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Integration and Synergy of EO-GMES Systems in a Pilot Black Sea STRATOM Project for Strengthening Technical and Operational Capacities in the Frame of EU Border Management Strategy and BG-CZ-PL-RO-SI Network

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Abstract

Four countries from the Central and East-South European GMES network are not only maritime but also EU border countries. Thus, their operational capacities in imagery and monitoring of Black and Baltic Seas are critical issues. ‹‹STRATOM›› can be an integrated stratospheric and satellite system for EU border control on three on-line levels, respectively: air-operational, air patrol and surveillance, stratospheric monitoring, and the last satellite off-line level. ‹‹STRATOM›› can also be considered as a programme of 4 projects oriented on aerospace monitoring of all EU sea regions as: *Black Sea* (STRATOM-BS), Mediterranean Sea (Stratom-ME), South Atlantic (Stratom-SA) and Baltic Sea (Stratom-BA).

The first and pilot project could be dedicated for support of the Black Sea Region and could be consider as a stratospheric part of a MONITORING AND SURVEILLANCE CO-OPERATION ON BLACK SEA programme as well as some extension of FRONTEX's systems. These project objectives are to improve the protection of environment and human life, infrastructure and other assets from man-made and natural disasters. Then, the result of

the STRATOM-BS project will provide amongst others a shared maritime situational awareness of the Black Sea and its approaches that will help nations to improve maritime security, for example regarding emergencies at sea, border control, crime prevention and environmental protection.

1. Introduction

With Regulation (EU) No 911/2010 [1], the European monitoring programme GMES (Global Monitoring for Environment and Security) has entered its operational phase. Concurrently from year 2007, the other programme INSPIRE (Infrastructure for Spatial Information in the European Community) is being implemented for providing over the internet information and services such as:

- possibility to search for spatial data sets and images;
- view services making it possible to display, navigate and overlay spatial data sets;
- download services, enabling copies of spatial data sets to be downloaded, and;
- other spatial data services [2].

In all cases satellite systems are basically the sources of data and images.

Meanwhile, a HALE UAV (High Altitude Long Endurance Unmanned Air Vehicle) has become a promising technology. It uses solar photovoltaic conversion as the technical solution for propelling energy and can stay airborne for a long time, in fact as long as there will not be a need for its technical or mission renewal. It can also follow any monitoring or measurement path or can circle over a given area at a high altitude of 18-27 kilometres. What is more, it will not only be the programmed autopilot system as a UAV payload with written mission and automatic take-off and landing possibilities, but also a ground station – human machine interface, that will both provide many opportunities for measurement and imagery of earth and atmosphere.

In April 2008, three American teams received Phase One contracts to begin developing a radical new aircraft, this is designing and implementing HALE UAV under a US Defence Advanced Research Projects Agency (DARPA) programme known as "Vulture."

In general, DARPA has announced that "the system has potential in numerous roles: *operation as a single platform*, as a formation of multiple aircraft, or as a ***constellation providing infrastructure augmentation or recovery***. Vulture technology enables a *re-taskable, persistent **pseudo-satellite capability**, in an aircraft package*. **The technology combines the key benefits of an aircraft (flexibility & responsiveness, sensor resolution, reduced transmit/receive power, affordability) with the benefits of space assets (on-station persistence, no logistics tail, energy independence, fleet size, absence of in-country footprint)**. The technology challenge includes developing energy management and reliability technologies capable of allowing the aircraft to operate continuously for five years. The Vulture program will conduct subscale and full-scale technology maturation and demonstration activities to prove critical technologies" [3]

Specific DARPA goals for Vulture are not trivial: 5 years on station with:

- a 450kg payload;
- 5kW of onboard power, and;
- sufficient loiter speed to stay on station for 99% of the time against winds encountered at 18000-27000m.

If Vulture reached its goals, it ***would become*** **a very potent lower-cost alternative** ***to the USA's recently cancelled*** **$20+ billion** ***satellite program***. The system could act as a substitute for communications relay or reconnaissance satellites, as long as the payload fits within the weight limit. Vulture would be more vulnerable to anti-aircraft missiles than a satellite, and could be targeted by fighter jets as well, given the right launch profile. On the other hand, **the same relative closeness to Earth would improve sensor resolution and communications capability.**

This way, the gap between cosmic and tropospheric surveillance and monitoring could be fulfilled by the photovoltaic airplane as a complementary solution of a stratospheric Unmanned Aircraft Vehicle (for example as the one being built in Warsaw Institute of Aviation - see Fig1).

Figure 1. Polish UAV “Phoenix”

Moreover, an unmanned aircraft is not only incomparably cheaper than a satellite in production and exploitation, but also it allows small and medium organisations for direct influence on its use, especially for an organisation’s own tasks of imagery and measurements and for choice of flying paths as well.

Having this in mind, the following preliminary deductions can be stated:

A. An Unmanned Aircraft System is a missing element in the GMES/INSPIRE strategy to get space and air benefits down to Earth.
B. Because HALE UAV is accessible even by small organisations, the Earth application part of GMES and INSPIRE and direct access to needed and relevant information, it can be a driving force for improvement of European information society in all levels of its hierarchy, especially in local and regional administrations for detecting e.g. conflicts between spatial planning and the existing infrastructure.
C. From both the above points it can be deduced that integration and synergy among the Services of Environment Protection and Security (SEPS) in South East and Central European countries could be based on an UAS pilot system built for the Black Sea Region (BSR) in a common project of Bulgaria-Czech Republic-Poland-Romania-and Slovenia.

It is worth noticing that the first idea about building some kind stratospheric monitoring platform occurred in Poland just before World War II at the Warsaw University of Technology when Professor Wolfke (1883 – 1947), famous for his discoveries of two types of liquid helium and holography technology, proposed to use a giant balloon called “The Star of Poland” with height - 120 meters, capacity of the bag - 124700 m^3, size - 12300 m^2, and total weight - 1500 kg including the gondola – 500 kg. This predecessor of the modern UAV attempted a stratospheric flight on October 14, 1938 in the Tatra Mountains, but the balloon caught fire when it was less than 100 feet above the ground.

Today, we have different possibilities but also different challenges.

2. EU Southern Border Control and a STRATOM Project

The pilot system of **Strato**spheric **M**onitoring of the Black Sea Region (BSR), called STRATOM-BS, is proposed for accomplishing a mission of support of situational awareness and operations management not only on this specific sea destination but also for every extensive geographic maritime and land area. It fulfils a gap between satellite and tropospheric monitoring and concurrently can be treated not only as an integrated stratospheric and satellite system for EU borders control on three on-line levels, respectively: air-operational, air patrol and surveillance, stratospheric monitoring, and the last satellite off-line level, but also it can be considered as a programme of 4 projects oriented on unmanned stratospheric monitoring of all EU sea regions as: *Black Sea* (STRATOM-BS), Mediterranean Sea (Stratom-ME), South Atlantic (Stratom-SA) and Baltic Sea (Stratom-BA).

The first and pilot project could be dedicated for support of the Black Sea Region and could be seen as a stratospheric part of a MONITORING AND SURVEILLANCE CO-OPERATION ON BLACK SEA programme as well as some extension of FRONTEX's systems. These project objectives are to improve the protection of environment and human life, infrastructure and other assets from man-made and natural disasters. Then, the result of the STRATOM-BS project will be among others a shared maritime situational awareness of the Black Sea and its approaches that will help nations to improve maritime security, for example regarding emergencies at sea, border control, crime prevention and environmental protection.

If we note that four countries from the Central and East-South European GMES network are maritime border countries, it will be obvious that their operational capacities in imagery and monitoring of Black Sea are critical issues. Until now, accessible and trusted data about different threats on the Black Sea is not available. That is why, we are listing not regional but global marine threats in the table 1.

Threat/source	Maritime sector
Vulnerable infrastructure and installations	**Ports/shores, equipment, transport systems, ships (especially tankers) offshore platforms, pipelines, electrical and optical fibre cables**
Terrorists and guerrilla	Attacks, kidnappings, coercion, integrity of supply chain, cyberterrorism
Criminals	Smuggling, kidnapping human trafficking and illegal human organs trade, large scale fraud, criminal organisations, pirates
Communities	Fundamentalism and religion orthodoxy, extreme alterglobalist movement
Ecological movement	Extreme groups
Internal threats	Theft and trade of radioactive substances, propriety information theft, corruption, violent movements

Table 1. Global maritime threats

Currently in EU membership countries, FRONTEX is developing a strategy of integrated and paneuropean response for threats like terrorism, illegal trade and smuggling. STRATOM can support this strategy in 3 main tasks of the control of EU borders:

1. Multisensory remote sensing of transport means and people in the area of stratospheric system and computer searching for correlations between collecting data and data from criminal intelligence, threat analyses and geospatial information.
2. Detection and early warning about threats in four tiers of UAS monitoring: satellite off-line and on-line: HALE UAV, airplane, unmanned helicopter, all of them especially before threats appearing on borders of EU.
3. Coordination of EU border control in transport space on national and international levels.

According to EU regulations, the seat of the European Agency for the Management of Operational Cooperation at the External Borders of the Member States of the European Union (FRONTEX) is Warsaw ([4],[5],[6]). Moreover, the regulation [6] allows the formation of **Rapid Border Intervention Teams** (Art. 12-8a) designated for crisis situations *"of particular pressure, especially the arrivals at points of the external borders of large numbers of third country nationals trying to enter illegally into the European Union*".

Such operations however, need:

- Earlier operational intelligence as well as threats and risks analysis.
- Preparing an operational initiative.
- Preparing an operational plan.

FRONTEX's operation then begins an analysis of threats and risks (Art. 4 of the Decision on Rules of Procedure) and responsibility is on the side of ***Head of Risk Analysis Unit*** (**RAU**). Thus, RAU is the fundamental element in initiating operations as well as being responsible for writing and updating the ***Common Integrated Risk Analysis Model*** (**CIRAM**).

On the other hand, a director of an operations unit (for land, maritime borders and airports) is responsible for activity coordination. With his cooperation the operation plan should include (Art. 6 of the Rules of Procedure): "*general description of the preparations, schedule, way of action, technical means and manpower available, detailed budget for the operation, implementation costs, risks connected with implementation, etc*".

Summarising, whatever a plan could be, without its support by a monitoring geospatial system, does not have a proper level of success probability for implementation. Thereby, the necessity of Stratospheric Continuous Monitoring System becomes evident.

From table 1 stems the fact that the worst threat scenarios are closely connected with vulnerable infrastructure and installations. Meanwhile, the everyday routine problem for EU is illegal immigration traffic from Asia and especially from Africa (sees Fig.2).

Figure 2. African illegal immigration (boat people) via Spain (source [7])

Illustration of these problems is the following table about the number of irregular immigrants in Spain.

Factor	Number of immigrants Year: 2003	2004	2005	2006
Irregular immigration	**9388**	**8426**	**4790**	**31863**
Boat People (Pateras)	580	274	214	603

Table 2. Comparative data on immigrant arrivals in the Canary Islands, 2003-06 (source [8])

Geographical scope of such traffic can be seen below on the Mediterranean example.

Figure 2. Mediterranean areas of illegal immigration to Spain [7]

These examples show that the scale of the problem is not local, but is related to the whole EU, all the more because it applies to only one immigration sector of one sea area.

Risk Analysis Centre (RAC) in Helsinki estimates this threat as high according to data of **OCTA** (***Organised Crime Threat Assessment***) and according to **RAU** "**Common Integrated Risk Analysis Model**" (**CIRAM**), the model based on a six element matrix of operational intelligence of border critical areas. Therefore, the STRATOM system would write into reports of liaison officers in third world and into exchange of information in internet network ICONet for coordination of EU border control.

It is worthwhile to emphasize here that the concept of Baltic Sea monitoring was first preliminary established June 1997 by Poland, Finland and Germany in the context of Baltic Sea Region Border Control Cooperation (BSRBCC). These ideas were later and independently developed by the network MEDSEA (Coastal Patrol Network in the Mediterranean Sea) and the supported project BORTEC about border technologies for Southern Maritime Borders of EU.

3. Main tasks and conditions of their fulfilment

3.1. Services of Environment Protection and Security

Services of Environment Protection and Security (SEPS), acting in the name of EU society, should be an efficient management tool of preventive and antiterrorism measures, especially in crisis situations.

In both cases of maritime and land areas, these services should cooperate with each other, that is with:

- cross-national and national Centres of Situation Monitoring and Crisis Management (CSMCM);
- national Civil Operations Centres (COC):
  - **national Border Control Centres (BCC);**
  - national Customs Centres (CC);
  - national Fire Brigade Centres (FBC) as well as Chemical and Radiation Rescue Centres (CRRC);
  - national Police Centres (POL);
  - national Land and Maritime Rescue Centres (LMRC);
  - national Military Reserve Centres (MRC);
- national Centres of Meteorology, Hydrology and Seismic Threats (CMHST);
- National Centres of Epidemiology of People, Animals and Plant Diseases (CEPAPD).

3.2. Fundamental conditions for synergetic and effective operations

Services of environment protection and security achieve the ability for effective accomplishment of their tasks if they will be able to coordinate operations in response to a sudden crisis situation.

Efficient coordination should be enforced on three platforms:

- internal – in the frameworks of national services;
- external – among national services, especially in the Black Sea Region;
- central – in the European Commission.

Environment protection and security and crisis management should be supported on all these levels by high technology, including by remote sensing, imagery and digital information and communication technologies.

3.3. General aim and some aspects of stratospheric monitoring

The organizational and technological, general aim of the project STRATOM-BS is to provide, as a pilot solution, the possibility to observe EU border areas by photovoltaic Unmanned Air Vehicles having stratospheric monitoring as the first system of the three countries: **Bulgaria, Romania and Slovenia.** Services of Environment and Protection of these countries could then have a common system of border control which would be very efficient and cheap in exploitation.

Note here that EU, aligning to progress in the use of high technology, is in any case introducing Earth remote sensing and imagery in the GMES and INSPIRE programmes. It means more than before the need to link relationships of Earth observation with applications of collected data related to the atmosphere, oceans and lands. For example, governments of EU Members spend money for monitoring and analysis of global warming effect. Meanwhile, the cost of research from a cosmic altitude and of its logistics cannot be avoided and moreover the research is conducted at a greater height than the stratosphere, which has almost all of the Earth's ozone protecting the planet against short wave radiation (maximal density of the ozone layer is on the altitude 25 km and has the value 10^{-7} kg/m^3 [9]).

Similarly, there is no cheap research of the atmosphere in the EU projects COPAL and EUFAR (***CO**mmunity heavy-**PA**yload **L**ong endurance Instrumented Aircraft for Tropospheric Research in Environmental and Geo-Sciences* and ***Eu**ropean **F**acility for **A**irborne **R**esearch*) with regard to short flight missions and the cost of ground infrastructure and services. Concurrently, the miniaturisation of measurement devices allows us, even today, to use a multisensory platform located on board of a HALE UAV for continuous monitoring.

4. Options of system purchasing and financing

4.1. Budget and external financing

If the European Commission decides for the implementation of STRATOM, then it could consider two possibilities for system financing. First, the EC can use budget funds; second, financing partly or totally would be received from external sources.

If the second variant were to be chosen, the cooperation between EC and suppliers of high technologies could prove effective. As a result of this, one can achieve investment sourced by technology producers or from a bank consortium.

Both of the cases should lead to a concept of financial engineering for the creation and use of appropriate funds. Among others, based on government guarantees one could apply for funds from 70 to 100 points above EURIBOR, i.e. 0.7-1.0% above. They could also assume specific scheduling of deferred payments and credits.

Financing from the European Bank for Reconstruction and Development should also be considered.

4.2. Governmental agency

An agency model of the system's exploitation provides additional possibilities of financing compared to traditional financial instruments such as purchase, credit, leasing, renting, and EU help funds. These instruments are not new in fact, but they allow a more elastic combination of different means based on net income and two principles:

- initial capital investment, and;
- reinvestment of initial capital by income generated by user payments.

In the STRATOM project there is also a possibility of creating a joint-venture with financial partners and the European Commission. The common agency allows for initial relatively low commission's expenses and transfers risk of agency activity to all stakeholders. In this variant Services of Environment Protection and Security would contribute monthly payments by a single user.

Both variants should be preceded by a prepared study of detailed analysis of different types of financing, but any precise calculation needs previous information about concession time, apportionment, potential numbers of users, and so on.

5. Conclusions

This paper was focused on the preliminary analysis of the characteristics and features of a proposed STRATOM-BS solution in the domain of Earth observation for Services of

Environment Protection and Security for whom it is designated as a monitoring pilot project on the Black Sea Region. Considerations above imply the following main conclusions:

A. The optimal solution is an implementation of an individual, specialised system for Services of Environment Protection and Security. It is justified by:
- special functions required by users from the security sector;
- different structure of transmission in cases of services and commercial users;
- security and system management.

B. Implemented system should be elastic and have to ensure possibility to enlargement and development according to:
- EU and national priorities and programmes;
- amounts of accessible budgets;
- decentralized and centralized structures of organizations;
- necessity of connection with existing systems of environment protection and security.

C. There is a need to establish an EU agency which would coordinate and fulfil tasks of monitoring of the Black Sea Region, its imaging and situational information dissemination from the four levels of Earth observation, unmanned: cosmic (satellites), stratospheric (UAV), and air-grounded (helicopters); and manned – tropospheric (airplanes).

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