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CERTAIN ASPECTS OF MILITARY APPLICATIONS OF ROBOTICS IN THE FUTURE MISSIONS

Abstract

As the popular saying goes,"Work ennobles." Besides its obviousness, the physical and mental loads for humans also need to take into account where the work tool has a key role, while also reflecting the degree of development of human intelligence. The advent of computers has radically changed our lives, man has created for himself so far the most versatile work tool, which is based almost entirely his present and expected future lifestyle too. In fact, the human brain, thinking was aimed to mechanize, thus the computer – its advantages and disadvantages – so far is the best technical formation of our brain, a suitable platform – might be regarded as the end goal – the development of artificial intelligence. The computer can be programmed to do anything infinite number of possible majority. It is now possible to create increasingly complex tasks, autonomous systems without human intervention as a result of the today experienced development of information technology. The author's goal is to briefly summarize in organized special majority the typical factors of robotics, especially the current international situation of scientific research, technical development and application of military robotics, furthermore their predictable development for the near and distant future. Nonetheless the importance of their existence hopefully also will be answered.

„A munka nemesít"– tartja a közmondás, amelynek igazságtartalma mellett, az emberre ható fizikai, lelki terheléseit is figyelembe kell venni, ahol a munkaeszköznek kulcsfontosságú szerepe van, egyúttal pedig az emberi intelligencia fejlettségi fokát is tükrözi. A számítógépek megjelenésével gyökeresen megváltozott az életünk, az ember megalkotta maga számára mindezidáig a legsokoldalúbb munkaeszközét, amelyre szinte a teljes mai, és várhatóan jövőbeni életvitelét is alapozza. Tulajdonképpen az emberi „agyat", gondolkodást célozta meg vele „gépesíteni", ezáltal a számítógép – annak előnyeivel és hátrányaival – az eddigi legjobb műszaki- technikai leképezés, egy alkalmas platform a - talán végcélnak tekinthető - mesterséges intelligencia fejlesztésére, mivel arra és úgy programozzuk, ahogy csak akarjuk, végtelen számú lehetőségben. Az információtechnológia manapság tapasztalható fejlődése következtében már lehetőség van emberi közreműködés nélkül is egyre komplexebb feladatokat teljesítő, autonóm rendszerek megalkotására.
A szerző célja, hogy röviden, sajátos rendezettségben összefoglalja a robotika ismérveit, azon belül kiemelten a katonai robotok kutatása-fejlesztése, és alkalmazása jelenlegi nemzetközi helyzetét, közel és távoli jövőre előrevetíthető

fejlődésüket, mindazonáltal választ adva létjogosultságuk jelentőségének mibenlétére is.

Keywords: *autonomous systems, security, defence industry, military robots, research and development, artificial intelligence, unmanned systems, defence ~ autonóm rendszerek, biztonság, hadiipar, katonai robotok, kutatás-fejlesztés, mesterséges intelligencia, személyzet nélküli rendszerek, védelem,*

INTRODUCTION

It is obvious fact that a new era has begun in the history of humanity by creating the computer, in which had an opportunity to improve the quality of our life by orders of magnitude. We had got a high degree of freedom of action into our hands with this device (also includes the directed equipments by this device), that humanity might also use up too much in every way (according to opinions of many scientists), inasmuch as their way of life is almost entirely based on this. Beside the countless advantages of this almost exclusive hodiernal solution it is known to have also several disadvantages, which actually means the vulnerability and its consequences. (Think of the problems caused by a simple power outage, or the various functions of computer viruses, not to mention the manipulation possibilities by producers due to their monopoly situation). We must meet this high-risk challenge (similarly to the possession of nuclear energy), which keyword is probably the control, absolutely keep a firm hand on this control, we can base our future security in the use of artificial intelligence (hereinafter referred to as"AI") avoiding the uncertainty.

The genius pioneers[1] of computer technology saw and anticipated the advantages and disadvantages of this revolutionary device from the very beginning (see mottos). It depends solely on people that how take this opportunity, when our typical general technological development generate new opportunities, skills day by day, which should be set in such a way to serve humanity, that would be ruled out its illegal use which harmful to society.

The author's objective of this writing includes a short, and specifically organised summary of characteristics of robotics, with high priority the research and development of military robots, furthermore the current and well known international results of their application. Due to all these the author will conclude their predictable development for near and distant future as well as logically infer the importance of reason for the existence of military robots.

The permanent actuality of the topic is justified by several significant factors:

- strengthening of respect for human life, and the objectives of improving the quality of life;
- needs of leveraged development of human capabilities in more and more areas;
- ongoing economic and scientific-technical expectations and needs, furthermore automation efforts;
- utilization of opportunities of technological development;
- ever-increasing security challenges today (e.g., terrorism, vigorous expansion of cyber warfare, disaster recovery tasks);
- reduction efforts of long-term development costs.

[1] Some internationally known Hungarian-born father of computing: János Bolyai (1802–1860) mathematician, military engineer, creator of non-Euclidean geometry (Appendix, 1831). János Neumann (1903–1957) chemical engineering, mathematics professor, his major works are: atomic (bomb) theory, exact foundation of set theory, the creation of game theory (1928), the mathematical foundations of quantum mechanics (1932), the principles of computer's internal structure and operation (Neumann principles, 1945). János Kemény (1926–1992) mathematician, computer scientist, creator of the programming language: BASIC with Thomas Kurtz (1967), E-mail pioneer (1970). Károly Simonyi Junior (1948–) software engineer, his major works are: virtual PC, object-oriented programming (1981–2002: one of Microsoft's leading software developers).

OBJECTIVES, COMPONENTS OF ROBOTICS

Occupied a special position among the controllable structures, equipments, process systems, those which redeems the role of man in physical and mental activities that previously required human intervention, these are the robots.

The word robot[2] sounds still strange the majority of people perhaps even today, maybe just because they are met with it in the science-fiction literature (which can be considered as the "founding fathers", as they described them together with their imaginable characteristics and types as their permanent player of their work much earlier before its technical implementation) and cinema (e.g. Star Wars movies). The robotics absolutely not a new activity for engineers and professionally dedicated economic experts, as already seek to automate their machinery and their equipment in order to facilitate the people live and work, improving the efficiency of the work since the ancient times dreamily about anthropomorphic auto systems too.[3]

A multidisciplinary technical research area called mechatronics deals with the tasks of robotics implementation in the scientific - technical life. More and more successful results are achieved in almost all areas[4] of life, as a result of the continuous and synergistic (reinforcing each other's effects), thereby increasing faster development of integrated techniques, as a specially important example of dangerous or very complex tasks for humans, which exceeding the limits of the practical human efforts (e.g. military operations, certain industrial processes, disaster management, space exploration, etc.).

Clarification needed for some of the basic concept circles that belong to the notion of management theory before you begin any discussion of topics, which can sometimes cause complications even for the experts, when they use these carelessly in everyday languages. It is not surprising fact that the topic pioneers (the exponents of science fiction) is at the forefront of creating concepts, because their imagination is mostly based on their scientific and technical skills and knowledge. In addition, it is clearly appreciated that human imagination exceeds the limits of science and technical feasibility in many areas.

Also characteristic feature of the sci-fi literature, that the authors give excessive human characteristics to their robot creations, thus force perplexing and mostly endless thinking on the laic reader, contrary to manipulative options of movies.

Closely related interlocking concepts of robotics:[1]

- *Control operation:* an operation, which launch, maintain, change, and stop a technical process, equipment, appliance in manual or automatic way.
- *Control engineering:* the control engineering is one of the branches of the technical sciences. This branch is the science of control theory, which deals with the laws of control and its practical implementation.

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[2] *Robot* – the word is relatively new, the Czech writer Karel Capek used it first in his play: ”Rossum’s Universal Robots” in 1921. The word "robot" means ”work” in the Czech language, Capek's robots gained the upper hand on mankind and threw them into slavery. The word robot was not widespread until 1950. The American writer Isaac Asimov completed this out, when he laid the out the three basic laws of robotics out in the short story “Runaround, I the Robot” (1950). Isaac Asimov (1920–1992) Russian-born American writer, biochemist, the most productive among the three most famous tiller of twentieth century’s science-fiction, also high on the dissemination of science. Source: http://www.vilagtudomany.hu, http://www.Asimovonline.com, [accessed 10 September 2015]

[3] Known literary example of the Iliad 18. song (Shield of Achilles): ”At once he was helped along by female servants made of gold, who moved to him. They look like living servant girls, possessing minds, hearts with intelligence, vocal chords, and strength. They learned to work from the immortal gods.” Source: https://records.viu.ca/~johnstoi/homer/iliad18.htm, [accessed 11 September 2015]

[4] One of the internationally known, Hungarian descent early scientists of robotics: Farkas Kempelen (1734–1804) polymath, lawyer, architect, engineer, inventor, the founder of modern phonetic research, his inventions are: chess playing automaton (1769), talking machine (1770), typewriter (1772), steam turbine (1788).

- *Automatic technology:* deals with the laws and practical implementation of autonomic control (full different from zero in the degree of human intervention) within the control engineering.
- *Automation:* is the technical implementation of theory of automatic technology, economic and technical activity with the substituting of human perception – controlling – and regulating activities by automatic machine process for maintaining a constant level or increasing of productivity, reliability, and quality, in order to increase process efficiency (productivity). The complex automation means the combined application of automatic regulation and control.
- *Automatic machine:* is a machine that can work automatically.
- *Operation:* is the main phase of the operation and maintenance process, when the machine or equipment of the work procedure is actuated.
- *Impact-chain:* means of the continuous chain of elements (marker – transmitter – relay – sensor – processor – interfering – working – etc. subassemblies) of relationship system between input and output signals of the process.
- *Regulating technology:* provides regulated operation to ensure constant compliance management features (hold control value), or deals with technological and technical implementation of the follow-up of set point changes (stable operation results in a closed impact-chain).
- *Control technology:* deals with technological and technical implementation of the controlled management features for providing of operation by the dispositional signal according to the sensed control signal (follow-up control), or programmed signal (programmed control), which can lead to unstable state in a closed impact-chain.
- *Mechatronics:* is the science of intelligent machines (automation, robotics), which achieves its objectives by a synergistic integration of mechanical engineering, electrical engineering and computer management.
- *Cybernetics:* is the general, summarized science of communications, management and information processing processes in living organism, machines.
- *Robot:* is an electromechanical structure, which has ability to implement various tasks (which formerly required human physical work). It may be under the direct human control, or independently carried out the work with supervision of a computer.
- *Robotics:* or robot-technique is one of the newest multidisciplinary branch of the technical sciences, deal with theme of creating robots and automating processes by robots.
- *Autonomy:* is the ability to perform tasks without human intervention (unmanned system) starting from the current state and processed the sensed conditions during the execution (according to the impact of operator, it may be gradual or full autonomy).
- *Artificial intelligence (AI):* is an artificially created logic control unit made from oorganic fabric and / or electronic components, which has ability to learn (artificial realization of human brain). AI is called the manifesting intelligence of a machine or software by an artificially created consciousness. The term is most often associated with computers. The AI is such a particularly important technological process (machine learning, adaptation of machines) through to completion from the product of science fiction, which currently represents one of the major branches of computer science.

Typically very diverse disciplines contribute to the technical realization of robotics (for almost the most elementary functional robots). Arguably, the most important here - as in the case of the computer - the work equipment operating program (software), which is a very

advanced multi-functional machine possessed a high degree of freedom[5], which in itself is very complex, continuously developable and can be self-learning.

Sciences, disciplines, and main research areas that constitute the robotics[6]

Natural Sciences

Mathematics and Computer Science:

- mathematical logic (automatic machine design)
- geometric relationships (mechanical structures)
- analysis and topology (the theory of dynamical systems)
- probability theory (for analysis)
- computer science
- operational research (programming, simulation, etc.)
- game theory (strategic and tactical issues)

Physical Sciences:

- Mechanics (hydraulics, pneumatics, statics, kinematics, kinetics, field theory)
- Dynamics (hydrodynamics, aerodynamics, thermodynamics, etc.)
- Thermodynamics

Chemical Sciences

Biological Sciences

Multidisciplinary Natural Sciences:

- electrochemistry
- biophysics
- biomechanics
- bioinformatics (since 1994.)

Technical Sciences (following research areas within almost all the branches)

- Control engineering (sensors, microcontrollers, etc.)
- Information technology (IT)
  - communication protocols
  - computer graphics
  - artificial intelligence
  - image processing
  - autonomous systems information technology
  - thermography and thermal imaging analysis
  - multi-processor systems informatics

Multidisciplinary Technical Sciences:

- mechatronics
- robotics

Medical Sciences

Theoretical Medical Sciences

Clinical Medical Sciences

Multidisciplinary Medical Sciences:

- neuro technology

[5] The number of degrees of freedom is 1 – 5 (at least one is forced between them) of the two neighbouring motion transmitting members of a mechanism, from the possible 3 axial and 3 rotational direction movements without their connection (0=hard contact, 6=no contact).

[6] Without completeness, here only the most visible or some relatively new areas have been listed in order to illustrate the extensive complex science relationship system of robotics.

Interdisciplinary Sciences:

- materials science
- cybernetics
- bionics

The specialists of robotics need to mobilize their imagination (bold assumptions, concepts) in order to find the most appropriate solutions to the expectations in addition to the scientific research methods.

For example the bionics is a much more concrete process, which deals with the understanding and studying of creators, phenomenons of biodiversity created during the amazing evolution of wildlife. Furthermore deals with the dual responsibility system of transposition of this knowledge to the technical area (such results, for example: the thistle - VELCRO™, locomotion techniques, friction reduction of artificial shark skin, etc.).

The basic terms of robotics progress, such as the high-technology of technical and technological development:

- automation needs for the job, the possibilities of its feasibility;
- scientific research and development;
- the application of revolutionary technologies;
- engineering and technician skills.

The engineer is the key player of the implementation of robotics:

- Adapt the scientific knowledge in order to achieve the goals of the technical task, which has usually many suitable solutions.
- Models, analyze and evaluate the variations of solutions, and select the optimum solution based on this.
- Forecasts the adequacy of the implemented technical solution according to the requirements which are based on investigations, tests, simulations with prototype.
- Draw up – with using safety factors – such plans as direct responsible professional for producing that provides the required functionality with reliability and adequate quality without risk.

The non humanoid robot or AI as early as 2025 plays a decisive role in people's lives, like the personal computers according to several professional forecasts.[2]

GENERAL FEATURES OF ROBOTS

The summary of the most important advantages of using robots in comparison to the human work activity:

- It reduces or triggers the level of human activity in specific tasks.
- It reduces or eliminates the burden of providing of human working conditions.
- The lack of human factors that negatively affect the efficiency of the work.
- It allows performing extremely high reliability, accuracy, and speed of multiple complex and complicated activities that exceeds the limits of human efficiency.
- Extreme duration /almost continuous/ workload during extreme environmental pressures and conditions (e.g., CBRN[7], space).
- Remote controllability – miniaturization.
- Parameters of the work is continuously measurable, recordable and predictable.

[7] *CBRN*: Chemical – Biological – Radiation – Nuclear (impacts)

– Its resource requirements are order of magnitude lower than cost of human work in the long run (immediately applicable, replaceable, and available in large quantities with the same quality).

The current main limiting factors in applications of robots:

– Their ability is orders of magnitude less than the complex sensing ability, the physical coordination skills, or the ability to think and to act of a man.
– Limited direct involvement in application, and opportunities for change by the lack of continuous communication skills.
– Local and high energy resource, therefore relatively short self-contained (powered) running time, thus there is an increased risk of total shutdown function.
– Very complex and comprehensive (so large and difficult to maintain) software environment.
– Other human factors deficiencies.

The foregoing has been partly due to how to increase the efficiency of the work of robots.

The promoting, enhancing factors of applicability of robots:

– quantitative and qualitative increase of the sensors;
– functional complexity, and increasing the effectiveness by development of control software and hardware;
– enhance the efficiency of power (and / or energy consumption);
– semantic interoperability capability.

Main technological features of robots:

– elektromechanical structure;
– scope for action;
– vehicle and/or arm system;
– coordinate system;
– degrees of freedom;
– capacity;
– accuracy of repetition;
– dynamic accuracy.

Table 1: Features of the application of robots[3]

FEATURES	*INDUSTRIAL ROBOTS*	*SERVICE ROBOTS*
WORK ENVIRINMENT	Controlled and well-defined environment	Disordered, difficulty defined environment
USERS	Teaching of some special work operations	Teaching of a wide range of activities
SECURITY	Machine dependent	Robot and user-dependent
WORK PHILOSOPHY	Robots and humans separation	Robots and humans working in collaboration on the same job site
MACHINE DESIGN	Order or respond flexibly	Respond flexibly to demand

CLASSIFICATION OF ROBOTS

The robots can be grouped based on a lot of aspects. The most important and commonly used aspects among these are as follows.

Stage of development /intelligence/:

– First generation robots (appearance in 1960s)

Typically pre-programmed functions and point to point (PTP or positioning: P-type) motion control system - signals from the environment does not affect the movement of the robot, therefore the proper precision positioning of the work tools and objects is important condition. There is usually applied to implement movement and transportation of materials and objects, or auxiliary operations of simple production lines (e. g. CNC - computer numerical control systems).

- Second generation robots (appearance in 1970s)

The current situation of the movement, task performance can be influenced (P-type, **L**ine-type, or **C**ombined-type mode) by a microprocessor control unit processing of environmental factors detected in the sensors (position, force, torque, temperature, etc.).

- Third generation robots (appearance in 1980s)

These robots have a high degree of shape and position recognition capability, artificial intelligence, which is formed from the information, obtained from the processing of our environment by the wide range of functions and sophisticated sensing devices. Thus, to perform complex tasks (e.g. automated process control, etc), autonomous decision, or to participate in complex processes are also suitable.

Of course, it cannot be a sharp dividing line between the robot generations, because nowadays more and more kinds of new robot models appear.

Service capabilities:

- *Simple robots* (These robots are used for simple tasks /e. g. movement/, usually pneumatically or electrically operated).
- *Universal robots* (They are mainly applied for technology work tasks /e. g. welding, surface treatment, assembly lines serve, etc./, mostly with hydraulic or electric drive, microprocessor control).

Service functional areas:

- robots performing movements (mainly transport and movement tasks);
- robots performing technological operations (in working processes);
- control robots (detection, measurement, testing, etc.).

Mobility, kinematics:[4]

- stationary robots
  - parallel kinematics
  - chained kinematics
- mobile robots
  - differential kinematics
  - homonymic kinematics

- mixed kinematics
- other

Size: macro-, small-, mini-, micro- and nano robots

Control mode (the degree of human intervention): (some features of a device may require a different mode or can be operated in various modes)

- semi-automatic (requiring constant human intervention, automated sub-processes, e. g. remote controlled equipments);
- automatic (requiring intervention in the sub processes, basically automated, complex automated systems, e. g. advanced industrial robots);
- gradual autonomy (human intervention needed only in the main control parts of the processes /e. g. start-stop, identification, selection, decision making, etc., e. g. unmanned aircrafts);
- full autonomy (task performance based on advanced AI that does not require human intervention, which is not possible in real-time to control, e. g. unmanned space vehicles).

The scientific community has not considered it appropriate to determine (due to their objectively unrealized projects yet) *the grouping of the structural integration of robots* (ratio of structural composition and relationship of organisms, organs and mechanical equipments) while the science fiction literature has long been a need for. The spread of these concepts still owe more on the appearance of the Star Wars movies, although there is no exact dividing line in this respect of certain categories of the mechanization rate (e. g. android[8], kiborg[9], etc.).

Robots play a wide range of functions already today, which is constantly evolving by the development of technologies. For this reason it is best to group them in fields of application, according to their function.

Application environment:

- on land, on water and under water, atmosphere and / or space;
- biological environment (human body, animals, plants, etc.);
- amphibious or multi movement area;
- cyberspace (cyber espionage, disturbing, blocking, destroying, etc. software).

Potential power sources could be:

- electric battery;
- hydraulics (liquids);
- pneumatic (compressed gases);
- solar power (using the sun's energy and converting it into electrical power);
- flywheel energy storage (FES, works by accelerating a rotor /flywheel/ to a very high speed and maintaining the energy in the system – typical in aircrafts);
- stirling engine (using almost any fuel);[10]
- nuclear energy.

Areas of application:

- industrial robots;
- service robots;
- Intelligence - Surveillance –Reconnaissance (ISR) robots;
- space robots;
- military robots;
- medical robots;
- domestic or household robots;
- social and welfare robots;
- entertainment robots;
- hobby and competition robots;
- other task ranging robots.

[8] The *android* is a robot or synthetic organisms, which mimics the shape and behaviour of the people. The word "android" already displayed in the US patents in 1863 referring to miniature automatic human-like toys. The *androids* today most exist only in the field of science fiction; the today increasingly appearing humanoid robots will represent their first generation.

[9] *Kiborgs (cybernetic organisms)* are the biological brain-controlled robots may be mentioned here that are controlled by animal brain cell cultures generated brain, which mostly means at least developed human development constructions / creatures. They are either originally creatures who have machine control implants in their body, or machines supported with living tissues, so this literary category does not determine by the degree of mechanization, but rather their functionality.

[10] DEKA Research and Development Corporation website, http://www.dekaresearch.com/stirling.shtml, [accessed 17 September 2015]

Of course, there are more complex robots, which can be classified into several categories based on the special nature of their multi-functionality tasks, or do not belong to either category.

Historical fact of Science that today the main generating factor of the industry's robotics research and development besides the scientific research and industry is the defence sector, and within that above all the military needs.

APPLICATION AREAS AND DEVELOPMENT TRENDS OF MILITARY ROBOTS

The initial steps of the use of military robots

The radio remote control was implemented with radio-controlled ship model for the first time in the world in 1898 by the genius Nicola Tesla during an electrical exhibition at Madison Square Garden in New York.[5]

The first truly successful radio remote-controlled aircraft was an anti-aircraft artillery target version of the De Havilland DH82A,B "Tiger Moth", the British made "Queen Bee" (420 pieces were made) in 1935.[6]

During World War II the advancing German troops to invade France found a small truck in 1940, which was a pioneering invention of the French engineer Adolphe Kégresse. It was a developed experimental remote-controlled explosive vehicle in 1939. Using this tool, a German engineer Carl Friedrich Wilhelm Borgward developed an armoured destruction equipment in his plant in Bremen in November 1940 (its transporting capacity was 60 kilograms of explosives) the remote mini crawler vehicle Goliath for demolition of fortifications, barricades and armoured equipments. Initially the device was wire-controlled and electric motor-driven, but could operate only less than 10 minutes due to its battery capacity (the Zündapp factory produced approx. 5000 units of improved combustion-engine version with 100 kg load capacity from 1942 until 1945.).[7]

Figure 1: Canadian soldiers with captured Goliath[11]

The use of remote control technology for military purposes was improved intensively during the Second World War, with many result of this being such as small destroyer boats, torpedoes, missiles and others. These initial steps have also appeared in other nations' armies (e. g. the Soviets had got also a radio-controlled destroyer vehicle called”Teletank”, similar to the German Goliath).

These devices were forgotten after the war, only the appearance of microelectronics, computing, aerospace, and industrial robots came to the fore once again.

[11] Histomil website: Canadian troops examine captured German equipment including a Goliath wire controlled mine tank. http://histomil.com/viewtopic.php?t=3918&start=6000, [accessed 20 September 2015]

The increasingly effective, advanced military robots are used in diverse military tasks nowadays. The United States is the leading developer-user in this area, with a large amount of deployed military robot technology in his recent wars; mostly its demolition expert tools and reconnaissance fighter aircraft (see *Figure 2*).

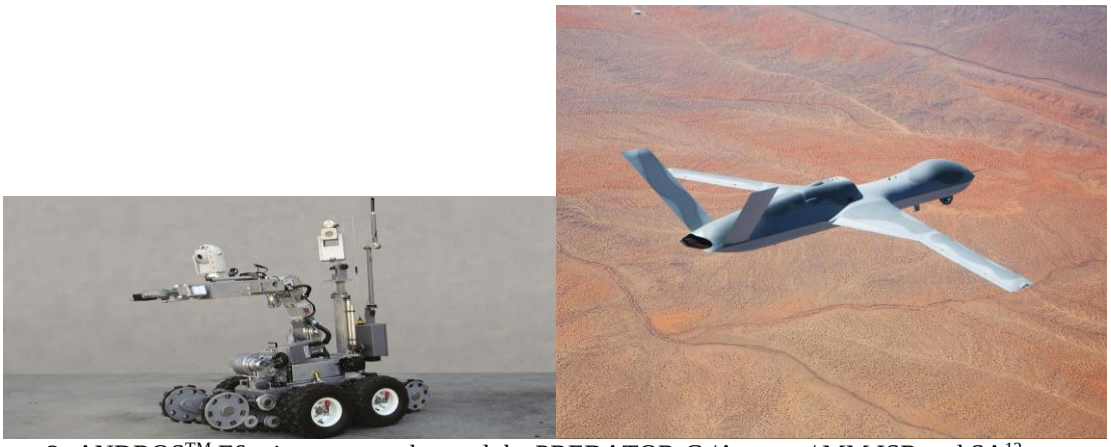

Figure 2**:** ANDROS™ F6 mine rescue robot and the PREDATOR-C /Avenger/ MM ISR and SA[12] unmanned aircraft (Photo: producer's websites)[13]

In the case of military robots, unfortunately the most people still associate the combat robots first (as destructive tools), and they do not accept the robot-human warfare from moral and ethical point of view.

This idea is one of the most important dilemmas of fighting robot category, which divides people according to their various political, economical interests and levels of knowledge. The robots are carried out their tasks (detection - analysis - decision - action) according to the above-described the limit level of their autonomy, that will not require human intervention during their operations in its final objective (AI), which ideas still contain a number of inherent unresolved risk factors.[8]

The international regulation and characteristic factors of research and development, and deployment of military robots

The imagination of science fiction foreshadowed (like also so many other things) the philosophical bases of applications of the really advanced, autonomous, self-learning robots of the future, so we owe the worldwide known unwritten 3 laws of robotics[14] to Isaac Asimov.[9]

Just recently we start to take the philosophical guides further consideration of the pressure of technological development. Unfortunately they still have not been clarified and regulated in the expected rate the fundamental, ethical and legal issues required for decades of development and application of the autonomous combat systems (e.g. is it possible to have a right of a machine to use force against the people /injury or death/, or even to restrict the people's freedom /detention/) and the tasks of arms control.

Unfortunately, this has been long-standing practice, as these are missing from all existing arms control treaty and agreement, or some essential items are not quite strictly regulated (e.g.

[12] *MM ISR* and *SA:* Multi Mission Intelligence, Surveillance, Reconnaissance and Strike Aircraft

[13] Sources: http://www.northropgrummaninternational.com/capabilities/andros/ and http://www.ga-asi.com/predator-c-avenger, [accessed 05 October 2015]

[14] The primary creator of 1-3 laws of robotics was Isaac Asimov, the best-known robot science fiction writer. https://www.technologyreview.com/s/527336/do-we-need-asimovs-laws/, [accessed 08 October 2015]

categories of weapons, verification, sanctions, etc.), therefore it is not surprising that many acceptor can interpret them in accordance with his own interests. Despite the autonomous weapons systems forward-looking capabilities, they will hopefully remain in the category of conventional weapons (they will not be the weapons of mass destruction), however they are definitely a special category because of their abilities. Hence its needed structural and operational regulation at international level in accordance with the principles proclaimed in the Declaration of NATO in Brussels, matching the current conventional arms control verification regimes (CCW, WA, OC, SALW, CCM, ATT)[15].[10]

The nations, alliances and research centers (e.g. NATO STO, DARPA, EDA, etc)[16] have begun to take these factors into account to their security and defense strategies in recent years. Experiencing the rapid expansion of the autonomous weapons systems over the last decade and recognizing the inherent dangers. They try to achieve the right regulatory for everyone by coordinated program suggestions and guidelines for security guarantees. The Multinational Capability Development Campaign (MCDC) is in the forefront of this process leading by NATO HQ SACT (Headquarters Supreme Allied Commander Transformations, Norfolk /USA/), as well as the collaborator and observer nations of the campaign.[17] A theoretical guidance has been released to their common understanding and solving of development and application problems of autonomous systems.[11]

Another problem with the robot warfare, that our stereotypical thinking is mostly identify this procedure firstly to the violent solution of the people's antagonistic interests, although the military defence capabilities of robots can and must be used to solve a variety of already very current problems. Just think of these days more and more actual disaster management tasks, or even unforeseen outer hazardous impacts on the Earth such as meteors, asteroids, comets constantly researched by the scientists, or perhaps avert invasion of alien civilizations or its discovery in the right case, just to mention the somewhat utopian, but it is not inconceivable possibilities.

Present and future possible using areas of military robots:

- autonomous ISR ground – maritime – air and space vehicles, etc.);
- explosive ordnance disposal (EOD) tasks (detection – classification and identification – disposal)
- low-intensity tasks (warning, alert, guarding, protection, detection, control and intervening automated equipment systems);
- communication (radio repeaters, electronic warfare /EW/, information dissemination, etc.);
- search and rescue (ground – air – maritime);
- cargo (resupply, aerial refuelling, etc.);
- personnel transport;
- medical (first aid, evacuation, diagnostic, performing surgery, etc.)[18];[12]

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[15] *CCW:* Convention on Certain Conventional Weapons (1983), *WA:* Wassenaar Arrangement (1995), *OC:* Ottawa Convention (1997), *SALW:* Small Arms and Light Weapons (2005), *CCM:* Convention on Cluster Munitions (2008), *ATT:* Arms Trade Treaty (2013)

[16] *STO:* Science and Technology Organisation (NATO), *DARPA:* Defence Advanced Research Project Agency, *EDA:* European Defence Agency

[17] *Collaborators:* Austria, Czech Republic, Finland, Poland, Switzerland, the UK's and the United States Observers: European Union, Germany, the Netherlands, Sweden

[18] The Robonaut 2 (R2, the successor of the R1, which has been developed from 1997) the successful humanoid robot of NASA has been at the International Space Station (ISS) since 25 February 2011, representing the most advanced robotic technology. Its ground version "twin brother" is also being tested today, with participation of a Hungarian physician, Dr. Zsolt Garami. http://spacecoastdaily.com/2015/06/video-first-humanoid-robot-in-space-receives-nasa-government-invention-of-the-year/, [accessed 13 October 2015]

- service (diagnostic – maintenance – repairs);
- combat action (with lethal or non-lethal weapons);
- service, escort;
- space research – space warfare;
- other new or complex functional areas (e.g. disaster management tasks).

Possible technical objectives of the development of military robots in the present and future:

- increasing the effectiveness of capabilities, such as perceptivity, speed, carrying capacity, duration of operation (energy consumption), protection, camouflage and other skills;
- autonomous operation (detection – sensing – analysis – evaluation – decision making – action);
- multifunctionality;
- cooperativity;
- miniaturization;
- reliable operation in extreme ambient circumstances;
- continuous operability (durability, reliability).

The eminent representatives of science and technology like to envision the anticipated new materials, technologies and technical solutions, trends of the future (biochip, IT, laser nano – hybrid – neuro – 3D product and process technologies, technical applications).[19]

Current characteristic factors of the development of military robots are:

- the primary of economic interests in the global defense industry;
- military equipment modernization based on civilian research and development;
- technical developments based on new technologies (microchip, laser, Kevlar, carbon, nano, bionic sensing and other technologies);
- the global proliferation of military robot weapons, that is the acceleration of its spread, is one of the significant elements of the new security challenges, respectively the increasing of number of capable countries for possible creating of such capacities in the future;
- demonstrations for the protection of human values.[13][14][20]

So yes, there is a need for military robots (whether we like it or not), their application is outstanding importance in all phases of the operations (prevention – protection – liquidation – recovery).

[19] Sources: http://www.techradar.com/news/world-of-tech/14-strange-and-scary-military-technologies-488161, https://www.pinterest.com/vrrbusinessinfo/amazing-military-technologies-of-the-future/, http://www.darkreading.com/risk-management/military-transformers-20-innovative-defense-technologies/d/d-id/1104353?, http://www.sciencefocus.com/feature/future/future-technology-22-ideas-about-change-our-world, [accessed 15 October 2015]

[20] Elon Musk /Iron man/ US robot manufacturer, millionaire inventor-businessman, and Steven Hawking British theoretical physicist campaigning against the development of combat robots**,** https://sg.hu/cikkek/113820/musk-es-hawking-fagyasszak-be-katonai-robotok-fejleszteset, [accessed 20 November 2015]

World widely well-known leading military robot manufacturers and projects today[15]

As already mentioned in the general classification of the robots, it is the best solution to classify the military robots according to their application areas, following the internationally accepted /widespread/ defense industrial and military practice:

- mostly, the term "unmanned systems" current in addition to the umbrella term of military robots, where the platform is a vehicle of the system, there is mostly used the term "Unmanned Vehicle (System) - UV / UVS", which is complemented by the application areas of the system, such as the following;
- Ground (UGS/UGVs)
- Maritime (UMS/USV - Unmanned Surface Vehicle)
- Underwater (UUS/UUVs)
- Air (UAS/UAV, or drone)
- Space (USS/USVs)
- Cyber (UCS), which mostly means software application and its hardware
- For an autonomous system, the above complement or the U replaced the letter of "A" (UAGV/AGV, UAAV/AAV, etc.)
- in addition to the foregoing, a wide variety of specific as well (one or more functional) therefore it appears more and more new categories, such as: ROV/RPV (Remotely Operated/Piloted Vehicle), UVS (Unmanned Vehicle System), TUGV (Tactical Unmanned Ground Vehicle), UCGV (Unmanned Ground Combat Vehicle), ASV (Autonomous Surface Vehicle), UCAS (Unmanned Combat Aircraft System), C2-5ISTAR (Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, Target acquisition and Reconnaissance Systems), etc. systems.

The term unmanned system as seen above a large umbrella term, which includes ground - water - air - space robotic vehicles (for carrying the major function devices and cargo), naval missile-torpedoes, ballistic missiles, satellites, IT applications, and other automatic solutions.

Below are shortly listed some typical project,[21] device or software application systems meeting the above grouping (developed for a long time, already used in some armies, or promising new technological innovations).[22]

US/UV projects by DARPA:[23]

- AMAS (Autonomous Mobility Appliqué System), Lockheed Martin /USA/
- M3 (Maximum Mobility and Manipulation) projects to support the natural environment mobile robot development, where the developments of robot locomotion capabilities of Boston Dynamics /USA/ are very promising[24]
- DARPA's SXCT (Squad X Core Technologies) project for comprehensive technical support of squads in military operations based on new technologies.

[21] Sources: http://www.baesystems.com, http://www.boeing.com/defense/, http://www.bostondynamics.com/, http://www.dassault-aviation.com, http://www.ecagroup.com, http://www.generaldynamics.com/our-businesses, http://www.lockheedmartin.com/us/what-we-do/aerospace-defense/unmanned-systems.html, http://www.northropgrumman.com/capabilities/unmannedsystems/Pages/default.aspx, https://www.qinetiq.com, http://www.raytheon.com/capabilities/, [accessed 01 December 2015]

[22] Without completeness, here only the most visible or a relatively new project is listed to illustrate the trends and partial results of the developments.

[23] DARPA website, http://www.darpa.mil/news-events/2015-12-10, [accessed 01 December 2015]

[24] Robots of Boston Dynamics, https://www.youtube.com/watch?v=hYya-i11OD8, [accessed 01 December 2015]

UGS/UGV projects:

- Andros™ EOD robot series, Northrop Grumman /USA/
- SMSS (Squad Mission Support System), Lockheed Martin /USA/
- MAARS (Modular Advanced Armed Robotic System), TALON® self-propelled armoured mini robot vehicle platform, QineticQ /USA/
- „Black Knight" autonomous tank, BAE Systems /UK/
- „Gladiator" small-medium sized TUGS (developed by a group of US defence industry companies since 1995)
- LS3 (Legged Squad Support System), the „Big Dog" is a load carrier robot, Boston Dynamics /USA/[25]
- „Talon" I - IV / SWORDS (Special Weapons Observation Reconnaissance Detection System), Foster-Miller Inc. /USA/.

UMS/USV projects:

- LCS (Littoral Combat Ship), General Dynamics /USA/
- „Inspector MK2" multifunctional robot ship, ECA Group /FRA/

UUS/UUV projects:

- Marlin® AUV, Lockheed Martin /USA/
- „Knifefish" surface mine-sweeper submarine, General Dynamics /USA/
- AN/AQS-24B mini countermeasure UUV, Northrop Grumman /USA/

UAS/UAV projects:

Boeing /USA/

- ULB „Little Bird H-6U" (Unmanned Little Bird multifunctional Helicopter based on AH-6i)
- „Phantom Eye" slow-flying, long-endurance (approx. 4 days) ISR UAV

Lockheed Martin /USA/

- UCLASS (Unmanned Carrier Launched Airborne Surveillance and Strike)
- VARIOUS (VTOL /Vertical Take-off and Landing/ Advanced Reconnaissance Insertion Organic Unmanned stealth air System)
- „Desert Hawk" (III/IV/EER) mini reconnaissance drone

Northrop Grumman /USA/

- „Global Hawk 2" ISR UAV
- X-47B „Pegasus" stealth UCAS

General Atomics Aeronautical Systems /USA/

- Predator B MQ-9 „Reaper" stealth UCAV
- „Lynx" UCAV with SWAP radar (minimal Size, Weight and Power)

Other producers

- HERMES™ 900 ISTAR UAS multifunctional medium-altitude (10 000 m), long-endurance (36 hours), Elbit Systems /USA/
- „nEUROn" reconnaissance UCAV, Dassault Aviation /FRA/(in cooperation with the Greek AI and EAB, the Spanish EADS CASA, the Italian Alenia, the Swiss RUAG Aerospace, and the Swedish Saab AB companies, developed since 2003)
- RLGS (Robotic Landing Gear System), developed by DARPA and GITU (Georgia Institute of Technology University, /USA/[16]

[25] LS3 - Big Dog, http://www.darpa.mil/program/legged-squad-support-system, [accessed 01 December 2015]

UCS projects:

- AN/ASQ-239 (installed on F-35 fighter aircraft) DEWS/DECM (Digital Electronic Warfare/Countermeasure System), BAE Systems /UK/
- cyber ISR (cyber defence and operational support services), Northrop Grumman /USA/
- RVSS (Remote Video Surveillance System), General Dynamics /USA/

USS/USV projects:

- „Phoenix" project to develop robotic satellite systems, DARPA /USA/[26]
- „WorldView-4" (formerly GeoEye-2) color, high-resolution satellite cameras, Lockheed Martin /USA/
- „Dong-Feng 41" (DF-41; NATO-code: CSS-X-10) rail-mobile ICBM (Intercontinental Ballistic Missile) launcher system (~12 000 - 15 000 km range), China Changfeng Mechanics /China/[17]

Figure 4: LaWS – Laser Weapon System integrated into US Marine's existing ship defence systems in September 2014.(Photo: DMN)[27][18]

The above-mentioned developments illustrate that the US military significantly support the robotics research, because robots save human lives, and perform various tasks better suited than humans. Most of the robots currently used in their work remotely, or under human supervision, but they also develop the autonomous robots with consistently great efforts.

Operational features of the application of military robots:

- The use of combat robots significantly affects the combat procedures requiring the development of new methods in the war as a result of technological progress.
- The autonomous systems are less vulnerable as a result of their self-reliance and full compatibility (there is no need for managing personnel, communications channels, and other supporting and auxiliary systems).
- Their efficiency significantly enhanced by their cumulative capabilities of swarm-mode application and a high degree of compatibility.
- Provides an outstanding level of camouflage, deployment time, velocity, detection, accuracy and resistance to environmental factors.

[26] Phoenix, http://www.darpa.mil/program/phoenix, [accessed 01 December 2015]
[27] Edward H. Lundquist (DefenceMediaNetwork, 30 December 2015): Lasers Belong at Sea, http://www.defensemedianetwork.com/stories/lasers-belong-at-sea/, [accessed 04 January 2016]

- Only systems with similar potential capable an effective defence against them, which it must necessarily raise the cyber warfare as the most effective option.
- It is typical of this category of military equipment, they possess so abilities that are far beyond the possibilities of human perception, so the chances of people's fight against robots significantly disproportionate and the result is doubtful.
- This is one of the main technical and technological solutions concerning to our current knowledge, which is probably relatively easier to implement,[28] which gives you the best chance that the most important quality characteristics of military operations can be met, such as: professional efficiency, reliability, precision, speed, timing, security, and mission success by all these.

Issues and predictable problems of the application of military robots:

- Moral and legal principles of autonomous system of human contact (does robot limit or influence someone for something, etc.).
- Integration of autonomous systems for military command and control system, especially the cooperation with human forces (who is leading whom?).
- Technical superiority mostly provides operational superiority, so hard to be limited and controlled development of robots.
- Theoretically it is possible to limit the tactical and technical parameters, conditions of use of robot arms, but they are almost uncontrollable in practice due to their high technical complexity, and many hide opportunity of adjustment, so their capabilities is almost indeterminable due to the mentioned technical facts (the verification of arms control is problematic).[29]
- The production of military robots has already been significant today, and it could be the major sector of the global defence industry in the future.
- One significant element of the new security challenges is the experienced global proliferation of military robot arms [30], increasing the number of States that may be able to build such capacity in the future, the possible illegal possession of these assets (the strengthening of the terrorist and criminal threats) incalculable extent jeopardize the safety of society.

SUMMARY

The full implementation of autonomy is still a very serious scientific – technical obstacle (identification and management of environmental impacts, evaluation and interpretation of the human manifestations, sophisticated vehicle propulsion and movement techniques, safety elements, extremely sophisticated control software, etc.). Many people working to resolve these technical problems worldwide, however the experts predict the possible time of the end goal of creation of autonomous robots (which are well known from the "The Terminator" or „Transformers" movies) just from the current pace of general technological progress. This is actually just a scientific perception, which is still uncertain of the date of the technological breakthroughs that create true artificial intelligence, which does not seem to be unpredictable time period, taking the development of computing and information technology in the last 50 years.

[28] Another main direction of development of human capabilities supported by a variety of technical and technological solutions, which only our imagination can limit in optimistic case (e.g. armour, camouflage, kinematical supporting structures, the development of telepathic ability, etc.).

[29] Think of the complexity of computer software which contains millions of instructions, or the possibility of new and more hidden integration of programs like viruses, not to mention the use of various technical tricks.

[30] Today almost all significant defence industry company participate in the development of autonomous systems.

Today we can use automation almost everywhere in military fields, even robots, which should make efforts of a state and its modern military forces (even including the other elements of his security sector) because of the importance and dangers of their tasks (exploit the beneficial factors referred to in this article).

Hopefully the sci-fi vision of struggle to against each other of robot armies or the fights of robot knights will be manifested in the future only in the today also existing science competitions of robot maker companies and research groups.

As a summary of thoughts expressed in this article, the author believes that spreading of robotics is obviously one of the key factor of economic development, and a necessary condition for the creation of a comprehensive security. Nonetheless the author trusts in the cooperation and the power of influence of the science and technical society in order to influence policy in the right direction for the benefit of humanity, which can lead to useful results.

Bibliography

[1] *Borsos József – Balaton Jenő – Csókás János – Puskás Aurél (Szerk.: Máté Károly – Polinszky Károly – Solt Pál):* Műszaki Lexikon I-III. + Kiegészítő kötet, Akadémiai Kiadó, Budapest 1970/72/74/78., pp. 1–982. / 1–1104. / 1–1088. / 1–1005. ISBN: 963-05-0168-6

[2] *Aaron Smith – Janna Anderson (Pew Research Centre):* Predictions for the State of AI and Robotics in 2025.http://www.pewinternet.org/2014/08/06/predictions-for-the-state-of-ai-and-robotics-in-2025/, [accessed 15 September 2015]

[3] *Dr. Szabó Zsolt – Budai Csaba – Dr. Kovács László – Dr. Lipovszki György:* Robotmechanizmusok, BME MOGI, Budapest, 2014., electronic textbooks, ISBN 978-963-313-170-1 http://www.mogi.bme.hu/TAMOP/robotmechanizmusok/book.html#table_V_PIII_1, [accessed 05 October 2015]

[4] *Haruhiko Asada – Jean-Jacques E Slotine (Massachusetts Institute of Technology):* Robot analysis and control, Wiley-Interscience Publication, New York, 1986., pp. 1–266., ISBN: 0-471-83029-1

[5] *The Tesla Memorial Society of New York website:* Nikola Tesla: Father of Robotics, http://www.teslasociety.com/robotics.htm, [accessed 20 September 2015]

[6] *The de Havilland Aircraft Museum website:* De Havilland DH82B Queen Bee, http://www.dehavillandmuseum.co.uk/aircraft/de-havilland-dh82b-queen-bee/, [accessed 20 September 2015]

[7] *The Militaryfactory website:* Tethered Remote-Controlled Tracked Demolition Carrier (1942), http://www.militaryfactory.com/armor/detail.asp?armor_id=476, [accessed 20 September 2015]

[8] *Jeffrey M. Bradshaw – Paul J. Feltovich – Matthew Johnson – Larry Bunch – Maggie Breedy – Hyuckchul Jung – James Lott – Andrzej Uszok:* Coordination in Human-Agent-Robot Teamwork, Florida Institute for Human and Machine Cognition (IHMC), , Pensacola, Florida (USA), 2008., pp. 1–23. http://www.aaai.org/Papers/Symposia/Fall/2007/FS-07-06/FS07-06-004.pdf , [accessed 05 October 2015]

[9] *Ulrike Barthelmess – Ulrich Furbach:* Do we need Asimov's Laws?, University of Koblenz-Landau, Koblenz, 29 April 2014, p. 1., http://arxiv.org/abs/1405.0961v1, [accessed 05 October 2015]

[10] *N. Rózsa Erzsébet – Péczeli Anna (szerk.):* Egy békésebb világ eszközei - Fegyverzetellenőrzés, leszerelés és non-proliferáció, Osiris Kiadó, Budapest, 2013., pp. 15-370., ISBN: 9789633899489

[11] *Artur Kuptel – Andrew Williams (MCDC NATO-ACT):* Policy Guidance - Autonomy in Defence Systems, Supreme Allied Commander Transformation HQ, Norfolk, United States, 29 October 2014., pp. 1 – 29., http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2524515, [accessed 08 October 2015]

[12] *Space Coast Daily.com:* First Humanoid Robot In Space Receives NASA Government Invention Of The Year (by NASA.gov , June 17, 2015), http://spacecoastdaily.com/2015/06/video-first-humanoid-robot-in-space-receives-nasa-government-invention-of-the-year/, [accessed 13 October 2015]

[13] *International Human Rights Clinic (IHRC), 2015:* Mind the Gap. The Lack of Accountability for Killer Robots, USA, pp. 1–44, ISBN: 9781623132408, https://www.yumpu.com/en/document/view/47291684/arms0415-forupload-0/15, [accessed 20 November 2015]

[14] *Sg.hu Informatika és tudomány (szerk.: Richárd Balázs, July 29, 2015):* Musk és Hawking: Fagyasszák be katonai robotok fejlesztését!, https://sg.hu/cikkek/113820/musk-es-hawking-fagyasszak-be-katonai-robotok-fejleszteset, [accessed 20 November 2015]

[15] *WinterGreen Research, Inc (2015):* Military Ground Robot Mobile Platform Systems to Engage Terrorists: Market Shares, Strategies, and Forecasts, Worldwide, 2015 to 2021, Lexington, Massachusetts (USA), pp. 1–644, http://wintergreenresearch.com/reports/Military%20Robots%202015%20brochure%201.pdf, [accessed 20 November 2015]

[16] *Defence Advanced Research Project Agency's news (10 September 2015):* Robotic Landing Gear Could Enable Future Helicopters to Take Off and Land Almost Anywhere, http://www.darpa.mil/news-events/2015-09-10, [accessed 01 December 2015]

[17] *Richard D Fisher Jr (IHS Jane's Defence Weekly, Washington, DC, 23 December 2015):* China developing new rail-mobile ICBM, say US officials, http://www.janes.com/article/56860/china-developing-new-rail-mobile-icbm-say-us-officials, [accessed 02 January 2016]

[18] *Edward H. Lundquist (DefenceMediaNetwork, 30 December 2015):* Lasers Belong at Sea, http://www.defensemedianetwork.com/stories/lasers-belong-at-sea/, [accessed 04 January 2016]