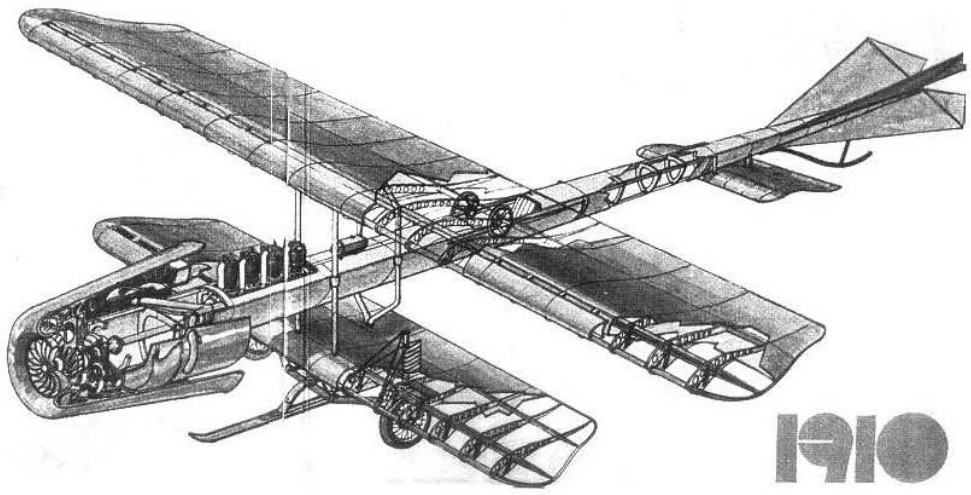
Review
of the Air Force Academy

The Scientific Informative Review, Vol. XVI, No.1 (36)/2018
DOI: 10.19062/1842-9238.2018.16.1



BRAŞOV - ROMANIA

© July, 2018

Visa 0574-07/2018

I.S.S.N. 1842-9238

"Henri Coandă" Air Force Academy Publishing House, 160, Mihai Viteazul St., Braşov, ROMÂNIA
Phone: +40 268 423421, e-mail: editura@afahc.ro

C O N T E N T S

MANAGEMENT AND SOCIO-HUMANITIES

BOOK REVIEW

HELICOPTERS IN COMBAT: METHODS FOR HELICOPTER USE IN SPECIAL OPERATIONS

Ioan MISCHIE

Air Force Headquarters, Bucharest, Romania (bar_onu@yahoo.com)

DOI: 10.19062/1842-9238.2018.16.1.1

Abstract: *The world is now marked by conventional and unconventional military actions, from classical armed confrontations, counterinsurgency, counter-terrorism to counter-act trafficking in human beings and drugs. In this wide range of actions, special operations play a particularly important role, solving sensitive issues in order to facilitate the achievement of political goals. These operations always begin with the action of introducing troops into the action area to carry out their missions. Helicopters are, by their characteristics, the means of transportation commonly preferred by commanders who plan and conduct such operations for the purpose of introducing, re-supplying, and extracting troops from the area of action.*

Keywords: *special operations, helicopters, combat methods, high-value targets*

1. INTRODUCTION

Following World War II, lessons were learned, according to which the support of a classical war would have been costly, both economically and in terms of the loss of human lives, to resolve misunderstandings or confrontations between states, more emphasis has been put on the use of armed forces in atypical ways to carry out the armed struggle. In this way, it was intended to influence the opponent in order to impose its own goals, avoiding an open confrontation between states.

In this new type of war, unconventional actions, meant to discredit and isolate the enemy on the international arena, have become increasingly important. Their main purpose is to erode the role of representative state institutions, to undermine the existing political system by creating or activating rebel groups followed by their propulsion to power, influencing the behavior of the population, changing attitudes, and forming a mass opinion that serves the purposes by taking control over links or vital points in order to promote or impose their own interests.

According to *Joint Publication 3-05 - Special Operations*, special operations involve the use of specially selected and trained personnel with special, state-of-the-art equipment and using unique and particular techniques, tactics and procedures. They are also conducted in a hostile or sensitive environment in terms of political and diplomatic relations.

Special Air Operation (SAO) is an integral part of any conventional or unconventional war, of psychological or anti-terrorist actions. These operations can contribute to the penetration/extraction of a force into a politically sensitive area, without being discovered.

The main features of this type of operation are:

- it must be well coordinated with other types of actions: insurgency, political and diplomatic, economic;

- it has a clandestine nature, unfolding in secret, the staff involved being characterized, for example, as "green men" [1];
- as a result of the clandestine nature of these operations, they have little visibility but underlie future behaviors influences;
- accomplish their goals through the forces or staff existing in the respective states;
- are in correlation with regional guidelines or trends;
- involves a high degree of risk and uncertainty.

So we can say that special operations are meant to facilitate the achievement of strategic objectives where the use of conventional forces is impossible.

Due to its unique and uniquely recognized features, air power is called upon to support this type of operation. Its most used means in special operations are vertical take-off and landing aircraft, namely helicopters and V-22 Osprey aircraft.

Considering helicopter vulnerabilities in threatened environments, is this combat platform useful for special operations forces?

2. A DOCTRINAL AND HISTORICAL FRAME REGARDING THE USE OF HELICOPTERS IN SPECIAL OPERATIONS

The helicopter technical-tactical characteristics, the ability to fly at very low heights (which makes it hard to be detected by the opponent) and the execution of the stationary flight above the target, as well as the unique capability to land in any place, regardless of the state and characteristics of the land, were immediately exploited by the armed forces. Thus, the helicopter has become the ideal platform for mobility and for supporting ground forces in general and Special Forces operations (SOF) in particular.

The helicopter was used for the first time on the battlefield during the First World War by the Austro-Hungarian Empire in observation mission. Later, during the Second World War, the Germans built several *FI-282 Colibri* helicopters, which they used on the eastern front, with the task of executing the artillery fire correction [2]. At the same time, observing the vulnerabilities of the helicopters, the Germans have made the first doctrinal conclusion, namely the need to obtain air space supremacy for the successful use of helicopters in military operations.

Towards the end of the war, the helicopter began to be used on a larger scale by several states. Thus, in Pacific operations, they were used to provide logistical support in shaken terrain and to carry out SAR and MEDEVAC missions.

As it was natural, the role of the helicopters on the battlefield increased, so on April 23, 1944, a helicopter was used for the first time in special operations by recovering, with a Sikorsky R-4 helicopter, from behind the Japanese lines, four US pilots [3].

The French were the ones who revolutionized, practically, the use of helicopter in combat operation doctrine. In July 1954, during the Vietnam conflict, Captain Puy-Montbrun proposed and carried out the first infiltration and exfiltration of a FOS detachment by helicopters.[4] It was the first time when helicopters were used in direct combat. This type of mission would be widely used later in the wars of Algeria and Vietnam.

During the war in Indochina, the French sought solutions to increase the mobility of land troops, especially those for special operations, during the guerrilla war. The helicopter seemed to be the means of fighting that can solve this problem. Thus, in view of their own use of helicopter experience and the success of the SOF infiltration/ exfiltration mission, they decided to set up a helicopters force to support tactical action.

The model was taken over by the most powerful states from the military point of view and reached its peak during the Vietnam conflict.

This conflict has stimulated the emergence and development of new types of helicopters, with transport and attack role and specific technologies. It were used on large scale, for supporting FOS, UH-1 helicopters, known as Huey, AH-1 Cobra – Attack, for escort and fire support, OH-6 and OH-58 – research and observation and CH- 47 – medium troop and cargo transport. In 1959, the army's inventory included 2489 helicopters. Beginning with 1969, as a direct result of Vietnam's rising action, the US Army had reached 9528 helicopters. In total, about 12,000 helicopters were used in Vietnam, of which about 5,000 were lost because of their vulnerability [5].

After this period, it was the turn of the Russians to make their contribution to the development of the doctrine of the use of helicopters in operations during the Afghan War (1979-1989). After the defeat of the Afghan Army in 1985, each Red Army district deployed in Afghanistan received a FOS (Spetsnaz) detachment and an attack helicopter (Mi-24) and transport (Mi-6, Mi-8) detachment to support operations [6].

After this period, practically all doctrinal principles have been established regarding the use of helicopters in support of the FOS. Later wasn't important doctrinal changes, the developments occurring only at the technological level with regard to the helicopters used. Night vision devices have been widely implemented, which has allowed these actions to be conduct during the night.

Also, due to modern avionics systems combined with operational status awareness systems, they can fly in all weather conditions, providing surprise for opponents.

The *Special Operations Forces Reference Manual,* fourth edition, specifies the basic activities of special operations, as follows [7]:

- direct actions;
- special recognitions;
- counter-terrorism;
- unconventional war;
- internal defense of foreign states;
- assistance to security forces;
- saving and recovering hostages;
- counterinsurgency;
- humanitarian assistance;
- information support of military operations;
- civil affairs;
- the fight against weapons of mass destruction.

Also, lately, V-22 Osprey aircraft have been introduced to support SOF, replacing traditional UH-1N, MH-53, MH-60 helicopters, due to their transport capacity, tactical radius and higher speed [8]. Currently, the US Army is already modernizing these aircrafts to deal with new threats and doctrinal changes in their use in the War On Terror.

The use of helicopters to support SOF requires detailed planning and coordination. Air support for SOF that does not have its own helicopters is provided by JFACC (Joint Force Air Component Commander) or AFCC (Air Force Component Commander). They will have an SOF liaison officer at the Air Operations Center to help coordinate the requirements for aviation support in special operations.

3. SPECIFIC METHODS FOR HELICOPTER USE IN COMBAT

During the Operation ENDURING FREEDOM (OEF) and IRAQI FREEDOM, Army Special Operations Aviation (ARSOA) units were used for the first time as constituents of the Joint Special Air Operations Component (JSOAC).

At the beginning of the operations, when the risks were very high, these units performed many missions in the form of raids against high-value targets placed in the depth of the enemy territory [9].

Helicopters use a wide range of methods in combat, depending on the specifics of the mission and the forces it supports. The most common methods used to support special operations are:

a) *Insertion*.

This method is used to introduce SOF groups into the tactical field for executing specific missions. It can be executed with a multitude of means (terrestrial, naval, aerial) but the helicopters are most suitable due to the advantages that they offer:

- relatively high speed comparing with land and naval means, but less than airplanes;
- short time to reach the target due to the fact that the air means do not have to follow certain land or naval access ways to the objective area;
- the ability to carry, in a single wave, a large number of fighters and necessary equipment with a small number of helicopters compared to other land or naval means;
- the unique ability to perform the insertion, through landing or various means (rappel, fast rope) within the stationary flight above the specific point, regardless of the physical nature of the land chosen by the SOF;
- the ability to run the mulled flight, following the features of the terrain, in the daytime and nighttime, by using night vision devices at very low meteorological conditions, making them practically undetectable to radar stations;
- by the way of action and the ones presented above, they are surprised and have a demoralizing effect on the opponent.

A special type of insertion is the one carried out by air assault, where the SOF and the helicopters secure each other with fire until the troops reach the ground and the helicopter can release the area. Very important in this type of insertion is the finalization of the attack scheme and the ground tactical plan. These must be the result of a collaborative process between all the forces involved and must be completed before the actual planning of the mission begins.

The most eloquent example in this way is the BARRAS operation, carried out by the British SOF on September 10, 2000 in Sierra Leone. In this mission a number of 3 CH-47 Chinook helicopters, 2 Lynx Mk-7 helicopters and 1 Mi-24 helicopter executed the insertion of approximately 130 soldiers, making fire support and annihilation of targets by attack helicopters and fire support to the SOF during by descending from helicopter [10].

As it results from this operation, infiltration can be accomplished either by landing or by rappelling, and rarely by parachuting.

b) *Extraction*.

This is the method by which SOF are removed from the tactical field after fulfilling the mission. As with the insertion, helicopters are the most used means, due to the same advantages.

Regarding the alternative means of extraction execution, I remember:

- Special Patrol Extraction System (SPES) – which consists of a rope with meshes in which the soldiers catch their specific hooks, the helicopter taking off with people on the rope. However, after extracting the troops from the dangerous area, the helicopter must land to allow access of troops inside of it, otherwise the speed restrictions will make it very vulnerable.
- Winch – which is an electric or hydraulic device through loads can be lifted or lowered on vertical from limited terrain. As a disadvantage is that the helicopter must stay in hover flight until the soldiers are on board.

c) *Fire support*.

This can be done using a wide range of means (planes, drones, cruise missiles, artillery, etc.), depending on the distance to which the SOF mission takes place.

Both attack helicopters and armed helicopters can provide fire support on request by the SOF. The main purpose of this type of support is the suppression or fixing of threats, distributed by SOF staff, in order to favor the maneuver of forces involved in ground fighting. At the same time, it is possible to accomplish, if necessary, the extraction of their own forces when their mission can no longer be accomplished due to the unfavorable tactical situation.

Within this method a very important role is played by air-to-air and air-to-air communication systems, which must be interoperable with those of the SOF. Also, these missions are usually pre-planned in order to be able to have a quick and precise response in support of troops operating in a hostile, non-permissive or politically sensitive environment.

In any military action, "time is a critical factor" [11] in integrating fire support, depending on the outcome or the level of its own losses. In this case, the time factor is even more important, because we are dealing with not so many quantitative fighters as the commanders of the joint operations want, but of inestimable qualitative value.

d) *Vertical replenishment*.

This method is specific to helicopters and is used when the intended place for replenishment, for tactical reasons to act in hiding, has obstacles (like forests) that do not allow for replenishment by other methods (parachuting, deletion). By means of on-board capabilities (e.g. winch, nets), helicopters are the most appropriate means to execute this method.

4. CONCLUSIONS

Due to the advantages that they offer, helicopters are critical aviation means for commanders' missions in achieving combat support. They are used throughout the range of missions, from airborne mobility to the support of forces for special operations, or the combat recovery of individuals who have been isolated behind enemy lines.

Special operations forces – small, well-trained and specially equipped units need, for the fulfillment of their specific missions, terrestrial, aerial or naval means to enter the area of action, re-supply them if necessary, support them with fire and, after completing the mission, recover them. Considering the unique capabilities of helicopters, namely landing in unplanned terrain or making insertion / extraction anywhere, regardless of obstacles, these are the most commonly used air forces for special operations.

The four methods of helicopter use in operations are specific to the support of troops for special operations, with much more support for ground forces.

I considered it necessary to present them because of the confusion created between the missions, methods and methods of helicopter combat use.

Currently, most SOF have their own helicopters in the organic or are supported with such capabilities by the other branches of the army who has helicopters. This is how Special Operations Air Task Group (SOATG) has been formed, where several Special Operations Air Task Units (SOATU) operate.

Helicopter Air mobility missions, in which are used SOF insertion/extraction methods are the most dangerous because they take place in sensitive areas, usually controlled by the opponent.

It should be noted, however, that in the USA the trend is to replace helicopters within the SOATG with CV-22 aircraft because it has long range capability and it can take-off and landing on vertical, like helicopters.

However, due to the high costs and the fact that these aircraft are at the beginning, most countries in the world will use helicopters as a preferred means of supporting special operations for a long time in the future.

REFERENCES

[1] P. Grier, *The Perils of Hybrid War*, Air Force Magazine, Arlington, 2017, p. 24;
[2] M. J. Hirschberg, *The American Helicopter, An Overview of Helicopter Developments in America 1908-1999*, Ross & Perry, 2002, p.22;
[3] M. J. Hirschberg, *The American Helicopter, An Overview of Helicopter Developments in America 1908-1999*, Ross & Perry, 2002, p.24;
[4] C. E. Goscha, *Historical Dictionary of the Indochina War (1945–1954*), NIAS Press, Copenhaga, 2011, p. 396;
[5] E. Durand, *Helicopter Warfare – The future of air mobility and rotary wing combat*, IFRI Laboratoire de Recherche sur la Defence, Bruxelles, 2012, p.15;
[6] E. Durand, *Helicopter Warfare – The future of airmobility and rotary wing combat*, IFRI Laboratoire de Recherche sur la Defence, Bruxelles, 2012, p.16;
[7] ****Special Operations Forces Reference Manual*, Ediția 4, MacDill AFB, Florida, 2015, p. i-6;
[8] E. Haase, Foreword, *Air Commando Journal*, vol. 6, nr. 2, Mary Esther, Florida, 2017, p. 4;
[9] C. M. Hutmacher, *Command and control of special operations* aviation: time for a change, Carlisle Barracks, 2011, p. 9;
[10] P. J. Evoe, *Operation Palliser: the british military intervention into Sierra Leone, a case of a successful use of western military interdiction in a sub-Sahara African Civil War*, Texas, 2008, pp. 74-76;
[11] M. Orzeață, C. Țenu, Calitate și cantitate în constituirea grupărilor de forțe cu rol operativ în războiul modern, *Tehnologii moderne la început de secol*, Ed. Universității Naționale de Apărare, București, 2004, p. 88.

THE CHARACTERISTICS OF UNCONVENTIONAL WARFARE

Ion BĂLĂCEANU, Constantin-Marian BÎRSAN

"Carol I" National Defense University, Bucharest, Romania
(balaceanugion@yahoo.com, birsan_marian76@yahoo.com)

DOI: 10.19062/1842-9238.2018.16.1.2

Abstract: *Unconventional warfare (UW) represents the most complex mission performed by Special Operations Forces (SOF). It is often executed deep in the enemy territory, in a clandestine/covert manner, having limited or no support from regular supply channels. Also, UW is often conducted over a long period of time to achieve strategic political and military objectives. Moreover, UW is a great option to protect national interests deploying small military elements. Special Operations Forces represent the force of choice for this type of missions. In recent years, in the context of Hybrid Warfare, the interest for UW has grown. Therefore, this concise study attempts to identify how the UW concept developed and changed throughout recent history in order to identify its main characteristics. In order to accomplish that, this paper will mainly look at the United States Army Special Operations Forces Doctrine post-World War II and highlight the main ideas surrounding UW evolution.*

Keywords: *Unconventional Warfare, Special Operations Forces, guerilla operations*

1. INTRODUCTION

The terms of *unconventional warfare*, *unconventional operations* and *unconventional military actions* are addressed in detail in unclassified, open-source literature. This study focuses on detailing these concepts and describing them through historical examples, especially from the Second World War and the Vietnam conflict in order to highlight their main characteristics. Addressing these concepts is not a contemporary scientific approach, but was done since the dawn of studying military science and art. Carl von Clausewitz [1], Jomini [2], Lawrence and Hart Lindell [3] looked at unconventional warfare, defining and explaining the concept as one of the main attributes of partisan organizations. On the other hand, Mao, Che Guevara and David Kilcullen believe that actions related to unconventional warfare are carried out solely by revolutionary movements or insurgency. Going forward, S.D. Maxwell, J. Osborne and D. Kilcullen address the current issue of terrorism, conceptualizing it as a global insurgency, which uses goals, tactics, techniques and procedures typical to those of unconventional warfare [4]. Regardless of how unconventional warfare is presented, we can highlight *three distinct characteristics* specific to this type of manifestation of war as a phenomenon, namely:

- the active involvement of the civilian population either as partisan organizations or insurgent movements;

- the use of tactics, techniques and procedures specific to this type of warfare (sabotage, subversion, small-scale raids, harassment of enemy forces, full exploitation of psychological effects, fostering chaos);

- the existence of an external support organization (usually a sponsor belonging to either the host nation or a different nation and it can be represented by the armed forces or the intelligence services).

These characteristics make the unconventional warfare phenomenon unique, and require a specific approach in order to understand the dynamics and mechanisms that influence its beginning, course and outcome.

From the above information we can easily see that most bibliographic sources are mainly from the academic and military domains from the Western countries and specifically the United States where the unconventional warfare issue is dealt with extensively in scientific papers. Although less studied, unconventional warfare is also reflected in the studies of Romanian authors. We note the interest shown by Valerică Cruceru who comprehensively addresses issues of guerrilla movements conducting unconventional warfare [5] as well as the correlation between insurgency and limited war [6]. Furthermore, Vasile Soare briefly presents the evolution of the war phenomenon, from the war in ancient times to the modern day unconventional warfare presenting historical examples showing the use of special operations forces in the full spectrum of missions assigned to these types of structures [7].

In the current operational context, the issue of unconventional warfare is found in scientific studies of both foreign and Romanian authors. The approach of this issue focuses mainly on identifying the characteristics of unconventional warfare and the presentation of the specific timeline of events occurring throughout an unconventional war. Also, a number of foreign authors, such as: S. Hy Rothstein [8], Susan L. Marquis [9] and John Arquilla [10] were committed to studying and understanding the use of United States Army Special Operations Forces in unconventional military operations. Given this context, our scientific approach aims to capitalize on the results of the scientific research of the mentioned authors and, combined with the personal experience in Special Operations Forces, we aim to identify the best ways and the most appropriate conditions for the use of special operations forces in unconventional military actions / operations and to highlight the crucial role of SOF in carrying out this type military action.

2. THE EVOLUTION OF THE MAIN CHARACTERISTICS OF UNCONVENTIONAL WARFARE

The definition of *unconventional warfare* has evolved over time, but this trend has brought no significant changes in the understanding of the actual term. As mentioned in the introduction, this concept has been discussed since the very beginning of studying military science. Theorists such as Sun-Tzu, Clausewitz and Jomini mentioned unconventional military actions in their works, each treating the subject in the context of their respective historical period. Furthermore, throughout the history of warfare, the belligerents have conducted operations specific to unconventional warfare. However, doctrinal record of this type of military action appears only after the Second World War, the determining factor for this being the experience of Great Britain, Russia and the United States in this conflict.

In terms of semantics, the term *unconventional warfare* is the opposite of *conventional warfare* in the sense that the dictionary-provided definitions of the former show the following characteristics: *not conventional, which is not subject to conventions, norms* [11].

Also, the objective in the two types of war differs in that while during a classical confrontation the emphasis is on neutralizing / destroying the opponents' military power, while in unconventional warfare the emphasis is on defeating the opponent without a direct military confrontation, but through external support for one of the warring parties.

Typically, the unconventional forces act undercover or discrete, their targets are not exclusively of military nature, and the techniques, tactics and procedures employed are distinct from those specific to purely military operations.

Studying these concepts is not an easy endeavor because there are few unclassified relevant bibliographic sources. In this context, most of the unclassified bibliography comes from the United States; therefore, we will particularly analyze how this term has evolved in the realm of United States Army Special Forces (USSF). This is due to the fact that the USSF were initially created in order to carry out unconventional warfare, currently this being the defining characteristic of their structure. Thus, under the current military doctrine of the United States military, unconventional warfare is defined as "*military operations conducted along with, or through irregular forces in support of resistance movements or conventional operations*"[12].

The concept of unconventional warfare appears in US military doctrine starting with the creation of the Office of Strategic Services (OSS), during the Second World War. This office was created to coordinate support for the resistance movements of the civilian population. Therefore, military forces and undercover agents coordinated by OSS acted in support of the partisans throughout Europe, especially in Belgium, France, the Netherlands and Poland, who fought against the German occupying forces. In the same time, OSS agents have acted in support of the resistance movement in the Philippines who fought against the Japanese occupying forces. Actions carried out and coordinated by OSS agents during the Second World War led to the definition of unconventional operations, in the context of guerrilla warfare, as military actions executed undercover in enemy-occupied territory, or where the enemy exercises influence. Probably the most famous unconventional missions carried out during the Second World War are those executed by the Jedburgh [13] teams in the territories occupied by German forces. Also, the establishment of these teams represented the first time that the United Kingdom, through the Special Operations Executive (SOE) and the United States, through the OSS, cooperated in the domain of special operations.

After the Second World War, the definition of unconventional warfare focused on the specifics of *guerrilla warfare*, and on the *covert actions* conducted in territories occupied by a foreign military force. The experience of working with partisan movements in Europe has broadened the definition to include actions executed by *partisans*. Therefore, in 1950, The Dictionary of United States Army Terms, defined actions executed by partisans as "actions against an enemy force carried out by people devoted to a cause, but were not part of the armed forces of a country. These actions include: *actions specific to guerrilla warfare, passive resistance of clandestine groups, espionage, sabotage and propaganda*" [14].

In 1951, the US Army established The Psychological Operations Bureau that included units tasked with the execution of unconventional warfare. Furthermore, the first two regulations detailing the execution of Special Operations were published, namely: F.M. 31-21, *Organization and Conduct of Guerrilla Warfare* and F.M. 31-20, *Operations Against Guerrilla Forces*. Thus, according to F.M. 31-21 actions specific to guerrilla warfare were defined as "operations carried on by small independent forces, generally in the rear of the enemy, with the objective of harassing, delaying, and disrupting military operations of the enemy.

The term as used in this manual also includes organized and directed passive resistance, espionage, assassination, sabotage, and propaganda, and, in some cases, conventional combat. Guerilla warfare ordinarily is carried on by irregular, or partisan, forces; however, regular military forces which have been cut off behind enemy lines or which have infiltrated into enemy rear areas may use guerilla tactics"[15].

Also, the same regulations indicated that actions specific to guerrilla warfare can influence political decisions and economic aspects of the country and their overall aim is to reduce the enemy's fighting ability by delaying and preventing its actions, thus weakening its morale and will to fight.

Once Special Forces were officially established, the earlier mentioned regulations were superseded, making room for new regulations and manuals specific to this type of forces that tackled the issue of unconventional warfare from a Special Forces perspective. Thus, in 1955 F.M. 31-20, *Special Forces Group* is published and supersedes the 1951 edition. This manual stated that the unconventional warfare includes actions specific to guerrilla warfare but also the escape from enemy occupied territories and the subversion actions carried out against a hostile force.

In 1958 a new version is published called F.M. 31-21, *Guerilla Warfare and Special Operations Forces*, which defines guerrilla warfare specific actions as "that part of unconventional warfare which is conducted by relatively small groups employing offensive tactics to reduce enemy combat effectiveness, industrial capacity, and morale. Guerilla operations are normally conducted in enemy-controlled territory by units organized on a military basis"[16]. The manual also points out that unconventional warfare includes, in addition to actions specific to *guerrilla warfare*, *evasion and escape from enemy-occupied territories* and *subversive actions* against hostile forces.

In 1969 F.M. 31-21, *Special Forces Operations* is published, detailing the concept of unconventional warfare. Thus, according to this manual, unconventional warfare consist of actions specific to *guerrilla warfare*, *escape from the enemy-occupied territories*, and *subversion* executed by the local population against hostile forces, supported by an external force. Unconventional actions are the *military, political, psychological and economic* actions executed *overtly* or *clandestinely* in areas that are under occupation or influence of foreign forces whose interests are conflicting with those of the US. These actions can be executed unilaterally by the USSF or in cooperation with the local population and will avoid formal direct military confrontation [17].

Currently, the assessment of cyber threats and the security of electronic means becomes a basic task to be taken into account in line with developments in the modern actions. The methods used depend on the direct cost-effectiveness ratio [18].

Unconventional warfare is executed in order to exploit the enemy's military, political, psychological and economic vulnerabilities through support and guidance offered to the resistance movements or unilaterally by USSF. These actions can be *covert*, *clandestine* or *overt*. Undercover operations are executed so as not to disclose the identity of the external sponsor. In the case of clandestine operations, the focus is on hiding both the operations and the sponsor. In a developed theater of war, in which conventional forces are fully engaged in armed conflict, SF will execute unconventional military warfare in support of the conventional campaign. The 1990 USSF doctrine slightly broadens the definition of unconventional warfare, introducing details regarding the duration of the campaign, but also the concept of "*surrogate forces*."

Thus, Unconventional Warfare consists of "*operations conducted behind enemy lines, mainly by indigenous people assisted and guided by allied forces, in order to fulfill political and military objectives. UW consists of guerrilla warfare specific actions, evasion and escape from the enemy-occupied territories and subversion against hostile states*" [19].

Throughout history, unconventional warfare was executed either during the staging phases of a conventional campaign or independent, the latter being executed usually undercover [20]. Therefore, according to the doctrine, unconventional warfare take place over *a long period of time*, through *indigenous or surrogate forces* and consist of the same type of actions that were included in previous definitions of this concept.

The doctrines that were developed later resumed this definition, the differences between them consisting in slightly different nuances of the same aspects.

Thus, The Joint Special Operations Doctrine introduces the concept of the unconventional assisted recovery as part of the unconventional warfare. Also, the doctrine states that the unconventional warfare represents the military and paramilitary aspects of resistance movements. Consequently, because of their implications the unconventional military actions are considered to be both *military* and *political* actions.

3. CONCLUSIONS

From the above information, we note that although each newly developed manual or regulation addressed the topic of unconventional warfare, essentially its definition has not significantly changed in over 50 years.

A classic example of a campaign where unconventional operations were conducted in support of actions carried out by conventional forces is Operation Allied Support (in support of resistance movements in Western Europe, the Balkans and the Far East during the Second World War). Regarding unconventional military actions executed unilaterally, they are much less known because they were conducted undercover. However, worth mentioning are the USSF actions conducted in Europe after the end of the Second World War in order to support and develop the capabilities of resistance movements in the event of an occupation of Europe by the Soviet Union. This operation was codenamed *Gladio* and USSF have recruited indigenous members from Europe, which they trained, organized in cells, and equipped to perform specific guerrilla warfare actions and sabotage in the event of an invasion of Western Europe by countries of the Warsaw Pact. Such cells have been set up and operated in several European countries such as Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Portugal, Spain, Sweden, and also Turkey. Furthermore, similar operations were executed in Afghanistan in the 1980s during the war with the USSR, where the USSF supported, organized and coordinated the actions of Afghan Mujahedeen. Also, we would like to mention the Russian Special Operations Forces unconventional warfare in Ukraine in support of conventional operations carried out by the Russian Armed Forces starting 2014. These operations require a separate study that the authors are committed to address in the near future.

Looking through the historical perspective at unconventional warfare, we can conclude that this type of operations was carried out in all major conflicts. Regardless of who executed UW, we can conclude that its main characteristics remained unchanged throughout history. They are: *the implication of local population, the presence of Special Operations Forces, subversive actions, the combination of military, and non-military means, and discrete execution.*

In the end, we estimate that UW will continue to remain an important mission for Special Operations Forces. Given its political and military implications, UW requires detailed planning and discrete execution.

REFERENCES

[1] Carl von Clausewitz, *On War,* 1832 – 1835;
[2] A. H. Jomini, *Precis del'art de la guerre*, 1834;
[3] L. Hart, *The strategy of indirect approach*, 1941, republished in 1942 with the title: *The way to win wars*;
[4] D. Kilcullen, *Countering Global Insurgency*, Small Wars Journal, 2004;
[5] V. Cruceru, *Theory and Practice in Modern Guerilla Warfare*, Bucharest, 2013;
[6] V. Cruceru, *Insurgență, contrainsurgență și război limitat. Aspecte ale artei militare în războiul din Vietnam,* "Carol I" National Defense University Printing, Bucharest, 2005;

[7] V. Soare, *Forțele Speciale – Comandouri aeropurtate în acțiune,* Ziua Printing, Bucharest, 2002;
[8] H. S. Rothstein, *Afghanistan&The Troubled Future of Unconventional Warfare,* Annapolis, Maryland, USA, 2006;
[9] S. L. Marquis, *Unconventional Warfare*, Washington D.C., USA, 1997;
[10] J. Arquilla, *Insurgents, Raiders, and Bandits: How Masters of Irregular Warfare Have Shaped Our World***,** Ivan R. Dee Editing**,** Lanham, Maryland, USA, 2011;
[11] *** Definition of *neconvențional* (Ro.), available online at https://dexonline.ro/definitie/neconven%C8%9Bional, accessed 21 February 2018;
[12] *** F.M. 3-05-130, *Army Special Operations Forces Unconventional Warfare,* US Government Printing Office, Washington D.C., USA, 2008, Appendix J, p. 219;
[13] http://www.soc.mil/OSS/jedburghs.html, accessed 23 February 2018;
[14] Dictionary of United States Army Terms, Special Regulation 350-5-1, USA, 1950, p. 15;
[15] *** F.M. 31-21, *Organization and Conduct of Guerilla Warfare,* Washington D.C., USA, 1951, p. 22;
[16] *** F.M. 31-21, *Guerilla Warfare and Special Forces Operations*, Washington D.C., USA 1958;
[17] *** F.M. 31-21, *Special Forces Operations,* USA, 1969, p. 14;
[18] O. Moșoiu, C. Cioacă and I. Bălăceanu, *Using the capital asset pricing model in information security investment,* in the 14th International Scientific Conference eLearning and Software for Education, eLSE, Bucharest, 10.12753/2066-026X-18-220, April 19-20, 2018.
[19] A. Bank, *From OSS to Green Beret: The Birth of Special Forces*, New York, NY: Pocket Books, 1986, p. 179.
[20] O. Moșoiu, I. Bălăceanu, *Managementul acțiunii militare*, editura Academiei Forțelor Aeriene "Henri Coandă", Brașov, 2012;

INNOVATIVE SOLUTIONS AT THE AIRPORTS

Aleksandra ŚLIWIŃSKA

War Studies University, Warsaw, Poland (alesliw@gmail.com)

DOI: 10.19062/1842-9238.2018.16.1.3

Abstract: *In the last couple of years, air traffic is keeping up its growing tendency. Among other factors, this is due to the globalization process, and the wider movement of people who are travelling by air transport. The increase in air traffic flow resulted in airports, which are required and necessary points for the air transport, becoming busier. It has also led to the need to meet the requirement of implementing innovative solutions, aimed to increase major indicators such as security issues, capacity, efficiency, higher passengers flow. Nowadays, all these factors play a key role in the efficient functioning of airports. Fortunately, we may also observe the emergence of new era in industry, which depends and relies more on new technologies and innovative solutions. Many solutions which are directly aimed at improving security, capacity, the speed and safety of the passenger's flow and at the airports' sustainable development are being implemented. The article presents the solutions which have already been implemented, as well as those which may be implemented in order to ensure the higher efficiency of operations, better security indicators, the sustainable development of the airports, as well as the better and more economical air transportation's organization. The main research question was: "Do the implemented innovative solutions help increase airport security, efficiency, capacity and sustainability?"*

Keywords: *aviation, air transport, airports, innovations at the airports, new technologies.*

1. INTRODUCTION

There are many solutions considered innovative, which may be implemented in all branches of people's life. All of them basically rely on the progress made in the areas such as information technology, digitalization, innovations and new, modern technologies. Their implementation has an impact on the faster development of the business sector, which is required by the wide globalization process and huge competition between enterprises. Having the advantage on the market helps, and may conduct to the success of the company. This is also directly connected with the possibility to afford for the new technologies, development and implementation of ready-made tools. In XXI century there is huge competitiveness. Many companies, if they want to survive, are forced to reduce either their productivity or the cost of theirs' production. Although the productivity reduction results in a long-term variable, the costs is reachable and give the short-term variables. That first, depends on the technological environment of the company, their Research & Development and innovation's level, quality of infrastructure, speed of technology-diffusion, advance of innovativeness of the local small-medium size enterprises sector. The impact have also the characteristics such as national business policy, organizational' culture and values, general working ethic, applied management tools and leadership culture, effectiveness of legislative environment and governance, interests' protection activities, general sanitary and health conditions at the workplace, as well as the trust from the society to the certain company.

On the other hand, on the company's competitiveness influences productions' cost which decrease may be achieved by reduction of the labor forces' costs, redistributions' costs (which is directly connected with taxes etc.), capitals' costs (e.g. of the loans), technology-related costs and by reduction of logistics' costs (which basically depends of the distance, transportation system, shipment methods etc. of the goods).

Air transport is the youngest type of transportation. However, it is undoubtedly the most dynamically developing branch. The increase in air traffic flow is keeping since last dozen years (except the crisis in 2009). Thus, as well as the need of adjusting to the modern, many changes on the market and the need of being by the company profitable, caused that aviation sector has to develop, take the actions for continuous improvement and increase quality of it's service. It is known, that only companies which will be flexible enough to adjust themselves to the new challenges and those, which are able to catch up the competiveness and other companies' developments will be able to be profitable, to cope and survive on the market.

2. SELF CHECK-IN INNOVATIONS

The first and the necessary point for air travels are airports. According to Polish law, airports are defined as public use aerodromes scarified for commercial flights and dedicated to commercial purposes. All the actions directed on the extension, improvement of the passengers' flow and the sustainable development of the airports are taken often nowadays. The goal is primarily put on the development of the airports based on the new, better, more efficient passenger and baggage security systems and on the solutions which help to increase passenger comfort at the airports. These changes are basically the solutions and activities which include and focus on improvements in the optimization and more efficient use of check-in and handling facilities. The implementation of solutions for improving the security management, passport control management, baggage handling are also common. All of them, undoubtedly, are new solutions that are included as the improvements of the industry, and which are considered as the innovative results of the industrial revolution.

FIG. 1. KIOSKs at the airport

There are provided plenty of solutions which may affect the quality of service, as well as the security issues at the airports. The first, already implemented almost at all airports are KIOSKs, called also as Common Use Self Service (CUSS). Those are the facilities for passengers to self check-in. The personal check-in may be conducted by all passengers, without any help of the handling agent hired at the airport.

The purpose of the KIOSKs' implementation is, among the others, the decrease of the number of traditional check-in desks [4]. What is more, theirs common use increases the usable area of airport's terminals and decrease the number of personnel needed, and hired for ground handling service at the airport. According to research conducted by one American airline, the use of such machines may bring some benefits as well to the airline. As it was presented, they have noticed that theirs profit after wide implementation of KIOSKs at the airports, where they operate from, had increased. On average, one passenger who is doing check-in by themselves at CUSS, generates 2.50 USD savings. Moreover, according to the same research, check-in with Custom Use Self Service machine by 40% of the passengers worldwide, can annually save 1 billion USD. To the proper functioning of the KIOSKs it is necessary to connect the system with the database which has current information about flights at the certain airport, as well as at the transfer airports. System has to be synchronized with the data of passengers who will be using air transport services in the near future, too. So KIOSKs are innovative, technology advanced solutions.

The success of CUSS caused that the airlines and the airport's management had begun to introduce the devices for self check-in for the passenger's checked luggage. This innovation is limited to the printing tags by the passenger for their own luggage. Although, this system is already used at some European airports, for example in Eindhoven in the Netherlands. Of course, there is provided some support and help of the handling agents in use of the self-check in device for the luggage. This solutions may be somehow a threat for the security aspects, because it increase the possibility of smuggling the forbidden stuffs in the luggage, as well as the thief from, and of, the luggage. On the other hand, so far the success of that solution caused, that some Asian airlines had already started to use and place special KIOSKs for the self- and luggage- check-in even in hotels' lobbies. The progress and development of the society's skills and the high level of theirs computerization will surely cause that printing own luggage's tags will be possible at passenger's homes, as it is common right now with the boarding passes. The implementation of CUSSs, both for passengers' and luggage check-in, instead of the traditional check-in desks at the airports influence onto limitation of its space and makes a possibility of using the free room more efficient. Unfortunately, the use of KIOSKs is a threat to the people as well, because they are replaced by a machine. Although, there are also many benefits of this solution. Among others, there is already mentioned reduction of space at the airports, huge economical savings, more efficient work of the hired at airports people and exclusion of human errors while the operational procedures.

3. INNOVATIONS AIMING TO INCREASE SAFETY AND SECURITY

Since last years, the problem of the losing the luggage while air transport is occurring more and more often. According to the international law, in this kind of circumstances the airlines are obligated to pay a compensation to the owner of missed luggage. To avoid the money expenses on those punishments, a solution for luggage tracking system called Radio-Frequency Identification (RFID) was created. It's been already implemented at Hong Kong International Airport, which is the largest user of this system in the Asia. RFID has generated 3.9 billion USD savings among Asian market, annually. According to Eric Wong, Hong Kong's International Airports' terminal manager, the use of Radio Frequently Identification tags to track and manage the movement of luggage can increase the productivity of ground handling and increase security aspects at the airports, as well as helps to reduce operational cost.

Another solution for better luggage's security management at airports is the implementation of the Integrated Baggage Management. This solution has been already used for several years at John F. Kennedy International Airport (JFK) in New Your City. In 2015, it was estimated that airlines who provide it's service at that airport, thanks to that solutions, can save up to 1.2 billion USD annually.

Bar-Coded Boarding Passes (BCBP) have already been used for decades. However, the aviation industry has started to use them to encapsulated boarding passes few years ago. The International Air Transport Association (IATA) had even decided to support that solutions, aimed for increasing the efficiency and reducing time of the passenger's flow, and promote it globally. What is more, that organization had counted that solution to one out of five IATA's initiatives, which were designed to simplify and speed up the handling processes at airports. The wide use of BCBP is primarily influencing onto reduce of queues at airports and cause of enabling greater throughput and quicker baggage and boarding passes check-in processes.

To enter the restricted area of the airport, every person has to undergo the security checking point. It concerns the passengers, people who are hired at the airport as well as the airline's employees. However, before the security checking, people have to show the appropriate document which confirms and is theirs permission of receiving the access to the airport's operation area. In addition to the traditional, manual checking of document's such as boarding passes for air passengers, or airport staffs' IDs, automatic pass-scanning readers may be used at the airports. What is interesting, in the main Polish airport - Chopin Airport, the authorization checking control is carried out somehow in a semi-automatic way. It is due to the fact that the code reader is fully automated, however, if there occurs any problem with it, there is manual checking carried out by the handling company's employee.

FIG. 2. Identification checking point at Chopin Airport in Warsaw

FIG. 3. Scanner for security control

Is also possible to observe the impact of new technologies and innovative solutions during security checking processes. The traditional manual security control conducted by the magnetic gates includes the scanning of passengers in order to detect metal objects. There can also be used hand-held metal detectors and traces to detect the explosives materials (used for both, passenger's and their hand luggage checking). The security checking of the cabin and checked luggage is carried out usually with the help of a conventional X-ray machine. Those scanners, which are based on advance technology, are used for the checking and scanning what is inside of both, hand/cabin and registered luggage. To those purposes most common are the Heimann scanners, which value exceed 1 billion Euro. Those scanners are highly efficient and are resistant to explosions of any pyrotechnic loads. What is more, those machines are constructed in the way, which helps to protect the machine's operator from any explosion.

The implementation of special cabins, such is presented on the picture, aimed to people's scanning while security controls, is common not anymore only in the United States of America, but also at European airports. These scanners are used e.g. at Stansted Airport next to London. The benefit of the use of those kind of cabins is theirs ability to data savings, identifying suspects who have been considered as a potential threat by the handling and security staff. What is more, those scanners let provide quicker and more accurate scanning of people, because of the better and improved technology.

Next solution, which could contribute even better and more efficient security scanning processes and thereby improve airport security is the implementation of adequate equipment for complete X-ray scanning procedure of the controlled person. These X-ray scanners would have, among others, made it impossible to bring explosives materials and substances on airplane's board. Its implementation at American's airports was common till 2015 [1]. All people before entering the protected part of the airports had actually a choice of being scanned by this kind of scanner. Unfortunately, those scanners were showing the entire silhouette of the controlled person, including the intimate parts. Thus, this was the main reason for the numerous protests of passengers who did not want to "pose" naked to the airport security personnel. This solution also has met the opposition from the humanitarian organizations. This is not surprising that those scanners are not common at the airports anymore. Although the use of such scanners would definitely increase the level of security at airport's operational zone and on the airplane's board. However, the social debate has shown a solution to this, in the eyes of many people, unethical security checking method. The scanning data could be shown to the person, who has access to the received data showing naked person, in a different building than the person who is being controlled.

In the eyes of many people, the bottleneck while handling processes at the airport is passengers' boarding. Long queues, pushing passengers on each other are exemplary defects of the traditional, common use approach while the passengers boarding. The use of electronic gates would have a positive impact on the entry into the aerodrome operating area, as well as would speed up the whole process. The implementation of fully automated gates also would reduce the operational cost due to the reduction of the number of needed handling staff. This solutions is actually implemented at Chopin Airport in Warsaw. However it is still used under the supervision of handling agent.

An analogous solution could be provided on the border control. It's wide implementation would also remove a problem which irritates many passengers traveling primarily to countries outside the Schengen zone. In this case, automated gates could be used to facilitate passport clearance faster and more efficiently. However, those gates could be used, of course, only by those passengers, who have biometric passports.

That automatic checking system is based on the matching the face overview and fingerprints from the passport with the impression and personal appearance of the checked passenger [8]. Using such a solution which is classified to as innovative provides convenience for the passengers and also improves airport security. In Poland this solution is implemented so far only at one airport, in Modlin (which is located nearby Warsaw). The special gate was designed by the Military Technical University in Warsaw and the Border Guards. The automatic passport's checking facility is based on a research project of the Institute of the Optoelectronics from Warsaw. Undoubtedly, the advantage of this solution is the ability to detect possible falsification of documents such as passport [7], and the faster authorization process, in general.

The increase of passenger's comfort at airports may be achieved by implementation of many solutions, which depends on the advanced technology. Few months ago at Amsterdam Schiphol Airport was launched, by KLM airline, a robot, which was called Spencer [5]. This device is a guide for passengers. The KLM's robot is helping the transfer passengers find their way between the gate they entered the airport to another gate, as quick and efficient as it is possible, at that busy transfer airport. Spencer is able to help also to scan the boarding passes, estimate and report how much time it will take to reach any point at the airport. Its implementation eliminates the need of the hired handling support staff, increases comfort and provides passengers with reliable data.

According to law restrictions, to perform the cargo transport service there should be prepared specified documentation. Those include the documents which are required to the national and international transportation, including those forms, agreements which are necessary to be prepared by transportation forwarder and carriers before, during and after the whole good's transporting processes. The basic and essential document for air transport is Air Way Bill – AWB. The obligation of preparing the AWB exists since the implementation of the Warsaw Convention, which was signed in 1929. In this document there is specified the relation between export and import transportation movement. For the valuable cargo goods, packages there are prepared usually also other documents such as: MAWB – Master Air Way Bill and HAWB - House Air Way Bill. To increase the efficiency of the whole air transport system, there had been developed by International Air Transport Association (IATA) the project of E-Freight system. This initiative is aimed onto reduction and speeding up the processes needed to send all required for efficient cargo transportation documents. It leads also to the decrease of the amount of printed documents as well as on higher efficiency, and reduction of the transported cargo's weight (all paper documents used to be flying with the cargo freight on the airplane's board). As it was counted, the E-freight platform helps save even up to 4.9 mld USD annually. Just the use of e-AWB, which is one out of the 30 different documents required in the air transport, leaded to decrease of the need of printed, collected and archived many paper documents. It caused as well as money savings, and also reduced the time of providing services, helped to increase the efficiency of the air cargo's staff and gave a possibility of tracking the cargo package online. IATA counted that the implementation of e-AWB helps to save 7 800 tons of printed paper documents annually.

4. INNOVATIONS CONCERNING AIRPORT SUSTAINABILITY

The negative impact of air transports' pollution emission to the natural environment is unfortunately huge. According to the estimations made by International Civil Aviation Organization (ICAO) in next years it is going to be even worse. However, there are many initiatives, programs created, implemented by various institutions e.g. by European Union, ICAO which are aimed to stop those changes, which occur on Earth.

Airports are places which influence on and generate much pollution emitted to the local environment. Its impact may vary (but stays mainly negative). However, the most annoying seems to be the emission of noise. Apart from these, there are other negative impacts which are destroying and decreasing the value of the environment. The examples of how the airports influence on the local environment are presented on the picture 4.

FIG. 2. Types of waste produced by airports

Fortunately, many steps and actions are taken to protect people and environment from the pollution emitted and released at the airports. A key step in this area and a huge increase in passenger satisfaction may be the change of the airplane's engines for newer, quieter and with release of lower emissions of pollutants to the environment. Other solutions, which also have a positive impact on reducing the amount of pollutants emitted to the atmosphere, ground and water by the air transportation sector is the redesign of the airspace. This can happen due to the succeed and full implementation of the European Union's SESAR initiative. The other solution for protection of the environment is common connection of the aircrafts parked at the airport's ground, to the sources of current from terminal's buildings. Increasing the number of air traffic controllers and decreasing the waiting time for receiving slots to the airport parking area is another, simple solution for reducing the environmental degradation and devastation by aviation sector. Increasingly popular (especially at American airports) philosophy of "Green airports" is a solution that in the next few years will most likely not be astonishing to the public. Already used electric buses, or small, wind power plants are the solutions already found at several airports (mainly American). An example of the airport which wants to be environmentally friendly, and should be an example for the others, is Denver Airport in Texas, USA [2]. There are implemented solar panels which are producing the energy needed at the airport [6]. There also are recycled waste, such as paper, plastic bottles and aluminum. Daily at Denver International Airport is recycled more than 20 types of materials, including restaurant grease, organics, aircraft deicing fluid, glass and demolition materials [9]. The goal in this branch is to introduce that philosophy at other airports around the globe.

5. CONCLUSIONS

All innovations presented and described in this paper are focused on the improvement of management, the processes within the aviation sector, as well as on increasing efficiency and increasing the capacity of current passengers' terminals buildings.

It was estimated that presented solution may conduct to the increase of the airport's capacity in the range of 30 to 60% (with just the reorganization of current infrastructure). Nowadays, improvements at the airports, which are based on the implementation of the solutions based on better and more advanced technology, are conducted to achieve the positive changes in passenger air traffic flow, by its speed up, as well as through optimization of security controls and the use of the tricks which help and let to reduce the handling's service time. Undoubtedly, changes at airports have a greater impact and are more needed than the increase of the flow of airlines' passengers, because the load factor may be increased without such an effort, like the reorganization and changes, which have to be implemented at the airports. There is a tendency at the airports which is based on the reduction of the space needed for the handling service such as passenger's check-in or luggage check-in by using the innovative, revolutionary solutions. The area saved by the implementation of those solutions may be converted into space dedicated for social and commercial purposes. This has an impact on the higher quality service and higher satisfaction of the travelling by air people and a positive economic influence. Optimizing services provided at the airports, as well as operations taken at them, technological advance and increased capacity of the airports may make the airport's more competitive. Thus, it's development may be threaten, because of the changes and the (negative) impact of the airports onto the environment. The threat is also in the limit of enlarging the operational area. Although taking and implementing the solutions which could help to make the airports more eco-friendly can help to make airports more sustainable, than they are now. What's more important, thanks to the implementation of innovative solutions, the airports will be more safe, efficient and open for the new business opportunities [3].

REFERENCES

[1] *** *Amerykanie wycofują z lotnisk "nagie skanery",* January 2013. Available at https://wiadomosci.wp.pl/amerykanie-wycofuja-z-lotnisk-nagie-skanery-6031591005045889a, accessed on 10 Feb 2018;

[2] *** *Denver International Airport Photovoltaic System*, Available at https://energy.gov/eere/solar/downloads/denver-international-airport-photovoltaic-system, Accesse on 10 Feb. 2018;

[3] ****Logistics 4.0- what does the business need?*, February 2017. Available at https://www.trans.eu/en/news/logistics-4-0-what-does-the-business-need, accessed on 19 Dec 2017;

[4] *** *Na lotnisku- odprawa automatyczna*, Available at http://www.lot.com/il/pl/na-lotnisku-odprawa-automatyczna, accessed on 11 Feb 2018;

[5] *** *Robot "Spencer" to guide KLM passengers at Amsterdam Airport Schiphol,* November 2015. Available at https://news.klm.com/robot-spencer-to-guide-klm-passengers-at-amsterdam-airport-schiphol/, accessed on 19 Dec 2017;

[6] C. Proctor, *Denver International Airport's fourth solar power system now producing power*, January 2014. Available at https://www.bizjournals.com/denver/blog/earth_to_power/2014/06/denver-international-airport-s-fourth-solar-power.html, accessed on 11 Dec 2017;

[7] K. Olejarz, *Kontrola paszportowa za pomocą maszyny? Trwają testy pierwszej w Polsce bramki biometrycznej na lotnisku w Modlinie*, February 2017. Available at https://www.tanie-loty.com.pl/blogi/13546-kontrola-paszportowa-za-pomoca-maszyny-trwaja-testy-pierwszej-w-polsce-bramki-biometrycznej-na-lotnisku-w-modlinie.html, accessed on 03 Dec 2017;

[8] P. Kunz, *Czy to przyszłość? Na lotnisku w Modlinie paszporty sprawdza bramka biometryczna*, February 2017. Available at https://www.fly4free.pl/czy-to-przyszlosc-na-lotnisku-w-modlinie-paszporty-sprawdzi-bramka-biometryczna/, accessed on 10 Feb 2018;

[9] S. Houston, *6 Eco-Friendly Airports*, October 2016. Available at https://www.thebalance.com/eco-friendly-airports-282729, accessed on 10 Feb 2018.

UNITED STATES SPECIAL OPERATIONS FORCES IN AFGHANISTAN

Ion BĂLĂCEANU, Constantin-Marian BÎRSAN

"Carol I" National Defense University, Bucharest, Romania
(balaceanugion@yahoo.com, birsan_marian76@yahoo.com)

DOI: 10.19062/1842-9238.2018.16.1.4

Abstract: *This synoptic paper lays out the particularities of the United States Special Operation Forces (SOF) missions in Afghanistan. It describes the activities undertaken by the deployed operational detachments in order to develop and set up a new Afghan security element. The paper focuses on the stages of the process by pointing out the accomplishments and difficulties encountered in the development process for each stage. The authors want to underline the efforts undertaken by the developing team in order to set up the Afghan National Police Provincial Response Company (ANP PRC) in the challenging local and international environment. The study is based on the first hand experience of the author, who was deployed with an US Special Operations Task Force in Afghanistan. During his combat tour, the author was part of the ANP PRC developing team.*

Keywords: *United States Special Operations Forces, Military Assistance, Afghanistan, Afghan National Police - ANP, Provincial Response Company - PRC*

1. INTRODUCTION

The United States deployed its first combat elements in Afghanistan shortly after the 9/11 attacks on World Trade Center, New York. The first units to be deployed consisted of Special Operations Forces (SOF) supported by Intelligence agencies and US Air Force. Their main focus was the defeat of the Taliban forces. Special Operations Detachments conducted combat missions along with the Northern Alliance in order to defeat the Taliban forces in Afghanistan. They were heavily supported by the US Air Force to conduct surgical strikes against key Taliban positions and combat elements. Within just a couple of months, the Taliban forces were defeated and the Taliban regime ousted from power. Immediately after, the North Atlantic Treaty Organization (NATO) [1] established the International Security Assistance Force (ISAF) mission in Afghanistan [2].

ISAF's main line of effort was to develop the Afghan National Security Forces (ANSF) in order to ensure local, regional, and national level security and stability to allow proper reconstruction of key infrastructure and government authorities. Within this line of effort, ISAF forces focused on training, assisting, and combat advising the existing ANSF units. In the same time, as situation on the ground required, ISAF forces helped local and regional authorities to set up new ANSF forces to deal with the security of the local population and to fight the insurgents in the respective areas. In this campaign, Romanian and United States SOF worked together to provide assistance to local and regional authorities.

This is part of the Military Assistance (MA) mission [3] which is performed by SOF. Although, this mission is not as exciting as other SOF missions (for example DA- Direct Action) it is a very important mission because it produces long term effects with regard to security and stability of a country.

During the combat deployments, the US and Romanian SOF helped Afghan local authorities to develop new security forces able to handle the complex security situation in different areas of the country. One of the most successful projects was the establishment of the Afghan National Police Provincial Response Company (ANP PRC). The process of establishing the ANP PRC was not an easy one and it will be the main focus of our short study.

2. BACKGROUND

After the initial push successfully conducted by SOF, the number of the NATO forces involved in the Afghan campaign grew. These forces were tasked to assist the ANSF in securing the country to allow for proper reconstruction. Even though the number of personnel has grown, Afghanistan was facing multiple security challenges. In some areas, security was so bad that reconstruction was impossible. In those areas, there were no public gatherings, no markets, and very limited movement on roads due to the Improvised Explosive Devices (IED). Since their initial deployment, SOF trained, assisted, and combat advised elements of the Afghan National Army (ANA). These were expeditionary forces which conducted missions across wider regions. In the same time, ANA was missing any connection with the regions they were operating in. Therefore, they had access to limited intelligence and support provided by the local population. In this context, SOF quickly realized that the military's main mission is to defend the country from external threats. The force of choice for internal security is the Police. Why? Simply because Police forces are usually recruited from the same area they are operating in. As a result, police officers have better access to accurate and timely intelligence which is the key to success for any operation. Also, being from the area allows police officers to better interact with local population who can provide a wide range of support for the local and coalition security forces.

Given the reasons mentioned above, starting 2009, US SOF part of ISAF SOF focused on developing a police force capable of providing security in some very troubled provinces of Afghanistan. A Memorandum of Understanding (MOU) was signed by ISAF SOF and the Afghan Ministry of Interior. But the simple signing of this memorandum did not change anything on the ground. In the majority of the provinces were ISAF SOF was operating, the security situation was getting worse. The teams deployed on the ground were demanding more ANSF to support their efforts to secure and stabilize the regions. In the majority of cases, the existing Afghan Police forces were low in numbers, poorly organized and equipped. Some of the police officers were corrupted and the local population did not see any difference from them and the Talibans. These factors prevented coalition SOF from securing some areas to allow for reconstruction.

3. ESTABLISHING THE ANP PRC

In the second half of 2009, US SOF started to concentrate more on developing the ANP PRC from a simple idea written on a piece of paper to a credible and effective force which could provide security for the provinces they were operating in. Within this frame, US SOF Task Force deployed with ISAF SOF established a partnering officer at the Task Force (TF) level.

His main responsibility would be to coordinate the efforts of all the teams on the ground in order to develop the ANP PRC. This would turn to be a very challenging task. Initially, there was a simple piece of white paper, like an empty canvas. There were no concepts, doctrine, Military/Modification Table of Organizational Equipment (MTOE), guidance and so on. The partnering officer had to envision a police force that would be capable to deploy throughout the province and effectively conduct high risk missions.

The initial stage took about two months to develop an MTOE. This involved multiple meetings, discussions, debates, and negotiations among different parties. The intent was to create a police force capable of collecting accurate intelligence in order to conduct operations throughout the province. Therefore, the force was designed to encompass an intelligence cell, a strike force, and a support element. To increase effectiveness, the ANP PRC had to be equipped with better and more modern equipment than the average Afghan police officer. This would include computers, intelligence collection devices, armored vehicles High Mobility Multipurpose Wheeled Vehicle (HMMVWs), and weapons optics. The ANP PRC would be controlled by the Afghan Provincial Police Chief and the Governor to avoid misuse of the force. Although this package looks like a military company, the ANP PRC was designed to operate in the volatile Afghan security environment. This is not the police force that most Western countries are used with. It had to be stronger and better equipped to accomplish the intended high risk missions. Also, the ANP PRC was designed as an independent force capable of collecting and processing intelligence to allow proper planning and execution of missions. In this way, the PRC would not have to rely on other agencies to provide intelligence.

The Afghan National Police Provincial Response Company is a tactical level unit of the Afghan Police which managed to achieve operational and strategic effects. PRCs successfully conducted independent high risk, warrant based operations which crippled the insurgent networks in the provinces they operated [4].

The next step proved to be as challenging as the initial one. This was to present the concept to other coalition partners, ISAF and Afghan decision makers. This step looked like an advertising campaign for a new product and involved a lot of discussions among all parties involved. As one can imagine, there was a lot of push back US and Romanian SOF had to deal with. There was a lot of reticence to adapt new forces, because the Afghan battlefield seemed suffocated by operating parties. The hardest entity to convince was the Afghan Ministry of Interior because they had to provide money for salaries. To complicate things even more, creating this structure involved estimating and finding funds to build training, working, and accommodation facilities. At this stage, the project became an interagency effort because it required the involvement of the engineers, both military and civilian, logistics commands, Provincial Reconstruction Teams (PRT), local Afghan companies, and the Afghan Ministries of Interior and Finance. Each one of these entities had to be convinced to support the project. This involved multiple rounds of negotiations and meeting with key personnel. United States and Romanian SOF consistently engaged these agencies to ensure the project is approved, funded, and integrated in the Afghan and coalition battle tracking systems [5].

Once the construction process started, SOF focused on recruiting and vetting of the future police officers. Since, US and Romanian SOF were already working with different local and regional security initiatives, these offered the initial pool of personnel to recruit from. Some of those initiatives were Road Maintenance Teams (RMTs) and Village Security Teams (VSTs). These were security initiatives of the local population who was tired of insurgents and organized into small groups to provide for their own communities security. SOF exploited and supported these initiatives to foster their combat capabilities. The personnel from RMTs or VSTs had been trained and vetted.

Therefore, it seemed like a logic and facile way to recruit the police officers needed to man the PRC in the provinces where these initiatives existed. This process posed legal challenges that SOF had to overcome. They required further negotiations with the Afghan decision makers to identify a legal way to get the locals operating security initiatives into the PRC. Once this was settled, SOF turned to the Police Academy and meritorious police officers throughout Afghanistan.

Simultaneously, SOF had to develop the training program Program of Instruction (POI). This was also a complicated process because the new police force required specialized training that the coalition military did not have. This included evidence collection, evidence handling, and prosecution techniques. Historically, ANSF and coalition forces have learned that it is not enough to capture a bad guy if one cannot provide timely and proper evidence to the Afghan court. In many instances, Afghan insurgents captured after risky operations have walked out of prison because there was little evidence or the existing evidence was compromised. To overcome this, SOF coordinated with deployed coalition police officers to teach the PRC police officers police type of training. Also, SOF coordinated with intelligence agencies to provide the Afghan police officers with the right intelligence training required to collect, analyze, and disseminate effective information to allow mission planning [6].

In the same time, SOF started to identify, track, and deliver the force the required equipment. Again, this stage had its own challenges. There were many instances when the equipment would disappear in the Afghan system. As a result, SOF realized that it had to provide people to track the shipments of equipment in order to get them to the intended beneficiary which was the PRC personnel. Upon completion of training, the PRCs conducted combat operations alongside coalition partners. Gradually, the coalition support reduced to allow the PRC to handle the security situation in their Area of Operations (AO). Eventually, by mid 2010, some PRCs started to conduct successful independent Warrant Based Operations (WBO). These were operations based on an arrest warrant granted by an Afghan judge.

4. KEY FACTORS IN ESTABLISHING THE PRCS

The most important factor was the hard work and dedication the men of the Special Operations Task Force put into this project. These counted many hours of discussions, brainstorming, and sleepless nights to develop the concept. Once the idea came to life, SOF personnel had to work hard to convince key leadership that the PRC is a viable solution to deal with the security challenges in the provinces ISAF SOF was operating. Then, they had to coordinate the interagency effort to build bases. Furthermore, SOF had to fight for money and equipment to support the PRC. Ultimately, they had to test the concept in real and high risk combat operations.

Another key factor was the dedication of some exceptional Afghan police officers. In some of the provinces, the PRCs were commanded by Afghans who understood the importance of this project for the security of their region and country, too. All of them along with the PRCs personnel jeopardized their lives every day to make a better Afghanistan. These officers provided the PRC with the legitimacy required to win the support of the local population who started to see the new force as an effective security provider in the region. Also, having courageous commanders sent a strong message to the insurgents in the area that the PRC will not give up and will continue to fight for the security of the province.

Despite all challenges, the first PRCs declared Initial Operational Capability (IOC) at the beginning of 2010. Furthermore, by mid 2010, there was a PRC in every province where ISAF SOF operational elements were deployed [7].

Moreover, the support of local authorities and population was crucial for the success of the PRC. It is well known that in any counter-insurgency campaign the local population plays a central role in the outcome of the campaign. This was also true for Afghanistan. In the provinces where the PRCs were most successful the local population supported ANSF and confronted the insurgents. Working together, locals, PRC, and coalition forces allowed the local population to return to normal lives, to travel, and to live with no fear for their lives.

Nevertheless, establishing the PRC offered the US SOF a chance to learn valuable lessons which could be used in similar deployments [8].

Ultimately, the relation between Special Operations Forces and their Afghan counterparts was very important for the success of this project. Intercultural skills and training provided to Special Operations Forces personnel before deployments allowed for a great working relationship with the PRC. This relationship was based on trust, respect, and mutual support. Members of the PRC fought and lived alongside with their Special Operations Forces operational teams. This increased the effectiveness of the PRCs and significantly contributed to the security of the provinces. Within this framework, personal relationships mattered the most. The majority of SOF operators were deployed several times in a couple of years in the same province. This gave them the opportunity to work with the same PRC, which saved time and effort in the long run, that would have had to be spent on understanding the operating environment [9].

CONCLUSIONS

The development of the project started in 2009 by the members of the United States Special Operations Force deployed under ISAF SOF command. This process was not an easy endeavor because SOF had to negotiate with many agencies to get this project moving forward. Furthermore, every stage of the development process came with its own set of challenges and obstacles. As a result, SOF had to constantly adapt in order to pursue the desired outcome. Members of the Task Force had to push hard to convince the decision makers about the importance of the PRC for the security of Afghanistan. Additionally, they had to coordinate an interagency effort to build bases, provide money for salaries, and conduct training with the PRCs.

Also, in the same year some PRCs conducted their first independent warrant based operations. This has to be considered a major success given the challenges and short period of time to stand this structure up. Probably, the factor that contributed to the rapid success of the PRC is that this structure was established at the regional level first. The PRC concept was approved at the Ministry of Interior and ISAF level, but was implemented regionally rather than finding a nation-wide solution. Each PRC had its own particularities based on the security situation from the province it operated in. The one-size-fits-all approach does not work in tribal societies. Approaching security at the regional level offered United States Special Operations Forces a greater chance of success in combating insurgency.

Also, it proved that small size elements like the Operational Detachments Alpha can have a significant impact at the operational and strategic level. The PRCs are still operational and they fight every day to provide security and protection for the local population. Also, they contribute to the strengthening of the local government which will eventually lead to a safer and better Afghanistan.

REFERENCES

[1] *** The official webpage of the North Atlantic Treaty Organization, NATO, http://www.nato.int/;
[2] *** United Nations Security Council Resolution number 1386, 20 December 2001, http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N01/708/55/PDF/N0170855.pdf?OpenElement;
[3] *** NATO Military Assistance Handbook, NATO Special Operations Headquarter,Bruxelles, July, 2014, http://istc-sof.org/wp-content/uploads/2016/11/MAHandbook.pdf;
[4] O. Moșoiu, I. Bălăceanu, *Managementul acțiunii militare*, editura Academiei Forțelor Aeriene "Henri Coandă", Brașov, 2012;
[5] *** A.J.P-3.5 NATO Special Operations, NATO Standardization Agreements, Bruxelles, 2015;
[6] *** Special Operations Forces Planning Manual, Bucharest, 2005;
[7] O. Moșoiu, *NATO 28 politici și strategii la început de secol XXI*, editura Academiei Forțelor Aeriene "Henri Coandă", Brașov, 2014;
[8] L.Gherman, O. Moșoiu and V. Bucinschi, *Information resources management based on feedback theory in a military organization*, in the 12th International Scientific Conference eLearning and Software for Education, eLSE, Bucharest, 10.12753/2066-026X-16-017, april 21-22, 2016.
[9] M. Moon, NATO Special Operations Forces in the Modern Security Environment, draft report presented to the Defense and Security Committee of NATO's Parliamentary Assembly, 4 April 2018; https://www.nato-pa.int/download-file?filename=sites/default/files/2018-04/2018%20-%20NATO%20SPECIAL%20OPERATIONS%20FORCES%20-%20DRAFT%20REPORT%20MOON%20-%20064%20DSCFC%2018%20E.pdf .

ROBUST LQG CONTROLLER DESIGN FOR THE SMALL UNMANNED AERIAL VEHICLE

Róbert SZABOLCSI

Óbuda University, Budapest, Hungary (szabolcsi.robert@bgk.uni-obuda.hu)

DOI: 10.19062/1842-9238.2018.16.1.5

Abstract: *This paper deals with the dynamic optimal control of unmanned aerial vehicles (UAVs) in the presence of the stochastic plant disturbances and sensor noises. The LQR static optimal control technique of the dynamical system is used for an ideal dynamics of the aircraft, determined under conditions of no external or internal disturbance, which can be rarely met in the practice. The more realistic dynamical model applied for the controller synthesis is the random dynamical model allowing consideration of both plant disturbances and sensor noises simultaneously. The purpose of the research is to propose and implement the LQG design method for the fixed-wing UAV controller synthesis procedure.*

Keywords: *UAV, modelling, automatic flight control system, dynamic optimal control, LQG design.*

1. INTRODUCTION

Recently, the unmanned aerial aircraft (UAV) has gained a widened range of possible applications. They can be used both for military and non-military applications. The versatile applications inside the two main classes listed above predict a need for the automation of different flight phases. Automation itself serves the need to meet the necessary flight safety level, or serves as the easy-to-use onboard platform supporting the actual user of the UAV.

The recently developed and used drone taxi concept is one of the promising fields of civil application of the UAV. However, the urban area UAV applications, which are not dependent of the application features, require robust control systems ensuring both stability and dynamic performances. Robustness must be provided by the controller designed for the given UAV.

Secondly, the existing UAV regulations often require the onboard autopilot supporting UAV operator for the successful execution of the flight mission. The reason behind this research is to design an optimal, robust dynamic LQG controller for the small UAV, and to present a numerical example, using the results gained during computer aided design and analysis.

2. LITERATURE REVIEW

The problems related to the design of the optimal control systems are in the focus of attention of many scholars since many decades. The early stage, called solution of the minimum energy problem, was exhaustively examined.

The LQR and LQE problem solutions have a long history with many powerful and attractive solutions. Industrial robust control systems are duly demonstrated in [1, 3, 4, 5].

The optimal control theory is elaborated in works of [2, 5, 6, 7, 8, 9, 10, 13]. The optimal control theory is widely applied to design both LQR and LQG controllers for the UAV applications. In [11, 12, 14, 17, 19], the dynamic controller synthesis based on LQ-techniques is presented. The design criteria applied in this article leans on [15, 16].

The robust controller design will be supported by MATLAB and by its required toolboxes [20, 21]. The UAV innovative solutions are thoroughly examined in [22]. The UAV launch is always a challenging task. There is a new concept of the electromagnetic launch, outlined in [23], and the calculations related to magnetic field issues are properly outlined.

3. THE MAIN IDEA OF THE LQG OPTIMAL DYNAMICAL CONTROL

The Linear Quadratic Gaussian (LQG) control problem is formulated for the linearized, time invariant plant model that is disturbed both with process and measurements noises. The random multivariable system is given with the state and output equations as follows below [1, 3, 4, 13]:

$$\dot{\boldsymbol{x}} = \mathbf{A}\boldsymbol{x} + \mathbf{B}\boldsymbol{u} + \mathbf{G}\boldsymbol{w}; \boldsymbol{y} = \mathbf{C}\boldsymbol{x} + \boldsymbol{v} \tag{1}$$

where **x** is a column state vector of length *n*, **u** is the control input vector of length *r*, **A** is an (*n*×*n*) square state matrix; **B** is an (*n*×*r*) input matrix; **y** is a column output vector; **C** is an (*m*×*n*) the output matrix; ***w***(t) is the vector of the process disturbances, **Γ** is the process disturbance input matrix, and finally, ***v*** is the measurement noise.

The plant noise ***w***(t) and measurement $\boldsymbol{v}(t)$ noise are usually assumed to be the uncorrelated Gaussian random processes with zero mean values, i.e.:

$$E\{\boldsymbol{w}(t)\} = 0; \quad E\{\boldsymbol{v}(t)\} = 0; \quad E\{\boldsymbol{w}(t)\boldsymbol{v}^T(t+\tau)\} = 0 \tag{2}$$

The covariance matrices of the two random signals are as follows below:

$$E\{\boldsymbol{w}(t)\boldsymbol{w}^T(t)\} = Q_0 > 0; \quad E\{\boldsymbol{v}(t)\boldsymbol{v}^T(t)\} = R_0 \geq 0 \tag{3}$$

The LQG controller design procedure is based on the minimization of the well-known quadratic optimization criterion as follows below [13]:

$$J_{LQG} = \lim_{T\to\infty} E\left\{\frac{1}{T}\int_0^T (\boldsymbol{x}^T\boldsymbol{Q}\boldsymbol{x} + \boldsymbol{u}^T\boldsymbol{R}\boldsymbol{u})dt\right\} \to Min \tag{4}$$

where matrices ***Q*** and ***R*** represent weighting matrices of the LQR problem, such that $\boldsymbol{Q} = \boldsymbol{Q}^T \geq 0; \boldsymbol{R} = \boldsymbol{R}^T > 0$ and, $E\{.\}$ is the expectation operator. Using separation principle, the LQG design problem can be solved in two decoupled stages [3, 13]:

– Determine the Kalman-estimator optimal static gain ***L*** allowing to reconstitute the estimated $\hat{\boldsymbol{x}}$ of the state vector ***x*** (Linear Quadratic Estimator (LQE) problem);

– Calculate the optimal control law of $\boldsymbol{u} = -\boldsymbol{K}\hat{\boldsymbol{x}}$, where ***K*** is an optimal static feedback gain matrix calculated in solution of the LQR (Linear Quadratic Regulator).

Using the principle of separation outlined above, the state space representation of the observer-based controller is given as follows:

$$\left.\begin{aligned} \dot{\hat{\boldsymbol{x}}} &= \mathbf{A}\hat{\boldsymbol{x}} + \mathbf{B}\boldsymbol{u} + \boldsymbol{L}(\boldsymbol{y} - \hat{\boldsymbol{y}}) \\ \hat{\boldsymbol{y}} &= \boldsymbol{C}\hat{\boldsymbol{x}} \end{aligned}\right\} \tag{5}$$

where Kalman-filter static gain ***L*** of the optimal observer is as follows [1, 3, 4, 5, 10, 13]:

$$\boldsymbol{L} = \boldsymbol{\Sigma}\mathbf{C}^T\mathbf{R}_0^{-1} \tag{6}$$

Matrix ***L*** is a solution of the observer's matrix Algebraic Ricatti equation (MARE) as it is expressed below [1, 3, 4, 5, 10, 13]:

$$A\Sigma + \Sigma A^T - \Sigma C^T R_0^{-1} C\Sigma + GQ_0G^T = 0 \tag{7}$$

Using equations (1) and (5), the following state space model can be derived:

$$\begin{bmatrix} \dot{x} \\ \dot{\hat{x}} \end{bmatrix} = \begin{bmatrix} A & 0 \\ LC & A - LC \end{bmatrix} \begin{bmatrix} x \\ \hat{x} \end{bmatrix} + \begin{bmatrix} B & G & 0 \\ B & 0 & L \end{bmatrix} \begin{bmatrix} u \\ w \\ v \end{bmatrix} \tag{8}$$

Combining equation (1) and (5), the Kalman-filter block diagram can be derived and depicted as in Fig. 1. [1, 3, 4, 5, 10, 13]:

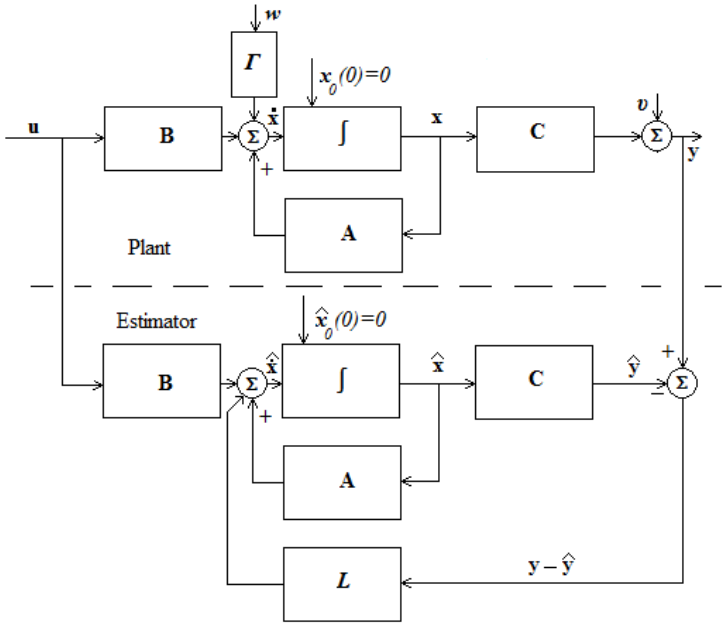


FIG. 1. Block diagram of the optimal Kalman-filter.

The Linear Quadratic Gaussian (LQG) Controller can be completed as follows (Fig. 2.):

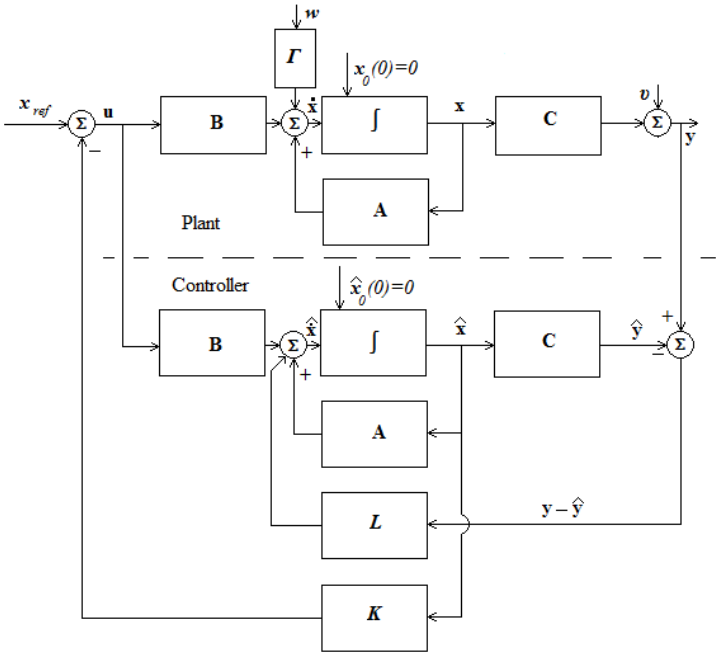


FIG. 2. Block diagram of the LQG Controller.

Combining the Kalman-filter and the LQR equations the following augmented closed loop system state equation can be derived [1, 3, 4, 5, 10, 13]:

$$\begin{bmatrix}\dot{x}\\ \dot{\hat{x}}\end{bmatrix}=\begin{bmatrix}A & -BK\\ LC & A-LC-BK\end{bmatrix}\begin{bmatrix}x\\ \hat{x}\end{bmatrix}+\begin{bmatrix}B & G & 0\\ B & 0 & L\end{bmatrix}\begin{bmatrix}x_{ref}\\ w\\ v\end{bmatrix} \tag{9}$$

4. DESIGN OF THE LQG OPTIMAL CONTROLLER FOR THE SMALL UAV

The identified dynamical model of the short period longitudinal motion of the Boomerang-60 Trainer UAV subjected to external and internal disturbances can be derived as follows [2, 18]:

$$\left.\begin{aligned}\dot{x}=\begin{bmatrix}\dot{w}\\ \dot{q}\end{bmatrix}=Ax+Bu+GW=\begin{bmatrix}-0{,}9966 & 19\\ -3{,}9794 & -12{,}991\end{bmatrix}\begin{bmatrix}w\\ q\end{bmatrix}+\begin{bmatrix}-1{,}2965\\ -18{,}789\end{bmatrix}[\delta_e]+\begin{bmatrix}1\\ 0\end{bmatrix}W\\ y=Cx+v=[1\quad 0]\begin{bmatrix}w\\ q\end{bmatrix}+v\end{aligned}\right\} \tag{10}$$

where w is the vertical speed, q is the pitch rate, δ_e is the angular deflection of the elevators, W is the plant disturbance, and finally, v is the speed measurement noise.

Let us find the stabilizing LQG robust dynamic controller of the Boomerang-60 Trainer UAV depicted in Fig. 2 able to manipulate the vertical speed of the UAV. The closed loop control system of the UAV is supposed to be the oscillatory one, and the expected dynamic performances are as follows below:

$$t_s \leq 1\ sec,\ \sigma \leq 5\ \% \tag{11}$$

where t_s is the settling time calculated for 2% of the tolerance field, and, σ represents the overshoot percent.

By using the $\mathbf{A}, \mathbf{B}$ pair of matrices, the system controllability has been evaluated. The controllability matrix was calculated to be [20, 21]:

$$Co=\begin{bmatrix}-1{,}2965 & -355{,}6989\\ -18{,}789 & 249{,}2472\end{bmatrix} \tag{12}$$

which has a rank of 2, i.e. the UAV dynamical system can be considered for the controllable one.

By using the $\mathbf{A}, \mathbf{C}$ pair of matrices, the observability matrix has been calculated to be [20, 21]:

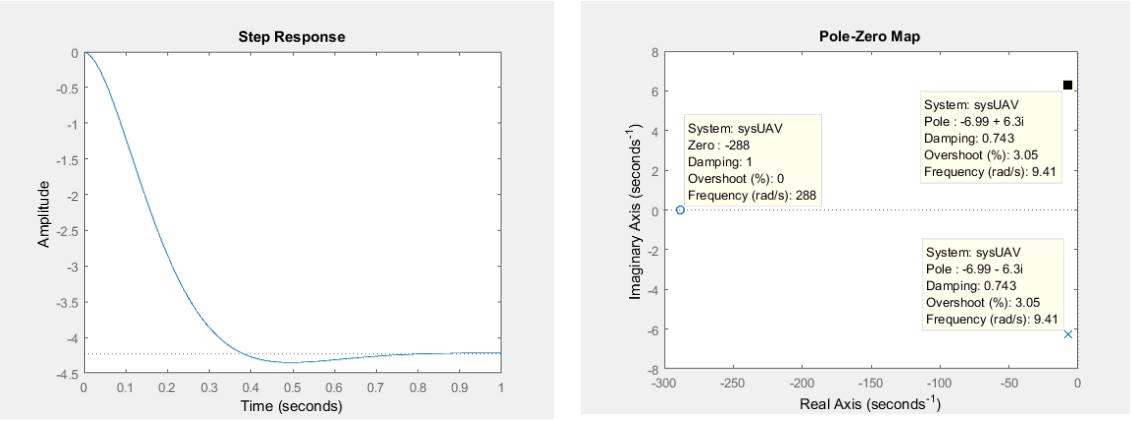
$$Ob=\begin{bmatrix}1 & 0\\ -0{,}9966 & 19\end{bmatrix} \tag{13}$$

which has a rank of 2, i.e. the UAV dynamical system is the observable one.

The time domain behavior of the longitudinal motion of the UAV has been analyzed. The result of the computer simulation can be observed in Fig. 3.a. The input of the UAV was the unit step change in the elevator angular position, i.e. $\delta_e = 1(t)\ deg$. From Fig 3.a it can be easily determined that the UAV vertical speed oscillates around its steady-state value.

The pole-zero map of the UAV's dynamical system defined by equation (10) can be seen in Fig. 3.b. The open loop UAV has two poles on the complex plane. The UAV's behavior is determined by the pair of complex conjugate roots called dominant, and located at $s_{1,2} = -6{,}99 \pm 6{,}3\,i$ on the right-half of the complex plane.

That pair of poles determines the UAV's time domain transient behavior with the damping ratio of $\xi = 0{,}743$, and with the overshoot percent determined by those dominant roots at 3,05% [20, 21].



(a) (b)

FIG. 3. The open loop behavior of the UAV (MATLAB-script: the author).

Using the separation principle, the LQG controller synthesis method consists of two main phases. The first one is the LQR design of the deterministic control system. The second stage is the design of the optimal Kalman-filter to estimate states. The LQR design phase was about finding the optimal state feedback gain matrix. Firstly, unit weights were applied in LQR design phase, and the UAV's closed loop control system has been tested both in time domain and in frequency domain. The system designed that way had dynamic performances different from those recommended by equation (11). After that, many trials were made to schedule dynamic performances into the ranges defined by equation (11). To ensure that the dynamic performance fits in the ranges defined before, the following weighting matrices were chosen heuristically and applied to minimize linear quadratic integral performance index:

$$\boldsymbol{Q} = \begin{bmatrix} 10000000000 & 0 \\ 0 & 0.000001 \end{bmatrix} \tag{14}$$

The optimal feedback gain matrix $\boldsymbol{K}$ and the Lyapunov (cost) matrix $\boldsymbol{P}$ were calculated using MATLAB software to be as follows [20, 21]:

$$\boldsymbol{K} = [-998{,}6082 \quad -13{,}2355]; \boldsymbol{P} = 10^6 * \begin{bmatrix} 6{,}9975 & 0{,}0486 \\ 0{,}0486 & 0{,}0037 \end{bmatrix} \tag{15}$$

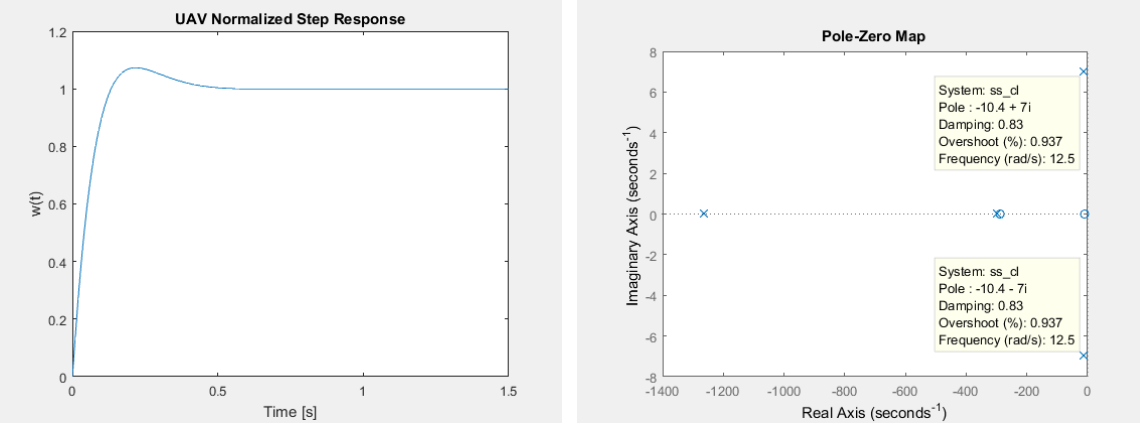
The linear quadratic estimator (LQE) optimal static gain was calculated for the following noise intensities [20, 21]:

$$Q_0 = 0{,}1; \text{ R=0,001} \tag{16}$$

The optimal Kalman-filter gain matrix $\boldsymbol{L}$ and the Lyapunov (cost) matrix $\boldsymbol{\Sigma}$ were calculated using MATLAB software to be as follows [20, 21]:

$$\boldsymbol{L^T} = [6{,}8207 \quad -1{,}0496]; \boldsymbol{\Sigma} = \begin{bmatrix} 0{,}0068 & -0{,}0010 \\ -0{,}0010 & 0{,}0003 \end{bmatrix} \tag{17}$$

The LQG regulator has been formed using MATLAB. The closed loop step response time domain behavior can be seen in Fig. 4. The UAV's closed loop control system is subjected to the input of $w_{ref} = 1(t)$.



(a) (b)

FIG. 4. The behavior of the UAV's closed loop control system (MATLAB-script: the author).

Considering Fig. 4.a, it is easy to see that the UAV's closed loop system based on an LQG robust controller responds very fast, and the unit input is maintained. The closed loop control system poles and dynamic performances are tabulated in Table 1. [20, 21]:

Table 1. Closed Loop Poles and Performances

Pole	Damping ratio ξ	Frequency (rad/sec)	Time Constant (seconds)
$-10{,}4 + 7\,i$	0.83	12,5	0,0961
$-10{,}4 - 7\,i$	0,83	12,5	0,0961
–296	1	296	0,00338
–1260	1	1260	0,000793

Fig. 4.b demonstrates that the four poles of the closed loop control system have a pair of complex conjugates and two roots which are real, negative values located at large distances from the dominant roots. In other words, it means that the UAV's closed loop control system behavior was mostly determined by the dominant roots, and the effects of the remaining two roots can be neglected.

The dynamic performances of the UAV's closed loop dynamical system based on robust LQG controller were found to be:

$$t_s = 0{,}5\ sec,\ \sigma = 0{,}937\ \% \tag{18}$$

Comparing those dynamic performances preliminarily defined by equation (11), and those performances provided for the UAV closed loop control system by the LQG controller based upon optimal gains of ***K*** and ***L*** given in equation (18), it can be stated that weights used for optimal design and given by equations (14) and (16), being chosen totally heuristically, properly fit the design problem.

Results of the computer simulation in frequency domain can be seen in Fig. 5. It can be concluded that the closed loop control system based on the LQG robust dynamic controller is stable, i.e. it has positive gain and positive phase margins. If stricter criteria are to be set for the gain margin, the weights defined by equation (14) applied in LQR design phase, or the LQE weights defined by equation (16) must be scheduled and varied to ensure both open loop control system and closed loop control system dynamic performances.

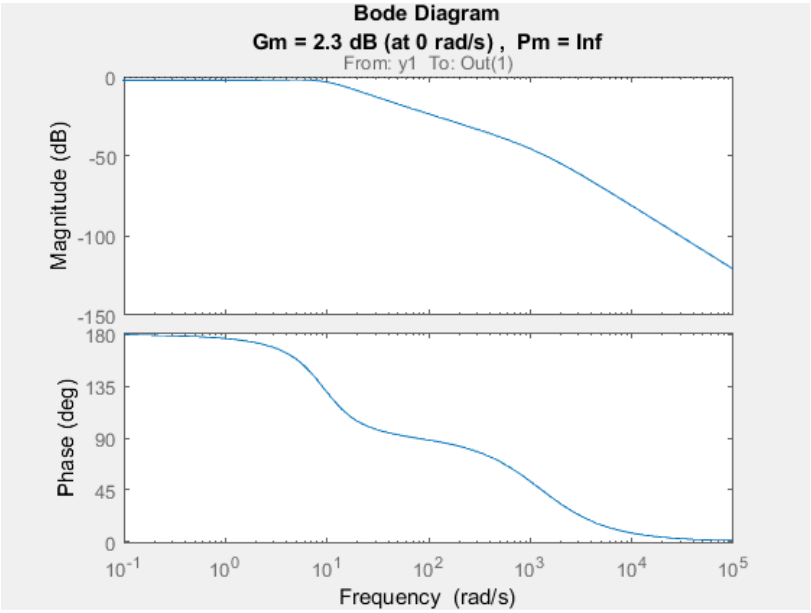


FIG. 5. The behavior of the UAV's open loop control system in the frequency domain (MATLAB-script: the author).

5. CONCLUSIONS

The main goal of this research was to solve the LQG design problem. The air in which UAVs fly is never still. The air turbulence can be considered as plant disturbance applied to the UAV's dynamical model.

The UAV on-board measurement process is a noisy one, due to several reasons. The measurement noise is modelled in output equation of the state space model of the UAV.

Due to the lack of UAV control system data, Bryson's Rule cannot be applied during the LQR design phase. Instead, the unit weighting principle was implemented. The proper set of weighting matrices applied in LQR design stage was found heuristically. The proposed weighting matrices ensured the stable behavior of the UAV's closed loop control system. Moreover, the dynamic performances advised for the small UAV were also within those tolerance domains defined to be met.

REFERENCES

[1] J. M. Maciejowski, *Multivariable Feedback Design*: Addison-Wesley Publishing Company, 1989.
[2] D. McLean, *Automatic Flight Control Systems*. New York – London – Toronto – Sydney – Tokyo – Singapore. Prentice-Hall International Ltd., 1990.
[3] B. Shahian, M. Hassul, *Control System Design Using MATLAB®*: Prentice-Hall, Englewood Cliffs, New Jersey, 1993.
[4] M. J. Gimble, *Robust Industrial Control Optimal - Design Approach for Polinomial Systems*: Prentice-Hall, Inc., 1994.
[5] K. Ogata, *Modern Control Engineering*, New York – London, Prentice-Hall, 1999.
[6] R. S. Burns, *Advanced Control Engineering*: Butterworth-Heinemann, Oxford-Auckland-Boston-Johannesburg-Melbourne-New Delhi, 2001.
[7] G. F. Franklin, J.D. Powell, A. Emami-Naeini, *Feedback Control of Dynamic Systems*: Prentice-Hall, Pearson Education International, 2002.
[8] R. T. Stefani, B. Shahian, C. J. Savant Jr., G. H. Hostetter, G. H., *Design of Feedback Control Systems*: Oxford University Press, New York-Oxford (2002).
[9] N. S. Nise, *Control Systems Engineering*, John Wiley & Sons, Inc., 2004.
[10] R. Szabolcsi, *Computer Aided Design of Modern Control Systems*, Budapest, Miklós Zrínyi National Defense University, 2011.

[11] H. Chingiz, S. Y. Vural, LQR Controller with Kalman Estimator Applied to UAV Longitudinal Dynamics, *Scientific Research*, 2013, 4, pp36-4, 2013 (http://dx.doi.org/10.4236/pos.2013.41005)
[12] A. Zulu, S. John, A Review of Control Algorithms for Autonomous Quadrotors, *Open Journal of Applied Sciences***,** 2014, 4, pp 547-556.
[13] J. Bokor, P. Gáspár, Z. Szabó, *Modern Control Engineering*, Budapest, Budapest University of Technology and Economics, 2014.
[14] H. Lee, B. Lee, D. Yoo, G. Moon, M. Tahk, *Dynamics Modeling and Robust Controller Design of the Multi-UAV Transportation System*, 29th Congress of the ICAS, St. Petersburg, 7-12 September 2014.
[15] R. Szabolcsi, Longitudinal Motion Flying Qualities Applied in Airworthiness Certification Procedure, *Land Forces Academy Review* 74:(2), 208-216, 2014.
[16] R. Szabolcsi, Lateral/Directional Flying Qualities Applied in UAV Airworthiness Certification Process, *Land Forces Academy Review*, 3/2014:(75) pp. 336-346, 2014.
[17] B. K. Aliyu, A. M. Chindo, A. O. Opasina, A. Abdulrahaman, Comparative Design for Improved LQG Control of Longitudinal Flight Dynamics of a Fixed-Wing UAV, *Advances in Research*, 3(5): 477-487, 2015, Article no.AIR.2015.043
[18] R. Szabolcsi, *Automatic Flight Control of the* UAV, Budapest, Óbuda University, 2016.
[19] R. Fessi, S. Soufiene Bouall`egue, *Modeling and Optimal LQG Controller Design for a Quadrotor UAV*,3rd International Conference on Automation, Control, Engineering and Computer Science (ACECS'16), 2016, pp 264-270.
[20] MATLAB® R2017b, User's Guide, The MathWorks, 2017.
[21] MATLAB® Control System Designer/Control System Toolbox 10.3, User's Guide, The MathWorks, 2017.
[22] V. Prisacariu, M. Boşcoianu, A. Luchian: Innovative Solutions and UAS Limits. *Review of the Air Force Academy*, No 2 (26) 2014, pp(51-58), 2014.
[23] L. Gherman: An Electromagnetic Launch System for UAVs. *Review of the Air Force Academy*, No 2/2012, pp(5-11), 2012.

REAL-EMULATED-SIMULATED INTEGRATED ENVIRONMENT FOR TESTING COMPUTER NETWORKS

Daniel-Mihai BENGA, Marian ALEXANDRU

Transilvania University, Brasov, Romania
(benga_daniel@yahoo.com, marian.alexandru@unitbv.ro)

DOI: 10.19062/1842-9238.2018.16.1.6

Abstract: *The goal of this paper is to identify the various problems that may arise within a computer network and monitor them by testing various scenarios encountered in everyday life. The network was configured with the GNS3 emulator simultaneously with SNMP and OSPF protocols in order to highlight the shortest way of data packets from source to destination.*

The results of the different scenarios tested can be interpreted using the MIB Browser (iReasoning), the SNMP protocol, and the CACTI tool so that the results of the different scenarios in the network could be observed.

Keywords: *GNS3, OSPF, SNMP, CACTI, iReasoning*

1. INTRODUCTION

The goal of this paper is to present Cloud integration of modern IP switching and monitoring techniques, validated through complex scenarios that include real, emulated and simulated nodes, with traffic generation, events and failures as well as checking pre-scheduled routing strategies.

Classical routing architectures use virtually a single numbering space that corresponds to the Internet Protocol (IP) and is used to find details about a device, its location and its identity within the network it is part of. One of the most noticeable effects of using a single numbering address was the fast increase of the Default Free Zone (DFZ), which is a consequence of using Traffic Engineering multi-homing or an unacceptable address allocation.

One of the biggest problems that the Internet is facing these days is the worrying rise of the routing tables. If this routing table reaches the limit, then some older routers will be out of memory and will no longer be the default gateway for the parts of the Internet that they connect. Additionally, the existence of larger tables will increase the stabilization time after a change in connectivity, leaving the network inoperative for a period of time.

This issue was addressed in different papers [4]. The negative effect of the increase in this Internet routing table was admitted and from that moment the whole community has begun to analyse the separating possibilities of the location from the identity of a host. This possibility has been discussed over many years, actually looking for a solution to reduce the size of the DFZ area in the Internet.

This problem has been restricted by some conditions, such as: limitation of IPv4 addressing space in the context of the explosion of devices that are connected to the network. A second condition is the emergence of the increasingly prominent market of routers that support both IPv4 and IPv6. The only difference between IPv4 addressing and IPv6 addressing is just the size of the address.

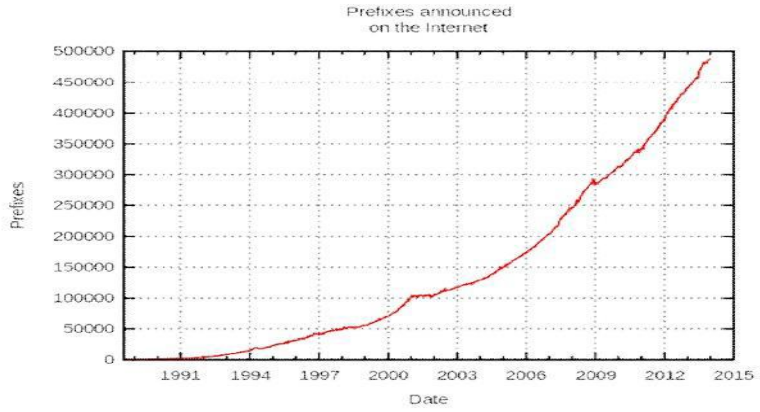


FIG. 1. Increasing the number of prefixes in the Internet
(Source: https://en.wikipedia.org/wiki/File:BGP_Table_growth.svg)

The advancement of the monitoring techniques - by completing any real node configuration via as many virtual nodes as possible and any kind of traffic - has reached the level where the simulator-emulator can become a network manager. The diversification of representation techniques (User Graphic Interfaces), interpretation (QoS calculations - "benchmarking") plus the development of scenarios can be immediately completed with a final step that closes the loop, namely the optimal decision for managing the resources and various exploitation situations (congestion, damage, etc.). The most advanced policy access control policies (PCRF - Policy and Charging Rules Functionality) come in support of these management functions.

2. MONITORING-TEST-ADMINISTRATION

The main purpose for monitoring a computer network is not only to continuously track the operating status of the communicating equipment, or the equipment which is intended for certain services, but also the simultaneous monitoring the load of the communicating channels.

All the information resulting from the monitoring of a network provides support for the rapid identification and fixing of the discovered defects. Two protocols are used to implement these functions: ICMP (Internet Control Message Protocol) and SNMP (Simple Network Management Protocol) [3].

ICMP is a protocol running at level 3 of the OSI model (network layer), and it is not necessary to use a transport protocol (TCP or UDP) or a communication port. The ICMP parameters can be configured to generate a response from the communicating equipment traversed by ICMP packages (trace route, ping route). SNMP [7] is an application-level protocol that includes one or more management stations and multiple managed network elements (server, switch, hub, router, etc.). The SNMP is a communications protocol that allows remote monitoring and management of devices running on an Ethernet network.

Remote administration of a network has some requirements: a SNMP manager, a SNMP agent, a communication protocol (SNMP) and a Management Information Base (MIB). MIB iReasoning browser [8] is a powerful and easy-to-use tool designed by iResoning SNMP API. This is an indispensable tool for engineers to manage the use of SNMP, network devices and applications. It allows users to upload standard or proprietary MIBs. CACTI is a web-based monitoring, open-source and graphics tool that has been designed as an open-source front-end application, allowing a user to analyse services at predetermined intervals, and to make a graph of the data. It is generally used to make graphs from time series of measurements such as CPU load and grid usage.

3. ARCHITECTURE IN GNS3. CREATION OF ARCHITECTURE - TOPOLOGY, STRUCTURE, IP PLAN

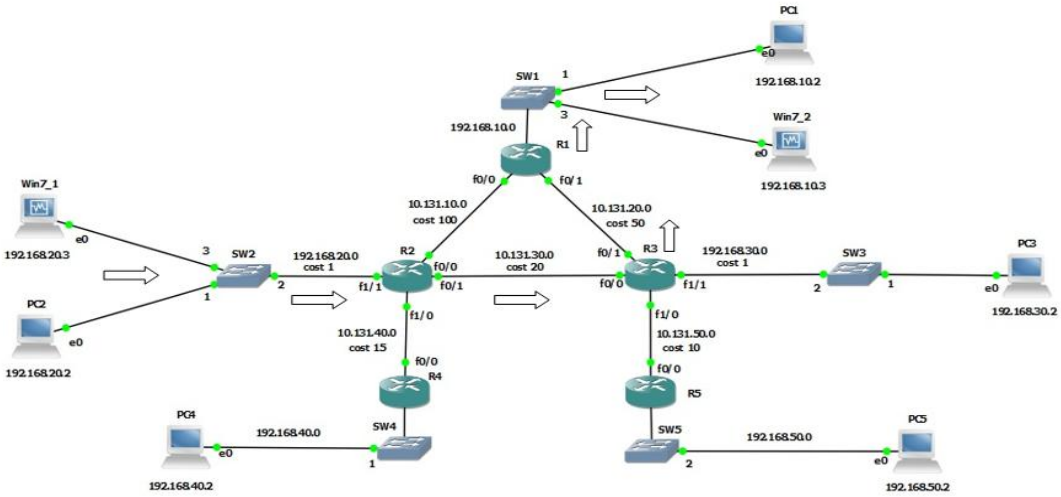


FIG. 2. Network emulated in GNS3

The network emulated in GNS3 is made up of a network that is configured with the OSPF (Open Shortest Path First) protocol [6]. It consists of intermediate equipment such as routers and switches, as well as end devices.

The OSPF protocol [2] is a link-state dynamic routing protocol, unlike other routing protocols such as RIP (Routing Information Protocol) and IGRP (Interior Gateway Routing Protocol) that are distance-vector protocols. This means that all routes know the complete network topology and can make routing decisions without the risk of looping into the network.

In the next figure the algorithm based on which the OSPF routing protocol works is presented, meaning the minimum cost route to a particular destination. As an example for this demonstration PC1 and PC2 were used.

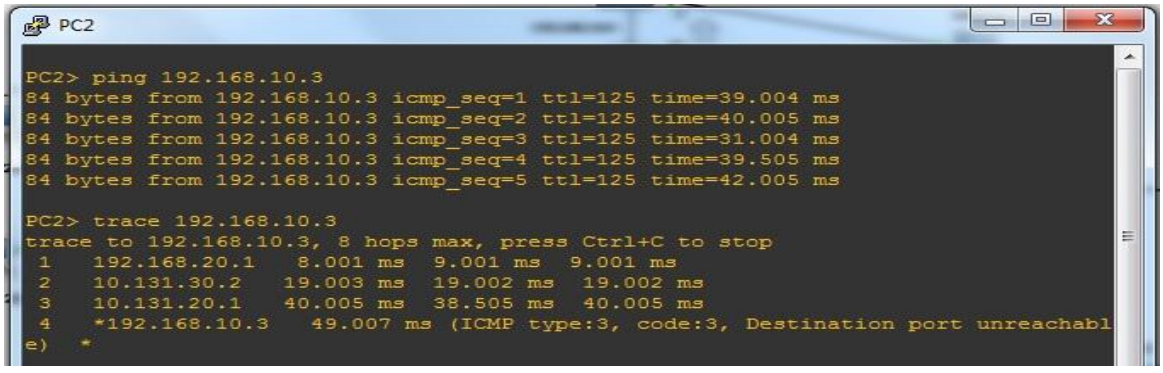


FIG. 3. Trace route between PC1 and PC2

To set the costs on each interface, it was necessary to configure each router with the following parameters.

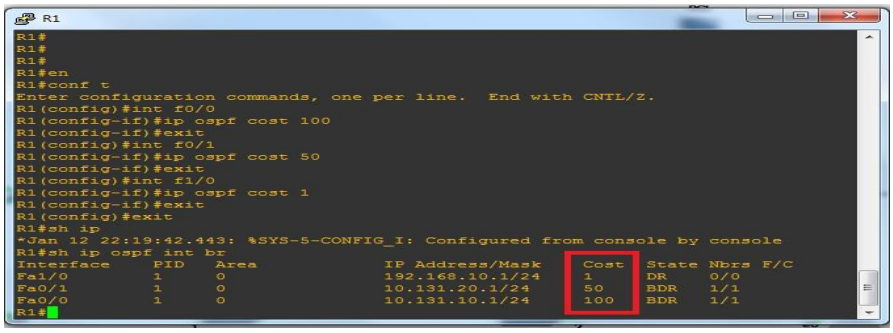


FIG. 4. Costs Checking on Router Interfaces 1

To start monitoring the network created in GNS3, the routers configuration is needed, using the SNMP protocol as follows:

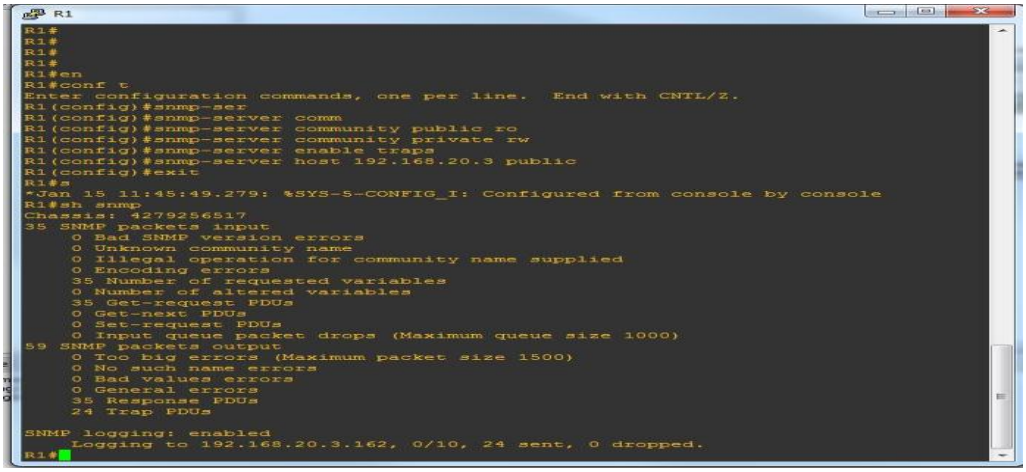


FIG. 5. Configuration R1 with SNMP protocol

For traffic monitoring, and for network administration, the CACTI application was used. To monitor the topology created in GNS3, each device we wanted to monitor was implemented in CACTI [5]. To begin network monitoring, in the Graph Trees menu, a new database was created on the devices we want to monitor. Once the database has been created, it required the introduction of each device that we want to monitor. From the Devices menu, the device was selected and then Create Graph for this Host. After selecting the Create Graph for this Host menu, the type of router tracking we want from the Graph Types menu was selected. Also, two options for monitoring, traffic and processor loading can be selected. To start the device monitoring process in CACTI, is necessary to click on the Graph Trees menu, then select the database, TEST LICENSE TEST.

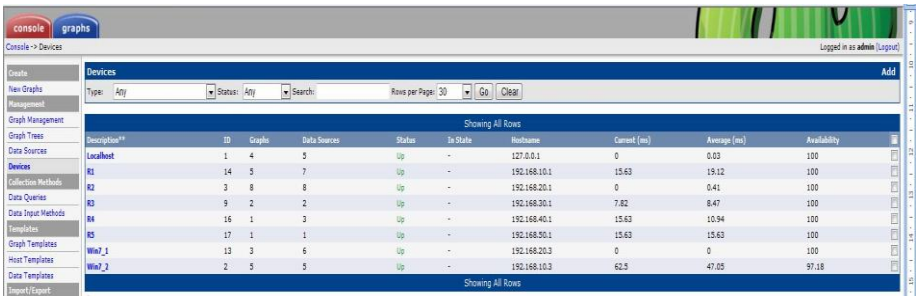


FIG. 6. Devices monitored with the CACTI application

FIG. 7. Selecting the database

After completing the add-on process of the type of devices intended to be monitored, the router's monitoring process is started, instantiating the router processor request tracking charts, as shown in the figure below.

Devices can be monitored for different periods of time, from the last half an hour to months or years. Monitoring is done on routers in different ways: the traffic on each interface, CPU usage.

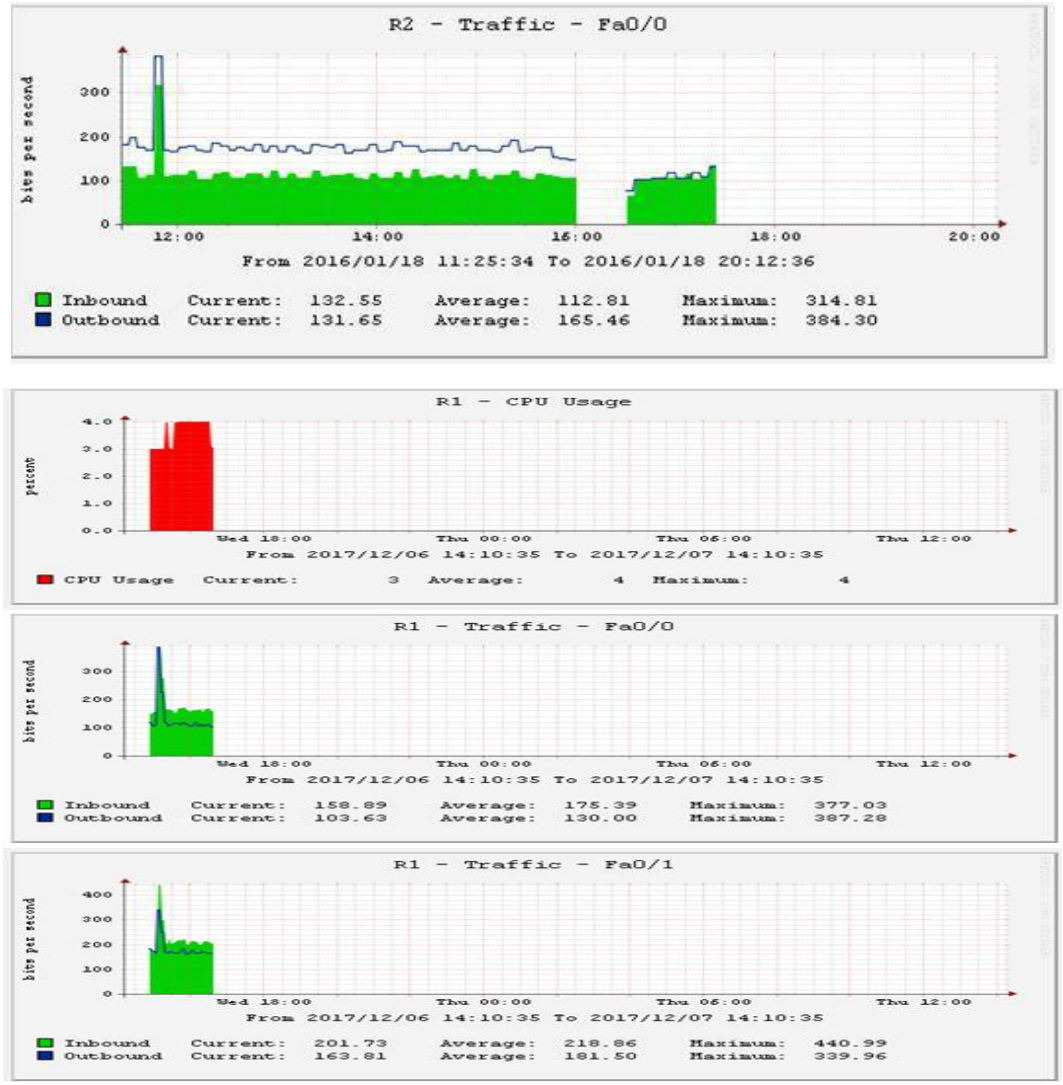


FIG. 8. Selecting the monitoring period

To receive the alarms related to a possible problem with a router, it will be monitored in a MIB browser, iReasoning being used in this case. It tries to restore the connection between the Fa0/1 interface of the router 2 and the F0/0 interface of the router 3. As long as the interface is administratively closed, the transfer of the packets between source and destination is done on another route. When the status of the interface monitored in its original state was changed, iReasoning issued a warning message about how to restore the status of the interface to its original state.

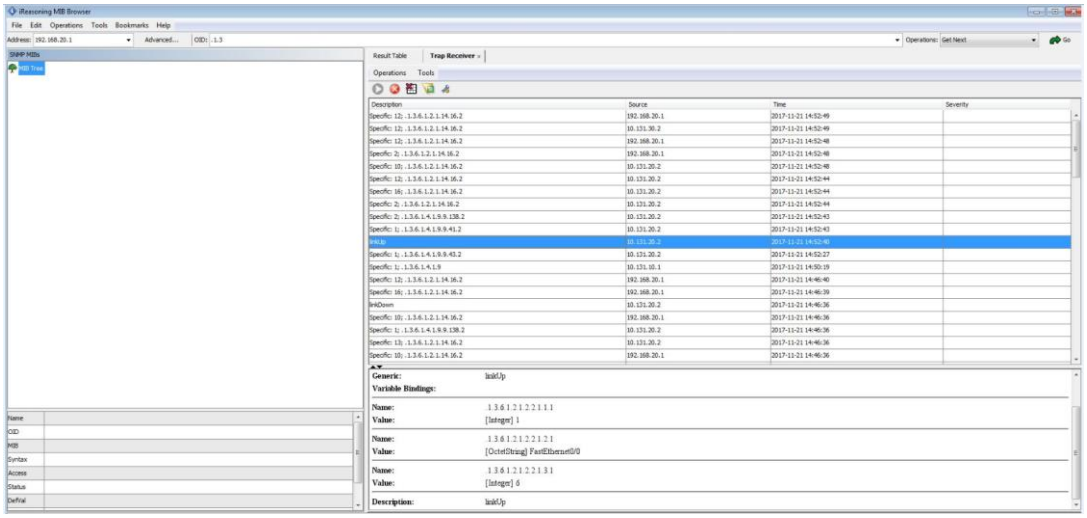


FIG. 9. The appearance of a warning about the incorrect operation of an interface

4. CONCLUSIONS

In order to integrate service-oriented modern IP techniques and computer network monitoring, specialized literature was consulted in order to identify and choose the most modern working technologies.

The test-integration environments have become so powerful that the emulator can turn into a network manager. The analysers can instantiate graphical and statistical representations in the nodes of the tested network for which the modern CACTI solution has been chosen and the scenarios can benefit from the decision-making functions offered by artificial intelligence for which the Management Information Base browser (MIB) was used.

REFERENCES

[1] *** uCertify.com, *uCertify Guide for CompTIA Exam N10-004 Network, Pass your Network Certification in first attempt*, 2010, ISBN-13: 978-1616910051;
[2] H. Helmi, *Monitor the Routing Using OSPF Protocol with Down State Neighbour*, 2011;
[3] A. S. Tanenbaum, *Computer Networks*, 4th Edition, Byblos, 2003;
[4] D.M. Curpen, O.M. Machidon, *Retele de calculatoare*, Transilvania University Press, 2012, ISBN 978-606-19-0177-7;
[5] T. Bălan, D. Robu, F. Sandu, *Integrarea Sistemelor de Calcul şi Telecomunicaţii*, Transilvania University Press, ISBN 978-606-19-0609-3
[6] R. S. Zahidur, *OSPF Network Routing*, Scholars' Press, 2015;
[7] L. Walsh, *SNMP MIB Handbook*, Wyndham Press, 2008;
[8] D.T. Perkins and E. McGinnis, *Understanding SNMP MIBs*, Prentice Hall, 1996.

DESIGN AND DEVELOPMENT OF THE LQR OPTIMAL CONTROLLER FOR THE UNMANNED AERIAL VEHICLE

Róbert SZABOLCSI

Óbuda University, Budapest, Hungary (szabolcsi.robert@bgk.uni-obuda.hu)

DOI: 10.19062/1842-9238.2018.16.1.7

Abstract: *This study deals with the optimal control of unmanned aerial vehicles (UAVs). Concerns about the minimum energy consumption of the UAV are still in the focus of attention of many researchers. The optimal control based on the cost function minimization of the closed loop automatic flight control systems of the UAV is one of the techniques effectively supporting solution of the gain selection of UAV autopilots. Recently, the worldwide application of the UAVs has resulted in the wider application of the computer aided design of the closed loop flight control systems. This study highlights the optimal control of the multivariable UAV control systems, and presents a new design example based on Linear Quadratic Regulator (LQR) optimal control.*

Keywords: *UAV, flight control system, optimal control, LQR design.*

1. INTRODUCTION

The optimal control has a long history. The LQR optimal design technique is still continuing to gain popularity among the optimal design methods currently available. The basic idea behind this method is that control law is designed via the minimization of the pre-defined quadratic integral performance criteria. The dynamical system being considered like UAV dynamics is a deterministic one, so latter work will extend the challenge of the controller design to the random systems. Solution of such design programs is supported often by such computer software as MATLAB®. In this paper, the author will present the solution of the basic mathematical problem using calculus of variations, like solution of the matrix algebraic Ricatti equation (MARE). This method gained degraded importance in modern control engineering. Finally, a design example will demonstrate a numerical example for the solution of the LQR design problem. A unique principle of setting weighting matrices in quadratic integral criteria using unit weights with further heuristic scheduling of weights will be presented.

2. LITERATURE REVIEW

Integral performance indices have been exhaustively demonstrated in [1, 10, 11, 12, 15]. There is a large variety of UAVs, being investigated and demonstrated in control law synthesis meaning. Design of the multirotor UAV, say, tri-, or quad copters are demonstrated in [2, 3, 4, 5]. The fixed-wing UAVs autopilot design examples are duly demonstrated by [6, 7, 8, 9]. The application of the LQR design method applied for finding optimal control laws is elaborated in works [3, 4, 5, 6, 7, 8, 9]. UAV automatic flight control systems design requirements are elaborated and presented in [13, 14]. The solution of the LQR design problem will be supported by MATLAB [16] and Control System Toolbox [17].

The impressive development path of the UAVs segmented to that of the classical and modern era is outlined in [18]. The challenging problem of the UAV integration into air defense is evaluated and a certain solution is proposed in [19].

3. LINEAR QUADRATIC PERFORMANCE CRITERIA

The optimal design of the closed loop control systems is a well-known design technique of the multivariable (MIMO) dynamic systems [1, 10, 11, 12, 15]. Optimal controllers, say, full state feedback gain matrix **K** is designed and scheduled to minimize the performance index describing the cost function of the system. Let us consider the multivariable deterministic system, and, it is also supposed that all *n* state variables are measurable ones and available for the controller. The state and output equations can be given as follows below [1, 11, 12, 15, 16, 17]:

$$\dot{\boldsymbol{x}} = \mathbf{A}\boldsymbol{x} + \mathbf{B}\boldsymbol{u}; \boldsymbol{y} = \mathbf{C}\boldsymbol{x} + \mathbf{D}\boldsymbol{u} \tag{1}$$

where **x** is a column state vector of length *n*, **u** is the control input vector of length *r*, **A** is an (*n*×*n*) square state matrix; **B** is an (*n*×*r*) input matrix; **y** is a column output vector; **C** is an (*m*×*n*) the output matrix; and finally, **D** is an (*m*×*r*) direct feedforward matrix.

For many physical systems the matrix, **D** is a null matrix. Thus, the system state and output equations can be represented in the following notation:

$$\dot{\boldsymbol{x}} = \mathbf{A}\boldsymbol{x} + \mathbf{B}\boldsymbol{u}; \boldsymbol{y} = \mathbf{C}\boldsymbol{x} \tag{2}$$

Block diagram of the open loop UAV dynamics built by equation (2) can be seen in Fig.1.

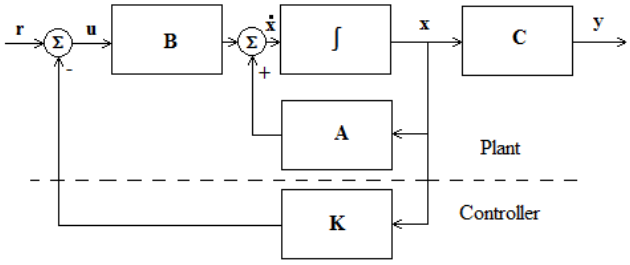


FIG. 1. Closed Loop block diagram.

The control law can be expressed using state feedback gain matrix of **K**, thus:

$$\dot{\boldsymbol{x}} = [\mathbf{A} - \mathbf{BK}]\boldsymbol{x} + \boldsymbol{BKr} = \mathbf{A}_{cl}\boldsymbol{x} + \mathbf{B}_{cl}\boldsymbol{r} \tag{3}$$

To find optimal control law, i.e. optimal state feedback gain matrix $\mathbf{K}_{opt}$ for zero reference signal, ***r***(t)=0, first let us find criteria of optimality. Let us consider a dynamical system with fixed end time, t_f. Let formulate the control problem: choose control vector ***u***(t) such that it minimizes the following cost function [1, 10, 11, 12, 15, 16, 17]:

$$J = \psi\left(\boldsymbol{x}(t_f)\right) + \int_{*}^{*J} L(\boldsymbol{x}(t), \boldsymbol{u}(t), t)dt \rightarrow Min \tag{4}$$

subject to $\dot{\boldsymbol{x}} = f(\boldsymbol{x}(t), \boldsymbol{u}(t), t)$ (5)

with initial conditions of $\boldsymbol{x}(t_0) = \boldsymbol{x}_0$ (6)

where J is the total cost, $\psi\left(\boldsymbol{x}(t_f)\right)$ is the terminal cost.

It I supposed that $L(\boldsymbol{x}(t), \boldsymbol{u}(t), t)$ is the non-negative cost function. Let us augment the cost function of (4) with co-state vector of $\boldsymbol{\lambda}(t)$ [10, 11]. The augmented total cost function now is as follows:

$$J = \psi\{\boldsymbol{x}(t_f)\} + \int_{\cdot}^{\cdot J} \{ L + \boldsymbol{\lambda}^{\cdot}(f - \dot{\boldsymbol{x}}) \} dt \rightarrow Min \tag{7}$$

The function of $\boldsymbol{\lambda}(t)$ can be chosen to be of any mathematical form, because it multiplies term of $f - \dot{\boldsymbol{x}} = 0$. It is well-known that along the optimal trajectory variations both in J and $\bar{J}$ should die as $t \rightarrow t_f$. Variation of the augmented cost function of (7) can be derived as given below:

$$\delta J = \psi_{\cdot} \delta \boldsymbol{x}(t_f) + \int_{\cdot}^{\cdot J} (L_x \delta \boldsymbol{x} + L_u \delta \boldsymbol{u} + \boldsymbol{\lambda}^{\cdot} f_x \delta \boldsymbol{x} + \boldsymbol{\lambda}^{\cdot} f_u \delta \boldsymbol{u} - \boldsymbol{\lambda}^{\cdot} \delta \dot{\boldsymbol{x}}) dt \tag{8}$$

where $\psi_x = \frac{\partial \psi}{\partial x}$, $L_x = \frac{\partial L}{\partial x}$, $L_u = \frac{\partial L}{\partial u}$, $f_x = \frac{\partial f}{\partial x}$, $f_u = \frac{\partial f}{\partial u}$.

Integrating by parts, the last term of the integrand of equation (8) can be expressed in the following form:

$$-\int_{\cdot}^{\cdot J} \boldsymbol{\lambda}^{\cdot} \delta \dot{\boldsymbol{x}} dt = -\boldsymbol{\lambda}^{\cdot}(t_f) \delta \boldsymbol{x}(t_f) + \boldsymbol{\lambda}^{\cdot}(t_0) \delta \boldsymbol{x}(t_0) + \int_{\cdot}^{\cdot J} \boldsymbol{\lambda}^{\cdot} \delta \boldsymbol{x} dt \tag{9}$$

Substituting equation (9) into equation (8) yields to the following augmented cost function:

$$\begin{aligned} \bar{\delta J} = \psi_x \left(\boldsymbol{x}(t_f)\right) \delta \boldsymbol{x}(t_f) + \int_{t_0}^{t_f} (L_u + \boldsymbol{\lambda}^T f_u) \delta \boldsymbol{u} dt + \int_{t_0}^{t_f} \left(L_x + \boldsymbol{\lambda}^T f_x + \dot{\boldsymbol{\lambda}}^T \right) \delta \boldsymbol{x} dt \\ - \boldsymbol{\lambda}^T(t_f) \delta \boldsymbol{x}(t_f) + \boldsymbol{\lambda}^T(t_0) \delta \boldsymbol{x}(t_0) \end{aligned} \tag{10}$$

Initial conditions can't vary at a later time. Thus, the last term in equation (10) is equal to zero. By evaluating the augmented cost function $\bar{J}$ defined by equation (10), it becomes evident that there are three variations inside the equation, which must be independently zero, i.e. any of $\boldsymbol{x}$(t), $\boldsymbol{u}$(t), or $\boldsymbol{x}(t_f)$ can be varied:

$$L_u + \boldsymbol{\lambda}^{\cdot} f_u = 0 \tag{11}$$

$$L_x + \boldsymbol{\lambda}^{\cdot} f_x + \boldsymbol{\lambda}^{\cdot} = 0 \tag{12}$$

$$\psi_{\cdot}\{\boldsymbol{x}(t_f)\} - \boldsymbol{\lambda}^{\cdot}(t_f) = 0 \tag{13}$$

Re-arranging equations (12) and (13) yields to:

$$-L_x - \boldsymbol{\lambda}^{\cdot} f_x = \boldsymbol{\lambda}^{\cdot} \tag{14}$$

$$\psi_{\cdot}\{\boldsymbol{x}(t_f)\} = \boldsymbol{\lambda}^{\cdot}(t_f) \tag{15}$$

The primary difficulty of the solution of that kind of optimal control problem is that state variables of the dynamical system propagate forward, while the co-state equation propagates backwards. The evolution of the co-state vector $\boldsymbol{\lambda}(t)$ is represented in reverse time, from its final state to the initial state. Next chapters deal with the solution of the optimization problems in backward time.

3.1 Solution of the optimal design problems using gradient method. The numerical solutions of the optimal control problems using gradient method can be explained in the following iterative steps and loops [10, 11, 12, 15, 16, 17].

Step 1) Define control input $\boldsymbol{u}$(t), for the given $\boldsymbol{x}_0$.

Step 2) To create the state trajectory, propagate state equation of $\dot{\boldsymbol{x}} = f(\boldsymbol{x}(t), \boldsymbol{u}(t), t)$ forward in time.

Step 3) Evaluate terminal cost function of $\psi_x\left(\boldsymbol{x}(t_f)\right)$, and propagate co-state vector of $\boldsymbol{\lambda}(t)$ backward in time, from t_f to t_0 using equation (14).

Step 4) At each step choose for the control input variation the following formula: $\delta u = -\mathbf{K}\left(L_u + \boldsymbol{\lambda}^T f_u\right)$, where **K** is positive scalar, or, for multi input systems, positive definite matrix.

Step 5) Letting $u = u + \delta u$.

Step6) Go back to Step 2, and repeat the calculation loop until solution converges.

3.2 The LQR solution of the optimal control design problem. Let us set terminal cost at zero, i.e. $\psi = 0$, and let the cost function *L* be defined as follows [10, 11, 12]:

$$L = \frac{1}{2}\boldsymbol{x}^t \boldsymbol{Q}\boldsymbol{x} + \frac{1}{2}\boldsymbol{u}^t \boldsymbol{R}\boldsymbol{u} \tag{16}$$

where, $L \geq 0$, $\boldsymbol{Q} \geq 0$ weighting matrix, $\boldsymbol{R} > 0$ weighting matrix.

For the linear (rather linearized) dynamical systems, one can set following equations:

$$L_x = \boldsymbol{x}^t \boldsymbol{Q} \tag{17}$$

$$L_u = \boldsymbol{u}^t \boldsymbol{R} \tag{18}$$

$$f_x = \mathbf{A} \tag{19}$$

$$f_u = \mathbf{B} \tag{20}$$

so that we have:

$$\dot{\boldsymbol{x}} = \mathbf{A}\boldsymbol{x} + \mathbf{B}\boldsymbol{u} \tag{21}$$

$$\boldsymbol{x}(t_0) = \boldsymbol{x}_0 \tag{22}$$

$$\boldsymbol{\lambda} = -\mathbf{Q}\boldsymbol{x} - \boldsymbol{A}^t \boldsymbol{\lambda} \tag{23}$$

$$\boldsymbol{\lambda}(t_f) = 0 \tag{24}$$

$$\boldsymbol{R}\boldsymbol{u} + \boldsymbol{B}^t \boldsymbol{\lambda} = 0 \tag{25}$$

Being interested in linear dynamical systems, the co-state vector can be represented as $\boldsymbol{\lambda} = \boldsymbol{P}\boldsymbol{x}$, where $\boldsymbol{P}$ is the cost matrix. By substituting this equation into equation (23), and using equation (21), we can get the following matrix-differential equation [10, 11, 12, 15, 16, 17]:

$$\boldsymbol{P}\mathbf{A} + \boldsymbol{A}^t\mathbf{P} + \mathbf{Q} - \mathbf{P}\mathbf{B}\boldsymbol{R}^{-1}\boldsymbol{B}^t\mathbf{P} + \boldsymbol{P} = 0 \tag{26}$$

Equation (26) is the matrix Ricatti equation (MRE). If $t_f \to \infty$, and $\boldsymbol{Q}$=const, and $\boldsymbol{R}$=const, $\dot{\boldsymbol{P}} \to 0, \ \forall t$, i.e. the steady-state solution of the equation (26) can be rewritten as follows [10]:

$$\boldsymbol{P}\boldsymbol{A} + \boldsymbol{A}^t\mathbf{P} + \mathbf{Q} - \mathbf{P}\mathbf{B}\boldsymbol{R}^{-1}\boldsymbol{B}^t\boldsymbol{P} = 0 \tag{27}$$

Solution of the equation (27) called the matrix algebraic Ricatti equation (MARE) yields to the cost matrix $\boldsymbol{P}$. Finding solution to the MARE is supported by many numerical tools in linear algebra.

MATLAB supports solution of Ricatti equations both in continuous (*are.m*) and in discrete time domain (*dare.m*) [16, 17]. Finally, equation $\boldsymbol{Ru + B^T\lambda = 0}$ will determine the optimal feedback law as it given below [10, 11, 12, 15, 16, 17]:

$$\boldsymbol{u = -R^{-1}B^{t}Px = -Kx} \tag{28}$$

where $\mathbf{K}_{opt} = \boldsymbol{R^{-1}B^TP}$ is the optimal state-feedback gain matrix for multivariable dynamical systems, or optimal scalar gain.

The optimal controller synthesis includes following steps [1, 10, 11, 12, 16, 17]:

Step 1) The pair $\{\mathbf{A}, \mathbf{B}\}$ must be controllable, and the pair $\{\mathbf{A}, \mathbf{C}\}$ must be observable by R. Kalman.

Step 2) Define weighting matrices of **Q** and **R** by Bryson's Rule.

Step 3) Solve MARE (equation 27) to find cost matrix of ***P***.

Step 4) Substitute matrix ***P*** into equation (28) to find optimal control law.

Step 5) Check closed loop dynamic performances for similarity with those of the pre-defined ones.

Step 6) If there is no precise match with the required performances, return to Step 2 and change weights heuristically whilst dynamic performances are met.

4. DESIGN OF THE LQR OPTIMAL CONTROLLER FOR THE SMALL UAV

The identified dynamical model of the short period lateral/directional motion of the Boomerang-60 Trainer UAV can be derived as follows below [15]:

$$\begin{aligned}\boldsymbol{\dot{x} = Ax + Bu} &= \begin{bmatrix}\dot{v}\\ \dot{p}\\ \dot{r}\\ \dot{\phi}\end{bmatrix} \\ &= \begin{bmatrix}-0{,}7724 & 0 & -18{,}9671 & 9{,}0867\\ 1{,}9247 & -19{,}9149 & 7{,}7565 & 0\\ 69{,}1314 & -23{,}8689 & -2{,}5966 & 0\\ 0 & 1 & 0 & 0\end{bmatrix}\begin{bmatrix}v\\ p\\ r\\ \phi\end{bmatrix} \\ &++ \begin{bmatrix}0 & 2{,}2582\\ -23{,}8289 & 1{,}5015\\ -11{,}7532 & -15{,}2855\\ 0 & 0\end{bmatrix}\begin{bmatrix}\delta_a\\ \delta_r\end{bmatrix}\end{aligned} \tag{29}$$

where v is the lateral speed, p is the roll rate, r is the yaw rate, ϕ is the roll angle position, δ_a is the angular deflection of the ailerons, and, finally, δ_r is the change in rudder angular position.

Let us find stabilizing LQR controller of the Boomerang-60 Trainer UAV able to manipulate short period motion of the roll position angle. Prior to any kind of design implemented, the dynamical model of the UAV defined by equation (29) must be reduced to that of the short period one. One can get the following state space model:

$$\boldsymbol{\dot{x} = Ax + Bu} = \begin{bmatrix}\dot{p}\\ \dot{\phi}\end{bmatrix} = \begin{bmatrix}-19{,}9149 & 0\\ 1 & 0\end{bmatrix}\begin{bmatrix}p\\ \phi\end{bmatrix} + \begin{bmatrix}-23{,}8289\\ 0\end{bmatrix}\delta_a \tag{30}$$

By using the $\mathbf{A}, \mathbf{B}$ pair of matrices, the system's controllability has been evaluated. The controllability matrix was calculated to be [16, 17]:

$$\boldsymbol{Co} = \begin{bmatrix}-23.8289 & 474.5502\\ 0 & -23.8289\end{bmatrix} \tag{31}$$

which has a rank of 2, i.e. the dynamical system is the controllable one using Kalman-criteria.

By using the $\mathbf{A}, \mathbf{C}$ pair of matrices, the observability matrix has been calculated to be [16, 17]:

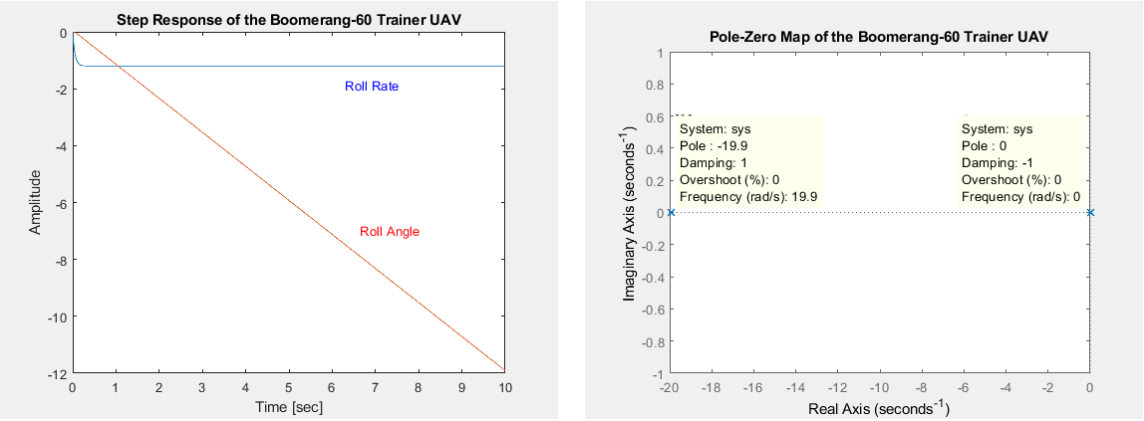
$$\boldsymbol{Ob} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -19.9149 & 0 \\ 1 & 0 \end{bmatrix} \tag{32}$$

which has a rank of 2, i.e. the dynamical system is the observable one using Kalman-criteria.

The time domain behavior of the lateral short period motion of the UAV has been analyzed. The result of the computer simulation can be seen in Fig. 2.a. The input of the UAV was the unit step change in the aileron angular position, i.e. $\delta_a = 1(t)\ deg.$

Fig. 2.a represents the roll rate and the roll angle behavior of the lateral motion of the UAV. The roll rate behaves as an exponential function, while the roll angle is an integral of the roll rate, i.e. it is a monotone increasing function of time.

The open loop UAV has two poles on the complex plain. The poles and dynamic performances can be seen in Fig. 2.b. From these s-plane roots it is easy to see that aperiodic instability can be eliminated using full state feedback, and the design procedure implemented will ensure the optimal solution.



(a) (b)

FIG. 2. The open loop system behavior of the UAV (MATLAB-script: the author).

The UAV closed loop system is supposed to exclude oscillatory behavior, and the dynamic performance expressed in settling time of the closed loop control system used for the design goal was [14]:

$$t_s \leq 2\ sec \tag{33}$$

During controller design, weighting matrices for the first trial have been chosen as follows:

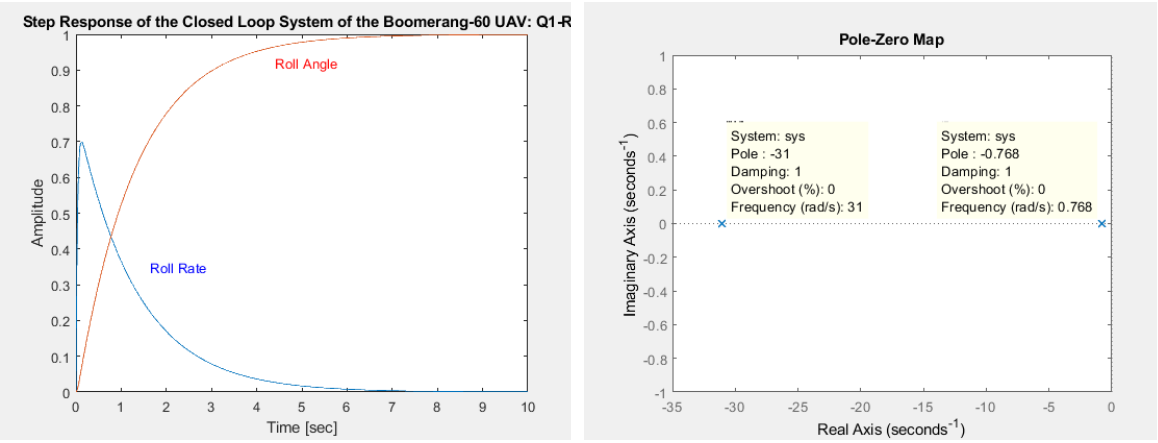
$$\boldsymbol{Q_1} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix};\ \boldsymbol{R_1} \tag{34}$$

The dynamical system is observable and controllable by the Kalman-criteria, thus, the optimal controller can be designed. The optimal controller was designed using the MATLAB *lqr2.m* function. Using equation (34), the cost matrix of ***P***, as solution of the MARE, and optimal state feedback gain matrix of **K** have been calculated to be [16, 17]:

$$\boldsymbol{K_1} = [-0{,}4993 \quad -1{,}0000];\ \boldsymbol{P_1} = \begin{bmatrix} 0{,}0210 & 0{,}0420 \\ 0{,}0420 & 1{,}3351 \end{bmatrix} \tag{35}$$

The closed loop UAV system has been evaluated in time domain. The closed loop system response was found for the unit step change of the roll angle, i.e. $\phi_{ref} = 1(t)\ deg$. Fig. 3.a. represents roll rate and roll angle time domain behavior. Finding settling time for the 5% static tolerance field yields to $t_s \cong 4\ sec$, which represents a very slow behavior of the UAV.

Roots of the closed loop control system of the UAV are located at $p_1 = -31$, and $p_2 = -0{,}768$. Thus, the open loop system root from the origin of the *s*-plane was shifted to that of the new coordinate of $p_2 = -0{,}768$.(see Fig. 3. b.). In other words, the state feedback was used to ensure the stability of the closed loop control system of the UAV.



(a) (b)

FIG. 3. The closed loop control system behavior of the UAV (MATLAB-script: the author).

From Fig. 3.a. it is easy to determine that the closed system time domain behavior is too slow. Therefore, to accelerate the transient response, let us use for the controller synthesis the following weighting matrices set heuristically to be:

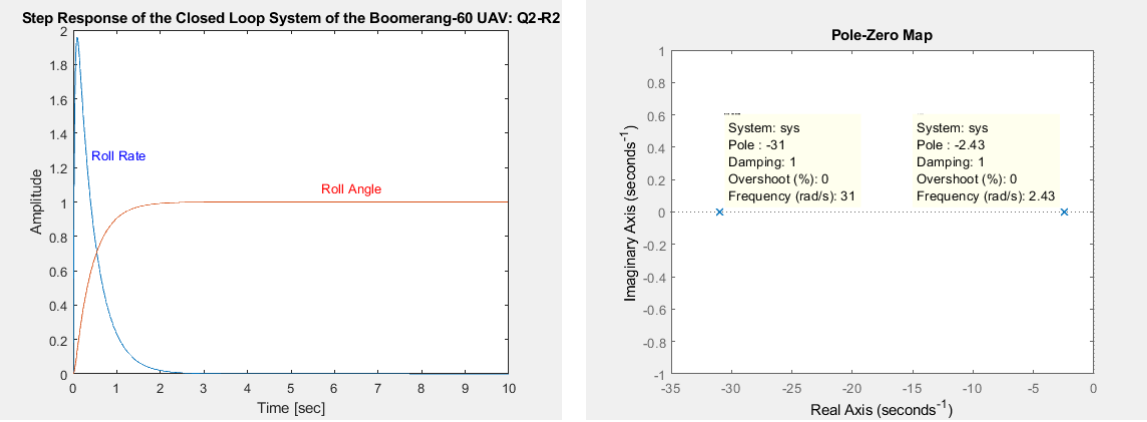
$$\boldsymbol{Q_2} = \begin{bmatrix} 1 & 1 \\ 0 & 10 \end{bmatrix};\ \boldsymbol{R_2} = 1 \tag{36}$$

The optimal controller was synthesized using the *lqr2.m* function of MATLAB. Using equation (36), the cost matrix of ***P***, and optimal state feedback gain matrix of **K** have been calculated to be [17]:

$$\boldsymbol{K_1} = [-0.5656 \quad -3.1623];\ \boldsymbol{P_1} = \begin{bmatrix} 0.0237 & 0.1327 \\ 0.1327 & 4.4316 \end{bmatrix} \tag{37}$$

The UAV time domain behavior has been evaluated. Results of the computer simulation can be seen in Fig. 4.

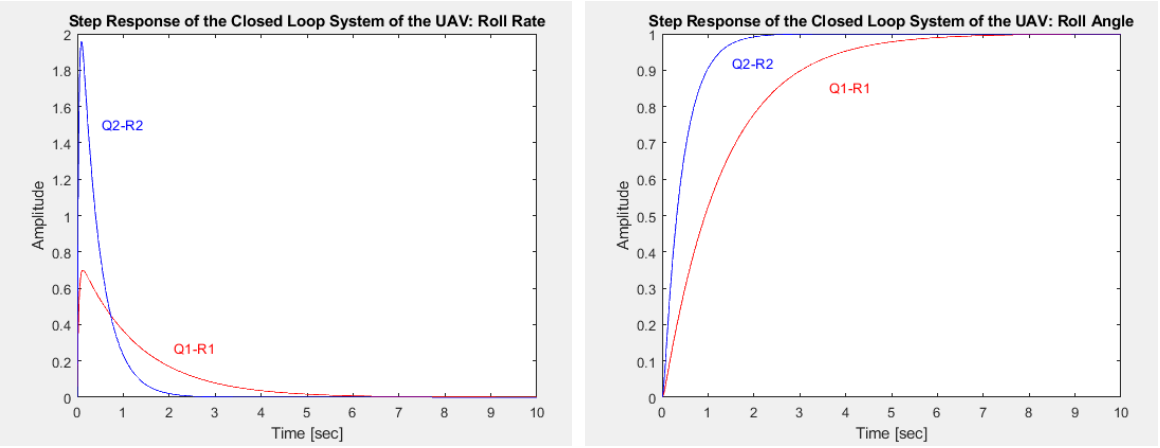
Fig. 4.a. demonstrates that the closed loop system of the UAV has faster response to the reference input. Finding settling time for the 5% static tolerance field yields to $t_s \cong 1{,}5\ sec$, which is in line with the criteria defined by equation (33). In Fig. 4.b. it is easy to see that a pole of $p_2 = -0{,}768$ is shifted to the newest place on the *s*-plane determined by $p_2 = -2{,}43$, whilst position of the pole with coordinate of $p_1 = -31$ is not varied.



(a) (b)

FIG. 4. The closed loop control system behavior of the UAV (MATLAB-script: the author).

The UAV's closed loop systems step responses have been compared. Results of the computer simulation can be seen in Fig. 5.



(a) (b)

FIG. 5. The UAV's closed loop control system behavior with different weights (MATLAB-script: the author).

Fig. 5.b. shows the UAV's roll angle outer loop of the closed loop control system. The heuristic set of the weighting parameters of **Q** and **R** has led to the system response with pre-defined dynamic performances given by equation (33). The roll rate inner loop transient can be seen in Fig. 5.a., which represents a meaningful increase of the maximum value of the roll rate. If such change in the roll rate amplitude is not allowed, weighting matrices of the integral performance index **Q** and **R** must be changed to those which would ensure a more complex and sophisticated set of closed loop dynamic performances.

The heuristic change of the weighting matrices requires high-level engineering experiences deduced from the solution of different problems of modern control engineering and optimal control. Moreover, the engineering intuitions can help scheduling the process described above.

5. CONCLUSIONS

The reason behind this research was to solve the basic optimization LQR design problem. This study has presented the solution to the LQR design method using calculus of variations. The optimal control strategy implemented for the design of the deterministic dynamical systems like UAV spatial motion has kept importance till recent days.

The study has provided striking facts regarding the optimal settings in the closed loop flight control systems of the unmanned aerial vehicles, which is an emerging problem during the flight path design of the UAVs, extending flight radius, or flight time. The proposed method and the design example presented in this paper is the first step in the solution of more complex and challenging engineering design problems.

Next step following the LQR design stage elaborated in this paper is the evaluation of the fitness of the proposed solution to the more sophisticated set of dynamic performance criteria. If there is a lack of any dynamic performances, the static proportional controller of the LQR solution will be supplemented with an integral term, so as to improve disturbance rejection ability. If it leads to extended settling time, a derivative term also must be introduced. The augmentation of the proposed results and future work is about to apply optimal PID-controllers ensuring dynamic performances set prior to.

REFERENCES

[1] J. Bokor, P. Gáspár, Z. Szabó, *Modern Control Engineering*, Budapest, Budapest University of Technology and Economics, 2014.

[2] Z. Tahir, M. Jamil, S. A. Liaqat, L. Mubarak, Waleed Tahir and Syed Omer Gilani, Design and Development of Optimal Control System for Quad Copter UAV, *Indian Journal of Science and Technology*, Vol 9(25), 10.17485/ijst/2016/v9i25/96611, July 2016.

[3] C. Z. Myint, H. M. Tun, Z. M. Naing, Development Of Linear Quadratic Regulator Design For Small UAV System; *International Journal Of Scientific & Technology Research* Volume 5, Issue 07, July 2016.

[4] A. Joukhadar, I. Hasan, A. Alsabbagh, M Alkouzbary, Integral Lqr-Based 6dof Autonomous Quadrocopter Balancing System Control, *(IJARAI) International Journal of Advanced Research in Artificial Intelligence*, Vol. 4, No.5, 2015

[5] D. C. Tosun, Y. Işık, H. Korul, Comparison of PID and LQR controllers on a quadrotor helicopter, *International Journal of Systems Applications, Engineering & Development*, Volume 9, 2015.

[6] K. Turkoglu, E. M. Jafarov, *Augmented optimal LQR control system design for the longitudinal flight dynamics of an UAV: Inner and outer loop concepts*, Proceedings of the 9th WSEAS International Conference on Automatic Control, Modeling & Simulation, Istanbul, Turkey, May 27-29, 2007.

[7] K. K. Yit, P. Rajendran, L. K. Wee, Proportional-derivative linear quadratic regulator controller design for improved longitudinal motion control of unmanned aerial vehicles, *International Journal of Micro Air Vehicles* January-March 2016: 41–50.

[8] C. Hajiyev, S. Y. Vural, LQR Controller with Kalman Estimator Applied to UAV Longitudinal Dynamics, *SciRes Journal*, 2013, 4, 36-41.

[9] H. Purnawan, Mardlijah, E. B. Purwanto, Design of linear quadratic regulator (LQR) control system for flight stability of LSU-05, *IOP Conf. Series: Journal of Physics: Conf. Series* 890 (2017) 012056.

[10] K. Ogata, *Modern Control Engineering***,** New York – London, Prentice-Hall, 1999.

[11] D. McLean, *Automatic Flight Control Systems*. New York – London – Toronto – Sydney – Tokyo – Singapore. Prentice-Hall International Ltd., 1990.

[12] R. Szabolcsi, *Computer Aided Design of Modern Control Systems*, Budapest, Miklós Zrínyi National Defense University, 2011.

[13] R. Szabolcsi, Longitudinal Motion Flying Qualities Applied in Airworthiness Certification Procedure, *Land Forces Academy Review* 74:(2), 208-216, 2014.

[14] R. Szabolcsi, Lateral/Directional Flying Qualities Applied in UAV Airworthiness Certification Process, *Land Forces Academy Review*, 3/2014:(75) pp. 336-346, 2014.

[15] R. Szabolcsi, *Automatic Flight Control of the* UAV, Budapest, Óbuda University, 2016.

[16] MATLAB R2017b, User's Guide, The MathWorks, 2017.

[17] MATLAB Control System Designer/Control System Toolbox 10.3, User's Guide, The MathWorks, 2017.
[18] S. Pop, A. Luchian, R. G. Zmădu, E. Olea: The Evolution of Unmanned Aerial Vehicles. *Review of the Air Force Academy*, No.3 (35)/2017, pp(125-132), 2017.
[19] V. Șandru, M. Rădulescu: The Use of UAV's During Actions of Integrated Air Defense Systems. *Review of the Air Force Academy*, No 3 (30) 2015, pp (133-138), 2015.

HARDWARE RECONFIGURATION OF A SOC

Alexandru DINU, Adrian CRĂCIUN, Marian ALEXANDRU

Transilvania University, Braşov, Romania
(alexandru.dinu.cor@gmail.com, adrian.craciun@unitbv.ro, marian.alexandru@unitbv.ro)

DOI: 10.19062/1842-9238.2018.16.1.8

Abstract: *The continuous advance of science often leaves behind devices, and makes their usage obsolete. This can be observed, for example, in the medical domain, where the performance of devices achieved tremendous capabilities, or in the latest increase of power of computing: today's top-ranked smartphones are comparable in performance with the best desktop computers of the previous decade. Therefore, significant research efforts are directed at the reusability of current technologies by updating them according to new discoveries. Among the existing solutions for device reusability, there are two concepts which are highly ranked: the usage of system-on-chip devices and partial reconfigurability implementation. This paper analyzes the benefits of using these solutions both independently and combined.*

Keywords: *SoC, partial reconfigurability, reusability, hardware, software, fabric area*

1. INTRODUCTION

Nowadays, technology evolves faster than ever. Some of the big steps in technology are represented by:

– the revolution in communications, where VoIP (Voice over IP) calls replace more and more business conversations which before were held mostly through landline phones;

– the development of social networks which allows one to get connected with more than one person simultaneously, due to the fact that a message can almost instantly reach a receiver located in a distant region of the planet;

– the widespread access to the Internet;

– all the facilities brought by a smartphone.

Among the aspects considered when developing a new item in technology, ease of use, performance, reduced costs, and novelty of the product are probably the most important. These are also the aspects further considered in this paper, in which the theory and application of two modern technological concepts relying on current technological advance in electronics is presented: the Partial Reconfigurability of Hardware (an idea that appeared in the sixties but was implemented in the eighties [1] and SoC (System on Chip), first SoC having appeared in 1974 [9].

Then, in terms of the implementation methods of algorithms, the software is appreciated for its flexibility and possibility to be easily updated, through a new release. Also, it is well-known that, in hardware, operational latencies are significantly decreased compared to software, therefore the algorithms run faster. Moreover, hardware equals to parallel computing and, as long as there is available area of the implementation fabric, it can accustom many independent functions which will not influence each other's execution time. The SoC combines both hardware and software, and this is the reason why this kind of device is very appreciated.

Also, partial reconfigurability proves its benefits in saving hardware area and, by making possible the moving of an increased amount of operations from software into hardware, it demonstrates its benefits in terms of processing speed.

2. A STUDY OF PARTIAL RECONFIGURABILITY

A reconfigurable device allows on-the-fly modification of one of his functionalities, while the rest of its functions remain unaffected. The implementation of a project which uses partial reconfigurability is realized in a way which is similar to the implementation of several non-configurable projects which use the same resources. In order to create this kind of project, hardware reconfigurable circuitry of the system (often represented by FPGA – Field Programmable Gate Array) is split in partitions. Some partitions are dynamically reconfigured during device operation, and some of them remain untouched to keep other functionalities available. The last ones are called static partitions, and one of their roles is to maintain the basic functionality of the device (i.e. for a bus slave, the static partition contains the communication protocol, which must be always available in order to respond to the master requests; the dynamic partition could contain different algorithms which represent the behavior of the slave). Fig. 1 shows the way in which a reconfigurable partition was delimited by the rest of design through the tool PlanAhead developed by Xilinx when we implemented partial reconfigurability on Artix 7 FPGA device.

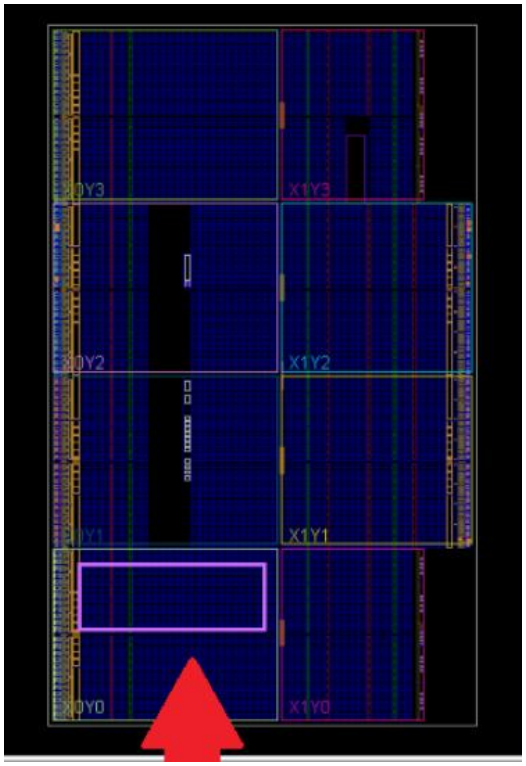


FIG. 1. Defining a reconfigurable partition (shown by the red arrow) in Artix 7 FPGA device using PlanAhead tool from Xilinx

One of the most important aspects is that the functions performed by the "static" partition will not be interrupted by reconfigurations of "dynamic" partitions of circuit. That creates a lot of advantages, some of them being in accordance with such principles as [7]:

– Reducing size of the required device to achieve a functionality, by implementing multiple functions which don't run in parallel on the same area.

– Because of this criterion, another two positive things result: reducing cost for device manufacturing; reducing power consumption by device while operating;

– Providing flexibility in the choices of algorithms or protocols available to an application;

– Enabling new techniques in design security;

– Improving the reconfigured devices' fault tolerance;

– Accelerating configurable computing;

– Implementing new devices, which can't be achieved in the absence of the partial re-configurability feature.

A proper environment to implement the principle of partial reconfigurability is represented by SoC devices, where the device operation is split between reconfigurable hardware and microprocessor. This way, the benefits come both from the flexibility of the software and the rapidity and parallel operation of hardware (according with [3]).

3. SYSTEM-ON-CHIP DEVICES

In a few words, a SoC consists of both hardware and software. Analyzing the details, according with [8], a SoC device represents an integrated circuit on whose logic fabric a lot of electronic system components are designed, from multiple domains: digital electronics, analog electronics, mixed-signal, radio-frequency elements and there can be other examples as well. A SoC device can be composed by a microcontroller (or microprocessor) and advanced peripherals such as a GPU (Graphics Processing Unit), wireless communication modules or another coprocessor. In general, there are three distinguishable types of SoC devices:

– systems which accommodate a microcontroller (i.e. *Xplained Evaluation Kit* for ATxmega128B1 microcontroller);

– systems which accommodate a microprocessor (a widespread example is the base board of smartphones);

– ASICs (Application Specific Integrated Circuit);

– systems which are user-configurable after their manufacturing, in order to perform a wide range of functions (for example PSoC devices from Cypress company or the boards which accommodate an embedded microprocessor on the FPGA fabric). The board *SoCKit - the Development Kit for New SoC Device* from Terasic company [5] is a member of the latter family of devices.

SoC devices are widely used in a lot of industry fields and for many purposes such as manufacturing of smartphones, tablet computers, wearables, digital cameras, wireless routers and the list can be continued (adapted after [10]).

The board mentioned before, *SoCKit - the Development Kit for New SoC Device*, is built around *FPGA Altera Cyclone V System-on-Chip.* A rough guide for the structure of this integrated circuit is presented in Fig. 2.

Between the two computational elements, embedded microprocessor and FPGA user-configurable logic, high communication speeds can be achieved. One of the reasons why Altera company (acquired by Intel Company) put the processor into the FPGA fabric is related to software limits: the applications which are built through a program which runs on a computing machine (in this case, the microprocessor) aren't very efficient, because these can produce an overhead to the processor even for simple tasks. Nevertheless, in software, different programs cannot run in parallel on the same core (however, these can run in pseudo-parallel, based on execution threads), and this fact creates another delay in achieving responses of the programs.

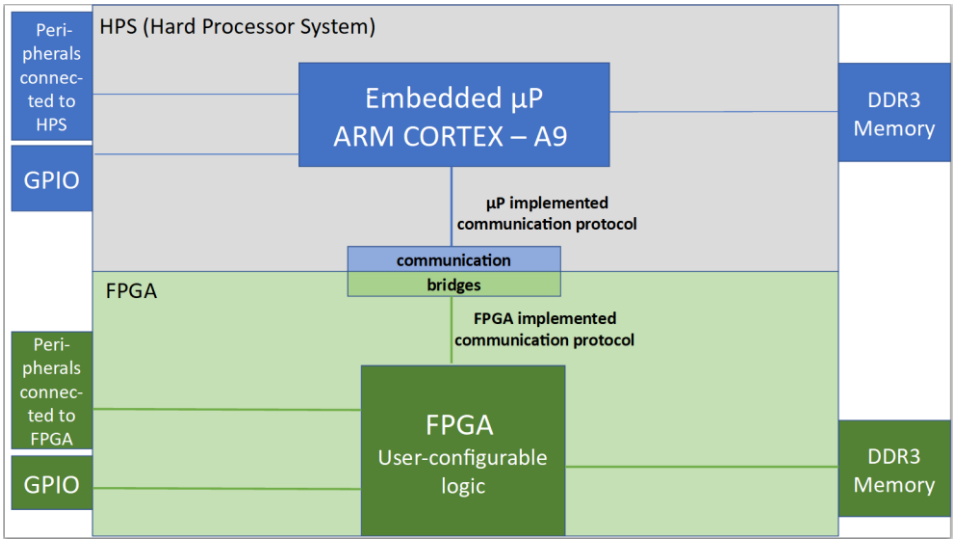


FIG. 2. Structure of *FPGA Altera Cyclone V System-on-Chip* integrated circuit drawn on an indicative basis.

In hardware, it is possible for different algorithms to run in parallel (the condition is that the parallel running algorithms do not share the same resources, as a memory with only one communication port, for example), and the operations often can be implemented more effectively than in a software solution. Here, it is necessary to be stated that there are two major kinds of hardware implementation target devices: ASICs and FPGAs.

When there is a large production of devices (millions of items), the ASICs are more convenient because a low price per item is achieved. The downside is that ASIC isn't upgradable, having a fixed structure and, thus, it can't be updated with the evolution of technology. A lot of devices which sometimes were bought for a huge price, aren't used anymore now, because their technology is too old as compared to the newest discoveries and it can't be updated. For instance, the pneumatic extradural intracranial pressure monitor replaced in 1980 the existing device for detecting ICP (intracranial pressure) from a site outside the dura (the outermost and toughest membrane covering the brain) with its very complicated and fragile pressure sensors (adapted after [4]).

Furthermore, in both ASIC and FPGA devices, implementing complex algorithms becomes a problem because too much area is used. The FPGA devices are more expensive than ASIC devices, but these are flexible and these can be upgradable. Bringing together software (implemented on the microprocessor, which is very flexible, even in what concerns the configuration of the interface, and can be updated as many times as necessary) and hardware (the FPGA, where fast operations can be done) can represent a good solution to make a device more flexible, updatable and reconfigurable in order to achieve dynamic, high performance, and market-request-adaptable appliances.

4. PARTIAL RECONFIGURABILITY INSIDE FPGA DEVICES

Usually, the configuration methodology of an FPGA device implies the generation of a file called *bitstream*. It contains the instructions needed for specific configuration and interconnection of logic blocks (there are two types: CLB – Configurable Logic Blocks - and Configurable I/O blocks) inside the FPGA. Therefore, by creating only one *bitstream* file for entire configurable hardware, it is considered that the gate array represents an atomic entity (adapted after [2]).

In contrast to this idea, partial reconfigurability methodology assumes that an FPGA device is divided in a minimum of two regions, one being called the "static" region and the other being called the "dynamic" region. The "static" region is the FPGA part which is configured only at start-up and after that remains untouched during device operation. The "Dynamic region" is the FPGA part dynamically reconfigured, at multiple times, and with different algorithm versions or with different steps of the same algorithm.

In order to implement partial reconfigurability, the following steps must be considered: after programming the FPGA with a complete *bitstream* file (through this file all logic blocks on the fabric get configured), through partial *bitstreams* one or more partitions (declared "dynamic" before) can be modified in order to extend functionality of device, as shown in Fig. 3.

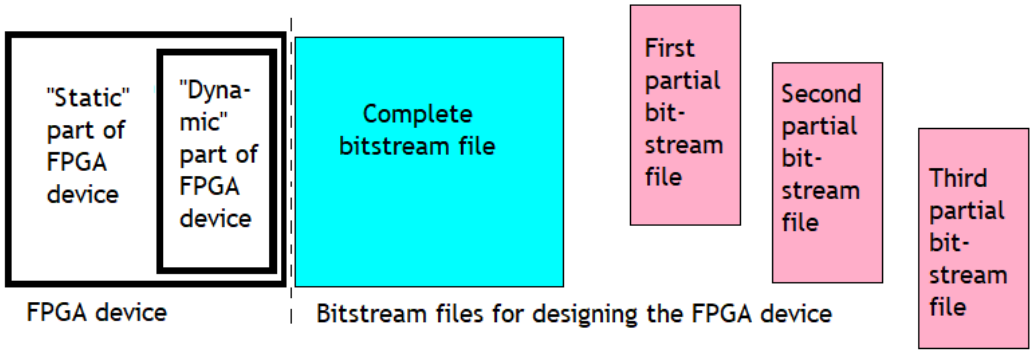


FIG. 3. Schematic of how partial reconfiguration is achieved

5. DIFFERENT WAYS TO IMPLEMENT PARTIAL RECONFIGURABILITY IN SOC

As written above, hardware partial reconfigurability allows the consecutive implementation of different functionalities in the same FPGA partition. Hardware configuration through partial *bitstream* files can be human-driven or realized automatically by microprocessor.

In accordance with [6], there are three possible ways to configure an FPGA: from an external configuration flash memory; with the Quartus Programmer tool; from HPS software.

In this paper, FPGA device configuring through HPS (Hard Processor System) which is on the same fabric was adopted. This method allows device configuration in a remote manner, through the modification of a register by a human, or even automatically, when the register is modified by hardware or software in SoC. In the latter situation, an automated process with negative feedback can be implemented.

6. LOGIC DISTRIBUTION BETWEEN HARDWARE AND SOFTWARE

The information provided so far shows that using both hardware and software in a project brings a lot of advantages. But how to split the logic of a project? Which are the parts which can be implemented efficiently in the hardware, and which parts could be better placed in the software? Below, some guidelines in order to answer these questions are listed.

Mainly, the hardware must contain drivers for peripherals used by designed system. Generally, these drivers communicate with microprocessor through addressable registers by the software; these are used as a medium were acquired data from inputs or data to be transmitted to outputs is stored.

Also, in hardware, the protocol which allows communication with the processor (often, this communication is realized through a bus) is also implemented. Also, the hardware can be used as a support for data processing algorithms. This way, the algorithms could run faster, but a withdrawal is represented by the used area which, as the other resources, is limited. If these algorithms are split in chunks, and every part of them is consecutively downloaded through a partial *bitstream* file into a reconfigurable partition on the FPGA, a big amount of fabric area is saved. In this case, a temporary memory must be used for saving the results produced by an algorithm step in order to be transmitted to the next algorithm step. Also, it must be mentioned that the logic which is in charge with the interface protocol of the microprocessor (it includes registers seen by software, too) must be maintained into the static hardware partitions. This way, registers are always available for software usage.

The software is tasked with the running of data processing algorithms. Also, it reads the data supplied by the hardware and sends back necessary data and commands to it. When necessary, updating its algorithms is a very simple process, consisting in creating a new programming file for the microprocessor.

The logic distribution concept between hardware and software is also represented in Fig. 4.

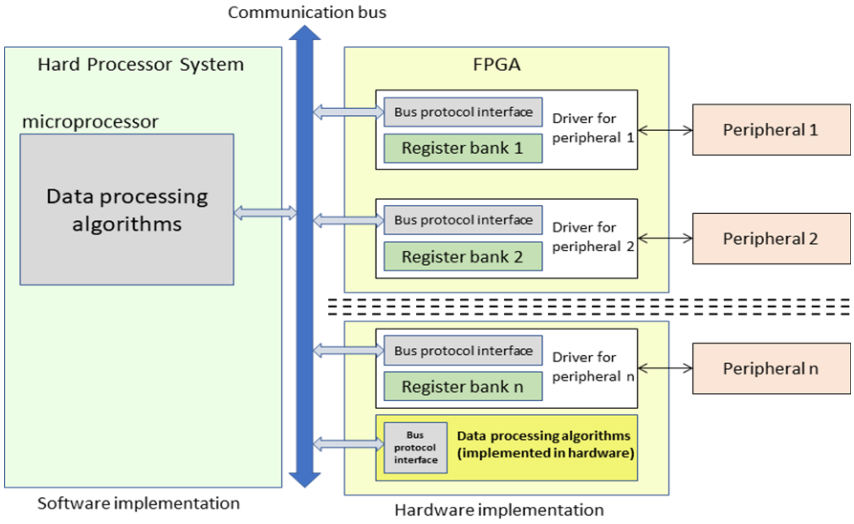


FIG. 4. Representation of the proposed distribution of logic between hardware and software

7. EXAMPLES OF PROJECTS THE EFFICIENCY OF WHICH CAN BE INCREASED BY USING HARDWARE RECONFIGURATION OF A SOC CONCEPT

The main advantages of partial reconfigurability implementation in a SoC relate to area saving, the continuity of device operation during configuration and the increased speed of algorithm execution by moving the logic from software to hardware. Below are some examples to demonstrate these advantages of the method.

1. A domain where partial reconfigurability can also positively influence an application is image processing. Let's suppose that a new version of intelligent military goggles is created. They must adapt instantly at every light changing event: when there is only darkness, infrared vision and thermal imaging must be activated, when a little amount of light appears, infrared vision is partially deactivated but thermal imaging is still working, when a heat source appears, both previous features are deactivated and an algorithm based on sound waves is activated.

The fast changing between algorithms can be achieved through partial reconfigurability. Also, supposing that these algorithms are very complex, their implementation will occupy a large fabric area. But great savings are realized, if these algorithms are implemented into FPGA fabric only during their active usage.

2. Another situation where partial reconfiguration can be really useful is using it into specialized communications terminals used by the military. Let us suppose that a device, which must be always connected to the GSM network in order to transmit critical information, is mounted on a fast car which gathers data from a large area. Because there is a lot of data which must be transmitted, the best available quality of transmission channel must be achieved. In this scope, the communication terminal must be able to fast switch from 4G to 3G network or even to 2G network, if only the last can represent at a given point a stable communication channel with a good signal strength. When a higher communication protocol becomes available, the terminal should be able to switch fast to it. Hereof, partial reconfigurability can be used, a single communication protocol being active at a time.

3. In another case, a SoC device is attached to a robot which works in a human-inaccessible place in order to analyze the environment. Depending on the ground type he is moving on, the robot needs to use continuous tracks, narrow wheels, wide wheels, climbing claws etc. Through infrared sensors, the robot captures data about ground type and analyze it. Therefore, the code of the ground is retained into a register, and based on it, the software is able to reconfigure the proper FPGA partition with the algorithm that the robot must use in order to keep going on.

In the situations above, partial reconfigurability is supposed to be automatically done by software based on specific input stimuli.

8. PROOF OF CONCEPT

To prove this concept on our side, we started to create a simple project using the board *SoCKit - the Development Kit for New SoC Device* consisting of a temperature regulator. The peripherals used are a fan driven by a simple DC motor, the DS18B20 temperature sensor with digital output and an electronic heating element (we have chosen a BD652 integrated circuit which becomes hot due to a current of 0,2 – 0,5A which is driven to it). A schematic of the project is shown in Fig. 5.

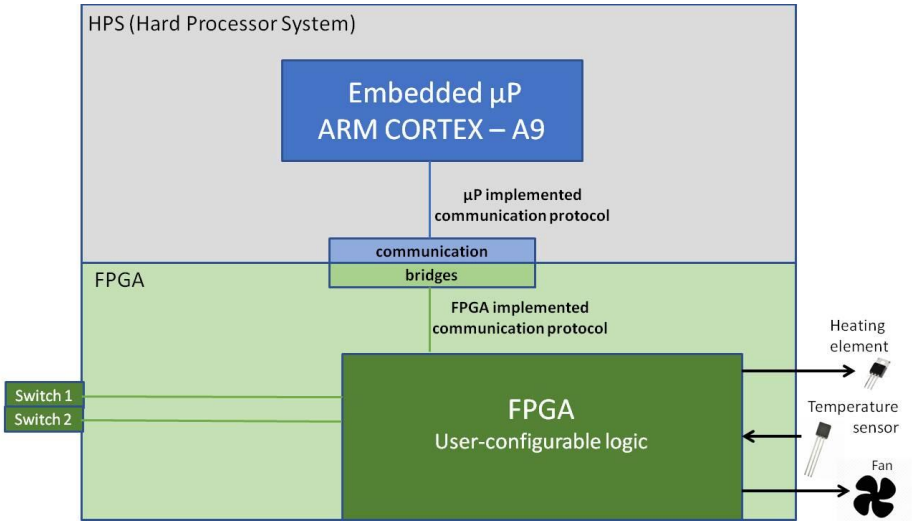


FIG. 5. Schematic of our project started in order to prove partial reconfigurability of a SOC concept

We communicate with the digital temperature sensor DS18B20 through its 1-Wire® protocol. There are multiple operations which the sensor is able to accomplish [11], but we only used the following three: writing scratchpad memory of the sensor, converting temperature in digital representation and reading scratchpad memory of the sensor. These operations can be realized by following the steps presented in Fig. 6.

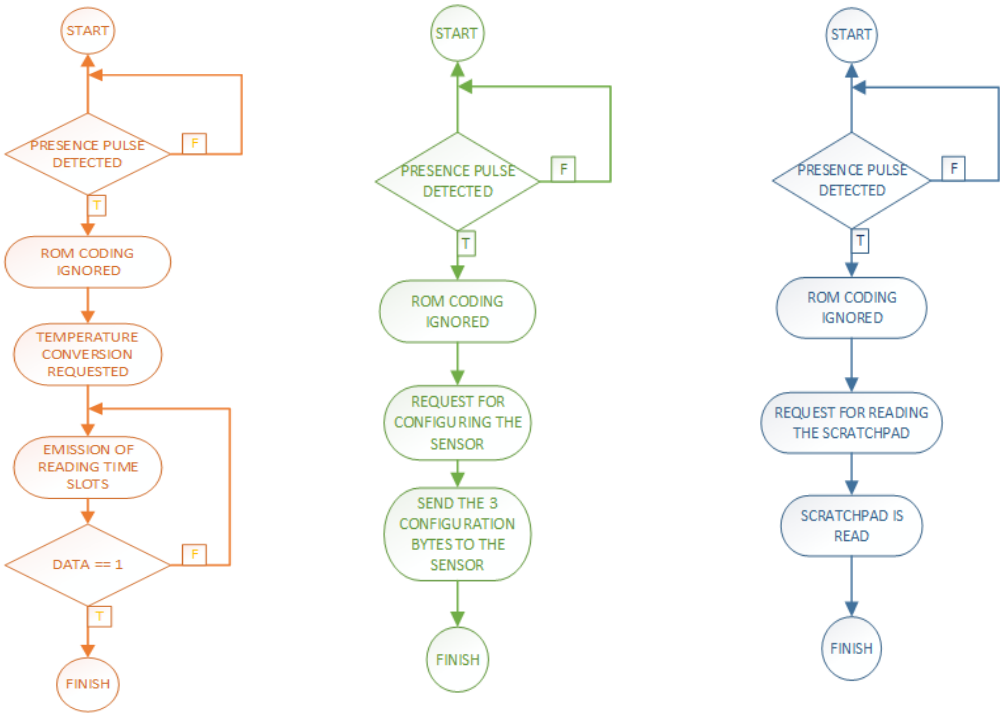


FIG. 6. Steps which must be followed, according to the sensor protocol, in order to:
a) initiate current temperature conversion by sensor to digital representation;
b) configure resolution of the temperature acquired;
c) read the temporary memory of the sensor.
The succession of these three steps makes possible reading the temperature from sensor.

In order to communicate with both microprocessor and temperature sensor in the three ways above, a "dynamic" hardware partition is created into FPGA, and a module for communication with the sensor is implemented inside it. It is connected with the data line of the temperature sensor via an input/output pin. Also, software sends commands to this module through a communication protocol (we have chosen APB – Advance Peripheral Bus – protocol by AMBA). In the example, the microprocessor sets a start bit which is used for starting current operation flow and reads the finish bit which is used to signal that the operation is finished. The start and finish bits belongs to a *control register*: the start bit can be only asserted by software and it is reset in the next clock cycle and the stop bit can be only read by software. Also, there are two more registers which can be accessed by software: the *temperature register* (read only by software) which is 16 bits width and contains valid data only when sensor memory reading operation is implemented and the *configuration register* (written only by software) which is 8 bits width and contains the resolution setting for temperature digital representation (its resolution can be 9, 10, 11 or 12 bits). This register must contain valid data when sensor memory writing operation is running.

Every 10 seconds, the microprocessor starts a reading temperature cycle. To do that, it firstly configures the dynamic partition with the algorithm that contains the operation steps for writing the scratchpad memory and assert the start signal. After finish signal becomes logic "1", the microprocessor loads into the "dynamic" partition the algorithm which contains the operation steps for converting temperature and monitors the finish signal as in the previous step. The last loaded algorithm is the one which reads the memory of the temperature sensor (called scratchpad memory). The data from the memory is saved into *scratchpad data register* which is also existent on the reconfigurable partition, but is used by hardware solely. The two least significant bytes from the *scratchpad data register* contain the value of temperature, are these are therefore copied in temperature register. After the finish signal is asserted again by the hardware, the microprocessor reads the temperature register and, depending of the temperature value, generates a convenient duty cycle for a PWM signal which is used to command the simple DC motor of the fan. The driving operation of the fan is implemented into a "static" partition of the FPGA, and this partition contains a register (written only by hardware) which contains a code of duty cycle value (that can vary between 0% (stopped) and 100% (full speed) with a resolution of 5%).

The heating element driver is implemented into another reconfigurable partition. The BD652 integrated circuit (which actually represents two power transistors in Darlington configuration) can be either heated or cooled (the cooling is realized by stopping the current which passes the integrated circuit) by software in a specific manner programmed by us, or the heating can be started and stopped manually through a switch (Switch 1 in Fig. 5) which is available on the project board. Also, the decision of reconfiguring the dynamic partition with one of the above methods is made by the software which reads a 1-bit register which is set and unset through a second switch (Switch 2 inside Fig. 5) available on the project board.

In Fig. 7 the structure of the FPGA which also was described above is represented. By implementing this project, we are able to prove that partial reconfiguration is a concept that saves FPGA fabric area. Also, because the project is implemented on a SoC device, the dynamic reconfiguration can be done automatically, through the software, in this case creating a well-operating independent device with negative feedback.

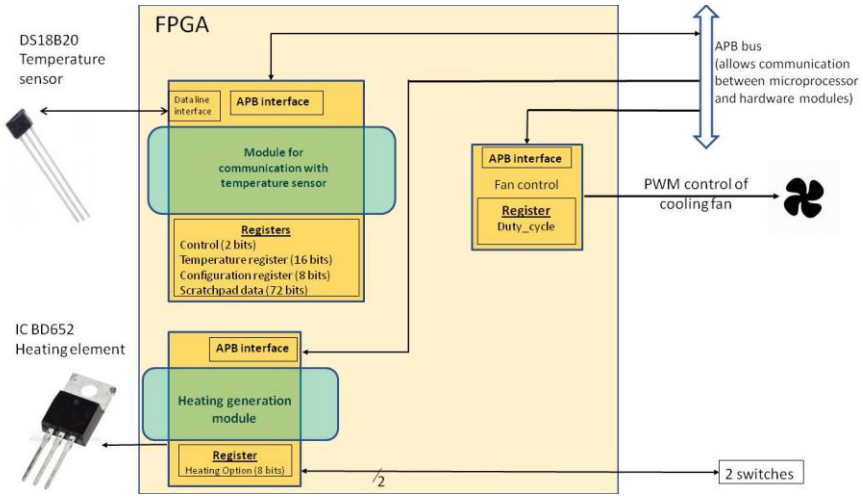


FIG. 7. The FPGA structure used in the project; reconfigurable partitions are colored in cyan.

9. CONCLUSIONS

For the increasing need of having updatable devices which are able to embed the latest discoveries, SoC devices can be chosen as a proper environment to develop competitive devices. And, in order to decrease logic fabric consumption, and therefore being able to move more logic from software to hardware (thus gaining processing speed), partial reconfigurability is always a solution which has to be considered.

This way, technological improvement will be welcomed not only by device manufacturers, who will benefit from shorter time to market cycles, but also by developers, who will be able to prove their concepts faster, and by end-users, who will benefit of enlarged time periods between the acquisitions of products created for the same purpose.

REFERENCES

[1] Radunovic, Bozidar, *An overview of advances in reconfigurable computing systems,* Systems Sciences, 1999. HICSS-32. Proceedings of the 32nd Annual Hawaii International Conference on. IEEE, 1999;

[2] Ashenden, Peter J. *The designer's guide to VHDL*. Vol. 3. Morgan Kaufmann, 2010;

[3] Popescu, V., – *Multimedia*. Editura Tehnică Bucureşti, anul 2000, p.78;

[4] National Academy of Engineering and Institute of Medicine, *New Medical Devices: Invention, Development, and Use*, Washington, DC: The National Academies Press, 1988, p.34;

[5] ***, *Overview page for SoCKit - the Development Kit for New SoC Device*, online resource accessed in April 24, 2018, at the address http://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English &CategoryNo=205&No=816&PartNo=1;

[6] Martin, C., *GSRD v13.1 - Programming FPGA from HPS*, online resource accessed in April 24, 2018, at the address https://rocketboards.org/foswiki/Documentation/GSRD131ProgrammingFPGA*;*

[7] Xilinx, *Partial Reconfiguration User Guide (UG702),* (2012), p.8, online resource accessed in April 24, 2018 at the address https://www.xilinx.com/support/documentation/sw_manuals/xilinx14_1/ug702.pdf;

[8] Daga, A., *SOC (System On Chip)*, online resource accessed in April 24, 2018, at the address https://techbuddiesbyajay.blogspot.ro/2017/10/soc.html;

[9] ***, *1974: Digital Watch is First System-On-Chip Integrated Circuit*, online resource accessed in April 24, 2018, at the address http://www.computerhistory.org/siliconengine/digital-watch-is-first-system-on-chip-integrated-circuit/;

[10] Neagu, C., *Întrebări simple: Ce este un SoC (System on a Chip)?,* online resource accessed in April 24, 2018, at the address https://www.digitalcitizen.ro/soc-system-chip;

[11] Maxim Integrated, *Datasheet for the Programmable Resolution 1-Wire Digital Thermometer,* online resource accessed in April 27, 2018 at the address https://datasheets.maximintegrated.com/en/ds/DS18B20.pdf.

SYSTEM ON CHIP DEVELOPMENT PLATFORM FOR SOFTWARE DEFINED RADIO

Dan DUŞTINŢĂ, Alexandra STANCIU

Transilvania University of Braşov, România (dan.dustinta@student.unitbv.ro, alexandra.stanciu@unitbv.ro)

DOI: 10.19062/1842-9238.2018.16.1.9

Abstract: *In a rapidly growing domain, Software Defined Radio platforms prove to be a sustainable and efficient way of testing and developing new features. By using the Xilinx Zynq-7000 programmable SoC (System on Chip), based on an ARM processor coupled with a FPGA (Field-programmable Gate Array) integrated circuit allows us to combine unique features into flexible and versatile implementations. The platform benefits from the large amount of existing support that a Linux based open-sourced software can bring to an embedded system with the highly reconfigurable logic blocks that can be used with the FPGA. This paper presents the method for setting up an Software Defined Radio work environment around Zynq processing system and Xilinx programmable logic*

Keywords: *SDR, development, platform, open-sourced, FPGA*

1. INTRODUCTION

As technology has moved forward, software development has begun to be highly dependent on the reusability and portability of existing source code. Many successful stratagems are based on this approach, Linux which was developed initially for personal computers has been ported to numerous platforms, including embedded systems. Although traditionally Linux is not a RTOS (Real Time Operating System) it's use in embedded platforms is fueled by great device support, network connectivity, file systems and of course it's UI (User Interface).

On a small embedded system with limited resources Linux is usually not viable, but on a more powerful system like the Zynq-7000 SoC the advantages become increasingly obvious. One could take advantage of the dual core ARM processor to virtualize certain non-critical and not real time dependent functionality on core which uses an embedded Linux operating system. The other core can be used as a "hard" real time operating system for functional relevant features or real-time applications. OpenAMP (Open Asymmetric Multiprocessing) allows multiple processing cores to interact between each other on a single SoC. Usually these software environments can run independently of each other and provide heterogeneous functionalities to the system. Moreover, system like Zynq-7000 SoC gives you the possibility to combine the software programmability of an ARM-based processor with the hardware reconfigurability of an FPGA, enabling hardware acceleration while integrating CPU, DSP and mixed signal functionality on a single device. The features listed above make the Zynq-7000 a good platform for Software Defined Radio (SDR) implementation.

The aim of this paper is to describe the method for setting-up an SDR work environment using the Linux ARM co-processor and the method to implement a minimal System on Chip – SoC using Xilinx Vivado at FPGA(Zync) level, using as radio interface the Analog Devices AD-FMCOMMS3-EBZ board.

This environment will be further used for creation and testing of SoCs in the telecom domain, taking benefit of the existing IP Cores in the Xilinx Vivado library like for example: Coder/decoder 3GPP LTE, Convolution Encoder, LTE FFT, LTE PUCCH Receiver, LTE RACH Detector, 3GPP LTE MIMO Encoder/Decoder.

2. SOFTWARE DEFINED RADIO IMPLEMENTED ON ZYNQ

Software Define Radio (SDR) is a popular prototyping technology for wireless communication systems, software programmability providing flexibility and enhanced utility. In an SDR system, all the signal computations are made on the host computer and then the waveforms are send to the RF front end [1]. Nowadays the signal processing is so computationally expensive, making it very difficult to find a properly host computer. In this paper we intend to show how a platform like Zynq-7000 SoC could be the host computer for an SDR due to its rich architecture. This product integrates a dual-core ARM cortex A9 based processing system (PS) and Xilinx programmable logic in a single device.

This paper intends to be a starting point for an SDR implementation using the Digilent Zedboard and the AD-FMCOMMS3-EBZ radio platform. By using the AD-FMCOMMS3-EBZ evaluation board, the SDR development platform can be used to implement both access network concepts and core network concepts. The ideea of using Zynq-7000 is to run computationally intensive algorithms on the FPGA and compute the rest of the chain using the ARM processors. Beside the existing Vivado IP cores (e.g. Coder/decoder 3GPP LTE, Convolution Encoder, LTE FFT, LTE PUCCH Receiver, LTE RACH Detector, 3GPP LTE MIMO Encoder/Decoder) new IP cores might be implemented in hardware description languages HDL for telecom mobile data networks [2], enhancing the idea of processing the signals into hardware in order to gain high speeds and low latencies.

One option for wireless communications implementations would be the use of the opensource GNU Radio toolkit as part of the Linux system running in ARM, but this would not take complete benefit of the Zynq-7000 programmable logic.

Thus, the optimum implementation would be to balance the computational tasks between the ARM processors and the FPGA based programmable IP cores, based on a common SoC platform. The three steps which will lead to an SDR application on the Zynq-7000 plus the FMCOMMS3 RF extention are summarized below:

1. create a System on Chip (SoC) hardware platform
2. setup the Linux on ARM processors
3. create the software application, using a mix of software implemented elements (e.g. in GNU Radio) and hardware blocks/IP cores.

The process for setting up the mixed platform is presented in the following sections, as follows. An example of hardware platform is presented in Section 3. A typical radio application will require an operating system. PetaLinux software development kit (SDK) has the complete environment for to building, developing, testing and deploying Linux on custom embedded systems [3]. Section 4 describes in detail how PetaLinux may run on the Zynq-7000 hardware platform. The software application could use the GNU Radio software toolkit which provides signal processing blocks to implement software radios [4].

Depending on the SDR power and efficiency requirements, it may be chosen which part of signal processing is implemented in software and which algorithms are developed in hardware.

3. SYSTEM ON CHIP HARDWARE PLATFORM FOR SDR

The hardware platform should contain at least the Zynq processor system and an interface between the processor system and the FCOMM3-EBZ, as we have implemented in the SoC that may be seen in Figure 1. The interface between the processor system and the analog device is implemented as an IP core in hardware description languages. The interface contains an AXI interface in order to be configured by the ARM cores and a digital interface for sending data to the analog device peripheral. The digital interface consists of 12 bits of DDR data and supports full duplex operation in all configurations up to 2x2. The transmit and receive data paths share a single clock. The data is sent or received based on the configuration (programmable) from separate transmit and to separate receive chains. The internal structure of the IP core is presented in Figure 2 [5]. The IP core may be found as a reference design on [5] and the AXI interface with the processor system could be generated using Vivado.

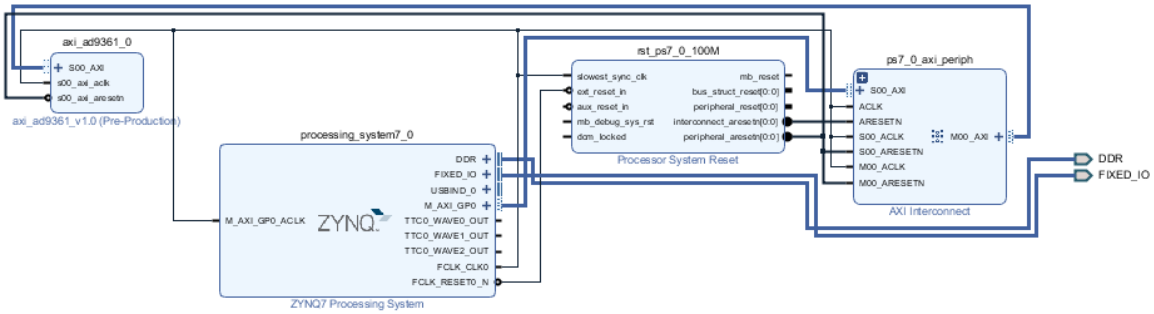


FIG. 1. ZYNQ Processing system implemented in Vivado

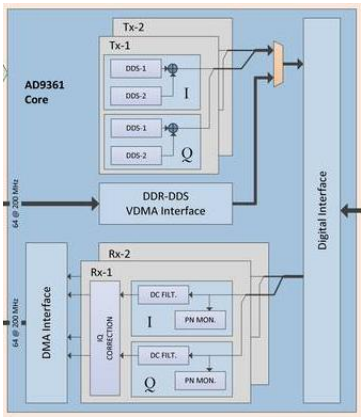


FIG. 2. AD9361 IP Core [5]

The hardware system may contain other peripherals included in Zynq processor system or implemented in the programmable logic resources in order to interact with other elements of the platform, like the HDMI controller, USB Keyboard, USB Mouse, Ethernet controller.

4. LINUX SETUP ON ZYNQ-7000 SOC

The Xilinx SDK(Software Development Kit) can be used to create the boot image for the system. The U-Boot(Universal Bootloader) is usually used in combination with the Linux platform. U-Boot provides the ability to start the application image, e.g. Linux [11]. Right away the advantages of using open source tools become obvious, as the development effort is greatly reduced.

In order to create the Linux image firstly the FSBL (First Stage Bootloader) must be created. This software component is responsible for the early system initialization and handing over control to the U-Boot. In order to build this component, the hardware designs must be available [6]. U-boot is an open-source primary bootloader that ca be used in embedded systems to start the system's kernel. In order to build U-boot for the Zynq-7000 platform the source files, the DTC (Device Tree Compiler) and the Xilinx SDK must be available [7]. Essentially the bootloader must handle the setup and initialization of the RAM, detect the machine type, setup the kernel, load the "initramfs" (root filesystems) and finally call the kernel image[8].The rootfs (root file system) must contain everything needed by our Linux system. The Zynq uses an "initramfs" which is extracted when the kernel boots up. Depending on the used Linux version (BusyBox, Linaro, etc.) the filesystem can be either persistent or it can be cleared on power-off [9]. The Device tree is used to describe the underlying hardware system. It is a data structure that can be read by the operating system. The kernel image is the one that will be called by the U-Boot at the end of the startup phase and is the heart of the embedded Linux system. In order to build the kernel, a cross compiler toolchain must be installed. In this case the boot image contains the above described components, U-boot is used to load the Linux image [13]. After formatting the SD card and copying the above described components, the SD card can be inserted into the Zedboard. All the steps are summarized in Fig. 3-8.

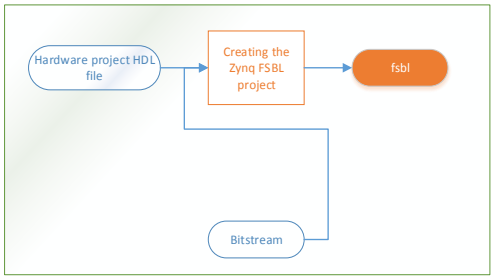


FIG. 3. FSBL development workflow

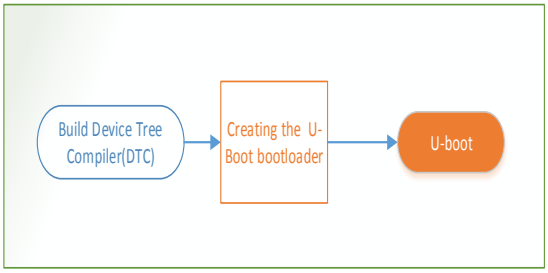


FIG. 4. U-boot development workflow

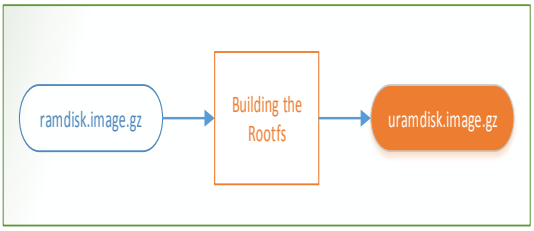


FIG. 5. Root File System development workflow

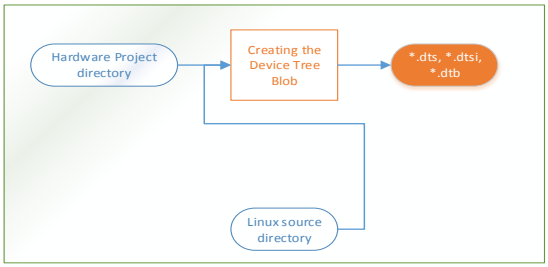


FIG. 6. Device Tree Blob development workflow

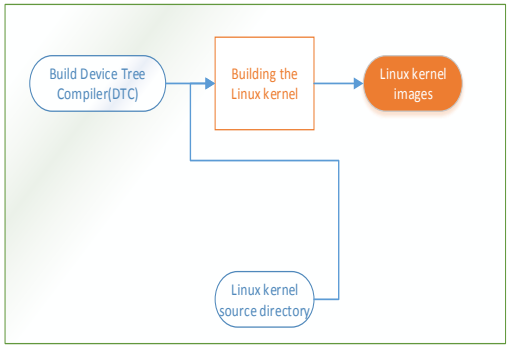


FIG. 7. Linux Kernel development workflow

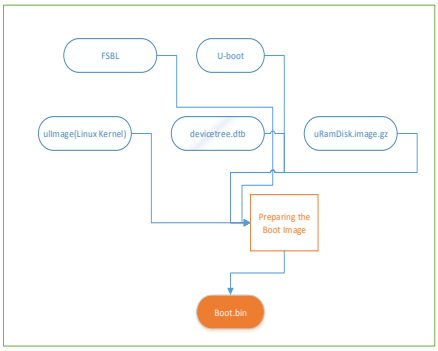


FIG. 8. Boot Image development workflow

In order to test our system, the mode jumpers must be set in the following configuration [8]:

– MIO[2]/Boot_Mode[3] sets the JTAG mode

– MIO[5:3]/Boot_Mode[2:0] select the boot mode

– MIO[6]/Boot_Mode[4] enables the internal PLL

– MIO[8:7]/Vmode[1:0] are used to configure the I/O bank voltages, however these are fixed on ZedBoard and not configurable

If the Linaro distribution was used, then HDMI output support exists and we can easily see the boot operation. Additionally if the Zedboard is used together with the AD-FMCOMMS3-EBZ development board then the ADI IIO Oscilloscope can be used to verify if the daughter board was recognized and if it is working correctly.

5. SOFTWARE APPLICATION

The AMP concept illustrated in Fig. 9. can be implemented on the Zedboard such as the Cortex-A9 processors run independent software environments in different contexts. Using the Xilinx SDK the Core running Linux can be configured as the system master and will be responsible for general system initialization, controlling the other core's startup, communication between the two cores and with the user [10]. Great care must be taken to control the private and shared resources of the processor, such as caches, timers, DDR memory, etc. One possible scenario is that the Linux master is in charge of controlling the shared resources (Fig. 10)

The software can be divided in three major software components, the FSBL(First Stage Bootloader), the Linux operating system and the Bare-metal application [12]. The FSBL is the first software component that is run after a system power-on or reset. This software component is responsible for loading the Application into the DDR memory and executing it. The FSBL must be modified so that the AMP configuration is supported.

To create a AMP Linux image the boot-image, device tree, root file system ramdisk must be modified.

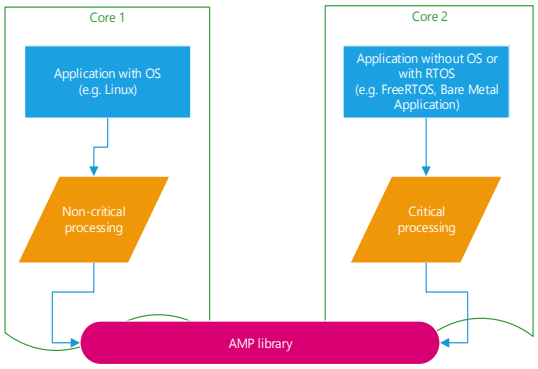


FIG. 9. AMP concept

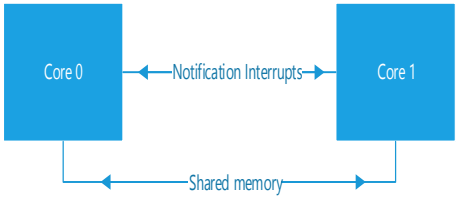


FIG. 10. Inter Core Communication

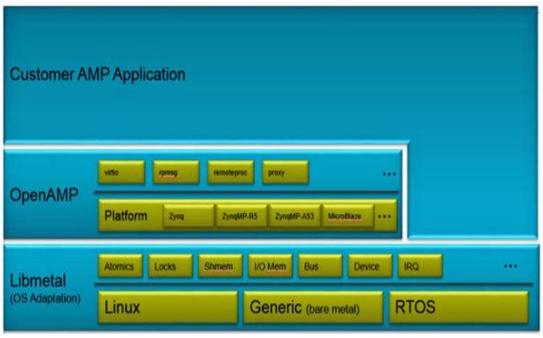


FIG. 12. Libmetal architecture

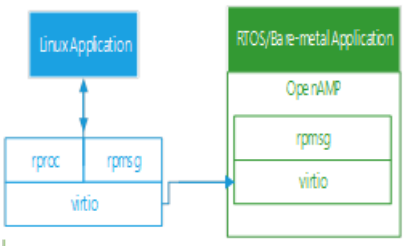


FIG. 13. Implementation in kernel

The basic concepts that are the foundation of AMP principles are the shared memory between the two different software environments and the notification interrupts that allow communication between the two contexts. OpenAMP uses the libmetal library to provide an API(Application Programming Interface) in order for the software components to be able to use the processors resources, and to handle the device's interrupts[9]. OpenAMP provides three important components. virtIO is used for managing the shared memory, this is a virtualization standard used for network and disk device drives. Remoteproc which provides life cycle management capability of the remote processor, it is used to allocate resources and to create virtIO devices. RPMsg is used for inter process communication, it allows different software environments running independently to communicate in the AMP system. OpenAMP uses the libmetal library to create an abstraction layer to the low level devices and to allow access to the shared memory. It provides a standardized way to access resources and to handle interrupts.

6. CONCLUSIONS

We have developed a working environment for Software Defined Radio using ZedBoard development platform and the FMCOMMS3 RF interface.

The created System on Chip using the Xilinx Vivado tool is integrating ARM microprocessors and the AD9631 IP Core as interface to the radio element. We have described the created SoC and the method for setting up the Linux environment at the ARM ptocessor level. The SoC is fully reconfigurable at both hardware level and software level.

As future work we intend to implement an SDR system based on FPGA programmable logic elements such as DSPs and software IP cores (Microblaze, Picoblaze).

REFERENCES

[1] X. Cai, M. Zhou, X. Huang, "Model-Based Design for Software Defined Radio on an FPGA", IEEE Access, Volume 5, April 2017.

[2]T. Balan, D. Robu, F. Sandu, "LISP Optimisation of Mobile Data Streaming in Connected Societies", Mobile Information Systems, Vol. 2016

[3] S. Gvozdenovic, Software Level Design of Software-Defined Radio Platform, Worcester Polytechnic Institute

[4] GNU Radio, Online: https://wiki.gnuradio.org/index.php/Main_Page

[5]AD9361 HDL References Design, Online: https://wiki.analog.com/resources/eval/user-guides/ad-fmcomms2-ebz/reference_hdl

[6] Booting ARM Linux, Online: https://www.kernel.org/doc/Documentation/arm/Booting

[7]Kernel Documentation File System, Online: https://www.kernel.org/doc/Documentation/filesystems/

[8] Xilinx Prepare Boot Image, Online: http://www.wiki.xilinx.com/Prepare%20Boot%20Image

[9]Xilinx, Libmetal and OpenMP for Zynq Devices User Guide, Online: https://www.xilinx.com/ support /documentation/sw_manuals/xilinx2017_3/ug1186-zynq-openamp-gsg.pdf

[10]Xilinx Application Note, Simple AMP Running Linux and Bare-Metal System on Both Zynq SoC Processors, Online: https://www.xilinx.com/support/documentation/application_notes/xapp1078-amp-linux-bare-metal.pdf

[11] Xilinx, Zynq-7000 All Programmable SoC Data Sheet, Online: https://www.xilinx.com/support/ documentation/data_sheets/ds190-Zynq-7000-Overview.pdf

[12] Xilinx Build U-Boot, Online: http://www.wiki.xilinx.com/Build%20U-Boot

[13] Xilinx Build FSBL, Online: http://www.wiki.xilinx.com/Build%20FSBL

STUDY OF THERMAL STRESSES OCCURRING IN THE VALVE OF A DISTRIBUTION MECHANISM IN THE COMPONENT INTERNAL COMBUSTION ENGINES

Ioan GHIMBASEANU

Transilvania University of Braşov, Romania (ghimbasani@unitbv.ro)

DOI: 10.19062/1842-9238.2018.16.1.10

Abstract: *The aim of the paper is to create interactive programmes for monitoring the thermal stresses obtained after the analysis with finite elements for the valve of a distribution mechanism in the component internal combustion engines. The method can also be applied for monitoring the thermal stress nodal of aircrafts, rockets, ballistic missiles and gun barrels.*

Keywords: *thermal stress, combustion engines, valve, finite elements.*

1. INTRODUCTION

In the operation of internal combustion engines simultaneously with the mechanical stresses, thermal stresses occur as a result of the transfer of heat from the gases to the adjacent parts of the combustion chamber **.**

In this paper we study the thermal stress of the valve in the distribution mechanism. During operation, the valve plate is subjected to the pressure of the gas. The valve operates under high temperature conditions. Mechanical and thermal stress causes elastic deformations of the plate and valve stem, leading to loss of sealing in the tapered contact area and rod grid. Thermal stresses that occur in the work piece during operation may be superior to mechanical stress, leading to damage to the work piece.

In this application, the field of displacements and stresses is emphasized as the sole effect of the thermal field. It is neglected the fields due to the pressure in the combustion chamber and the force of the holding spring. The temperature distribution on the outside surface of the valve is approximated by a constant field corresponding to the temperature T = 620 degrees Kelvin. For the valve execution, taking into account the conditions imposed on the material (low thermal expansion coefficient, good thermal conductivity), the best behavior has the alloy steel with nickel and chromium. The occurrence of thermal stresses in internal combustion engine elements may frequently occur.

2. STATICAL ANALYSIS WITH FINITE ELEMENTS FOR MONITORING THE THERMAL STRESSES

2.1. Analysis model processing

In order to draw up the analysis model with finite elements associated with the application, it is necessary to identify: shape and geometric dimensions, restrictions imposed by adjacent connections, external temperature loads, material characteristics.

Geometrical modeling. The geometric shape and dimensions of the geometric model of the valve are shown in fig. 1 and fig. 2[1,2,6,7,8].

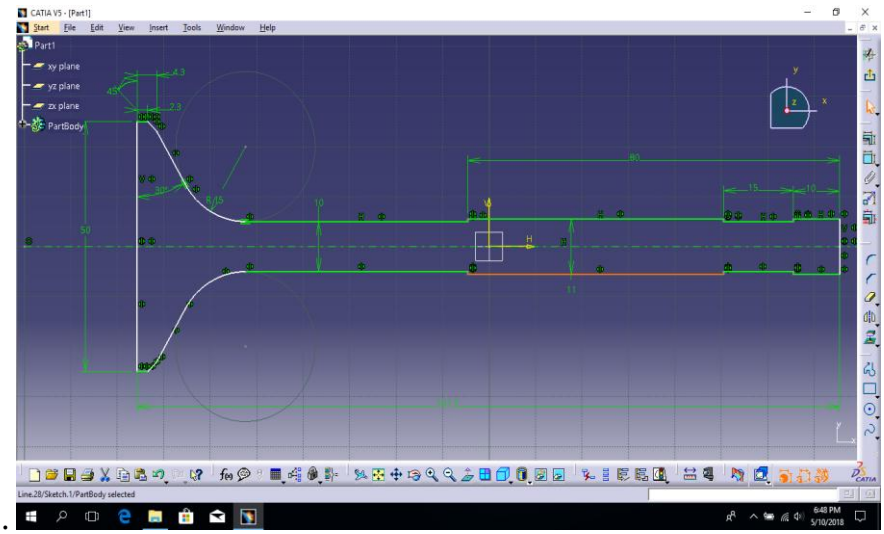


FIG. 1. The model 2d of valve

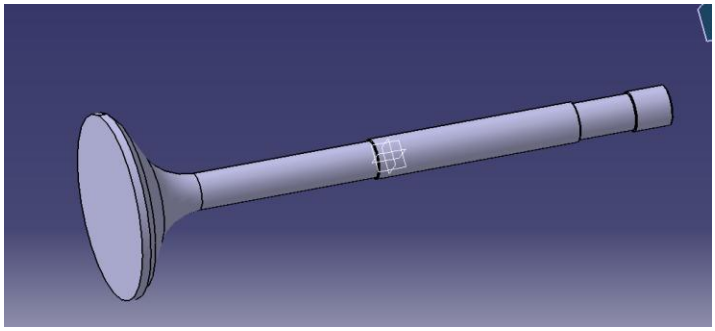


FIG. 2. The model 3d of valve

Modeling the characteristic of the material. The introduction of the values of the material characteristic necessary for the finite element analysis is made through using the CATIA programmer`s library of materials.

The steel material is selected[3,4,9].

2.2 Finite element modeling

CATIA Analysis & Simulation packed is launched for generating the finite element.

This packed makes the static analysis of the structure when some constraints are imposed and when some stress is independent-time.

Modeling of geometrical constrictions. Movement restrictions and isostaticity are introduced. These are shown in Fig. 3 [5].

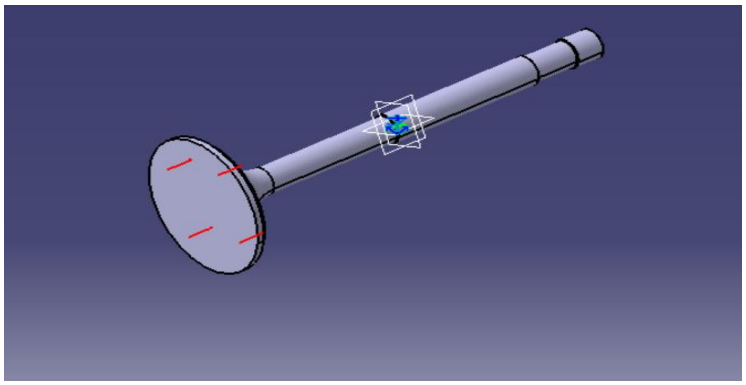


FIG. 3. User's defined restraint and isostatic restraint

Load modeling. The temperature distribution on the outside surface of the valve is approximated by a constant field corresponding to the temperature T = 620 degrees Kelvin.

Solving the model and post processing the result. Then the calculation model is launched.

Fig. 4 shows the deformation, Fig. 5 shows the displacement and Fig. 6 shows the von Mises stress.

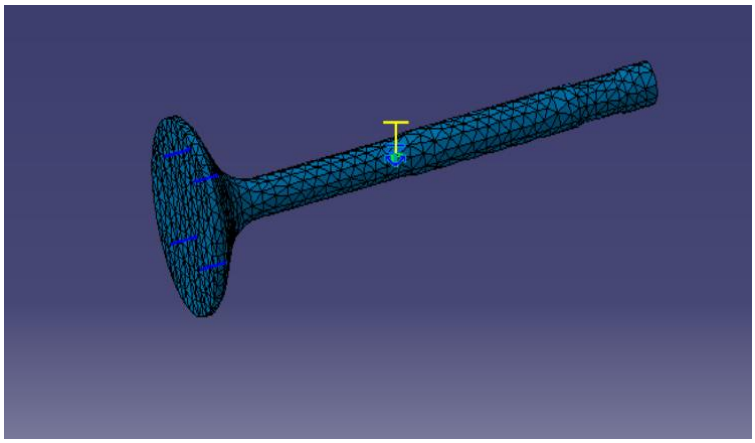


FIG. 4 Deformation of valve

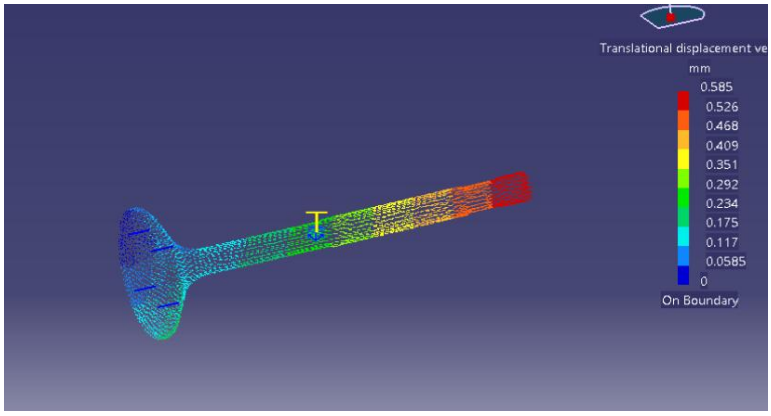


FIG. 5. Displacement of valve

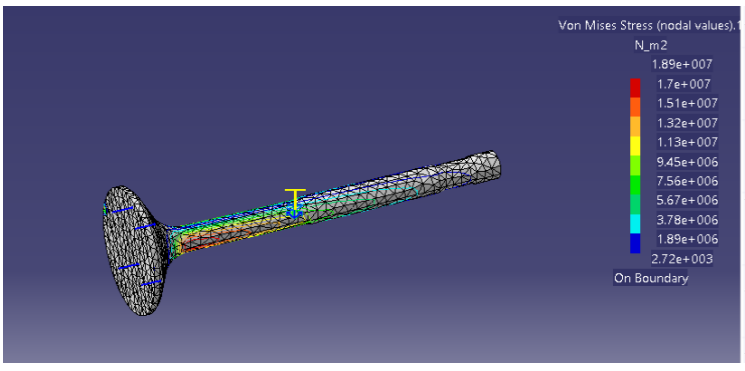


FIG. 6. Von Mises Stress

Some values of mechanical stresses in the valve are shown in Table 1.

Table 1. Value of Von Mises Stress

X[MM]	Y[MM]	Z[MM]	T[N/M2]
-52.41	4.38	2.39	18.89E+006
-52,41	-4.38	-2.39	18.6789E+006
-73.46	21.93	11.98	1.6689E+006
-75.76	21.93	11.98	17.489E+006
62.63	-4.38	-2.39	1.9589E+006
-48.32	4.38	2.39	17.8 E+006
-44.22	4.38	2.39	17.32 E+006
-52.41	-4.99	-0.05	18.1 E+006
-42.93	-4.38	-2.39	17.2 E+006
-38.93	-4.38	-2.39	16.7 E+006
-36.16	-4.38	-2.39	16.22 E+006
44.08	2.42	4.37	12.66 E+006
-36.08	2.43	4.36	11.8 E+006
-32.16	3	4	12.8 E+006
-27.98	2.34	4.41	10.77 E+006
-24.16	3	4	11.91 E+006
-20.07	2.42	4.37	10.13 E+006
-16.16	3	4	10.95 E+006

3. CONCLUSIONS

When performing programs based on MEF, one can solve a practical problem for the analysis of mechanical and thermal fields from solid media.

Performance programs using MEF allows the study of mechanical fields in high temperature parts. A good program based on MEF can also be appreciated by the types of materials that can be selected. Programs based on MEF have meshing possibilities based on a geometric model.

The efficiency of preprocessing programs is also due to the possibilities of introducing limit conditions and loads. In the case of the analyzed valve, the maximum displacement of 0.6mm requires adjustment to the installation.

Table 1 shows high values of mechanical stresses in the connection area of the plate with the valve stem due to the change of section.

The study of thermal phenomena in the mechanical systems structures using finite element analysis programs is the solution for determining the resultant fields.

REFERENCES

[1] Ghionea I., *Desing in CATIA v5*, Bren Publisching House,, Bucharest, 2007;
[2] Ghionea I., *CATIA v5 Aplicatii in ingineria mecanica*, Bren Publisching House,, Bucharest, 2009;
[3]Zecheru Gh., Drăghici Gh., *Elemente de ştiinţe şi ingineria materialelor*, vol. 1 şi 2, Editura Universităţii din Ploieşti, 2001;
[4] Lates T., *Metoda elementelor finite, Aplicatii*, Editura Universitatii Transilvania, Brasov, 2008;
[5] Mogan G., Butnariu S., *Finite element analysis in engineering*, Brasov, Transilvania University of Brasov Publishing, ISBN 978-973-4, 2007;
[6] Ghimbaseanu I., *Comparative method for determing the mechanical stress*, Review of the Air Force Academy, Vol.XIII, nr.1(28), 2015, pag 105-108;
[7] Ghimbaseanu I., Monitor the simulation of *mechanical stresses by computer*, Review of the Air Force Academy, Vol.XIV, nr.1(31), 2016, pag 105-110;
[8] Ghimbaseanu I., *Simulation of mechanical stresses of a assembly connecting rod*, Review of the Air Force Academy, Vol.XV, nr.1(33), 2017, pag 105-108;
[9] Metal testing, *tensil test*, STAS SR EN 10002-1:2002.

INDICATORS OF SOCIAL SECURITY IN BRAŞOV COUNTY THAT MAY CAUSE SOCIAL INSECURITY

Mariana CÂJU

Doctoral School of "Carol I" National Defence University, Bucharest, Romania
(marianacaju@yahoo.it)

DOI: 10.19062/1842-9238.2018.16.1.11

Abstract: *The article presents a case study referring to the area of Brasov county, where the citizens' security is closely analyzed in all its dimensions. The increase in citizen security in a community is evaluated through a framework concerning the planning and evaluation of the administrative system, the analysis of the situation before and after the attainment of results, by collecting data from the persons involved. The pillars of such a planning framework are to set objectives, measuring instruments, to determine responsibility and effects or impact. Objectives are established through analyses such as the one presented here.*

Keywords: *social security, local public authorities, sociological survey, Brasov County*

1. INTRODUCTION

The administrative system, the "resistance structure" of a state, directly influences its development and the standard of living of its citizens. Local public authorities are the foundation of regional development and the interests of citizens and communities to create well-being and security. From this perspective, I will analyze the general framework of organization and functioning of the authorities, their role and attributions, in relation to the interests of the citizen and of the communities, especially in the light of the three indicators that have been criticized for perceiving insecurity: health, transport and safety [1].

Security and threats are increasingly emerging as a problem of perception. If, during the Cold War, the international relations theorists considered the threat to be exclusively military in nature, the security referring to the survival of the state, the concept of security subsequently became widely developed, expanding a lot, becoming a multidimensional concept with extreme complexity of pregnant. Especially after the research of the Copenhagen School specialists, we talk about economic, political, military, social, cultural, environmental, and even human, security, the concept of "human security" being launched in 1994 through the Annual Human Development Report.

Security is defined as the perception, organization, identification and interpretation of primary environmental information as being free of risks, dangers and threats [2]. The theory of human security is, however, an extremely complex one, but also challenged, under the sign of subjectivity, the lack of consensus on how the intensity and repercussions of a particular threat can be measured, as well as on ways to prevent or eliminate them. Thus, security appears to be a state in which subjective and objective factors play equally important roles.

2. THE PERCEPTION OF SECURITY / INSECURITY AND ITS REFLECTION IN THE COMMUNITY

In order to study the subjective and objective dimensions of the security phenomenon a quantitative research through the method of oral questionnaire based on a standardized questionnaire was applied in the county of Brasov at the level of the non-institutionalized population, aged over 14 years. The questionnaire was applied in Brasov County in two intervals: the first one, between September 26 and November 7, 2014, and the second one between September 15 and November 3, 2017. The respondents' training was based on the following information protocol: "This questionnaire addresses the issue of risks and threats to you, as a citizen of Romania and a resident of Brasov County. To discuss these issues, you were randomly chosen as a lottery. If you agree to answer your questions, we hope you will not be kidnapped for more than 15 minutes. Responses are anonymous and will not be communicated to anyone in this form. " In the first period, out of a total of 50 questionnaires, 30 were applied in the urban area (Brasov municipality) and 20 in the rural area (10 questionnaires in Sânpetru, 5 in Feldioara and 5 in Dăişoara-Ungra). In the second interval, out of a total of 30 questionnaires, 20 were applied in the urban area (Brasov municipality) and 10 in the rural area. The technical data and results of this research will be further detailed below.

The research objectives aim to identify the most frequently mentioned risks at the level of the Brasov community, describing the profile of vulnerable to risks persons in the Brasov community, and correlative analysis of the interdependence of the perceived risks [3].

Using the questionnaire, as a data collection tool, we aimed to analyze the security issue on the classical dimensions promoted by the Copenhagen School: economic, political, social, military and environmental. Starting from the five-dimensional generalization scheme presented above, the following indicators (with the corresponding items in the questionnaire) were formulated for the subjective perception of security / insecurity:

– the economical dimension: interest in economic news, satisfaction with the economic situation of the family, concerns about living conditions in Brasov County, and the cost of living, food prices and unemployment in Brasov County, etc.;

– the political dimension: the assessment of the lack of citizens' participation in local decision-making, of corruption, respectively the political crisis, the degree of satisfaction with the way in which different areas of public life (housing, transport, etc.) are managed at the level of Brasov County, such as and the degree to which their faulty management affects their personal lives;

– the social dimension: interest in information in areas such as health, education, accidents at work, road accidents, satisfaction with particular aspects of life such as personal and family safety on the streets, physical safety at work and personal and family health, assessment of the severity of some community problems such as crimes, violence, access to the social assistance system, access to the health system, access to the educational system, discrimination, ethnic conflicts and social cohesion, the degree to which the respondent considers that these problems affect his life in the county;

– the military dimension: the degree to which the respondent considers the problem of military conflict with another state or group of states adversely affects the life of the county's inhabitant;

– the ecological dimension: interest in environmental disaster information’s, satisfaction regarding the climate in the geographical area in which it lives, concerns about the community's environmental degradation, the extent to which the respondent considers certain issues such as floods, droughts, landslides earthquake, earthquake similar to 1977, nuclear accident adversely affects the life of the county.

3. METHODOLOGICAL REPORTS

The pool of research is represented by the non-institutionalized population of Brasov county, who is over 14 years old. According to the official data provided by the National Institute of Statistics, Brasov County in 2015, it had a resident population of 550981 inhabitants distributed as follows: 268598 men (48.7%) and 282383 women (51.3%); 393316 urban residents (71.3%) and 157665 residents of the rural environment (28.7%).

Unemployment benefits (unemployed with work experience) decreased in 2015 compared to 2014 by 35.5%, while unemployment benefits (unemployed without work experience) decreased by 36.6% in the same reference period . This reflects an increase both in the performance of the active labour force and in the employers' preference for it, namely, the increase in the labour market penetration of the unemployed without work experience.

The unit of analysis and registration is the individual, a resident of Brasov County, uninstitutionalised and aged 15 and over. Due to the difficulty of accessing a sampling frame, an un probabilistic sample of 50 respondents was used. In order to compensate for the lack of representativeness of this type of sample, the procedure for choosing uncombined shares (residence environment, age, gender, education level) was used so that the structure of the sample approaches the structure of the framework population. Given the small volume of the sample and its unproblematic character, the probability of guaranteeing the results and the allowed limit error cannot be calculated in this case. In spite of these disadvantages, we considered that the reproduction of population characteristics at the sample level increases the quality of the data, although they cannot be generalized with great precision on the framework population, they still have the advantage of providing an overall radiography of the analyzed situation and generates hypotheses that can form the basis of more extensive probabilistic sample research.

The structure of the sample used approximates that of the frame population.

Thus, in the first research (2014), at the sample level, 60% of respondents are rural residents and 40% are urban; 64% are female and 36% male. With regard to the population age of the sample used in the first wave: 2% are under 18, 24% between 18 and 30 years, 20% between 31 and 39 years, 22% between 40 and 49 years, 16% between 50 and 59 years and 16% over 60 years. In terms of education level, the population in the sample used in the first wave is distributed as follows: 20% have post-graduate studies, 18% have university studies, 2% post-high school, 30% high school, 14% , 4% have 10 grades (grade I of high school), 10% gymnasium (7 or 8 grades) and 2% have elementary school (4 grades). As an occupational profile, respondents in the first wave are distributed as follows: 10% are pupils / students, 2% households, 4% unemployed, 66% work, work permit or contract, and 2%).

In the second research (2017), at the sample level, 67% of the respondents are rural residents and 33% of the urban area; 63% are female and 37% male. With respect to the age of the sample population used in the second wave: 20% between 18 and 30 years, 37% between 31 and 39 years, 10% between 40 and 49 years, 13% between 50 and 59 years and 20% over 60 years. In terms of education level, the population in the sample used in the second wave is distributed as follows: 30% have post-graduate studies, 27% have university studies, 20% high school, 13% have graduated from vocational school 10% gymnasium (7 or 8 grades). As an occupational profile, respondents in the first wave are distributed as follows: 70% work with a work card, authorization or contract, 27% are retired, and 3% work on their own (including farmers).

4. DATA ANALYSIS AND INTERPRETATION

The data collected from the respondents through the response sheets were entered into a database, using tabular computational programs, containing 98 variables and 50 cases (respondents) for the first wave, respectively 30 cases for the first wave - the second wave. On them were used statistical procedures for calculation of frequencies, averages, correlation coefficients and association tables.

In terms of the social dimension of security, in the light of media coverage, the interest of respondents in the first wave (at the level of 2014) is focusing on news from the field of "health" and less on news from the field of "work accidents" and "road accidents". It can be said that from the point of view of possible dangers exposed in the media in 2014 the respondents are, on average, more attentive to the social dimension of security than to the political one.

In 2017, on average, respondents are most interested in the news about "natural disasters" and the least interested in news on "work accidents". At the level of 2017, under the only aspect of the social dimension of security, the highest average level of respondents' lack of interest refers to "work accidents" and the lowest level of disinterestedness in "health" issues.

Compared to 2014, in 2017, on average, the highest interest in "health" and "education" news and less interest in news in "economy" and "society" grew most, and the lack of interest in " political "and news about" natural disasters ". The average level of respondents' interest in news related to "crimes," "accidents at work" and "road accidents" remained constant during 2014-2017. Simply put, during the analyzed period, the interest in the mediatization of "natural disasters" and "politics" has increased, and interest in "health", "education", "economy" and "society" issues has been diminished.

From the point of view of the social dimension of security, in terms of assessing the gravity of public problems, on average, the most worrying issue on the agenda of the citizens of Brasov is "access to the health system" in 2014; in terms of the political dimension "political crisis" and "corruption", and in terms of the economic dimension "food prices". Also, on average, in 2014, respondents ignore the seriousness of potential public issues related to "ethnic conflicts," "discrimination," "social cohesion," or "living conditions." Discriminating on the residence environment, we find that at the average of 2014: there is no difference in the perception of the severity of the "housing conditions" problem between rural and urban residents; problems of "crime", "violence", "living cost", "food price", "unemployment", "access to the social assistance system", "access to the health system" , "Discrimination", "ethnic conflicts", are perceived as more serious by those in rural areas compared to urban ones (the biggest differences being recorded as regards "access to the education system").

Three years later, the issue of "access to the health care system" is on the top of the agenda of the people of Brasov, and on the last position, the problems related to "living conditions" and "ethnic conflicts". Discriminating on the residence environment, we find that, at the level of 2017, on average: all the problems used in the scale (which the exception of the problem of "ethnic conflicts" is perceived as more serious by those in the rural compared to those in urban areas.

In terms of the political dimension of security, in 2014, on average, respondents' biggest dissatisfaction with local government concerns areas associated with "poverty reduction" and "job creation", with respondents less dissatisfied with the management the "urban development" domain. If we relate to the residential environment, we find that, on average, urban respondents, as opposed to rural ones, tend to be more satisfied with the local management of different areas, especially in terms of " urban development "and" transport ".

Also, in terms of the political dimension of security, three years later, on average, respondents' greatest dissatisfaction with local public administration is about managing health, the least dissatisfaction being related to the management of "urban development". If we relate to the residential environment, we find that, on average in 2017, urban respondents, unlike rural ones, tend to be more dissatisfied with the local management of the transport sector and more dissatisfied with the management the area of "education".

Tabel 1. Assessing administrative efficiency in improving risk
(„*To what extent are you satisfied with the way the following domain are managed at the level of Brasov County?*")

Dimensions	Indicators	Average values* 2014	Average values * 2017	Differences (2017-2014)
Economic	-	-	-	-
Political	Housing	2.5	2.30	-0.2
	Urban development	2.2	2.14	-0.06
	Rural development	2.6	2.57	-0.03
	Transport	2.4	2.43	0.03
	Reducing crime	2.6	2.33	-0.27
	Reducing poverty	3.0	2.83	-0.17
	Creating jobs	3.0	2.63	-0.37
	Professional reconversion programs	2.8	2.79	-0.01
	Social assistance	2.9	2.76	-0.14
	Health	2.7	3.03	0.33
	Education	2.7	2.60	-0.1
	Social cohesion	2.7	2.66	-0.04
	Environment	2.5	2.62	0.12
Social	-	-	-	-
Military	-	-	-	-
Ecological	-	-	-	-

* where 1 represents "very much" and 4 "not at all" (high values indicating the perception of insecurity)

CONCLUSIONS

From the point of view of the possible dangers exposed in the media, in 2014, the respondents were most attentive to the social dimension of security, being very much interested in "health news", and in 2017 at the ecological dimension of security, being the most attentive to "news about natural disasters". The general satisfaction with life is high in the Brasov community, with most respondents being satisfied and very pleased with their own life in both waves of research (with the satisfaction that in 2017 the satisfaction decreased slightly).

In terms of life satisfaction broken down by fields, in both waves of research, the most common concerns are of a social nature and concern "personal and family safety on the street", as well as economic concerns about the "economic situation of the family".

As a rule, correlations that have been highlighted in both waves of research retain their direction of linkage, with two exceptions:

- the backward correlation between "general life satisfaction" and "assessing the severity of the issue of discrimination" highlighted in 2014, becomes a direct correlation at the level of 2017;

- the direct correlation between "interest in pursuing economic news" and "assessing the severity of the housing problem" highlighted in 2014, becomes a reverse correlation in the year 2017.

Most of the correlations highlighted in both research waves tend to have an increase in the intensity of the link between the variables. The greatest differences in intensity (in the sense of increasing the intensity of the relationship between variables in 2017) between the two waves of research are related to the correlations:

- between "interest in pursuing health news" and "assessing the seriousness of the political crisis";
- between "satisfaction with personal and family safety" and "assessing the extent to which the pollution problem adversely affects the life of the respondent as a citizen of the county".

The multitude of correlations between variables that measure sub-dimensions of risk / hazard vulnerability demonstrate that they are interdependent, with security and insecurity being dynamic and complex concepts.

It is clear from the analysis that any administrative system in any democratic country must represent the interests and needs of its citizens through effective organization and functioning at all levels of government

REFERENCES

[1] D.Dincă, *Public services and local development*, Lex Publishing House, Bucharest, 2008;
[2] D.Dincă, *Romanian Administrative System - French Inspiration and local adaptation*, Economic Publishing House, Bucharest, 2012;
[3] *** Chancellery of the Minister - Ministry of Regional Development and Public Administration, *Strategy for Strengthening Public Administration 2014-2020*.

INNOVATION MANAGEMENT AND ARTIFICIAL INTELLIGENCE: THE IMPACT OF DIGITALISATION ON MANAGEMENT PROCESSES

Dragos TOHĂNEAN

Bucharest University of Economic Studies, Romania (tohanean_dragos@yahoo.com)

DOI: 10.19062/1842-9238.2018.16.1.12

Abstract: *We stand on the brink of a technological revolution that will fundamentally change many current practices, from the way we work to how we live, innovate management and work processes. In its scope and complexity, this transformation will be a huge step forward focused on: routing decisions in accurate information, fraud detection (transactions, data prediction), diagnosis and recommendation systems, real time data analysis and security forecasts.*

This coincides with the beginning of the fourth industrial revolution, which allows products, equipment and people to communicate via the Internet or different interfaces – but for this to improve and work, an involvement from the public and private sectors of both civilian and military environments is necessary, in order to make the switch from classical to innovation thinking.

Keywords: *innovation, AI (Artificial Intelligence), industry, innovation, management, digitalization*

1. INTRODUCTION

The term innovation etymologically originates in the Latin words *"novus"* = new and *"innovare"* = renewing. From this developed the word *"innovatio"* – which means renewal, change. Anyone who creates something new today – be it in companies, universities, or other organizations – is "innovative". The vague and inflationary use of the term has meanwhile also led to the labelling of anything that is issued or even slightly modified as "innovative" [1].

The world is considered a mature industry where the introduction of new processes and functions is necessary due to product complexity. Those changes require high investments and careful preparation and the right decisions – innovation through technical, social or economic change.

The operational technology and innovation process has to face the challenges of structured development of new technologies, products and processes. Research and advance development are designing new thinking and methodologies for a decade, to be implemented on a central information and communication platform to continually improve the technology and innovation process, leveraging enterprise-wide skills and creativity.

Faster and more powerful supercomputers are being build and are beginning to analyze the data volumes the world generates. They are helpful in finding better solutions, answering challenges such as research or data privacy more quickly. Digital technologies were combined with Artificial Intelligence (AI) to become more efficient and innovative – by working closely with people. Ultimately, human beings are always the focus of new developments, ideas and continuous progress – to be responsible, well-informed and to play a part in shaping the future.

2. FROM 1.0 TO 4.0

Nothing is more constant than change and it is also becoming faster and faster in industries, schools, corporations, institutions – in every corner or aspect of the world. In recent years, the industry is in an exciting phase, comparable to a strategic and technological change, thus inaugurating a new era. Politicians came up with the idea to name this 4th revolution of industrial development, in short, Industry 4.0.

First of all, several hundred years ago there was no such thing as an agenda for Industry 1.0, Industry 2.0, Industry 3.0 and now Industry 4.0. Looking back, however, it is appropriate for the individual development stages before Industry 4.0 to be versioned in order, for simplification. Thus, industrial change can be divided into four roughly subdivided phases – from Industry 1.0 to Industry 4.0 – with focus on development phases, progress that can be assigned to the respective version (Industry 1.0, Industry 2.0, Industry 3.0 and Industry 4.0), processes and also innovation in all sectors (from mechanical or technological ones to human capital) [2].

Development to Industry 1.0 – The first mass production by machines started around 1800, so if we look backwards in history, this is when the Industry 1.0 phase started. The first machines, such as the looms, were operated by human power. Mechanical production facilities were built and motorized by water and steam power.

Hydropower was the first primary energy. After that, steam engines were used. In this phase of development, the earliest successes of early industrialization included the first railways, coal mining, heavy industry, steamship, cloth manufacture, transport and textile printing. People just started to realize what *investment* and *progress* meant.

The first foundations for the later following Industry 3.0 were developed as soon as the 19th century, such as what we call today computer work, but realized on a mechanical level. British mathematician *Ada Lovelace* is considered the first programmer ever to have done such work in her program for *Charles Babbage's Analytical Engine* (in which she developed key aspects of later programming languages).

Development to Industry 2.0 – The introduction of electricity as a driving force at the end of the 19th century was the starting signal for the 2nd industrial revolution (Industry 2.0). From the first, early 20th century automobiles onwards, work in the production halls continuously evolved towards automation. The factory halls produced on-line in record time, and engines continued to work.

During this development phase, bureaucratic workplaces such as offices also experienced a further development in communication. Telephone calls and telegrams simplified communication, which accelerated work processes. But efforts to simplify correspondence began as early as 1714 with Henry Mill's description of a typewriter for which a patent was granted. The first typewriter was probably a device manufactured in 1808 by *Pelligrino Turri*, for the blind *Countess Carolina Fantoni da Fivizzone*. As people dared give way to their ingenuity more and more freely, other devices followed, such as the writing piano by *Karl Drais (1821)*, the typewriter models made of wood by the Tyrolean *Peter Mitterhofer (1864)* or the writing ball by *Malling Hansen (1865)* [3].

Success factors in the second revolution were the first steps of globalization. The production of automobiles, clothing, raw materials and food were automated.

Traffic also continued to develop for the first time across continents. Aviation began its operations and ships crossed the world's oceans.

Development to Industry 3.0 – This phase had already been masterminded in the 18th century: together with the already mentioned *Ada Lovelace*, *Charles Babbage* is considered to be the prime mover of the individually programmable computer, with his Analytical Engine.

The developments worked out by the thought leaders eventually resulted in the first functional devices. The German civil engineer *Konrad Ernst Otto Zuse* developed the functioning computer of the world with the *Z3* in 1941. It was program-controlled, freely programmable and fully automatic. In 1950, the *Z4* model was the first commercial computer, followed by others. Rapid development followed and the development cycles became shorter and shorter.

In the 1970s, the 3rd industrial revolution started. Here, the focus was on further automation through electronics and IT. After the big calculating machines, the personal computer for offices and households established a whole new branch of industry.

Development to Industry 4.0 – We are in the middle of the 4th industrial revolution when it comes to the theories and insights of tangible developments, possibly even at the end. In this phase, the focus will be on the increasing digitization of earlier analogue techniques and the integration of cyber-physical systems. For many years now, many companies have stopped producing in-stock, producing many products on demand or according to actual needs. Just-in-time strategies could be implemented thanks to the constant development in information processing and technology. In addition to the ever faster manufacturing, progress was also made in the field of environmental protection and occupational safety [4].

Industry 4.0 is the term for modern technology and production in the age of the digital revolution. This not only describes the industrial development of other technologies, as in the past two centuries, but the changed world of production and work in the global age as well.

"Computerization" is taking on more concrete forms in Industry 4.0. Traditional industries such as the construction industry are being digitized further and new forms of communication created – even commodities and packaging are connected to the Internet via barcodes.

Industry 4.0 can also respond faster and more precisely to trends, tastes and the needs of the sales market. A wider range of models and product designs will be produced as quickly as responding to the rapid developments in the marketplace. And new, digital factories can produce affordable individual pieces without sacrificing what they need.

Development of computing (supercomputers are creating a stir as lighting fast virtual analyzers and it is planned that quantum computers take the corresponding leap to their assistance in the future) [5]:

-1941: Konrad Zuse's Z3, Germany – the world's first functioning computer;
-1946: ENIAC, USA – the first electronic universal computer;
-1964: CDC 6600, USA – the first super computer;
-1984: M-13, Soviet Union – the first computer in gigaflop (floating point operations per second) range;
-2017: Sunway TaihuLight, China – the fastest computer to date.

From a global perspective, there is a growing emphasis on globalization and digitization. Developed countries have an interest in maintaining their international competitiveness and are actively looking for ways to respond as effectively as possible to consumers' needs and requirements, analyze real-time data, identify and respond to the demands of the ever-growing market by being as innovating as possible.

Emerging markets are looking for international networks or are developing their own solutions to ease their access to the international scene. All this leads to changes from management methodologies, business models, digital solutions to new processes and innovative ideas.

Innovation or digitalization has a similar effect in the military sector – flying drones, robots, cybersecurity, automated processes or weapons, data control are receiving more and more attention.

Governments around the world are investing huge sums of money in their defense apparatuses, whose arms race is increasingly turning towards digitization and virtualization. Warfare in cyberspace costs. According to the Swedish Peace Research Institute SIPRI, global military spending in 2015 totaled $ 1,760 billion. Cybersecurity becomes the new key market for the defense industry. And major arms companies such as BAE Systems, Lockheed Martin Corporation and Raytheon Company are increasingly turning to the civil sector. The innovative technologies that they develop affect society as a whole.

Today, a number of both publicly known and secret research institutions operate on behalf of the armies. These may be small initiatives, such as the "Athena Project", in which the crew of a ship of the U.S. Navy brainstorming on technical and organizational issues. Or large organizations like the U.S. Army Research Laboratory (ARL), which conducts research into Nano-aircraft drones with in-house specialists and in cooperation with private companies and universities.

Some innovations of military origin have shaped our civilian lives so profoundly that we almost forget where they came from. This is true for the Internet, which started as the US Department of Defense Arpanet in the 1960s. This also applies to the American positioning system GPS, which today everyone uses for navigation while driving and as tracking technology while jogging. The public funds for research and development in the army can today also promote basic research that could greatly change the everyday life of civil society in the future. Special attention is currently focused on drones and exoskeletons.

The U.S. Army has been using drones for years, and developed European countries such as Germany, Italy, France and Spain are also investing to have their own ones by 2025 – a common goal for increasing safety in Europe.

Exoskeleton is the term borrowed from the animal world for a hydraulic robotic suit that anticipates and amplifies the movements of its user. In France, the model *Hercule* was introduced in 2014, which is specifically designed for military use – to strengthen the physical strength of soldiers – as well as for civil use, for medical purposes.

On the one hand, this is nothing new: Man and technology have always been in a relationship of co-evolution. And since time immemorial, man tends to humanize technology. The military has always been a fertile ground for innovation. "Power" is a key driver in technologisation, the evolution of technical innovation.

3. ARTIFICAL INTELLIGENCE

"Artificial intelligence" (hereafter referred to as "AI") represents a threat (according to some experts) and a chance to a new evolution (according to others). For some it is a figment of the imagination and for others it is only a matter of time. As a result, it becomes clear that this topic is playing a crucial role today.

What is intelligence? There are different understandings of the term and it is usually assumed that intelligent behavior is tied to the controlled use of the mind. Under the scientific definition of mind, one understands the ability to think in terms and draw logical conclusions as in the processing of symbols and the use of logical operations (for example: solution of a three-sentence task).

Another approach, according to the literal meaning of intelligence, which translates to insight, reason, perception, is the ability to solve problematic and insightful behaviors. Actually it has a different definition for each individual, as we are not the same – and the same applies to AI.

Human vs. Artificial Intelligence – So far, in our society, intelligence has always had a biological form, and it is hard to imagine translating that principle into something entirely different or transferring the complexity of thinking processes that lead to the present evolution of the world – to a non-living system. A computer does not have the ability to recognize emotions and to situate them in real situations. Thus, it seems almost impossible to convert some subcomponents that make up human intelligence into a system. However, AI is more of a field of research, a branch of computer science that deals with the replication of certain aspects of human intelligence on computer systems such as speech recognition, deduction, interference, creative behavior, the ability to learn from personal experience, and the ability to draw conclusions from incomplete information - *AI will support people not replace them.*

The road to super-intelligence:

-1951: *Marvin Minsky* builds the first neurocomputer, *SNARC* (Stochastic Neural Analog Reinforcement Calculator);

-1956: Scientists present the first AI program, *Logic Theorist*;

-1972: Introduction of *Mycin* expert system for the diagnosis and treatment of infectious diseases;

-1994: First test of autonomous automobiles on German roads;

-1997: The *Deep Blue* computer beats the world champion Garry Kasparov at chess;

-2011: IBM brings the powerful AI computer *WATSON* onto the market;

-2017: The *Libratus* software beats four world-class players at poker.

Generally, the ultimate goal is to develop machines that behave as if they had human intelligence. They should act and think like a human being, but also rationally, and try to imitate the thinking and working of a person to solve a task. The computer stores repetitive operations, addressing or information as so-called empirical values and searches out of well-known behavioral structures the one that does justice to the situation. Another task is to analyze raw data in order to draw possible conclusions or offer possible solutions [6].

Intelligence types of AI – The goals that this new discipline seeks to achieve can be assigned to different subfields. *Visual intelligence* focuses on perception – image recognition, especially. The systems are capable of recognizing images or shapes, such as crime fighting. Fingerprints, handwriting recognition and the detection of the human iris are the tasks of the AI. In *linguistic intelligence*, the goal is to recognize natural language, to translate an input text into speech, and vice versa.

Programs such as SHRDLU or ELIZA are among the best-known language systems. ELIZA is a computer program developed by Joseph Weizenbaum in 1966 to show the possibilities of communication between a human and a computer through natural language. *Robotics* as a third sub-area seems to dominate the future.

The number of programmable robots is increasing, as they are often used in manufacturing technology for dangerous work or perform monotonous operations. A fourth subsection is made up of *computers* used in the field of *rational intelligence* called expert systems. These are based on a database in which expertise is stored and are often used in medical computer diagnostics.

The future of human-machine cooperation – It's not about simply replacing humans with machines, but about redeploying activities - an ideal distribution of work in terms of individual competences. This benefits individuals and computers on a case-by-case basis: a person builds relationships with other people, is intuitive and creative. Computers, on the other hand, calculate faster, they analyze vast amounts of data in a shorter time than any human. The fact is that there will be much closer cooperation with intelligent machines in the future. In the future, only those who join in this digital transformation will still be a wheel in the gear of the working society [7].

AI systems are already capable of doing things that we achieve through learning experiences and intuition. They do this just with great computing power and sophisticated mathematics. It is, undoubtedly, a significant innovation, and we should make use of it. Sooner, the existing algorithms will evolve and also be used in decision making situations in business, study or politics [8].

4. INNOVATION MANAGEMENT IN IT PROCESSES

Innovation management mediates between the operational implementation and the strategic decision-making levels. It supports the work of both levels by providing suitable framework conditions. These support services include, for example, leadership, processes, resources, methods, mediation, communication, tools, information, and preparation of decisions. The aim is to combine the right information in the right form with the right competence at the right time.

Strategic and methodological approaches are implemented on a central information and communication platform to permanently improve the technology and innovation process, leveraging enterprise-wide skills and creativity. The motivation here is to increase collaboration, information transparency, networking density and improving decision-making.

Strategic innovation management plays a key role in the early stages of the product development process. The task of innovation management is the identification, prioritization and control of innovation projects as well as the qualification of technologies and competences. Decisions of this kind have a long-term and strategic significance. To decide, for example, in which technologies should be invested, which projects must be funded or stopped and what expertise is necessary for this. However, shorter development and technology cycles mean faster and faster decisions. On the other hand, this requirement is counteracted by the increasing complexity of performing such action, due to the amount and haziness of existing information [9].

Innovation methodology is advancing at an even quicker pace, allowing individuals, companies or institutions to learn and grow four times faster than they were able to in the past. The huge amount of data available is opening borders never imagined before: data prediction, digitalization, research, development, network to communications and no limits.

Countries like Germany are already investing in this direction. The Army's Cyber Innovation Hub (CIHCyber Innovation Hub) is the interface between the startup scene and the army. His job is to drive digital innovation within the army.

The hub identifies innovative technologies in the international startup scene and develops and validates these for the German Armed Forces. A special focus is on disruptive technologies in the fields of cyber/IT information technology and digital products and services.

The Cyber Innovation Hub acts in the field of tension between startup culture and army tradition and is intended to deliberately introduce mindset and working methods as an ability in the army. At the same time, new ways should be deliberately tried out.

The team consists of soldiers, civilians and serial entrepreneurs who want to contribute to a successful digital transformation of the armed forces. The Cyber Innovation Hub also sees itself as a platform to specifically attract and integrate innovators and talents from the public sector.

Army management processes and innovation all come closer and closer together, having the same scope – to discover the unknown.

5. CONCLUSIONS AND FURTHER DEVELOPMENT

In summary, the use of modern IT technologies in the business, institutional or private environment is becoming increasingly important due to the high dynamics and limited information processing capacities. Virtual methods can assist people in answering specific questions and analyzing complex issues by processing data and making it understandable. Man continues to be responsible for the interpretation of the results and the final decision. At present, the gap between a strategic decision and its decision-making basis is still very large and depends heavily on the experience of the decision-maker. Humans can make wrong decisions within this scope of interpretation. With the gradual improvement of technology in the fields of innovation and artificial intelligence, as well as the related ability to process large amounts of data – this gap can be gradually closed. This applies in particular to the integration of data from the Internet, the potential of which is still underutilized. The Internet as a rich knowledge resource offers opportunities to develop new technological insights, more accurate trend detection, market changes, customer expectations and inspirations for new products and business areas.

However, in addition to the advancing technical possibilities, it should not be forgotten that human beings continue to be at the core of creativity, knowledge and thus added value within any company. Most of the necessary information for methodological processing is provided by humans. In order to further improve the acceptance between man and machine, a continuous investment in innovative management processes, revolutionary technologies and human capital has to be made.

REFERENCES

[1] Henning Breuer, Florian Lüdeke-Freund - Values-Based Innovation Management: Innovating by What We Care About, Palgrave publishing house, 2017, ISBN 978-1137516619;
[2] "Industry 4.0 – Challenges an solutions for digital transformations and use of exceptional technologies", https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/manufacturing/ch-en-manufacturing-industry-4-0-24102014.pdf, [accessed in Nov. 2017];
[3] "The invention of the modern computer keyboard", http://history-computer.com/ ModernComputer/ Basis/keyboard.html, [accessed in April 2018];
[4] Alasdair Gilchrist - Industry 4.0: The Industrial Internet of Things, Apress publishing house, 2016, ISBN 978-1484220467;
[5] "Supercomputer ranking", https://www.top500.org/statistics/, [accessed in June. 2018];
[6] Christian Ehl, Sharad Gandhi - AI&U: Translating Artificial Intelligence into Business, Independently published, 2017, ISBN 978-1521717202;

[7] Paul R. Daugherty - Human + Machine: Reimagining Work in the Age of AI, Harvard Business Review Press publishing house, 2018, ISBN 978-1633693869;
[8] Klaus Mainzer – "Creating Chemistry – Age of super brains", BASF, 2018, page 17;
[9] INNOVATIONSMANAGEMENT - StarterPaket http://www.inknowaction.com/blog/wp-content/uploads/2011/03/Starterpaket-Innovationsmanagement.pdf [accessed in Jan. 2018].

MYERS-BRIGGS TYPE INDICATOR INFLUENCE IN TEAM BUILDINGS

Cristian PANAIT, Vasile BUCINSCHI

"Henri Coandă" Air Force Academy, Braşov, Romania (cristian_pnt@yahoo.com)

DOI: 10.19062/1842-9238.2018.16.1.13

Abstract: *Every person we meet or interact with is a unique individual. Each has their own preferences, expressed in different styles, mannerisms and ways of approaching challenges. Myers-Briggs Type Indicator is one of the many approaches available to study human interaction. One of the fundamental functioning principles of the military environment is teamwork, which requires comprehensive knowledge in regard to human personality. The research question that prompted this study is whether or not this theory can lead to better team building activities in the military. The present approach should help us improve our understanding of other people's reactions and attitudes, open lines of communication, reduce misunderstandings at the interpersonal level, foster mutual acknowledgment and intellectual openness. The research is based on an experiment involving a multinational group consisting of 33 members from 9 different countries. The group was split in 'same-personality' teams created according to the Myers-Briggs Type Indicator survey, which had to compete during team building activities.*

Keywords: *Myers-Briggs Type Indicator, team building, teamwork, Johari's Window, intercultural team*

1. INTRODUCTION

The Swiss psychologist, Carl Jung believed that observation of the habitual exercise of individual choice, consistent with certain shared preferences, could be used to help identify fundamental differences in people. According to Jung, each person is born with a specific predisposition toward a particular preference.

In 1962, Katherine Briggs and her daughter, Isabel Briggs Myers published a book entitled „The Myers-Briggs Type Indicator" (MBTI), which developed the personality model belonging to Jung. This new model was conceived in a form that made it more accessible to the large public. MBTI didn't capture the attention of the scientists due the fact that the validation tests were not considered solid enough. Personality is a qualitative variable and is thus hard to measure. A validation of an instrument of research is represented by its capacity to successfully measure what it was designed for. These tests find their importance at a specific level, as we succeed in making a difference between our values, skills and behaviours [1]. MBTI is nowadays one of the most widely used personality surveys in the world. It causes individuals to question themselves about how much they know when it comes to their own personality and those around them.

2. MBTI THEORY AND SURVEY DESCRIPTION

MBTI is based on 16 types of personalities and it creates models to approach human personalities without qualitative judgement, all being treated equally.

The goal of this paper is to demonstrate the relevance of such tests during military team-building activities or for the better understanding of our co-workers. For a military leader, this test can also represent a tool for better knowing his subordinates.

Predicting someone's behaviour is difficult, because a personality is a complex phenomenon and may encompass a large variety of traits. Every one of us has a part of those traits, and what makes us different is the amount at which we are characterised by them, our personal evolution and our preferences when it comes to determining which ones we appreciate the most.

Based on this survey, we can determine whether someone prefers competence and logic, or relationships over other preferences, to be organised or the excitement of spontaneous decisions.

The MBTI reflects our own preferences along four dimensions. Each dimension is expressed as one of two choices or dichotomies, so there are 16 possible MBTI types. Each type is summarized by a combination of 4 letters based on the person's preferences across the following dichotomies:

(E) Extraversion vs. (I) Introversion
(S) Sensing vs. (N) Intuition
(T) Thinking vs. (F) Feeling
(J) Judging vs. (P) Perception

A person's MBTI type consists of one letter for each of the dichotomies (e.g., ENTJ, ISFP).

The four MBTI dimensions are characterised by:

1. the way in which we interact with others – from the point of view of the direction in which we manifest our interest in actions, object and humans, from the outside (Extraversion) or from an inner world of concepts and ideas (Introversion);
2. the way in which we obtain our information and ideas – from direct experience of reality based on facts (sensing) or from possibilities, meanings and connecting experiences (intuition);
3. the way we judge and make decisions – analysing facts without personal bias (logic) or putting in a personal balance the importance of a choice (affective);
4. the way we organise ourselves and our activities – through planning and living organised in order to control events (rational) or more flexible, in a spontaneous way with the purpose to understand and adapt to situations (perception).

Table 1. Myers – Briggs Type Indicator

	Sensing (S)	**Sensing (S)**	**Intuition (N)**	**Intuition (N)**	
Introversion (I)	ISTJ	ISFJ	INFJ	INTJ	Judging (J)
Introversion (I)	ISTP	ISFP	INFP	INTP	Perceiving (P)
Extraversion (E)	ESTP	ESFP	ENFP	ENTP	Perceiving (P)
Extraversion (E)	ESTJ	ESFJ	ENFJ	ENTJ	Judging (J)
	Thinking (T)	Feeling (F)	Feeling (F)	Thinking (T)	

From the description of each type made by the authors of the theory I extracted the details that are important for a group dynamic:

Extraversion (E). An extraverted person projects their internal psychological tendencies to the world that surrounds them by exteriorizing their feelings, by socializing.

The decision making process of an extravert depends on the information he or she receives from external sources by communication, verbalizing the process.

An extravert needs independence, public acceptance and encouragement for his enthusiasm that has the power to energise the people around them.

Introversion (I). An introvert is focused on his or her inner world and all its complexity.

The decision making process of an introvert happens within his or her thoughts, analysing the process with information provided by themselves and based on their own experience.

An introvert needs intimacy, time and no pressure while making a decision and works best in a group with proactive members.

Sensing (S) and Intuition (N) both refer to the way in which we acknowledge the world around us and receive information from it.

Both are telling us how we observe people, things, situations and how we assimilate what we read and what we are told. These are predispositions we have, our decision processes depend on the way we perceive and observe the world around us.

Someone who relies on sensing will appreciate the facts and will work with them to understand situations and see the bigger picture, words and symbols are less appreciated than experience in order to build trust.

An intuitive person will look for the meaning while reading between the lines, using the bigger picture rather than going to the detailed facts as a basis for their understanding process.

Thinking (T) and Feeling (F) also refers to the predispositions we have to give meaning to the world around us. A Thinking (T) person will look for explanations and solutions to problems that are logical, in a calculated and emotionless way. This is why they may sometimes be judged indifferent to other people, uncaring and orientated towards a task.

Someone with a high Feeling (F) score will appreciate people, their feeling while he or she is drawn into communication, and show a concern for harmony and care about others. For this reason, they may sometimes by perceived as idealists who make decisions based on feelings.

Judging (J) and Perceiving (P) represent the way we function best while dealing with situations, projects and how we manage time. Someone who is Judging (J), while having nothing to do with being judgmental, will be someone who enjoys to be task oriented while planning in advance, having a checklist before starting an action.

Someone that scored high Perceiving (P) will prefer going with the flow, adapting on spot for the best course of action. New circumstances are seen as opportunities that are better to be left open. The tendency is to procrastinate actions and work in bursts of energy, sometimes being perceived as casual.

While personality is not binary, each pair of traits is a spectrum as nobody is purely introverted or extraverted, for example. The resulting trait is the one that a person has a stronger tendency towards.

Distribution in the general population

Type	Frequency in Population	
ISFJ	■■■■■■■■■■■■■■	13.8%
ESFJ	■■■■■■■■■■■■	12.3%
ISTJ	■■■■■■■■■■■■	11.6%
ISFP	■■■■■■■■■	8.8%
ESTJ	■■■■■■■■■	8.7%
ESFP	■■■■■■■■■	8.5%
ENFP	■■■■■■■■	8.1%
ISTP	■■■■■	5.4%
INFP	■■■■	4.4%
ESTP	■■■■	4.3%
INTP	■■■	3.3%
ENTP	■■■	3.2%
ENFJ	■■■	2.5%
INTJ	■■	2.1%
ENTJ	■■	1.8%
INFJ	■■	1.5%

Males

Type	Frequency in Population	
ISTJ	■■■■■■■■■■■■■■■■■	16.4%
ESTJ	■■■■■■■■■■■■	11.2%
ISTP	■■■■■■■■■	8.5%
ISFJ	■■■■■■■■	8.1%
ISFP	■■■■■■■■	7.6%
ESFJ	■■■■■■■■	7.5%
ESFP	■■■■■■■	6.9%
ENFP	■■■■■■	6.4%
ESTP	■■■■■■	5.6%
INTP	■■■■■	4.8%
INFP	■■■■	4.1%
ENTP	■■■■	4.0%
INTJ	■■■	3.3%
ENTJ	■■■	2.7%
ENFJ	■■	1.6%
INFJ	■	1.2%

Females

Type	Frequency in Population	
ISFJ	■■■■■■■■■■■■■■■■■■■■	19.4%
ESFJ	■■■■■■■■■■■■■■■■■■	16.9%
ESFP	■■■■■■■■■■	10.1%
ISFP	■■■■■■■■■■	9.9%
ENFP	■■■■■■■■■■	9.7%
ISTJ	■■■■■■■	6.9%
ESTJ	■■■■■■	6.3%
INFP	■■■■■	4.6%
ENFJ	■■■	3.3%
ESTP	■■■	3.0%
ENTP	■■	2.4%
ISTP	■■	2.3%
INTP	■■	1.7%
INFJ	■■	1.6%
INTJ	■	0.9%
ENTJ	■	0.9%

FIG. 1. Distribution of personality types

3. APPLYING THE MBTI SURVEY

The MBTI survey is connected with the self-awareness someone has. In 1955, Joseph Luft and Harry Ingham [2] have developed a model to illustrate what we are aware of and how others perceive us by creating a matrix with four quadrants. In every quadrant, there are adjectives characterising one from their own point of view or from another's. The authors have thus created a list of adjectives from which characteristics of a subject are chosen.

The "Blind Spot" quadrant refers to an aspect of our personality which is not known to self, but is known to others, and represents something that characterizes it. For example, others may notice that someone lacks eye contact when talking to people. That person, however, may be completely unaware of this. Communication and the process of receiving feedback from the people around us can open the Blind Spot to our own perception and help us address it. Therefore, the Blind Spot can be reduced through identification and learning, moving to the left of Johari's Window into the area of "known to others and known to self".

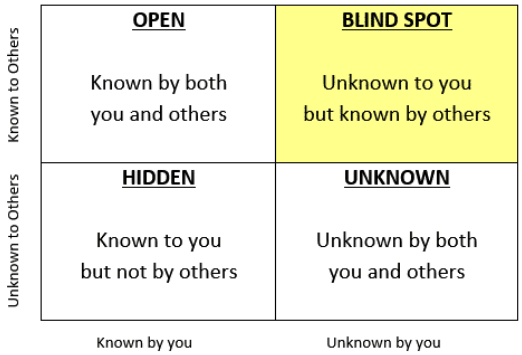


FIG. 2. The Johari Window

During an MBTI assessment, a series of questions indicating people's preferences are asked. If someone scores low in one of the personality types, they might have a Blind Spot in that area. For example, someone who scored high in Thinking (T) type might score lower in Feeling (F), which indicates that the person might be known for preferring structured, disciplined environments, schedules and timelines – for being real task-orientated.

However, he or she may have difficulty expressing emotions or being affectionate to others and sensitive to their feelings. People around such a person may perceive him or her as "insensitive" or "cold", which may discourage efforts to maintain healthy relationships with this person.

The first step to reducing these Blind Spots is being aware of them. Once we realize they exist, we can then explore ways to reduce our Blind Spots.

Tests have shown that the percentages of each personality style work the same way throughout the world. Every culture has every personality style in much the same proportions as ours does. However, other cultures, ours included, develop stereotypes about foreign cultures. Stereotypes come from our perceptions – not from objective testing. Different cultures might have strong characteristics like being punctual, being expressive or even being relaxed versus formal. Still, some cultures place great value on specific characteristics – which correspond to the characteristics of a certain personality type.

Our perspectives on what we value most, what we feel about our homes and how we view other cultures are all very much influenced by our own cultures, but they are still consistent with our underlying personality types. Just as our perspectives about our environment and life circumstances colour our views, so does our personality type reflect our perspectives on place and culture. Thus, different personalities have different perspectives.

During a multinational activity that took place in the Romanian Air Force Academy, I conducted the formal activities related to team building. At the beginning of the program, I asked the participants to complete the MBTI survey. The purpose was to mix the members from different nationalities and come up with a group.

The group was formed by 33 participants from 9 countries (Romania, USA, France, Belgium, Latvia, Poland, Holland, Italy, Bulgaria). Analysing the data from the surveys, I obtained the following data:

Table 2. Personality types of the study group

ESTJ – 8	ESTP – 1
ISTJ – 7	ESFP – 1
ESFJ – 4	ENFP – 1
ISFJ – 4	INFJ – 1
ENFJ – 2	ENTJ – 1
INTJ – 1	ISFP – 0
ENTP – 1	ISTP – 0
INTP – 1	INFP – 0

4. CONCLUSIONS

One of the caveats of using the MBTI in team building is that at the beginning of the activity, it gives the impression that one personality type is better than the other, especially after presenting the distribution of personality types among the general population. Each personality has a unique set of strengths that the others don't have. Recognising, accepting and validating them is important to the success of any team. The team building participants understood this in the end, but it is necessary to have each team present their strengths as most people have the desire to feel special.

Having the possibility to test this theory in a multinational group brought me to the conclusion that the MBTI approach to develop such teams is highly recommendable because it gives members a different criterion according to which they can organise in groups, other than their nationality. In time, under the influence of a good leader, even this barrier can fall and the group will start working towards a common goal with added knowledge about each other's preference for human interactions.

Everyone is their own unique blend of traits, and a better understanding of this fact while avoiding to stereotype the other or compare, compete when it is not necessary can lead to better relationships among the members of a team.

Understanding the weaknesses of a certain personality type that someone is identified with doesn't mean that it can be transformed into an excuse. It is counterproductive to blame one's personality type for a certain behaviour or non-behaviour. The MBTI identifies our preferences, not our capabilities.

MBTI may not be a scientifically valid personality assessment [3]; however, validity is not an element in a test, but has to do specifically with test score interpretation. Personality assessments can be validated for specific purposes. The purpose of this research was to remove cultural barriers between members of a group coming from 9 different countries and build a team at a specific time (retaking the assessment can bring minor differences in time). For this purpose, the assessment is valid based on the observations I have made while leading the group. There are caveats, but if a leader is ready to invest their experience in the process, they can be overcome.

This research gave me a starting point for further testing of the theory of different groups, especially with military students that will become officers in charge of other people. Officers are expected to lead teams, solve problems and effectively execute missions. In order to do that, they must interact and communicate with others. In an ideal situation, we would have to work with a team made up of as many personalities as possible, which would provide optimal problem solving potential; however, such a team can also have great potential for inner conflict. Officers who understand this strive to use their knowledge of personality (their own as well as others') to help teams focus on the task by tapping into strengths and mitigating conflict in order to get all members to work together toward a common goal.

The MBTY assessment is a way to learn about ourselves. It is the beginning of self-awareness.

REFERENCES

[1] Samuel Messick, *Meaning and Values in Test Validation: The Science and Ethics of Assessment*, Educational Researcher, Vol 18, Issue 2, First Published March 1, 1989,pp. 5 - 11

[2] Luft, J and Ingham,H., *The Johari Window, A Graphic Model of Interpersonal Awareness*, Los Angeles: UCLA, 1955, p. 32

[3] Pittenger, David. (2005). *Cautionary comments regarding the Myers-Briggs Type Indicator*. Consulting Psychology Journal: Practice and Research. 57. pp. 210-221.

PERSPECTIVES ON CONTEMPORARY CEREMONIALISM

Review of the volume
***Dalla quotidianità alla cerimonia. Fondamenti sociologici e antropologici della cerimonialità* by Mariselda Tessarolo, Milano, FrancoAngeli, 2018**

Adrian LESENCIUC

"Henri Coandă" Air Force Academy, Brașov, Romania

DOI: 10.19062/1842-9238.2018.16.1.14

Abstract: *The topic of the present analysis is Mariselda Tessarolo's book Dalla quotidianità alla cerimonia. Fondamenti sociologici e antropologici della cerimonialità. This book deals with the fine intersection between the horizontal dimension of daily social life and the vertical dimension of ceremonialism, highlighting history traditions, values, and rituals. By analysing ceremonialism in daily life, Professor Mariselda Tessarolo brings additional sociological and anthropological insight to this very delicate research area which includes military ceremonialism.*

Keywords*: daily social life; ceremony; communication; military.*

1. MARISELDA TESSAROLO: *OPERA OMNIA*

FIG.1. Mariselda Tessarolo, *Dalla quotidianità alla cerimonia. Fondamenti sociologici e antropologici della cerimonialità.* Front cover.

Mariselda Tessarolo is a Senior Scholar of Padua University, a renowned professor teaching the Sociology of Cultural and Communicative Processes. Prior to this position, she has worked as a professor at the Faculty of Sociology in Trento, then at the Faculties of Political Science and Communication Science in Trieste. From the very beginning, her research interests focused on the symbolic construction of culture, on cultural aspects of communication, on interpersonal communication.

Then, from the same symbolic interactionist perspective, professor Tessarolo gained expertise on artistic communication and published *L'espressione musicale e le sue funzioni* [Musical expression and its functions] (1983, Giuffrè); *La poesia tra individuo e società* [Poetry between the individual and society] (2003, Unipress); *L'arte contemporanea e il suo pubblico* [Contemporary art and its public] (2009, FrancoAngeli).

In the area of communication studies, she published *Minoranze linguistiche e immagine della lingua* [Linguistic minorities and the image of the language] (1990, FrancoAngeli); *Divismo vecchio e nuovo* [Old and new stardom] (1998, Cleup); *Moda e comunicazione* [Fashion and communication] (2001/2004, Il poligrafo); *La comunicazione interpersonale* [Interpersonal communication] (2007/2012, Laterza). In addition to the prestigious Italian publishing houses, mentioned so far, here is a series of international publishing houses having included her works: Springer ("The last 'touch'turns into an user", in A. Scarinzi, ed., *In Aesthetics and the Embodied Mind*, 2015) or Cambridge Scholar Publishing ("Seriality and globalization of fairy tale narratives in postmodern culture", in E. Polyudova, ed., *Once Upon a Time in the Contemporary Word*, 2016). Professor Tessarolo founded the journal *Metis* in 1994 (Cleup, Padua), and is still the scientific director of this publication today; she is also included in the scientific board of many other publications, from Italy and abroad, including the prestigious *Interdisciplinary Journal of Family Studies* (Padua University Press) and the present scientific journal, *Review of the Air Force Academy*. She is also a member of numerous national and international associations (IAEA, ICP, AIS) and the director of the *Centro Interdipartimentale di Ricerca sulla Famiglia* [Interdepartmental Center of Family Research] (CIRF).

Dalla quotidianità alla cerimonia. Fondamenti sociologici e antropologici della cerimonialità is the latest work of the highly-regarded professor of the sociology of communication. The study basically focuses on the institutional formality required to express identity: "L'argomento travatto riguarda la cerimonialità che verrà analizzate partento dalla vita quotidiana [...] e la formalità institizionale socialmente condivisa" (Tessarolo, 2018:7).

2. CEREMONIES IN EVERYDAY SOCIAL LIFE

2.1 The structure of the study. Professor Mariselda Tessarolo's book is a balanced study, articulated by three major pillars (three chapters dealing with ceremonial activity as a social need, the processes of social differentiation in ceremonial activities and the the evolution of ceremonialism, respectively): 'Il cerimoniale come necessità sociale'; 'I processi di differenziazione sociale e il cerimoniale' and 'Il cerimoniale in corso'. Starting from the individual and opening the discussion toward society, the particular actor of social acts (who exhibits his or her own life organized in clusters separated by interstices in which the expression of interpersonal relationships is realized), as a 'collective subject' (*soggetto collettivo*), is the actual depositary of cultural values, and sees his or her daily interaction with society as a fertile ground for social innovation. In a synchronic analysis, social life (i.e., the entire range of everyday activities) is therefore perceived as a dimension of existence that conveys particular ways or styles of thought and action. Everyday life involves routine facts and contributes to the expression of personality and personal identity, thus encompassing Ervin Goffman's theory on the staging of daily life). Inserted into everyday life, ceremonies are considered to be short-term social hypostases, with a solid symbolic ground, and are thought to express a person's own identity based on its historical depth.

Starting from these two levels– the relationships between the individual and society in a (synchronic) due to the temporal section of everyday facts, and the dimension of ceremonials, spotlighting the behavioural codes and ritual forms which express identity through continuity (diachronic analysis) – Mariselda Tessarolo proposes a complex and up-to-date approach. Her work is all the more important as ceremonial forms are constantly eroded in postmodern societies in which systems of values in general tend to progressively weaken.

The Italian scholar's book highlights the individual statuses in society and the roles implied in an updated understanding of the individual /vs./ society relationships in the light of contemporary ceremonialism. From a communicative perspective, the book deals with the issues related to maintaining the communication channels opened, which also recalls the classical phatic (or empathic) function of communication in Roman Jakobson's model. The subject of analysis is the ceremonial repertoire of community, including different forms of ceremony, good manners and courtesies, forms of recognition of a position or status, assigned or acquired, in a society where the inter-individual relationships are becoming more dynamic and more superficial than before.

2.2 Ceremonies as a social necessity. The analysis of ceremonies as a social necessity stems from a deep understanding of daily ceremonialism (in specialized or official language), which helps people provide an adequate image, and thus transmits an institutional message with a predominantly phatic function:

> Nel cerimoniale tutto è 'adequato' e preparatto per sottolineare ogni comportamento sia esso parola, movenza, gestualità o presenza 'corporale' che comprende abbigliamento, aspetto esteriore, fino alla presentazione dei participanti secondo l'prdine e il grado (Tessarolo, 2018:14).

Under the analytical magnifying glass, taking into account one of the fundamental dimensions of the organizational or national culture in Geert Hofstede's model, individualism vs. collectivism, the necessity of everyday ceremonialism brings the institutions to the forefront. They protect the society from unpredictability, and stop the acute manifestations of deepened individualism: „per 'frenare' l'individualità e per 'proteggere' all'interno della comunità". Institutions become the apparatus able to develop a society and serve public interest. Ceremonialism concerns institutions, and institutions are legitimized by ceremonies, through which they receive legal validity; in addition, the modern state itself (understood from an institutional point of view) is based on legal-rational legitimacy (Poggi, 2004).

Rituals are frequent, regular, prescriptive and traditional forms of public behavior that are meant to draw attention to values or beliefs by symbolizing. Rituals (both public and religious) bring the past to the present and, through their cyclic character, configure the calendar of a society's everyday life. This calendar has an important symbolic dimension, and so does the whole ritual: „Il rituale ha come finalità intrinseca la riconstruzione di un ordine simbolico sempre in divenire" (Tessarolo, 2018:30). Rites have an extraordinary emotional force, manifested at the scale of an entire community. They are useful for both institutions and organizations through their power of legitimating, of establishing a symbolic order. Together, rituals and rites compete for the formation or integration of the cultural models.

Through the perpetuation of the forms of ceremonial communication, a certain tradition is highlighted and valued. Tradition is a structural element in any society not because it brings multiple, cyclical replications of a perspective from the past, but because it provides continuity:

> La tradizione è importante per capire la necessità del cerimoniale: transmettere qualcosa a qualcuno ha importanza in sé e non perché è una replica del passato (Tessarolo, 2018:39).

Under these conditions, in fluid times, characterized by an accelerated (postmodern) dynamics, the ceremony itself evolves with the flow, serving social groups, and the social life as a whole, but also the nation:

> La cerimonia in quanto momento ufficiale dovrebbe essere la parte più rappresentativa non solo della vita sociale di un gruppo, ma di quella di un'intera nazione (Tessarolo, 2018:41).

In the chapter dedicated to the processes of social differentiation in what concerns/through their ceremonies, Mariselda Tessarolo distinctly analyzes the historical roots of behavioural codes, the relationship between common sense and routine, the ability to perpetuate a society's cultural heritage through language, but also the forms of status translatable through communicative actions characterized by the prevalence of the phatic function. The nonverbal dimension of those aspects is distinctly analysed: visual contact, greetings, clothing and other elements related to a person's exterior countenance, olfactory aspects etc.

3. CURRENT CEREMONIALISM. CEREMONIAL FORMS IN MILITARY ACTIVITY

The typical daily ceremony does not greatly differ from its previous forms, as established by institutions in their role of 'generalized interlocutors', meant to control individual behaviour for the benefit of individuals themselves (this time, considered as citizens):

> Le istituzioni sono 'interlocutori generalizzati, un vero e propro mecanismo di controllo dei comportamenti individuale: l'individuo si comporta come gli alti pensano mettendo in atto quelle aspettative ha introiettato nella sua vita sociale. Sotto questo profilo la cerimonia non si diferenzia di molto dalla quotidianità. [...].
>
> Si può affermare che gran parte delle cerminoie sono realizzate favore dei cittadini (Tessarolo, 2018:85).

The ceremony aims at taking into account the possibility of perfect action, for the distinct emphasizing of each symbolic element that has a distinct content and for the legitimation of social connections at a different level than that of daily routine activities. Bringing along nearly five thousand years old cultural tradition, the ceremony as a set of written rules regulating action has been used for the same purposes. The rules of ceremonials contribute to the creation of a common language or code of behaviour. Under the terms of denunciating the great narratives, postmodernity sees contemporary ceremonies in a different light (Tessarolo, 2018:91). However, contemporary rituals do not produce a new sense of time – the flow of time is just a constant and a norm that does not correspond to the restraints proposed by postmodernity as it reinterprets the history.

Under these circumstances, the protocol is self-established as a rule governing particular forms of prefigured action. Not everything is written in the ceremony. That is why the ceremony is based on the implementation of the protocol rules – and this aspect is clearly and meticulously analysed by professor Tessarolo. From the diplomatic protocol to the protocol which functions as a constitutive element of some institutions that benefit from their own ceremonies (and adjacent rules, symbols, gestures, forms, rituals etc.) such as the military or the church, it evolves into its double quality: diplomatic and extended. The last one refers to the general rules of public relations: „il protocollo è l'insieme delle consuetudini, degli usi e delle norme che hanno disciplinato e che disciplinano tuttora la vita di relazione pubblica" (Tessarolo, 2018:93).

Moreover, the distinction between ceremony and protocol is eloquently highlighted:

> Il protocollo è l'applicazione del cerimoniale: si può fare un parallelo tra ciò che è la legge (cerimoniale) e i suoi decreti applicativi (protocollo) (Tessarolo, 2018:93-94).

With regard to the ceremonial dimension of military institutions, the elements of protocol are prescribed. The normalization of this protocol (explained by an indirect reference to the Romanian military regulations) regarding the non-verbal communication is important and consistent:

> Nei vari regolamenti scritti o in parte consuetudinari, tutto ciò che riguarda il comportamento non verbale è descritto comunque in forma verbale e si evidezia nell'insieme del contesto. Il comportamento non verbale è un comportamento prescritto e complementare alla comunicazione verbale in modo di disciplinare per esempio: l'allineamento di base dei soldati, gli ordini di „attenti!" o „riposo!", „fianco destr!", tipi di corsa ecc.). In practica gli ogni comprendono la posizione del corpo, delle gambe, della testa e anche degli occhi (Lesenciuc, Saghin, 2015) (Tessarolo, 2018:94).

The organization of ceremonies, including military ceremonies, implies a deep understanding of the rules of ceremonialism, but also of those rules which relate to the sense of belonging to a certain community. Linguistic and relational skills, organizational and communicative competencies are also mandatory requirements for a good organization of the ceremony.

4. CONCLUSIONS

The Italian scholar Mariselda Tessarolo's book *Dalla quotidianità alla cerimonia. Fondamenti sociologici e antropologici della cerimonialità* is a reference work in the apparently more and more restricted research area studying ceremonialism in the contemporary world. Spotlighting the society instead of individualism (that erodes interpersonal connections), ceremonialism reorganizes and fortifies the communicative functions of society and institutions. By debating the two dimensions: the horizontal of daily life, and the vertical of ceremonialism, that explores the history in order to bring practices, traditions, or values belonging to a certain society closer to the present, Mariselda Tessarolo proposes a complex analysis of an area that did not receive sufficient attention from sociological or anthropological perspectives before. Through this analysis, the panoply of representative works approaching communication from the perspective of symbolic interactions is diversified. Moreover, a distinct area or sector of activity, rather dealt with by means of applicative prescriptions, is now analysed with scientific tools, and within the limits of epistemological neutrality.

REFERENCES

[1] Lesenciuc, A. & Saghin, C. (2015). General Military Regulations – Nonverbal Communication Handbooks? The Prescriptive Nonverbal Profile of Romanian Soldiers. *Redefining Community in Intercultural Context.* Vol.4, no.1. 65-86;

[2] Poggi, G. (2004). *Weber*. Bologna: Il Mulino;

[3] Tessarolo, Mariselda. (2018). *Dalla quotidianità alla cerimonia. Fondamenti sociologici e antropologici della cerimonialità.* Milano: FrancoAngeli.