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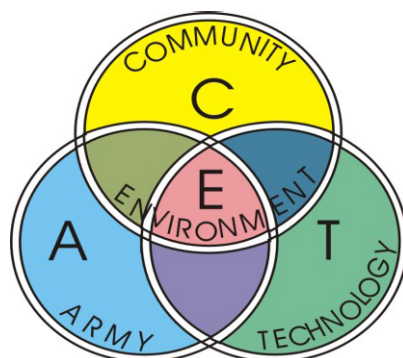
Mezinárodní konference
International Conference

BEZPEČNOSTNÍ MANAGEMENT A SPOLEČNOST

SECURITY MANAGEMENT AND SOCIETY

konaná v rámci
held as a part of

CATE 2011



Sborník
Conference proceedings

Brno 2011

MODERN TECHNOLOGIES IN BORDERS PROTECTION

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Abstract:

Integration of countries brings about abolishment of internal borders control instruments between member states as in the European Union, but on the other hand increases the need for better control of their external boundaries. The paper presents possibilities which offers up-to-date technology especially in area of applying unmanned aerial and surface vehicles as well as seismic intrusion detectors, and other types of sensors applicable for border control and safety. The author focus on current solutions in this area and presents research programs such as the European Union TALOS which should help to support security and protection level of the international borders.

Keywords:

Border security, border control, surveillance equipment, unmanned aerial vehicles (UAV), and unmanned ground vehicles (UGV), TALOS

NECESSITY FOR BORDER PROTECTION

Security of a person, a society or a country was always the biggest challenge for rulers or governments. Human beings joined in groups, tribes, societies which established countries. Those social-political formations obtained territories and demarcated boundaries which they try to control in order to protect their own territory against foes and enemies.

The idea of setting up and marking frontiers is very old. Already ancient Sumer marked their borders with special signs. One of the first border posts was called the Stele of the Vultures between kingdoms of Lagash and Umma 2500 B.C. which informed potential assailant about

the miserable fate of previous intruders⁹⁸. Other rules wanted to protect their territories against an enemy attack or intrusion using more sophisticated means and they built a system of supervision of their boundaries. One of the greatest examples is the Great Wall of China – the proof of genius of technical thought of ancient civilizations. Its might and beauty one can admire even nowadays after more than 1000 years and its enormous length of this edifice ca. 6700 km, from which still 4500 km still remain⁹⁹, dumbstruck even present architectures. The Great Wall was a military structure protecting Chinese dynasties from enemies while an European construction from 3rd century A.D. called the Hadrian Walls had another extended function. Namely according to archeological excavations this ca. 119 km long (80 Roman miles) long edifice was rather used for movement control and prohibition of illegal activities as such smuggling, border crossing etc. than as a protective measure against barbarian invaders.¹⁰⁰ In this sense the wall could be considered as the first known and documented border control system with function comparable to current boundaries.

One can say that border fortifications are rather ancient and obsolete methods of protective measures, but even 20th century history knows special structures for military purposes such as the French Maginot line facing the German “Siegfriedstellung” line. Walls and fences can serve even for discouragement of own citizens from leaving a country just to mention the German Berlin Wall. Border constructions can physically protect nations from an enemy aggression as South/North Korean border line along 38 parallel or the Israelis technical fence at the border with Lebanon or the wall at the Gaza strip, which protect the country against Hezbollah and Hamas terrorist activities. An American hi-tech border protection system guards US boundaries with Mexico against illegal immigration, drugs and weapons trafficking.

On the one hand, countries tend towards integration and elimination of their internal frontiers, integrate their markets, to cooperate closer, to abolish visa regime, as in case of the European Union, but on the other hand, they try to tighten up migration regulation for foreigners and protect their external frontiers better. Extension of the European Union causes demands their better protection. A “classical” system of controlling by border guards,

⁹⁸ VAN DE MIEROOP M., *A HISTORY OF THE ANCIENT NEAR EAST, CA. 3000-323 BC.* 2 ED. BLACKWELL PUBLISHING 2004, P. 46. ISBN 0-631-22552-8

⁹⁹Turnbull S., *The Great Wall of China 221 BC 1644 AD*, OSpray Publishing 2007, p.59 ISBN 987 1 84603 004 8

¹⁰⁰ Ganster P., Lorey D.E., *Borders and border politics in a globalizing world.* Rowman & Littlefield, 2004 p.2. ISBN 08420-5104-0

military or police is expensive obsolete and ineffective in many cases. Technological progress especially in electronics allows nowadays to construct hi-tech machines and devices which can support human activities in matters of border protection and even replace a human factor in the most dangerous and hazardous environment. Dedicated robots equipped with sophisticated technology can operate in the sky, on the ground and under sea surface, 24/7, during the day and at night in all-weather and climate conditions in order to protect countries' frontiers better.

PROTECTION FROM THE SKY – UNMANNED AERIAL VEHICLES (UAV)

Unmanned Aerial Vehicles are very effective, advanced devices for monitoring, detecting and tracking intruders. The UAV is "...is a remotely controlled or autonomous aircraft used for surveillance and strike missions. Known as UAV's, these aircraft are useful in situations where it is too dangerous to use manned aircraft."¹⁰¹ There are two categories of the UAVs: fix wing- like Short Take-Off and Landing (STOL) and helicopter - like operated Vertical Take-Off and Landing (VTOL) vehicles. Furthermore, there are two types of UAVs according to the control system - remotely piloted vehicles (RPVs), which are navigated by a skilled operator from a remote special unit/center and newer autonomous UAV, which flight is fully programmed and they can use Global Positioning System for flight control or target acquisition. Some of the drones can operate in both modes. The concept of the UAVs is connected with the development for military purposes. Although the first drone was used as a target in 1922 later on as an assault vehicle in 1944, the first flight for surveillance purpose took place in 1955 done by the Northrop Radioplane SD-1 Falconer/Observer¹⁰².

The UAVs equipped with electro-optical and infrared cameras, night vision systems, movement indicators, sensors and surveillance or surface search radars can control remote land or maritime borders. Via up-to-date satellite communication systems, the devices can provide in real time day and night imagery of monitored area to manned control centers. Additionally, if the UAV spots suspicious activities, an operator can navigate the device remotely (switch to RPV's function) and track a suspected person, vehicle, boat or ship.

¹⁰¹ <http://www.army-technology.com/glossary/unmanned-aerial-vehicle.html> access 29.03.2011

¹⁰² Zaloga S., Palmer I., *Unmanned Aerial Vehicles: Robotic Air Warfare 1917-2007*. Osprey Publishing (UK) 2008 p. 10. ISBN 978-1846032431

Furthermore, there exist technical possibilities to arm UAVs with non-lethal weapon systems which can be used to stop or discourage an intruder.

Currently some countries begin the extensive use of the drones for border protection such as Israel (Hermes 450) or the USA where recently MQ 9 Predator B drone monitor US/Mexican border¹⁰³. What's more, Predator can operate at the altitude up to 15 km with the operational speed ca. 300 km/h and endurance ca. 30 hours¹⁰⁴ what means the UAV can follow undetected every moving object and be used not only to identify and to stop suspicious persons but what is more important, it can help in investigation of trafficking routes, hideouts or locations of criminals, their HQs and network systems.



UAV MQ 9 Predator B¹⁰⁵

The machines can conduct missions in all weather conditions, during the day and at night and it can undertake much more hazardous missions where there is a danger of using fire arms or anti-aircraft systems especially when drones are armed with non-lethal weapons. Furthermore, it can be used for Search and Rescue (SAR) tasks especially in case of illegal crossing of maritime borders where capsizing of boats with emigrants happened quite frequently. Another very important argument for the drones is their cost-effective factor. The unmanned vehicles are much cheaper for exploitation in comparison to “classical” border patrol aircrafts or helicopters, there is lesser need for manpower in order to operate the system. To sum up, the drones are very effective, inexpensive solutions which can support border guard activities. But one can remember that UAVs can reduce manpower, support but not to replace a human.

¹⁰³ Lavandera E., *Drones silently patrol U.S. borders*. CNN. http://articles.cnn.com/2010-03-12/us/border.drones_1_border-patrol-predator-unmanned-aircraft?_s=PM:US access 12.03.2011

¹⁰⁴ Predator B/MQ 9 Reaper. Information Brochure, General Atomics Aeronautical Systems Inc, 2009

¹⁰⁵ http://www.ga-asi.com/products/aircraft/pdf/Predator_B.pdf access 15.11.2010

SAFEGUARDING OF MARITIME BOUNDARIES

Protection of the access to homeland territory is a real challenge for countries especially with an extensive costal line. Although the sea surface can be protected with surveillance radars, sophisticated cameras mounted on costal guards ships or costal remotely control observation points, autonomous ground surveillance vehicles, the above mentioned drones or even satellites, protection underwater areas is more difficult. Modern researches connected with this subject focus on two areas: protection of harbors against underwater intrusion and inspection of ships and boats under waterline as well as protection against underwater access to shoreline which started to be a way of illegal drugs and human trafficking.¹⁰⁶

US Cost Guard uses two types of automated protection systems. One of them is Underwater Inspection System manufactured by CodaOctopus based on special sonar (echoscope) which creates 3-D pictures of undersurface areas in real time. It can be used for searching, inspecting, detecting and tracking unexpected divers¹⁰⁷. The other system for costal guards used to protect access to harbors is the Integrated Anti-Swimmer System (IAS), which allows to "...detect, track, classify, localize, notify and respond to potential underwater threats"¹⁰⁸ such as produced by Kongsberg company. The system receives acoustic signals and then the software based on a sonar signals identifies if the signal was generated by a human (diver) or by another harmless object such as sea creatures or rubbish.

Another option for increasing maritime security are Autonomous Underwater Vehicles (AUVs). Those up-to-date robots as REMUS family manufactured by Hydroid Inc.

REMUS AUVs could operate up to a depth of 6000 m depends of the model (version REMUS 600 used by Australian Navy¹⁰⁹ and military of other countries can operate up to 600 m), can be stuffed with large amount of tracking equipment with acoustic imaging systems still and video cameras, optical and iridium type sensors, side scan sonars and other equipment

¹⁰⁶ Stickney R., *Illegal Drug Fight Moves Underwater*. NBC San Diego
<http://www.nbclosangeles.com/news/local/Fighting-Illegal-Drugs-Shipped-Underwater-118907489.html> access 04.04.2011

¹⁰⁷ <http://www.codaoctopus.com/echoscope-uis/> access 10.04.2011

¹⁰⁸ Walker R., *Coast Guard's Underwater Port Security R&T*.
<http://onlinepubs.trb.org/onlinepubs/archive/Conferences/MTS/1A%20WalkerPaper.pdf>
access 10.04.2011

¹⁰⁹ <http://homelandsecuritynewswire.com/australia-buys-hydroids-auvs>. access 10.04.2011

requested by users. The AUVs are small (REMUS 600 is only 3,25 m long) endurable solutions for protecting coasts from unwelcome access from the depths.



AUV REMUS 600¹¹⁰

FRONTIERS' GROUND PROTECTION - UNMANNED GROUND VEHICLES (UGVs)

An abbreviation UGV stands for “Unmanned Ground Vehicles” which are autonomous or remote operating mobile ground robot systems. Sometimes an abbreviation USV (Unmanned Security Vehicle) is used in publications, but the term UGV has a brighter spectrum of meaning included robots’ potential combat abilities. A concept of using UGVs for protection of land boundaries consists of wheeled or tracked transport platform with cross-country abilities equipped with high-tech surveillance technology depends on purpose of the UGV. Similar to UAVs, the idea of UGVs comes from military concept of replacing human soldiers in a hostile and dangerous environment where there is a very high risk of losing a life. The first idea of an unmanned battle vehicle comes from WW I when the vehicle called “Land Torpedo” was supposed to make a passageway in enemies’ obstacles. There is no evidence that the construction was introduced to armies for practical use.¹¹¹ In 1930’s Russians developed the concept of remote controlled tanks (TT-26), steering from an another tank from the distance 500-1500 m, which can fight using remotely ignited flame-throwers, smoke

¹¹⁰ <http://www.suntrill.com/Remus-600-764.html> access 15.04.2011

¹¹¹ Finn A., Scheduling E., *Developments and Challenges for Autonomous Unmanned Vehicles: A Compendium*, Springer 2010, p.10 ISBN 978-3-642-10703-0

grenades, the apparatus could deliver and detonate explosives near enemies fighting positions or even distribute chemical agents (fortunately never happened). So called tele-tanks were practically used during Finnish-Russian War in 1939-40.¹¹² However, the first operative small scale UGV (ca. 370 kg) was a German demolition vehicle called "Goliath" (Sd.Kfz. 3 02/303a/303b). It was wire-controlled light demolition carrier used during WW II, especially during the Warsaw Uprising in 1944 against insurgents' fortifications. The first fully autonomous (not operated by a human) UGVs were apparatuses were "Elsie" and "Elmer" constructed in 1949 at the Burden Neurological Institute, Bristol UK.¹¹³ However, present UGVs are mainly operated by humans, but some constructions could act fully independently. Today the vehicles could be equipped with a very broad variety of sensors, cameras, manipulators, etc. that's why, they are used by military, police, UXO and EOD squads, fire departments, SAR teams- it means everywhere where there is a hazard for a human life. The UGVs, as machines, which are small, compact, durable with quite good cross-country abilities represent modern and effective support for everyday work of public security services. Because in some countries protection of their borders is war-like activates, it is logical that military application of the ground robots come to border protection services. One of the example can be UGV "Guardium" developed by G-NIUS Unmanned Ground Systems (UGS) Ltd. used for protection of Israeli border.



UGV Guardium¹¹⁴

¹¹² Ibidem p.12

¹¹³ Mulder T., Das adaptive Gehirn: Über Bewegung, Bewusstsein und Verhalten, Georg Thieme Verlag 2006, p. 81. ISBN 978-3-13-143361-9

¹¹⁴ <http://g-nius.co.il/unmanned-ground-systems/guardium-ugv.html> access 11.04.2011

The UGV equipped with optical acoustic sensors and tracking radars can operate independently from operation center according to preplanned routes and scenarios or could be controlled remotely from command post and used for investigation suspicious areas or activities, controlling border infrastructure or support border patrols. In autonomous mode the system can avoid obstacles using laser radar. Other devices which can be mounted on the platform are infra-red cameras, night vision systems, a hostile fire indicator, a missile approach warning system, a laser beam detector, chemical agents identification systems, radiation sensors, even fire extinguishers and more according to the buyers' choice.¹¹⁵ Because of the possibility of terrorist infiltration the robots can be additionally equipped in a 12,7 mm machine gun¹¹⁶ and they can physically fight invaders. To sum up, the system is a very effective high-tech border guard which can protect a human life in the extreme condition.

The South Korean SGR-A1 developed by Samsung used in demilitarization Zone between South and North Korea, has a similar task. The robot can be used in a stationary version or mounted on a mobile platform. It has an infra-red and an high resolution digital camera which allows to detect and to track targets during the day and at night and in all weather conditions.¹¹⁷ It can distinguish human beings from animals and the device has a voice recognition system in order to identify friendly guards with passwords as well as loudspeaker system which allows to issue orders independently by the robot or to communicate with a command center. SGR-A1 is equipped with weapons (Samsung claims that they are non-lethal) in order to stop or discourage every intruder. At present South Korea started to install this kind of security systems along its northern land border with North Korea.¹¹⁸

The UGVs will be used not only for physical border control, but they will be applied for protection of international airports and harbors. Equipped with sensors for detection of chemical, biological agents, radiation, and high explosives substances (CBRNE), the mobile robots can control suspicious materials, cargo or luggage in ports of entry. Good example of

¹¹⁵ *ELBIT EXPANDS RANGE OF AUTONOMOUS GROUND VEHICLES*, DEFENSE UPDATE, MARCH 2007

[HTTP://DEFENSE-UPDATE.COM/FEATURES/DU-1-07/ELBIT_UGV.HTM](http://DEFENSE-UPDATE.COM/FEATURES/DU-1-07/ELBIT_UGV.HTM) ACCESS 24.11.2010

¹¹⁶ Krishnan A., *Killer robots: legality and ethicality of autonomous weapons*, Ashgate Publishing Ltd., 2009, p. 72. ISBN 978-0-7546-7726-0

¹¹⁷ *Ibidem*, p.73

¹¹⁸ *SOUTH KOREA DEPLOYS ROBOT CAPABLE OF KILLING INTRUDERS ALONG BORDER WITH NORTH*, DAILY TELEGRAPH 14.04.2011
[HTTP://WWW.TELEGRAPH.CO.UK/NEWS/WORLDNEWS/ASIA/SOUTHKOREA/7887217/SOUTH-KOREA-DEPLOYS-ROBOT-CAPABLE-OF-KILLING-INTRUDERS-ALONG-BORDER-WITH-NORTH.HTML](http://WWW.TELEGRAPH.CO.UK/NEWS/WORLDNEWS/ASIA/SOUTHKOREA/7887217/SOUTH-KOREA-DEPLOYS-ROBOT-CAPABLE-OF-KILLING-INTRUDERS-ALONG-BORDER-WITH-NORTH.HTML) ACCESS 15.04.2011

such small, not expensive, commercial off-the- shelf technology (COTS) is USV GRUNT developed by KVH Inc. which can be affordable even for industrial companies for security and protection.¹¹⁹

Mentioned above platforms are only some examples of wide spectrum of those security devices. There are plenty of scientific researches and developments conducted by military industry in order to construct effective ground security/ combat vehicles for security/military purposes. Just only to mention some of them such as “Defender” developed by AFLR, General Dynamics “MDARS” or iRobot “PackBot”.

Border security services have in their arsenals not only unmanned vehicles. One of the “popular” means in frontiers’ protection are technical fences or walls with fully automated watchtowers bristling with high-tech equipment as all types mentioned above cameras, infra-red or seismic sensor systems, acoustic detectors, microwave operated movement detectors and radars which can send data to sophisticated control centers where human operators can make decisions. Those constructions can be augmented by UAVs and UGVs for monitoring death zones or as rapid reaction forces.



Elbit hi-tech fence¹²⁰

¹¹⁹ *Frontline Robotics keeps unmanned security vehicles on track with KVH fiber-optic gyros, Military & Aerospace, Vol. 20, No.4 April 2009 p.19*

¹²⁰ <http://www.elbitsystems.com/elbitmain/area-in2.asp?parent=8&num=67&num2=67> access 10.04.2011

INTEGRATED BORDER PROTECTION SYSTEMS

TALOS – panacea for guarding of the European Union’s land borders?

Although the presented above sophisticated hi-tech solutions are quite very efficient, but real effectiveness in border security matters can be obtained by integrating them in one complex security system. Currently many countries try to establish combined frontiers surveillance and reaction systems for border violation. The researches go towards development of security solution which will be consisted of aerial and ground/underwater fully autonomous robotic guards phalanx, which can register and track suspicious activities, communicate independently or via a human operator with a suspect in order to identify a detected person, send information and images to a command and control center, where a human operator will make a decision about further procedures. Current technologies allow to equip the robots with lethal or non-lethal weaponry, but still there is rather a moral concern about giving a machine a full autonomy for applying lethal force towards a human being and trepidation what can happen in case of malfunction of an armed apparatus.

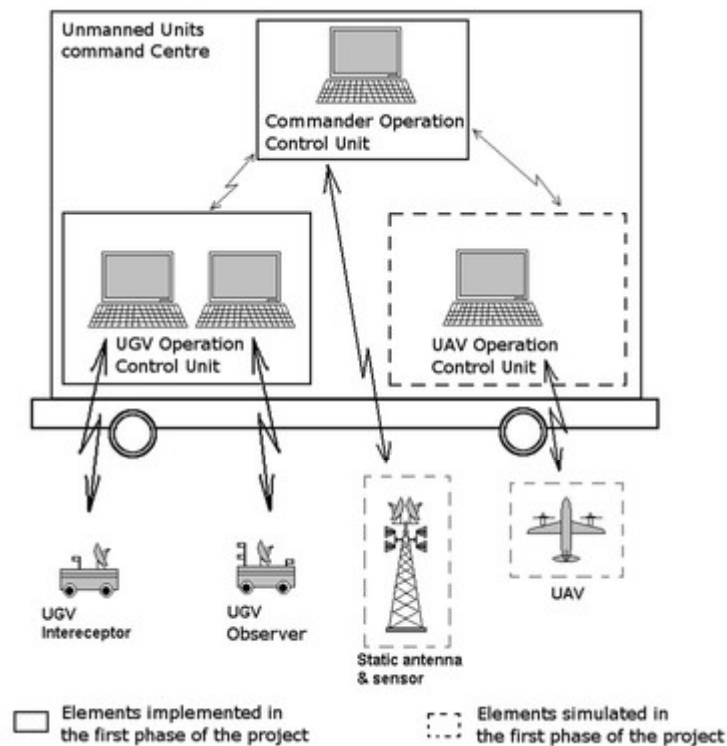
The European Union is one of the organizations which is very interested in increasing its borders’ security and sponsors scientific researches for developing border protective aerial, land and maritime systems under the 7th Framework Programme in Security priority co-financed by the European Commission.

One of the examples of such research programs for land border security is TALOS - Transportable Adaptable Patrol for Land Border Surveillance which started in 2008 and should be finished in 2012. By the way, in Greek mythology Talos was a bronze giant who protected island Crete from invaders. Currently TALOS consortium consists of 14 research institutes, industries and technology universities lead by the Polish Industrial Research Institute for Automation and Measurements (PIAP)¹²¹. The objective of the project is to develop an autonomous mobile platform with cross-country abilities working in all weather conditions during the day and at night. The model should be modular with possibility of installing wide range of modules used for safeguarding of European frontiers. The final product of the researches in the first phase should be a demonstration system consisting of two UGVs (a sentry and an interceptor) and a command center unit, which can show application of the technology. Further development of the concept should include incorporating of UAVs with a control unit and sophisticated watch towers with detectors and

¹²¹ TALOS project web-page: www.talos-border.eu

sensors. The 1st stage prototype has to be tested in the field condition similar to European geographical environment and presented in 2012. The developed technology and gained experiences can be used in the future for manufacturing a fleet of robotic guards. TALOS budget amounts 20 million Euro and European Commission sponsors 65% of the project.

Generally speaking the concept includes two types of autonomous UGVs: a sentry and an interceptor, an UAV and C2 center. The “sentry” UGV and UAV will be used for patrolling border areas and detecting intruders, sending data to the human operated control unit and track him/her in case of escape. An “interceptor” UGV (or several) will be sent by a human operator on the spot in order to stop and to halt a suspect until arriving a border guard squad. According to PIAP representatives, there is a possibility to equip the interceptor unit with non-lethal technologies for autonomous acting, but this idea was rejected according to advice of the European Commission¹²².



Proposal for TALOS configuration¹²³

TALOS project elements are not only mobile platforms but they are hi-tech robots with so called artificial intelligence – they follow procedures used by border guard’s services and the

¹²² Information from TALOS project manager

¹²³ http://talos-border.eu/index.php?option=com_content&view=article&id=52&Itemid=60

behavior of the robots can be modified according to the needs or changing intruders' tactics. Introduction of a mature system to border security agencies in EU countries with external frontiers should dramatically improve security not only European Union boundaries but can be introduced by other countries.

SUMMARY

Security of homeland borders is a concern of all countries over the world. Traditional methods of using human border guards equipped with traditional binoculars, watch towers, operated as aerial, ground or maritime patrols are expensive, ineffective and unreliable. Nowadays modern technology and current solutions which are an effect of technological progress can support the routine activities of border guards teams responsible for security of countries' frontiers. The hi-tech machines equipped with artificial intelligence can help to fulfill such a kind of tasks effectively to aid border services routines. The apparatuses equipped with artificial intelligence, can make decisions autonomously without the human involvement or transfer data to a control center run by an operator who will decide about further actions.

In comparison to people the machines are never fatigued or sick, they do not have personal or moral problems, can operate round-the-clock regardless the weather and seasons conditions, during the day and at night. The sophisticated devices cannot only identify presence or movement of intruders, distinguish if someone is a friend or a foe, detect or react to enemy fire, but they can detect and identify hazardous materials even WMDs. Furthermore, the robots can be fitted out with lethal or non-lethal force in order to stop or to react to intruder's behavior, but autonomous use of that possibility by robots is rather more moral issue than technical one. The robots can save a life of human beings in conducting the most hazardous tasks and can be used in environment which can be extremely hostile for men. Although the technology, which some years ago could be found only in science-fiction books, is used nowadays for constructing the sophisticated artificial guards but humankind has to keep in mind that the presented above hi-tech solutions cannot replace fully humans and take their functions. The robots can only support and make more effective men's job which has to be done in order to protect countries' borders.