

C4I SYSTEMS CONCEPT: DEFINITION AND DEVELOPMENTS

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I. INTRODUCTION

The fast developments in technology and, especially, in the information field cause major changes at all levels of human activities, the military one included.

In our approach, we could start from the *Microsoft's* father, Bill Gates's statement that "The instruments of the industrial period extended our arms' capacities. The instruments of the digital period extended our mind's capacities".

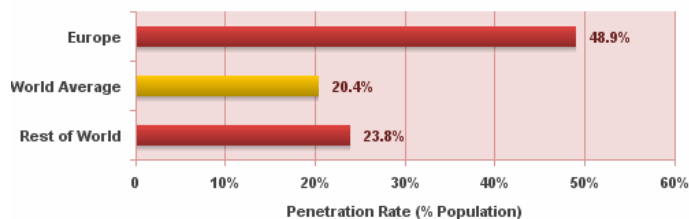
Since the advent of the Internet networks in '60s (Arpanet network was developed by, and started to work for, the US Department of Defense), the tremendous, worldwide development, has extended to the underdeveloped countries too. From a few hundreds users, especially the governmental institutions, universities and R&D institutes, in December 2008 the world wide web extended to 1.6 billions, which represents a penetration degree of 23.8% of the world population.

Internet Usage in						
	Population (2008 Est.)	% Pop. of World	Internet Users, Latest Data	Penetration (% Population)	User Growth (2000- 2008)	Users % Table
Europe	803,903,540	12.0 %	393.373.398	48,9 %	274,3 %	24,6 %
Rest of World	5,906,125,530	88.0 %	1.202.896.71	20,4 %	370,1 %	75,4 %
TOTAL WORLD	6,710,029,070	100.0 %	1.596.270.10	23,8 %	342,2 %	100,0 %

NOTES: (1) European Internet Statistics were updated for. (2) Population is based on data from the Census Bureau. (3) The usage numbers come from various qualified sources, mainly from data published by Nielsen Online, ITU Gfk, and other trustworthy sources. (4) Data may be cited, giving due credit and establishing an active link back to Internet World Stats. Copyright © 2009, Miniwatts Marketing Group. All right reserved worldwide.

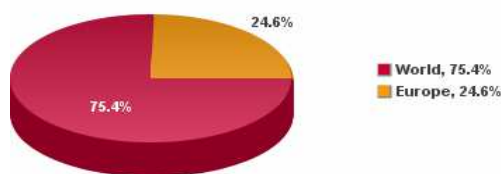
Figure no. 1. The use of the Internet

Internet Penetration in Europe



Source: Internet World Stats - www.internetworldstats.com
Based on 1,596,270,108 world Internet users for March,31 2009
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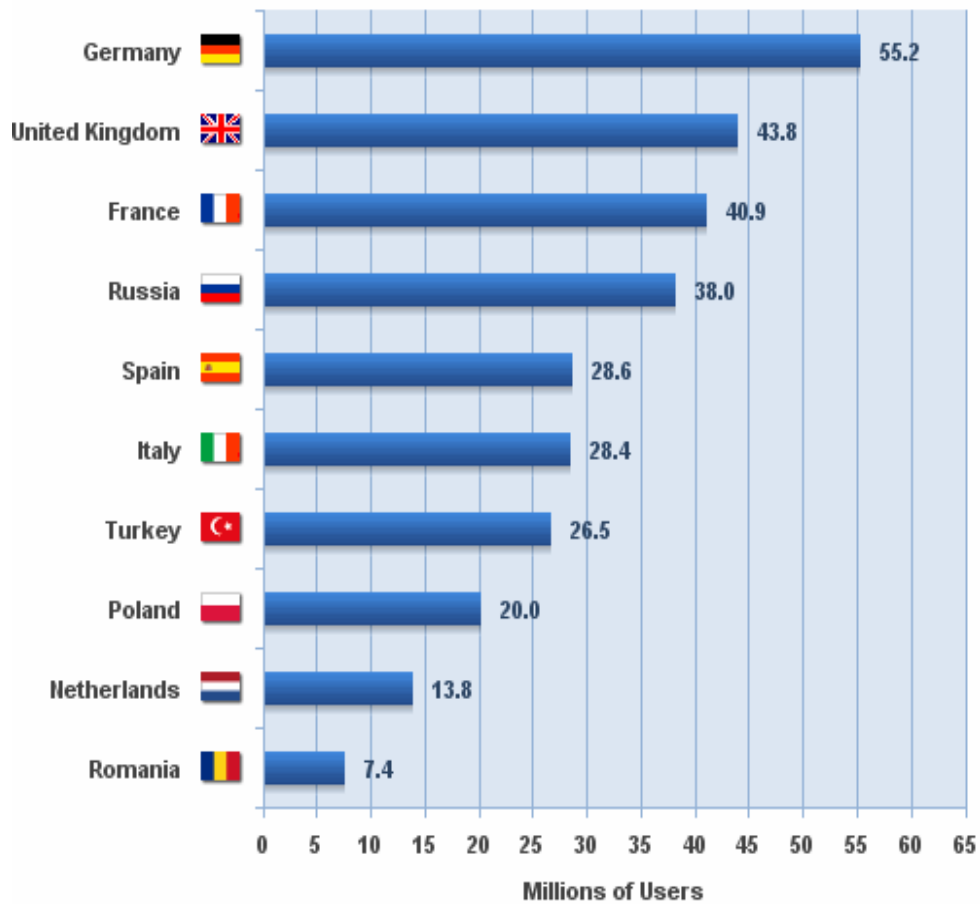
Internet Users in Europe vs. Rest of the World



Source: Internet World Stats - www.internetworldstats.com
Based on 1,596,270,108 estimated world Internet users for March 31, 2009 Copyright © 2009, Miniwatts Marketing Group

Figure no. 2. The use of the Internet in Europe

Internet Top 10 Countries in Europe



Source: Internet World Stats - www.internetworldstats.com
Basis: 393,373,398 estimated Internet Users in Europe for March 31, 2009
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Figure no. 3

No. Crt.	Country	Population (estimated in 2008)	Internet users – December 2008	% of the population (penetration)	Development (2000-2008)
1	Estonia	1.307.605	854.600	65,4 %	133,1 %
2	Slovenia	2.007.711	1.300.000	64,8 %	333,3 %
3	Latvia	2.245.423	1.324.800	59,0 %	783,2 %
4	Lithuania	3.565.205	2.103.471	59,0 %	834,9 %
5	Slovakia	5.455.407	3.018.400	55,3 %	364,4 %
6	Hungary	9.930.915	5.215.400	52,5 %	629,4 %
7	Poland	38.500.696	20.020.362	52,0 %	615,0 %
8	Czech Republic	10.220.911	4.991.300	48,8 %	399,1 %
9	Croatia	4.491.543	1.984.800	44,2 %	892,4 %
10	Macedonia	2.061.315	906.979	44,0 %	2.923,3 %
11	Turkey	75.793.836	26.500.000	35,0 %	1.225,0 %
12	Romania	22.246.862	7.430.000	33,4 %	828,8 %
13	Bulgaria	7.262.675	2.368.000	32,6 %	450,7 %
14	Serbia	8.032.338	2.602.478	32,4 %	550,6 %
15	Bosnia-Herzegovina	4.590.310	1.441.000	31,4 %	20.485,7 %
16	Belarus	9.685.768	2.809.800	29,0 %	1.461,0 %
17	Russia	140.702.094	38.000.000	27,0 %	1.125,8 %
18	Moldova	4.324.450	700.000	16,2 %	2.700,0 %
19	Albania	3.619.778	580.000	16,0 %	23.100,0 %
20	Ukraine	45.994.287	6.700.000	14,6 %	3.250,0 %

Figure no. 4. The use of the Internet in the Central and East Europe

No. Crt.	Country	Population (estimated in 2008)	Internet users – December 2008	% of the population (penetration)	Development (2000-2008)
1	Netherlands	16.645.313	13.791.800	82,9 %	253,6 %
2	Iceland	304.367	273.930	90,0 %	63,1 %
3	Sweden	9.045.389	7.295.200	80,7 %	80,2 %
4	Norway	4.644.457	3.993.400	86,0 %	81,5 %
5	Denmark	5.484.723	4.408.100	80,4 %	126,1 %
6	Finland	5.244.749	4.353.142	83,0 %	125,9 %
7	Luxembourg	486.006	363.900	74,9 %	263,9 %
8	United Kingdom	60.943.912	43.221.464	70,9 %	180,7 %
9	Faroe Islands	48.668	37.500	77,1 %	1.150,0 %
10	Switzerland	7.581.520	5.762.700	76,0 %	170,0 %

Figure no. 5. Top 10 European states according to the penetration rate of the Internet

CAI SYSTEMS
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All the institutions of a modern state (political, financial, cultural, educational, scientific, military, a.s.o.) that store and process a large volume of data by using hardware infrastructures and a proper set of software applications cannot do without the efficiency and competitiveness the IT&C contribute.

Coming back to the military field, one can notice and analyze the evolution in the information systems domain, especially starting from the 70's. Important progress has been determined by factors such as:

- *the technological developments* in the manufacturing of the civil and military communications equipment (miniaturization, power, extension of the frequency bands, types of modulation, large transport capacities, a.s.o.);
- *the increase of computer performance* of all kinds (memory capacities, processing speed, user-friendliness, miniaturization, rigidity, a.s.o.);
- *conceptual, technological and operational cooperation* of the digital communication equipment and networks with the electronic calculation equipments and software applications typical for each activity field;
- *the huge pressure on the command and control structures* to shorten the leadership cycle and to perform a fast multicriterion-based analysis of a huge volume of data and information necessary to plan and conduct the operation (the battle);
- *the opto-electronic sensors state-of-the-art development* and the emergence of new types of high performance, placed on different platforms (i.e., land, air, sea, space);
- *the digital maps emergence and development* using cartography methods with the help of the aerial and cosmic photos, as well as the calculation capacities of some supercomputers (especially for the USA);
- *the "information war" concept emergence and development* and, as a consequence, of the protection measures for the personal information infrastructure, simultaneously with the destruction of the enemy infrastructure;
- *the development* of new concepts regarding the war command.

II. DEFINING SOME CONCEPTS AND SYSTEMS

In the information period, the exploitation of the information and communications technology is paramount, to facilitate the development of the so called “knowledge-based society”, fast and simple access for billions of people to a huge virtual library, disseminated into thousands of storing capacities. This evolution has had great impact on the military environment, especially in the sense that some important achievements have been generated or made by officials of many armies.

For the purpose of outlining as realistically as possible the problems that emerge out of defining some concepts and realities, in the information systems field, known as C4I (and the variants that have been developed in time), we will try to make some clarifications, as follows:

- *the global information environment* which includes the personalities, organizations, systems a.s.o., many of them being outside the military environment or the national command authorities, that collects, processes and distributes information at the national and international level;
- *the national information infrastructure* which includes the public and private telecommunications networks, satellite and terrestrial technologies, especially in the radio and optic fibres communications field that delivers the information to the institutions and the people’s homes, the information and its contents that circulate in the infrastructure for the data bases, hardware terminals and software products for access to information, the personnel who collects, stores, processes and generates new information, a.s.o.
- *the defense information infrastructure* which includes the necessary resources to transfer, process, store and display the information, the technical means for command and control, research and other categories of means to transmit voice, the immobile and moving images, multimedia services especially useful for the national defense system;
- *the military information environment* which consists of the information systems and personnel and the enemy’s organizational structures that support or significantly influence the military operations. This must supply services for the connection of the terminals from home to the operations area systems, passing from peace to warfare, supplying the technical

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support for communications in real time, necessary to execute the mission and ensure cooperation among all the categories of military, economic, social, political and administrative structures that can be local, regional and national;

- *the information systems (C4I)* which consist of the infrastructure, organizational structures, personnel and components that collect, process, store, transmit, display, distribute and act according to the information collected. These constitute the structure that supports the staff process, as well as the decision-making ones and which ensures a relevant common picture that contributes to the synchronization in the use of force, movement of sensors and weapon systems by the commanders, supports the combat capability and protects the command and control systems and activities.

The correlation between these environments is presented in the Fig.6.

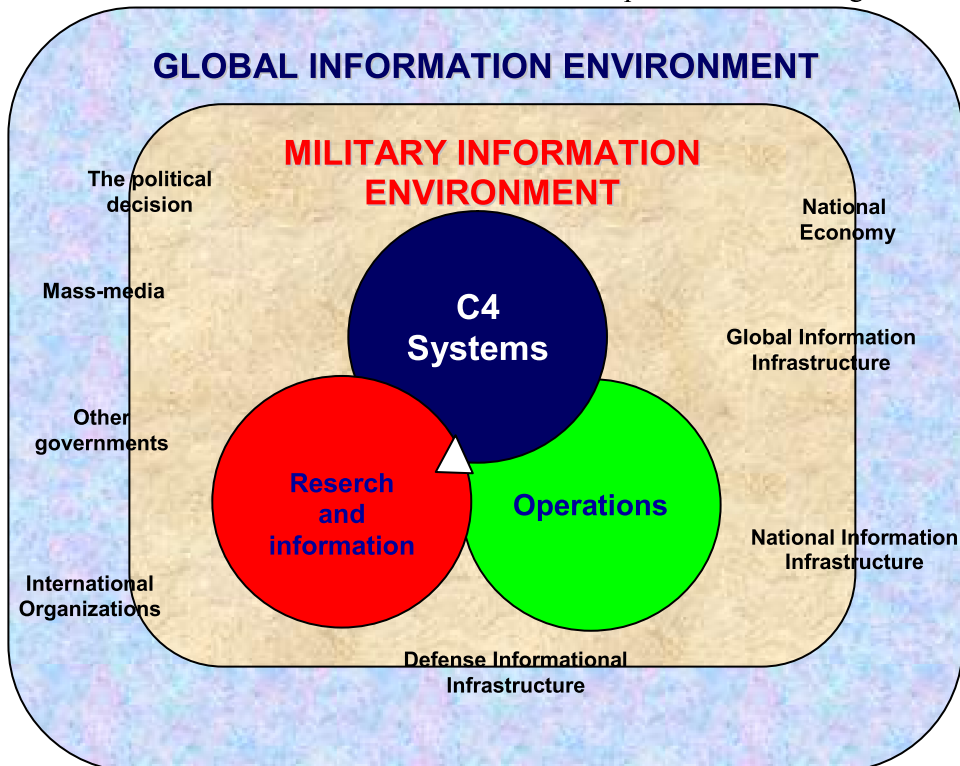


Figure no 6. The global and military information environment

The unprecedented development in the information and communications technology set up new administration and data processing methods. They include images, color graphics, schemes, digital maps, data bases that can be combined with modern communication techniques (satellites, radio stations with frequency hopping, radio relays on microwaves, tropospheric and ionospheric radio stations) which, once deployed, ensure military and national global infrastructures.

The military actions deployment environments became more diverse and acquired new dimensions:

- the physical environment (land, air, sea, space);
- the electromagnetic environment;
- the psychological environment;
- the cybernetic environment.

The battlefield typology, in some western experts' opinion, is analyzed based on conceptual, psychological, geographical, physical criteria of command and control, information systems, a.s.o.

The information supremacy represents the information prevalence degree offering the personnel the possibility to use information systems (C4I) to obtain operational advantages during conflict, or to control a certain situation, by simultaneously reducing the enemy's possibilities to use information that is necessary to the similar processes for own troops.

The increase of the information flow through the use of the communication systems with distributed structure, the use of special units, officers and research teams, as well as the innovations in the sensor systems, processors, communications and computers, can offer commanders knowledge about the operational situation through immediate access to information with regards to the enemy and own troops.

The battlefield image with clear knowledge of the current situation of own troops in connection with the enemy's and the environmental conditions, the image of the final desired situation which represents the accomplishment of the mission, the sequential visualization of the activities that will lead own forces from the initial situation to the final one.

The knowledge of the situation through analysis, assimilation of the commander's intent and of the battle (operation) concept in connection with the clear image of the conflict, the enemy's possibility and own forces.

The information management by collecting and processing large amounts of information, the reduction of the command cycle period, the elaboration of the decisions in a short period of time.

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CONCEPT: DEFINITION AND DEVELOPMENTS

The command, control, communications, computers and information (C4I) systems have a very important role in achieving these capital desiderata to have success in the military activities.

C4I integrated systems (+ variants) include doctrines, procedures, organizational structures, personnel, auxiliary equipment and devices destined to support the commander and his staff in exercising command and control on the entire battle actions spectrum (efficiency).

To understand correctly the problems referring to the structure and the operation of these systems, we consider it useful to clarify the specific minimal terminology:

- *Command* – the authority that a commander, in military service, exercises legally on his subordinates, according to his rank and attributes. Command includes the authority and responsibility to use efficiently the available resources and to plan the use of military forces to accomplish the missions received. Also, it includes the responsibility for the state of health, the welfare, morale and discipline of the subordinated personnel;
- *Control* – the authority that can be exercised by the commander on some part of his subordinates' activities or on some other organizational structures that are temporarily subordinated to him;
- *Command and control* – the authority and leadership exercised by a designated commander on the organic forces that are temporarily subordinated to accomplish the mission. The command and control functions are exercised through an aggregate organized by the personnel, technical equipment, communications, auxiliary apparatus and procedures used by the commander to plan, lead, coordinate and control the battle forces and actions to accomplish the mission.

The Correlations between Command, Leadership and Management

- First of all, management refers to the allocation of resources and control (human, material and financial) to meet the objectives. In the military field, management is defined as “the use of a large variety of techniques to improve planning, organization and deployment of the operation (battle), logistics, administration and acquisition”. In essence, both management and command contain elements that belong to leadership, elaboration and control (with the meaning of checking, observation and correction).

As a rule, command (especially, the identification of the missions that must be accomplished and their motivation) includes activities that are connected to

management (the allocation of the means and other resources to accomplish this) and leadership (the assignment of missions to the subordinates).

Figure 7 shows the relations between the aspects of command (leadership, decision elaboration and control) and the three base components (conceptual, moral and physical). Command is defined as “the capacity and will to join the subordinated personnel for the common purpose in connection with the commander’s character that inspires trust”.

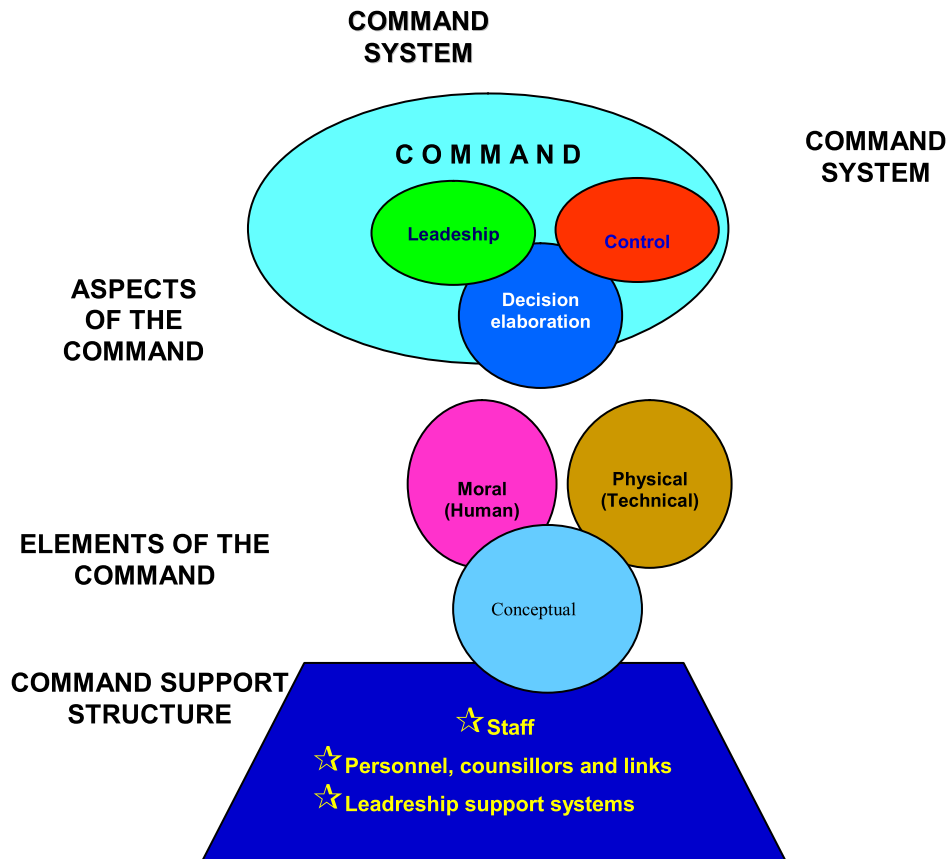


Figure no 7. Command model

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As a rule, the command cycle, assisted by the C4I integrated systems, consists of 5 sequentially deployed elements:

- *The situation awareness* which includes the activities of information collecting, storing, completing and validation;
- *The situation analysis* which includes activities regarding foresight, comparison and valuation of the information obtained in the first stage, the evaluation of the general situation, the effects of the current and future actions, own and the enemy's, combat capacities and comparing the battle courses of action;
- *The planning* which includes the activities of using the results of the situation and mission analysis, as well as updating (changing) the action plans;
- *The elaboration of the action orders* that require the participation of the commanders or the officers who were designated by them and implies making decisions through the application of the plans and changing the intensity or the scope of action;
- *The execution and control* that follow the decision implementation and imply continuous links with the higher echelon, subordinates and neighbours to monitor the mission accomplishment.

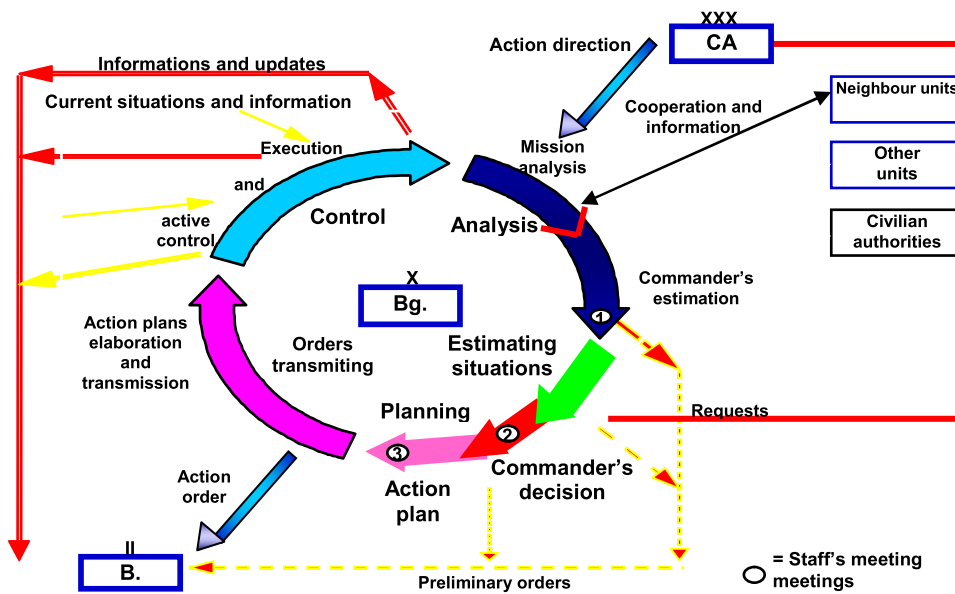


Figure no 8

The information activities imply information collection, transport, process, conversion, distribution, use, protection and exploitation.

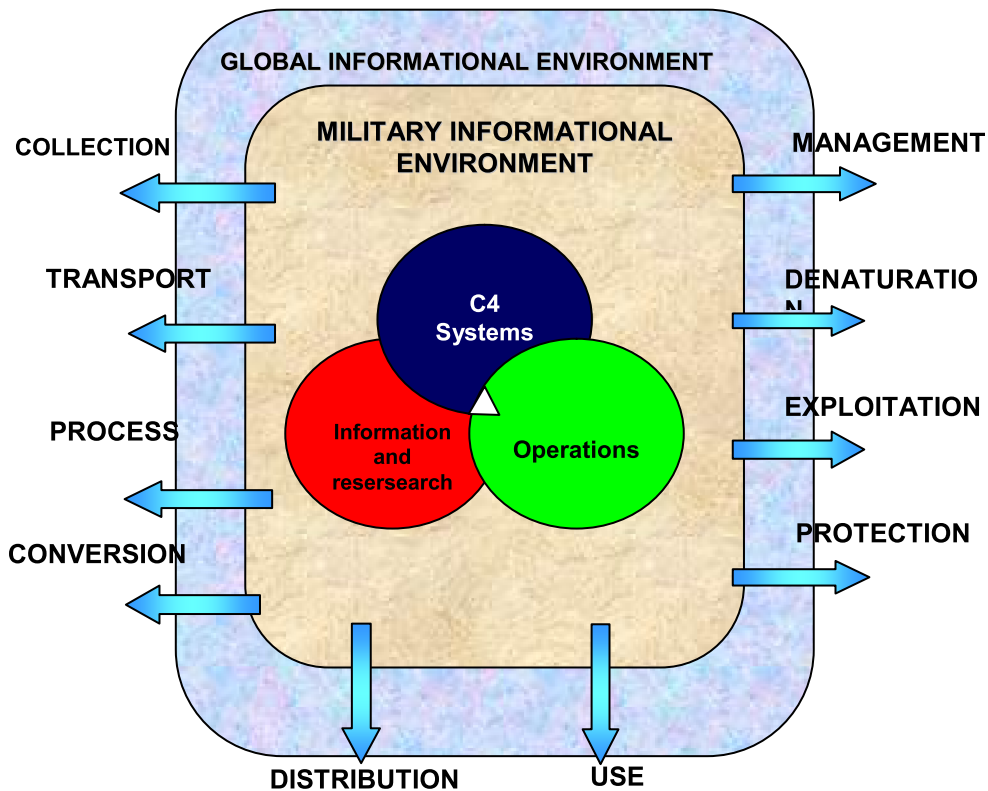


Figure no. 9. Information activities in C4I systems

Collection implies the initial data acquisition (obtaining) and filtration based on the planned needs and their presentation in an adequate form for being transmitted. This information refers to the mission, enemy, own troops, terrain, weather, and time available. The collection of information is done with the help of electronic systems, operational research and reconnaissance activities, strategic, operational and tactical research, cooperation with the police and the media.

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Transport implies information and data transmitting or communication to the destined reception devices.

Data processing consists of data storing, extraction from the memory devices, updating, filtration and their synthesis to obtain minimum of information that can be used.

Information conversion implies info transformation from one form to another without loss and or change of accuracy, so it can be transmitted and displayed as a text, image in immobile or moving format, computer data, a.s.o.

Information distribution (dissemination) implies transmitting the processed information to the potential users.

The use of information (after the data have been obtained, analyzed and checked) has as a purpose the updating and knowledge of the real situation to continuously improve or adopt decisions, plans and military actions.

Information protection implies the analysis of the vulnerability of the forces and own command and control means for the enemy's electronic actions, physical distruction, deceit, propaganda, as well as establishing the means, application and checking countermeasures. The infrastructure elements that need to be protected are the data bases, the computer networks, communications and research systems and the auxiliary means.

Information exploitation is described as the action of obtaining advantages out of any acquired information for the military operational purposes. This implies the interception and analysis of the enemy's messages, extracting the information from his data base, taking misrepresentation, degradation or manipulation measures against his information capabilities.

The enemy's information misrepresentation is made through the attack measures against command and control (C2W) and refers to degradation and destruction of his intelligence and information systems (C4I).

Information management requests careful coordination and sychronization of the intelligence and information systems (C4I) and includes: electromagnetic spectrum management, choosing the sources and systems to be used, ensuring reliable information flow (i.e., vertically and horizontally integrated), interception of the information from several sources.

The C4I2 systems structure can be analyzed on subsystems, as follows:

- command and control subsystem (C2) with organizing structures to achieve the command cycle and adjacent technical and information support;
- communication system – equipment, methods, procedures and personnel for transmitting the information among all the battle (operational) components;

- local and extended computer network – hardware and software support to process, store and convert information;
- information subsystem which collects, processes and distribute the staff information (about the enemy, own troops and environment);
- interoperability – the requests implemented in the technical components (hardware) and programming (software) that allow the easy interconnection of the structural elements and the information transfer without impediments.

There are some variants of integrated command and control systems:

- *C3I* – Command, Control, Communications and Intelligence;
- *C4I* – Command, Control, Communications, Computers and Intelligence;
- *C4I2* – Command, Control, Communications, Computers, Intelligence and Interoperability;
- *C4RISTA* – Command, Control, Communications, Computers Reconnaissance, Intelligence, Surveillance and Target Acquisition;
- *C4ISR* – Command, Control, Communications, Computers Intelligence, Surveillance and Reconnaissance;
- *C4IFTW* – Command, Control, Communications, Computers, Intelligence For the Warrior;
- *C4IEWS* – Command, Control, Communications, Computers, Intelligence, Electronic Warfare and Sensors;
- *C4ISTAR* – ISTAR: information, surveillance, target acquisition and research.

Command and control represent an essential cyclic process through which the military forces' actions are planned, led, coordinated and controlled (corrected) to accomplish a mission. This process starts by collecting the information about the situation that is being evaluated and analyzed, the alternative action courses to change the situation in the commander's favour and, then, once proposed and elaborated as plans, making the decisions regarding the actions that are going to happen; decision approval and its application. So, the actions change the initial situation and the whole process is restarted. The essence of the process is making the decisions and their application in due time. The maximum responsibility belongs to the commander who requests the staff support concerning the information collection and provision, analysis and anticipation of the situation; he recommends the best courses of action, prepares the plans, orders and dispositions, approves and orders the dissemination of decisions, supervises and monitors the way they are executed.

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All staff compartments participate in these activities.
 For this, the following logical structures can be set up (figure no. 10):

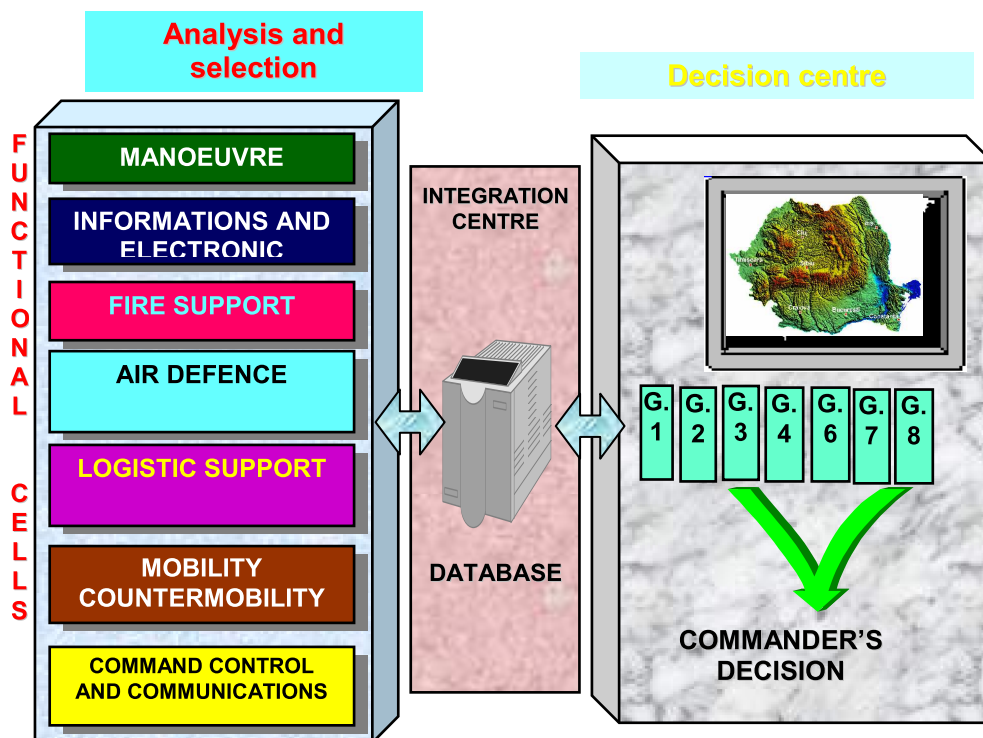


Figure no. 10. The logical organization of a command

- *a number of functional cells within an information selection and analysis centre* which depends on the type of command and the latter's hierarchical level;
- *a decision centre* where the commander, supported by the staff, analyzes the situation and gives orders and dispositions;
- *a synthesis centre* which ensures information and communication services to the functional cells and the decision centre.

In the information analysis and selection centre the following cells can function:

- *the manoeuvre control led by G 3* responsible for the control and support of actions. For this, it prepares the action plans and operational orders,

receives, analyzes and approves the requests for air support, coordinates the troops manoeuvre in the tactical field, keeps the evidence of the units use and proposes the use of the special armament;

- *the fire support, also led by G 3*, is responsible for planning and coordination, elaborates the plans for this and monitors their application, proposes the field artillery and missiles and the priorities to hit the enemy targets;

- *air-defense (G 3)* coordinates this activity and fulfils the air control functions by updating the air situation, plans and leads the air-defense fire at different heights in their responsibility;

- *information and electronic warfare (G 2)* processes and synthetizes the research information. The main responsibilities regard information management: collection, analysis, processing and distribution. Also, it cooperates with other specialized organs from the area of responsibility to plan the future actions;

- *logistics (G 1 and G 4)* provides the human, technical, material and medical resources management, well as transport and maintenance management;

- *mobility and countermobility (G 3)* is in charge of the communication ways status and actions for the preparation of the land, builds passages and obstacles, plans and accomplishes destruction and fortifications;

- *command, control and communications (G 6)* plans, achieves and ensures the communication and information systems functioning, and also leads the special elements and units.

At the same time, between these logical structures there are tight functional relations, strengthened by the internal link system (through communication means and work stations from the local computer networks) and the external link system (through the communication system) between the command structures and the operational ones (Fig. 11).

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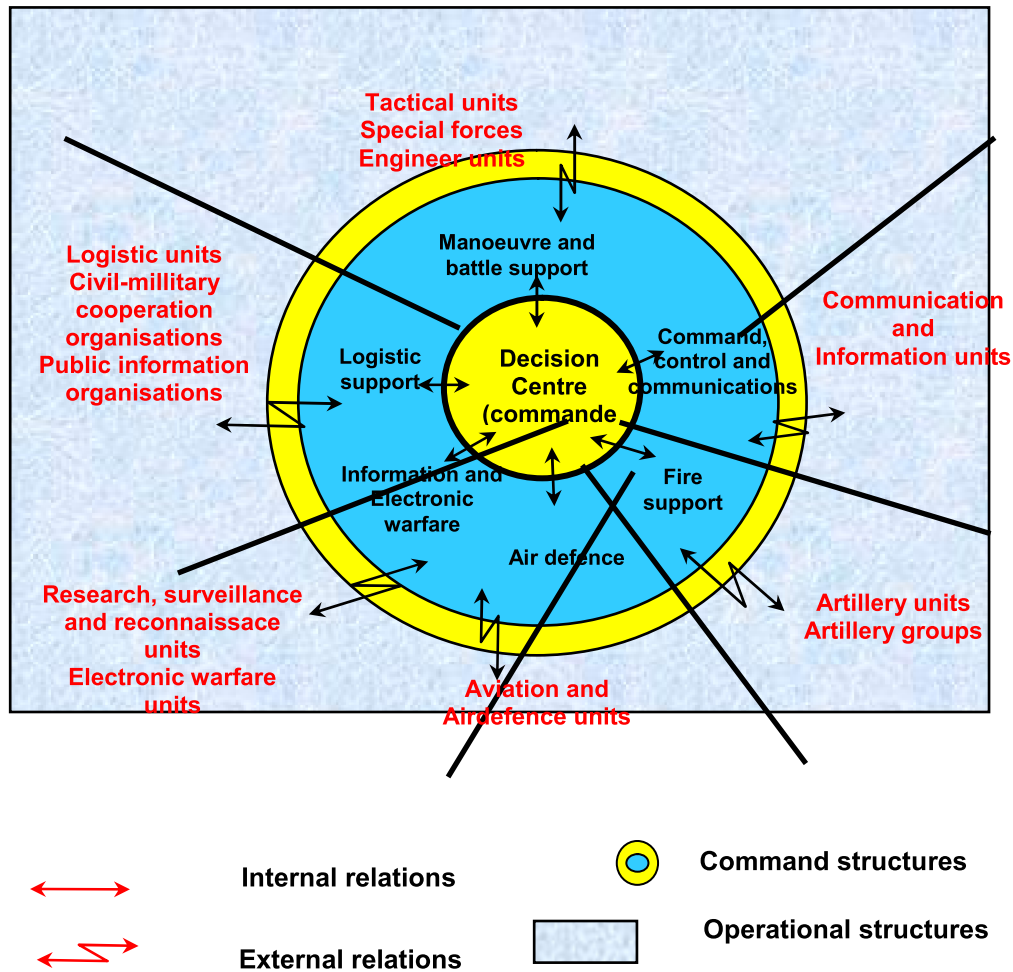


Figure no 11. Functional organization of a command

III. C4I SYSTEMS (+ VARIANTS) OF SOME MODERN ARMIES (1970 - 2009)

All the NATO armies, beginning with the 70s, have initiated an ample process of modernization of the communication and information systems (CIS), and later, of some integrated system complexes type C3I (C4I, variants).

Without insisting too much on the reasons that determined this option, we can speak about the following stages:

▪ *The 70s:*

1. The development of some permanent military communication networks, analogic at first, then mixed analogic-digital and, finally, digital in the 80s (USA, France, Germany, Italy, the UK);
2. The increase of the data transport capacity to the detriment of the voice communication use, and, as a result, the commercial global network boom, generically called Internet;
3. The research, development and implementation of some automatized CIS systems (networks) for the operational and tactical echelons, such as:
 - M.S.E. – USA;
 - AUTOKO – Germany;
 - SOTRIN – Italy;
 - RITA – France.
4. The increase of the military communications' role, based on:
 - HF, VHF and UHF land, air and navy;
 - Radio communications through civil and military satellites.

▪ *The 80s and 90s*

1. The development and implementation, to all the echelons, of some strictly integrated system type (C4I and variants)
 - promoters: USA, Great Britain, Italy, France, Germany.
2. The emergence and use of the digital maps at the troops level, permitting a high precision level of the forces in motion and a stronger integration of the diverse opto-electronic sensors;
3. The development of a new category of opto-electronic sensors and their integration in the weapon systems, resulting in greater accuracy and reaction in real time;
4. The application of some lessons learned from conflicts that took place worldwide (especially by the US Military);
5. The elaboration of new concepts in the C4I domain (+ variants) in USA and NATO.

▪ *After 1999 to date*

1. The development of new concepts within NATO in the NATO ENABLED CAPABILITIES (NEC);
2. The initiation and strengthening of the "Network Centric Warfare" concept (by the US Military after 1999);
3. The increase of NATO's efforts to raise the level of the European armies of NATO memberstates, in the C4I field (+ variants) (the case of Romania also);

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4. The development of the concept of „network of networks” or „system of systems”, meaning a very high level of compatibility (interoperability) between different systems from the same country and between systems of the allies;
5. The extension of the VoIP communications role following the commercial networks model (INTERNET);
6. The improvement of physical and electronic means to protect the data and voice communications;
7. The wider use of the GPS systems both in the C4I systems planning and in the weapon systems.

IV. CONCLUSIONS

1. The armies of the NATO states (and not only) allocate considerable human and financial resources for consolidating some C4I (+ variants) capabilities at all echelons, for all services and in all environments for combat actions (in the US Military, 10 – 14% of the procurement budget goes to this area every year).
2. Important progress is being made in the implementation of the “Network Warfare Enabled Capabilities”. In USA, the action started in 2002 with a budget of 7 billions until 2009.
3. The Internet model is penetrating faster and faster in the military networks. The soldier will search for the wanted information by using a search engine similar to the Internet Google, for example (passing from pushing the information to extracting the information).
4. The C4I system is being developed following the commercial solutions’ model, the distributed calculation systems, the distributed data bases and complex collaboration applications.
5. The researchers and the personnel involved in military and technological developments are working to produce some systems (networks) that provide security and configuration control.

