U.A.V. TECHNOLOGY FOR THE DETECTION OF SPATIO-TEMPORAL CHANGES OF THE USEFUL AREA FOR FORAGE OF GRASSLAND

M. SIMON[1], Loredana COPĂCEAN[1], Luminiţa COJOCARIU[1,2]

[1]Banat's University of Agricultural Sciences and Veterinary Medicine"King Mihai I of Romania" from Timisoara, 300645, 119, Calea Aradului, Timisoara, Romania
[2]Centre for Mountain Economics, "Costin C. Kiritescu" National Institute for Economic Research, Romanian Academy, Academy House, Calea 13 Septembrie Nr. 13, Sector 5, Bucureşti, Romania
e-mail: mihai_simon91@yahoo.com

Abstract. The research presented in this paper was carried out in the western part of Romania, on the administrative territory of Arad County, in Halmagiu commune. The use of drones in the field of geospatial science is currently very demanding due to its relatively light operation and relatively affordable cost compared to satellite systems, especially high resolution images. In the last decade, the use of unmanned aerial vehicles as remote sensing platforms has become more and more popular for a wide range of disciplines and scientific applications. At present, many photogrammetric mapping methods have used drones to retrieve and record data on objects on the earth. Starting from the above considerations, the use of the drones in the "scientific exploitation" of the areas used as meadows is justified and appropriate. Conceptually and practically, this study seeks to quantify the process of reducing the useful area for feeding a meadow in time and space, using UAV technology and satellite imagery, by achieving three main objectives: Surface exploration through UAV technology, setting spatial-temporal evolution and cause-effect analysis. In the case of this study, a flight with the DJI Phantom 4 Pro equipment was performed, and the image processing was done with the Agisoft PhotoScan Professional software. The comparative analysis was done in the GIS environment, by overlapping and marking the negative changes occurring in the meadow analyzed over the course of four years. Between 2014 and 2018, the useful area of the analyzed meadow was reduced by 21.1%, from 5.83 ha to 4.60 ha, mainly due to two natural phenomena: the extension of the bushes and hence the afforestation and hydrological changes on the course of Crisului Alb, associated with erosion phenomena. Orthophoto and geospatial data from aerial photographs are particularly useful in other types of analysis: vegetation studies, topo-cadastral measurements, 3D modeling, land planning, hydrological studies, etc.

Keywords: Unmanned Aerial Vehicle, flight planning, DJI Phantom 4 Pro, grassland, Google Timelapse

INTRODUCTION

If initially the Unmanned Aerial Vehicle (UAV) was manufactured and used exclusively by defense companies, costing them up to several million dollars, today there are numerous variants on the market, including small and cheap drones, which can be controlled with the smartphone and can be used successfully in scientific research [14].

In the last decade, the use of unmanned aerial vehicles as remote sensing platforms has become increasingly popular for a wide range of disciplines and scientific applications [12], given that drones can be technical means for: monitoring forests and natural phenomena that occur in them; assessment of damage after certain natural disasters; observing and alerting the authorities about the victims of unfortunate events; observing and assessing the growth and harvesting of agrarian products in agriculture, etc. [15].

At present, many photogrammetric mapping methods have used drones to retrieve and record data on objects on the earth. This is due to the fact that using a Global Positioning

System for air measurements is very efficient and cheaper than hiring an airplane [13], it also allows for overfishing of hard-to-reach areas and significantly reduces run-time of the work.

Developing U.A.V. in Romania is still at the beginning, and the legislative framework is extremely restrictive, even for small drones, which significantly affects the expansion potential of this area. U.A.V. must be recorded and a fee that sometimes exceeds the value of the equipment must be paid. Thus, in order to use the aircraft, you need approval from the Romanian Civil Aeronautics Authority. Flights are limited in distance, altitude and area, and requests must be sent at least 45 days before the flight. In short, flight with an aircraft must be approved by the same air traffic monitoring institution [16]. In another aspect, the "ground pilot" requires advanced training, both for the use of the equipment and especially for the processing of recorded data.

In terms of the area occupied by meadows, comparing the share of pastures in agricultural land in other European countries, Romania ranks 5th in Europe after countries such as France, Great Britain, Spain and Germany. [9]

The distribution of meadows on reliefs in the country indicates: 1.09 million ha of meadows in the area, 2.59 million ha in the hill area and 1.24 million ha in the mountain area [10]. For mountain pastures, restrictive factors are numerous and one of the processes that can be regarded as a limiting factor in their potential for use is afforestation as a result of poor management.

Because of abandonment and overloading with animals, very large areas of mountain pastures are in various afforestation stages, a process that has grown over the past two decades. In order to maintain the productive circuit of existing pastureland and preserve the pastoral landscape, large and sustained efforts are required to remove the woody vegetation that replaces the grassy carpet with the forage purpose. These undesirable downward trends in mountain pastures, with incalculable losses, are not unique in the European Union. In the whole country, on the beech floor, but especially on the floor of the spruce, there are still quite large areas of meadows covered with stands, in many cases in the form of closed forests [17].

In the grassland analysis, data taken in the U.A.V. mode may be complemented by geospatial and satellite data, with diversified research being undertaken in this field ([1], [3], [4]).

Starting from the above considerations, the use of the drones in the "scientific exploitation" of the areas used as meadows is justified and appropriate. Conceptually and practically, this study seeks to quantify the process of reducing the useful area for feeding a meadow in time and space, using UAV technology and satellite imagery, by achieving three main objectives: surface exploration through UAV technology, setting spatial-temporal evolution and cause-effect analysis.

MATERIAL AND METHODS

The researches presented in this paper - case study - were made in the western area of Romania, on the administrative territory of Arad County, in Halmagiu commune, situated in the depression with the same name, at the confluence of the river Halmagel with the Crisul Alb at the foot of the Bihor Mountains. The working methodology underlying the present study is summarized in figure 1.

Figure 1 – Workflow

- ➢ In the **choice of the study area**, the following conditions were started:
- • be located near the "mobile" environmental components, in particular expanding forest bodies and / or water bodies that change their course;
- • be used as a meadow, in line with the main purpose of the study;
- • be abandoned, otherwise the afforestation process is stopped.

Under these conditions, a grassland area was selected from Arad County, located in a meander of Crisul Alb (figure 2), an area covered by previous research [11].

Figure 2 – Location of the study area (processing after [18], [19])

- ➢ **In selecting the data used**, given the "spatial" technical possibilities, the area of interest was investigated by two types of data:
- • Data retrieved in U.A.V. mode with DJI Phantom 4 Pro equipment on 11.08.2018
- • Free satellite imagery available on Google Earth Pro, purchased on 05.07.2014
- ➢ **Preprocessing and processing**
- • Images taken in U.A.V. mode - made with Agisoft PhotoScan Professional software that performs photogrammetric processing of digital images and generates 2D and 3D spatial data for use in GIS applications
- • Satellite images were made with ArcGIS 10.1 software

334

On both types of images, the boundaries of grassland and forest areas were identifie and marked by the vectoring of 2014 and 2018

➢ **The comparative analysis** of the two sets of vector data was done in the GIS environment, by overlapping and marking the negative or positive changes occurring in the meadow analyzed over four years.

RESULTS AND DISCUSSIONS
Exploring the area of interest and creating orthophotoplan by U.A.V.

Under the technical and technological aspect, in the topo-cadastral field, in the last decades, there is a remarkable, galloping progress. From the theodolite, used to measure horizontal and vertical angles, at the total station (tachymeter), an "improved" theodolite which, by electromagnetic waves, measures angles, distances, coordinates or level differences, the terrestrial surface can now be "scanned" and measured with unmanned aircraft, commonly called drone (figure 3).
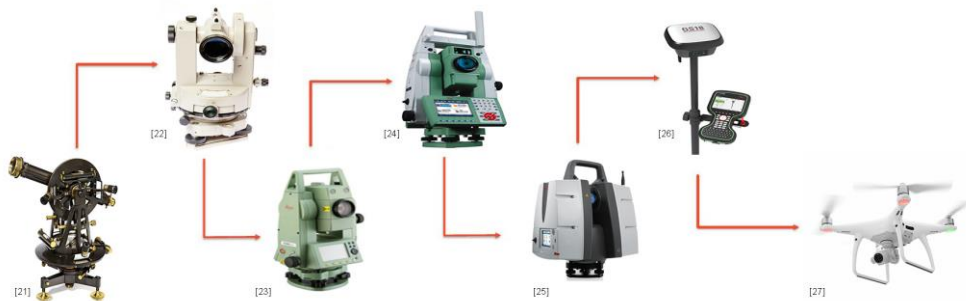

Figure 3– Evolution of technologies ([21], [22], [23], [24], [25], [26], [27])

The use of drones in geospatial science is currently very demanding due to its relatively light operation and relatively affordable cost compared to satellite systems, especially high resolution images [5]. One of the advantages of using drones is to take photographs or aerial photographs that are then processed for mapping so that they can be used to support the acquisition of spatial data [6]. Also, investment and operational costs are reduced, data acquisition is quick and flexible, and the resulting information may be more detailed than satellite data. In addition, as the drones can fly under clouds compared to satellite images that are influenced by atmospheric conditions, droning data is more detailed and clearer than satellite data.

In the case of this study, a flight with the DJI Phantom 4 Pro DJI equipment (figure 4a) was performed to estimate the process of reducing the useful surface for forage for the analyzed meadow.

Figure 4– a: DJI Phantom 4 Pro, b: Photos made by FC6310 (original photo)

335

In the first stage, aerial images were collected based on the flight performed. The flight was made manually via the DJI GO 4 application on 11.08.2018 from 12:45 to 13:15. During this flight 142 photos were taken from which 134 were used for processing (figure 4b), the flight was performed at an altitude of 120 meters, the pictures being made using the FC6310 camera (table 1), covering an area 9.14 hectares.

Table 1

Cameras properties

Camera Model	Resolution	Focal Length	Pixel Size
FC6310 (8.8 mm)	5472 x 3078	8.8 mm	2.53 x 2.53 um

All aerial photographs are based on the WGS 84 (World Geodetic System) coordinate system, thanks to the Global Navigation Satellite System (GNSS) technology present in the UAV equipment.

In the second step data was processed with the Agisoft PhotoScan Professional software. This data processing is done by determining the drones flight path (figure 5a). Stereoscopic view allows us to see an object from two different perspectives, such as aerial photography taken from different camera positions. Therefore, the result of data mapping by using this droning can produce images of very high resolution, also produces a three-dimensional image of the recorded surface

Aligning photos (figure 5b) is done to identify the points in each photo and to do the same matching process in two or more photos. The process of aligning photos will generate the original 3D model.
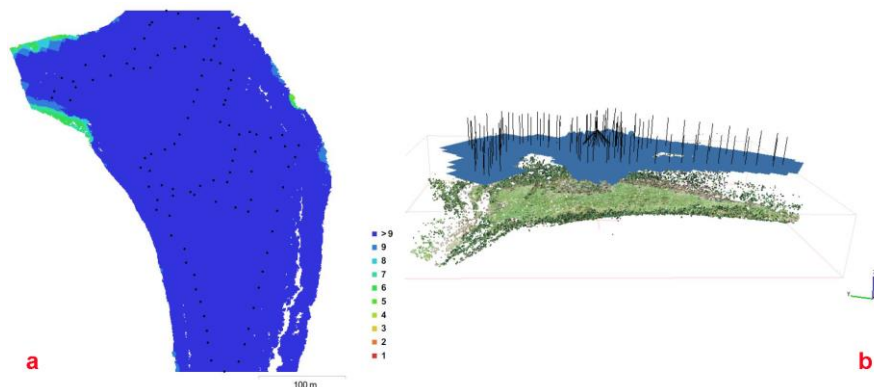

Figure 5 – a: Camera locations and image overlap, b: Alignment of aerial images

The next step is the realization of the 3D model (figure 6) which will be used as the basis for the Digital Elevation Model (DEM) of both Digital Surface Model (DSM) and Digital Terrain Model (DTM), also for the orthophotomap .
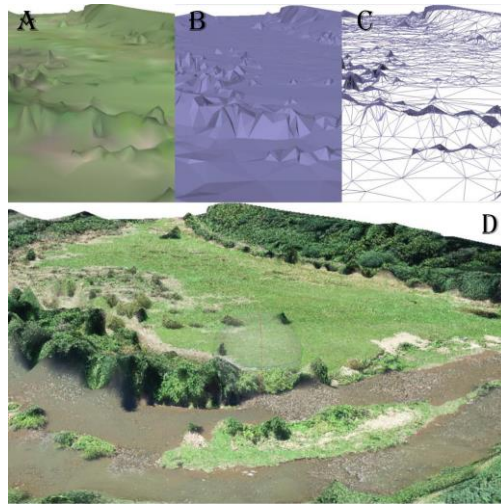
Figure 6 – The processing steps
A-Shaded; B-Solid; C-Wireframe; D-Textured

Cameras locations and error estimates are shown in figure 7. The altitude error (Z) is represented by the color of the ellipse, and the planimetric error (X, Y) is represented by the shape of the ellipse.

| 6 m |
| 4.8 m |
| 3.6 m |
| 2.4 m |
| 1.2 m |
| 0 m |
| -1.2 m |
| -2.4 m |
| -3.6 m |
| -4.8 m |
| -6 m |

100 m

X error (m)	Y error (m)	XY error (m)	Z error (m)	Total error (m)
1.6039	2.10448	2.64601	0.729717	2.74478

Figure 7 – Camera locations and error estimates

The final step after performing the Dense Point, Mesh and DEM steps in this aerial photogrammetric process is the orthophotomap of the studied area, used to delineate the meadow analyzed (figure 8).
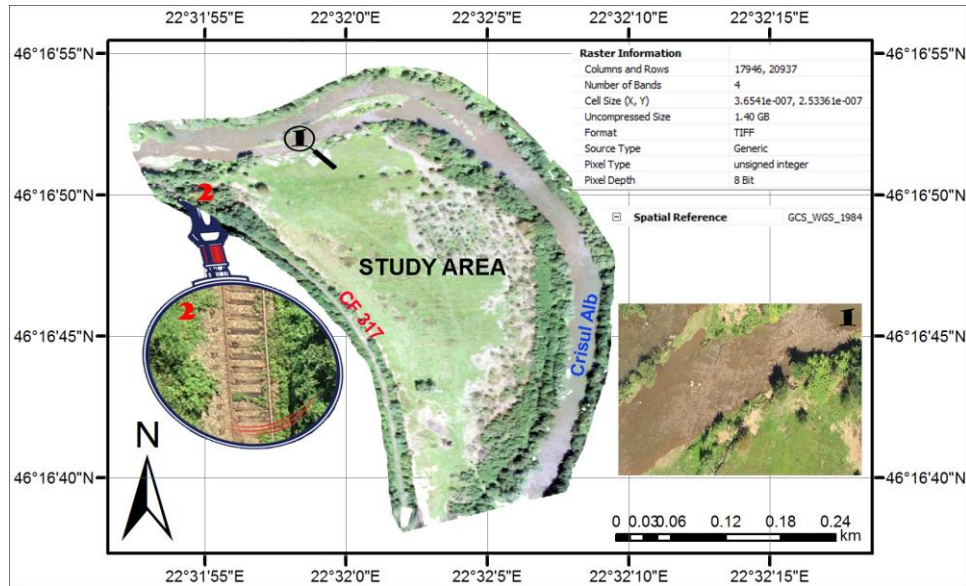
337

Figure 8 - Ortofotoplan in the area of interest

Vectorizing the area of interest on satellite imagery

The emergence of new mapping technologies such as Google Earth, which offers free satellite imagery and aerial photographs of most of the Earth's surface, has led to increased use of mapping technology [2]. The quality and resolution of the maps offered vary greatly, and better quality maps in general are available for Europe and North America [7].

Although Google Earth Pro has limitations in map manipulation and analysis [8], it features Timelapse, which allows you to view land-based changes over the past 32 years: developing large cities, tracking things "destroyed" by human intervention, the melting of the glaciers, the erosion of the land and the transformation of the cities into huge parking spaces. In Romania this function is available for all 32 years only in some imported cities.

A satellite image acquired on 05.07.2014 was used for the area of interest which is the subject of this work (Figure 9).

On the Landsat 8 satellite image, the boundary of the meadow surface analyzed (figure 9) was vectorized so that it could then be compared with the current area of the meadow, thus making the changes that occurred within four years.

The studied area is surrounded by the Crisul Alb River in the North and East and CF317 at the bottom of the forest in the West.
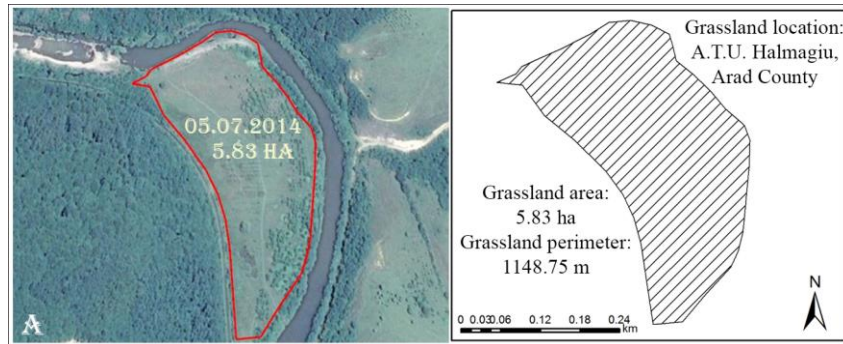
Figure 9 – Study area – Google Earth Timelapse ([20])

By processing vector data in ArcGIS 10.1, the area of interest area (figure 9) and other features relevant to the study were calculated automatically.

Detecting spatio-temporal changes
In order to analyze the changes during the four years, the two vector formats obtained by digitization on the satellite image in 2014 and on the orthophotoplan made in 2018 (figure 10) were compared.
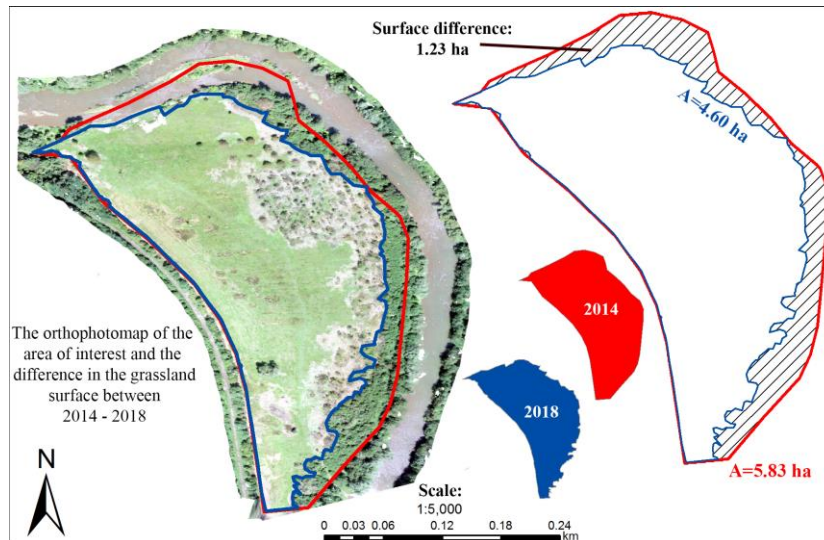

Figure 10 - Analysis of changes in grassland area between 2014 and 2018

As a result of the analysis of the changes, the decrease of the grassland surface was found (figure 10). This 1.23 hectare surface reduction occurred over time through two natural phenomena:

1. Expansion of arbustive formations, particularly in the eastern part; the western limit of the meadow is formed by an exploitation road and therefore the afforestation process is excluded.

The presence of arbustic formations is the cause of the abandonment phenomenon, so that over time they tend to expand without the work of clearing grasslands or the presence of livestock to pasture and thus limit the process.

2. Changes of hydrological nature: large waters and overflows of the Crişul Alb, at different times, modify the area of the meadow in view of its location in the meadow. In 2018, the minor bed of the White Cris extended into the grassland area, thus reducing its useful area. This phenomenon adds to the erosion phenomena that occur along the banks.

In the analyzed time frame, 2014-2018, the area of the meadow considered case study decreased by 1.23 ha, which means a relative percentage decrease of 21.1%. In other words, within four years, the grassland area can be used in a proportion of approx. 80%.

CONCLUSIONS

Between 2014 and 2018, the useful feed area of the analyzed meadow was reduced by 21.1%, from 5.83 ha to 4.60 ha, mainly due to two natural phenomena: the extension of the arbustive formations and therefore the tendency for afforestation and hydrological modifications on the course of Crisul Alb, associated with erosion phenomena.

Using U.A.V. in the analysis of the changes but also in the investigation of the territory at present, had remarkable results, with great precision and accuracy, with minimal costs and resources. Orotopotlan and geospatial data from aerial photographs are particularly useful in other types of analysis: vegetation studies, topo-cadastral measurements, 3D modeling, land planning, hydrological studies, etc.

BIBLIOGRAPHY

[1] BÂRLIBA LUMINIȚA LIVIA, BÂRLIBA C, ELEȘ G, Computing and verifying the land surface without visibility by using GPS and classic procedures, SGEM 2013, Conference Proceedings, Vol.I, 355-362, ISSN 1314-2704, ISBN 978-954-91818-9-0.

[2] BOULOS MN: Web GIS in practice III: creating a simple interactive map of England's Strategic Health Authorities using Google Maps API, Google Earth KML, and MSN Virtual Earth Map Control. Int J Health Geogr 2005, 4:22.

[3] COJOCARIU LUMINIȚA, COPĂCEAN LOREDANA, POPESCU C, Remote sensing and GIS techniques to analyze invasion into grassland of the species *Pteridium aquilinum (l) Kuhn*, Romanian Journal Of Grasslands And Forage Crops, no. 14/2016, ISSN 2068-3065, pp. 31 – 42, 2016

[4] COJOCARIU LUMINITA, COPACEAN LOREDANA, POPESCU C, BORDEAN DESPINA – MARIA, Normalized Difference Vegetation Index in „vertical" analysis of grasslands, SGEM 2017, Conference Proceedings, ISBN 978-619-7408-03-4 / ISSN 1314-2704, 2017, Vol. 17, Issue 23, 625-632 pp, DOI: 10.5593/sgem2017/23/S11.078

[5] COLOMINA, I., MOLINA, P., Unmanned aerial systems for photogrammetry and remote sensing: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 92, 79-97, 2014

[6] HIDAYAT, F. N., WIDARTONO, B. S., Pemodelan Kenyamanan Jalur Sepeda Kampus Universitas Gadjah Mada Memanfaatkan Foto Udara Format Kecil. [Skripsi]. UGM (ID): Universitas Gadjah Mada, Yogyakarta, pp. 1-77, 2014

[7] KAMADJEU R: Tracking the polio virus down the Congo River: a case study on the use of Google Earth in public health planning and mapping. Int J Health Geogr 2009, 8:4.

[8] LOZANO-FUENTES S, ELIZONDO-QUIROGA D, FARFAN-ALE JA, LORONO-PINO MA, GARCIA-REJON J, GOMEZ-CARRO S, LIRA-ZUMBARDO V, NAJERA-VAZQUEZ R, FERNANDEZ-SALAS I, CALDERON-MARTINEZ J, ET AL.: Use of Google Earth to strengthen public health capacity and facilitate management of vector-borne diseases in resource-poor environments. Bull World Health Organ 2008, 86(9):718-725.

[9] SAMUIL, C., Producerea şi conservarea furajelor (Material de studiu ID, anul I), Editura "Ion Ionescu de la Brad", Iaşi, 2009

[10] SIMA, N., Ecopratologie. Editura Accent, Cluj – Napoca, 2006

[11] SIMON M., COJOCARIU LUMINIŢA, Quantitative analysis of surfaces of greensward through GIS techniques, Romanian Journal of Grasslands and Forage Crops 15 (15), 8, 73-80

[12] VON BUEREN S. K., A. BURKART, A. HUENI, U. RASCHER, M. P. TUOHY, AND I. J. YULE, Deploying four optical UAV-based sensors over grassland: challenges and limitations, https://www.biogeosciences.net/12/163/2015/

[13] WENANG ANUROGO, MUHAMMAD ZAINUDDIN LUBIS, HANAH KHOIRUNNISA, DANIEL SUTOPO PAMUNGKAS, ADITYA HANAFI, FAJAR RIZKI, GANDA SURYA, ARINI DEWI LESTARI SITUMORANG, DIRGAN TIMBANG, PERDI NOVANTO SIHOMBING, CATUR AGUS LUKITASARI, NOVITA AYU DEWANTI, A Simple Aerial Photogrammetric Mapping System Overview and Image Acquisition Using Unmanned Aerial Vehicles (UAVs), https://www.researchgate.net/publication/318112712_A_Simple_Aerial_Photogramm etric_Mapping_System_Overview_and_Image_Acquisition_Using_Unmanned_Aeria l_Vehicles_UAVs

[14] https://www.descopera.ro/stiinta/9249085-drona-ochiul-din-cer-care-vede-tot

[15] https://www.forbes.ro/dronele-intre-experiment-si-necesitate_0_9944-16102

[16] https://www.zf.ro/business-hi-tech/conferinta-zf-go4it-ro-revolutia-dronelor-din-romania-inovatie-in-tehnologie-piata-dronelor-este-inca-la-inceput-in-romania-dar-legislatia-restrictiva-afecteaza-puternic-dezvoltarea-15488785

[17] http://www.agrinet.ro/content.jsp?page=320&language=1

[18] http://www.geo-spatial.org/download/romania-seturi-vectoriale

[19] https://earthexplorer.usgs.gov/

[20] https://www.google.com/intl/ro/earth/desktop/

[21] https://imged.pl/zabytkowy-teodolit-g-gerlach-warszawa-3-19962209.html

[22] http://www.tpi.com.ro/topcon-dt-200

[23] http://topografiebistrita.ro/?page_id=293

[24] http://swanseasurveys.com/product/leica-viva-ts15-total-station/

[25] https://leica-geosystems.com/products/laser-scanners/scanners/leica-scanstation-p40--p30

[26] https://globalsurvey.co.nz/shop/solutions/surveying-gis/gps-gnss/surveying-gnss/leica-gs18t-smart antenna/

[27] https://www.dji.com/phantom-4-pro