral water and current water, public drinking pipe (20 ml each);
- Work with spectral analyzer:
  - Selection of active frequency bands;
  - Viewing the reflection parameter with circular diagrams;
  - Data storage on memory stick.
- Data processing and identifying the spectra.

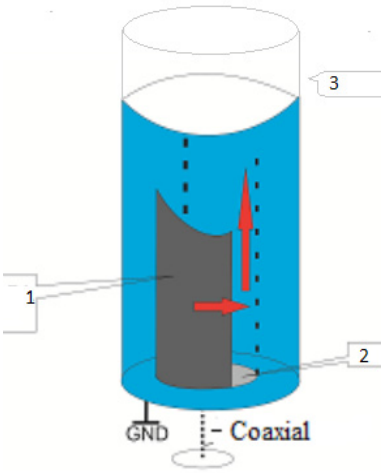

Fig. 2 Antenna measurement unit scheme: 1 - metal armature; 2 - metal disk; 3 – glass cylinder.

3. PROPER ANALYSIS (EXPERIMENTAL RESULTS)

In the following is presented the analysis for each frequency band of the substances studied have responded. Measurements were made for 4-6 frequency bands, but because of space limitation in the article, will be presented only two spectral bands, results are shown in the diagrams fig 1-30.

3.1 Frequency band I: 2.85-2.9 GHz.

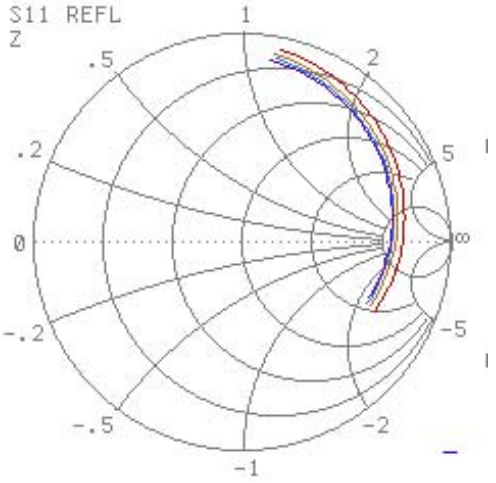

Fig. 3 Smith diagram in frequency band I, with all etalons and reference: reference (red), etalon 0,02% (orange), etalon 0,01% (mauve), etalon 0,005 % (blue).

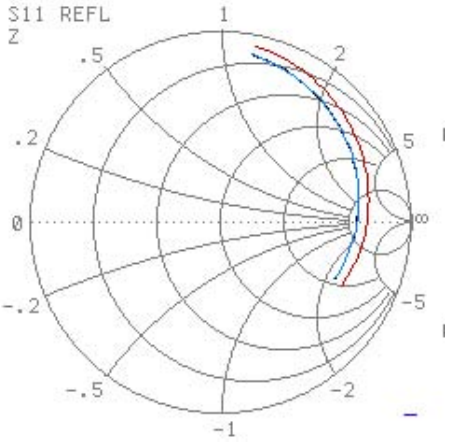

Fig. 4 Smith diagram in frequency band I, with: reference (red), etalon 0,005 % (blue), drinking water sample (black).

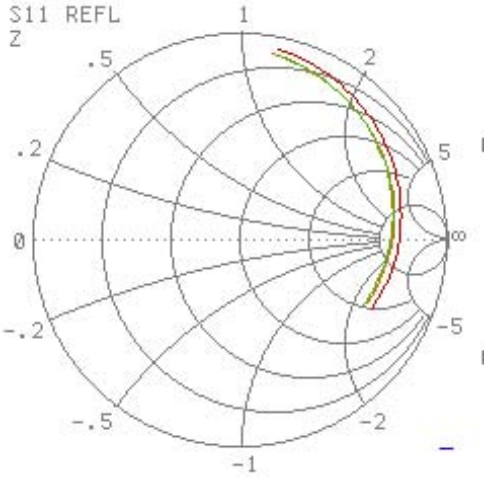

Fig. 5 Smith diagram in frequency band I, with: reference (red), etalon 0,02% (orange), mineral water sample (green).

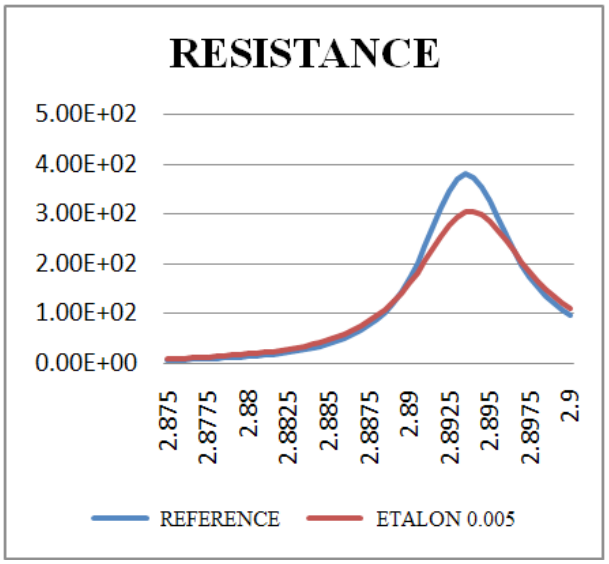

Fig. 6

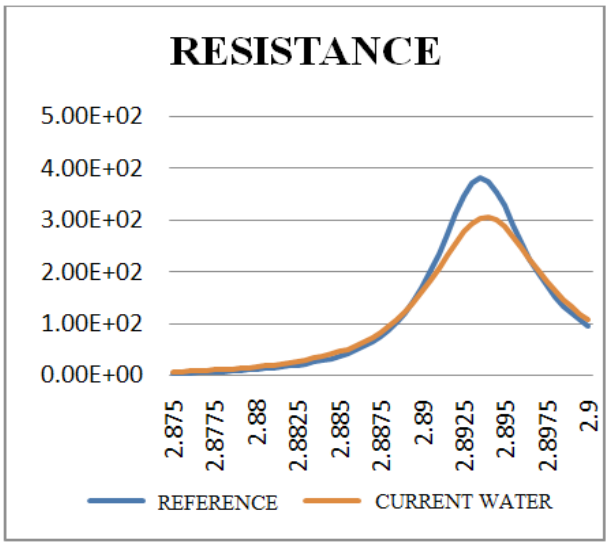

Fig. 7

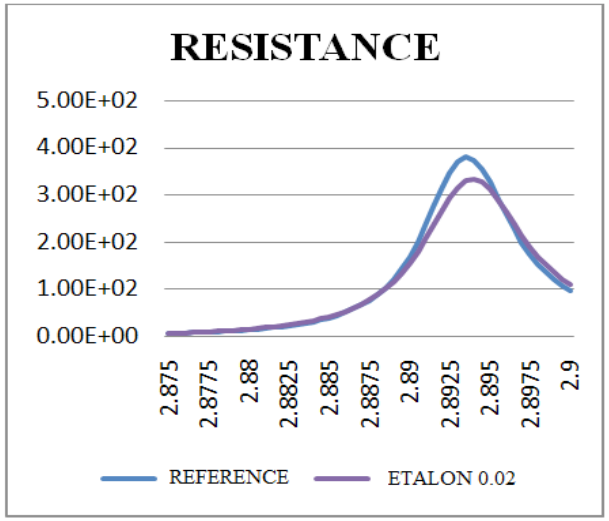

Fig. 8

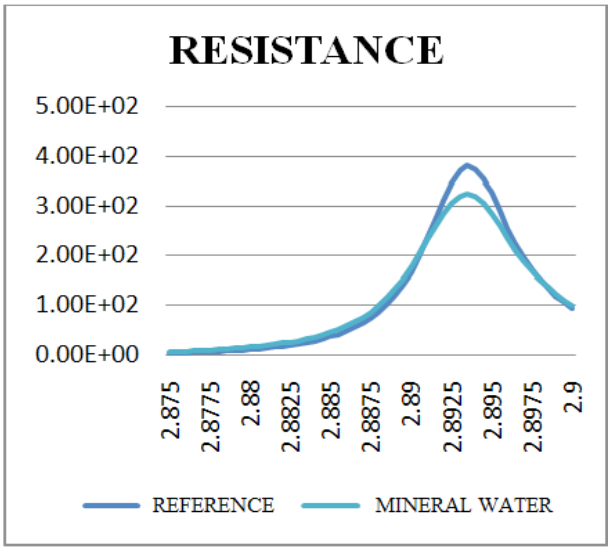

Fig. 9

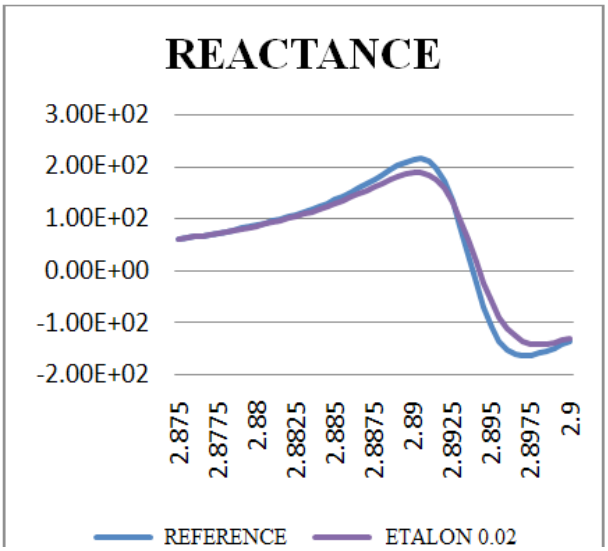

Fig. 12

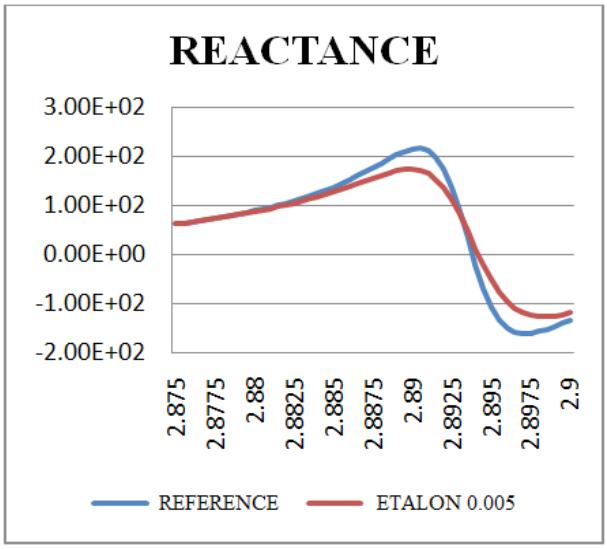

Fig. 10

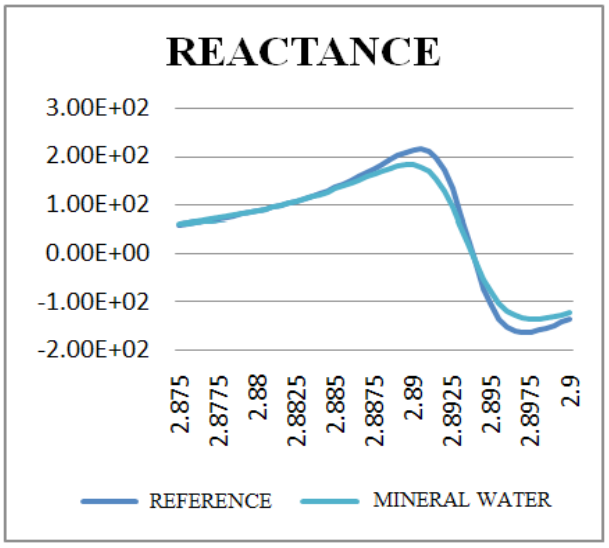

Fig. 13

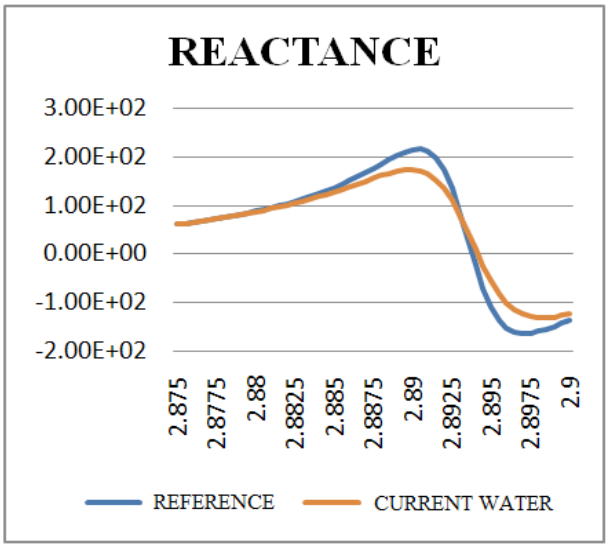

Fig. 11

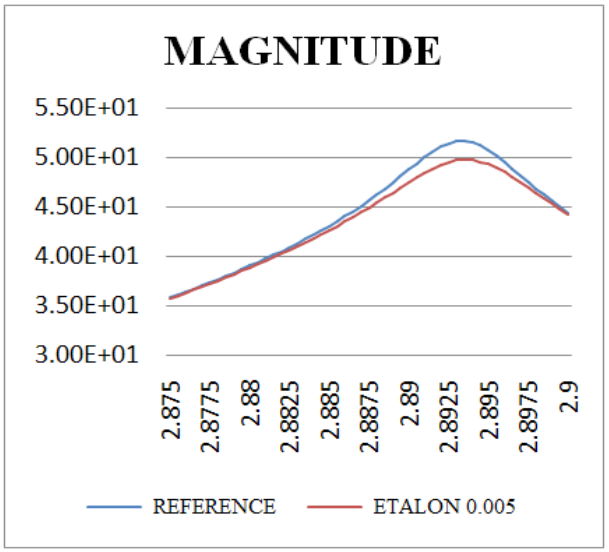

Fig. 14

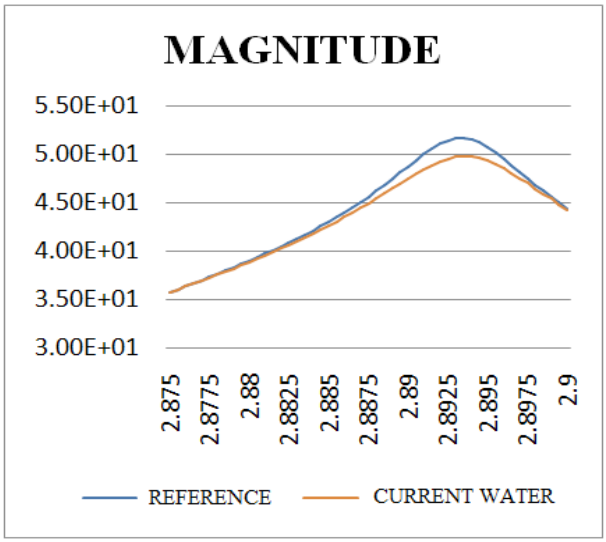

Fig. 15

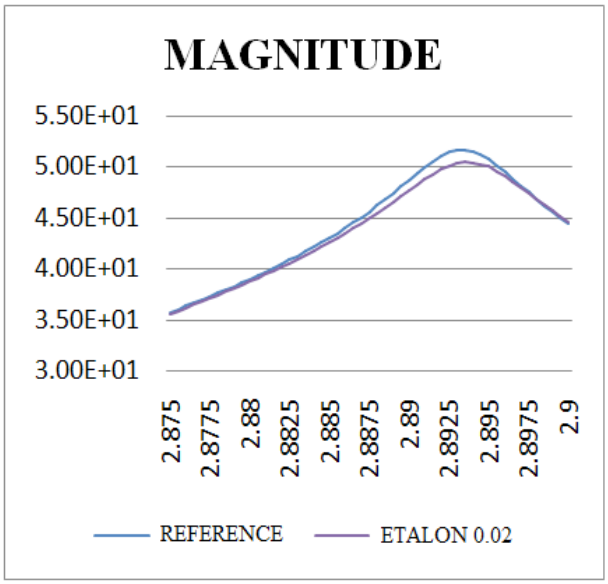

Fig. 16

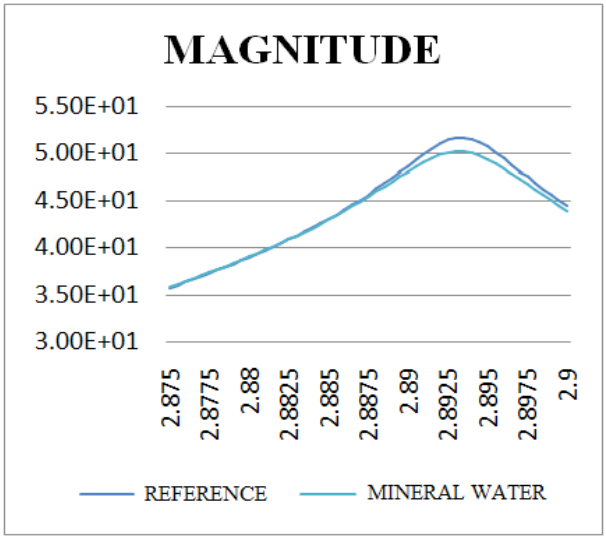

Fig. 17

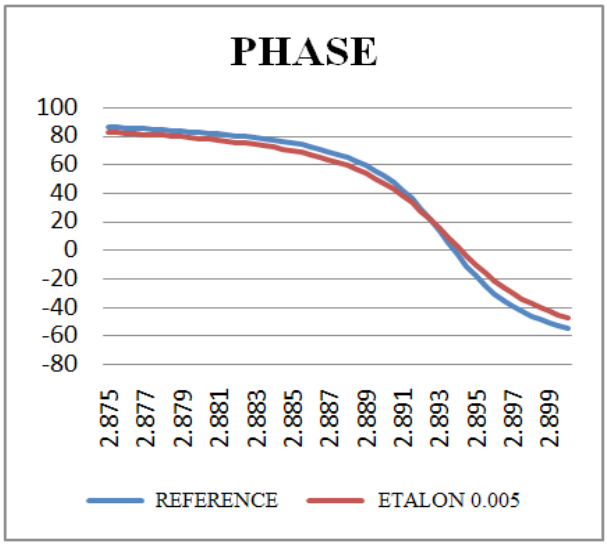

Fig. 18

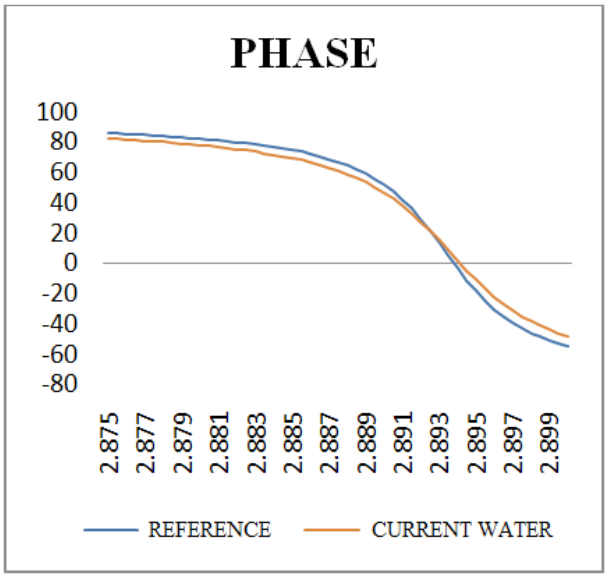

Fig. 19

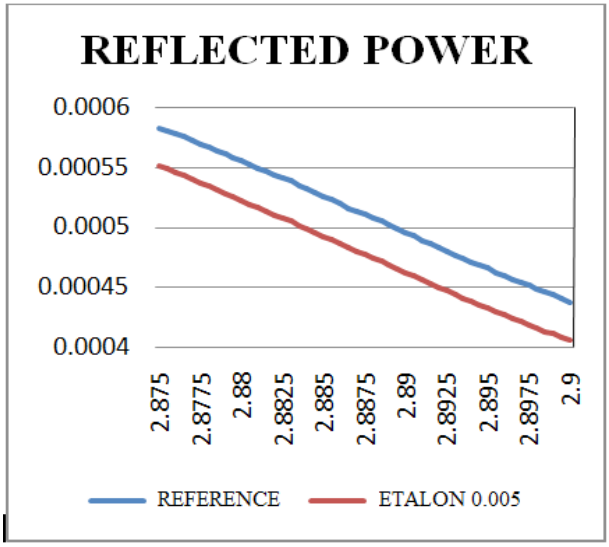

Fig. 20

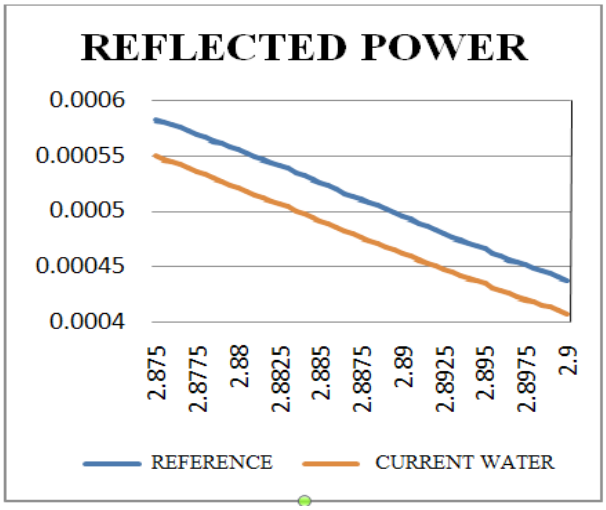

Fig. 21

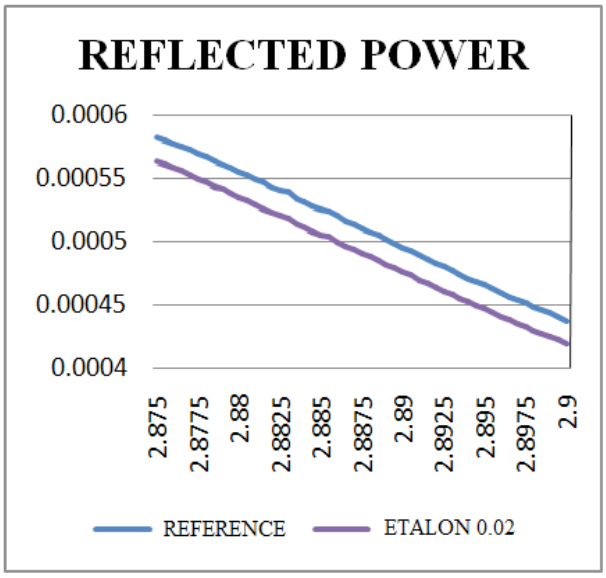

Fig. 22

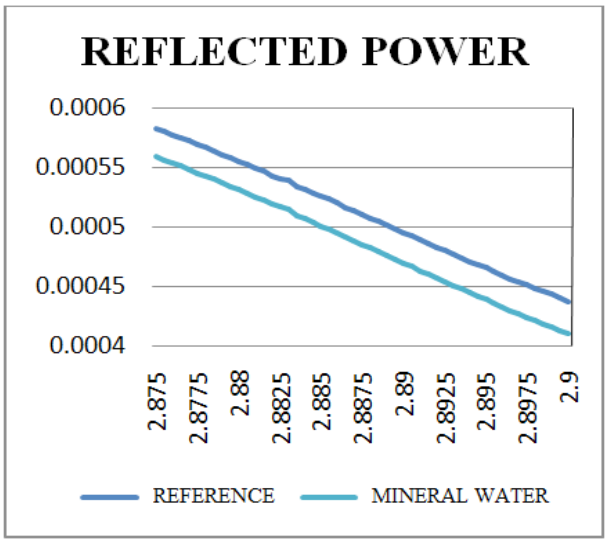

Fig. 23

3.2 Frequency band II: 5.6-5.67 GHz.

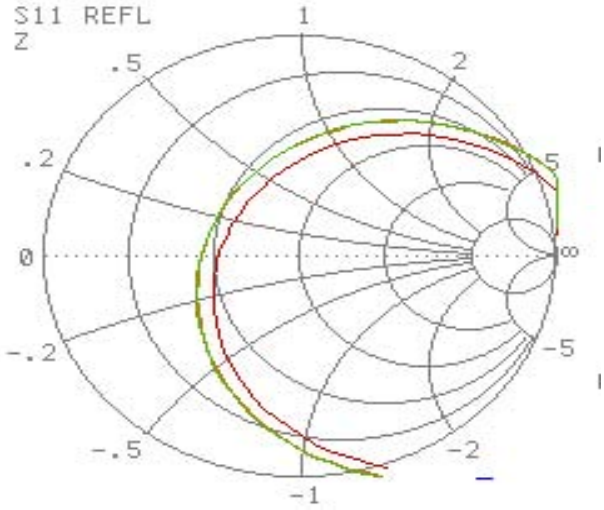

Fig. 24 Smith diagram in frequency band II, with: reference (red), etalon 0,02% (orange), mineral water sample (green).

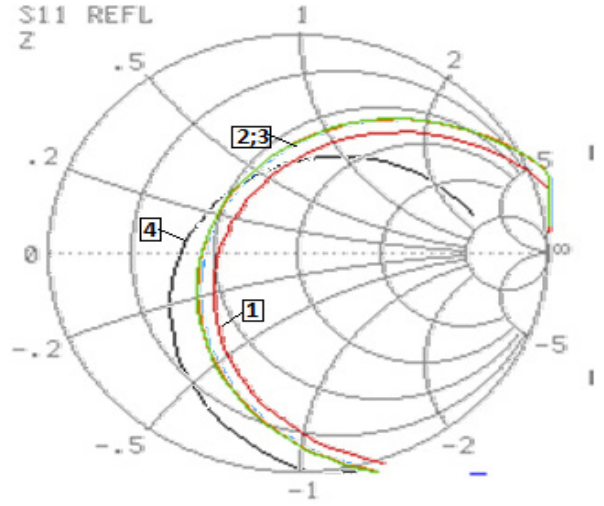

Fig. 25 Smith diagram in frequency band II, with: reference (red), etalon 0,005 % (blue), drinking water sample (black).

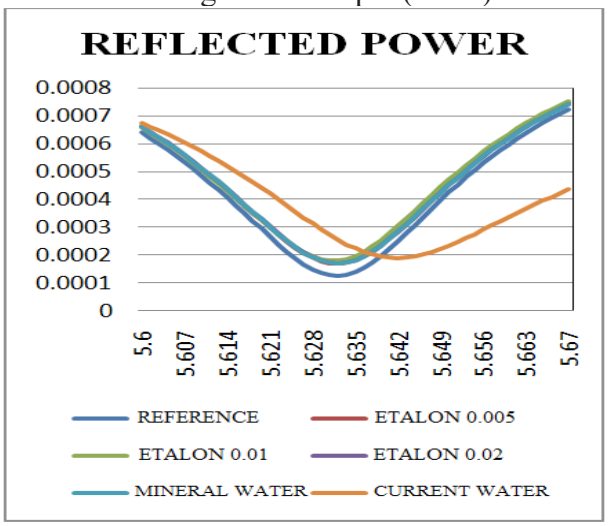

Fig. 26

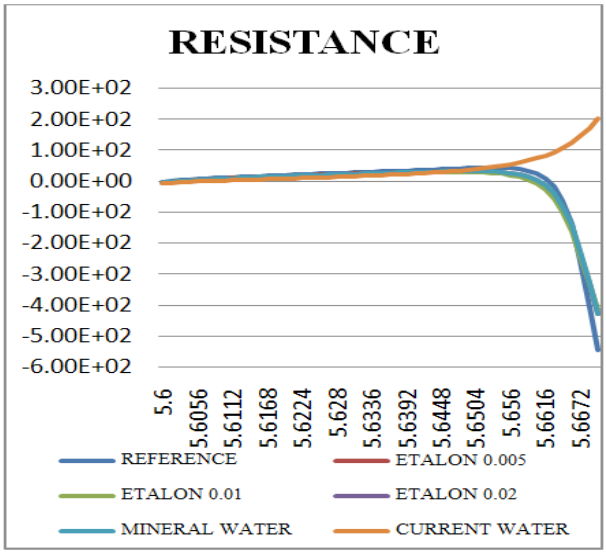

Fig. 27

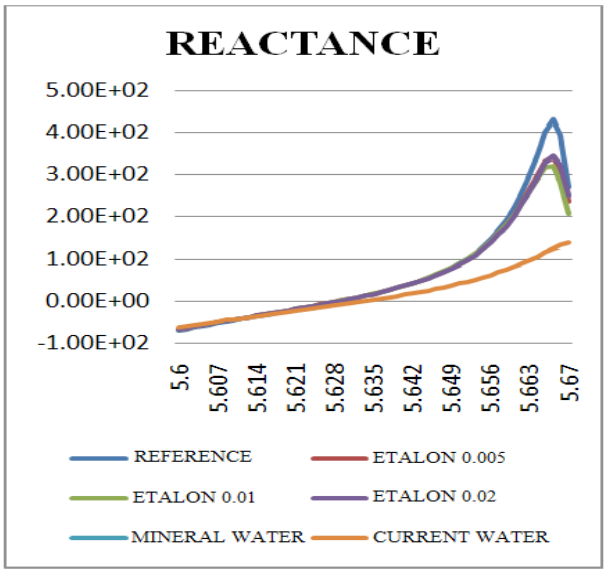

Fig. 28

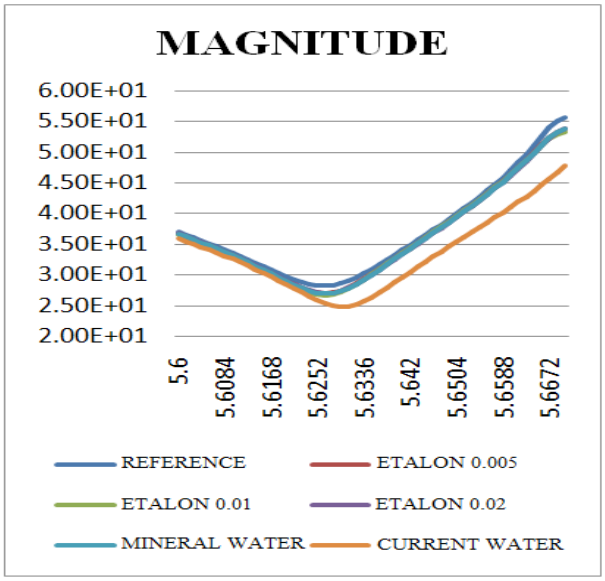

Fig. 29

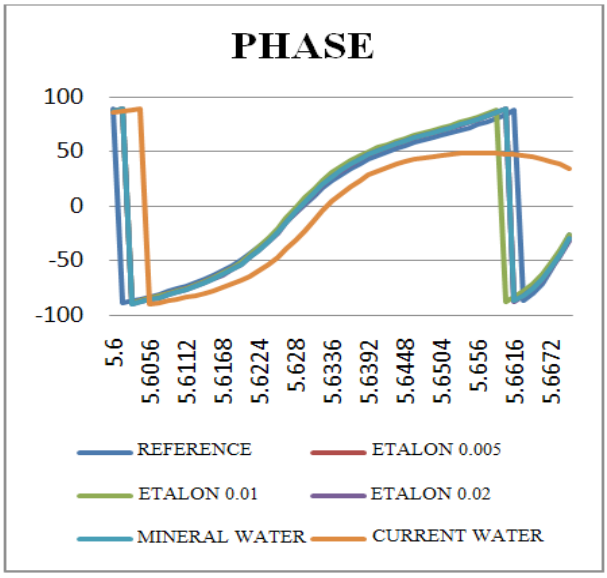

Fig. 30

CONCLUSIONS

This work is an extension of vector analysis, providing information about the the reflection coefficient based on the supply of data related to both the magnitude (general case) and phase. It is a novelty in the analysis, because the etalon does not have to be present, as a blank sample, in analyzing with spectral analyzer. Each test substance is introduced into the resonator antenna, data are collected and then introduced the new analyte.

After analyzing graphs of magnitude and phase, I noticed that mineral water sample approaching (as values) 200 ppm etalon, which indicates the presence of sodium chloride in the composition.

For drinking water, we noticed nonuniform behavior, keeping, largely, etalon of 50 ppm profile, but showing deviations from the rule beam, probably due to the presence of other compounds such as chlorine.

All measurements must be made under the same environmental conditions: at the same temperature, pressure, humidity.

An advantage of this analysis is a very small amount of analyte, tens-hundred parts per million, which shows a very high sensitivity of the analyzer, being able to identify traces of substance. It is a simple method that does not require long measurement, and allows both quantitative analysis (who told us about the concentration of sodium chloride in the two samples) and qualitative analysis (which confirmed the presence of sodium chloride in mineral water and drinking water samples).

This work opens the way towards a more complex analysis.

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REAL TIME MONITORING AND TRACKING SYSTEM FOR AN ITEM USING THE RFID TECHNOLOGY

Paul KIS, **Marian ALEXANDRU**
"Transilvania" University, Brasov, Romania
DOI: 10.19062/1842-9238.2015.13.3.12

Abstract: *Describing an application based on the RFID technology is the goal of this paper. This application is designed using RFID technology as a simple and viable solution for online item tracking. It provides an easy to use interface via a website and it follows the same steps and methods as a real world track and trace program. In it, the user has the ability to search, buy and track the item's location in real time, and can easily be modified for other purposes (military, business, personal).*
Keywords: *RFID, database, tracking, Arduino*

1. INTRODUCTION

For the past few years, location systems have become a major studying field, in which more and more field researchers are trying to innovate. Developing new location systems in the outdoor area seems to be covered by the GPS system. However, when apply it to an indoor location system; we see that the precision and accuracy of GPS is not satisfactory. In order to enhance the precision of indoor location systems, there has been a development in a number of fields, each providing their own advantages and disadvantages. Therefore we encounter Wi-Fi systems (802.1x), Bluetooth (IEEE 802.15), infrared, ultrasounds, RFID.

RFID (Radio-Frequency Identification) refers to small sized electronic devices, known as RFID tags, which contain a small chip and an antenna. The chip, usually, is capable of storing 2000 bytes of information (or less).

RFID devices have similar uses to that of a product barcode, or a magnetic strip on the back of a credit card. These offer a unique ID for that object, and just like a barcode or credit card, they need to be scanned in order to extract the information stored.

RFID is a wireless technology which uses electromagnetic fields in order to transfer data, for the purpose of identification and automated tracking of a tag placed on an object. The tags contain electronically stored data.

Some tags are powered by an electromagnetic induction provided by the magnetic field of an RFID reader. Other tags have an internal power supply, in the form of a battery, and can function at hundreds of meters from the reader. Unlike a regular barcode, the tag doesn't have to be in the line of sight of the reader and can be incorporated in the object itself.

RFID tags can be active, semi-active and passive [1]. These tags can store up to 2 KB of data and are built using a microchip, an antenna, and in the case of active and semi-passive tags, a battery.

Active and semi-passive RFID tags use internal batteries to power their circuit. Furthermore, an active tag uses its battery to transmit radio waves to a reader, while a semi-passive tag relies on the ability of the reader to provide it with the necessary power for transmission. Due to the fact that these tags contain more hardware than passive tags, they are more expensive. Active and semi-passive tags are used for high value items which can be read at larger distances - broadcasting at high frequencies of 850-950 MHz and can be read from a distance of 30 m. If it's required to read the tag from a larger distance, additional batteries are added which improve the range up till 100 m.

Passive RFID tags rely entirely on the reader as their power source. These tags can be read from a distance of 6 m, and are significantly cheaper, meaning they can be applied to cheaper objects.

These tags are made to be disposable, along with the disposable consumer goods they are placed on (unlike a military package which contains an active tag, a bottle of shampoo would have a passive tag).

The range of a RFID tag depends on its broadcasting power, reception sensitivity, the environment, orientation of the tag when it's scanned, operating frequency, as well as how it was designed, planned and installed.

2. LOCALIZATION AND TRACKING METHODS

2.1 Overview. A few decades ago, tracking every single object seemed a futuristic and advanced thought, and was considered impossible in the near future. Nowadays, the surrounding world is becoming increasingly "smaller", due to advanced technology.

Surveillance cameras are installed at every traffic light, at work, in stores, as well as in our homes. Now, these cameras are used by new technologies in order to track the location of cars, cell-phones and possibly even our shopping.

This tracking technology is used to ship consumer goods faster, and to prevent their loss or misplace.

Current technologies used to create location based systems include: Geographic Information Systems (GIS), Global Positioning System (GPS), Radio Frequency Identification (RFID) or Wireless Local Area Network (WLAN).

Every tracking system or location based system uses one, or a combination of these technologies. RFID systems require a particular tag to be placed on the object, animal, or person intended to be tracked.

For instance, the GPS receiver of a cell-phone, or the RFID tag on a DVD, can be used to track that particular object through a detection system such as GPS satellites or RFID receivers.

2.2 Object tracking: how does it work? Developing fast delivery systems for orders or products, which are shipped anywhere in the world, has created the need for a system to determine the location of every item, at any point during the day.

Generally, an item is equipped with a barcode, which once it's scanned, contains every detail, from the delivery location, to the seller/sender.

This bar code, "carries" this data all throughout its journey and allows the addressing person to find out it's location at any moment.

The item is scanned, repeatedly, at every sorting and shipping office, and this information is immediately inserted into a database, for better tracking and tracing of its movement.

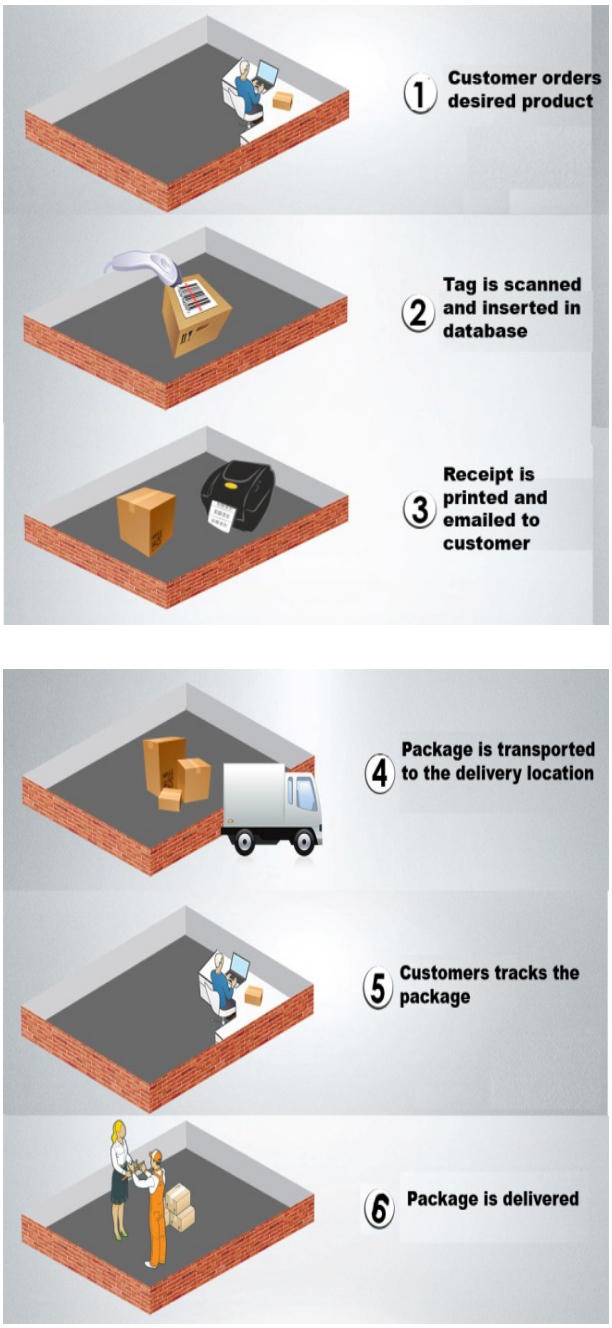

Fig 1. Item delivery and tracking

3. SYSTEM IMPLEMENTATION AND EXPERIMENTAL RESULTS

3.1 Equipment used

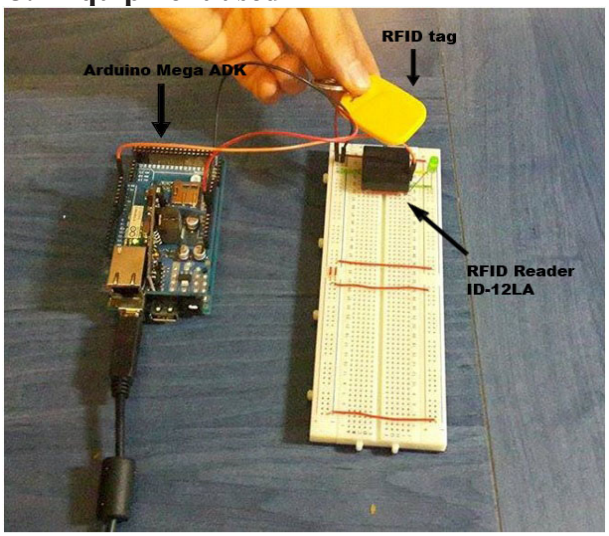

Fig 2. Equipment used

Arduino Mega ADK is a microcontroller based on the ATmega2560. It has a USB interface for connecting with and Android phone, 54 pins I/O (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UART, a power supply port and a reset button.

The used RFID reader is ID-12LA, a simple to use RFID reader, designed by ID Innovations along with other RFID readers: ID-2LA and ID-20LA. ID-12LA is an intermediary reader, with an antenna operating a low frequencies, but with a smaller size than the rest. It contains a built-in antenna having a range of a few centimeters, being used frequently for scanning tags or access cards. The programming language that was used is Java, being a technology which offers support on a wide range of applications, and a database designed in MySQL.

3.2. Application description. In order to track an object, it was necessary to create an e-commerce type website, inspired by online stores available on the Internet. The chosen name was "Music Instruments", and the products available are from the music area.

The application follows a set of rules and can easily be adjusted for other purposes, for instance tracking military equipment, vehicles, personnel or the shipment of packages on the field of operation.

A database was used in order to insert the instruments in the created application. The number of products is relatively small, used only for simulations, but more can be added easily as the application evolves.

Once launched, the application displays a welcome page for the user containing information about the contents of the website and the available products.

At the top of the page, there's a docked menu that is displayed on every page of the website, thus helping with a easier navigation of the user.

Depending on the type of request the user wants, it needs to press the according button, and the pages will automatically load.

The types of instruments available on the website are guitars, drums and keyboards. Every instrument has a detail description, a price and a "Add to cart" button.

The user can browse any section of the website, and when he wants to buy a certain instrument, the "Add to cart" button needs to be pressed.

After that, the user can continue browsing the website, in order to buy more, or he could proceed to the next step.

Fig 3. The "Guitars" page of the website

At any moment, the user can press the button "Shopping cart", and a page will display all of the items placed in his cart, as well as the quantity of them and the total price.

The user can return to any page in the website via the menu located in the upper part of the web page.

If the user decides to check-out his cart and pay, the button "Proceed to checkout" is pressed and the shipping details and billing information are required.

For this, the user must enter all the required details in the spaces provided, which are: First name, Last name, Email, Street, Zip Code, City, and Country followed by a click on the "Checkout Button".

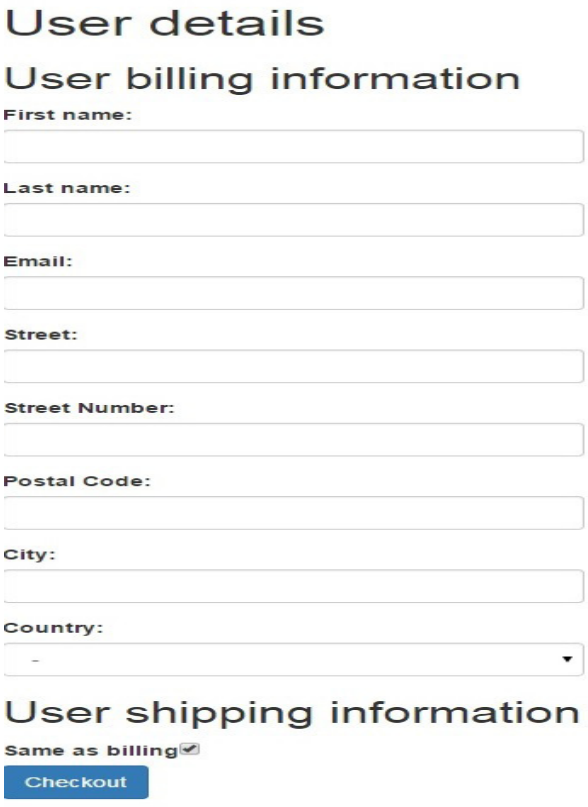

Fig 4. The form for billing and shipping

A confirmation message is displayed, "Order Completed", and the order will be placed and ready to be tracked by clicking the button "Order Management", where all the details of the order are present.

At this point, the order is not yet processed, simulating its packaging: being tagged and placed in the delivery vehicle.

In order to tag and process the order, we find the "Attach RFID" button.

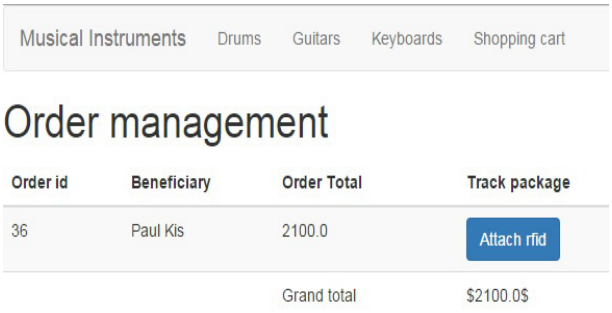

Fig 5. Details of a placed order

Once pressed, this requests the scanning of the RFID tag that will be used for the duration of the transport via the message "Scan RFID".

This is exactly what's happening in real life: before the order is processed, it needs to be scanned and placed in the database for user notification. When the card is scanned (see the Fig. 2), the order will be processed and the website will display a page containing the location details of the item.

The location details provided are the current city and country, by default being New York, USA, and also the destination city and country. This simulates the fact that the web-store, "Music Instruments", is based in New York, USA.

In reality, the item will be constantly moving, from one collection center to the next, where it will be scanned and the tracking details are refreshed, all the way to the delivery. The same thing happens in this application: the location of the item will change with every new scanning of the RFID tag. Also, similar to how a barcode works for a certain product, the RFID tag used for processing the order, will be used for the duration of the transport, meaning that if a different RFID tag is used for the original order, the website will have no modification.

This scanning process will be repeated until the current city and country matches the delivery (Fig 7).

At this point the item has been delivered, and the current city and country matches the destination city and country.

The user has followed the same steps to place, track and receive the desired product similar to the behavior of a real life online order.

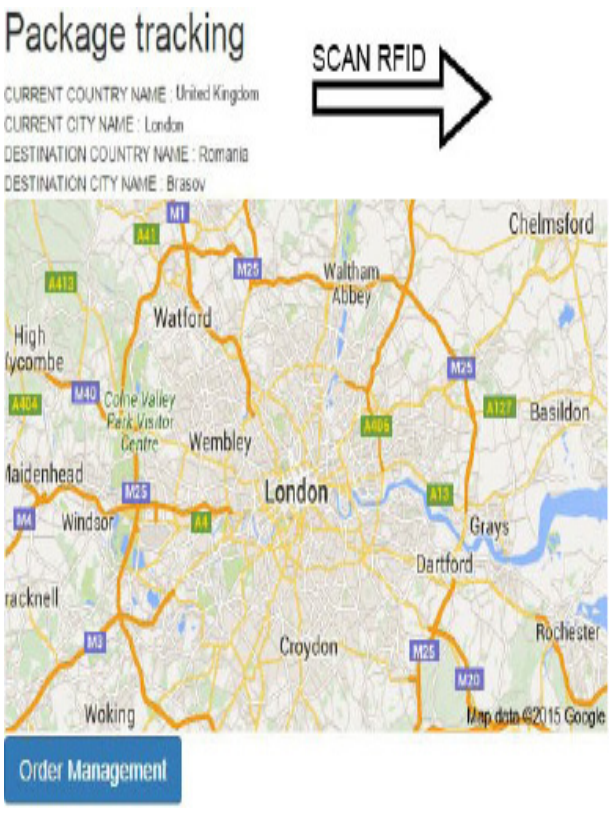

Fig 7. The RFID tag is scanned and it eventually reaches the destination

CONCLUSIONS AND FUTURE WORK

The whole premise of the application was building an e-commerce website with products, adding them in the user's shopping cart, filling in the desired billing and shipping information and having the possibility to track the location of the item anytime and anywhere throughout its transport.

An easy and effective management of item tracking within a company or business is achieved by gathering all the useful information within a database.

This application provides that as well as an easy to use interface and designed specifically for object tracking with very few costs in developing.

Without having a specialized program, keeping track of every information will prove to be difficult, especially with a high number of data which is constantly changing.

For the time being the application can only be used by accessing it from a laptop or PC, but it can be upgraded by adding new functionalities such as:

- push notifications for the user when the item changes location
- developing the application for smartphone use
- adding a credit card type of payment in a secured environment.

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NUMERICAL STUDY OF HEAT TRANSFER IN TURBULENT FLOWS, WITH APPLICATION

Laura Alina STIKA *, **Valeriu Alexandru VILAG** *, **Mircea BOSCOIANU** **, **Gheorghe MEGHERELU** *
*Romanian Research and Development Institute for Gas Turbines COMOTI,
**"Henry Coandă" Air Force Academy, Brasov, Romania
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Abstract: *This paper describes a numerical method for analyzing the heat transfer, in a hot section of a turbo shaft. The high temperatures of the struts behind a free turbine are transferred, through conduction, to the casing of the free turbine's shaft. In this way, there is a risk of overheating the oil inside this casing. To reduce this risk, on the casing can be added a part, crossed by a mass flow of cool air. The application focuses on the performance of this cooling part. In order to study the heat transfer from the strut to the oil housing, several computations were performed, using the CFD software Ansys CFX. Several cases were analyzed, by slightly modifying the geometry, as well as the air mass flow passing through the analyzed part. The different results were compared, the best configuration in terms of cooling efficiency being the one predicted by the theory.*
Keywords: *heat transfer; CFD; cooling.*

1. INTRODUCTION

In gas turbines, lubrication systems usually have two functions [1]: to oil and to cool the regions between rotating and stationary bearing surfaces.

In order to function properly, the oil must be kept under a maximum admissible temperature; therefore the majority of the gas turbine's lubrication systems include oil coolers [1].

Although the oil coolers are efficient, they are only required to remove the heat from the oil before it is re-introduced into the gas turbine.

In other words, they aren't designed to protect the lubricant along its route inside the gas turbine, thus there is a possibility for the oil to encounter hot surfaces that could increase its temperature to more than the admissible one.

In this case, additional cooling solutions must be applied.

This paper focuses on one of these solutions, which consists in adding a component on the casing of a power turbine's shaft, highlighted in Fig. 1.

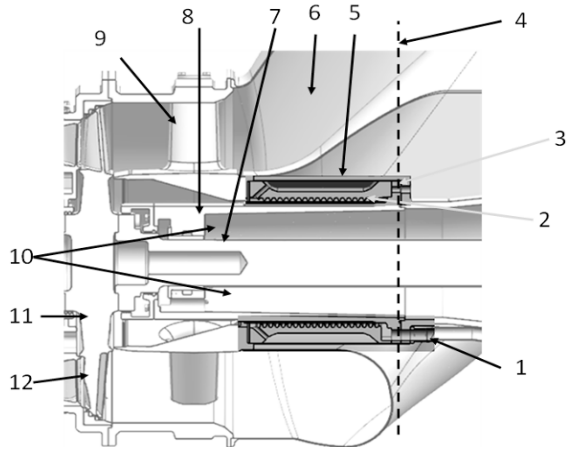

Fig. 1- Schematics of the cooling part and its position. 1-Air inlet; 2- The helically coiled passage; 3- Contact surface between the cooling part and the shaft's casing (the "measure wall"); 4-"Measure wall's" position; 5- Position of the air outlet; 6- Exhaust system of the turboshaft; 7- The power turbine's shaft; 8- The shaft's casing; 9- Strut; 10- Region with oil, surrounding the shaft; 11- Power turbine's disk; 12- Power turbine's blade.

This element prevents the transfer of high temperatures form the struts to the oil.

Concerning its geometry, the part is a hollow cylinder crossed by a mass flow of cool air, which follows a helically coiled path, with a trapezoidal cross-section. The coiled form was chosen based on its good results in terms of heat transfer of the coiled tubes [2], hence their wide variety of applications like chemical process reactors and industrial marine boilers [2].

2. DATA BASE AND METHOD

2.1 Method. The numerical simulations provided the temperature transferred to the shaft's casing, the temperature distribution on the domain walls and also information about the flow inside the part. The maximum temperature and its distribution on the "measure wall" - presented in Fig. 1 - were analyzed for each case. This parameter was considered to best describe the performance of the cooling part.

Table 1. Configuration and boundary conditions for the numerical simulations.

C	Geom type	Inlet		Outlet	Solid
		p* [bara]	T* [°C]	p [bara]	Mat
1	1 coil	1.5	30	1.1	STL
2	1 coil	2	30	1.1	STL
3	3 coils	1.5	30	1.1	STL
4	3 coils	2	30	1.1	STL
5	3 coils	2.3	30	1.1	STL
6	3 coils	2	30	1.1	S/S

Where C- Case number, Geom- geometry, p*- total pressure, T*- total temperature, p- static pressure, mat- material, STL- steel, S/S - stainless steel.

Regarding the geometry, the part analyzed has a hollow cylindrical form, with a length of 193 mm, an exterior radius of 113 mm, for geometry type with 1 coil and an exterior radius of 115 mm for the geometry type with 3 coils and an interior radius of 81.5 mm.

For the geometry type with 3 coils, the exterior radius was enlarged by 2 mm, due to mesh issues.

This change was made only on the solid domain; the fluid domain in that specific region is the same for the two types of geometries. It is assumed that this change doesn't influence the configuration in an optimistic manner, in other words, adding some more material in that specific area, it will make the exterior solid wall thicker, thus harder to cool.

The path of the airflow can be observed in Fig. 2 and in Fig. 3. The only differences between the two types of geometries are the number of coils and the enlarged radius earlier presented.

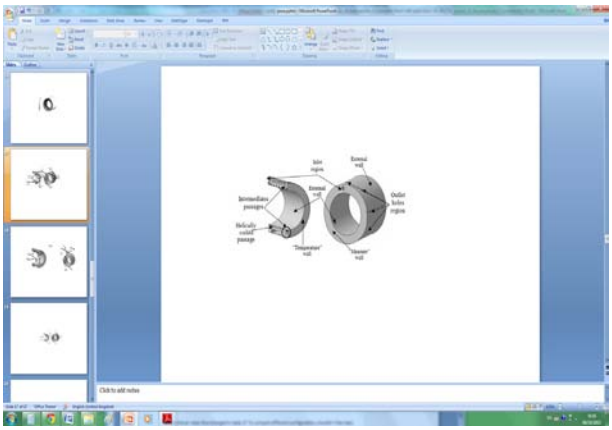

Fig. 2- Solid block domain used for the simulations (left: view of half of the domain; right- isometric view)

The fluid enters the domain through the circular inlet surface of radius 7 mm; crosses the trapezoidal cross-section of 36 mm2 area coil or coils; passes through the 6 intermediates 3 mm radius cylindrical holes and then exits through the outlet which consists in 8 cylindrical, 5 mm radius holes.

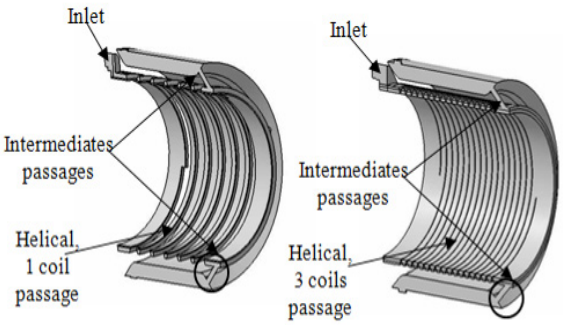

Fig. 3- Half of the fluid block domain, for the two types of geometry (left: one coil geometry; right- 3 coils geometry)

The numerical simulations have been carried out in the Reynolds Averaged Navier Stokes (RANS) formulation, using the Ansys CFX commercial software. For each type of geometry a computational domain containing two blocks (a solid one and a fluid one) -presented in Fig. 2 and Fig. 3- was defined. These domains were meshed by means of an unstructured grid into 1706426 tetrahedral computational cells, resulting in 414074 nodes for the one coil geometry and 2186629 tetrahedral computational cells, resulting in 498733 nodes for the three coils geometry.

The following boundary conditions were applied on the surfaces indicated in Fig. 2 and Fig. 3, for each of the 6 numerical simulations.

Inlet: Subsonic inlet boundary conditions with the total pressures in Table 1 and a temperature of 30 °C.

Outlet: Subsonic outlet boundary condition with the static pressure in Table 1.

"Temperature" wall: Wall with fixed temperature of 600 °C.

"Measure" wall: Solid, no-slip, adiabatic wall.

External wall: Solid, no-slip adiabatic wall.

The walls surrounding the fluid were set as interfaces between the fluid and the solid blocks, except for the inlet and outlet surfaces.

The fluid for all the numerical simulation computations was set to Air Ideal Gas, with a reference pressure of 1 atm.

For the solid domain, steel was used for the first five numerical simulations and stainless steel for the last one. The properties of these materials are presented in Table 2.

Table 2. Proprieties of the materials used in the numerical simulations.

Proprieties	Steel	Stainless steel
Molar mass [kg/mol]	55.85	55.91
Density [kg/ m^3]	7854	7900
Specific heat capacity [J/ (kg*K)]	434	500
Thermal conductivity [W/(m*K)]	60.5	15 [3]

In the first attempt to carry out the simulations with the inlet and outlet boundary conditions presented above, because of the solver numerical characteristics [4], as the solution progressed, reversed flow occurred at the outlet and at the inlet boundary. To work around this, the CFX-solver tried enforcing the flow by creating artificial walls at the entry and the exit of the domain [4], which caused a solver failure. To solve this, the numerical simulations were initialized by another set of numerical simulations, where all the inlet and outlet boundaries were set as openings. Once the solutions of the initialization numerical simulations (with the inlet and outlet boundary conditions set as openings) converged, the solver was restarted and the original, inflow and outflow, boundary conditions were restored. As it is stated in [4], if the problem doesn't persists after changing the boundary conditions from "opening" type to "inlet/outlet", the error isn't in the case definition. Basically, the first simulations were only used to calculate initial conditions for the computations presented in this paper. After the boundary conditions have been restored, the solver no longer had an abnormal behavior, which indicates that the location of the inlet and outlet was set properly, meaning that they are not located in a recirculation zone.

The simulations were carried out until convergence of the results was reached. The convergence criterion was a Normalized Residual level of the order 10-5 [4].

2.2 Results. In order to analyze the performance of the configurations presented, a target was set. The function of the cooling part is to prevent high temperatures from the struts to reach the oil inside the shaft's casing and therefore the obvious target was chosen based on the operating oil temperature. In high temperature applications, synthetic lubricants are used at temperatures up to 175 °C [1], therefore the studied element should transfer to the shaft's casing a temperature lower than this value. This means that if in the studied application the averaged temperature on the "measure" wall defined earlier, is lower than 175 °C, the cooling part fulfills its purpose.

The results are presented, for all 6 cases, in Table 3.

Table 3. Averaged numerical simulation results.

C	"M" Wall	Outlet		Inlet	Fluid domain
	T [°C]	T* [°C]	v [m/s]	v [m/s]	$\dot{M}$ [kg/s]
1	505.4	585.4	6.4	5.6	0.001349
2	355.1	534.4	12.5	9.8	0.003454
3	485.4	590.7	22.3	17.9	0.004751
4	237.4	504.3	40.8	30.9	0.01089
5	184.8	421.6	47.5	34.9	0.014126
6	156.4	380.0	39.0	35.0	0.012553

The first analyzed case was the reference, Case 1, configuration. First, the velocity vectors were checked to ensure that the phenomenon of inflow at the outlet boundary and outflow at the inlet boundary hadn't occurred. As it can be seen in Fig. 4, the velocity vector is towards inside the domain at the inlet and towards the exit at the outlet.

The second check was to verify the temperature after the intermediate circular passage. Although this temperature was higher than at the outlet, the difference was small, of about 17°C, so the geometry surrounding the fluid, after the intermediate passage, was kept the same for all 6 cases. This phenomenon of cooling the air after the intermediate passage no longer occurs in the three coils configurations where the mass flow is increased.

The total temperature of the outlet surface is only with 15 °C lower than the one imposed on the "temperature" wall, which illustrates the fact that this configuration is working, though, as seen in the Table 3, it gave poor results compared with the imposed target. The difference between the so called "temperature" wall and "measure" wall was of only 100 °C which means that to increase the element's performance it is required to enhance the heat transfer.

In general, there are two types of techniques to enhance the heat transfer, in this configuration: active and passive techniques [5]. The active techniques require external forces, while the passive techniques require geometry or material changes [5]. Both techniques were used in this study.

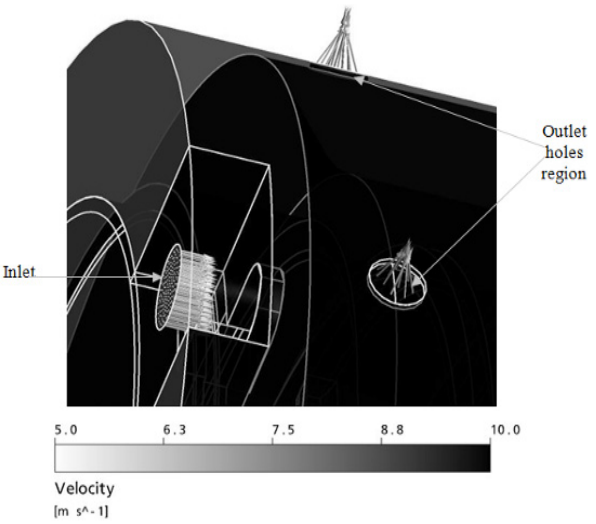

Fig. 4- Velocity vector at: inlet and on two surfaces of the outlet, for the Case 1.

In numerical simulations, the easiest and fastest way to get results is using the active techniques, namely increasing the total pressure at inlet boundary and thus the cool air mass flow.

For the Case 2, the total absolute pressure at the inlet boundary was increased at 2 bara, as seen in Table 1, but it still wasn't enough to reach the desired temperature on the "measure" wall.

The same phenomenon occurred as in the first case, namely the averaged total temperature of the fluid after the intermediate passages was a little higher than the averaged total temperature at the outlet. As seen in Fig. 5, this cooling of the air doesn't have a considerable consequence on the averaged temperature of the "measure" wall.

The contact surface between fluid and solid domain is proportional with the heat transfer [2]. Hence, to further improve the performance of the cooling part, this surface was increased. In this way, the 3 coils geometry resulted, as presented in Fig. 3 and used in the Cases 3, 4, 5 and 6.

As in the configurations with one coil, the total pressure on the inlet boundary was increased from 1.5 bara, this time up to the value of 2.3 bara.

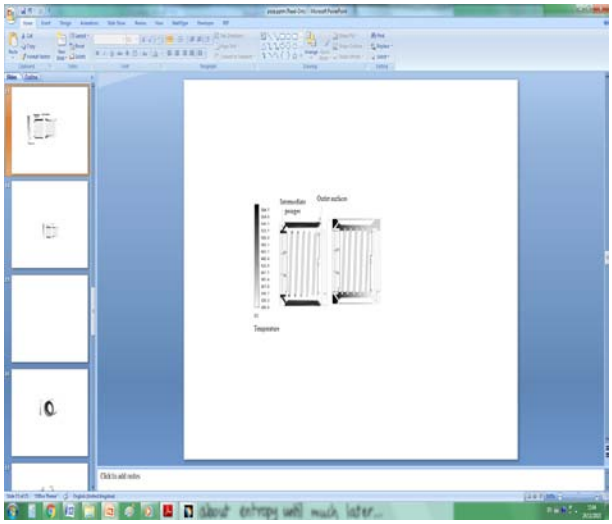

Fig. 5- Temperature distribution on the mid-section plane, for Case 2 (on the left: fluid domain; on the right solid domain)

The best result, using steel as material for the solid domain, is obviously the Case 5, with the total pressure boundary condition of 2.3 bara, resulting in the greatest air mass flow of all 6 cases. Still, the recorded temperature was 10 °C above the target.

As in the configurations with one coil, the total pressure on the inlet boundary was increased from 1.5 bara, this time up to the value of 2.3 bara. The best result, using steel as material for the solid domain, is obviously the Case 5, with the total pressure boundary condition of 2.3 bara, resulting in the greatest air mass flow of all 6 cases. Still, the recorded temperature was 10 °C above the target.

Also it can be noticed that, for the Case 3 the air mass flow is little higher than the one from Case 2, even though Case 2 has a higher inlet pressure, and both cases have the same inlet area (as it is known, a mass flow is related to the density, velocity of the fluid and area through which the fluid passes [6]). This can be explained by the fact that the air mass flow is proportional to the narrowest area of the air path [6], that being, in this case, the entrance in the helically coiled passage.

For Case 3 (geometry with 3 coils) the narrowest area is three times bigger than for Case 1 (geometry with 1 coil).

Hence, increasing this area had more effect in terms of air mass flow than changing the inlet total pressure.

The solution used in Case 6 was changing the material. In the numerical case, the properties of the solid domain were changed according to those showed in Table 2, for stainless steel. It is worth noting that there are big differences between the thermal conductivity coefficients of steel, of 60 W/(m*K), and of stainless steel, of 15 W/(m*K) [3]. This distinction between the proprieties of the two materials led to a global difference of 81 °C, in terms of averaged temperature. The plotted temperature on the solid domain used in Case 6 is presented in Fig. 6. It can be noticed that, on the region of interest, respectively the "measure" wall, the temperature is smaller near the inlet area and increases until the maximum value obtained in the diametrically opposed point. To obtain an uniform distribution, another inlet placed in the hottest region of the "measure" wall is required.

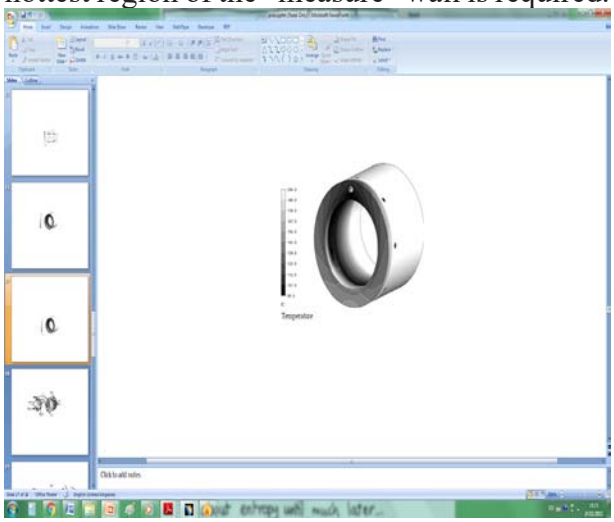

Fig. 6- Temperature distribution on the solid domain for Case 6

CONCLUSIONS

Several geometrical configurations, materials and inlet pressures were analyzed in order to select the best configuration for the cooling part used that prevents the transfer of high temperatures form the struts to the oil in a turboshaft.

Compared to the reference configuration (Case 1), it was found that only increasing the inlet pressure from 1.5 to 2 bara was not enough to reach the desired temperature on the "measure" temperature wall, even though an improvement was achieved.

Next, the geometrical configuration of the cooling part was modified, by raising the number of coils from 1 to 3, and raising the inlet pressure from 1.5 to 2 and finally to 2.3 bara. It was found that the 2.3 bara Case 5 provides the highest cooling mass flow, but still failing to meet the temperature requirements.

Finally, the cooling part material was changed from steel to stainless steel. It was found that for the three coils geometry, even the cooling flow provided by a 2 bara inlet pressure is sufficient to meet the temperature requirements.

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POD ANALYSIS OF THE REACTION RATES IN A TURBINE STAGE WITH IN SITU COMBUSTION

Sterian DANAILA, **Dragos ISVORANU**, **Constantin LEVENTIU**
University Politehnica of Bucharest, Romania
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Abstract: *This paper presents the in-situ combustion concept and preliminary numerical results in a one stage turbine combustor. The main purpose of the simulation is to assess the stability of the in situ combustion with respect to the unsteadiness induced by the rotor-stator interaction. In order to identify information on the sources of instability for this complex flow, proper orthogonal decomposition technique is adopted to analyze the natural patterns and couplings between various modes of pressure, temperature, velocity and chemical production rate distributions. The major find of this investigation is that contrary to all other primitive variables, the reconstruction of chemical reaction rates needs a larger number of energy modes to attain a reasonable normalized error.*
Keywords: *turbine in-situ combustion; POD reconstruction;*

1. INTRODUCTION

Turbine combustion is a relatively recent concept, and the amount of work published in the open literature is presently quite limited. A turbine-combustor is defined as a turbine in which fuel is injected and burned. The process of combustion in the turbine is called *in situ* reheat.

A review of recent work carried out in the field is concentrated on four related areas [1]: (i) thermodynamic cycle analysis, (ii) reacting mixing layers in accelerating flows, (iii) flame holding in high speed flows and (iv) compact combustors.

A comparison of the Brayton, regenerative Brayton, Ericssson, Carnot, and Isothermal expansion, isentropic compression cycles, concludes that the Ericsson cycle has the highest thermal efficiency and highest dimensionless net work; therefore it should be the prime candidate for GTE cycle [2].

A second option is the isothermal expansion, isentropic compression cycle whose thermal efficiency and net work are better than those of the Brayton and regenerative Brayton cycles.

Thermodynamic cycle analysis has been carried out for both continuous combustion [3] and for inter-stage combustion [4], using component efficiencies based on typical, real-life values.

These studies demonstrate performance gains related to lower fuel consumption, higher specific thrust, and enhanced operational speed and compressor pressure ratios for both turbojet and turbofan engines. In addition, a CFD analysis based on the RANS equations coupled with a two-step, global, finite rate model for methane combustion [5] showed for a land-based GTE a power increase of up to 5.1% in a four-stage turbine combustor with a 2% mass flow rate of fuel [6]. The results are clearly showing benefits of the technology.

2. CFD COMPUTATIONAL MODEL

The computational model is based on a CAD model inspired from a true one row turbine with 26 stator vanes and 61 rotor blades that expands 8.1 kg/s burnt gas from 911 kPa total pressure and 1263 K total temperature.

The rotation speed of the rotor wheel is 22000 RPM. Apart from previous attempts, the salient feature of this CFD approach is the new fuel injection concept consisting in a perforated pipe placed at mid-pitch in the stator row passage.

The flow and combustion are modelled by the Reynolds averaged Navier-Stokes equations coupled with the species transport equations. The turbulence model used is the scale adaptive simulation-shear stress trans-port.

The chemistry turbulence interaction is described in terms of finite rate-eddy dissipation concept. The choice we have taken was to increase the inlet total temperature at 1550 K in order to succeed in firing up the flow of injected pure methane using the two-step, global, finite rate chemical mechanism of Westbrook and Dryer [7]. This increase amounts to the modern combustors usual outlet temperature.

The simulation was performed in ANSYS CFX simulation environment. The composition of the inlet burnt gas is given in terms of the mass fraction distribution computed from equilibrium calculations at the given inlet temperature: $Y_{CO2} = 0.064$, $Y_{CO} = 10^{-6}$, $Y_{O2} = 0.0152$, $Y_{H2O} = 0.035$, $Y_{N2} = 0.751$.

The fuel inlet parameters are: 50 m/s, 350 K and 0.00127 kg/s.

The turbulence intensity for both inlets was 5%. The ignition of the cold, slow fuel jet diffused in the hot, fast stream of oxidizer is delayed until the mixture achieves both the necessary local oxidizer-fuel ratio and the temperature to boost the chemical mechanism.

The enhanced turbulence in the wake of the stator airfoil trailing edge accelerates the mixing between the two streams.

The flame front starts just before entering the rotor and moves downstream. The flame is broken into patches of burning mixture by the intermittent passage of the rotor leading edges.

The patches of burning mixture slide along the rotor airfoil, continuing to burn due to the lower velocities in the boundary layer. These patches of burning mixture expand their volume due to the temperature raise and pressure drop. Coherent flame structures are formed downstream of rotor's trailing edge.

The rotor-stator interaction unsteadiness effect can be expressed in terms of the outlet average temperature variation which amounts to 10-15 degrees K for the *in situ* reheat.

3. POD METHODOLOGY. MODAL DECOMPOSITION

The Proper Orthogonal Decomposition (POD) is a method that reconstructs a set of data from its projection on an optimal basis.

Besides using an optimal basis for reconstructing data, POD does not use any prior knowledge of the data set. Because of this POD is also used in natural patterns analysis of the flow field.

To rebuild the dynamic behavior of a system, POD breaks down data into two parts: a time dependent part, that generates the amplitude coefficients $a_k(t)$ and a spatial coordinates dependent part that yields a orthonormal functional basis $\psi_k(\mathbf{x})$. The reconstructed model reads:

$$u(\mathbf{x},t) = \sum_{k=1}^{M} a_k(t) \cdot \psi_k(\mathbf{x}) \tag{1}$$

where M is the number of data snapshots. The reconstruction dataset error is:

$$\varepsilon(\mathbf{x},t) = u(\mathbf{x},t) - \sum_{k=1}^{M} a_k(t) \cdot \psi_k(\mathbf{x}) \tag{2}$$

The functional basis on which this set is reconstructed is optimal because the average of the squared error is minimized for any number $m \le M$ of base functions from all possible sets of orthogonal functions $\varepsilon_m = \langle (\varepsilon, \varepsilon) \rangle$. In reference [8] was showed that the minimization condition is equivalent to maximizing the ratio:

$$\lambda = \langle |(u,\psi)| \rangle / (\psi,\psi) \tag{3}$$

which happens when the base functions $\psi_k(\mathbf{x})$ are solutions of the Fredholm integral equation:

$$\sum_{j=1}^{M} \int R_{ij}(\mathbf{x},\mathbf{x}') \cdot \psi_j(\mathbf{x}') d\mathbf{x}' = \lambda \psi_i(\mathbf{x}) \tag{4}$$

where R_{ij} is the correlation kernel.

Following this approach, one transforms the decomposition into an eigenvalue problem where λ_k is the associated eigenvalue to the eigenmode ψ_k.

As the inner product $(\cdot,\cdot)$ can be thought of in terms of "energy", the value of λ_k is linked to the energy content of the ψ_k characteristic.

Hence, for short, the POD optimization process represents the way in which the dataset is projected on a basis that maximizes the energy content. The first mode will be the most energetic.

In the field of fluid mechanics, two main approaches have been used: the first one, the classical, continuous POD was promoted by Lumley [8]; the second one is based on the so called snapshot approach and originates in the works of Sirovitch [9]. The main difference between these approaches is the way in which the correlation matrix is built.

Following the Sirovitch methodology, we will build the time-correlation matrix:

$$C = \int\int u(\mathbf{x},t)u(\mathbf{x},t')d\Omega \tag{5}$$

which is only of the order of the square of time snapshots. The spatial proper modes are to be computed from:

$$\psi_k(\mathbf{x}) = \frac{1}{\sqrt{\lambda_k}}\int \phi_k(t)u(\mathbf{x},t)dt \tag{6}$$

where ϕ_k are the eigenvectors corresponding to λ_k.

3. DISCRETE POD-SNAPSHOT FORMULATION

We start form a set of *M* snapshots obtained from the numerical simulation of the given model. The simulation can be performed either with a commercial or in-house code. The sampling rate must comply with Nyquist-Shannon [10] criterion used for signal reconstruction. The construction of the correlation matrix is done as follows, either for a vector valued or scalar valued function. Assuming that the quantity of interest is denoted by *u*, first we have to arrange all its values for a certain snapshot in a vector with dimension *N* (*N* could be very large depending on the discretized model). Then, for each following snapshot, we proceed identically in order to build the next $N \times M$ matrix. The correlation matrix is then built as $C_{M\times M} = W_C^T \cdot W_C$.

The previous square matrix is positive definite, hence it yields positive,

$$W_C = \begin{bmatrix} u(\mathbf{x}_1,t_1) & u(\mathbf{x}_1,t_2) & \cdots & u(\mathbf{x}_1,t_M) \\ u(\mathbf{x}_2,t_1) & u(\mathbf{x}_2,t_2) & \cdots & u(\mathbf{x}_2,t_M) \\ \vdots & \vdots & \cdots & \vdots \\ u(\mathbf{x}_N,t_1) & u(\mathbf{x}_N,t_2) & \cdots & u(\mathbf{x}_N,t_M) \end{bmatrix} \tag{7}$$

real eigenvalues λ_k and the associated eigenvectors ϕ_k that are rearranged in a matrix Φ from the most energetic to the least energetic content (eigenvalues in decreasing order). The eigenmodes with only spatial dependence ψ_k are obtained as:

$$\Psi_{N\times M} = \left(W_{N\times M} \cdot \Phi_{M\times M}\right) \cdot L_{M\times M} \tag{8}$$

where $L_{M\times M}$ is a diagonal square matrix with elements $1/\sqrt{\lambda_k}$ arranged in descending order. The reconstruction of $\tilde{u}(\mathbf{x},t)$ based on $m < M$ modes follows the equation:

$$\tilde{u}(\mathbf{x},t) = \sum_{k=1}^{m}\sqrt{\lambda_k}\phi_k(t)\psi_k(\mathbf{x}) = \sum_{k=1}^{m} a_k(t)\psi_k(\mathbf{x}) \tag{9}$$

Considering the flow variables of interest, ROM models (Eq. 9) can be devised for each one of them.

Another approach takes into account a different structure for the inner product defined in Eq. (5). For example, following Rowley et al. [11], one can consider

$$(\mathbf{q}_1,\mathbf{q}_2) = \int_\Omega (\rho_1\rho_2 + u_1u_2 + v_1v_2 + w_1w_2 + p_1p_2)d\Omega \tag{10}$$

but in this case, care should be taken to use an appropriate non-dimensional form. The discrete counterpart of Eq. (10) can be deduced from Eq. (7) by simply putting one quantity below the other in the vectors chosen for the matrix construction.

4. RESULTS

The simulation performed for the turbine combustor offered the requested snapshots with a sampling rate of 10 snapshots per cycle. Herein, a cycle is defined as the time requested for the rotor to travel a distance equal to the stator pitch length at midspan. First 41 out of 200 snapshots were analyzed. The configuration space contains density, absolute pressure, velocity components in stationary frame, temperature, static entropy, Mach number and the reaction rates for methane and carbon mono-oxide oxidation. Applying the procedures described by Eqs. (7)-(9) we obtained the specific eigenspectra. Figure (1) illustrates these spectra CO and methane decomposition reactions, while Fig. (2) shows the almost harmonic behavior of temporal coefficients for CH4 reaction rate.

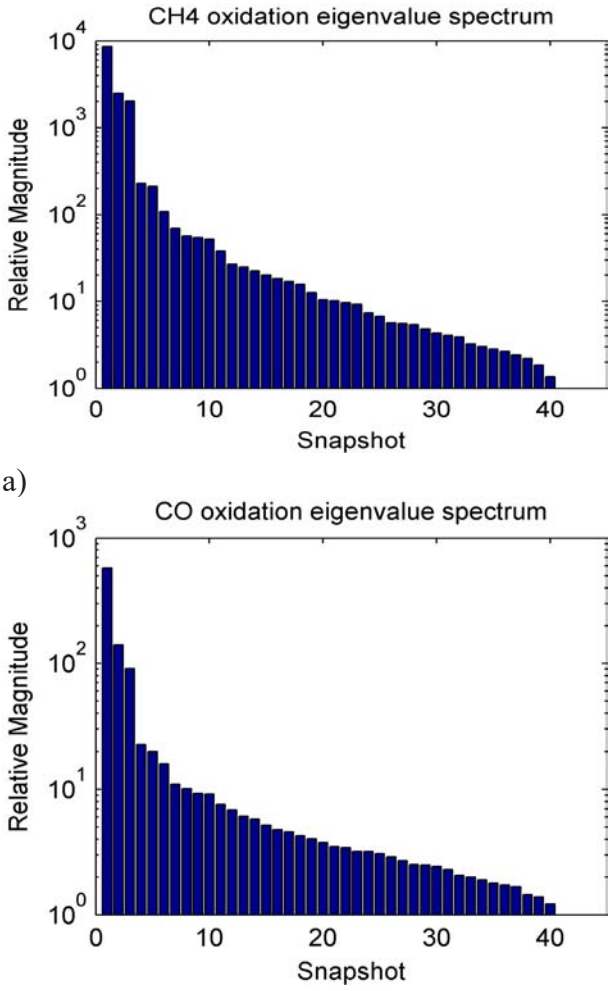

Fig. 1 Eigenspectrum for the reactions of the chemical mechanism.

The most outstanding feature of the eigenspectra for the specified configuration space is the similarity of the eigenvalue modal distributions among all flow variables except for the two reaction rates. The "energy" spectrum for the methane oxidation rate needs at least 20 modes to cover 95% of the total energy content, while for the rest of the variables 1 mode is sufficient.

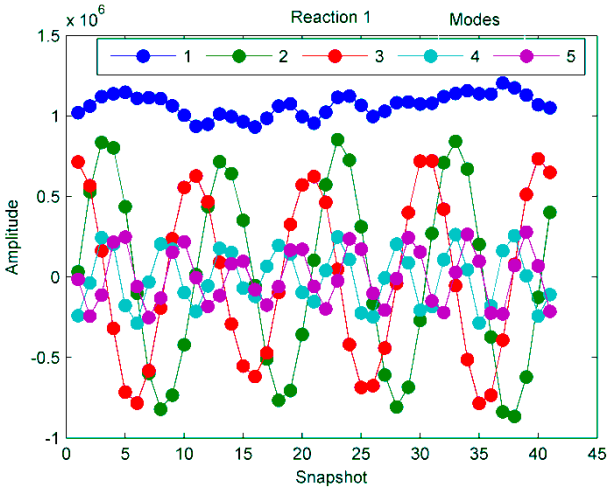

Fig. 2 Amplitude variation for the first five modes for methane decomposition.

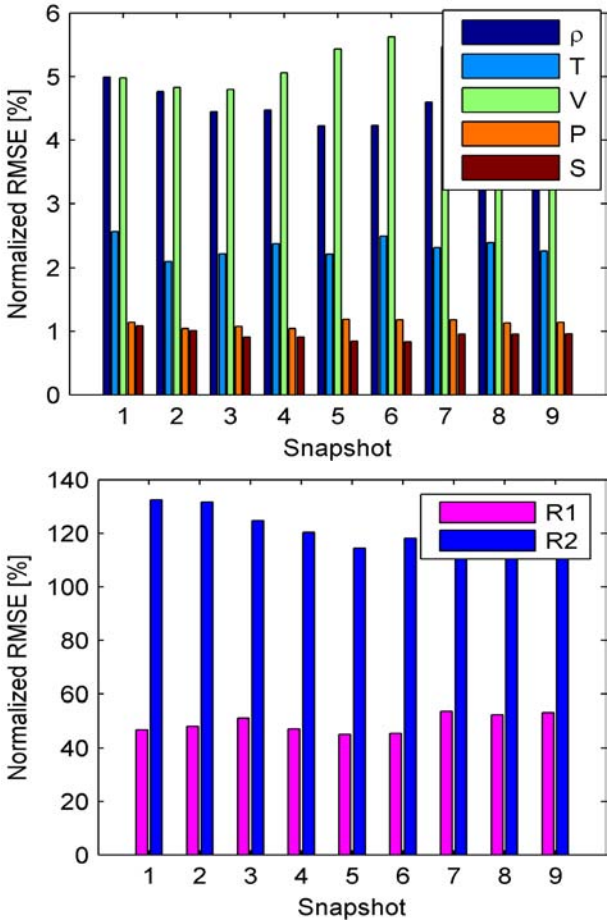

Fig. 3 Five modes reconstruction accuracy

Five modes are needed for CO oxidation rate. The same observation becomes apparent from the normalized RMSE of the reconstructed snapshots displayed in Fig. 3.

The error is unacceptable for CH4 oxidation rate and still too large for CO oxidation rate. The natural patterns of the reactive flow are associated with the eigenmodes ψ_k distributions.

As expected, the reaction rates and temperature modes are well coupled up until the third mode (Fig. 4) even if the nodes and antinodes switch places along the rotor-stator interface. Beyond third mode, these correlations are lost for CH4 reaction rate but remain visible for CO reaction rate and temperature up to fifth mode.

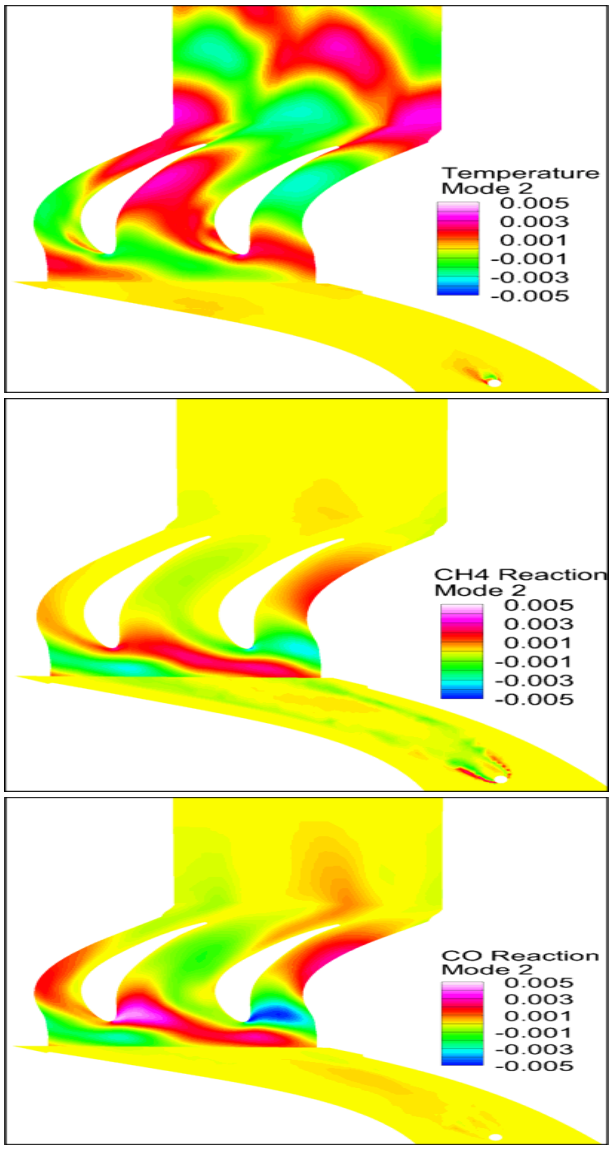

Fig. 4 Temperature and reaction rates correlations on the second mode.

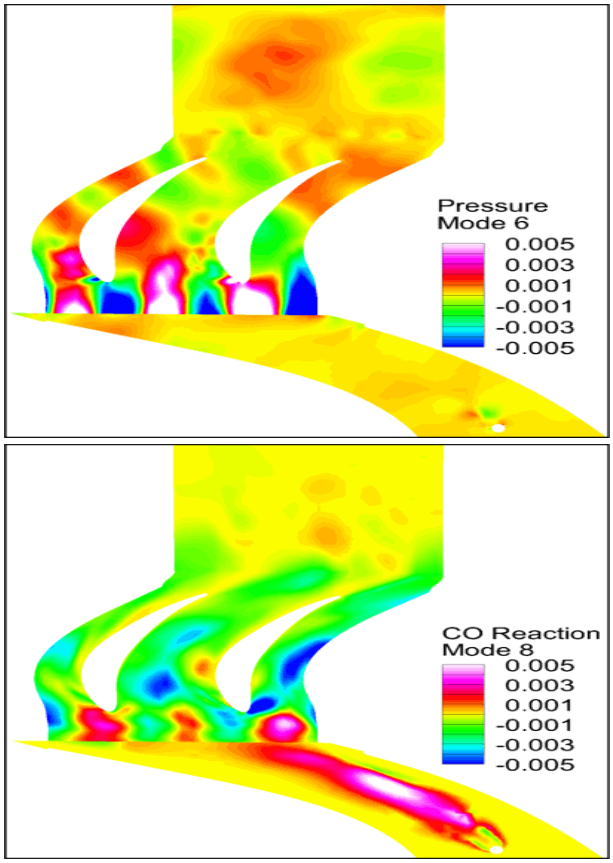

Fig. 5 Acoustic correlations between pressure and CO reaction rate.

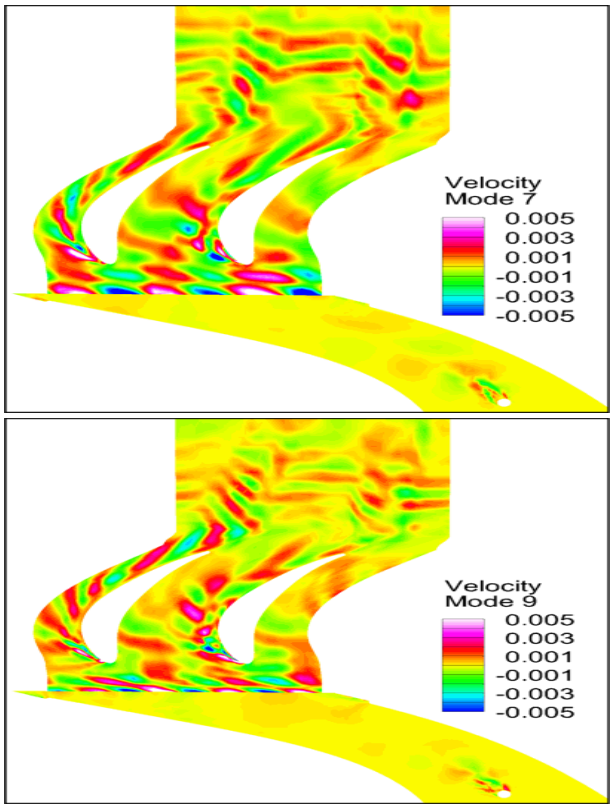

Fig. 6. Velocity odd-even decoupling in the wake of the injection pipe.

The next acoustic modes bring new correlations between absolute pressure and CO reaction rate along the rotor-stator interface which are apparent from Fig. 5.

Odd-even decoupling and oscillations are characteristics emerging from higher acoustic modes for pressure and velocity, especially in the wake of the injection pipe, as depicted in Figs. 5a-5b and Fig. 6.

CONCLUSIONS

In this study we have emphasized the possibility of using POD technique in order to obtain information on the natural patterns for various thermodynamic and flow quantities defining the process of gas expansion in a turbine burner. The precision of the reconstruction depends on how many eigenvectors (basis functions) are considered. The analysis shows only the first step in obtaining an useful reduced order model. The salient features observed concern especially the reaction rates described in the Westbrook-Dryer mechanism. It seems that higher modes for CH4 oxidation need to be taken into account which amounts to either using smaller time steps in the numerical simulation approach or revisit the reaction mechanism and find appropriate reaction rate coefficients. Due to the large errors in the reconstruction of the reaction rates snapshots, a reduced order model is not feasible based on the available CFD data. The stability, sensitivity or inverse analyses have to be postponed until solving the previous mentioned shortcomings resulted from the POD investigation.

ACKNOWLEDGMENT

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OPTIMIZING A SPACE MISSION USING ION PROPULSION

Grigore CICAN
National Research and Development Institute for Gas Turbines COMOTI, Bucharest, Romania
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Abstract: *The purpose of this paper is to describe a method of optimizing a space mission using ion propulsion, the calculation method of the parameters that belong to a spacecraft equipped with ion propulsion, the speed variation of a spacecraft depending on the evacuation speed of the particles for variation t, variation α and other parameters. The following elements will be calculated: the evacuation speed variation depending on the potential acceleration, force variation depending on the potential acceleration, flow rate variation depending on the potential acceleration.*
Keywords*: mission, ion propulsion, optimization, parameters, payload, propellant*

1. INTRODUCTION

From the oldest times one of the biggest dreams of humans was the flight, especially the flight to other planets. One of the first previews of this idea was the great scientist Konstantin Eduardovitch Tsiolkovsky [3]. We can say that the history of modern rocket flying and astronautics starts in 1903 with the famous article "Investigation of Universal Space by Means of Reactive Devices, [6] from which the following quote is taken. That article contains the rocket equation of Tsiolkovsky in differential form, which is the fundamental mathematical expression in the field of space propulsion.

In the field of electricity the first scientists who see the possibility and the potential of electrical propulsion are: Robert H. Goddard [8], in 1906, expressed many of them just as simple information; Konstantin Eduardovitch Tsiolkovsky which in 1911 published an idea of electric propulsion: "It is possible that in time we may use electricity to produce a large velocity for the particles ejected from a rocket device" [6] and Professor Herman Oberth, which in 1929, included a chapter on electric propulsion in his classic book about rockets and space travel [5]. There are three types of electrical propulsion systems: electro-thermal, electrostatic (ionic) and electromagnetic; a detailed description of these propulsion systems can be found in reference [1].

For studying the travel to Mars it was chosen the electrostatic (ionic) propulsion system. This propulsion system was developed since the beginning of 60's by projects NASTAR. Over the time this systems were made and perfected especially for satellites, in order to do the orbit correction and satellite transfer from an orbit to another.

After perfecting these propulsion systems they were used during some Terra outer space missions, the first success mission which used ionic propulsion was in 1998 during the American Deep space mission 1 [10]. Another successful mission which used the ionic propulsion was the Japanese mission Hayabusa [11] from the year 2003 which had as main objective the study of an asteroid. The last major success mission which used the ionic propulsion was Dawn [12] launched in 2007, the purpose of the mission was to study the Vesta and Ceres asteroids, which arrived at her destination in 2015 passing near Mars by using the planet's gravity in order to continue the travel. A future interplanetary mission will be made by ESA and JAXA in 2017 and it will be a travel to Mercury planet, the name of the mission is BepiColombo [13].

In this paperwork we try the optimization the performances of a spacecraft, especially by optimizing the propulsion system seeing the technological actual limits and the calculation extension of the improvement possibilities.

2. THE RUNNING PRINCIPLE OF THE ELECTRIC PROPULSION SYSTEMS

The running principle of electrical propulsion systems consists of making the gas molecules or, in general the particles which have to be ejected, sensitive to the action of an electric field and to send them the desired energy using this field. The known method for making a conductor from a gas it is by ionizing it, in this case the gas becomes sensitive to the action of an electric or magnetic field. If we ionize a gas in a given chamber we obtain negative and positive charges. In a ionic rocket the charges are separated first, the negatives from the positives and the ion obtained are accelerated in a particle accelerator.

Electrostatic propulsion, regardless of type, consists of the same series of basic ingredients, a propellant source, several forms of electric power, an ionizing chamber, an accelerator region, and the means of neutralizing the exhaust. While Coulomb accelerators require a net charge density of one polarity, the exhaust beam must be neutralized to avoid a space-charge build-up outside of the craft which could easily cancel the operation of the thruster. The neutralization is given by the injection of electrons downstream as in picture 1, a schematic diagram of the NASTAR ion thruster, as used on Deep Space 1 [7]. The neutralization of the ion fascicle as one of the most difficult problems of this propulsion system.

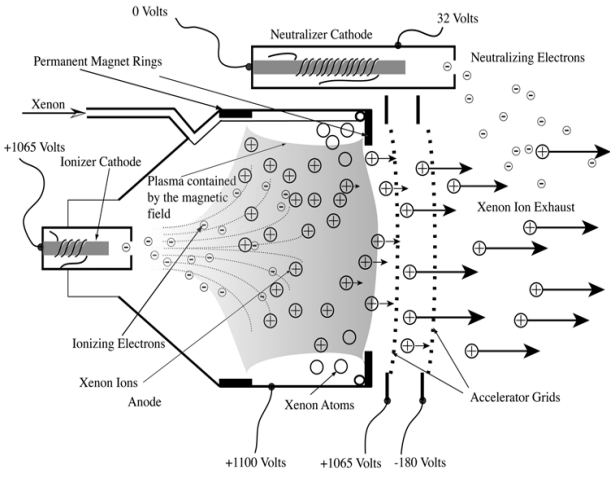

Fig 1 The schematic diagram of the NASTAR ion thruster.

The evacuation speed at which the particles arrive it is determined in a particle accelerator. We analyzed the direct particle accelerator because it is the most used particle accelerator. This particle accelerator is described in reference [2].

According to reference [9] we will present the calculation method for the ionic engine. For starters it will be analyzed the situation of an ion which has the load q and mass m located in an electric field $\vec{E}$, determined by the tension $V_{acc} = V_2 - V_1$ which applies between A anode and C cathode, as it can be seen in the picture below.

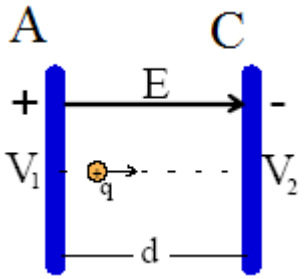

Fig 2 The schematic diagram of the electric field.

The ion is accelerated until it gets a speed v_e determined by the next equality: the kinetic energy of the electron it is equal with the kinetic energy variation of the particle, conditioned by the electric field action.

$$\frac{1}{2}\cdot m\cdot v_e^2 = q\cdot V_{acc} \Rightarrow v_e = \sqrt{\frac{2\cdot q\cdot V_{acc}}{m}} \quad (1)$$

The below expression is valid if the particle takes off from the ion source with the speed 0, during the acceleration interval there is an uniform electric field

$$E = \frac{U}{d} \quad (2)$$

where d is the distance between the two electrodes.

In order to calculate the propulsion force produced by the ionic engine we used the expression below:

$$I = \dot{m} \cdot \left(\frac{e}{m} \right) \quad (3)$$

The propulsion force is defined as:

$$F = \dot{m} \cdot v_e = I \cdot \sqrt{2 \cdot \frac{m}{e} \cdot V_{acc}} \quad (4)$$

We have to determine the intensity of the electric current by defining the current density $j = \frac{I}{S}$.

Using the Poisson's equation we obtain:

$$\frac{d^2 V}{d^2} = \frac{\rho_e}{\varepsilon_0} \quad (5)$$

where d is the distance, ε_0 is the vacuum permeation and ρ_e current density.

Solving the equation below we obtain the current density:

$$j = \frac{4 \cdot \varepsilon_0}{9} \cdot \sqrt{\frac{2 \cdot q}{m}} \cdot \frac{V_{acc}^{\frac{3}{2}}}{d^2} \quad (6)$$

For atomic or molecular ions we obtain:

$$j = \frac{5.4 \cdot 10^{-8} \cdot V_{acc}^{\frac{3}{2}}}{M^{\frac{1}{2}} \cdot d^2} \quad (7)$$

And for circular form holes we have:

$$I = j \cdot S = j \cdot \left(\frac{\pi \cdot D^2}{4} \right) \quad (8)$$

where D is the hole diameter.

$$F = \left(\frac{2}{9} \right) \cdot \pi \cdot \varepsilon_0 \cdot D^2 \cdot \frac{V_{acc}^2}{d^2} \quad (9)$$

The electric power is:

$$P_e = I \cdot V_{acc} = \frac{1}{2} \cdot \frac{\dot{m} \cdot v_e^2}{\eta} \quad (10)$$

The performance of an electrical rocket can be conveniently analyzed in terms of the power and the relevant masses [4].

Using Țsiolkovski's equation we obtain the formula:

$$v = v_e \cdot h \frac{m_0}{m_f} \quad (11)$$

m_f is the final mass of the rocket, m_p is the propellant mass from aboard, v is the rocket speed at the time moment t, m_0 is the initial mass of the rocket, m is the mass of the rocket at t moment, v_e is the evacuation speed of the propellant from the engine.

Before the rocket take off, the initial mass is given by:

$$m_0 = m_p + m_{pl} + m_{pp} \quad (12)$$

m_u is the mass of the payload, m_{pp} is the mass of the power plant from aboard, $\alpha = \frac{P_e}{m_{sp}}$,

P_e is the electrical power of the power source.

Between the electrical power of the source and the power of the jet we have the relation:

$$\eta = \frac{P_{jet}}{P_e} \quad (13)$$

η is the system's performance.

$$P_{jet} = \frac{1}{2} \cdot \dot{m} \cdot v_e^2 \quad (14)$$

$$P_e = \alpha \cdot m_{sp} = \frac{P_{jet}}{\eta} = \frac{m_p \cdot v_e^2}{2 \cdot t_p \cdot \eta} \quad (15)$$

In order to determine the rocket's performances:

where t_p is the time in which the propellant is used.

3. RESULTS OF MISSION OPTIMIZATION

The performances of the mission will be optimized depending on different parameters as it can be seen below:

For study of the performances we know about the mission η=0.7, α=500, $\frac{m_{pl}}{m_p} = 3$, $\frac{m_{pp}}{m_p} = 0.15$, $t = 10^7$ s.

The following information is known about the ionic engine:

The working fluid is xenon which molecular weight is 131.3 kg/kg-mole, the distance between the acceleration grids d= 2.5 mm, the diameter of each hole of the grid D=2 mm, the number holes in the grid No=2200.

After variation the parameters obtain:

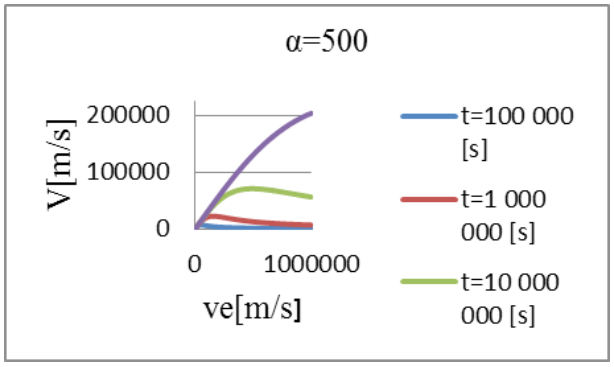

Fig. 3 Rocket speed variation depending on the evacuation speed of the particles for variation of t.

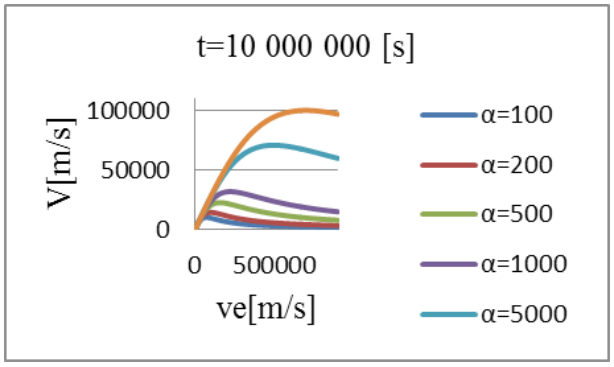

Fig. 4 Rocket speed variation depending on the evacuation speed of the particles for variation of α.

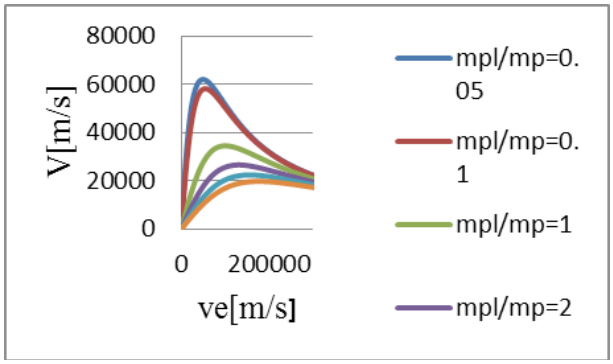

Fig. 5 Rocket speed variation depending on the evacuation speed of the particles for the $\frac{m_{pl}}{m_p}$.

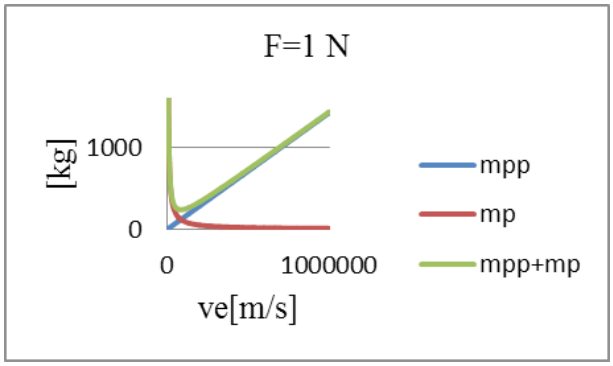

Fig. 6 m_{sp}, m_p and $m_p + m_{sp}$ variation depending on the evacuation speed of the particles.

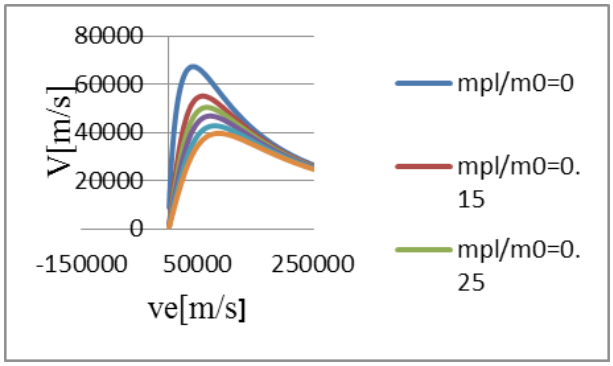

Fig. 7 Rocket speed variation depending on the evacuation speed of the particles for $\frac{m_{pl}}{m_0}$.

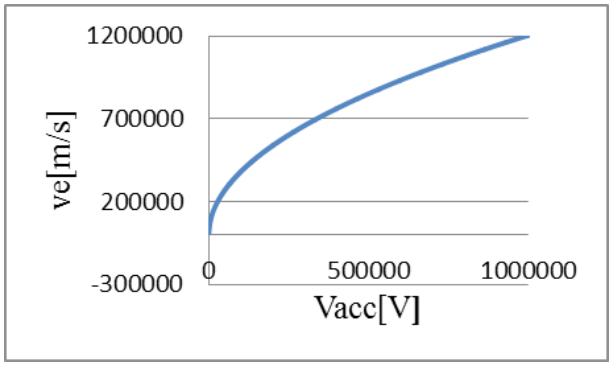

Fig. 8 Evacuation speed variation depending on the potential acceleration

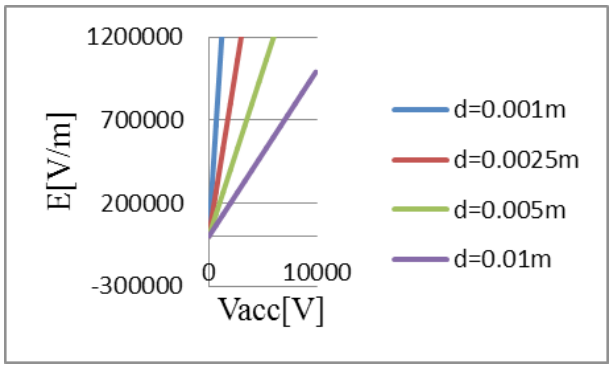

Fig. 9 Electric field variation depending on the potential acceleration

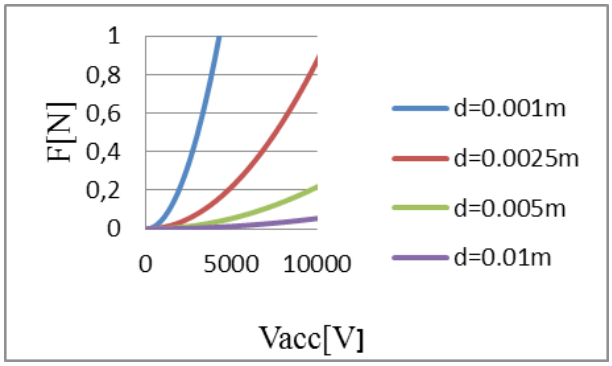

Fig. 10 Force variation depending on the potential acceleration

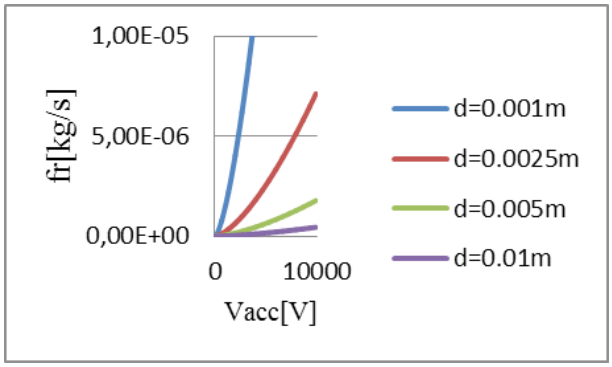

Fig. 11 Flow rate evacuation depending on the potential acceleration

CONCLUSIONS

As you can see in the figure 3 the variation of the ship's speed is maximum with the evacuation speed for each time of the mission.

From the figure 4 it can be seen that for each α there is a maximum for the speed rocket depending on the evacuation speed of the particles for variation of α. Therefore if there would be high values for the α parameters the rocket could achieve higher speeds for the ship.

For choosing the propellant quantity aboard figure 5 shows that the maximum speed that can be achieved by the ship for a certain evacuation speed of the particles.

From the figure 8 it can be seen the variation of speed of particles depending on the potential of acceleration so the higher the potential for acceleration, the higher the exhaust speed.

The variation thrust and propellant flow is greater as long as the distance d between the two boards is less, so a higher electric field is present.

For a certain space mission, a spacecraft that must reach a certain speed, it can be chosen a certain optimal exhaust speed depending on the parameters studied in this article.

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PARTICULARITIES OF THE INTERACTION BETWEEN THE AIRCRAFT WAKE VORTICES AND THE ATMOSPHERIC BOUNDARY LAYER

Cristian-Emil MOLDOVEANU*, Pamfil SOMOIAG*, Oscar HEMELAAR, Martin AUBERT*****
* Military Technical Academy of Bucharest, Romania, ** IUT Paul Sabatier Toulouse, France,
*** ECAM Strasbourg, France
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Abstract: *The most important consequence of aircraft wake vortex is the risk of aerial accidents as another aircraft can come across the wake left behind by the preceding one. This occurs more frequently during the take-off/landing phases when the wake vortex interaction phenomena could enhance the intensity of the wake vortex. Modern airports are faced with the optimization problem of the aerial traffic so as to allow maximum aircraft turnover without thus endangering them in any way. A wake reduction method is represented by acceleration of the instability mechanisms which develop in wake vortex. In this paper will be studied the wake's interaction with the atmospheric boundary layer in the proximity of airports in order to highlight the turbulent instability mechanisms. Positioning and dimensions of the airport infrastructure can modify the atmospheric boundary layer and will lead to a decomposition of the wake vortex.*
Keywords: *wake vortex; instability mechanism; boundary layer.*

1. INTRODUCTION

When a plane is flying, there is a high pressure below the wings and a low pressure over them. So at the extremity of the wings, there is an air flow from the high pressure to the low pressure [1]. This flow has circular movement and that's why some vortices are created. We call them wake vortices: two contra-rotating vortices which have the same radius and the same intensity (figure 1).

Figure 1: The origin of wake vortices

This phenomenon 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 [4]. There are a lot of researches ongoing about wake vortexes because of the several issues related to it [5].

First of all, it is a great source of drag, representing approximately one third of it. In the current economical context, both aeronautical manufacturers and airline companies look for solutions in order to get lower flying costs. Even a small decrease in drag would allow billions of litters of fuel economy each year.

But the main issue with vortexes is the incidents that can happen when a plane flies through it. If the plane is too light compared to the vortex, it will experience a rolling motion, sometimes surprising the pilot and creating dangerous situations [5].

Around airports, at takeoff or landing, when several planes have to follow each other, this problem is frequent. In order to minimize the amount of accidents, the 'Federal Aviation Administration' put minimal distances between each planes depending on their sizes in 1970.

Several accidents still occurred years after, and not only small planes but also medium-sized ones like an Airbus A300-600 on November 12th2001, which lost its rudder due to an excessive force applied on it by a wake vortex [6].

Our work will be split in several stages. The very first one is to generate a laminar boundary layer on a surface with a side wind. Then, we will insert an obstacle which represents an airport building in order to disturb the boundary layer and generate a turbulent boundary layer [7]. Next, we will generate vortexes and look at their evolution without a side wind [9].

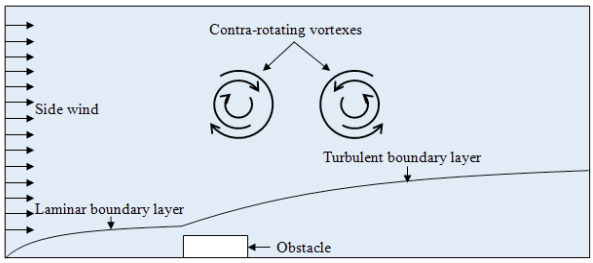

Figure 2: The wake vortex in boundary layer effect

This will allow us to predict their behavior in the final stage and adapt the geometry of our simulation [2]. And finally, we will overlay the two cases in order to look at the interactions between a turbulent boundary layer and a pair of contra-rotating vortexes (figure 2).

2. BOUNDARY LAYER

A fluid flowing along a surface leaves a layer on the surface [8], which becomes attached to it, wetting it in the case of water for example. This is called the 'no slip condition'. Alongside with the effect of viscosity, the flow along the surface will have a specific speed field [10].

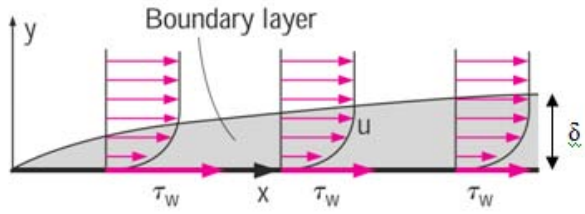

Figure 3: Boundary layer

Figure 3 shows a laminar boundary layer on a horizontal plate for a flow along the x axis, where δ is the height of the boundary layer, distance at which the speed of the fluid is equal to 99% of the initial fluid speed.

We can see that the value of δ increases with the distance to the starting point of the plate. Over a certain distance, the value of δ becomes too important and instabilities appear, leading the laminar boundary layer to a turbulent state [3].

The first case we will study is a laminar boundary layer over a surface. The geometry will consist of a rectangle with $L_x = 1\,m$, $L_y = 1\,m$, $d_x = 0.02$ and $n_y = 100$ with a successive grading ratio of 1.033 in order to make the cells smaller near the surface. The total amount of cells is 5000. A velocity inlet at the left side will simulate the presence of wind at a speed of $1\,m/s$.The bottom boundary will be a Wall, the upper boundary Symmetry, and finally the outlet will be at the right side. After 466 iterations the simulation converged with very little residuals. We can now proceed to analyze the results.

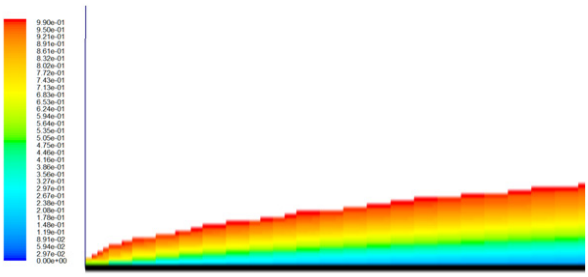

Figure 4: X velocity for a boundary layer

First we will look at the shape of the boundary layer. To do so, we have to look at the longitudinal speed field at the beginning of the surface. In figure 4 the scale on the y axis has been modified in order to make it easier to see the thin boundary layer [2]. Then, we will look at the speed field near the end of the plate.

In this second case, we will insert an object within the boundary layer, simulating a building, and perturbing the laminar boundary layer [3]. This will result in a turbulent boundary layer being generated. Finding the right mesh in order to do this was the main difficulty here, because the cells around the object had to be small enough in order to see the influence of the boundary layer, but not too small in order reduce computing time [8].

We even came up with cases that would converge while being physically wrong, due to a particular mesh disposition.

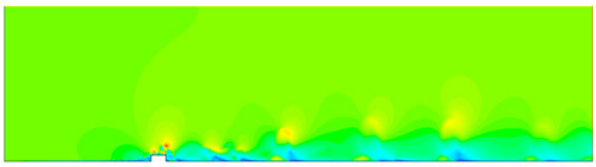

Figure 5: Velocity magnitude after 6000 iterations

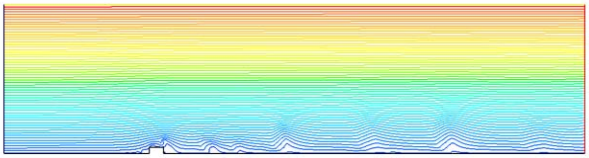

Figure 6: Streamlines within the turbulent boundary layer

We then iterate our case for a large amount of time. This is necessary because else there would be little to no turbulences generated. After 6000 iterations, we obtain the speed field on figure 5. The streamlines are presented in figure 6. We can see there are turbulences on the right side of the object, and their growth in size corresponds to that of a turbulent boundary layer.

3. WAKE VORTEX SIMULATION

Our goal here is to look at the evolution of a pair of vortexes. To do so, we could make a large rectangular mesh with symmetry boundaries and generate the vortexes in the middle.

We will use to the left and right sides of the domain the symmetry boundaries and the upper and down edges will have periodic boundaries.

The mesh is therefore a rectangle, with $L_x = 15\ m$, $L_y = 5\ m$ and $d_x = d_y = 0.05$, $n_x = 300$, $n_y = 100$ and the total amount of cells is 30,000. The origin being in the left bottom corner, the center of the first vortex will be at coordinates $Xc_1 = 6\ m$ and $Yc_1 = 3\ m$, and the center of the second vortex will be at coordinates $Xc_2 = 9\ m$ and $Yc_2 = 3\ m$.

The core radius of both vortexes will be $r_0 = 0.2\ m$ and the circulation contained in the vortex will be $\Gamma = 10\ m^2/s$.

The dimensions used here were chosen arbitrarily because we just want to watch the evolution of any pair of contra-rotating vortexes. Figure 7 shows the streamlines after we've generated the vortexes.

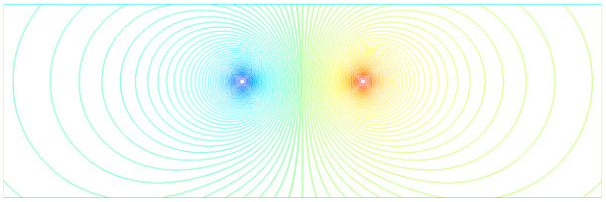

Figure 7: Streamlines showing the two generated vortexes

Running an unsteady simulation, we follow the evolution of this pair of vortexes every second for six seconds. What we were able to see is that they move, going downwards, and their centers reach the bottom of the mesh between $T = 5\ s$ and $T = 6\ s$. So they have an approximate descending velocity of $V_d = 0.5\ m/s$ (figure8).

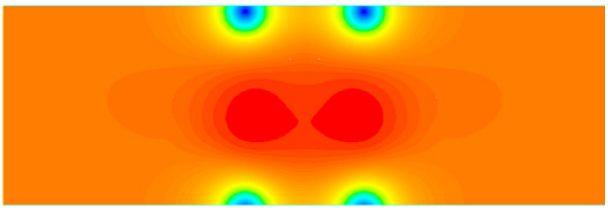

Figure 8: Static pressure at T = 6 s, showing the center of the vortexes after reaching the bottom of the mesh

We can verify the results we have obtained through simulations for the descending velocity using the next equation: $V_d = \frac{\Gamma}{2\pi b}$

In this formula, V_d is the descending velocity, Γ is the circulation within the vortex, and b is the distance between the two vortexes [11]. With the values we have chosen to generate the pair of vortexes with, we find a value for the descending velocity $V_d = 0.531\ m/s$, which verifies the results of the simulation.

4. WAKE VORTEX IN GROUND EFFECT

In order to study the evolution of a pair of vortexes near a wall, we will use the same mesh as in the previous section. The only thing we need to change are the boundary conditions, putting symmetries everywhere except at the bottom which will be a wall [12]. Running an unsteady simulation with 0.1 seconds time steps, we capture an image every 10 time steps, and then compare them (figure 9).

On figure 9 we can see that the vortexes separate when approaching the wall. If we make a graph out of their positions (figure 11), it would look like the theoretical one presented in figure 10.Their trajectory look like an inverse function, first going down almost vertically, and then continuing along the wall asymptotically.

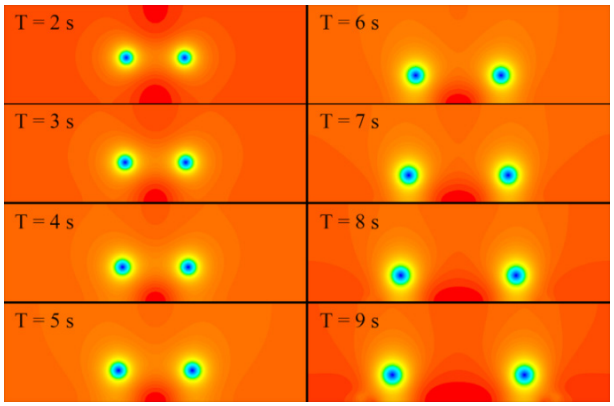

Figure 9: Position of the centers of the vortexes shown by static pressure

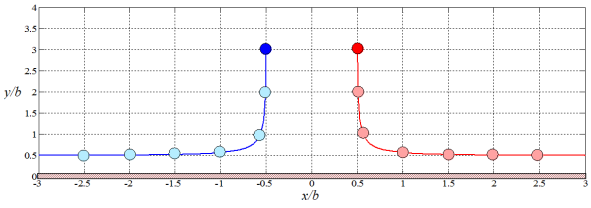

Figure 10: Graph showing the trajectory of the centers of the vortexes

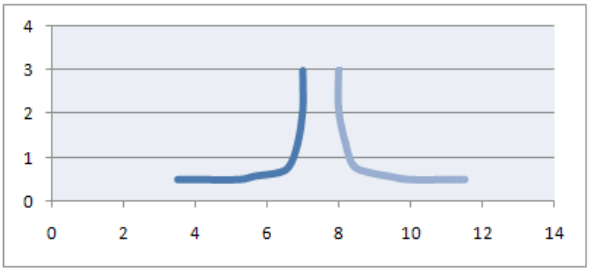

Figure 11: Graph showing the calculated trajectory of the centers of the vortexes

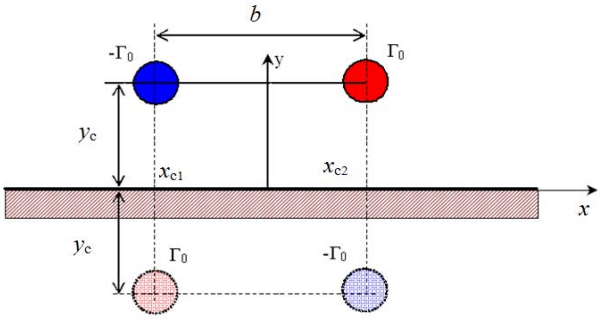

Figure 12: Representation of the “mirror” effect created by the wall

The reason of this particular trajectory is that the wall acts a little like a “mirror” for the vortexes. This is explained in figure 12, where the two contra rotating vortexes approaching the wall begin to interact with two other vortexes. The blue vortex rotating clockwise, its image will be a counter-clockwise vortex, leading it to the left following the same rules as of the two initial vortexes. The same happens with the red vortex on the right side.

5. WAKE VORTEX IN BOUNDARY EFFECT

For this final step, the idea is to overlay the vortexes and the turbulent boundary layer. Doing it in a single stage is the first approach, but we’ll quickly see that it will not work.

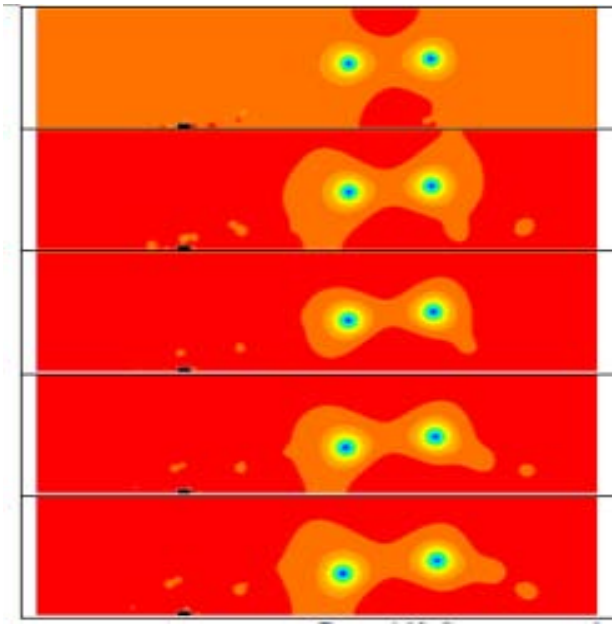

Figure 13: Static pressure for a pair of vortexes near turbulent eddies

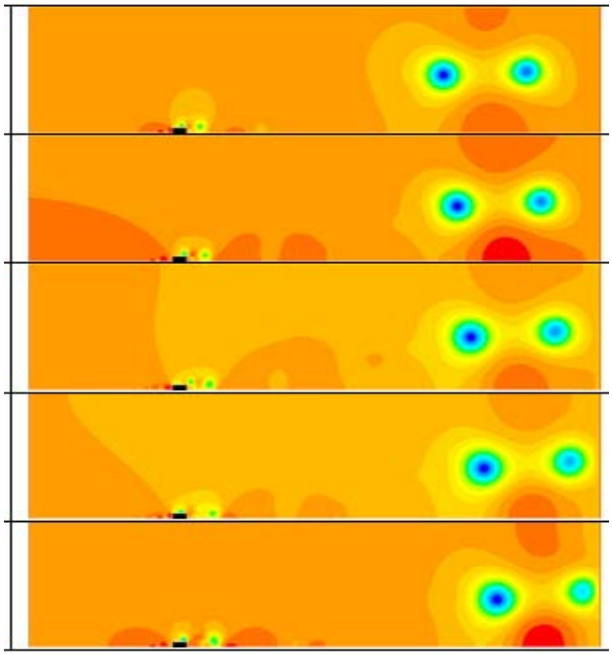

Figure 14: Static pressure for a pair of vortexes with a side wind

This is because we have to find an equilibrium between three times: the time needed for the vortexes to reach the ground t_d, the time before a turbulent boundary layer is formed t_f, and the time before the vortexes are pushed out of the simulation by the wind t_v. In this case it is impossible, because $t_f > t_v$, so even if we increase the strength of the vortexes to reduce t_d, they will never meet a turbulent boundary layer.

We chose a value for $\Gamma = 50$, this way the descending speed $V_d = \frac{\Gamma}{2\pi b} = 2.65\ m/s$ which, compared to the side wind speed of $5\ m/s$, makes it possible for the pair of vortexes to get near the ground before exiting the mesh.

However, it still did not let us enough time to study the vortexes. They got close to the turbulences, but their interactions can't clearly be seen because of the proximity of the pressure outlet which makes the results false.

Raising the value for Γ would speed up the process, but it would also increase the difference of intensity between the vortexes and the turbulences, making the output useless (figure 13 and 14).

CONCLUSIONS

In this study we have emphasized how we can create some turbulence thanks to a building of an airport. This turbulence can weaken a vortex contrary to the ground which, when the vortex touches it, increases the strength of this vortex. Moreover a small building is more effective than a big one to weaken a vortex.

So we can reduce the life expectancy of the wake vortices created by the planes thanks to the building of the airport. So it is important to have some building not too far to the landing runway in order to make sure that there is some turbulence and that the vortices are weakened quickly. Thus we can reduce the delay between to plane.

This study has shown that using the building of an airport is really a solution to reduce the life expectancy of vortices. But know it could be interesting to work on the disposition and the form of these building to find the best way to improve the security in an airport.

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AEROSPACE PERFORMANCE FACTOR OPTIMIZATION

Monica VLAD, Octavian Thor PLETER
University Politehnica of Bucharest, Romania
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Abstract: *This paper illustrates a possible optimization enhancement for the APF (Aerospace Performance Factor). The APF is an approach to measure safety performance. It is a tool that visually assesses safety and its evolution over time, for the purpose of aiding the decision makers to take the most effective safety measures. Given a specific situation, the optimized APF calculates the best areas where investment is effective and, in the same time, budget considerate. This is possible by using the already implemented What-if function. This function simulates what would happen to the APF index in a scenario where a certain hypothetical decision reduces a certain contributing factor. The tool works symmetrically with mitigating factors by artificially increasing the percentage. Assuming enough data is included in the APF, the optimization returns the contribution/mitigation factor/s with the best ratio between cost and effect on the APF index.*
Keywords: *APF, optimization, safety performance, what-if tool, AHP*

1. INTRODUCTION

Costs in the context of aviation safety have always been a sensitive subject. The moral question is how to put a price on the safety of passengers - there is no possible good answer.

The paradox of costs is that you should invest an infinite amount of money (or not fly at all) to bring a zero rate of incidents and accidents and in the same time to decrease infinitely the money investment to obtain profits, at the end of the day aviation is a business. But that of course is not possible.

Because it is such a delicate topic, the cost notion is not included in safety organizational tools. Nevertheless on the day to day operation of a company, money represents the main deciding actor.

The question that this paper intends to answer is whether the cost notion can be introduced successfully in a deciding tool, namely the Aerospace Performance Factor (APF).

The Aerospace Performance Factor is a tool that is able to assess the internal safety situation of a company based on the businesses' own ranking of elements.

The second version of the APF introduces another scope of the tool, one that helps in making decisions.

The cost notion will be included in the deciding part of the APF in order to assess if the money factor can bring an added value to the Aerospace Performance Factor tool.

2. DATABASE AND METHODS

2.1 The Aerospace Performance Factor (APF) and the Analytical Hierarchical Process (AHP). This paper used as a research base the Aerospace Performance Factor (APF) tool. The APF represents a large incident data base that returns the safety evolution of an organization based on its own rankings. The company establishes the ranking of different relevant elements, this way founding its mind-map. After creating a mind-map the APF has to be populated in time by events. If enough data is introduced in the APF, the tool returns a visual situation of the companies' incidents calibrated to the ranking made in the mind-map. To make the explanation simpler an example is in order. Let's suppose an airport is the organization that uses the APF. At the level of management it is established that they have 3 big categories of incidents (Technical Events; Ground Incidents, Missed Approaches), each with its own sub-category. Each of the three is given a weight/an importance at the level of management.

Because this part of the process represents a very subjective task, the method used by the APF to decide on the ranking of incidents is the Analytical Hierarchical Process, method that will be discussed in the following rows. The weights given to each category and sub-category forms the mind map of that specific organization. As mentioned, after the formation of the mind-map the APF has to be populated by events. Based on the number of events and on the weight given to each category, the APF produces an index of the companies' situation for the specific time (usually a month). Extrapolating the same process to a larger period (for example an year), the variation of this index represents the safety evolution of the organization.

One of the key aspects of the APF is the mind-map formation. This is made by using the concepts behind the Analytical Hierarchical Process. The AHP method is used in synthesizing complex decision making. Most of the important decisions require a trade-off between different goals, both of objective and subjective nature. This process offers a systematic and approachable way in which such decisions could be made. AHP builds ratio scales from paired comparisons. These ratio scales derive from the principal Eigen vectors.

The method can be split into four parts:

1. The construction of the hierarchy of the problem: selecting the overall goal, the criteria and the alternatives of the situation
2. Using judgments to develop the relative importance of each criterion in terms of its significance to the achievement of the overall goal
3. Indicate the prioritization of each decision alternative in terms of its contribution to each criterion
4. Using the AHP mathematical method, the relative importance of the criteria and the prioritization of alternatives are synthesized to obtain a relative ranking of all alternatives in terms of their overall preference

Assuming that the hierarchy of the problem has been established, the mathematical method of the AHP will be described next.

This method can also be split into four main parts:

1. Computing the vector of criteria weights. In this part judgments are used to calculate the relative importance of each criterion with respect to the overall goal. In order to achieve that, the AHP method constructs a pairwise comparison matrix A. A is a real matrix, mxm, where m represents the number of criteria. The relative importance between two criteria is measured on a 1-9 scale[1]. The interpretation of this specific scale is given in Table 2, where it is assumed that the j-th criterion is equally or more important than the k-th one. Intermediate numbers can also be given.

The following rules apply when constructing the pairwise comparison matrix:

Table 1. Matrix elements meaning

Comparison	Meaning
$a_{jk} > 1$	then j-th criterion is more important than the k-th criterion
$a_{jk} < 1$	then j-th criterion is less important than the k-th criterion
$a_{jk} = 1 \quad a_{jj} = 1, \forall j$	then the two criteria have the same importance

Constraint:

$$a_{jk} * a_{kj} = 1 \tag{1}$$

If a matrix is said to be pairwise consistent then it obeys (1). A is a pairwise consistent matrix. The number of comparisons depends, of course on the number of objects to be compared. For the case of A, the total number of comparisons is:

$$\frac{m(m-1)}{2} \tag{2}$$

After building the A matrix, the normalized Eigen vector of the matrix has to be calculated.

1 Research and experience have confirmed that a nine-unit scale is a relative good basis for discriminating between two items (Lin)

The following method is an approximate calculation of the Eigen vector that works well with small matrix sizes m ≤ 3. Therefore we construct the normalized pairwise comparison matrix A_{norm}

Table 2. Score interpretation

Value of a_{jk}	Interpretation
1	j and k are equally important
3	j is slightly more important than k
5	j is more important than k
7	j is strongly more important than k
9	j is absolutely more important than k

Each element of the A_{norm} matrix has the following formula:

$$\overline{a_{jk}} = \frac{a_{jk}}{\sum_{i=1}^{m} a_k} \tag{3}$$

Finally, after the construction of the normalized matrix A, the criteria weight vector[2] is developed. Each element is built by averaging the values of each row:

$$w_j = \frac{\sum_{i=1}^{m} a_j}{m} \tag{4}$$

2. Computing the matrix of option scores. The next step in the AHP method is computing the matrix of option scores. This matrix will show the ranking of each option with respect to each criterion. In order to obtain it, another pair wise matrix must be built $B^{(j)}$. $B^{(j)}$ is a nxn matrix, where n represents the number of options under evaluation. The elements of $B^{(j)}$ will have the form:

$b_{ih}^{(j)}$ – Evaluation of the i-th option compared to the h-th option with respect to the j criterion

The construction rules of $B^{(j)}$ matrix are the same as for our first pair wise comparison matrix A.

These rules can be found in Table 1 and Table 2. $B^{(j)}$ is also a pairwise consistent matrix.

The following step in the AHP method normalizes each matrix $B^{(j)}$ (the approximate method presented divides each element by the sum of the elements in the same column, and then it averages the entries on each row). Out of each normalization, a score vector is obtained $s^{(j)}, j = 1,...,m$. Finally after obtaining all score vectors, the matrix of option scores has the following form:

$$S = [s^{(1)},...,s^{(m)}] \tag{5}$$

3. The option ranking. The results of steps one and two are combined here in the final step. The global score vector v has the following formula:

$$v = S * w \tag{6}$$

Where the i-th element of $v(v_i)$, represents the global score assigned by the AHP to the i-th option. The final step of the AHP method orders the global scores in decreasing order.

4. Checking consistency. Because of the high number of comparisons, inconsistencies may rise. A simple example of such inconsistency is shown below.

Inconsistency example: Let's say there are three criteria to compare: A, B and C. The first judgment evaluations are as follows:
A is slightly more important than B (3) 3>1
B is slightly more important than C (3) 3>1

If C is equal or more important than A – evident inconsistency (transitivity)

If A is slightly more important than C - slight inconsistency

If A is more important than C- consistent evaluation

The AHP method incorporates a method of checking consistency of judgment. The method implies calculating the Principal Eigen value, this value is obtained from the summation of products between each element of the Eigen vector/weight matrix (w or $S^{(j)}$) and the sum of columns of the respective matrix A or $B^{(j)}$.

2 m dimensional column vector

For A:

$$\lambda_{\max} = \sum_{i=1}^{m} w_i * (\sum_{j=1}^{m} a_{ij}) \quad (7)$$

A matrix A is said to be consistent if $a_{ij}a_{jk} = a_{ik}, \forall i, j, k$. However the consistency is not forced. In the example above A doesn't have to have a score 9>1 in comparison with C. In his work Prof. Saaty proved that for consistent reciprocal matrixes the largest Eigen value is equal to the size of the comparison matrix (for A, the size is m). He also gave a measure of verifying consistency, the Consistency Index (CI).

$$CI = \frac{\lambda_{\max} - m}{m - 1} \quad (8)$$

He also introduced the Random Consistency Index by randomly generating reciprocal matrixes and calculating the CI for each of them. The two numbers the CI and RI are compared:

$$CR = \frac{CI}{RI} \quad (9)$$

If the Consistency Ratio (CR) is smaller or equal to 10 the inconsistency is accepted, otherwise the comparisons need to be reviewed.

2.2 The What-if function-this application was developed in the second version of the APF. It has the scope of simulating what would happen to the APF index if at a certain moment in time one or more contributing factors are reduced. The logic behind the reduction of a contributing factor answers the question what would have happed to the APF index if at x point in time a decision would have been made to reduce the contributing factors with y%. The application works symmetrically with mitigating factors, this time augmenting the APF index.

If a reduction with y% of a contributing factor is considered the following changes will occur:

- Incidents that have these specific contributing factors (CF) as the unique CF will fall by y%
- Incidents that have two contributing factors, out of which one is decreased with y%, will decrease with y% with a probability of 50%
- By continuing the pattern, incidents that have k contributing factors, out of which one in lowered with y%, will fall with y% with a probability of 1/k (x/k%)

As mentioned, the question that this paper intends to answer is whether such a tool can be developed further into an application that incorporates a cost input. What-if optimization The idea is that the program should return the best investment option based on two factors: the effect of each contributing/mitigating factor on the overall APF index and the cost of such an investment.

The cost of investment will be based on expert opinion and will be introduced in the program in the following way:

"1% of reduction of Contributing Factor 1 would cost X units"

2.3 Area Calculation-Firstly the area of the overall APF index graph on a specific period of time is calculated. After that the APF area produced by the total reduction of a chosen specific contributing/mitigating factor is formed. The difference between the two will then be the denominator of the ratio.

When calculating the area, the supposition made is that there is a way in which that specific cause can be entirely nullified. This is of course not feasible; nonetheless it does not negate the validity of the search - the greatest effect on the overall APF index is the purpose of the calculation.

2.4 Introducing the Cost-Cost will be introduced in the APF without a specific unit in mind; it will be a general monetary unit and will be built-in by experts.

Cost will be thought out in this way:

"1% reduction of Contributing Factor 1 would cost X units"

By introducing the cost the nominator of our ratio will be formed. The cost will decrease the ratio as it gets bigger.

2.5 The logic of the optimization- The optimization involves maximizing the ratio between the effect (surface area) and the cost: the larger the area the bigger the ratio, the smaller the cost the bigger the ratio.

$$R_i = \frac{Area(APF_{real} - APF_{i100\%reduced})}{C_i} \quad (10)$$

$$R_{opt} = \max R_i \quad (11)$$

For each contributing/mitigating factor a ratio between area and cost will be calculated. The optimum ratio will be the maximum of all ratios.

2.6 Results- Four random modifications of the APF index are made, which represent the effect of 4 different 100% reductions of four contributing factors on the APF index. For each reduction the area beneath the function is calculated. In TABLE IV there are represented the area differences between the real APF index (first line) and the APF indexes resulted from the each of the four reductions.

Table 4. Area differences

	Mar	Apr	May	Jun	Jul
ANSP	0,33	0,24	1,16	0,79	0,46
Area	0,28	0,70	0,97	0,62	0,56
Cause 1	0,21	0,21	0,99	0,67	0,36
AreaC1	0,21	0,60	0,83	0,51	0,39
Cause 2	0,32	0,24	1,16	0,79	0,45
AreaC2	0,28	0,70	0,97	0,62	0,55
Cause 3	0,24	0,16	1,00	0,61	0,34
AreaC3	0,20	0,58	0,81	0,48	0,43
Cause 4	0,32	0,23	1,15	0,78	0,45
Area C4	0,27	0,69	0,96	0,61	0,55

For each contributing factor a cost is given, symbolizing the monetary units that would suffice to produce a 1% reduction for that factor. In TABLE V there are both the denominator and nominator of our four ratios. The next step is to calculate the ratios between them (Ri). As can be seen in TABLE V, the biggest ratio is the one associated with the first cause.

One possible way of going further is to attribute a weight to cost and one to efficiency. When making a decision sometimes a greater importance is given to the cost and sometimes costs are not as significant as immediate and efficient action. We can therefore attribute weights to the two criteria considering the specific situation.

In the example below a 70% weight is given to efficiency and 30% to cost. The change can be seen in Ri weight.

2.7 Discussion- As can be seen in Table 5 R_{opt}, corresponds to the first causal factor. This causal factor has the second best effect and the smallest price. The second biggest ratio is the one corresponding to causal factor 3, which has the greatest effect, much larger than the other three and the second expensive price. The smallest ratio corresponds to contributing factor 2 which corresponds to the smallest effect and the second cheapest price. The results are consistent with the scope of the optimization, which is to return the best possible investment considering the effect and cost.

Table 5. Ratio calculation

	C1	C2	C3	C4
Area differences	0,822	0,017	1,254	0,116
Cost	1,000	2,000	3,000	5,000
Ri	**0,822**	0,008	0,418	0,023
Ri weight	0,352	0,019	**0,975**	0,054
Cost	0,300			
Efficiency	0,700			

Table 5 also shows that if a significant importance is given to efficiency and cost, the results change. Because the most efficient causal factor reduction is what is being searched after, the results show that this happens for contributing factor 3. It has the greatest area difference and it is the second expensive. The smallest ratio corresponds again to the second contributing factor, which makes sense because it has the smallest effect on the overall APF index.

CONCLUSIONS

Cost represents one of the most important factors, if not the most important, in everyday decisions. Its inclusion gives the APF a realistic feel about how decisions are made.

The idea presented accompanied by the example shows a straight forward method of introducing cost into the APF tool.

The question that is asked is: what is the best investment option that we need to implement?

The Optimized APF returns the causal factor that has the best ratio between the effect on the APF index and the cost of a possible improvement. The added value that this brings to the APF is that it is a palpable and visual answer that can convince the management of an organization to make a change in one aspect or another.

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MULTI-STAGE SUBORBITAL LAUNCHER MODAL AND DYNAMIC TEST PROGRAM

Mihai MIHAILA-ANDRES*, Flore LICA*, Paul-Virgil ROSU**
* Institute for Theoretical & Experimental Analysis of Aeronautical Structures,
**Military Technical Academy, Bucharest, Romania
DOI: 10.19062/1842-9238.2015.13.3.18

Abstract: *The launch phase of a suborbital rocket is always associated with severe structural stresses and they need to be cautiously accounted for during the design level. The structural testing and the numerical analysis of six degrees of freedom and variable mass multi-stage suborbital launcher at launch are reported here. The paper describes the results of free-free modal analysis followed by static and dynamic finite element model analyses of a three-stage rocket prototype subject to launch stresses. The numerical natural frequencies are compared with an experimental modal analysis conducted with the Impact Hammer Modal Testing method. The dynamic results obtained with a finite element model are also compared with dynamic tests in order to validate the numerical model. These results are part of the ROSA-STAR national project "Technologies for Testing and Validation of the Structure, and Modified Hybrid Rocket Motor for Suborbital Launcher- STRAC".*
Keywords: *suborbital launcher; modal analysis, dynamic test*

1. INTRODUCTION

The assemblies of a suborbital launcher are subject to various loads and environmental factors during space missions and they need to be carefully taken into account during the design and test phases to avoid mission failure or degradation of its subsystems.

Among all possible cases of mission failures, the structural vibration of the structure is a very important condition to be included since it may cause the overstress and/or the fatigue of materials. Mechanical vibrations are often most predominant during the launch and ascent phases of flight but, depending upon the structural configuration and mission details, they may also become critical during space flight and/or atmospheric reentry. Depending on the monitoring points and the structural and aerodynamic configuration of the launcher, the relative magnitude of the vibrations during space flight phases will vary considerably: locations near the rocket engine will undergo high vibrations during the launch phase and low vibrations during other phases while locations near the payload of a launcher will undergo high vibrations during transonic/supersonic periods of flight and low vibrations in all other phases [3,5].

Apart from the classic static and thermal requirements, the development programs of any launcher should therefore integrate these considerations by means of design and test requirements.

With all these requirements in mind, the purpose of this work is to present the vibration and dynamic tests performed on a three-stage suborbital launcher within the ROSA-STAR national project "Technologies for Testing and Validation of the Structure, and Modified Hybrid Rocket Motor for Suborbital Launcher-STRAC" [1,2].

In the light of the European Future Launchers Preparatory Programme, the project proposed a guided Suborbital Launcher (SLT) with a hybrid propulsion system used to launch small payloads (5-10kg) at heights of 100-150km. The prototype has three stages made of steel (Table 1): the first stage with a length of 1.145mm and a diameter of 0.120m is equipped with a hybrid rocket engine; the second stage with a length of 1.319m and a diameter of 0.120m is also equipped with a hybrid rocket engine; the third stage with a length of 1.890m (with a payload of 0.720m) and variable diameter (0120m-0.66m) has a solid propellant engine.

Table 1. Material Characteristics

Young's Modulus	Poisson's Ratio	Bulk Modulus	Shear Modulus	Tensile Yield Strength	Tensile Ultimate Strength
[Pa]		[Pa]	[Pa]	[Pa]	[Pa]
2.1e11	0.3	1.66e11	7.69e10	2.5e8	4.6e8

2. STRUCTURAL TESTS SETUP

The tests of the full-scale SLT structure had as the primary objective the acquisition of experimental data to validate the analytical models, which would then be used to simulate numerically the structural loads during the launch phase. An additional objective of the structural tests was to verify the finite element model and the accuracy of nonlinear capabilities implemented in the ANSYS structural analysis software.

In the framework of the project, two tests were performed: a modal test whereby the characteristic frequencies, modal masses and mode shapes of the SLT are determined and a dynamic test to determine the liftoff release loads caused by the rocket engine thrust during take-off phase. Extensive effort was dedicated in the design of both tests to closely approximate the boundary conditions and the launch loading conditions of the SLT.

For the experimental modal analysis, elastic straps were used to suspend the rocket (Figure 1). This type of support is designed to ensure that the rigid body's mode frequencies are isolated from the fundamental frequency of the structure by at least one order of magnitude.

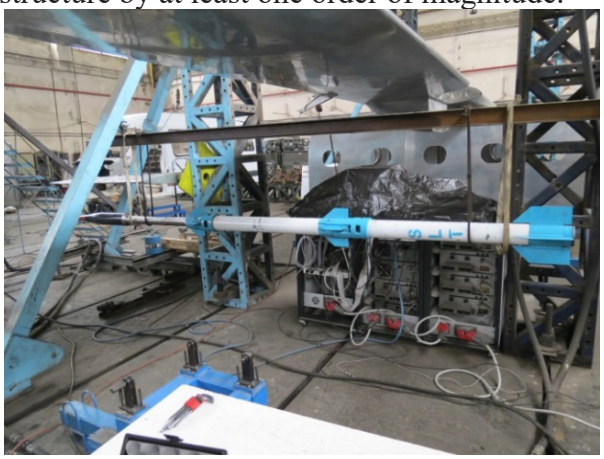

Fig. 1 Modal test support system

Mode testing has taken advantage considerably from the many advances in digital acquisition and processing systems, transducers, testing accuracy, and mode extraction algorithms but shaker (vibration tester) testing and impact hammer testing are still commonplace today. For the impact hammer test used in the project, the instrumentation of the structure consisted in a load cell attached to the end of the hammer to record the force and an accelerometer moved in different positions on the structure during multiple tests.

A single accelerometer was fixed in several positions and the structure was excited with different hammer tips in different positions. This is a combination of "roving hammer" test and "roving accelerometer" test allowing to use the least resources at the expense of time needed to take several measurements and to move the accelerometer.

Fig. 2 Dynamic test bench

For the dynamic test the structure was mounted on a custom made test bench. The set-up was arranged to test the SLT under a variable load applied directly through an Electro-Servo-Hydraulic Schenk Hydropulse System (Figure 2). The hybrid rocket engine thrust diagram presented in Figure 3 shows a maximum thrust of 300daN at 0.1 seconds from ignition followed by a constant thrust of 205-215daN between 0.6 and 1.9 seconds from ignition. On the last interval, between 1.8 and 2 seconds, the thrust decays abruptly to 0.

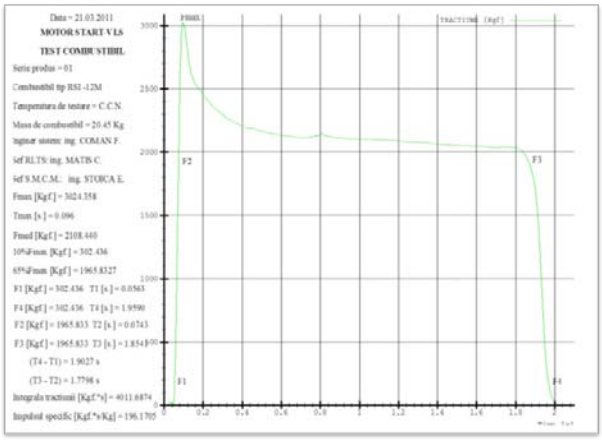

Fig. 3 Hybrid rocket engine thrust diagram

Due to the particular shape of the exhaust system, the axial force of the hydraulic cylinder was applied on the back of the first stage through a cylindrical interface device which ensured perfect contact between them. Strain gages were used to measure the local strain of the structure and compensation gages were used to reduce the thermal sensitivity.

The data acquisition and post-processing system included the HBM MGCPlus Measuring Amplifier System Multi − channel I/O module, the Spider 8 Measuring System and the Catman Professional 5.0 Data Acquisition Software.

3. TEST RESULTS

With the structure suspended on the elastic straps and instrumented as described before, 19 modal tests were prepared for different structural configurations during flight (all three stages - the launch configuration; two stages - after the jettison of first stage; stage three with payload – the end of ascent phase), different hammer tip types (rubber, plastic, metal) for a wide range of impact times, different directions of excitation (horizontal, vertical, torsion) and different positions of the accelerometer (Figure 4).

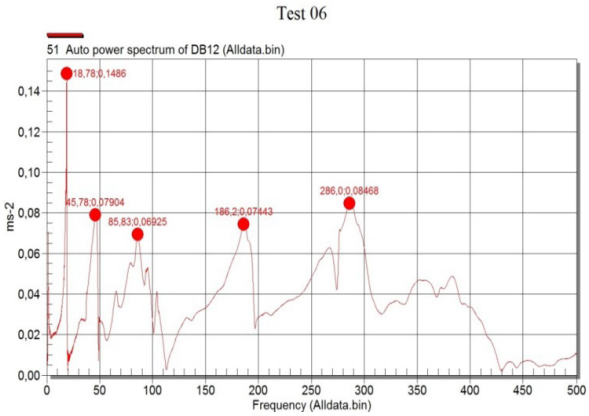

Fig. 4 Impact hammer test no.6

The modal test configurations are presented in Table 2 and the natural frequencies extracted are presented Table 3.

Table 2. Modal test configurations

Test	Hammer Tip	Direction	Excitation	Accelerometer position
3 stages				
01	Rubber	Horizontal	Stage 1	Payload tip
02	Plastic	Horizontal	Stage 1	Payload tip
03	Metal	Horizontal	Stage 1	Payload tip
04+05	Plastic	Horizontal	Stage 1	Payload tip
06+07	Plastic	Vertical	Stage 1	Payload tip
08	Plastic	Torsion	Stage 1 wing	Payload side
09	Plastic	Torsion	Stage 2 wing	Payload side
10	Rubber	Torsion	Stage 1 wing	Stage 1 side
11	Rubber	Torsion	Stage 1 wing	Stage 2 side
12	Plastic	Vertical	Stage 1	Stage 2 tip
13	Plastic	Vertical	Payload tip	Stage 2 tip
14	Plastic	Vertical	Payload tip	Stage 2 side
2 stages				
15	Plastic	Horizontal	Stage 2	Payload tip
16	Plastic	Vertical	Stage 2	Payload tip
17	Plastic	Torsion	Stage 2 wing	Payload side
18	Plastic	Torsion	Stage 2 wing	Payload side
1 stage				
19	Plastic	Horizontal	Stage 3	Payload tip

Table 3. Modal test results

Natural Frequency [Hz]	Three stages	Two stages	One stage
Frequency 1	18.27-18.93	26.70-28.90	267.50
Frequency 2	43.72-44.02	74.97	-
Frequency 3	83.19-85.83	87.88	-
Frequency 4	185.20-187.80	224.00	-
Frequency 2	200.90	233.60-235.30	-

For the dynamic test the structure was mounted on the custom made test bench and two strain gages were mounted (Figure 5).

Based on the thrust diagram of the hybrid rocket engine, the RIGOL DG1022 Arbitrary Waveform Generator was used to simulate the thrust force during the launch phase. The generated force was axially applied with the Electro-Servo-Hydraulic Schenk Hydropulse System to the rear of the launcher (Figure 6).

Fig. 5 Strain gages position

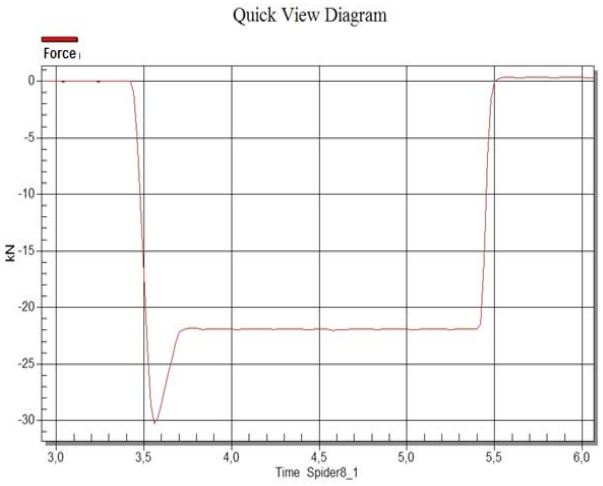

Fig. 6 Generated thrust diagram

The signal from the strain gages is presented in Figure 7.

The interpretation of all test results should be made in compliance with existent standards [4,6,7,8,9,10].

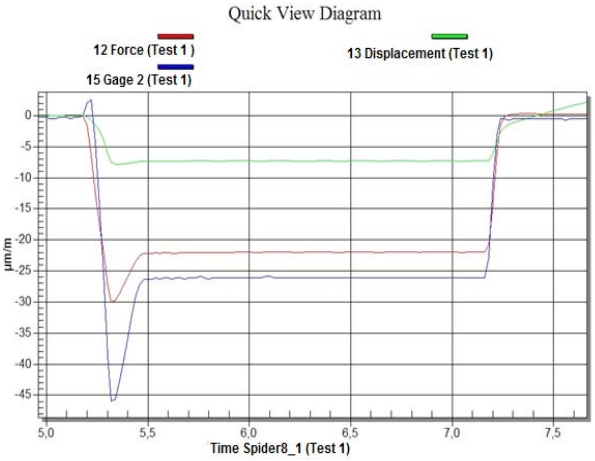

Fig. 7 Quick-view diagram of strain gage reading

According to NASA-STD-5001B and ECSS-E-ST-32-10C standards, depending on the type of test (qualification tests, acceptance tests, protoflight tests) different structural factors of safety should be applied. Since the structure of the launcher is a complex one, with junctions between stages, one should use a yield design factor of safety (FOSY) of 1.1 and an ultimate design factor of safety (FOSU) of 1.25. With these factors, based on the strain gage readings (Figure 7) the axial compression on the structure at launch is 10MPa which gives a yield safety factor of 25 at the gage position compared to minimum accepted 1.1 for FOSY.

4. NUMERICAL ANALYSIS/TESTS CORRELATION

A detailed finite element model was developed using ANSYS 14.0 structural software to simulate the loading of test configurations. All components of the launcher were modeled, including the junctions to properly distribute loads between the stages (Figure 8). The stages were modeled as thin walls cylinders and they were meshed with SHELL181 elements and the propellant and the payload were modeled as concentrated masses and represented as MASS21 elements. The contact between stages and junctions and between stages and stabilizing wings was represented by contact elements CONTA174 and TARGE170.

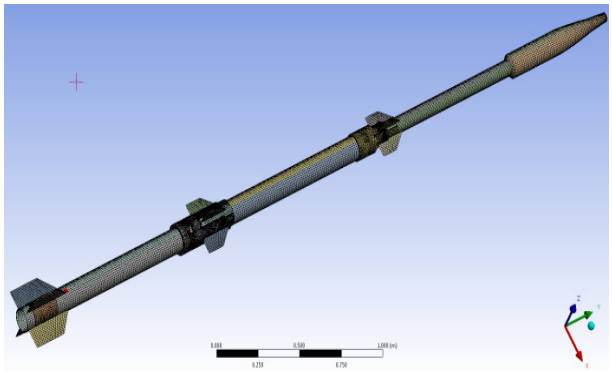

Fig. 8 Launcher's finite element model

The finite element model has been verified and calibrated through extensive simulations of the structural response to unit accelerations and through mesh density convergence analysis.

For the free-free modal analysis the contacts were declared BONDED because only linear elements are allowed. The solution confirmed the expected rigid modes (the first six natural frequencies are zero or at least one order of magnitude smaller than the first characteristic frequency). The value of the first natural frequency obtained has an 8% error compared to the modal test results (Table 4).

Table 4. FEM modal results

Natural Frequency [Hz]	Three stages	Error
Frequency 1	20.56	8%
Frequency 2	51.23	14%
Frequency 3	113.07	33%

A nonlinear static analysis of the launch phase was computed on the same free-free configuration (no constraints).

Using inertia forces calculated in a static linear analysis where the maximum thrust force of 300daN was applied with a multiplication factor of 2 to account for the dynamic nature of the thrust force. Reading the equivalent (Von-Misses) stress presented in Figure 9, the minimum yield factor of safety is 10.8 and is located on the junction between stages 2 and 3.

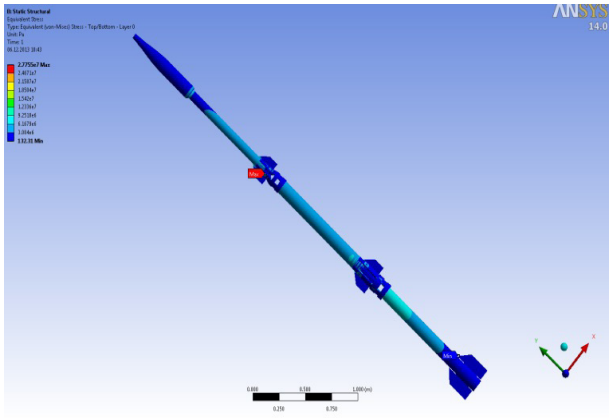

Fig. 9 Von-misses stress in nonlinear static analysis

CONCLUSIONS

The development of the proposed suborbital launcher cannot be completed without a thorough analysis of structural vibrations under various loads and environmental factors. This analysis should be performed as early as in the design phase of the project through experimental tests and numerical simulations.

The structural testing and the finite element model analysis of a multi-stage suborbital launcher were reported here. The paper described the results of free-free modal tests and dynamic tests followed by modal and dynamic FEM analyses of a three-stage rocket prototype subject to launch stresses. The numerical natural frequencies of vibration were compared with the experimental modal analysis conducted with the Impact Hammer Modal Testing method. The dynamic results obtained with FEM were also compared with dynamic tests in order to validate the numerical model.

Several considerations can be emphasized as a result of the experimental tests and the numerical analysis. It is critical to adequately represent the boundary conditions and to properly load the model in both tests and simulations. The mesh resolution can limit the accuracy of numerical simulations and poor representation of structure's interfaces can negatively influence the numerical results. Residuals convergence and solution controls must be tuned and verified by experimental data and care must be taken to monitor and evaluate the tests or the simulations as they are running to confirm proper model behavior.

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AUTOMATING TELECOM EQUIPMENT FOR CLOUD INTEGRATION

Sorin ZAMFIR, Titus BALAN, Florin SANDU
"Transilvania" University, Brasov, Romania
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Abstract: *Integration of equipment in the cellular networks was always considered a challenge mainly due to the heterogeneous nature of architectures and compatibility problems that may arise from them. Testing and prototyping new services is always preceded by a big effort with the environment setup and while communication standards aim to provide a very strict guideline when it comes to offering telecom services they fail to establish a unified way of how these are provisioned within different equipment. As a result most equipment vendors offer custom equipment administration solutions that are better known as Operating Support Systems (OSS) that impose specific know-how and deal with proprietary provisioning workflows. In this article we present a brief survey of the operator challenges identified with the integration of telecom equipment. We explore the possibility of offering a Cloud based model of cellular network equipment, to help third party vendors achieve faster time to market when releasing new services. Lastly, we propose our vision towards a unified provisioning and aggregation system of both new and legacy traditional telecom equipment by abstracting proprietary provisioning workflows in a vendor-agnostic way.*
Keywords: *telecom-cloud, automation, IaaS*

1. INTRODUCTION

The telecom market has evolved to a liberalized model that imposes rough competition between classical service providers and has also a huge impact on the Telco manufacturing ecosystem. While the number of services in the mobile world has exploded in the recent years this has yet the effect that operators would have hoped on the ARPU (average revenue per user).

A recent study by the EU commission shows that the average revenue per user has been dropping on a constant basis in the last 4 years from an average of 211.5€/year in 2010 to 171€/year in 2013. [1]

As a result we cannot fail to observe how operators struggle to find new ways of monetizing the already existing resources (usually characterized by big CAPEX) and how network equipment vendors continue to push to in-house solutions as a method to protect their own market share.

In fact compatibility between network equipment is driven mainly by the 3GPP alliance but this can only address specific parts of a network.

The provisioning and configuration aspect remains something sporadically touched by standard bodies.

There are however some bold initiatives, especially coming from the network operators and test equipment vendors ecosystem (NTAF-Network Test Automation Forum) that propose a uniformed way of administration and configuration of the telecom systems by abstracting equipment based on the functionality and capability they provide [2].

The NTAF initiative relies on the premises that in the future vendors will make their equipment compatible with the standard.

Non-compatible equipment can also be integrated but these must be proxy-ed by 3rd party software that acts as translator between NTAF standard and the non-standard administration interfaces.

In order to fully understand the problem we are trying to address, below one can find a summary of the issues and challenges network operators are facing:

1. Telecom networks are heterogeneous which means that a topology usually contains equipment of different generations from different vendors.

2. Development of Telco equipment is done in a closed-source environment and, as a result, administration and control interfaces are in most cases proprietary.
3. The equipment management is usually done with custom solutions that are provided by the equipment vendor. Even compatibility with different generations of the same vendor is quite problematic.
4. „Leasing" un-used Telco equipment to reduce OPEX and increase the ROI (return of investment) is limited to specific scenarios and introduces security vulnerabilities in the network by allowing direct contact of 3rd parties to the equipment.

In order to address these concerns the authors propose a framework for standardizing the remote configuration and aggregation of Telco equipment so these can be later offered as IaaS (Infrastructure-as-a-Service) by the operators, similar to traditional Cloud services.

The idea behind it is to ensure a generic provisioning interface that hides the implementation complexity through a set of standard capabilities that are vendor independent.

The real challenge is to ensure compatibility between different generations of equipment that even belong to specific functional classes.

In order to integrate "legacy" elements with Cloud telco elements, the actual deployment of network configurations must be done automatically to ensure an end-to-end solution; in the end the user must not be concerned by specific provisioning tasks and should only be focused on the capabilities it requests.

2. INTEGRATING THE EQUIPMENT

Existing network management systems have been developed with focus on accessibility and ease of use in mind to mitigate provisioning tasks. While traditional solutions such as Nokia's NetAct™[3] or Erricson's NetOp™ [4] evolved in such a way that provisioning can be somehow automated they were never conceived for integration within a Cloud environment.

Furthermore these custom solutions only work for custom equipment which makes it difficult for an operator to manage the network from a single point.

To allow future extensibility our solution makes use of dynamic typed languages, most notably Groovy that allows further definition of platform configuration language on the spot without the need to redeploy the whole solution.

This modular approach allows the operator to add new equipment with ease in this ecosystem and just provide the provisioning language adaptations required on the spot.

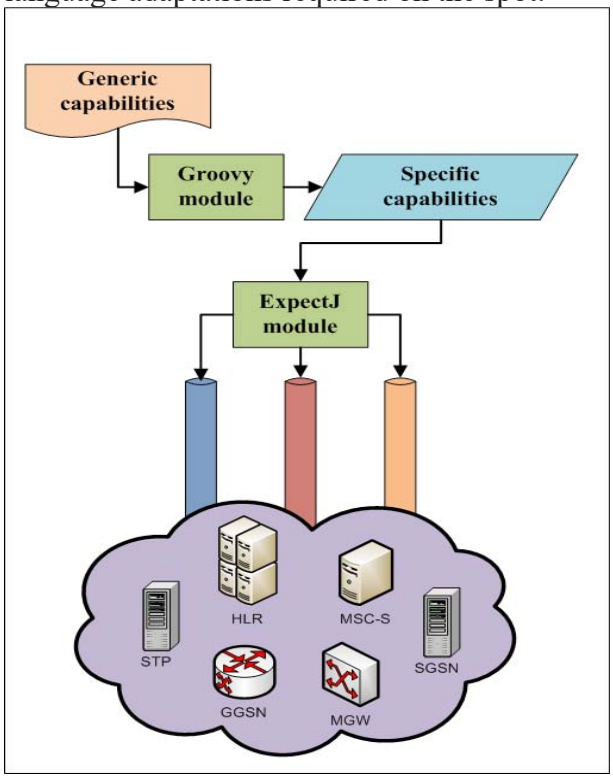

Fig. 1 Overview of the integration framework

As Figure 1 points out , the solution introduces two indirection layers between the end user and the real equipment (in our case telecom network elements form GSM and 3G architecture) with the scope of adapting the vendor independent provisioning to hardware specific semantics and then automating the whole deployment.

```
<Hlrs>
  <Hlr DisplayName="HLR0" HostName="LAB11" ID="1"
      <ProjectData>
          <NetworkSetup MNC="153" MCC="01" MSINR
      </ProjectData>
      <MobileSubscribers>
          <Msub ID="1">
              <AuthenticationData IMSI="01153000"
              <ProfileData Services="TS10,TS21"
          </Msub>
          <Msub ID="2">
              <AuthenticationData IMSI="01153000"
              <ProfileData Services="TS10,TS21"
          </Msub>
      </MobileSubscribers>
  </Hlr>
  <Hlr DisplayName="HLR1" HostName="LAB12" ID="1"
      <ProjectData>
          <NetworkSetup MNC="154" MCC="02" MSINR
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          </Msub>
          <Msub ID="2">
              <AuthenticationData IMSI="02154000"
              <ProfileData Services="TS10,TS21"
          </Msub>
      </MobileSubscribers>
  </Hlr>
</Hlrs>
```

Fig. 2 Sample generic configuration

The proposed and implemented concept borrows ideas from the distributed instrumentation ecosystem such as the key aspect of generic equipment „drivers" that can be modified on the spot by the operator. One can observe the resemblance with traditional device drivers from the PC world where a set of common functionalities is abstracted from the actual implementation. This kind of generic middleware offer the user only the basic features that are present on every implementation.

By extension the same pattern can be applied to the Telco ecosystem where a set of basic provisioning services can be offered to the end user.

Figure 2 showcases such a scenario in which the generic capabilities are described through a set of language-independent XML files. These are processed by a domain specific logic and translated into actual configuration commands that are sent to the real network equipment.

The Groovy module implements the domain specific logic responsible for interfaces adaptation. As you would expect the translation could have also been done in a static typed language but the choice of Groovy is not random since it offers a future proof solution.

The idea behind it is that it runs on standard JVM[5] and it binds very well with other parts of the solution that are written in Java.

```
#HLR0
     CRACMSUB:IMSI=011530000000101,A4P
     CRMSUB:MSIN=0000000101,BSNBC=TELE
#HLR1
     ZMAC:IMSI=021540000002101:KI=CF0S
     ZMAI:IMSI=021540000002101,MSISDN=
```

Fig. 3 Specific capabilities syntax

Interaction with the equipment is based on shell services (either Telnet or SSH) because it is the most elementary way in which automation can be achieved.

The purpose is to automate the configuration sessions through means of stream indirection in order to avoid direct dependencies on vendor libraries. In this way we also ensure the all the features of the equipment interface are used.

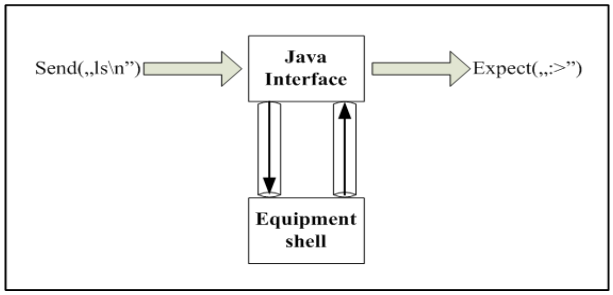

Fig. 4 Interaction with real equipment

Furthermore it is possible to orchestrate complex configuration scenarios with the help of the ExpectJ utility library that implements the Java binding of the well known automation utility Expect [6]. Specific syntax is retained under the form of a collection of Java objects that are passed to Expect utility for shell automated interaction.

3. TESTING AND VALIDATION

In order to validate the solution a test topology was configured with the help of the framework. Initially in this scenario a Tektronix K1297 (telecom network protocol emulator) was used for emulating two network elements HLR (Home Location Register) and a BSC (Base Station Controller) by running two predefined emulation scenarios.

Unfortunately one of the first challenges was to make the host OS (Win NT) to offer some kind of shell process handling. This was achieved by installing PsTools for Windows and by deploying a SSH server to allow secure remote connections.

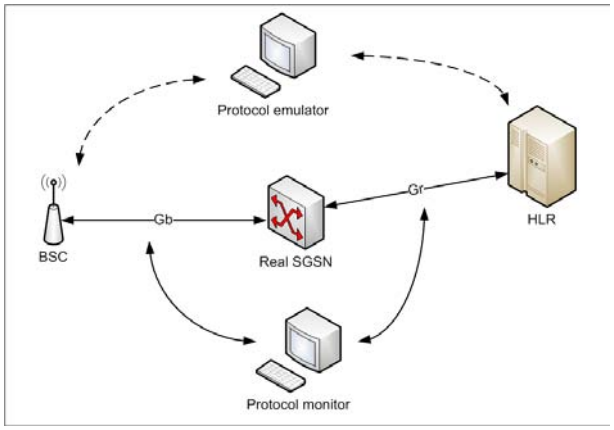

Fig. 5 Test environment

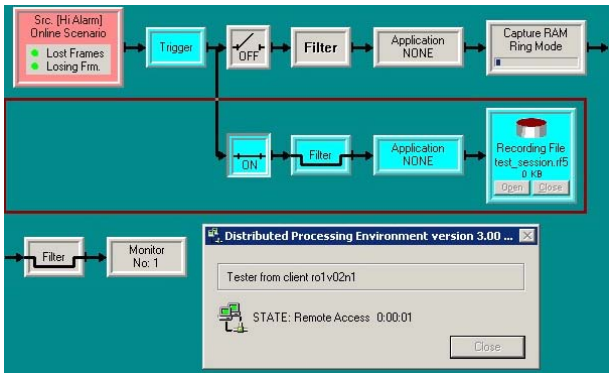

Fig. 6 Remote control of Tektronix K1297

A second Tektronix K1297 (a newer generation) was used for monitoring the messages on the Gb and Gr interfaces thus isolating the device under test which is the real SGSN (Serving GPRS Support Node). In this way the end user is only aware of the high level network topology (figure 5) and doesn't care about actual configuration details (figure 6).

CONCLUSION

One of the biggest challenges of network operators refers to managing a complex topology from a single point of control. While this usually is aimed by classical OSS their approach is limited to a set of equipment of the same generation.

With our solution we succeed in establishing an end-to-end provisioning solution, vendor independent and viable for cloud integration thus opening new service opportunities for operators. Future works could include developments towards network function virtualization (NFV) concept as well software defined networks (SDN) to tighten even more the gap between the telecommunications and Cloud ecosystems.

In the end offering Telco domain specific equipment as a cloud IaaS model aims to decrease time to market, add new revenue streams and increase ROI for network service providers.

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COMPARATIVE STUDY OF SAR VALUES FOR THE GSM 900 AND GSM 1800 FREQUENCY BANDS

Marian ALEXANDRU, Dorin NICULESCU
"Transilvania" University, Brasov, Romania
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Abstract: *The reason for this study is to present the results of the SAR (Specific Absorption Rate) measurements for a mobile phone EUT (Equipment under Test) that works on the GSM 900 and 1800 bandwidths, to compare these results with current standards and to extract practical conclusions of the way in which we must protect ourselves from electromagnetic radiation. In order to accomplish the experiment, special equipment and specific software for these measurements were used. This equipment is meant to simulate human tissue and real conditions for the mobile phone to work.*
Keywords: *SAR, GSM, standard, EUT, OpenSAR, Kuka robot*

1. INTRODUCTION

The electromagnetic radiation to which the human body is exposed represents an extremely serious problem and this is the reason why measuring methods for the amount of radiation absorbed by the tissues were created.

SAR is a parameter introduced to measure the rate of absorption of energy by the human body when it is exposed to a radio frequency electromagnetic field.

For an equipment to be valued on the market, it has to correspond to certain standards in which the SAR limits are specified.

So a mobile phone is in compliance with the requirements of the test standard if SAR measurement results are lower or equal to the limit.

This limit is specified for the maximum emission power of the mobile phone and it is checked in the laboratory. Even so, in real conditions, the SAR value varies.

SR EN 50360 [1] test standard applies to all broadcasting devices that are used near the human body ear. It is a product standard that was introduced to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300 MHz - 3 GHz).

The exposure limit is found in the European Council Recommendations 1999/519 / EC from the 12th of July 1999 [3].

Alternatively, the limit set by the International Commission on Protection from Non-Ionizing Emissions (ICNIRP) can be applied: "Guidelines for limiting exposure in time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)", April 1998.

2. THE MEASUREMENT SET UP

2.1 SAR dosimetry evaluation system. The dosimetry evaluation system used for measurements is able to determine the distribution of SAR inside a SAM (Specific Anthropomorphic Mannequin) phantom [4] that complies with European and American standards (EN 50361, IEEE 1528).

The system consists of a robot (Kuka KR5) [5], a robot controller (Kuka KRC2sr), an electric field probe calibrated for use in liquids, a "twin" phantom, an "elliptic flat" phantom, a fluid simulating the human tissue, a EUT clamping device and the OpenSAR software [7].

The phantom is a container (shell) made out of a low loss and low permittivity material, embedded in a mass of wood. Dosimetry assessment can be made for EUT left or right ear utilization. The amount of fluid required to fill the phantom is around 20 liters.

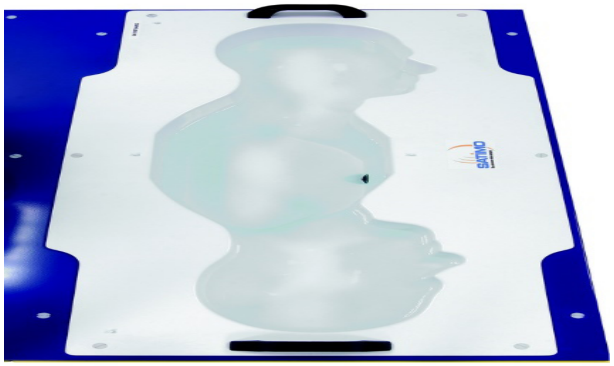


Fig. 1 The SAM phantom

The electric field probe has a triangular cross section. On each side there is a dipole which is connected to a Schottky diode with low levels of detection. Due to the high sensitivity of the probe, its output voltage is measured without amplification. The electric field probe corresponds to CENELEC and IEEE recommendations for measuring electromagnetic fields of mobile phones, base stations and radiating devices.

The EUT clamping device is constructed of a low loss and low permittivity material. It allows movement along the axes Ox, Oy, Oz or rotation around the phantom ear for precise positioning of the EUT.

The OpenSAR software controls the robot movement, it determines local SAR values, and calculates SAR values, averaged at 10 g and 1 g of tissue.

2.2 SAR measurement procedure. The OpenSAR software was used to measure the SAR for the mobile terminal and included the following steps: measuring the liquid; dosimetry evaluation system checking and the effective measurement of the SAR value.

The steps above were completed at each running frequency of the EUT for each measured radio channel (low, middle and high), using two measuring locations (left head, right head) and two EUT positions (cheek and tilt).

The fluid measurement. The dielectric properties of the fluid that simulates the human tissue are calculated before measuring the SAR, at the same temperature. The electrical permittivity ε and conductivity σ are measured and the obtained values must match the tolerance of ± 5% from the values specified in the standard.

Dosimetry evaluation system checking. Before measuring the mobile phone SAR value, a checking that the dosimetry evaluation system operates according to the technical specifications was performed. This check is a SAR measurement using a scheme where the signal comes from a sinusoidal signal generator and is emitted by a dipole antenna.

This measurement is the "validation" of the test system. Components and measurement procedures for verifying performance are the same as those used in actual measurements. The result of this verification must be within ± 20% from the prescribed standard value.

As an example, checking of the SAR dosimetry evaluation system (GSM 900 band, channel 62CH - uplink) performance is presented below. This procedure was performed also for the GSM 1800 band 698CH (1747.4 MHz - uplink).

The experimental conditions include: signal – continuous wave CW (crest factor: 1); channel – middle; EUT position – dipole; frequency – 902.4 MHz; relative permittivity (real part) – 41,746; relative permittivity (imaginary part) – 18.625; conductivity (S/m) – 0,933.

The SAR 10g (for 10g of human tissue) measured value was 6.09216 (W/Kg) and the standard reference SAR is 6.9 (W/Kg), so the difference represents -11.74% (within the limits). This maximum value was obtained for the position X = 0; Y = 1, as can be seen in the figure representing the surface SAR below. For this specific position, the volume SAR was determined, scanning the Z axis. The results are shown in the Fig. 4 (the limit SAR 10g is 2 (W/Kg)).

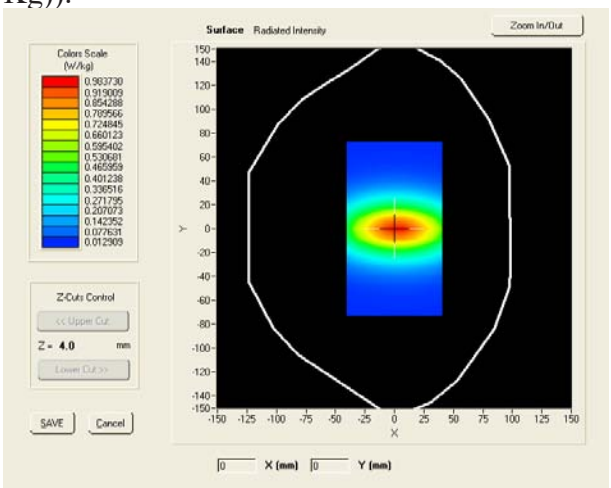


Fig. 2 Surface SAR

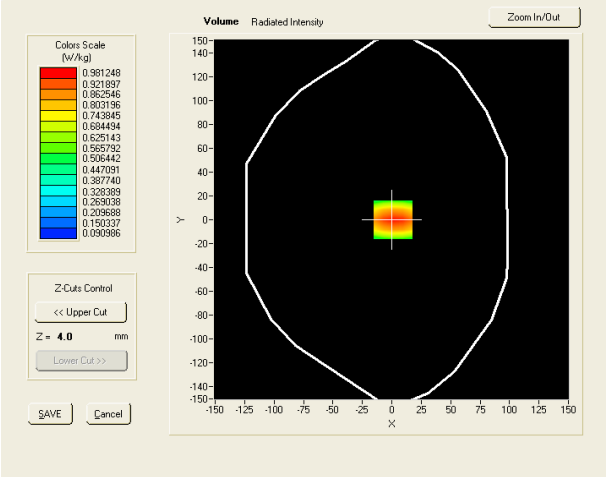


Fig. 3 Volume SAR

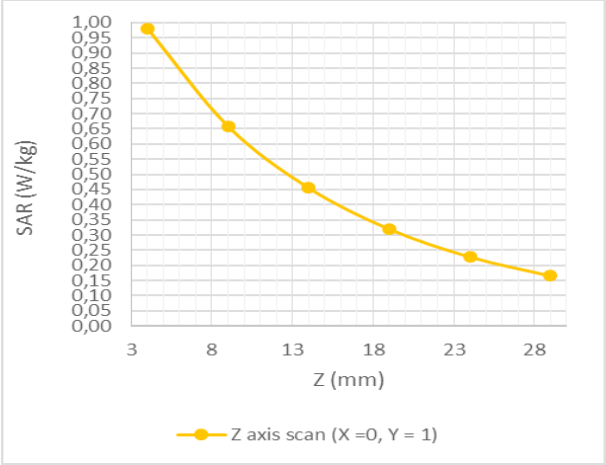


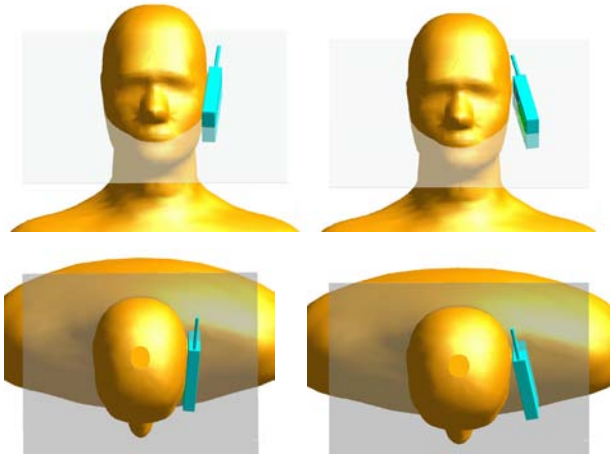
Fig. 4 SAR 10g values, GSM 900, CH62, dosimetry evaluation system performance

The effective measurement of the SAR value. The EUT is used with its internal transmitter, antenna(s), battery and accessories supplied by the manufacturer. The battery was fully charged before each test and there were no external connections to it. The output power and frequency were controlled with a GSM base station simulator (Rohde & Schwarz CMU 200).

For each position of the tested mobile phone, the following steps were done:

- Establish a radio connection with the base station simulator at EUT maximum power;
- Measurement of the SAR values in a network of equally spaced points on a surface located at a constant distance from the inner surface of the phantom;
- Measurement of the SAR values in equidistant points in a cube;
- Calculating the average value of the measured SAR data and comparing with the limit.

The mobile phone was placed in cheek and tilt positions, at the right "ear" or left "ear" of the phantom and measurements were performed at each transmitting band frequencies, respecting the required conditions.



"Cheek" position "Tilt" position

Fig. 5

Description of the interpolation / extrapolation method. The top of the probe has not been in contact with the inner surface of the phantom to minimize measurement errors.

Local SAR values are highest on the inner surface of the phantom and a method of extrapolation applies for their assessment.

The extrapolation is based on the measured data approximation using an order 4 polynomial, determined by the method of least squares. Local SAR values are extrapolated starting from the liquid surface with a step of 1 mm.

The measurements were performed in a limited time due to the battery life of the EUT. To reduce the measurement duration, the measuring step should be higher. It can vary between 5 mm and 8 mm. But for an accurate assessment of the maximum SAR value averaged over 10 grams and 1 gram a fine resolution of the scan in three dimensions is required.

Interpolation is used to obtain a sufficiently fine resolution. The measured data and the extrapolated SAR values are interpolated and on a grid with a step of 1 mm with a three dimensional "thin plate" spline algorithm.

3. EXPERIMENTAL RESULTS

Mobile phone SAR measurement ("Right Cheek" position, GSM 900 band, 62CH channel) is presented below as an example. The other measurements were performed in the same initial conditions: measured temperature - 27 ± 0.5 ºC (imposed values 18 ºC ÷ 28 ºC); measured atmospheric pressure 1008 ±5 mbar; measured relative humidity 49 ± 2%.

Used equipment: SAR dosimetry evaluation system, type Comosar Twins, manufacturer SATIMO France.

Possible kinds of operation of the equipment under measurement: waiting; conversation; communication via Bluetooth, WiFi, etc.

Operating procedure used during these measurements: a GSM communication has been established between the mobile phone under test and the base station simulator CMU200 for measuring the specific absorption rate (SAR).

The "Right Cheek" GSM 900 experimental conditions include: phantom – right head; EUT position – cheek; signal – TDMA (crest factor: 8.0); channel – middle; frequency – 902.4 MHz (uplink); relative permittivity (real part) – 41.746; relative permittivity (imaginary part) – 18.625; conductivity (S/m) – 0.933.

3.1 The results of the SAR measurement

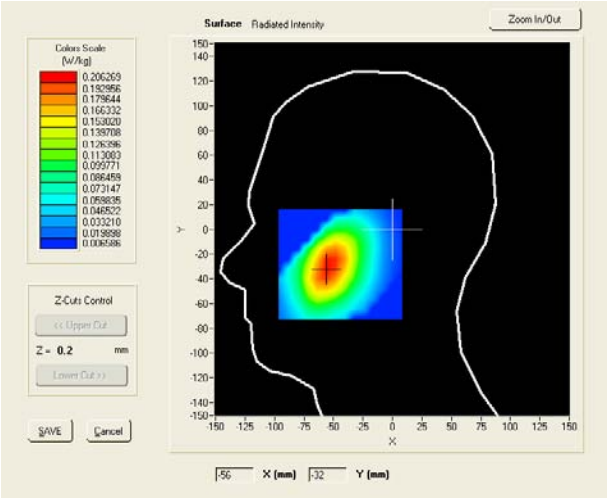


Fig. 6 Surface SAR – Right Cheek, GSM 900

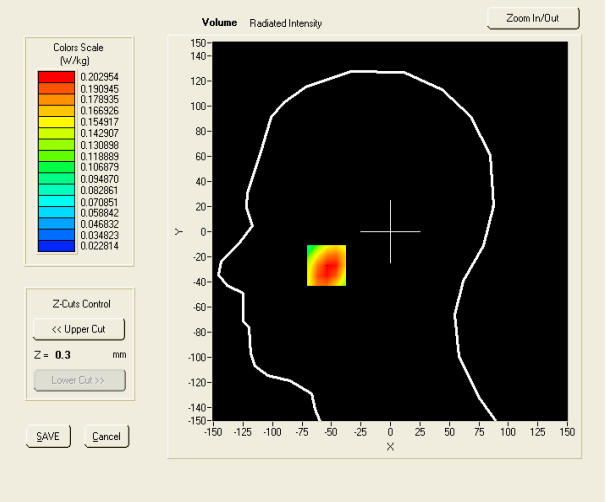


Fig. 7 Volume SAR– Right Cheek, GSM 900

The maximum SAR 10g value (0.143648 W/Kg < 2 W/Kg) has been obtained for X= -54.00, Y= -27.00. For this maximum position the volume SAR has been determined (900 Right Cheek curve from the Fig. 8 below). Also, the same kind of pictures (from Fig. 6 and Fig. 7) have been completed by the computer for each SAR measurement set and the SAR curves are represented in the Fig. 8.

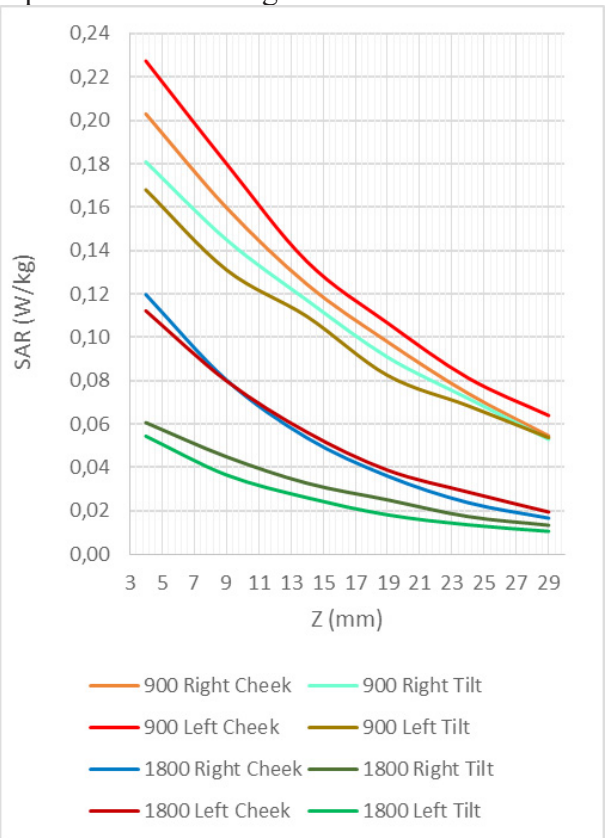


Fig. 8 SAR values obtained for different mobile phone positions and operating frequencies

Analyzing the curves obtained in the above figure, we can see that the highest values of SAR (for the specific mobile phone under test) were obtained for the GSM 900 band. Of course, the phone position (cheek or tilt) has to be taken into account, and if it is used for left or right ear.

To see which are the SAR values in the points of maximum obtained on 62CH and 698CH, the curves in the Fig. 9 were plotted, where the mobile phone emitted on other channels. The results show once again that the SAR value is higher in the GSM 900 band.

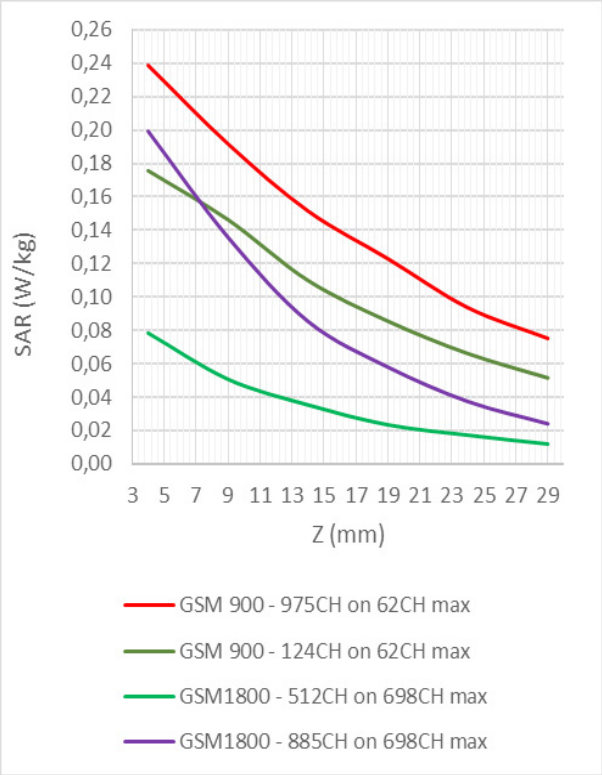


Fig. 9 SAR values obtained on different channels for the maximum position found on 62CH and 698CH

Fig. 10 The SAR measurement equipment and the EUT under test

CONCLUSIONS & FUTURE WORK

This paper shows a set of SAR measurements done on a single mobile phone. We have noticed that the highest values were obtained in the GSM 900, where the maximum emission powers had to be bigger in order to cover macro cells.

In reality, for a lowest possible SAR reading, but also for preserving battery life, the emission power is kept as low as possible.

From the SAR point of view, the tilt position is more advantageous than the cheek position, especially if, for protection, the antenna is placed on the lower part of the device, in order for it to be further away from the human brain.

In the future, more sets of measurements on more types of phones will be done and the results will be compared. There will be parametric variations and the influence on SAR values will be noticed. Either way, it's predictable that a mobile phone with smaller SAR values (declared by the manufacturer) does not necessarily offer the user better protection from the electromagnetic radiation as a device with higher declared SAR value. In real working conditions, the SAR values vary depending on propagation conditions, as well as the way in which the phone is used by its owner.

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PROMOTING SECURITY INTERESTS OF ROMANIA IN THE CURRENT GEOSTRATEGIC CONTEXT

Gabriel GABOR[*], Doina MURESAN[**], Laura UNGUREANU[***], Alexandru CRISTIAN[***]
*„Nicolae Balcescu" University, **"Dimitrie Cantemir" Christian University,
***College of National Defence, Bucharest, Romania
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Abstract: *At the beginning of the XXI[st] century, geopolitical and geostrategic situation has undergone deep and dramatic changes with some essential consequences on collective and national security of states, as well as on their ability to protect the national interests. The world has become more complex and interdependent, and the phenomenon of globalization is irreversible, which will cause radical changes in affirmation and consolidating power of new actors on the international stage.*
Keywords: *security, geostrategic, international relations, security strategy, national interests, NATO, Ukraine, military bloc*

1. INTRODUCTION

World needs a conceptual re-thinking in most social fields. We live in a dynamic and flexible period, in which we do not know what concept is more suitable to reality and which one we should choose. The main paradigm-anarchic international system – seems to have finished it's on the international political stage. Globalizations moves forward, with its beneficial effects for society, but i tis consumed with internal disorder. Current geopolitics is questioned as well as geo-strategy. Some specialists proclaim a planetary geopolitics, others proclaim a regional geopolitics oriented to power.[1]

This century opens a new window in international politics in which security and implicitly competition for getting a place in the hierarchy of world power are becoming increasingly stringent. Having a central position in determining the evolution of the world and deciding the new international order[2] is the objective of the great economic powers and their actions are focused on that.

The concept of security has been an object of research for all philosophical schools right from the appearance of state as a distinct political entity within the international relations. At present, a rapid evolution of this concept is observed and its adjustment to the realities of the modern world is a certainty and a necessity.

The National Defense Strategy promotes the concept of enlarged security, based on constitutional democracy and mutual respect between citizens and state. The concept focuses on the interests that lead to providing national security in essential domains of Romanian society: defense, public order, intelligence, counter-intelligence and security, education, health, economy, energy and other strategic fields.[3] The strategy refers to strategic consolidation of Romania throughout promoting continuity and predictability that derive from being a member state of the North Atlantic Treaty Organization (NATO) but also of the European Union (EU).[4]

1 Alexandru Cristian, Foreign Policy and Security Policy of the European Union and New Paradigms of International Environmental Security, thesis, National Defense University ‚Carol'', p.69

2 Petrescu Stan, *Mediul de Securitate Global şi Euroatlantic*, Editura Militară, Bucureşti, 2005, p.48

3 National Strategy for the defense of the country for the period 2015-2019, "Ä strong Romania in Europe and the rest of the world", the presidential administration, Bucharest, 2015, online http://www.presidency.ro/static/Strategia%20Nationala%20de%20Aparare%20a%20Tarii.pdf, p.5

4 Ibidem, p.6

The fundamental values on which the National defense Strategy is based on are dignity, civic cohesion and national identity, constitutional democracy and lawful state, territorial and national integrity of Romania.[5]

The National Defense Strategy is consolidated through promoting the national security objectives decided at internal and external level. In the current geo-strategic context, characterized by heterogeneity and heteroclite, objectives are combined in order to underline the strategic position of Romania in the region.

National security objectives at external level are decided upon by meeting the requirements and promoting the interests of Romania not only within the alliances and partnerships that we are part of but also within the regional security policy. They point to consolidate Romania's profile within the North-Atlantic Alliance and the European Union through conceptual and operational contributions, respect of the EU fundamental values and principles, consolidation of the strategic partnership with the United States of America, providing security in the Black Sea Region, strong cooperation with the neighboring states and those in the Eastern flank of the North-Atlantic Alliance, intensifying regional cooperation, including defense, supporting the European roadmap of the Republic of Moldova, promoting security, economic and political interests in regions of strategic relevance for our country.[6]

Given the circumstances of the modern world, in which security and prosperity are inseparable terms of the same equation, the progress, prosperity and national defense of Romania cannot be anything but the major result of a complex process of promoting and guaranteeing the national interests and values.

According to the Explanatory Dictionary of the Romanian Language[7] security refers to the reality "of being sheltered by any possible danger; the feeling of confidence and tranquility that the absence of danger gives it to someone".

As an extension, collective security can be imagined as "the condition of relationships between states, created by taking collective defense measures against aggressions through the mean of a treaty".

That is possible the starting point for the expressions used mainly in the field of interest: "national security", "collective security", "international security", "and global security". However, there still has to realize the operational and conceptual dimension of the term at collective, national, regional and global level, etc.

Security must be considered as the capacity of a geopolitical actor to protect the fundamental national values maintaining the possibility to effectively engage in the international context by preserving its own interests.

Within the concerns of specialists in the security domain, it is observed the reality that a precise definition of the concept is not unanimously accepted. In a natural evolution, semantic determinations regarding the security concept are continuously changing.

The concept has known particular interpretations, determined by the national interest of the state that promotes it, and so the fact that the reality regarding the operational and conceptual elements of the national security is dictated by the active components, derived from national interest is taken into consideration.

The modern security concept consists of five cumulative factors that have ample determinations and multiple interdependent effects. We mention here the political component of security, the military, economic, societal and ecologic ones.[8]

In this environment, Romania is an integral part of the European Union and of the Euro-Atlantic community, two large alliances that bring major influences in the analyzed area. Jacques Delors,[9] former president of the European Commission, underlined the necessity to build a European structure dealing with security, but compatible with NATO.

In this conflicting, dynamic and complex world, in full process of globalization, meeting the essential condition of progress and prosperity, doubled by the right knowledge, understanding, adapting and evaluation of events both internally and internationally are essential factors in the development of the capacity to anticipate and for pro-active action by each state.

5 Ibidem, p. 7

6 Ibidem, p. 10

7 The Romanian Explanatory Dictionary (OFX), 1975 Edition

8 See: Common Foreign and Security Policy of the European Union, http://www.eeas.europa.eu/csdp/

9 DELORS, J. , European integration and Security Survival, vol.33 nr.2, martie-aprilie 1991, p.99-109

2. PROMOTING THE SECURITY INTERESTS OF ROMANIA IN THE CURRENT GEO-STRATEGIC CONTEXT

In the strategic and political post-modern world, knowing how to promote own interests means to smartly know how to re-vitalize them or at least how to not let yourself trapped by the old illusion of their absolute character, how to negotiate top positions in an institutional plan relevant even for the global equilibrium of power[10].

The current international context is marked by profound mutations of global security architectures, which determines new responsibilities and generates complex challenges. New actors have shown up and affirmed on the international arena, which has induced the strong growth of interdependency between states. Still, experts consider that "….national state continues to be the most important player of the contemporary world".[11]

Providing security and defense to the states can be considered accomplished when national interests do not have to be sacrificed for another state, group of states or international organizations, and in case its security components are at risk, it can maintain them even by using military force.

Sources for national security options are internal situation, international situation, and the common interests of citizens and the potential of society to support them determine.[12]

The new millennium has brought to the attention of people, especially the political decision makers, new risk, dangers and threats to the security of nations and implicitly to the international security generated by internal vulnerabilities of states and by those of the current security system. Unprecedented technological development and significant differences between rich states and poor ones bring with them different crisis and unexpected reactions within the security area.

So, we talk about economic-financial crisis, which has affected the majority of states; economic instability generated by the level of external debts, problems associated with globalization; terrorism – that tends to become an international flagellum; production, transportation, trade and consuming drugs; internal and international corruption and organized crime; degradation of the natural environment through irrational exploitation of resources, all equally representing risks to national security.

The fact that our national geo-politic and geo-strategic position plays a very important role within the Europe's security is no longer at all a novelty, and this is due to both the vicinity with great powers and regional powers and the Black Sea access.

A new understanding of threats such as terrorism, cold conflicts, massive migration and trends of geo-political realignment more and more visible has generated a high interest for NATO and the EU for the Black Sea region with the perspective of the enlargement of the stability area as a pre-condition for prosperity.

The Black Sea represents an important transit line for energy resources and for passengers and cargo, too. The EU has unequivocally become an important actor in coordinating evolutions and transformations within the Black Sea region.

The geostrategic position and opportunities offered make the Black Sea region more and more interesting for the European and trans-Atlantic organizations, and at the same time determine the neighboring states and the other states to address the problems within this area more carefully.

Its geographic position, current risks and threats as well as the advantages in terms of military, economic and political cooperation make this area become more and more attractive, but at the same time to require a more careful approach of the problems in the Black Sea region.

The global developments within the international politics are fought back by Russia's attempts to create a system of client states that have created a perpetual vulnerability

10 George Cristian Maior, the new ally - *Reconsideration defense policy of Romania at the beginning of the 21st century*, Bucharest, Editura RAO, 2012, p.76

11 See Bogdan Stefanachi, *As state and globalization challenges-decentralization decentralization government and knowledge,* online http://www.sferapoliticii.ro/sfera/151/art05-stefanachi.html

12 Col. prof.univ.dr. Mihai Neag – *Values and national interests in the context of the current security environment*, http://www.rft.forter.ro/

and instability in the area[13].

Recent events in Ukraine prove one more time the major transformations brought by the reality in the concept development of security and to strengthen the necessity of its adaptation and development.Solving each of the latent or current conflicts within the ex-Muslim states from the ex-Soviet Republic raises specific problems. Even though, we notice more regional tendencies that facilitate the will to solve the conflicts and the triumph of democracy. The regional streams in and from the Black Sea region indicate the new availability of local societies and leaders to control violent means. This will is obvious in Armenia's efforts to establish relations with NATO.

Ukraine, from geo-strategic and geo-politic point of view, represents the most important territory between Europe and Russia. Although highly economically dependent on Russia, Ukraine has considerable military and economic resources, which gives it a certain particularity of its international relations. It benefits from a special cooperation relation with NATO and as a result, it has a privileged position in the regional security architecture, cooperation and partnership Agreement has been concluded and it is preoccupied with the development of relations with the International Monetary Fund (IMF), the World Bank and the European Bank for Reconstruction and Development (BERD).

In the current economic and political-military context in the Black Sea region, the geographic position of the Snakes' Island gives it a distinct strategic value.

All this trends are a proof for what the North-Atlantic Alliance, the European Union and the United States have offered to the governments decided to get rid of the arrangements in place within the post-Soviet area. However, for a gain in the security domain, a price must be paid. The price consists of the democratic reforms connected with the interests of the European Union, of NATO and Washington regarding the enlargement of the trans-Atlantic and western security community. Both NATO and EU have the instruments that they can use to enforce the specific standards for the organizations to the governments concerned as a condition for joining. These reforms create also the premises for their consolidation on both geographic and institutional level, which will make them irreversible.

To conclude with, promoting the security interests of Romania takes into consideration both the national interests and the allied partners' interests all these based on global evolutions in the area. Promoting the security interests of Romania in this dynamic environment, influenced by multiple interests is provided by joining collective security systems, connecting the internal security with the external one and by regional and international security agreements.

Taking into consideration that globalization is the main factor that influences significantly the security environment and the new threats have the same global feature we can talk about a globalized security in which Romania strongly promotes its interests.

3. MEANS AND INSTRUMENTS TO PROMOTE SECURITY INTERESTS IN THE GEOSTRATEGIC CONTEXT

Means of promoting security interest can be shaped and they have a high degree of adaptability to changes in the international security environment. Currently we witness the enlargement of spectrum of risks and threats to national security, especially those of nonconventional and asymmetric nature that can generate major crisis and armed conflicts, and that requires strong reactions based on mobility, flexibility, diversity, coherence and complementary in using the instruments to defend own interests. Romania has at its eastern border areas of instability that amplify and diversify the asymmetric risks and threats, and this fact can influence the national values and interests and can affect the national security. From this perspective, the risks and threats to national and regional security make NATO and EU members, as well as maritime neighboring countries to cooperate on many aspects in order to promote and defend the security interests, the democratic principles and the common values in the area.

With regard to this aspect, Romania is developing its strategic profile as a security and stability provider, participating in accomplishing the missions decided within NATO and the EU, as well as in the actions

13 Andrei Vocilă - *Perspective of national security to restrict the Black Sea geopolitical and geostrategic context of global security*, http://andreivocilă.wordpress.com

to accomplish the cooperation and partnership international agreements within the Black Sea region.

Pro-active engagement of Romania in the stabilization and democratization process of the eastern area of the maritime space is a major objective for the rational use of national power instruments in order to promote and defend the security interests. In this context, the complex and dynamic maritime space facilitate the connection between the western area of Europe as a security provider and resource consumer in the eastern area, marked by insecurity, but with significant essential resources.

As long as we cannot talk about stability in Ukraine and given the fact that in the neighboring country almost all democratic mechanisms have been suspended, we can easily conclude that the measures taken to defend the security interests of Romania must be tailored to the new context.

The new National Defense Strategy, at sub-regional and regional level, reveals that the environment in which Romania defends and protects its values, principles and interests is in a new reconfiguration phase, the current security dynamic can affect both directly and indirectly the security state of Romania and its citizens.[14]

Romania supports a strong regional cooperation, the eastern and southern flanks of euro-Atlantic area.

A neighboring state where the democratic institutions are altered can become unable to stop the threats in the Border States. Least but not last, energy independence of Romania could suffer if the transit of hydrocarbons on the territory of neighboring states was negatively affected.

The regional energy architecture can suffer mutations determined by possible syncope in benefiting from energy projects competing with those supported by the European Union and Romania.[15]

As a result the means of defending the security interests have to be adapted constantly to the changes of geopolitical context. On the other hand, the geopolitical situation can give Romania important strategic opportunities.

They are empowered by being a NATO member, the integration in the security, justice, cultural, political and economic space of the European Union, the strategic partnership with the USA, the high degree of interoperability of the Romanian defense and security institutions with similar structures of NATO and EU member states. In this respect, in the content of the institutional documents develops the concept of instrument of power[16] of a military, informational, economic and diplomatic nature that uses the mechanisms and procedures specific for promoting and defending the security interests. The instruments of national power are normally used together in order to reach the required response capability in specific situations that include disputes, crisis and conflicts generated by potential risks and threats. It is true that the operational process of the instruments of power used to promote national security interests has to be run and developed constantly, in order to increase the multiple role of Romania as a connecting bridge between civilizations and cultures, trampoline for European liaisons and those between Europe and neighboring regions as well as to develop the strategic profile in its role as a security and stability provider.

CONCLUSIONS

The new euro-Atlantic and European identity that Romania has to build can become a vector of prestige, essential requirement for national security.

Romania, also currently not in very favorable situation, must look for an identity to be recognized at European level and must make its voice heard in the current European context.

To make assure the credibility and the strategic consolidation of Romania, the National Defense Strategy underlines the main directions of action.[17]

14 National Strategy for the defense of the country for the period 2015-2019, *A strong Romania in Europe and the rest of the world*, the presidential administration, Bucharest, 2015, online http://www.presidency.ro/static/Strategia%20Nationala%20de%20Aparare%20a%20Tarii.pdf, p. 13

15 Ibidem

16 Duţu Petre, Cristina BOGZEANU - *National interests and the use of national power for the promotion and defense: the case of Romania*, University of National Defense "Carol I", 2010, p.20

17 National Strategy for the defense of the country for the period 2015-2019, *A strong Romania in Europe and the rest of the world*, the presidential administration,

These direction are: consolidation of strategy's credibility by continuity and predictability at internal and external level that are achieved through the consolidation of security, public order and defense capabilities, creation a legal framework adapted for a common coordination of activities specific to national defense and national security at the level of the National Defense Supreme Council, intense inter-institutional cooperation to identify and accomplish the strategic objectives of national security, building up preventing mechanisms and also focusing on vulnerabilities, threats and risks prevention as well as allocating resources through rigorous, multiannual, continuous, integrated planning process, capable to meet the national requirements and those of the North-Atlantic Alliance and the European Union.

Romania assumes its role as an equal partner in the great European construction and its voice is heard in the EU forum through its Euro-parliamentarians at Brussels that represent and promote the national interests. In this way, Romania proves its interests in playing an active and constructive role at both European and regional level, in being a connecting bridge between civilizations, different cultural and economic interests for the benefit of stability and prosperity of the whole Europe.

In his role as a state in a geopolitical area of strategic importance, Romania's objectives have to concentrate on gaining a predominant role in the implementation process of stability and security and cooperation policies of the European Union and NATO in this part of central and southeast Europe.

Having said that, Romania's action, in terms of overall interoperability with the two organizations, is focused on solidarity, economic growth, promoting democracy, etc while the globalization marks its boundaries not only as a characteristic of competitiveness based on the growth of internal market, on economic performance, common currency stability but also as a result of technological level, social cohesion and internal stability, all under the spectrum of political influence and military power of the states that are part of these integrated systems for globalization.

Bucharest, 2015, pp.17-18

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CIMIC – CONCEPTS, PRINCIPLES AND FUNCTIONS

Cosmina-Oana ROMAN
„Henri Coandă" Air Force Academy, Braşov, Romania
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Abstract: *CIMIC is a NATO concept, used not only in Peace Support Operations but also in any kind of mission that requires this structure. In July 2003, NATO published its proper CIMIC Doctrine , being described as "the co-ordination and cooperation, in support of the mission, between the NATO commander and civil actors, including national population and local authorities, as well as international, national and non-governmental organizations and agencies" (NATO, 2003, p. 1-1). According to this AJP-9, it represents the means of linking with the civil environment, which in its turn, provides the adequate conditions in which military force can accomplish the final objective.. It is a rather new concept in military culture although its activity does not represent a new phenomenon but it has acquired new connotations after the 90s. The word, diplomacy, the convincing power and the ability to communicate in a foreign language are the assets of a good CIMIC officer. To this vocation, the emphasis on human quality and the ability to communicate efficiently in a crisis are to be added.*
Keywords: *civil-military cooperation, civilian actors, NGOs, local authorities*

1. INTRODUCTION

CIMIC is a component of military action, having as a final purpose the accomplishment of the objectives of all parties involved.

This cooperation fulfills the political and military objectives of operations, including political, military, civilian and humanitarian elements. In fact, this type of cooperation between civilians and militaries implies the incorporation of military capabilities into a joint reaction in front of all types of human needs.

It refers to all measures undertaken between a military commander and national authorities in peacetime, crisis or war (civil and military).

It involves the relation between military forces, national government and civilian population in an area where military forces are employed.

Such measures might also include co-operation between military commanders, NGOs, IOs and authorities.

In the short-term, CIMIC structures aim to set up and continue the complete collaboration of the civilian population and institutions within a commandant`s area of operation in order to create the civil/military conditions that offer him the greatest possible moral, material and tactical advantages.

Furthermore, in the long-term, it aims at creating and sustaining conditions that will support the achievements of a lasting solution to the crises.

Thus, in complex humanitarian crises, the coordination of civil-military structures is vital and may require multiple CMOCs (Civil-Military Operation Centers that is, an ad hoc organization to assist in the coordination of activities of engaged military forces, and other UN Government agencies).

These structures must be easily accessible to the NGO community, support NGO requests for assistance and operate at the local level. However, in-country communication within the NGO community itself is a complex issue. In some situations, parallel UN/military structures of coordination are established which simply serves to complicate coordination.

Improved relations between NGOs and the military through increasing opportunities for closer cooperation in areas such as joint training, joint planning and joint assessment, help each in understanding the other and bring about greater effectiveness during missions.

Differing missions and needs contribute to distinct perceptions of priorities on the part of both the military and NGOs.

These organizations do not always understand the military focus on force protection as a priority and feel that military logistics should be used to transport supplies in the field, and not used for force protection.

On the other hand, the military also needs to consult more with reliable NGOs and co-ordinate with the DART (Disaster Assistance Response Team).

2. CONCEPTS

CIMIC represents therefore a NATO concept, generally used during peace supporting operations, enjoying the support of the governments, the NGOs, the international organizations and the armed forces. Still, the CIMIC cannot be regarded only as a contemporary type of military activity, as the idea of the cooperation between the civil and the military authorities during this type of operations is not new.

The Romanian CIMIC concept involves the deployment of two activity types. First, there are activities that support the military actions, carried out by the civilian institutions and by the population, during the military actions, by establishing their concept of action, but also their coordination framework.

Another type of activities is represented by those deployed as a support for the central (local) administration or for the population, in order to establish the constitutional order after the end of the hostilities, for the normalization of the situation in the conflict areas or for the removal of the effects of natural or industrial disasters.

The concept of CIMIC was founded throughout the Cold War period and began to take shape only after the fall of the Iron Curtain and the involvement of massive multinational Forces in theaters of operations, especially after the lessons learned from the Gulf War of the early '90s. With the end of the Cold War and the initiation of new types of military operations, the European countries began to develop CIMIC operational structures and the way of understanding the concept by most European countries is in accordance with "NATO CIMIC Doctrine".

Besides NATO, there is also a definition proposed by the United Nations, which gives the concept a broader perspective, defining CIMIC as "mutually supportive, integrated planning and exchange of information needed at all levels between military forces and organizations or humanitarian agencies acting to fulfill a common purpose in response to a humanitarian emergency." Regarding the definition proposed by the European Union, CIMIC is presented as containing "specific tasks or activities conducted by EU forces, alone or in partnership with one or more civil bodies, always supporting the commander`s mission." Thus, between CIMIC and civil affairs there are no basically too large differences, the object of the activity being the same. The phrase "civil affairs" is used by the US military, but the structures involved in "civil affairs" types of activities are part of the forces conducting special operations.

Gradually, both the concept and CIMIC activities, have acquired new meanings, becoming part of military activities and part of peace support operations implicitly, including the support of the military governments or local authorities from a certain area or theater of operations. Military operations are currently conducted in a wider political and military context, where the influences (from the physical and economical to the social ones) can trigger a crisis or may arise as a result of some conflicts in regions where they did not previously exist. Besides the Romanian CIMIC conception and general principles found in NATO CIMIC Doctrine we must consider other factors. These relate primarily to CIMIC activities as part of military operations. These represent the command responsibility and an essential part of the mission of each military. Staff elements and CIMIC forces are the basic means for carrying out the CIMIC tasks. Equally important are CIMIC activities that take place with the intention of ensuring the overall success of the mandate by maintaining full cooperation between commanders, civilian population and institutions in their area of responsibility. This cooperation is essential to create conditions for civil-military commanders to provide the best benefits possible, moral, material and tactical.

3. PRINCIPLES AND FUNCTIONS

CIMIC elements usually encountered in stability operations mainly include three main **functions**: the link between the military personnel and all civilian actors in the area of operation, assistance to the civilian surroundings, and support to the force. Thus, a good example is the completion of the General Framework Agreement for Peace (GFAP) in Bosnia and Herzegovina, where CIMIC personnel paid an important role.

Usually, CIMIC develops tasks that the U.S. military consider as being "Civil Affairs (CA) activities" which apply primarily to "support of the civilian environment." It covers activities carried out so as to establish and maintain connections between military forces and civil authorities together with the local population. Whereas CIMIC and CA tasks often overlap, there is a clear doctrinal dissimilarity when it comes to their purpose. CIMIC concentrates on humanitarian necessity and offers supervision for how to interact with civilians (civil authorities, locals, international organizations, and NGOs, etc.) in order to complete effectively the tasks of a humanitarian mission. CA, on the other hand, centers on military requirements and necessities, providing ideas for how to obtain the help of civilians for the military mission. In this respect, NATO regards CIMIC as the crossing point meant to predominantly improve coordination and diminish overlap and replication of hard work between civilian organizations and authorities in order to meet humanitarian needs even more efficiently. In a different way, CA, as described in the U.S. Department of Defense Doctrine for Civil Affairs, tries to shape and persuade the civilian environment in support of the armed forces. Regardless of these conspicuous features between CA and CIMIC, the two methods reveal enough common terrain so as to be well-matched and harmonious.

According to Romanian CIMIC Handbook (pp.11-12), drafted in accordance with ACO CIMIC Manual 86-1-1 and NATO CIMIC Policy, the basic functions of CIMIC are as follows:

a) Civil-military relations that involve maintaining connections with civilian actors so as to coordinate, cooperate and spread information efficiently;
b) Support provided to civilian actors – that involves a wide range of military resources: information, personnel, technical equipment, transmission facilities – communication and informatics – expertise and specialists training. This support is provided only when and if necessary to facilitate mission accomplishment;
c) Support provided to military forces – if circumstances impose, commanders may request and use support from the civilian side in areas of operations. In this particular situation, the role of CIMIC is highly important through identifying resources and people who can support the military personnel. This support may consist in: information necessary to evaluate the civilian situation in a certain area, promotion in terms of accepting militaries in the area and access facilitation to civilian resources when necessary.

The overall support given both ways is perceived by civilians as a must, as something that comes with the territory, thus, a refusal from the military side is not quite welcomed and fully understood.

CONCLUSIONS

In conclusion, the different themes reflect the mix of experience and knowledge; theory and practice that are so characteristic to living and working on the dynamic civil-military interfaces and are very deserving of in-depth research. Both civilian and military parts share the long-term objective that is to promote human security and to develop those conditions, in case of societies characterized by conflict to return to nonviolent and long-standing structures. At first, civil-military relations were formed in the field, when forces intervened to fill the gaps in civilian capabilities. In return to the increasing complexity of operational requirements, countries are gradually acknowledging the escalating working links between military and civilian actors and are currently implementing their proper doctrines underlying the characteristics of civil-military cooperation (CIMIC).

Therefore, CIMIC offers the best mechanisms to establish the link between military and civilian activities in various areas of operations. Civil-military cooperation is thus vital for success in any mission and it is the responsibility of the command. It is thus part of the responsibilities of each individual working in this field, calling for a clear doctrine that is transparent, understandable for both military and civilian personnel. CIMIC also involves training in this regard for all military personnel.

Civil-military cooperation is therefore a dimension of operations in which the policy is conducted at strategic level, and its implementation is at operational and tactical levels, being the responsibility of the commander, who will ensure the correlation of military action with the requirements of military and civil authorities empowered to materialize defense policy.

Future work will be carried out to identify the particular skills a CIMIC officer should have so as to establish and/or continue the cooperation with the civilian authorities within a certain area of responsibility.

For that, special courses have been developed to train future CIMIC specialists of how to approach locals, how to learn, understand and assimilate their culture and last, but not least, how to behave efficiently and effectively under such special conditions.

A CIMIC officer must also adapt the present social and political conditions that are rapidly changing, leading to changes both in human behavior and approach to life as a whole.

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THE USE OF UAV'S DURING ACTIONS OF INTEGRATED AIR DEFENSE SYSTEMS

Vasile ȘANDRU*, Marius RĂDULESCU **
*„Henry Coandă" Air Force Academy, Brașov, ** Electromecanica SA ,Ploiești, Romania
DOI: 10.19062/1842-9238.2015.13.3.23

Abstract: *The missions that Unmanned Aerial Systems can run represent the main goal for which they were designed, if in case the missile's mission is clear, meaning that their missions are outlined, when we speak of unmanned aircraft, the range of missions in which they are involved is wide, being extremely flexible regarding their use. There are a multitude of aircraft destinations they can run both in peacetime and crisis or war times. Areas of their use are diverse, and there are concerns for the development of unmanned aerial vehicles and for their integration into the airspace.*
Keywords: *Integrated Air Defence system; support making ; tactical mobility*

1. INTRODUCTION

Considering that the UAV systems cover a very wide range of missions with high efficiency, we have found that they can bring visible improvements in the Surface Based Air Defense (SBAD) missions.

On the base of the sensors or weights that can be incorporated or transported by the aerial platform, next to the ground station, I found a solve to some problems (confinements) related to the artillery and ground-air missiles' missions.

Surface- to -Air Missiles next to the defense systems create the nucleus of the air defense with the base on the ground. SBAD plays a decisive role that is in a continued growth due to the threatens that covers, as: TBM (Tactical Ballistic Missile), battle

The advantages that SBAD structures have in this moment are the following:

- TBM engaging;
- the ability to engage two or more targets at the same time;
- the ability to engage aerial targets, that fly currently with very high speed and at different altitudes;
- quick reaction time;
- the ability to engage aerial targets in all weather conditions, both day time and night one;
- low vulnerability.

The creation of combined cannon-missile structures is determined by the fact that, under the aspect of destruction possibility, there is a complementarity report, because the cannons are effective at very short ranges (0-1000m), and the missiles above 1000m. Combining two systems, one of them SHORAD type and another VSHORAD type, in an integrated entity under tactical and operational aspect, represent one of the noticeable trends that characterize the evolve of these defense systems. The components are actionably and functional integrated through a fire guidance center (FDC), in a shooting entity that disposes of connection capabilities with command-aerial control systems [10].

2. UAS SUPPORT MAKING FOR AIR DEFENCE INTEGRATED SYSTEMS

All the same the usage of Air Defense systems that can be used for covering the *empty spaces* from the staffing zone of ground-air missile systems with a medium or long range is imposed.

These empty spaces exist due to the fact that there are distances between 200-1000m where the missile can't operate, due to the necessary time to get in the supervision stage.

The effective action ray of the systems is about 4-5 km, and approximate 10-15 km for short range Air Defense systems, presented in [3].

Aerial defense with CLUSTER surface base, means the usage of more types of missiles/ artillery systems with a different action range, so that the destruction areas overlap for creating a simultaneous disproof of the uncovered targets on different directions and in the same time, for the reciprocal assistance of them, presented in [3]

The disposal of the dislocation areas of Air Defense systems within CLUSTER may be circular (balance defense) ore one of the waiting direction of the threaten (weight defense) [2].

The performances of the percussion with or without a pilot (airplanes, helicopters, voyage

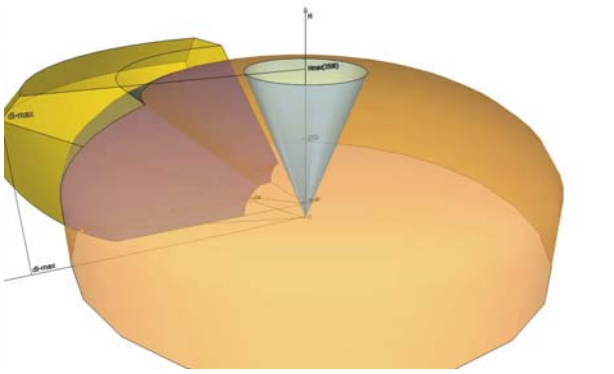

Fig. 1 Action areas of integrated systems used in the CLUSTER configuration 3D

For this, I propose creating a conceit related to the architecture of a multiagent systems which is compounded by an integrated ground-air missile system, SHORAD-VSHORAD, with a mixt cannon-missile group, beside a UAV system able to defense an aerial object.

So, a commander is placed in the highest point of the hierarchy.

The architecture is generically and flexible to facilitate the fusion between different types of technologies.

In the network, the autonomous UAVs can be centralized controlled; this thing needs each UAV to communicate all the data's from sensors and receives control signals.

This structure offers an environment in which the agents coordinate themselves, cooperate and negotiate in order to take the needed measures and right decisions in order to achieve the objectives.

With a view to the coordinated control between aerial vehicles, each person from the team is considered an agent with particular capacities involved in the execution of a part of the mission.

The UAS has the ability of correcting the artillery fire, not only by the simple view of the projectile orbit, by the appliance of the corrections remembered above, in case in which the intended effect of destruction of the target is not created. In this way it is obtained a high efficacy, a high destruction probability with reduced ammo consumption in a short period of time.

The spectators monitories the battlefield from a distance and with an aerial perspective that allows the ground station to see 360^0 around the target and to deliver the data's at users in real time.

In case a shooting session is executed simultaneous with more cannons, an UAV is capable of engaging more targets in the same time and offers split information for each cannon. In the planning of the mission, we have to consider the following requests:

- the existence of a qualified
- spectator - FO (Forward Observer) available to execute the mission, to monitories the video space and deliver the information to the Fire Sharing Center (FSC), to determinate the disproof method, and after this at the battle subunits

- GCS (Ground Control Station) is located in the tactical center of operations in order to simplify the commands and the control, to ensure the engagement of more targets in the same time
- to assure the video take-overs from a longer distance and maintain the communications with the GCS
- to exist communications with the battle subunits

The targets are video monitored, and when fire is executed over them, in the moment of the impact image captures are realized in order to appreciate the shooting and the adjustments execution.

The locating of the target is realized with the help of Cartesian coordinates.

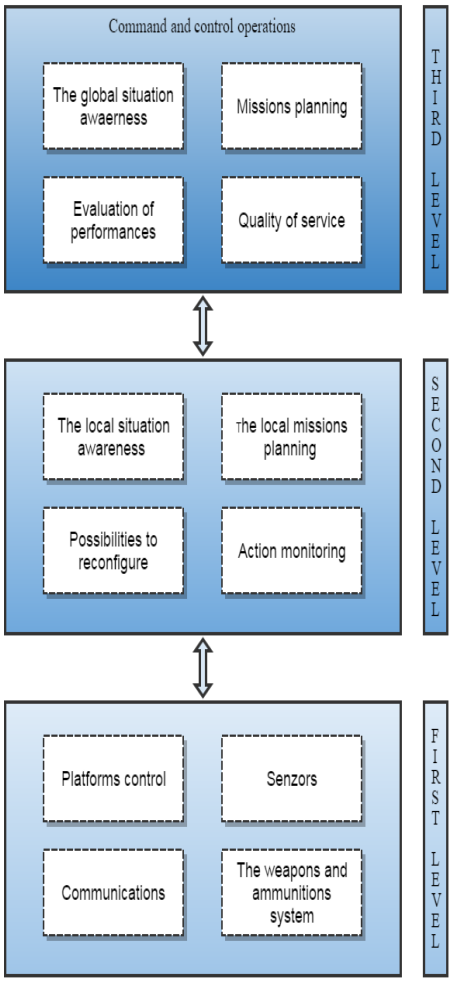

Fig. 2 Hierarchical Architecture of a multiagent system

The UAS (Unmanned Aerial System) order of actions to support the artillery firing is presented in figure 3.

Using the UAV in artillery support, that explores and carefully oversee the allocated space and transmits the information in real time or almost real, the subunit can place the cannons in hidden places, behind some obstacles, ground unevenness, they can guide them for a reduced visibility of the enemy, so he doesn't know where to attack, but where he is attacked from either.

All the operations are centralized in FDC, which could be also in a hidden location.

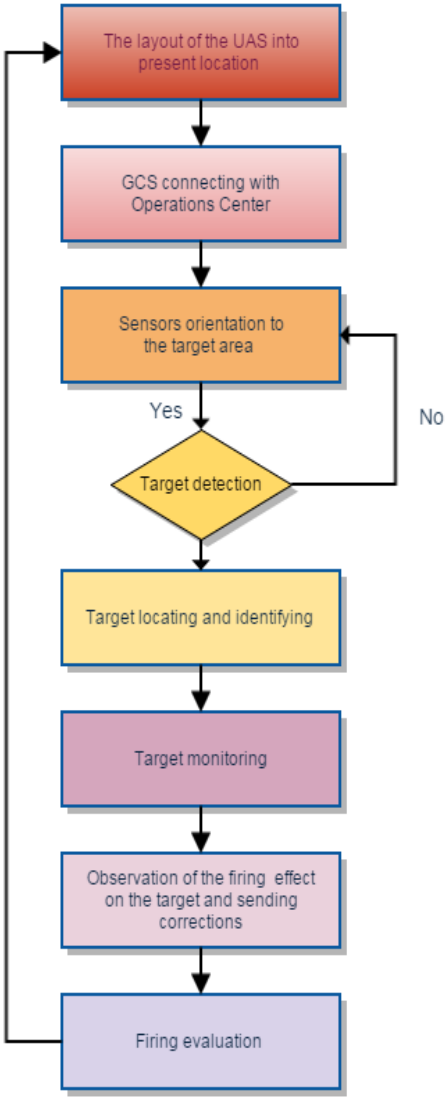

Fig. 3. Chronological order of actions

With the help of the UAV sensors, the commander can see the whole situation behind the obstacles because the aerial vehicle has the appellation of "commander eyes" because it is located above the area, being in the same time located very hard.

In FDC all the operations take place and from here are given all the orders.

An UAV equipped with a lot of sensors can accomplish a few missions of the reconnaissance group, in a long or shorter time, with lower resources consumption and with a limited number of personnel.

Taking into account that it has in its compound TV cameras during the day, and also during the night or infrared video cameras, photo cameras, exploring systems through and of radiolocation and auto control termichal systems it can offer the commander a whole series of features.

In such situations, the usage of the UAV is necessary because it can offer the commander a overview image of the examined terrain, but one actualized that can present in a detailed way the elements or the information needed to start the march.

This can offer information related to the road length, possible march itineraries, and also choose the most suitable route for displacement with capturing the interested areas (perimeters).

The captured images are processed on the ground, so the displacement itineraries are established considering them to have the following characteristics: short distance and maximum safety.

Missile systems have in their compound radars that they use in the purpose of detecting the targets, aerial overview and offering the data's about the aerial situation needed to the recognized air picture (Recognized Air Picture - RAP), but also for directing the missiles to the target.

These radars have a series of advantages that are implemented during the technological and scientific progress, but they also have some confinements related to the coverage of the whole threaten eidolon.

In case of a diversified relief (the presence of the mountains, of the hills and of the plateau) some rules are imposed in order to place the action formations.

The own explore radars, for data's achievement, for illumination have to be placed on the highest point in order to use their whole exploring capacity.

Aerial threatens of the aerial objects that should be under defense and of the means and missile systems forces are represented by the enemy's aerial means and the lethal/unlethal actions that they can use.

The most spreader aerial threatens, with improvement tendencies in the future are: airplanes of all types, helicopters, airships without a human pilot and missiles [5].

In this moment, the main threatens related to the radars from the missile systems compound are represented by helicopters and by UAV because they evolved at low heights and can't be seen on the radar because are hard to find and disprove because of their reduced dimensions and of their termichal and small radiolocation prints, characteristics that assure them great possibilities of detection.

These two types of threatens have the advantage that they can execute the wonder attack, choosing a flying direction on valleys, where the radar detection abilities are almost null.

The targets detected by the radar can be disproved by the missiles, but the others will succeed into accomplishing the mission.

This situation is illustrated in the figure 4.

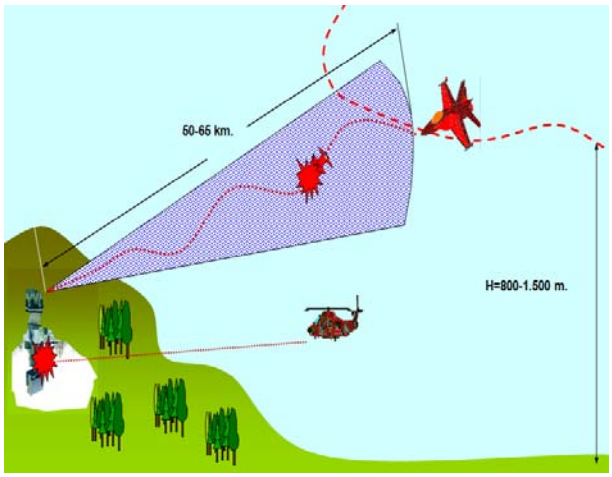

Fig. 4 The radar uncovered area

The radar maximum range (unambiguous) is given by pulse repetition period T_R; ambiguities arise over this distance.

The formula for calculating the maximum distance is :

$$D_{max} = \frac{c \cdot (T_R - \tau)}{2} \quad (1)$$

$$D_{max} \approx \frac{(T_R - \tau)\ [\mu s]}{6.66\ \mu s} \quad [km] \quad (2)$$

where:

c is the speed of light $3 \cdot 10^8$ m/s ,

τ is the pulse duration of the survey.

If the pulse width is small compared with the repetition period, it can be ignored in the formula. It should however be considered if large radar pulse duration, pulse compression using the reception.

It follows that the pulse repetition period is a very important factor in determining the maximum range by the radar as targets whose time delays occur at distances exceeding the wrong T_R indicator.

These targets are called echoes (second - sweep or second - time - around).

CONCLUSIONS

In this study we have emphasized the continuous knowing of the aerial evolution by the omnidirectional view (360^0) it is imposed a short reaction time. Also, the tactical mobility is effective created by the help of an UAV.

One of the solutions related to a counteraction method of a wonder attack from some airships that evolve through the valleys, consist of placing an UAV in the area that has a high risk and where the helicopters and enemies can action against objects under defense.

Considering that the UAV delivers through GCS the information in real or almost real time, by detecting the targets located outside the action area of the radar, can warn about a wonder attack.

Having the information provided by the UAV sensors at hand, the launch ramps of the missiles are directed to the attack direction and are waiting for their disproof.

The authors take full responsibility for the contents and scientific correctness of the paper.

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THE RISK MANAGEMENT, DETERMINANT FACTOR OF INCREASING THE LOGISTICS PERFORMANCE

Marius MILANDRU
Territorial Internal Audit Section No. 5, Braşov, Romania
DOI: 10.19062/1842-9238.2015.13.3.24

Abstract: *Evolution of the new European and regional environment, the updated economic circumstances and legislations, determined utilization of new mechanisms to identify and control the risks associated to these changes. The risk could be defined as a continuous danger inside organization activities and decision process, and also as a quantifiably measure of a possible event, which is not desired. So, all organizations, without taking into account the genders and dimensions, will be exposed to some risks which those probabilities and impact must be evaluated.*
Keywords: *military organization; management; process; logistics risk, performance.*

1. INTRODUCTION

At the level of military organization, the risk management represents the activity by which the risks administration is achieved, its task being optimization of risk exposure.

The specialists in domain sustain[1] that the level of risk which a organization will maintain after implementation of a risk management program, is named residual risk.

To increase the logistic performance, it's mandatory for logistic structures to define their own strategy related to specific risks of a military organization.

Also, it must ensure a complete and adequate strategy and also the accessibility of specific documents for all logistic personnel.

Realizing this aspect will determine the insurance of logistic risk management which facilitates the efficient fulfillment of military structures goals.

The logistic risk can be defined as a possible danger for military organization or for a system inside it; in other words, this represents a certain event, behavior, action or no action which could jeopardize the patrimony, the mission's achievement or logistics objectives of military units.

1 Orzan, M., Risks management associated to marketing instruments, Online marketing magazine, vol.1, no. 2, A.S.E., Bucureşti, 2007, page 4.

2. CONSIDERATIONS ABOUT THE LOGISTIC RISK

The logistic risks evaluation presumes identification and analyzing those through the danger common sense view which is represented related to military organization objectives.

The logistic risk management is a a repeating process, continuous which is identified a mechanism of detection and evaluation of dangers, of analyzing and controlling the risk, its effect or consequences being the increase of logistic performance of structures and microstructures.

This aspect determines the maximization of positive events consequences and minimizing the negative events consequences which take places at logistic structure level.

The steps of logistic risk management process are the following:

1. identifying the logistic risks / hazards (dangers, vulnerabilities), this step presumes applying of the methods, techniques or tools adequate for identifying the risks associated to certain logistic action or activity.

Practically it starts with identification of activity domains inside military unit, detail inventory of logistic processes, specific phases and activities, to the level of basic tasks.

Then each activity / domain inside institution will be detailed, in successive operations, showing who and what is doing, the inputs which are used for every task / activity and what outputs are expected.

The inventory and particularization of logistic processes and activities are doing with the scope that all members of managerial team to have a clear and comprehensive image on organization, in this way being identified all the potential risks from inside or outside.

2. assess the logistic risk / hazards, presumes applying of quantitative and qualitative measures to determine the probability or severity of potential negative effects which results from exposure to a certain danger or threat.

This aspect can be started according to the following indicators:

-the probability of starting or possibility of initiating a specific risk;

-the risk impact, in other words the effect or consequences which appear through materialization of a certain risk;

To evaluate the probability and impact / meaning of logistic risks could be used the following evaluation scale:

Table 1 Assessment of logistic risk and its impact

RISK ASSESSMENT		**SEVERITY**	
Extremely high	5 = frequent appearance	Extremely high	5 = major impact/ catastrophic
High	4 = likely appearances	High	4 = considerable impact/ critical
Medium	3 = occasional appearances	Medium	3= medium impact/ moderate
Low	2 = seldom appearances	Low	2= minor impact
Very low	1 = unlikely appearances	Very low	1= negligible impact

The team designated to do the logistic risk analysis has the role to estimate and determine the unit management capacity to administrate the identified risks, and the efficiency of existing internal controls, using the following scheme:

Table 2 Internal controls efficiency

INTERNAL CONTROLS EFFICIENCY	
Very efficient	4
Efficient	3
Acceptable	2
Ineffective	1

So, knowing those three indicators (appearance probability, impact and control efficiency), can calculate the logistic risk value (LR), using the following formula:

$$LR = P \times I / C:$$

where:

P = Probability of appearance / risk assessment;

I = Impact / severity (consequences gravity);

C = Efficiency of existing internal controls.

The logistic risk doesn't have a meaning as an absolute value, will serve as a synthetic indicator (priority risk) to compare the logistic risks which are identified.

3. hierarchy of logistic risks (classification) is the step in which is realized a hierarchy on domains or specific activities, establishing the logistic risks levels, as high, medium, low; also in this step it can be removed the insignificant risks.

4. evaluation and analyzing the logistic risk control measures (develop controls and make risk decisions), presumes identification of procedures and strategies in order to reduce or remove the risks identified at the level of the military organization;

5. the logistic risk control represents the step in which the logistic managers will take adequate decisions of establishing control measures on logistic risks;

6. implementation and analyzing the corrective actions of logistic risk is in fact applying a strategy of implementing the identified control measures (implements control).

The manager team will establish terms and will designate the responsible personnel for decreasing the logistic risks consequences, this information will be realized through a "The Action plan against logistic risks";

7. monitoring the attenuation actions of logistic risks (supervise and evaluate).

Because the management of logistic risk is a continuous process, the process has to be supervised or even reevaluated from time to time.

Inside logistic structure, the risk management represents a key part of logistic management, so the risks must be taken into account in the moment of taking the logistic decisions and the opportunities will be maximized just administrating, in an active way, the risks and threats / hazards which can prevent the appearance of success.

To fulfill the specific objectives, we all agree that the logistic manager must have a concrete approach, as it follows:

- establishing a clear responsibility, roles and lines of reporting to administrate risks, these being established and maintained in all functions and structures ;
- analysis of logistic risks will be incorporated and considered as an integrated part of logistic decision process ;
- the measures taken to manage individuals logistic risks will be adequate to probability of appearance and the impact potential of those risks to structure objectives fulfillment;
- the performances of logistic risk management activities will be measured according to specific mission and objectives.

CONCLUSIONS

The logistic risk management is identified as a process complementary to intern control; this id made by the team manager in relation with execution personnel, through will be used tools and ways which will follow identification and administration of threats which could have a negative impact to objectives, in the same time with awareness of risks.

Because the military structures are subject to risks, indifferent of their nature (operational, law, financial) it is mandatory to ensure and implement a process of managing risks, also those logistics. This aspect is determined also of the fact that the risk is everywhere, in any circumstances and actions and it can be eliminated.

The solution is to minimalize or maintain the logistic risk in a certain accepted limits, agreed by unit management. Inside military organization, the logistic risk management was created on the concept of internal control, but the accent is on the way of risk administration and also to incorporate basic concepts according to internal control in the process of risks administration.

From time to time it is mandatory to analyze inside military units, at least 2 times per year, the risks related to logistics activities and domains associated, with the scope of identifying viable solutions which will be materialized through action plans.

The knowing of threats levels and realizing of an hierarchy of those taking into account of their appearance, impact, and efforts of reducing the chances of appearance or limitation the undesirable effects, it is a necessity in the logistic risk management process.

At the level of logistic structure administration of risks represents identifying and evaluation of those and establishing the way of reaction against risks, also to operate with internal control means which can attenuate the possibility of appearance or the consequences which can be produced if they are materialized.

The logistic risks must be identified at any hierarchic level, where the possibility of appearances of negative consequences in fulfillment of military unit objectives can be found, also the necessity of identifying and applying the specific measures to settle problems related to those risks.

In practice, the logistic risks is based on incertitude's but also on perception of incertitude, in this way it is mandatory to have data and information to administrate efficiently the logistic risks.

In the process of administration the logistic risks, resources are always limitated and for these reasons the management of military units will find an optimal response in the problem of administrating the risks, in a certain way of priorities, aspect which results from the activity of risks evaluation.

The practitioners recommends to managers to take into account of the fact that the logistic risks can't be avoided, in these conditions they have to keep them at a level considerate acceptable and tolerated by organization and do not try to eliminate them because this action can lead to the appearance of other risks absolutely unexpected.

The logistic manager has to apply a risk management process which will facilitate the efficient realization of organization objectives. Always, in practice, the logistic risks have to be related to objectives, they have to be evaluated and prioritized starting from the individual's objectives and continuing with collective's objectives of unit.

In order to realize a successful management, the logistic structures have to fulfill the following criteria:

- to define their own strategies of logistic risks with which the unit can be confronted;

-to define specific objectives and associated the logistic risks;

-to create and maintain an efficient system of logistic risk management;

I said that the logistic risk management must be based on the exact knowing of processes and specific activities of unit, and also the operational frame in which unit acts;

Ensuring a performant logistic risk management will accomplish the objectives of military organization and those related.

Also the knowing of logistic risks and the accepted level of risk exposure will contribute to a realistic fundamental of managerial decisions.

I consider that the viable solution of managing the logistic risks is represented by finding a balance between the residual risk and the risk which are prepared to accept or tolerate.

In approaching the logistic risk the logistic manager must straighten its attention also to internal factors inside organization (personnel quality and motivation, quality of internal control system and necessity of fast increasing of activity volume) and to external factors (the legislation, technological development and the major force).

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A COMPARATIVE ANALYSIS BETWEEN TWO TYPES OF VEHICLES WHICH COULD BE USED AS UAV LAUNCHERS MOBILE PLATFORM

Cornel ARAMĂ, Constantin ROTARU, Mariana ARAMĂ, Eduard MIHAI
*"Henri Coandă" Air Force Academy, Braşov, Romania
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Abstract: *The following scientific study is about of two possibilities to use different types of vehicles as mobile platform which could be used to launch an UAV. One of them is a light off-road articulated prototype vehicle, DAC 2.65 FAEG and the other one is a classic off-road vehicle named BCV-320, prototype too. Both of them are going to be integrated into a mobile cell for forward reconnaissance missions. The advanced multi-criteria analysis method is going to be used by the researchers in order to establish the best solution for a mobile platform capable to launch different types of UAV's. Due to the fact that both suggested prototype vehicles have high modularity, the final conclusions are very interesting and some test exercise in military fields is going to be done.*
Keywords: *prototype, UAV, off-road, mobility, platform*

1. INTRODUCTION

The current global situation is an unstable environment which is characterized, first of all, by a lot of asymmetric conflicts where one of the engaged parties, the weak one, has been specializing in classic or urban guerrilla conflicts and the military-developed countries have been developing their antiterrorist fighting capabilities continuously.

This is one of the reasons why the weapons industry of these military-developed countries is focusing more and more on the combat mobile cells production as a solution to fight against terrorist cells. These kind of military technical systems have to display a more increased viability in antiterrorist or guerrilla fights. From the point of view of the researchers who try to find out new solutions of the problem, a combat/fighting mobile cell, which could be seen as a military acting system, must comprise the following main parts (Figure 1):

- the ground subsystem which could consist of crew, intelligent equipment (gadgets such as: special shock resistance computer, data sensors, signal and reception data gadgets etc.), maintenance equipment, different military assets and the special vehicle;
- the flying subsystem consisting of, first of all, the UAV, the intelligent equipment for acquisition, signal and control data, and maybe special equipment for self-destruction;
- the interface/link between flying and terrestrial parts.[1]

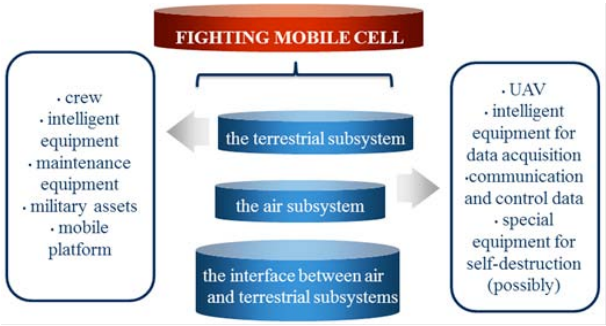

Fig. 1 The overall structure of a fighting/ combat mobile cell [1]

The researchers analyzed two possibilities to use two types of vehicles as mobile platform which could be used to launch an UAV.

One of them is a light off-road articulated prototype vehicle, DAC 2.65 FAEG (Figure 2) and the other one is a classic off-road vehicle named BCV-320 (Figure 3), prototype too.

Both of them are going to be analyzed as the terrestrial mobile part for an UAV Forward Reconnaissance Mobile Cell.

Fig. 2 The light off-road articulated prototype vehicle, DAC 2.65 FAEG

Fig. 3 The classical off-road vehicle named BCV-320

2. A SHORT PRESENTATION OF THE VEHICLES

As it is known, the maximum weight for a light off-road articulated vehicle (in our situation, DAC 2.65 FAEG) is less than three tones.

It consists in two equal vats connected to each other through a central pivoting bearing which allows moving both parts around the vehicle longitudinal central axis.

All wheels of this kind of vehicle are live and steering and it has no suspension.

The transmission is inside of the body (capsulated could be said), so, theoretically, the designers consider that the vehicle cannot be stuck in the mud.

BCV 320 is a prototype too, as the DAC 2.65, but this general structure has a classic conformation: 4 live wheel, high ground clearance, front wheels steering etc.

The DAC 2.65 FAEG vehicle was made up by the designing engineers from the National Institute of Road Vehicles (INAR) and ROMAN/DAC Truck Factory in the late 80's and BCV-320 is proposed by the Institute of Road Vehicles (INAR) in the beginning of 2010 decade. The main technical characteristics of these vehicles are presented in Table 1.

Table 1. The main technical characteristics

Item	DAC 2.65 FAEG	BCV 320
Weights and dimensions		
Overall length [m]	2.95	4.67
Overall width [m]	2.06	1.89
Overall height with hood [m]	2.05	1.95
Unload vehicle weight [kg]	1600	1750
Gross vehicle weight [kg]	2000	3500
Crossing capacity items		
Ground clearance [m]	0.27	0.285
Front overhang [m]	0.75	0.72
Rear overhang [m]	0.565	1.35
Wheelbase [m]	1.634	2.6
Track (front/rear) [m]	1.65	1.475/1.525
Engine performances		
Type	4-cylinder, Otto cycle	4-cylinder Diesel engine, turbocharged
Displacement [cc]	1397	2436
Maximum output [HP/rpm]	65/5500	120/4200
Maximum torque [Nm/rpm]	102/3300	260/1800-2200
Transmission		
Type	combined: automatic +conventional	conventional

3. THE SUGGESTED OPERATIONAL MILITARY REQUIREMENTS WHICH HAVE TO BE TAKEN INTO CONSIDERATION

Due to the fact that the rear vat, in case of the DAC 2.65 FAEG, and the platform, for the BCV 320, are almost empty, the vehicles have large possibilities to be equipped in order to fulfil different kinds of missions from the civilian and military fields.

A wide range of vertical equipment can be attached on the DAC 2.65 FAEG platform (the rear vat) without affecting too much its stability because it has the advantage of the low center of gravity.

The BCV 320 is rather high for an off-road vehicle but it has a large platform which could be endowed with a large area of types of assets.

The operational military requirements which could influence the mission and which is studied in this article (the forward reconnaissance missions using the UAV-s) are [1]:

- constructive simplicity;
- high reliability;
- compactness;
- tactical-operational mobility;
- low overall dimensions;
- low weight;
- easy exploitation to fulfil the missions;
- high maintainability;
- high ergonomics for the crew;
- high range;
- transportability;
- efficiency of combat actions – the results that can be obtained;
- profitability – the fast and restoration costs of fighting capacity.

First of all, the researchers will remove one operational requirement which has the same value for both vehicles: the profitability.

Also, the efficiency of combat actions criterion will be eliminated because it is going to be derived from the other criteria.

After that, they are going to select from this list the most important military operational requirements.

The purpose of the study is to reveal the most viable vehicle for this kind of mission.

4. ESTABLISHING THE BEST VEHICLE FOR THIS KIND OF MISSION BY USING THE ADVANCED MULTI-CRITERIA METHOD

As we know, in order to compare many item categories the advanced multi-criteria analysis method is one of the best methods.

The main reason is to obtain some important conclusions for the vehicle which are going to be used as a mobile platform which has been purposed to be part of the mobile cell which is going to be used in air force missions in general, and to launch UAV in our situation.

In this situation, the market demands involve the endowed of the mobile cell for forward reconnaissance missions with a new type of vehicle (the most viable) which are going to be used as mobile platform to launch an UAV system. So, the project main theme and the purposed mobile platforms for the project have been identified. The suggested types of vehicles (there are two completely different types of mobile platforms) are:

- the light off-road articulated prototype vehicle, DAC 2.65 FAEG and
- the classic off-road vehicle named BCV-320, prototype too.

4.1 The Criteria Establishment. In this research eight operational requirements were selected as criteria for the advanced multi-criteria analyzing method. Thus, the chosen criteria are:

- constructive simplicity;
- low overall dimensions;
- low weight;
- tactical-operational mobility;
- easy exploitation to fulfil the missions;
- high maintainability;
- high range;
- transportability.

4.2 Determining the weight of each criterion. A weight factor is calculated separated on each criterion. The following abbreviations are used into Table II:

- constructive simplicity - CS;
- low overall dimensions - OD;
- low weight - LW;
- tactical-operational mobility - TM;
- easy exploitation to fulfil the missions - EE;
- high maintainability - HM;
- high range - HR;
- transportability - TB.

Within this table, the classical annotations, for this method, to compare the criteria are used: 1 when the row criterion is more important than column criterion, 0,5 when both of them are equally important and 0 when the column criterion is more important than the row criterion.

The amount of the row points for each criterion determines the classification of the criteria.

The weight factors can be calculated by using different formulas. The very practical formula FRISCO was used to calculate the weight factors in this situation:

$$\gamma_i = \frac{p+m+\Delta p+0,5}{-\Delta p'+\frac{N_{crt}}{2}} \quad (1)$$

where:

p, m, Δp, Δp' and N_{crt} are according to the technical literature

Thus, the results are presented into the Table 2.

4.3 The identification of the variants, granting the N grade and the establishing of the consequences matrix. This comparative analysis intends to compare two variants of special vehicles and establishing the best of them in order to fulfill the air force mission, mainly forward reconnaissance missions using UAV systems. The suggested mobile platforms are the light off-road articulated prototype vehicle, DAC 2.65 FAEG and a classic off-road vehicle named BCV-320, prototype too.

Each criterion received a grade of importance from 1 to 10. Normally, it is called importance grade or contribution to a criterion grade. This importance grade is granted to each variant based on the technical and/or tactical characteristics, taking into consideration each criterion. The grades N_i which were granted to each variant are presented in Table 3.

As it is known, the weight factors influenced the importance grades. The wedge between the weight factors and the importance grades must be calculated for each criterion in this method. The final classification will be logically established by the sum of the N_i x γ_i wedges. Into the Table 3 these calculations are presented.

THE RESULTS INTERPRETATION – CONCLUSIONS

Under this analysis, as it could be seen in Table III, DAC 2.65 FAEG has the best structure for this kind of missions. What is remarkable is that the difference between the purposed variants is quite large. This situation can suggest that the designers of DAC 2.65 FAEG prototype were well inspired and the solution of this kind of structure (light and articulated vehicle, all live and steering wheels) is viable for forward reconnaissance missions using UAV systems.

This situation is a challenge for the researcher in order to try to insert into exploitation this type of vehicle taking into consideration more criteria, for example the ease of manufacturer. It could be difficult to make an original vehicle from the zero stage.

Table 2. The main technical characteristics

Criteria	CS	OD	LW	TM	EE	HM	HR	TB	Points of the criterion	Level (classification)	Weight factor [γi]
CS	0.5	0.5	0.5	0	0	1	0	0	2.5	6	0.61
OD	0.5	0.5	1	0	0	0	0	0	2	7	0.47
LW	0.5	0	0.5	0	0	0	0	0	1	8	0.14
TM	1	1	1	0.5	0	1	1	1	6.5	2	3.70
EE	1	1	1	1	0.5	1	1	1	7.5	1	5.37
HM	1	1	1	0	0	0.5	0.5	0.5	4.5	4	1.64
HR	1	1	1	0	0	0.5	0.5	0	4	5	1.40
TB	1	1	1	0	0	0.5	1	0.5	5	3	2.07

Table 3. The consequences matrix

The type of vehicle		**DAC 2.65 FAEG**		**BCV 320**	
Criteria	**Weight factor** $[\gamma_{ij}]$	**Importance grade** $[N_i]$	$N_i x \gamma_i$	**Importance grade** $[N_i]$	$N_i x \gamma_i$
CS	0.61	9	5.49	8	4.88
OD	0.47	10	4.70	7	3.29
LW	0.14	9	1.26	8	1.12
TM	3.70	8	29.60	7	25.90
EE	5.37	9	48.33	7	37.59
HM	1.64	9	14.76	8	13.12
HR	1.40	6	8.40	9	12.60
TB	2.07	7	14.49	9	18.63
The final classification			**127.03**		**117.13**
The place			**1**		**2**

Fig. 4 DAC 2.65 used as an UAV Forward Reconnaissance Mobile Cell (temporary launching platform)

Fig. 5 DAC 2.65 used as a combat mobile cell carrying a mini antiterrorist team (demonstrative exercise)

Only one DAC 2.65 vehicle is still functioning and it has been tested during some demonstrative exercises by the researchers of the "Henri Coandă" Air Force Academy from Brașov in two conformations: as an UAV Forward Reconnaissance Mobile Cell (Figure 4) and as a combat mobile cell carrying a mini antiterrorist team (Figure 5).

The BCV 320 structure is a classical one and it can be manufactured very easy comparative with the DAC 2.65 FAEG.

Thus, the analysis can become more complex and it can be the main subject of some next investigations…

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PSYCHOLOGICAL TRAINING AND COUNSELING FOR THE INCREASE OF PERSONNEL WELL-BEING AND FLIGHT SAFETY

Laura Raluca ŞTEFAN
Academy of Economical Studies, Bucharest, Romania
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Abstract: *Mental health and well-being of the flight personnel is very important to flight security. Statistics shows that in Europe 1 of 3 people suffer from mental problems. In 2020 depression will be the most frequent disease according to World Health Organization. Measures should be implemented to reduce the risk of human error affecting flight safety. Therefore I propose to establish a compulsory psychological examination for flight personnel. This examination should take place at the beginning of the contract, then periodically, once a year as a minimum, preferably every six months. Preventive measures can also be put in place. Training and counseling can be offered to flight personnel to enable them to use stress reduction techniques and improving emotional balance. Qualified psychologists should be available to give professional advice and spot signs of mental illness. The benefits will go beyond the psychological level, down to physical health, since the two are closely connected.*

Keywords: *flight, safety, psychological, training, health, stress, well-being,*

1. INTRODUCTION

Flight security is a very important matter. This issue is directly linked to human personality and the potential for human errors. Therefore I suggest that a compulsory psychological examination for flight personnel is really necessary, especially since statistics show a significant percentage of the general population is affected by mental problems.

At the moment, personnel selection in the aviatic industry only considers visible psychopathological signs, the already manifested mental disease.

The psychological examination can show latent psychological problems, psychopathological potential or atypical personalities, and not just manifested psychological problems.

This psychological examination should be completed by qualified psychologists. Such a measure would improve flight personnel's health and well-being.

2. STATISTICS AND DEFINITIONS

Optimizing working conditions is an important issue for individuals and professional groups and also a public concern, prompted by both humanitarian and economic considerations. Work health and safety is one of the main objectives of the EU social policy, according to consolidated versions of its Treats [17]. An essential element of work performance is a safe and healthy working environment, closely related with diminishing stress and decreasing work accidents.

Work-related stress, depression and anxiety is defined as "a harmful reaction people have to undue pressures and demands placed on them at work", according to HEALTH AND SAFETY EXECUTIVE, (HSE) U.K. [14]

Hans Selye defined stress as a "non-specific response of the body to any demand of change", according to the website [4] and more modern definition shows a link between the environmental demands and our response, as I have showed in the previous paragraph. "There is a difference between pressure and stress. Pressure can be positive and a motivating factor, and is often essential in a job.

It can help us achieve our goals and perform better. Stress occurs when this pressure becomes excessive. Stress is a natural reaction to too much pressure." [14] Stress is a normal response, is not himself an illness or a disease, but if the everyday stress reaction occurs too often, too severely, or if it becomes long-term, then a range of other physical or psychological illness can be produced.

The socio-economic impact of the stress work is huge, according to the website [1, 11,]

- 300 billion of dollars from productivity and work disabilities,
- increasing with 50% of the health system's costs,
- 80% from the personnel declare that they are confronted with work stress in U.S.

LABOR FORCE SURVEY (L.F.S., from U.K.) [12] show that in 2014:

- The total number of cases of work-related stress, depression or anxiety in 2013/2014 was 487 000 (39%) out of a total of 1 241 000 cases for all work-related illnesses.
- The number of new cases of work-related stress, depression or anxiety in 2013/14 was 244 000.
- The total number of working days lost due to stress, depression or anxiety was 11.3 million in 2013/14, an average of 23 days per case of stress, depression or anxiety.

In E.U. the occupational stress is the second between health risk factors.

The most stressful jobs in 2015 according to an American study made by the organization CAREER CAST [7] are:

- firefighter
- enlisted military personnel
- military general
- airline pilot
- police officer

According WORLD HEALTH ORGANIZATION (WHO)' document [21], in 2005 in the world 27% suffered from a mental disease in a year and the most frequent was depression and anxiety.

Deaths by suicide numbers are higher than car accidents, crime or HIV / AIDS deaths added together. 1 million deaths every year are linked to depression. [20] In 2008, at the conference "Together for Mental Health and Well-being", Belgium, Brussels [8], it was shown that 11% of people are suffering from mental disease, with an increasing number of depressions. Depression accounts for 13% for the total burden of diseases. A study estimated that the cumulative global impact of mental disease in terms of economic lost output will be almost US$ 16.3 million between 2011-2030. [18] Suicide is the second cause of death among young people worldwide. [19] At its worst, depression can lead to suicide. From a study we find out that in U.E. suicide represents a significant cause of death merely through men: from 55.000 persons who commits suicides, three quarters are men. [16] The number of people suffering from depression is currently double compared to 40 years ago. Statistics show that in Europe 1 of 3 people suffer from mental problems, among which depression, anxiety and insomnia were the most frequent. [6] By now 350 million people are depressed and in 2020 depression will be the most frequent disease according to WHO. Just one in three depressed persons received the necessary treatment. [2]

There is a powerful link between stress and mental disease or physical or psychological conditions.

If a psychological problem is underestimated or neglected it can became chronic, it can exacerbate or lead to serious illness.

WHO' studies show that in Romania there is an increase of 25% in mental disease patients over the last few years. In Romania the incidence of depression is 9% to 10%. This statistic places Romania in third place among European countries. [5, 15]

3. RESULTS

In view of the above statistics, it is necessary to take a responsible attitude towards testing and selecting flight personnel, so that adequate measures can be taken to limit human error and risks affecting flight safety.

It is time to give proper consideration to mental conditions and stress as risk factors in physical or psychological illness. The benefits will be shown both on a psychological and physical health level because these areas are interdependent. Emotional problems can lead to psychological disease or to physical illness, as shown by both medical and psychological studies. [3, 5]

Therefore I propose to establish a compulsory psychological examination for flight personnel. It is important for flight personnel to consult a psychologist - a specialist who can deploy scientific methods to identify early signs of mental illness and psychopathological potential.

At present, medical specialists have the task of noticing if their patients have psychological problems and will refer patients to a psychiatric clinic if necessary. There are some problems with this approach. [9]

First, the doctor is focused on the patients' physical sign of illness and pays no attention or too little attention of other problems.

Second, the doctor has very little or no psychological training and may be not qualified to spot all psychological conditions.

Third, the doctor does not deploy any psychological tests and has no other scientific methods to elicit possible psychological problems.

Fourth and the most significantly, some psychological conditions are unlikely to show any visible signs at a routine medical control.

At present, only visible psychopathological signs or expressed mental disorders are considered i.e. the ones that are already manifested.

The psychological examination can show latent psychological problems, dysfunctional tendencies, atypical personalities, psychopathological potential, socio-pathological signs, anxiety, not just manifested psychological problems.

Some psychological problems are difficult to identify, that is why the psychologist must have an up to date collection of tests, scientific methods and training.

Even if the patient wants and makes efforts to hide some personal psychopathological tendencies, a well trained and experienced psychologist will be able to identify the problems and will lead the patient to a psychiatric examination if necessary.

The logical steps are: first, a psychological examination and second, if the mental problems are more serious, the psychiatric / neurological examination.

The psychological examination should take place at the beginning of the contract, then periodically, once a year as a minimum, preferably every six months because a psychological problem can occur any time.

It is the patients' and employer organization' benefits to have the psychological examination because that can improve physical and psychological personnel health and well-being and can diminish the working problems, sick leaves days, teams' conflicts, accidents at work etc.

This is especially true for flight personnel as they are responsible for the health and safety of many others.

As I have highlighted before, occupational stress is one of the most important health risk factors. Work-related stress or occupational stress is the response people may have when presented with work demands and pressures that are not matched to their expectation, knowledge and abilities and which challenge their resilience. Stress can occur in a wide range of work circumstances but is often made worse when employees feel they have little support from supervisors and co-workers, as well as little control over work processes.

Occupational or other type of stress can be expressed through various signs [3, 6].

Body signs of stress: headaches, nausea, fatigue, aches, pains etc.

Mind sign of stress: worries, anxiety, depression, panic attacks, negatives thinking…

Behavior sign of stress: agitation, forgetfulness, tics, restlessness, changes in usual behavior, lack of attention etc.

Stress can lead to various physical illnesses: psoriasis or other skin problems, asthma, HTN, cord problems, tachycardia, stomach pains, digestion problems, muscular contractures, hair problems, sexual problems etc.

Every single health problem can increase stress levels and can lead to a more complicated situation for the patient.

Working as an airline pilot was considered one of the most stressful jobs in 2015 in one American study, therefore training and counseling can be offered to flight personnel to enable them to use stress reduction techniques to improve their emotional balance. Qualified psychologists should be available to give counseling and professional advice and spot signs of mental illness.

The first steps in counseling are finding out one's stress level, determining the specific stress factors and attitude to stress. Based on these, the level of stress vulnerability can be established. Specialized questionnaires can be deployed for this purpose.

A set of tools can be offered to diminish stress, according to the circumstances and personality of each individual. These tools can empower people to take action in order to diminish stress levels in the long term, improving resilience and the capacity to cope. Specific muscular and mental relaxation exercises, breathing exercises, thinking techniques can be used in order to diminish stress, to empower a positive way to approach the problems, to find inner resources, to raise assertiveness etc.

Follow-up sessions are used to discuss how the agreed stress-reduction tools are applied by each individual. The psychologist can offer further feed-back and guidance.

The exercises for occupational stress reduction can be done either individually or in groups.

Training and counseling provided by specialized psychologist will contribute at an increase in mental and physical health for flight personnel and also to increase health and safety at work, in accordance to WORLD HEALTH ORGANIZATION definition [13].

A healthy work environment is one where the requirements for employees are appropriate in relation to their competencies and personal resources, to the amount of control they have over their work, and to the support they receive from manager and colleagues. To improve working condition is an important European objective. [23]

With psychological support, flight personnel can reduce the work place stress and increase individual resilience and can accomplish a better health. According to World Health Organization, health is not merely the absence of disease or infirmity but a positive state of complete physical, mental and social well-being [22]. Well-being is defined as a good or satisfactory condition of existence, a state characterized by health, happiness and prosperity, welfare. [10] In Merriam-Webster dictionary well-being is defined as the state of being happy, healthy or prosperous.

Stress-reduction counseling helps people realize their potential, cope with every day stresses of life, and increase work efficiency.

Psychologists are able not only to offer psychotherapy and counseling for psychological conditions, but also to enrich patient/client's personal abilities and contribute to the patient's personal development.

CONCLUSION

In this article I have emphasized the synergy between many different factors which can contribute to both psychological and physical health for the flight personnel and ways to improve well-being.

My objective for this study is to raise awareness about the existing Romanian and world mental statistics and forward-looking statements on this subject. This study also analyses the factors which affect flight safety for both flight personnel and passengers and advance interventional modalities in order to prevent and limit existing human flight risks.

Flight security can be improved through measures proposed in this paper, like session trainings provided by specialized psychologists on the subject of stress management which can include relaxation exercises, increase of assertiveness and resilience.

I sustain that through the proposed measures: introduction of a compulsory psychological exam and stress management sessions training provided by specialized psychologists will accomplish two targets: the increase of flight safety and flight personnel' mental and physical health state improvement. I am confident that through the measures I propose in this paper the rising flight safety target will be attained based on the specified statistics and specialized studies. For these presumptions to be confirmed it is necessary that the advanced measures from this study to be implemented for the flight personnel. Addressing these issues would have great benefits, principally diminishing the risk of work accidents during aeronautical journeys. Mental health and well-being of the flight personnel is very important to flight security.

Work-related stress, depression and anxiety are very common in our society. Statistics shows that in Europe 1 of 3 people suffer from mental problems, including depression, anxiety and insomnia as the most frequents. 350 million people are depressed according to current statistics [21]. By 2020, depression will be the most frequent disease according to WORLD HEALTH ORGANIZATION.

Measures should be implemented to reduce the risk of human error affecting flight safety. Therefore I propose to establish a compulsory psychological examination for flight personnel in order to identify the vulnerable persons and offer them counseling and tools that will enable them to cope with everyday work pressures. The examination should take place at the beginning of their contract, then periodically, once a year as a minimum, preferable every six month if possible.

At the moment, personnel selection in the flight industry only considers visible psychopathological signs, the already manifested mental disease in the possible, non-compulsory psychiatric examination established by the doctor during generally medical examination. Psychological examination will go deeper, by showing latent psychological problems, atypical personalities, mental illness tendencies, psychopathological potential, not just manifested psychological problems.

The latent psychological tendencies can lead any time at manifest mental disease, so it is very important to increase awareness about this aspect.

Working as an airline pilot was considered one of the most stressful jobs by an American study conducted in 2015.

Therefore training and counseling can be offered to flight personnel to teach them how to use stress reduction techniques and improving their health and well-being. Qualified psychologists should be available to give counseling and professional personalized advice in order to increase stress resilience and individuals' capacity to cope with work and life pressures and accomplish a good physical and psychological health.

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CAPTURING HAZARDS AND ERADICATING HUMAN ERRORS IN AIRCRAFT MAINTENANCE

Florin NECULA, **Sorin Eugen ZAHARIA**
Polytechnic University of Bucharest, Romania
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Abstract: *This research paper focuses on specific issues of the aircraft maintenance environment and pleads for a systematic approach in managing human errors. With a continuously growing number of airplanes in service, the maintenance operations are becoming more complex both from increased complexity of the aircraft technology and from the operational perspective. Recent studies show that 80% of the aircraft accidents have as a main cause human error. Maintenance errors play a very important role in this percentage and this is why is significant for the industry to find solutions which can reduce their frequency. It is estimated by certain studies that for every flight hour there are attributed approximately 12 man-hours of maintenance [1]. The paper considers the importance of the maintenance in safe operation of the aircraft and highlights the related maintenance aspects starting with aircraft design phase and continuing with normal maintenance operations. A vital role in avoiding maintenance errors is a proactive approach consisting in identifying hazards in maintenance environment, investigating the issues and proposing solutions to avoid such issues to escalate in undesired outcomes as incidents or accidents. Finally, some mitigation strategies for specific risks in aviation maintenance environment are presented to eliminate and, were not possible, to diminish the human errors.*
Keywords: *aviation maintenance, errors, human factors.*

1. INTRODUCTION

Most of the modern aircraft nowadays have a lot of automation. They are able to fly and even land by themselves. However, the human being role cannot be neglected as it is very critical in most of the phases of an aircraft lifecycle e.g. designs, manufacturing, operation, maintenance and modification. To totally eliminate the human error is impossible as it is impossible to entirely eliminate the failures in a mechanical system, or in other words, to design and manufacture a system with 100% reliability. There is also a proverb which refers to this stating that "To Err Is Human" which makes us to understand that the human error issue was considered long time ago when people realized that despite whatever they do, to eliminate human error is impossible.

In 2003 an International Air Transport Association (IATA) Safety Report found that 26% of the accidents have a maintenance cause event which started the accident chain [2]. According to Boeing (2007), the overall percentage of the human error (including engineers, pilots, air traffic controllers, etc.) causing accidents is approximately 80% [3].

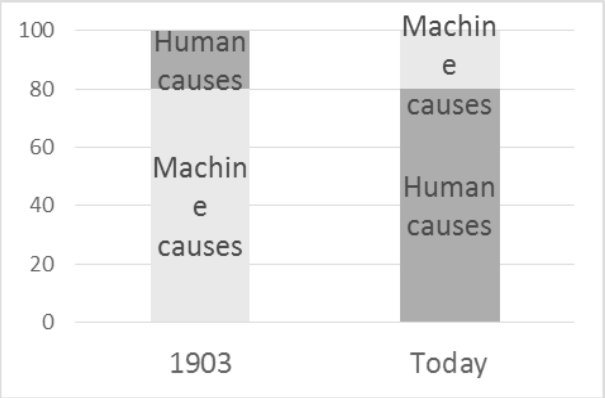

Fig. 1 Causes of accidents (source: adapted from Boeing, 2007)

Human errors are estimated to contribute to over 70% of the accidents in various industries, including nuclear power plant, chemical industry and transportation [4]. In some cases human error can have catastrophic consequences, especially if we consider what can go wrong with a nuclear power plant. In aircraft maintenance, the consequences can also be catastrophic if we consider what can go wrong after improper maintenance on some safety critical systems such as power plant, flight controls, engine controls, emergency backup systems, etc.

The majority of the human activities depend on the task itself, working conditions, and the person himself. With other words, the human activities depend on the context comprising of man, technology and organization (MTO) triad [5].

With a more and more increased safety level demand from both commercial aviation industry and passengers, maintainers have to eliminate as much as possible human errors in aircraft maintenance.

2. THE HUMAN FACTORS ISSUES IN AIRCRAFT MAINTENANCE

History of Human Factors concept in aviation can be traced back in 1970s where it was found under the designation of Cockpit Resource Management and primarily used in pilot training.

The main scope was to train flight crews in order to reduce the pilot errors by making better use of the resources in the flight deck. The name was changed from Cockpit to Crew Resource Management (CRM) to emphasise the focus on cockpit group dynamics [6]. Some airline programs dealt with specific topics such as team building, briefing strategies, situational awareness and stress management [7]. Starting with 1990s, CRM training began to reflect some other factors, such as organizational culture within the aviation system in which the crew must perform their duties.

From aircraft maintenance point of view, the concept was introduced later in 1990s following a series of accidents with serious safety consequences. Among them, American Airlines Flight 191 (1979), Aloha Airlines Flight 243 (1988), United Flight 232 (1989) and British Airways Flight 5390 (1990). All of them have maintenance human errors as a main cause or at least as an important contributory cause to the accident.

From regulations point of view, at international level, ICAO amended Annexes 1 and 6 referring to Personnel Licensing respectively Operation of Aircraft to include human factors considerations in the regulation of aircraft maintenance.

It can be affirmed that human factors issues are related not only to the maintenance stage of an aircraft lifecycle but also to design and manufacture. In Europe, there are specific designing and certification requirements for aircraft used in commercial air transport enforced by European Aviation Safety Agency (EASA) which take into consideration the human factors issues. As for example, AMC 25.783 referring to latching and locking fuselage doors states the following: "*The operating handle loads on manually operated doors should be based on a rational human factors evaluation*." [8]. EASA CS 25.1309 concerning equipment, systems and installations states the following: "*Systems and controls, including indications and annunciations must be designed to minimize crew errors, which could create additional hazards*." [9]. During the design phase human errors must be considered for the maintenance process in order to either make the errors impossible to occur or to reduce their consequences or probabilities of occurrence. Three basic strategies can be considered to prevent errors through design: exclusion, prevention and fail-safe design. Exclusion refers to designing components and systems in such a way that it will be impossible for the maintainer to commit an error (e.g. different size elevator cables fittings). Prevention refers to designing components in such a way that it will be difficult for the maintainer to commit an error, but not impossible (e.g. installation of a check valve which has a drawn orientation arrow on it). Fail-safe design is a concept used in designing aircraft structures and is defined as a structure which can retain a required residual strength for a period of unrepaired use after failure or partial failure of a principal structural element [10]. Related to maintenance error, fail-safe means to design a component in a way that the consequences of an error will be reduced (e.g. a structural element which failed in time due to a missed crack during a maintenance inspection. The remaining structures will be able to carry out the loads for safe operation).

When moving to the maintenance environment, the human error issues are seen from a different perspective compared to design.

The highly complex maintenance environment makes very difficult to find a strategy which will be able to solve the human error problems.

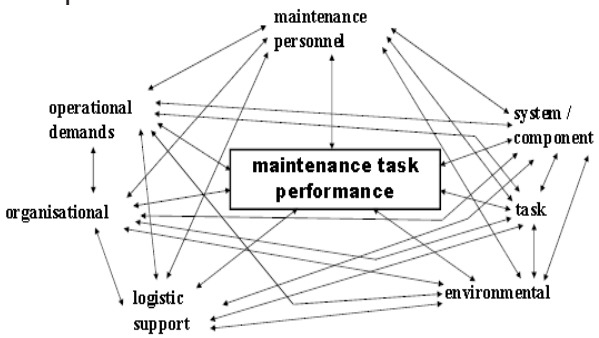

Fig. 2 Factors affecting maintenance task performance (source: Airbus)

Research studies showed which the most error-prone maintenance activities are. Confidential Human Factors Incident Reporting Programme (CHIRP) (2003) mentioned 63% of errors occurred during installation, 12% during servicing and 7% during fault isolation. Airbus (2007) mentioned 72% of the errors occurred during installation and 9% during servicing [11]. UK CAA (2009) concluded in a study analysing 3982 Mandatory Occurrence Reports that 43,7% were incorrect maintenance and 17% were incomplete maintenance [12]. From the above data can be concluded that maintenance errors follow somehow a constant pattern over time and this can be used to make a step forward in dealing with maintenance errors and this will be to make predictions. The lack of such statistical data makes it very difficult at the moment but with the implementation of Safety Management Systems, is mandatory for maintenance organizations to collect data.

The unique maintenance environment makes aircraft technicians to confront with a set of specific human factors issues. The environment is more hazardous than in most of the usual jobs. It involves working at heights or in very tight spaces (e.g. fuel tanks), performing activities in inclement weather conditions (e.g. negative or very high temperatures, wind and rain), working with dangerous materials and tools, working in teams or alone, following procedures and taking decisions, facing time pressure and confronting with unique type of stress.

Compared to pilots and air traffic controllers activities, in which an error will have an immediate impact, maintenance technicians and engineers will know that their responsibility is not finished with the end of the shift and their activity could have an impact minutes, days, months or even years later.

This type of stress is encountered by maintenance personnel. A conclusive example in this direction is the crash of Japan Airlines Flight 123, in August 1985 [13], due to an improper structural repair which happened seven years earlier when the aircraft suffered some structural damage due to a tail strike.

Following the accident, the maintenance manager killed himself.

3. CAPTURING HAZARDS IN AIRCRAFT MAINETANCE ENVIRONMENT

"A hazard is a condition or object with the potential to cause death, injuries to personnel, damage to equipment or structures, loss of material or reduction of ability to perform prescribed function" [14].

Aircraft maintenance environment is highly complex and is almost impossible to think about all the conceivable situations which can appear.

However, maintenance organizations must continuously seek for new hazards in their activities.

When looking for capturing hazards in aircraft maintenance, four main areas can be considered: the individual, the maintenance task, the environment and the organization.

The following aspects can be taken into account for identifying hazards:

- At individual level: fatigue, medical condition (hearing, sight etc.), theoretical knowledge, practical skills, working shift patterns (dayshift/ nightshift), communication skills, attitude towards safety, morale, initial and recurrent training, workload and stress;
- At maintenance task level: complexity of the task, access, working position, repetitive or novel task, availability of the maintenance data, unambiguous maintenance data, availability of specific tools and equipment;

- At environment level: extreme weather conditions, high noise level, insufficient lightning, insufficient environment protection, workplace layout and cleanliness, provision and use of safety equipment, toxic materials, time pressure;
- At organizational level: lack of resources, lack of spare parts and materials, inappropriate equipment, supervision, duplicate inspections, procedures (unclear or not present), reward system, selection of staff and competence assessment, training programs, planning of scheduled maintenance tasks, planning of critical tasks, promoting safety culture;

To identify hazards, the organization has two categories of methods available: reactive and proactive. Reactive hazards identification refers to learning from occurrences that have already happened. Examples are incidents and accidents investigations which can be external (carried out by competent investigation bodies) or internal (carried out by company's safety department). Proactive hazards identification methods are safety surveys, safety audits, safety reporting, brainstorming and safety assessment (e.g. Failure Modes Effects and Critical Analysis (FMECA), Event Tree Analysis (ETA)). A very important role in identifying hazards in a maintenance organization is played by the safety culture of that particular organization, in other words it depends by people, how much importance they confer to safety or how much they believe in it. A safety culture consists of:

- Just culture (everybody is responsible for safety within the organization and people are held accountable for the system);
- Reporting culture (people report, without fear of punitive actions against them, everything they consider as being a safety issue);
- Learning culture (employees in the organization are open to learn and management will be aware that people can improve the system);
- Informed culture (people are knowledgeable about the system and stay connected with it to be updated with changes);
- Flexible culture (people accept changes within the organization and adapt to the system).

All of the above elements of safety culture will impact the process of capturing hazards and therefore the safety performance of the organization. A complex hazard identification program at a maintenance organization level will use a combination of reactive, proactive and predictive methods to improve their safety performance.

4. ERADICATING HUMAN ERRORS IN AIRCRAFT MAINTENANCE. IS THAT AN ACHIEVABLE OBJECTIVE

Eradicating human errors in aircraft maintenance is the most desirable goal in the context of aircraft maintenance, but in reality is simply not possible to consider all the conceivable situations an organization or individual will face during maintenance activities.

Some classical methods, like telling people to pay more attention, or to retrain them, appeared to have very limited effects. Therefore, a more realistic approach will be to manage the errors in a systematic way.

The following approaches can be used as maintenance error management strategies: prevention, reduction, detection and recovery.

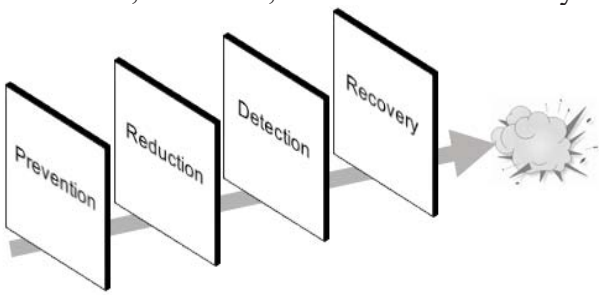

Fig. 3 Maintenance errors management strategies

Prevention as a maintenance error strategy is the most desirable approach, but in the context of real life is not all the time an option.

It aims to fully avoid the error and requires most of the times a design solution.

Avoiding maintenance errors through design can be achieved using technology (e.g. Health and Usage Monitoring Systems (HUMS), Interactive Electronic Technical Manuals (IETMS), software logics and on-board diagnostics).

Error reduction refers to minimizing as much as possible the probability of an error to happen and the consequences of that error. Detection is a strategy which enables the error to be easily discovered by the person who committed it, by another person or by the system. Recovery refers to the capability to return the system to its safe condition easily, as soon as possible after the error was committed.

But to be able to eliminate or to manage an error is important to understand the root cause of that particular error. Understanding the root cause of a maintenance error will enable the organization to take the proper decision concerning remedial actions. Root cause analysis can be used not only post incident or accident event, but also following a safety report, a quality finding or whenever a safety concern is perceived. There are several tools which can be used to perform root cause analysis as for example Events and Causal Factors Charting method, Ishikawa Fishbone Diagram, Management Oversight and Risk Tree Analysis (MORT), Five-Why method and Fault Tree Analysis method (FTA) [15]. The purpose of identifying all the possible causes which led to an error is to find the fact which, if eliminated, would have stopped the event from happening and to find the most cost effective solution to the problem.

The error management will leave two possibilities for the maintenance organization: error reduction and error containment. Error reduction comprises of the measures that a maintenance organization can take to limit the occurrence of errors while error containment comprises measures to limit the consequences of that errors that still occur. Typical constituents of an error management program include measures to:

- discover, assess and eliminate error-producing factors within the organization;
- minimize the error liability of the individual;
- reduce vulnerabilities of specific tasks;
- identify the organizational factors that contribute to error-producing factors at individual, team, task and workplace level;
- enhance error detection;
- make latent conditions more visible and
- increase error tolerance of the system.

Some of the most efficient tools in aviation, proven by the history, available to improve safety performance are technology, training and regulations. Besides that, the maintenance organizations can include quality monitoring, safety audits, inspections, feedback from accident investigation and feedback from reporting system including confidential reporting.

CONCLUSIONS

Human errors can be managed starting with design phase. Prevention is probably the first choice as it will eliminate the error but in reality this is not possible all the time due to compromises in design requirements (i.e. costs, capabilities, safety and aircraft performance).

Modern technologies can aid reduction in maintenance error accidents.

Maintenance organizations have to continuously look for hazards considering at least the following areas: the individual, the maintenance task, the environment and the organization. A functional hazard identification process is reliant on a mature safety culture.

An error can be corrected or its re-occurrence avoided only when the entire background behind that particular error is understood.

Real solutions for improving human performance and avoiding maintenance errors sit with both the maintenance organization and the individual and consist of improving the maintenance environment (e.g. working conditions, procedures and knowledge).

Human errors cannot be fully eradicated but for sure they can be reduced both in frequency and consequences and this can be achieved through the error management approach.

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THE IMAGE'S STATUS DURING THE RENAISSANCE – A GATEWAY TO TRUTH AND SELF-KNOWLEDGE

Ioana-Antonia PEARSICĂ
University of Bucharest, Bucharest, Romania
DOI: 10.19062/1842-9238.2015.13.3.28

Abstract: *The influence of Platonic philosophy during the Renaissance is undoubtedly vigorous. However, during Quattrocento and Cinquecento, Plato's negative view about image is no longer shared by the scholars of that time. It seems that during the Renaissance the honor with which the* logos *are invested by Plato begins to be attributed to the image, too. Thus, the image becomes an indispensable tool in the process of knowledge and in the philosopher's search of truth. There are some main reasons which underlie this change of perspective and which deserve to be called into question.*
Keywords: *image, Renaissance,* logos*, Plato, knowledge*

1. INTRODUCTION

An obvious statement, almost a cliché: Platonic philosophy underpins the conceptual construction of the West.

However, this is a statement from which anyone who wants to know and understand the tortuous threads of the Renaissance way of thinking or of the other major time periods in the history of Europe is bound to return.

During the Renaissance in particular, the updating of Neoplatonism, the translation and the interpretation of Platonic dialogues, and the general orientation of the educated people towards the Greco-Roman philosophy and morals certainly justify the attempt of building a parallel between the Renaissance and the Platonic views.

Assuming that language, either verbally or visually, reflects the profound beliefs of those who use it, I want to focus my attention on the relation between *image* and *word* as Plato presented it in his written dialogues, and then to investigate the changes this perspective had suffered during the Renaissance.

Thus, I will try to enrich and also to clarify the definition of this relation as it appears in the Renaissance.

Undoubtedly, there are differences between the way the rapport *εἰκών*/*λόγος* is understood by the Renaissance Neoplatonists and the way it is formulated by Plato.

My hypothesis is that during the Renaissance, ***the images cease to be mere copies of sensitive world – they become channels of communication with the divine, with the intelligible world, just as* logos *is the bridge between the sensible world and the Ideas in Plato's view.***

A notorious figure serves me as a landmark in the world of Renaissance: one of the most dedicated philosophers in the search of ancient thought vestiges, namely Marsilio Ficino[1].

I will begin my study by presenting the role of the *logos* in Plato's philosophy, and then I will discuss about the status Plato confers to painting and image in general.

I will return to later XIV-XVI centuries AD, focusing my attention on the signs' reception and on the magic valences of meaning contained in that specific manner of reception[2].

1 Thomas Noble, Barry Strauss, Duane O'Shea, Kristen Neuschel, Elinor Accampo, "The Renaissance" in *Western Civilization. Beyond Boundaries*, Boston, Wadsworth Publishing, 2010, p. 328 (Ficino is the first author of the Platonic dialogues that were translated into Latin, being thus a great contributor to the reopening of the Platonic Academy).

2 I will base my clames on Michael Foucault's theory from *Words and Things* (Foucault, *Les mots et les choses*, Paris, Éditions Gallimard, 1966, pp. 57-77).

As Ernst Gombrich[3] had pointed out, Botticelli's *Primavera* is, as it will be revealed at the end of this study, a case in which it is highlighted the similarity between the main function of *logos* (in Platonic philosophy) and the image's main function during the Renaissance period.

2. THE *LOGOS* IN PLATO'S VIEW

"For Paganism, no tree carried a forbidden fruit."[4] The Pantheon, which is inhabited by capricious gods and heroes, seems less distant to people than the Heaven Adam has been chased away from. For many ancient Greek (Pythagorean, Socratic, Peripatetic) schools of philosophy achieving the knowledge of good and evil and the knowledge of truth becomes the core of the philosophical research and the very meaning of life. From the exoteric teachings[5] of Plato's dialogues, a complex worldview is revealed: Plato argues that the changeable and perishable material world is categorically split by the intelligible world of ideas, of pure, eternal, unchangeable forms; and that the human soul, because of its similarity with the Ideas, it can and should transcend the material limitations of this world so that to return to the lofty spheres where it belongs (*Phaedrus*, 245c-249B). The material world is knowable through the senses, whereas the intelligible world can be achieved only through reason and recollection. Only the reason and the connections inside the process of thinking (*logos*) allow the soul to access its forgotten knowledge (*Phaedrus*, 249A-250C). Thus the searched truth, the truth that claims universality, is paradoxically the inner truth of a human being.

Truth cannot be taught, but it needed to be found inside the individual self. Hence, the knowledge of good and evil becomes possible only through self-knowledge.

What is, therefore, the role of the word in such a philosophical system? The Greek translation of the term *word* is *logos*, but *logos* also mean *speech*, *reasoning*, *explanation* or *proportion*[6]. *Logos* – as Plato defined it – is the bridge between the physical world and the intelligible plan. It does not belong to any of them; neither is it emanated by things, nor is arbitrarily chosen by people[7]; that means *logos* is only the instrument of knowledge, not containing the knowledge itself. Since the words are often used without taking into account their true meaning and significance, reality can be distorted and the untruth is designed precisely through them. Words are thus those that enable the knowledge, but they are also those that can sink the human soul into an even more pressing confusion than that caused by the senses.

The meaning of the words can be questioned through the dialectic process so that this danger to be removed. Plato argues that the dialectical method is the main method by which reason can be educated/practiced: by examining a subject (often a concept/word such as *virtue* or *beauty*) through dialog, a vague and generic declaration can be clarified and the essence of the subject can be revealed (deduction) or a sure and punctual statement can be developed until it turns into a general and valid statement (induction) (*Phaedrus*, 265d-265E). In dialectics, the word becomes the gateway to understanding – the word correctly used empowers the man to fight against oblivion, to reconstruct lost memories, to "transpose the existing relations within being into the human soul."[8]

3 Ernst H. Gombrich, "Botticelli's Mythologies: A Study in the Platonic Symbolism of His Circle", in *Journal of the Warburg and Courtauld Institutes*, Vol. 8 (1945), pp. 7-60.

4 Gebhart Mile and Victoria Charles, *Botticelli*, New York, Parkstone Press, 2010, p. 77.

5 There are many scholars who tend to believe that Platonic esoteric philosophy is inaccessible to us since Plato preferred to transmit it orally only (Glen Most, "Plato's exoteric Myths" in Collobert, Destrée & Gonzalez, *Plato and Myth. Studies on Use and Status of Platonic Myths*, Leiden and Boston, Brill Publishing House, 2012, pp. 20-21).

6 http://www.upm.ro/cercetare/CentreCercetare/DictionarCritica/Logos.pdf, accessed at: 22/12/2014.

7 In *Cratylus*, Plato clams through his personage Cratylus that there are elementary words whose origin is divine – primordial words of which all the other words are drawn – "I believe […] that a power more than human gave things their first names and that the names which are thus given are necessarily their true names." (438c).

8 Leon Robin, *Platon*, Bucharest, Teora Publishing House, 1996, p. 64.

But, as I noted above, the misuse of words estranges man from truth. Many scholars believe that Plato criticizes the rhetoric for its power to help man to deceive others and to delude him/herself with empty but nicely polished words. Actually the issue is more nuanced[9], but what appears necessary to bear in mind is that for Plato *logos* is not a "powerful master" (as Gorgias define it in the *Encomium of Helen*, 8) but *logos*' power seems to depend on how it is used.

The relationship between dialectics and rhetoric is investigated in the Platonic dialogue *Phaedrus*, the rhetoric being associated with writing (whereas the dialectics is, at least in Socrates' opinion, dependent on the word of mouth). Both the writing and the painting are subject to comparisons, and these comparisons emphasize the negative similarities between them, namely that neither the written speech, nor the painting can clarify perplexities that are awaken by themselves in the reader/viewer mind; the written speech and the painting offer themselves to anyone – to those who are ready to receive their information, but also to those unprepared to receive it – to all in the same form; and since they have been wronged, they are unable to defend themselves, requiring that their father – the creator of the text or of the image – to come to their aid (275d-275e). Speech writing and painting are thus disregarded, being understood as inanimate copies of the sensible world, the sensible world itself being just a reflection of the divine. Plato calls the writing *φαρμάκων* through the character of Socrates (*Phaedrus*, 275a). Jacques Derrida points out the bivalent meaning of the term, as *cure*, but also as *poison*[10]. The writing claims to be helpful for the memory but, in fact, it harms the memory, because it ceases to be practiced; a man could memorize a text without understanding its meaning. Extrapolating, the image is as misleading as the writing is.

Fascinated by the image, the viewer believes he is in the presence of the represented object, when in fact he sees only a representation, a second-hand reality – the painted image.

Thus, the painting is considered an "*eloquent* art", through which the painter can obtain the enjoyment, the excitement and eventually the persuasion of the viewer[11].

Therefore, in Plato's view, the close rapport between word and image, between speech and painting is not favorable to the image/painting.

However, unlike the word (which can be ennobled by dialectics), painting remains an occupation, in any case, of low quality. In the next pages of this study we will see that, during the Renaissance, the perspective described above has changed.

3. THE IMAGE'S STATUS DURING THE RENAISSANCE

During Trecento, a moral structure of the state is accepted for the first time, independent of religious or philosophical traditions[12], which gives freedom to sight to see beyond the limitations of these traditions and it also leads to the construction of an anthropocentric system – humanism – in which the man enthrone himself in the center of the world, where "the miracles of the spirit are [considered to be] greater than those of the sky."[13]

In this historical period, it is evident the attempting to update (to copy and to combine) classical elements with early Christian items because these traditions are considered as giving the formula of a superior society to the medieval one – the traditional values are rediscovered, and based on these tradition, man has the possibility for further assessment and interpretation of the Christian conceptions[14].

9 In my Bachelor's Thesis, I had demonstrated that rhetoric in the process of knowledge, in Plato's view, is as important as dialectics is (*Rhetoric in Plato's View – a Tool of Knowledge of the Truth*, 2014).

10 Jacques Derrida, "Plato's Pharmacy", in *Dissemination*, London, The Athlone Press 1981, p 70.

11 Victor Jerome Stoichiță, „Critica de artă la Veneția și dilemele picturalității", in *Creatorul și umbra lui*, Bucharest, Humanitas, 2007, p. 84.

12 Jacob Burckhardt *apud* Thomas F. X. Noble *et alii*, *op. cit*., p. 321.

13 Jean Seznek, "The Phisical Tradition", in *The Survival of the Pagan Gods*, New York, Harper & Brothers, 1953, p. 60.

14 Thomas F. X. Noble *et alii*, *op. cit*., p. 322.

In addition to these two dimensions – the Christian theological view and the Neoplatonic philosophy – there is a third *magical* dimension of the existence that encompassed and altered the other two.

A good example of how these three dimensions (the philosophical, the theological, and the magical one) overlap is given by the Paracelsian theories. For Paracelsus the signs had appeared as a result of the original sin (as a form of coercion, but also as a form of help offered by God to man in order to enable him to regain the understanding he held in Heaven)[15]. Man, although conditioned by the heavenly forces, can "submit" these forces provided that he understands the signs by which it was conditioned in the first place. Thus man regains his right to maintain "his inner sky" "autonomous"[16]. Therefore, knowledge frees the human being, just as for Plato truth frees the soul from the vagaries of body. Knowledge becomes possible through signs, and through their interpretation[17]. To interpret is a faculty of reason, but reason cannot overcome by itself the plausibility in order to accede to the truth. The signs – videlicet the images of the things – are the ones who offer the proper information to the reason, helping the reason to discover in them what is real (and not just what seems to be so). The signs are animated by the *signatures* – a sign "idle and silent" comes to life because of the signatures[18]. The sign is the evidence of a resemblance, and the signature is precisely the relationship between the sign and the likeness; the signature is the element that makes possible for the sign to indicate a resemblance.

The mentality which sustains such a perspective integrates a ternary system of signifying the world, as Michel Foucault argues – a system of correlations and similarities, in which knowledge can be gained only through the observation of likeness, by deciphering the signs which make up the visible world[19].

The reception of signs involves three levels of meaning: "the mark's formal domain", the content they indicate and "the similarities that links the marks to the designated things"[20].

The mark is what can be seen – that is the image.

Behind what can be seen lay the hidden meanings and the true knowledge that the divinity has scored into things ("the primary text") and that man has the duty to discover.

Between humans and images there are interposed the interpretations which are nothing else then the human attempts to reach the primary text.

Regarding the language, it is not an arbitrary construction, but a part of the vast distribution of the signatures and similarities and therefore it should be studied as a natural thing, too.

From this perspective, the language can be considered as a sign of the things it denotes[21] *– the word and the image merge into the same category*.

In this train of thought, each nature's tiny item indicates another item, and thus the nature's matrix is branched through symmetries and reflections, so that the image becomes a gateway to understanding something else then itself; each image is a gateway to understanding the essence of the thing it represents.

Through image, the Renaissance man seeks not only to establish links between things, to know and to communicate with them or to gain their forces, but *he especially seeks to get to know himself* (by getting to know them).

In the process of knowledge, it is important to consider that man observes the similarities between things by him/herself – he or she, as a as part of the whole, is the one who ascertains, unravels and establishes the validity of these links by the sympathies and antipathies between him/herself and the things.

Man – a microcosm built alike the macrocosm – is able to know the outside world based on what he notices in him/herself and *vice versa*, observing the outside world he/she gets to know he/herself.

15 Giorgio Agamben, "Theora des signatures", in *Signatura Rerum sur la méthode*, Paris, Library philosophique J. Vrine, 2008, pp. 37-39.

16 Paracelsus *apud* Foucault, *op. cit*., p. 62.

17 Michel Foucault, *op. cit*., p. 82.

18 Jakob Böhme *apud* Agamben Giorgio, *op. cit*., p. 47.

19 Michel Foucault, „Partie I", în *op. cit*.

20 Michel Foucault, *op. cit*., p. 84.

21 *Ibidem*, p. 74.

As Protagoras asserts, man is the measure of all things (*Theaetetus*, 152a), but for Renaissance people the assertion's meaning is not the one given by Protagoras, namely that things judged by man to be true are true as long as the judgment is plausible, but that the outer world's truth is reflected in the inner world's truth of a human being.

Both in the Renaissance Neoplatonicians' view and in Plato's view, the truth comes from inside.

So the possibility of deciphering the sign's meaning exists only if the sign's meaning had been stated in the human soul as a kind of analogous information. Reality is reflected in man's *pneuma*, and so man is reflected in the outer reality.

Man is looking outside for what he carries inside him/herself, but he/she cannot understand what it is outside him/herself without understanding his or her own inner world.

The process of knowledge is circular. The images can be understood as a projection of the human's phantasmal world, projection which correspond and communicate with the external reality.

However, the communication is not linear (like from a transmitter to a receiver), but it is a circular one, in which the receiver is also a transmitter.

This perspective can be recognized in the Ficinian philosophy, too. In Marcilio Ficino's view, everything in the world is connected, maintaining a continuous exchange of information. Ficino illustrates the relationship between *body* and *soul* – the communication between them is possible thanks to the *spirit* who is an intermediary between the two.

The spirit receives through the senses the stimuli generated by the body, and then translate these stimuli into images, into *phantasms* that can be recognized by the soul[22].

For Ficino, "thinking is the main activity of the soul" – the soul moves/operates through thought[23].

Because the sight is the chief sense that helps the man to build images, and because the images are needed in the process of thinking, the sight acquires the status of the noblest of the senses[24]. The connections and similarities between things can be recognized by dint of the; the phantasms bring about realities. Even the heavenly forces can be persuaded to work in the support of the magician just with the aid of the *phantasms*, as communication with these forces cannot be done otherwise than trough them. *The task of* logos *is taken in Ficino's view by the image.*

Concerning the ability of knowing, we have to take into account that in the ideal citadel described by Plato, the teaching of *logos* (i.e. the exercise of reason) is available only to those prepared to reach it, which means that not everyone has the traits and the required capacities in order to receive the knowledge.

The position of the Renaissance philosophers towards the teaching of the image's subtleties is exactly the same.

It is considered that only the wise can acquire the deeper meanings of the images and that knowledge can be transmitted only to those worthy enough to receive it.

Some of the roots of the Renaissance system of signification come from the Arabic collection of magic and astrology, *Picatrix*. *Picatrix* is highly-cherished by the intellectuals of the time (like Paracelsus and Ficino).

One of the premise-beliefs on which this collection was drawn is that the images "were meant to stimulate the spirit, using secret signs and veiled forms which would only be understood among the wise"[25].

However, the difference that occurs between Platonic perspective about the *logos* and the Renaissance view about the *image* appears in the function Plato assigns to the *logos*: for Plato, *logos* has the power to save the soul; on the other hand, the function assigned to the image during the Renaissance is not only about the spiritual fulfillment of the man, but also about the material achievements.

22 Petru Culianu, *Eros și Magie în Renaștere. 1484*, Bucharest, Nemira Publishing Press, 1994, pp. 55-56.

23 Marsilio Ficino, „Asupra iubirii", in *Banchetul. Asupra iubirii*, Oradea, Editura de Vest, 1992, p. 120.

24 Petru Culianu, *op. cit*., p. 56.

25 Christopher Warnock, *Picatrix. Picatrix. Selected Translations Edited with Commentary*, p. 4.

As it is stated in *Picatrix,* the magic and the astrology main aim is "to improve the conditions of spiritual, physical, mental and social needs of the operator himself and of his client"[26].

During the Renaissance, *the image* is undeniable rehabilitated, not only by means of the humanistic philosophers' theories, but also through the work of painters and Maecenas. In painting, the beauty becomes a resort to the higher spheres (and this is exactly the assumption that Plato uphold about the beauty). At a social level, during the Quattrocento, "the concept of *mimesis* becomes the *modernity's* guarantee of the artistic field", claims the art critic Victor Ieronim Stoichiţă; the new breakthroughs about the pictorial and the study of proportion and perspective invest painting with the prestigious "state of *science*"[27]. The study of perspective emphasizes the possibility of a painting to manifest itself: the space is conceived as "an open window"; the image itself is beyond the frame/window[28]. Thus, the composition, the light, the colors harmonize with each other in the pictorial space and so the parts of the painting get to form something more than their sum – a whole from which the Idea transpires. Leonardo da Vinci stated that the painting "must comprise the unity, not the multiplicity"; it follows that what the artist seeks to capture is not the object (from a multitude of objects), but its essence[29]. The same vision appears differently worded by Michelangelo for whom images are more than a mere copy of the world – they are "a copy of the perfection of God and a reminder of the divine painting" [30], a direct reflection of the divine, just as the Platonic *logos* is a reflection of the divine truth of Ideas.

In his study of Botticelli's *Primavera*, E.H. Gombrich notes that the Renaissance paintings with mythological themes are probably inspired not only from ancient (Greek and Roman) texts, but also from some philosophical *programs* of contemporary humanists.

Gombrich claims that *Primavera*, painted for Lorenzo di Pierfranceso de Medici, a Ficino's student, was designed in line with Ficino's views about Venus. Several letters that Ficino had addressed to Lorenzo di Pierfrancesco have to be considered, as the scholar does, as a main source of information in the attempt to interpret this painting. These letters serve as a support for the hypothesis such as the representations of the mythological figures aim to establish a link between the viewer and the Idea contained in those figures and, therefore, the painting aim is also to facilitate the knowing of man's inner sky or, in Platonic terms, to facilitate the soul's process of remembering[31]. Memories about the Images are reawakened in the soul through painted images. The deities that govern the stars also govern the tendencies of the soul which correspond to the defining traits of those deities, "because all the heavens are within us"[32]. Therefore, the image of Venus in *Primavera* is not just an appeal addressed to the goddess Venus, but also a way to determine her to offer her gifts to the caller.

The painting invokes Venus's powers, powers which man already holds and which, by the instrumentality of the goddess' image, are awakened in him. In this context, the image makes possible the vertical communication with the heavenly forces and it represents a key to spiritual evolution, too.

The gathering of Venus, Mercury, Eros, Flora, Chloris, and Zephyr in the same composition is very meaningful.

Although the composition scenes seem separate from each other and hence the characters seem to ignore the presence of the other characters around, the overall view of the composition brings about a certain interpretation of the painting.

The characters mirror each other, allowing different aspects of the viewer's self to reflect through them in the picture.

26 Petru Culianu, *op. cit*., p. 200.

27 Victor Ieronim Stoichiță, *op. cit*., pp. 78-79.

28 *Ibidem*, pp. 115-116.

29 *Ibidem,* p. 117.

30 Michelangelo *apud* Stoichița, *op. cit*., p. 121.

31 For example, "Your Luna – the continuous motion of the soul and the body – [...] should fix her eyes on Venus herself, that is to say on Humanity (*Humanitas*)"; "If you thus despose the heavenly signs [...] you will escape all the threats of fortune" etc. (Ficino *apud* Gombrich, *op. cit*., pp. 16-17.)

32 Ficino *apud* Gombrich, *op. cit*., p. 16.

Venus alongside Flora is defined as a regenerative force, and through her association with Eros (Cupid), she appears as the goddess of love. The story, so stated in painting, leads the viewer's soul to recall about itself.

Images have an educational role: for Ficino "nothing seems more natural than to translate [the teachings] into visual reality" in order to explain to young Lorenzo astrology [33]. The fascination exerted by the images on the viewer can condition him both in a negative and in a positive way. Precisely for this reason achieving accurate visual reproductions of the deities is an issue of a prime importance – the "real essence" of the gods was believed to be revealed through the way they were portrayed[34]. Through images, useful information is "inoculated" almost instantly in the viewer's mind, so the level of effectiveness of this teaching method is highly appreciated. *Thus, both* logos *and images are necessary tools in the process of knowledge, but their effects are beneficial only if they are used properly.*

CONCLUSIONS

As Culianu stated, "Renaissance culture was a culture of the fantastic" and phantasms "are nothing else but idols begotten by the internal sense"[35], *carved shapes* into imagination, shapes which are worshiped by people. The concepts and different perspectives are covered in pictures – the image is placed above a matrix of beliefs and ideas. During the Renaissance (as during any other historical period), the visible is placed on an ideological mold and that mold – i.e. the archetype that dwells in the depths of the human being – is believed to come from the Divine, from a space beyond man's logical comprehension. Undoubtedly, the demonstration can be carried forward to the thread of alchemy's study, because alchemy is a part of the magical dimensions of the existence, so that new facets of image/word rapport to be revealed. A further research could, therefore, be fruitful.

Up to this point of the research, however, we can conclude that the relationship between image and word (*logos*) has a different meaning for the Renaissance's Neoplatonics then it had for Plato: if for Plato *logos* is the main instrument through which knowledge can be acquired by man, the image being rejected and blamed, during the Renaissance the picture is revalued and revived, assuming a certain share of the function of *logos*.

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IMPROVEMENT THE QUALITY OF INDUSTRIAL PRODUCTS BY APPLYING THE PARETO CHART

Raluca NICOLAE (MĂNESCU), Anişor NEDELCU, Adela-Eliza DUMITRAŞCU
"Transilvania" University of Brasov, Romania
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Abstract: *Into an organization it can apply various methods in order to improve the product quality for monitoring and measurement of manufacturing processes, so as to demonstrate that by keeping under control the processes it obtain an improvement in terms of quality of industrial products. In this paper, using the diagram Pareto, the defects are examined for a manufacturing process of a drill with CMS interchangeable plates. A two months data had been collected (March 2015 and April 2015). The results indicate that the share of the biggest flaws is the tool traces on the head, scratching, streaking and variation of trading in spare parts. For this purpose, it was implemented corrective actions in order to minimize the defects and to improve the manufacturing process.*
Keywords: *Pareto diagram, Pareto Analysis, defects analysis, manufacturing process, product quality improvement.*

1. INTRODUCTION

Methods and techniques to improve quality are known as "quality management tools", being used to solve process improvement steps that can solve most of the problems of quality and is used for [1]:

- coordinate and consolidate the data concerning quality;
- making decisions on the quality of batches of products (spare parts), based on the analysis of the sample taken;
- process control in order to achieve the level of quality.

In production, Pareto's observations generated the analysis of product distribution according to their presence in the list of goods. Thus, in every enterprise we have 3 groups of products offered by the specialized literature in the following percentage [2]:

Table 1. Class formation limits

Class	The technological component/ The value component
A Class	5-15% / 50-60%
B Class	20-30% / 25-40%
C Class	55-75% / 5-15%

2. CASE STUDY

The case study is based on monitoring and control of defects for the manufacturing process.

To identify the main problems which cause frequent defects of manufacturing process, a two months data had been collected (March 2015 and April 2015).

The Industrial product is made of drill, with OLC from CMS with interchangeable plates.

The actual rejection is grouped in their respective type of defects identified (Table 2 and Table 3) [10].

Table 2.Defects analysis (March 2015)

No.	Type of defects	Total number of defects	Defects percent
1	Traces of tools on the head-scratching, streaking	30	23%
2	Variation of quotas to spare	21	16%
3	Under bavurehead/ head on	18	14%
4	Cracks on the head	16	12%

5	Surface roughness after finishing process	14	11%
6	Burr on the stem or on intermediate diameters	11	8%
7	Traces of tool Rod-scratching, streaking	8	6%
8	The lack of intermediate diameters	6	5%
9	Incompletely net formed or top ogivale without net	4	3%
10	NOK looking-dirt, oil on surface	3	2%
	Total	131	

Table 3.Defects analysis (April 2015)

No.	Type of defects	Total number of defects	Defects percent
1	Traces of tools on the head-scratching, streaking	17	16%
2	Variation of quotas to spare	16	15%
3	Under burrhead/head on	16	15%
4	Cracks on the head	15	14%
5	Surface roughness after finishing process	13	12%
6	Bavure on the stem or on intermediate diameters	10	9%
7	Traces of tool Rod-scratching, streaking	8	7%
8	The lack of intermediate diameters	6	6%
9	Incompletely net formed or top ogivale without net	4	4%
10	NOK looking-dirt, oil on surface	3	3%
	Total	108	

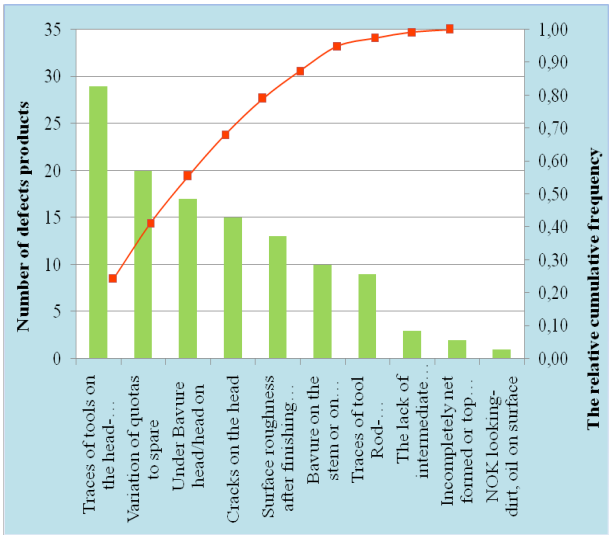

Fig. 1 Pareto chart for March 2015

Analyzing the diagram in Figure 1, it is easy to draw conclusions on the main causes of defects. It can be seen that the most significant of them have as their cause, “traces of tools on the head, scratching, streaking” and“ variation of quotas to spare”. The first category of defects has the largest share of 23%.

We observe that the most expensive or most frequent question appears to the left while the others are displayed in descending order. The segment of the line, we start from the bottom left corner and ending in the upper right corner, showing cumulative percentage.

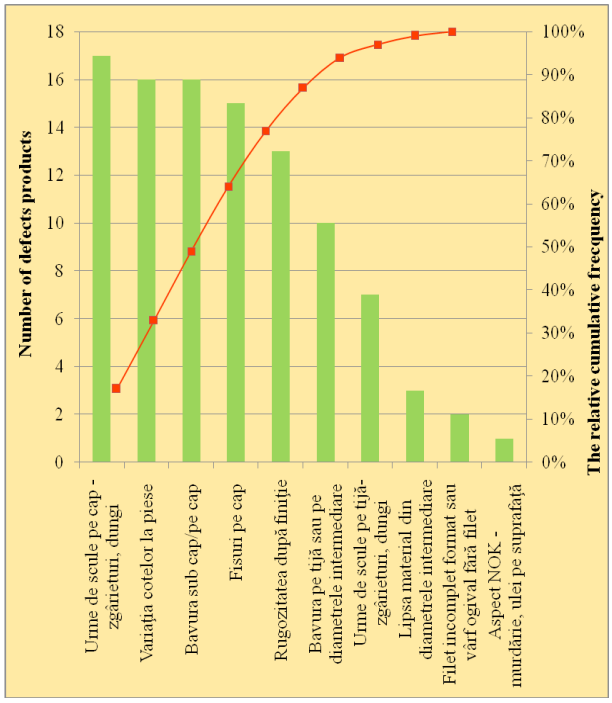

Fig. 2 Pareto chart for April 2015

Analyzing the diagram in Figure 2, it can be seen that nearly two-thirds of them have as their cause, traces of tools on the head, scratching, streaking "and" variation of quotas to spare".

The first category of defects has the share of respectively 16% (Figure 2). Taking into account the fact that it's easier to reduce a high frequency, low than one diagram shows that would be more useful to focus on the improvement of the first two reasons (few and important) than secondary ones (many and insignificant).

CONCLUSIONS

A Pareto chart is used to highlight the most frequently occurring defects, the most common causes of defects, or the most frequent causes of customer complaints [11]. The prioritization of evaluated defects consists on their analysis and implementation of corrective and preventive actions.To improve the quality of industrial products, it can apply the Pareto Analysis, this contributing to keeping control of defects and improve manufacturing processes. By applying them it will get many advantages such as:

• Solving in the effective mode problems by identifying and prioritizing major cause in order of importance to them;

• Establishment priorities of many practical applications, such as efforts to improve a process, customer needs, suppliers, investment opportunities;

• Shows us in what direction must be directed at efforts in order to improve the process/product.

To analyze and prioritize the manufacturing defects it was used Pareto chart that allows to eliminate or to minimize the causes. Pareto diagram allows us to identify the problems (causes) and to minimize the defects with the highest percent. To identify and analyze the main problems which cause the most important defects of manufacturing process, a two months data had been collected (March 2015 and April 2015).

Analyzing Figure 1 it can be observed that the first two categories ("traces of tools on the head, scratching, streaking" and "variation of quotas to spare") of defects represent 39%of the total number of defects for March month.

Analyzing Figure 2 it can be noticed that the same categories of defects represent 31% of the total number of defects for April month.

It was implemented corrective actions in order to minimize the defects and to improve the quality of industrial products. In this respects, the implemented corrective actions consists on adjusting the parameters of the cutting regime and periodical operators' training. In conclusion, it can be observed that the defects percentage of 39% for initial stage it is reduced to the 31%.

After it has been implemented the necessary measures to minimize or eliminate these two categories of defects we can draw another Pareto diagram to verify the effectiveness of the actions implemented, as well as for the reduction in the number of complaints relating to both categories.

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CHALLENGES IN INTERNATIONAL NEGOTIATIONS: CULTURAL BACKGROUND AND CONTEXT

Delia POP-FLANJA
"Babeș-Bolyai" University, Cluj-Napoca, Romania
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Abstract: *Cultural differences have an effect on a multiple range of interactions and the domain of international negotiations is nevertheless strongly influenced by the cultural background of its actors. In this article, we will bring into discussion the applicability of Geert Hofstede's widely quoted cultural dimensions to the negotiation process. To what extent can cultural differences have a saying in a world strongly influenced by political and economic factors? Also, the notions of fairness and non-negotiable will be analyzed, starting from the existing literature and continuing with a series of current events that set the scene for tenacious negotiations within the European Union.*
Keywords: *negotiation, cultural dimensions, fairness, non-negotiable*

1. INTRODUCTION

Categorizing should not invalidate a person as a good negotiator and should not fall under the denomination of unethical behavior. In a handbook on humanitarian negotiation, Deborah Mancini-Griffoli and André Picot explain that categorization is necessary in organizing reality. In making reference to the categorization based on the cultural identity of the counterpart in a humanitarian negotiation context, they consider it to be "at once unavoidable, useful and dangerous". It might appear to be an unusual association of terms at first, conveying neutral, positive and negative connotations, but the authors clearly explain their choice: "It is unavoidable because you cannot stop yourself from trying to frame the person with whom you are establishing a relationship [...] useful because by drawing up a provisional image you will later be able to modify it little by little as you get to know the person better […] dangerous because you run the risk, due to a lack of information or curiosity, of sticking to your first impressions, stereotyping and never adapting your view." [1, p.126]

This is how we consider that cultural typologies should be used in a negotiation context, as categories that we can group people on, so that we have a possible starting point.

In order to support this idea, the following article follows two main directions, namely the cultural dimensions proposed by Geert Hofstede and their possible applicability to international negotiations, and the manner in which the notions of fairness and non-negotiable are perceived depending on the context.

2. CULTURAL DIMENSIONS IN NEGOTIATIONS

To begin with, we have chosen to discuss Geert Hofstede's cultural dimensions theory and its applicability to the domain of international negotiations. Following a study on the attitudes to work of the employees of multinational companies, based on their cultural specificities, Hofstede classified cultures, at a first stage of his studies, into four major bipolar groups. The first four dimensions were introduced in 1980, and a fifth one was added in 1991.

Hofstede activated in the intercultural environment since 1965, which makes his studies the result of personal experience combined with statistical data obtained through the surveys and questionnaires applied to representatives of 55 countries.

The researcher analyzed a sample of 116.000 employees of IBM, and he concluded that there is a difference in the systems of values of these representatives.

Between 1990 and 2002, Hofstede published six more studies in this domain. In 2010, he published another edition of the book *Cultures and Organizations: Software of the Mind,* with the contribution of Michael Minkov and Gert Jan Hofstede; in this volume the authors analyze the cultural dimensions in 76 countries.

Hofstede distinguished four fundamental terms to describe the manifestation of cultural differences: symbols, errors, rituals and values. Symbols are the most superficial manifestations and values are the most profound ones. He also considers that there are different prominent levels of culture, namely: national level, regional/ ethnic/ religious/ linguistic affiliation level, gender level, generation level, social class level, organizational level. [2, pp. 23-26]

The first five cultural dimensions identified by Hofstede that we are going to present are: Power Distance Index, Individualism versus Collectivism, Masculinity versus Femininity, Uncertainty Avoidance Index, and Long-Term versus Short-Term Orientation. [2, pp. 29-32]

Power Distance Index (PDI) – refers to the attitude of the people from a particular culture to social inequality. This dimension quantifies the interdependencies between the people in a leading position and their subordinates, the degree to which people of a lower hierarchical position allow their superiors to have a bigger or smaller power over them. In low PDI societies, there is a limited dependency between superiors and subordinates, which make formalities and statue, have a smaller importance. In high PDI societies, the emotional distance between superiors and subordinates is very high, power may overcome justice, and there is a high degree of obedience and respect. [2, pp. 40-60]

The dimension Individualism versus Collectivism (IDV) is the extent to which a culture encourages the dependence of an individual on the group or groups that he belongs to. In a highly individualistic society, the task is more important than the inter-group relations and the relations between people are more reduced. On the other hand, in societies with a higher degree of collectivism, it is the interest of the group that prevails, the groups are very strong, with well integrated individuals, and there is a strong accent on a participative type of management. [2, pp. 68-86]

The dimension Masculinity versus Femininity (MAS) deals with the distribution of roles between men and women and what values are dominant in a society. In societies with a high degree of masculinity, the values that prevail are prosperity, recognition, gain, competition, support for the strong, whereas the values that are considered to belong to femininity are cooperation, safety, strong relations between people, perseverance, support for the weak. When dealing with conflicts in a society focused more on masculine values, the tendency is towards dispute, as opposed to compromise and cooperation. [2, pp. 101-125]

Uncertainty Avoidance (UAI) comprises the attitude of a society to uncertainty and the manner in which uncertain situations are dealt with. In some cultures, people consider that uncertainty is part of their lives and that there is little they can do to influence it. Hence, individuals are more open to risk-taking and to innovation. In other cultures, people strive to control the future, they have a strong need for security and there is a high confidence in specialists and their knowledge. Hofstede points out the fact that avoiding uncertainty is not equivalent to avoiding risk. To support this idea, he gives the example of high road speed limits in high UAI countries, as the priority is to avoid the uncertainty and the stress caused by wasting time and not the risk of accidents to occur. [2, pp. 133-149]

The fifth dimension, Long-Term versus Short-Term Orientation (LTO) deals with the period of time allocated to planning. Societies with a high LTO level adapt traditions to the modern context, they are judicious when using resources, and they aim at long term results. Societies with a low LTO do not place a lot of emphasis on saving and investments; they focus on short term results, and have a great respect for traditions. [2, pp. 169-202]

In the 2010 edition of *Cultures and Organizations: Software of the Mind*, a sixth dimension – Indulgence versus Restraint - was introduced. Indulgence refers to the tendency of allowing the satisfaction of basic and natural human drives, to the tendency of enjoying life and having fun. In restraint driven societies, there is the conviction that satisfying the above mentioned needs should be subject to strict social norms. [3, p.281]

When applying these results, one must take into consideration the fact that cultural dimensions, in spite of the fact that they proved to be rather stable and that Hofstede's cultural model was and continues to be quoted on a large scale, are nevertheless relative. [4]

Before discussing how these cultural dimensions can influence the negotiation process, it is noteworthy that this model did not lack criticism. For example, in an article published in 2002, Brendan McSweeney, professor at the School of Management of Royal Holloway University of London, criticizes the fact that Hofstede overgeneralizes the results obtained from relatively limited samples to the national level, and the fact that the subjects of his survey were the employees of a multinational company, which makes them less representative. [5]

However, we consider that, as people become more conscious of their cultural specificities when they are able to compare them and they enter into contact with different systems of values, analyzing individuals that work in a multinational company does not automatically make the results biased. Also, when a person is old enough to be employed, a lot of cultural specificities already exist and are noticeable, whether that person is aware of them or not.

Another objection brought forward by McSweeney is directed towards the bipolarity of Hofstede's dimensions, towards the fact that they are presented in contrast one to the other. The reason behind this criticism is the fact that the two antipodes can coexist, depending on the situation that determines each of them to stand forward, on the context. [5, p.105]

Hofstede answered these accusations by stating that the cultural dimensions he he identified should not be regarded as the sole instrument of measuring cultural differences. Even if he agrees to the fact that nations might not be the best units of studying cultures, they were the only ones available for comparison. Also, he points out that his intention was to show the differences between national cultures, not to make a thorough description of them, and that the results of his findings turned out to be valid throughout his additional research and not only. Hofstede adds that his intention was to explain behaviors, and that culture is not the only aspect that should be taken into account. [6, pp. 1357-1359]

But Hofstede was not alone in his attempt to justify the validity of his research methods. For example, Dermot Williamson, professor at Lancaster University, also analyzed McSweeny's criticism. He considers that Hofstede's dimensions were not designed as absolute measurements, but as relative positions based on which nations can be compared. [7, p.1375]

His answer to McSweeny's observation that dimensions should not be presented as bipolar is that, even if this perspective of bipolarity can neglect the complexity of the cultural world, it can facilitate quantitative analysis. Also, he condemns the fact that McSweeney does not demonstrate that the results obtained by Hofstede have been compromised, and that there are actually studies that confirm his discoveries, such as the *Chinese Culture Connection* 1987, a study not on the corporate environment, but on a series of students, which led to similar results. What Williamson reveals is the fact that, even if there are some aspects of McSweeny's article that should be taken into consideration, there is no substance to his criticism, as he does not offer his own perspective on the dominant cultural dimensions. Also, rejecting Hofstede's model would mean rejecting the nomothetic techniques of analyzing cultures, and his conclusion is that culture should be analyzed using multiple methods of research.[7, 1380-1389]

In order to bring forward the possible usage of the cultural dimensions by the negotiator activating in the intercultural environment, we will make use of a series of guidelines for humanitarian negotiations proposed by Deborah Mancini-Griffoli and André Picot. According to the authors, power distance has a great influence on the negotiation process, as people's attitudes to power guides their behavior towards discussion, deference or dissent. Also, male-female relationships have an impact on how a mixed team will be viewed. Whether we are addressing counterparts form a more individualistic or more collectivistic society should help in deciding whether to argue in favor of individual rights or the rights of the group. High uncertainty avoidance negotiators will probably not go back on clarifying certain aspects at a later stage of the negotiation process or leaving some grey areas, whereas those of a low uncertainty avoidance background would probably want all details to be settled during the negotiation.

The perception of time also has a great

influence in the negotiation process, as some might perceive offering more time as a sign of respect and others might interpret it as a waste of their own time; similarly, choosing the right moment for a meeting is not always an easy task. Non-verbal communication, the delimitation between public and private space, offering gifts or not, whether it is the buyer or the vendor who makes the first bid, using a more or less aggressive style of bargaining, all these aspects can be influenced by the cultural background and can lead to the success or failure of a negotiation. Also, as useful as being familiar with your counterpart's habits and customs might be, imitating them is not always the best option, as instead of perceiving this endeavor as a sign or respect, it might be put people in awkward positions. [1, pp. 127-129]

It is noteworthy that, just as we can talk about differences in the negotiation styles depending on the national cultural background of the negotiator, in international relations we can also talk about an even wider style of negotiation, the style of the international institutions negotiators. In an article on how institutional environments impact the styles of negotiation, Jeffery Lewis indicates a European *dynamic density* and a *cooperative style* of the Council of the European Union that is not applicable to the Asian institutional context. [8, pp. 20-21]

Professor Vasile Pușcaș, an expert in the domain of European negotiations, states that in spite of the fact that we cannot consider that there is a particular European style of negotiations, European negotiations are characterized by a *certain specificity or individuality*: "formal negotiations are connected to the informal ones, creating a link between both the internal levels and sectors, as well as between the internal and external negotiation of the European Union". [9, p. 18]

3. THE FAIR AND THE NON-NEGOTIABLE

Alfredson and Cungu bring into discussion the concept of fairness in the negotiation process, more precisely the *perceived fairness* driven by the joint decision-making process, which leads to positive relations between parties and improves satisfaction. To exemplify this process, the authors give an example from day-to-day interactions.

How should a father divide a piece of cake between his two children, without risking that one or both of them will be discontent? A *fair process* would be for the father to ask one child to cut the cake and to establish the proportions, and then for the other to decide who gets each piece. In this scenario, both parties take part in the decision-making process, and they cannot argue its legitimacy. [10, p.23] Discussing the concept of justice in negotiations over global public goods, Cecilia Albin, professor at the Department of Peace and Conflict Research of Uppsala University, considers that what is interpreted as fair in a more narrow, regional context, can be interpreted as unjust from a global, more wide perspective, and the other way around. Reciprocity and mutual advantage represent different things to different parties. Also, even though justice and fairness should be taken into account, they are not the main objectives in negotiations. [11]

But how can the principles of fairness be illustrated in arranging and conducting the negotiations? Some of the solutions proposed by Albin are:

- having a broad and inclusive agenda that addresses issues of interest to all parties,
- facilitating all parties to be represented – which in many cases is not effortless because parties can be numerous -,
- the existence of clear and transparent rules,
- the attention to venue - which should be neutral and accessible - ,
- giving all parties a chance to participate actively and proportionally in the process and to have an effective voice - which comprises having access to relevant information -,
- the responsibility of each party to act in good faith and in accordance with the principle of fair play. [11, pp. 270-274] Fairness is also perceived differently depending on the cultural background of the negotiators. To support this affirmation, we can bring forwards the concept of norms, in the analysis offered by the social psychologist Harry Triandis. Norms represent what is considered to be a fair behavior by the members of a particular group. Let us suppose that two friends were compensated with 50 dollars for their work. In the USA, the norm of equity is considered to be very strong, so the solution would be for the money to be divided depending on the contribution of each of the two friends, without taking into consideration the relationship between them.

But, in more collectivist cultures, norms such as equality or necessity will probably be taken into account. The shepherds of Sardinia, for example, guide themselves by the norm of equality. Starting from this assumption, stealing animals from other shepherds will probably not generate feelings of guilt, as it is the divine desire that people are equal. In this case, there is certainly a discrepancy between traditional norms and the legislation of the state, but this does not make their culture inferior to others. [12, pp. 100-103]

However, in intercultural negotiations these principles are not easily applicable, as collectivists might not behave the same way outside the group as they do with in-group members. If they are not closely related to their counterparts, they might have a more individualistic behavior and use the principle of equity. [13, p. 757] Also, as we can notice in Hofstede's studies on cultural dimensions, instead of referring to cultures or to individuals as being individualistic or collectivist, a correct approach would be to talk about degrees of individualism and collectivism.

As previously mentioned, in a negotiation process, each party tries to obtain an advantage, but how fairness is perceived by the counterparts is important in finding the appropriate arguments to convince them, in establishing what can and cannot be negotiable.

Hence, in the following paragraphs we are going to discuss he notion of non-negotiable, who establishes what is negotiable or not, and on what grounds. One would logically presume that fundamental human rights should not be negotiable. However, in an article focusing on human rights, conflict transformation and peace building, Michelle Parlevliet attributes to human rights four different dimensions that should be taken into consideration when trying to deal with conflict resolution: human rights as rules, as structures and institutions, as relationships, and as a process. Parlevliet makes an interesting observation that "while fundamental human rights can be taken as absolute concepts that are non-negotiable, their application, interpretation and realization is not absolute". These types of rights set the parameters, but context dictates how specific rights are realized. [14, p. 22]

The notion of non-negotiable is also worthy of analysis in the context of EU negotiations, which are largely intergovernmental due to the involvement of supranational actors.

Some of the aspects that have been justifiably considered to be non-negotiable are independence [15], free-movement [16, 17], EU values [18], democratic values [19], data protection rights [20], the rule of law, freedom of the media [21], safety [22] or transparency [23].

However, let us keep in mind that we are currently living in a 2015 when the European Union is confronted with an unprecedented number of refugees and migrants coming to Europe across the Mediterranean Sea or Southeast Europe and applying for asylum. EU Heads of State or Government met on 23 September 2015 in Brussels to discuss and decide how to deal with the refugee crisis, and a unanimously agreed decision was not reached [24]. Concepts such as human rights, common responsibility, European values of freedom, on the one hand, and cultural identity, sovereignty and border control, on the other hand, have been brought into discussion. Finding a solution to this problem is nevertheless a challenge and the extent to which the negotiations take place is very high, involving EU countries and institutions, international organizations, civil society, local authorities and national partners outside the EU.

Hence, even though some aspects are considered to be non-negotiable, history has proven that context can make them interfere with others, perceived in a similar way. Having a clear position is essential in negotiations, as otherwise reaching an agreement would not be possible, but, nevertheless, one should be open to the counterpart's opposing position and to be prepared to offer strong arguments, as opposed to eliminating certain aspects from discussion and classifying them as non-negotiable.

CONCLUSIONS

To conclude, culture does influence the negotiation style, but culture is regional, national, institutional, supranational, etc., which makes it difficult to keep track of what cultural trait influences particular negotiation behaviors. As in a negotiation process conveying the proper message is equally as important as properly understanding and interpreting the message of your counterpart, being familiar with national or regional cultural traits could help in setting the context , but should not prevail, as it could lead to preconceptions and stereotypes.

Fairness and what is negotiable can also be perceived differently depending on the parties involved in the process and on the context, which makes an open-mined attitude vital in the negotiation process. As the importance of context is so high and tensions between global and national norms may occur, understanding the reasons behind the different positions taken at the negotiation table increases the chances for success. However, closing a negotiation is just the beginning, not the end. The events that follow are those to prove if the negotiation reached its purpose or not.

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