

## DEFENCE ARCHITECTURE BASED ON INFORMATION AGE OODA LOOP

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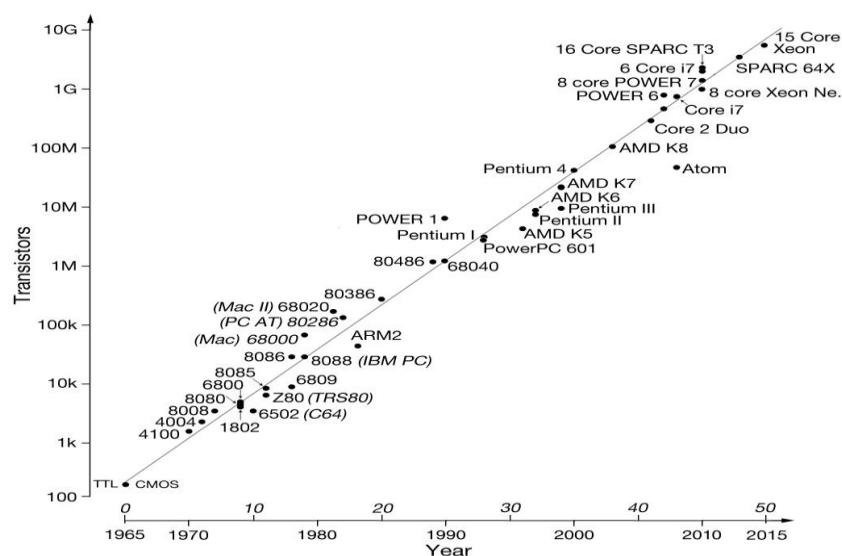
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**Abstract:** The paper analyzes the OODA loop from the Information Age point of view to find if is possible to use it without any changes. According with the results of this analyze the loop was created based on a kinetic confrontation and must be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

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

### 1. INTRODUCTION

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



**FIG. 1** Moore's law during the last 50 years

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

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

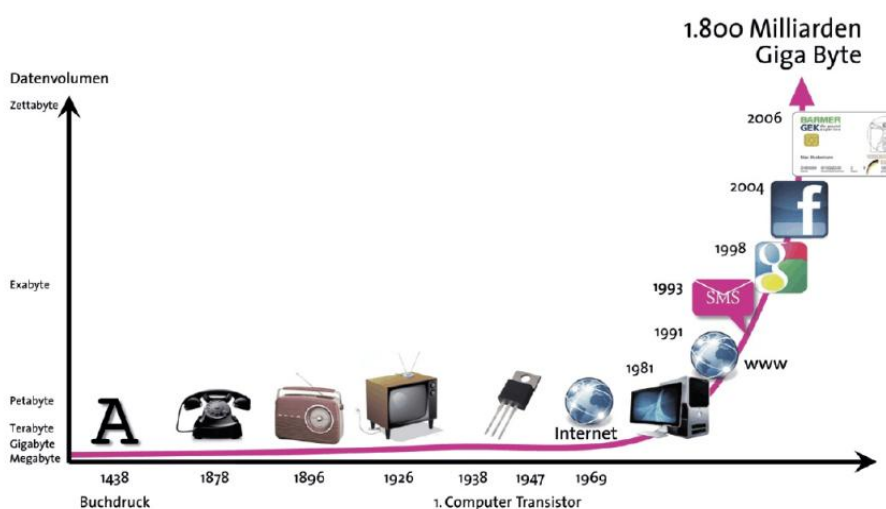


FIG. 2 Possible causes for big data according to Bitkom [1]

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

- a) The amount of data in the world will affect each organization also military organizations;
- b) The amount of data able to be handled by a hierarchical organization is limited;
- c) The amount of data in the world had increased exponentially and will continue to increase;

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

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

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

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

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

## 2. OODA LOOP MODEL

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

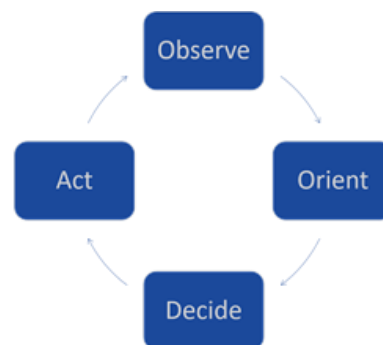


FIG. 3 OODA loop

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

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

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

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

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

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



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

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

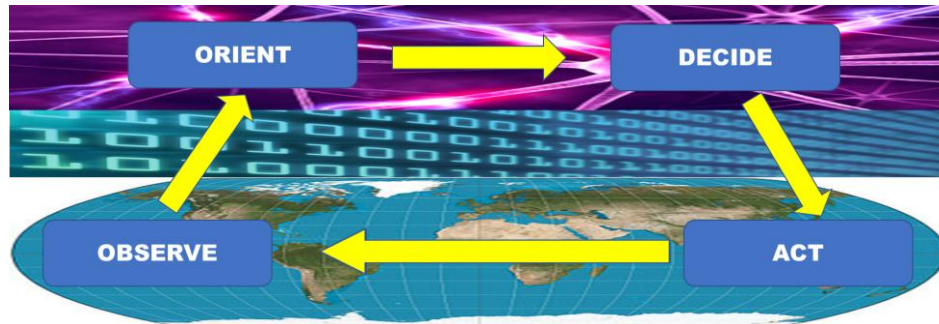


Fig. 5 OODA loop from Information Age perspective

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

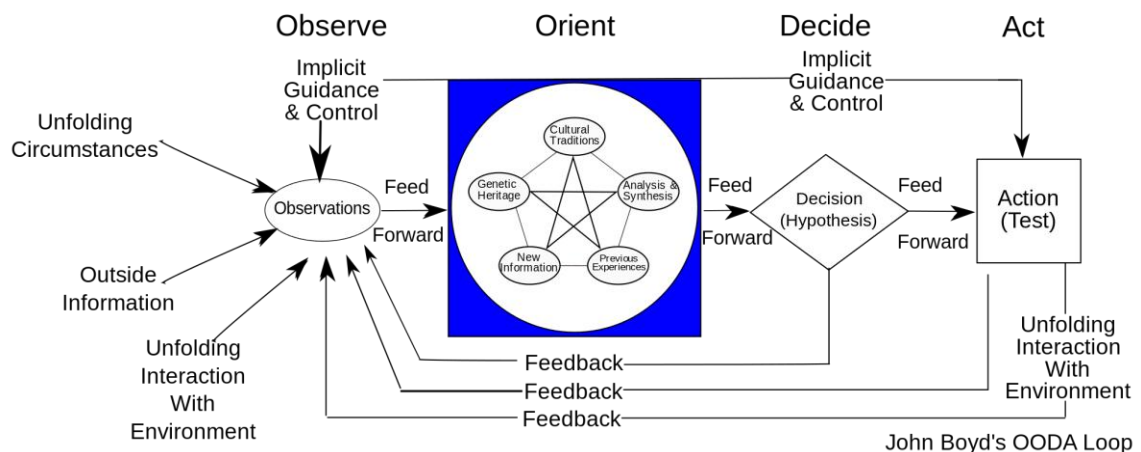


FIG. 6 John Boyd’s OODA Loop 2001

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

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

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

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

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

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

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

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

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



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

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

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

### 3. OODA LOOP MODEL UPDATED TO INFORMATION AGE

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



**FIG. 7** The evolution of Information domain

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

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

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

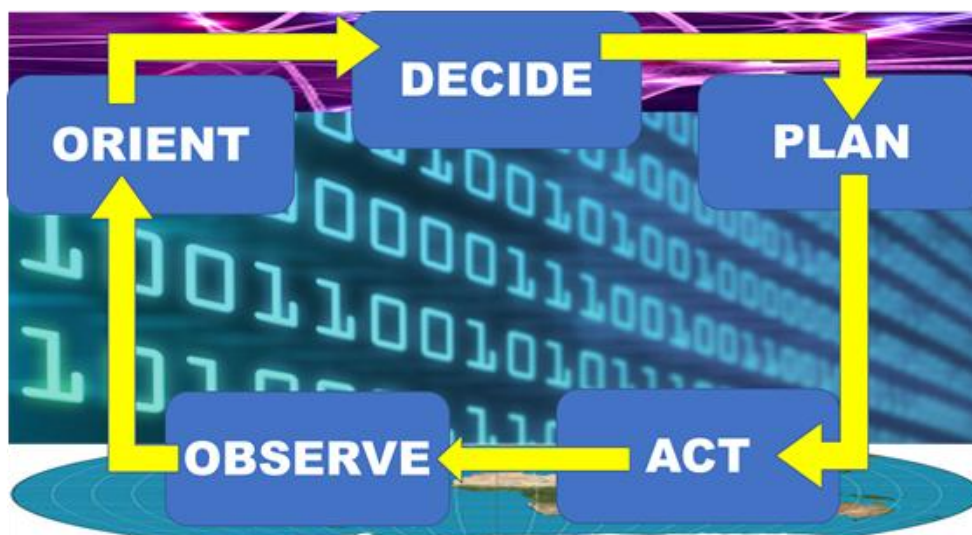


FIG. 8 The updated OODPA loop

## CONCLUSION

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

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

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

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

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