THE MONITORING OF THE ROMANIAN LITTORAL CLIFFS USING AUTOMATIC FLIGHT SYSTEMS

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ABSTRACT

The Southern Sector of the Romanian shore, from Cape Midia to Vama Veche (the Bulgarian border), stretching about 74 km of cliffs shore, having 70 m maximum high, mainly protected with small beaches at the slope basis, is in a continuous erosion process. The work presents certain results obtained with UAV (Unmanned Aerial Vehicle), mapping activities extended on the southern unit of the Romanian shore, providing certain terrain data, represented by the Ortho-mosaics, Digital Surface Models (DSM), refined 3D models of coastal facilities and waterfront slopes. The integration of new mapping techniques with various data provided by the old topographical and hydrographical surveys, developed on the coastal area, can offer the basis of precise spatial changes and evolution trends, supporting the continuous improvement of the coastal protection and planning strategies.
Thus, the shoreline changes of the cliffs coast will be studied based on a new approach, taking in consideration the physical and outsized calculus limitations of the UAV survey technology.
Keywords: *cliffs erosion, UAV survey, coastal changes, coastal evolution trend.*

INTRODUCTION

One of the most dynamic areas on the Romanian territory, the coastal zone is the subject to a constant interaction between different natural elements: earth, water, atmosphere and also the anthropogenic influence. The accelerated changes on landscape may be manifested within months, weeks or days.

The extreme weather events, the dynamics of seawater masses, the intake of fresh water and alluvial deposits carried by the Danube river, all combined with the intense human activity, represented by industry, maritime transport, tourism, are constantly shaping the coastal zone. The waves and currents can influence the geometry of seaside beaches, the coastal works, the planning and conception of ports building.

Therefore, the wave becomes a transfer agent for water energy to the coastal areas, generating currents which affect the sediment transport, causing the coast erosion. The hydrodynamics of coastal marine area is a very complex problem, causing evolution in time and space of different processes, whose solution can be done only partially, due to many factors. Thus, the dedicated numerical models, used in movement of water masses modeling, do not take into account the near shore specific processes, such as wave diffraction or reflection, because this type of simulation uses specific parameters, which are measured in the off-shore area. A better numerical model calibration and data validation requires the use of a superior observation and data collection method.

The southern sector (Midia - Vama Veche) presents structural and morphological characteristics of the relief which are different from the Romanian northern sector. The relief of the southern sector consists of low altitude shores - beaches (approx. 80%) and high shores - cliffs (approx. 20%), being a land of alveolar type, with beaches and cliffs (mostly active, whose height reaches approx. 35 m) is affected mostly by the marine abrasion, which is here irreversible. The negative impacts of the coastal erosion in this sector relates to the withdrawal of the shoreline, cliffs loss through erosion, damage, destruction of some tourist or economic interest buildings (fishing and fisheries units, touristic facilities, etc.) and not least the effect on the coastal ecosystems, including the coastal slopes of the coastal ecosystem.

In the last 4 years about 80% of coastal bluffs were protected by sloping, including drains, geotextile columns of and shore defenses by stones, which give stability to the afferent shoreline. This stability, however, is only apparent, because if the storms and eventual activation phreatic layers, the shore is subject to the collapse and/or sliding distances amending the base of the cliff having significant value, exceeding a few meters from one event. Further, this type of shore is characterized by exclusivity of negative balances and the need for the regular maintenance is evident.

The coastal erosion supervision is done along the Romanian seaside by making specific measurements on the hydrological parameters, geomorphological and sedimentological inshore. The integrated surveillance program of the coastal zone achieved during the past years, has been continued by monitoring works of the natural shoreline status with cliffs, started 29 years ago (1986), but now using unmanned aerial vehicle/UAV or automate mini-air models. Given the particularity and the high shore irreversible changes in planning and lack of actions under the influence of combined natural factors, represent the action of marine hydrodynamics drive through runoff and infiltration of the groundwater in some areas, the change rate in this area are still negative, showing annual rates between 0.1 - 0.5 m.

MATERIALS AND METHODS

The investigations throughout the coast with protected amd active cliffs have been consisted of accomplishing surveying with GPS and TruePuls rangefinder alignments in certain landmarks aproximately 20% remaining from the 50 new landmarks planted by CN " Romanian Waters" on each characteristic southern sector alignments at the level of year 2011, following the disappearance in recent years of the landmarks ICPGA/IRCM . Two time horizons 2011 and 2012 were done aerial-lidar measurement effectuated on the entire coastal strip of the cliff slopes, but in the last year were implemented methods of UAVs surveys.

Aerial photogrammetry

This is a classic technology applied for over a century, which uses photogrammetric cameras installed on airborne platforms (typically jets) to obtain aerial imagery and elevation data. It has gained precision and enhanced productivity in the information technology era by converting them into digital photogrammetry, which allows the collection of a high resolution multispectral digital imaging and precision (pixel size in the range 10-50 cm) and obtain the precise digital terrain models and ortophotoimages (DTM), at the same order of magnitude. On these surfaces can easily identify the areas covered with vegetation or built. For the low and flat areas, the DTM accuracy may be insufficient when it is desired to obtain an accurate flow patterns.
Due to the high cost of obtaining data (the works being generally carried out by the specialized companies, which have own cameras, expensive aircraft and trained personnel) this technology is feasible to be used for the large areas of hundreds or thousands of square kilometers. Other disadvantages are the relatively long contracting and flight preparation, the need for the photogrammetric register device works on the ground and laborious data processing. By the dependence on the weather conditions, this makes the return time intervals to the same area to be very long.
But the images obtained by the official photogrammetric flights programs, including those of the past decades can provide a valuable source of information, including historical concerning the evolution of the coastal zone, which must be exploited by the topographical maps, cadastral plans and classics drawn on their account.
The use of the LiDAR equipment (Light Detection and Ranging - technology that uses laser beams to determine distances and angles) located on airborne platforms provides high accuracy digital models (DTM) of the overflow areas. On the coastal areas, are used specialized LiDAR devices, which provide information relating to the continental shelf, but for precise studies requires high cost.

UAV- UAS
A relatively new type of platform utilized for taking high-resolution images for remote sensing measurements / earth's surface photogrammetry, are the unmanned aircraft (small airplanes or helicopters, autonomous drone or remotely piloted). The UAV's together with the ground control center forms an unmanned aircraft system - UAS). The UAV's presents many advantages by the small size and low costs. The offer can be customized according to the user's needs. The UAV can be adapted according to the purpose in which they will be used, based on the modular kits of miniaturized components. The scheme for some components can be downloaded and 3D printed.
On an UAV can be installed a variety of sensors, from commercial optical digital cameras, multispectral infrared sensors or thermal cameras which can send information in real time, from inaccessible places, to small LIDAR sensors. The main advantages are the lower cost and easiness to operate.
The sensors that can be mounted on UAV are very varied, from commercial optical digital cameras to multispectral sensors in infrared or thermal cameras that can transmit in real time the situation in difficult to access areas, but their common characteristic being the price and greatly reduced dimensions compared to sensors on manned aircraft. The current trend is to move the focus from taking images with high-performance metric cameras, large and expensive, followed by the laborious processing, the data obtained by cameras with sensors with optical stabilization and sensors trading miniaturized, with medium and low cost characteristics, which are then processed with cheap but enough efficient software. They began to appear even smaller LiDAR sensors

that can be installed on the UAV, which brings all the advantages of this technology with much lower costs and greater easiness to use within southern Romanian coastal area (fig 1).

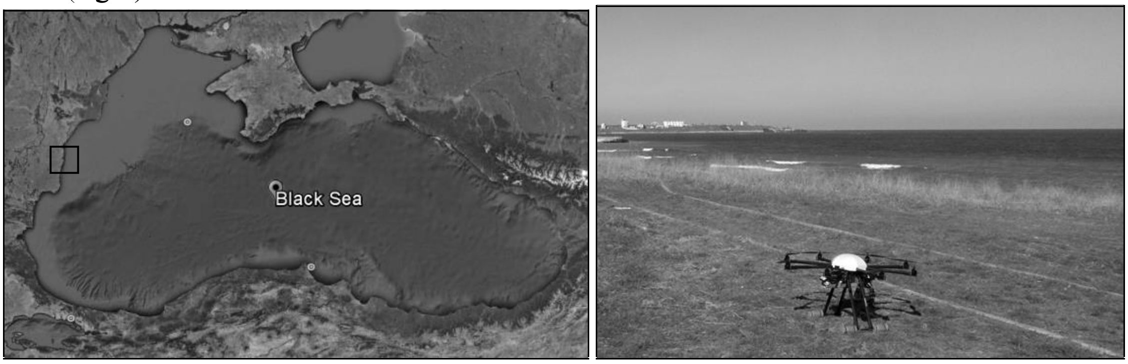

Fig.1. UAV octo-copter lancing point for cliffs survey – Costinesti area

UAV is a versatile, cheap and productive solution of high resolution photogrammetry for average area of the order square kilometers compared to the conventional aerial photogrammetry, manned aircraft and specialized expensive cameras. UAS offers the possibility of obtaining color or multispectral aerial photograms, orto-rectified plans, 3D point clouds and digital surface model (DSM) with high resolution and precision (centimeters order) very quickly and cheaply, with low processing, minimal field work preparation and performance of flights and photogrammetric landmark. The obtained data allow an accurate identification of areas with vegetation or obtain detailed and accurate drainage models.

Using the UAV technology enables the development of methodologies by which, on account reflecting the sky and the sun shining on the waves, they can make quantitative measurements on the roughness of the sea surface and detailed description of the sea state conditions, especially due to the wave slope distribution at different wind speeds.

As any aircraft, the use of UAV is influenced by the weather conditions, but in the case of those performance, they cope in the conditions when is used a manned aircraft may be considered too dangerous or impossible. When is absolutely necessary to obtain real-time images (in stormy conditions or in the event of an emergency, such as pollutants leaks or fires etc.), it is desirable to use a cheap drone to search and supervision than the life be risked of a manned aircraft and expensive drone. The qualification required to the personnel who operating the drones and which processes and uses the obtained data is much smaller and less expensive than the manned aircraft and classical photogrammetric cameras.

According to the current trends, we estimate that this technology will become more refined, more widespread and accessible, thanks to their advantages given by the low cost, easiness of operation, high resolution, getting and rapid data processing.

An example with the main module of a UAV photogrammetry workflow is defined as succession of certain steps (fig. 2.) [2]: starting with definition of the project parameters (PP) and flight planning (FP), follow by photogrammetric UAV autonomous flight (APF), Checking the data quality (QCD), Triangulation of the UAV images (UAV BT), and obtaining of different product such: Collection DSM, ortho-photoplans, 3D Model (DO3D) and Proximity terrestrial photogrammetry.

• The high resolution topographic measurements are traditionally associated with high logistics costs, so that the data acquisition is often carried out by the specialized third-party organizations. In several applications, the high costs of data collection are from earth sciences, exacerbated by the remoteness and inaccessibility of test areas, making it impractical even the use of cheaper portable surveying platforms (eg, terrestrial laser scanning and GPS measurements). But proximity terrestrial photogrammetry techniques have been appeared, cheap and easy to use, which allow high resolution data sets at large-scale, technique called 'Structure-from-Motion" (SFM). Photo from land with ordinary photographic cameras, then processed with specific software.

- The traditional digital photogrammetric methods require 3D location, the position of the camera (e) and the 3D position of ground control points to be known, to facilitate the photogrammetric triangulation and reconstruction of ground models. The used cameras are also very expensive and require specialized operators. In contraposition, the SFM method solves the camera position and the photogram geometry simultaneously and automatically, using redundant image adjustments based on the multiple overlapping of their matching characteristics. The technology is similar to that used for aerial drones equipped with optical cameras. The method allows the creation of digital elevation models (DEM) with high resolution, wide image sets obtained with low-quality digital photographic cameras [1]. The method is applicable in the cliffs or built-up areas monitoring, allowing the highlighting of the vegetation, because it is present the spectral additional information.

The air-borne bathymetric LiDAR

The LiDAR system is a relatively new technology that enables the collection of large amounts of data which underlie three-dimensional models, used in multiple fields. Airborne bathymetric LiDAR makes possible the obtaining of high-resolution data about the dynamics of the water masses in the shallow zone, the wave spectrum, sea level and ocean-atmosphere interaction. A portable LiDAR system installed on an UAV could quickly collect the high-resolution data at a reasonable cost. A disadvantage could be the relatively small over flown cliffs areas due to steep slopes.

RESULTS AND DISCUSSIONS

Remote sensing systems, used to observe the Earth's surface from satellites and aircraft, make it possible to collect and analyze the information about the resources and land use over large areas. The Geographic Information Systems (GIS) allow the resource managers to process large volumes of geographically referenced data from multiple sources. These data can be integrated to produce maps, monitor changes in resources and model the impacts of management decisions.

Remote sensing and GIS are technologies whose potential has yet to be fully explored. Nevertheless, many resource managers in both developed and developing countries have already benefited from these technologies in fields such as town and country planning, watershed management, agriculture, forestry, conservation, mineral resource development and prevention and mitigation of natural disasters.

Remote sensing and GIS are complementary technologies. A GIS can be used to interpret remote sensing data more accurately by integrating them with data derived from other sources and can analyze large volumes of geographically referenced data that would be overwhelming to process manually. On the other hand satellite images can help to update efficiently certain data layers in the GIS.

Integrate UAV data in GIS. Associated to an operative data a geographic information system GIS / GIS can be a main / effective engine of a dynamic decision system.

The specific Geographic Information Systems, powered by quality information fed with the pitch (in- situ) and remote sensing data type may allow:
a. monitoring the physical, chemical and biological components of the transitional waters and national coastal;
b. monitoring the dredged sediment discharge into the sea ;
c. natural erosion monitoring of the Romanian coastal zone and evaluation of the changes due to the implementation of projects previewed"protection and rehabilitation plan of the Romanian Black Sea shore "

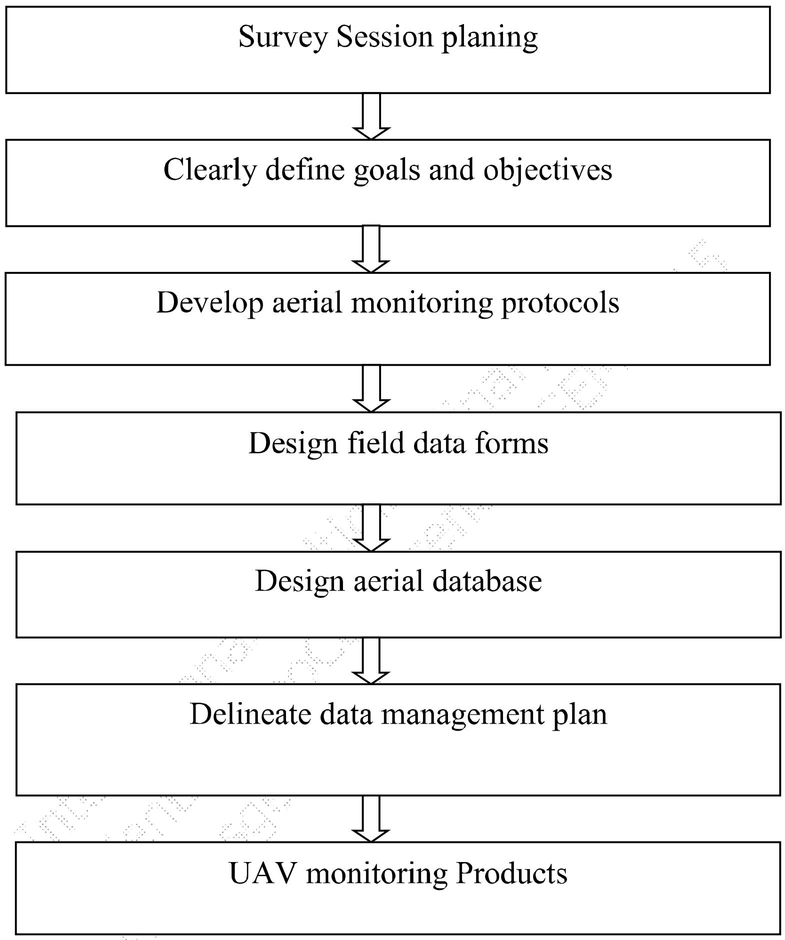

Fig.2 Tasks that need to be completed for UAV monitoring

The results obtained by the technologies implementation for the use of drones, target an integrated surveillance program developing of the Romanian coastal zone. The investigations and measurements developed subsequently have been materialized in the technical reports and studies form, technical reports related documents, which were submitted to the funding agency project that allowed the assimilation, implementation and technology development.
An application of drones in geodesy domain is to develop the digital models of the surfaces or ground (DSM / DTM). Such an application, aimed at tracking the implementing effectiveness of cliff protection solutions, was held in the Costinesti area–Schitu zone [5].

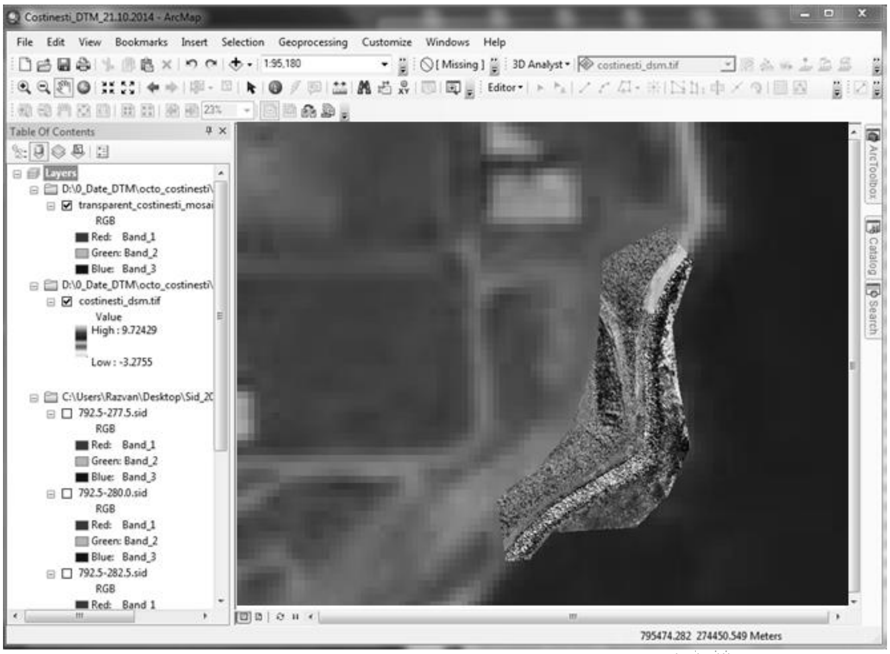

Fig.3. Costinesti area: Schitu Cape – resolution differences between the UAV orto-mozaic images and the correspondent ortophotoplans

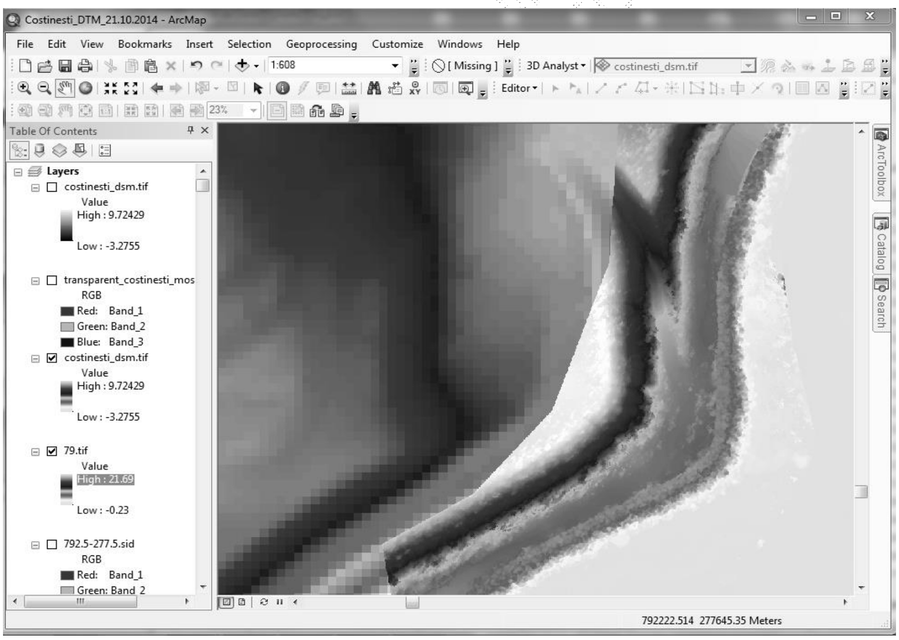

Fig. 4. Costinesti area: Schitu Cape - DSM (Digital Surface Model) obtained using UAV octo-copter vs. Lidar data

DTM data obtained through the image processing, using the software package Pix4D, have been allowed to be performed one comparison of two time horizons, before and after the setting of the cliff slopes, respectively evaluating the effectiveness of adopted protective solution, habitat mapping and depth contours in shallow zones of the investigated areas [3], [4].
Following the implementation of the surveillance technologies using drones / UAVs in the monitoring of the coastal cliffs and the related ecosystem status was extensive

expertise in the field of implementing appropriate the protection solutions and environmentally friendly.

CONCLUSIONS

The positive and negative consequences of the protective works effectiveness carried out in the cliffs sector can be easily quantified using UAV/UAS methods, which provide spatial analysis methods that allow high degrees of adoption optimizations / corrective measures to be taken in adopting concrete measures to protect the coastline/cliffs slopes. Using the aerial vehicles widely available in the civilian sector to obtain a wide variety of remote sensing data as a scientific discipline, especially recently developed photogrammetric digital technology has enabled integration of databases vector and raster GIS. Although the traditional coastal monitoring techniques represented by classical techniques of survey, mapping the topo-bathymetric using various tools of classical and seismic investigations, investigations on the ground and airborne video can be optimized and expanded by modern techniques using aerial drones related to the complementary LIDAR system, the use in specific applications related to implementation of different research methods in order to increase the current level of the processes understanding, of the Romanian natural and engineered coastal environment.

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