SYNTHETIC ANALYSIS OF GEOINFORMATICS TECHNOLOGIES FOR PRESERVATION OF CULTURAL HERITAGE, METHODOLOGICAL APPROACH

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ABSTRACT:

Currently in Transylvania there are over 600 castles, considered monuments belonging to the world or national heritage. Some of them have disappeared, some are in an advanced degradation, the vast majority being in different stages of degradation, but recoverable, through very expensive investments. The first condition for them to start a program of recovery and put them again in the tourist and cultural circuit is to know exactly the state in which they are, to evaluate the costs. The development of geomatics technologies now allows for the high fidelity assessment of this aspect. These included Global Navigation Satellite System (GNSS) - Total Stations + Levels precision, terrestrial and aerial photogrammetry, laser scanners with fixed stations, for each presenting technical data and products analyzed sequentially and corroborated-complementary. The purpose of the entire action was to establish a Workflow as dedicated as possible to the requests of the specialists involved in such projects, architects, builders, restorers, historians, cultural people, etc. The paper can highlight a model of good practices in this field, the researches continuing, by consulting the beneficiaries of products from the range offered through these activities.

1. INTRODUCTION

Walking through the entire European territory which, over time, was under Hungarian and Austro-Hungarian rule, it can be seen that in all areas of Central and Eastern Europe, currently part of Romania, Hungary, Slovakia, Austria, Czech Republic, southern Ukraine, impressive vestiges such as castles, mansions and other historic monuments have remained. There are thousands, some are listed as historical monuments of global or national interest and are in danger! In a very broad sense, Transylvania represents the Romanian territory west of the Eastern Carpathians and north of the Southern Carpathians, totaling 100,293 km².

In this concept, to the territory of Transylvania, comprising 10 counties are added Maramureș, Crișana and Banat with another 6 counties. It is estimated that on this territory there are more than 600 castles, mansions and other historic monuments, and we can find them among the Database, made by the Pont Group from Cluj Napoca (https://www.castelintransilvania.ro/castele.html) which contains 301 castles and mansions. Of these, 209 are listed as historical monuments of national or international interest. The oldest is Károlyi Castle located in Carei, built in an Eclectic Style. The construction dates from 1482, when a fortified house was first built. In 1592, in the face of the Turkish danger, it was transformed into a fortress, with defensive ditches and bastions in a quadrilateral shape. The fortress was demolished in 1794 and replaced by a castle, the residence of the Kàroly nobles. In 1894 the castle was rebuilt in the form in which it is preserved today (http://ghidulmuzeelor.cimec.ro/). The castle was restored and rehabilitated through the Regional Operational Program 2007–2013, currently housing the local history museum. The most recent of the castles mentioned in the documents is the Castle from Izvoru Ampoiului, Zlatna, built between 1936–1939. Some of these castles have been restored, benefiting from government funds, such as Teleki Castle in Posmuș (Bistrița-Năsăud County), in which 4.5 million euros were invested, Rákóczi-Bánffy Castle in Gilău (Cluj County), 4.5 million euros

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or Teleki Castle in Coltău (Maramureș County), 1.4 million euros.

In the period 2014-2020, the amount of 300 million euros was allocated at national level from the national budget, insufficient funds for the rehabilitation of the castles located in the mentioned area. In 2017 and 2018, the European Commission approved for Romania the amount of 256 million euros, non-reimbursable funds, for projects submitted on priority investment axis 5.1 of the Regional Operational Program (ROP) 2014-2020, for "conservation, protection, promotion and development of natural and cultural heritage" (https://www.fonduri-structurale.ro/program-operational/1/, https://www.castelintransilvania.ro/pdf/STRATEGIA_CIT.pdf)

Going through the literature in the field, the authors find that over time great importance has been given to the field of conservation of the heritage built in the former Austro-Hungarian Empire. Thus, in his work, Pachauer (Pachauer, 2018) deals with Austro-Hungarian Fortification in Bosnia-Herzegovina and Montenegro, Salihbegovic and co-authors (Salihbegovic, 2017) Austro-Hungarian Public Building Refurbishment in Sarajevo, Glavaš and co-authors, Cultural Heritage Buildings in Croatia (Glavaš, 2019), Ognjanović and co-authors, Cultural Heritage Digitization in Serbia (Ognjanović, 2019), Hejmanowska and co-authors in Poland (Hejmanowska, 2017), or Hognogi and Pop, Transylvania, Built heritage in the land of Hațeg - result of the historical evolution and contemporary urban planning tool (Hognogi, 2016) and Niedermaier, The Genesis of Medieval Towns in Transylvania (Niedermaier, 2016).

The new Geomatics technologies allow a better knowledge of the state in which each objective is, these being promoted, through theoretical approaches and/or case studies in several works published in recent years. Thus, the application of the laser scanner in the creation of the 3D Model of the studied objective was presented in various works (El-Hakim et all., 2007; Hattab et all., 2017; Remondino, 2011; Melvin and Basiliki, 2009), terrestrial photogrammetry, frequently used in the field, present in works, such as those cited in positions (Yilmaz et all., 2007; Sužiedelytė-Visockienė et all., 2015; Barbetti et all., 2013) aerial photogrammetry with UAV technology, more and more frequently used, including in this field (Murtiyoso and Grussenmeyer, 2017; Manajitprasert et all., 2019; Azzola et all., 2019; Adamil et all., 2019; Mascort-Albea et all., 2014), numerous works presenting the previously mentioned methods in parallel, for example laser scanner and UAV (Jo and Hong, 2019; Urbančič et all., 2019; Cintra and Gonçales, 2019; Jo and Kim, 2017; Xu et all., 2014, Nas 1 et all, 2020). The results obtained by the previously mentioned techniques were used in the creation of GIS systems in Cultural Heritage (Ruoss et all., 2013; Petrescu, 2017; Bushmakina et all., 2017; Nandi et all., 2015; Diofantoset all., 2011), integrated in BIM systems of Cultural Heritage (Del Giudice and Osello, 2013; Sun et all., 2019; Jouan and Hallot, 2020), and other authors such as Lourenco and co-authors discussed them in their paper (Lourenco et all., 2011), Document Management System for the Conservation of Cultural Heritage Buildings.

2. METHODOLOGY

Starting from the two realities mentioned above:

1. The situation of the built patrimony, with emphasis on the castles, mansions and other historical monuments from Transylvania, which is largely disastrous,
2. The new Geomatics, Geoinformatics technologies are booming, creating new opportunities for investigation, findings, data collection that can contribute decisively to the protection and conservation of the built cultural heritage.

The authors built, in stages, models, workflow logic schemes, presenting at the end of the paper a case study made on a castle in Transylvania. As in any investment project, those involved will have to go through mandatory stages, their synthesis, with emphasis on castles, as historical monuments in the category of buildings, being presented in Figure 1.

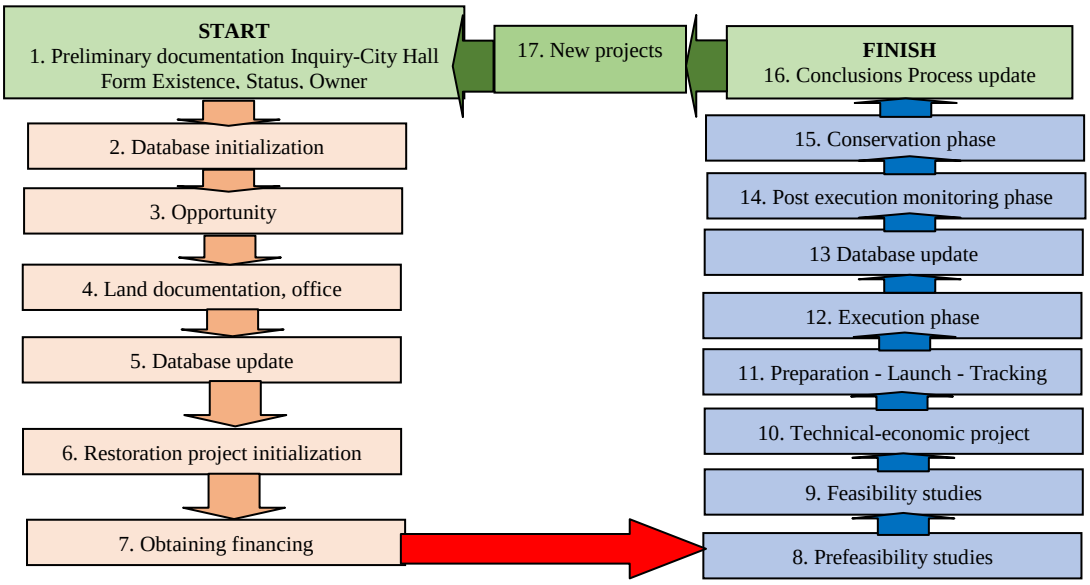


Figure 1. Mandatory stages of an investment process of evaluation, reconstruction, restoration and conservation of castles in Transylvania

The fact that in the previous figure the idea of Database is mentioned three times is not accidental, because there is currently a huge gap in this respect. Not only do we not known the status of historical monuments in the category mentioned in the analysis area approached, but we also do not know their quantity and location. Only by knowing exactly the current situation one could define and follow a strategy for highlighting at least the most representative of constructions. There are numerous Databases concerning the built cultural heritage, or systems and principles of their construction, relevant examples being presented by the works of Jan (Jan, 2018), who developed "a web-based GIS (WebGIS) using Arches-Heritage Inventory. Package (HIP), an open-source geospatial software system for cultural heritage inventory and management", Maurice (Maurice et all., 2009), Nas(Nas 2 et all., 2020), "Historic building information modelling (HBIM)", the Bulgarian IT group Sirma (https://sirma.com/industries/cultural-heritage.html), which developed Museum Space, a turn-key for Museum Management Software, one of the most representative being Arches, an open-source, geospatially-enabled software platform for cultural heritage inventory and management, developed jointly by the Getty Conservation Institute and World Monuments Fund(http://news.getty.edu/getty-conservation-institute-world-monuments-fund-arches.htm).

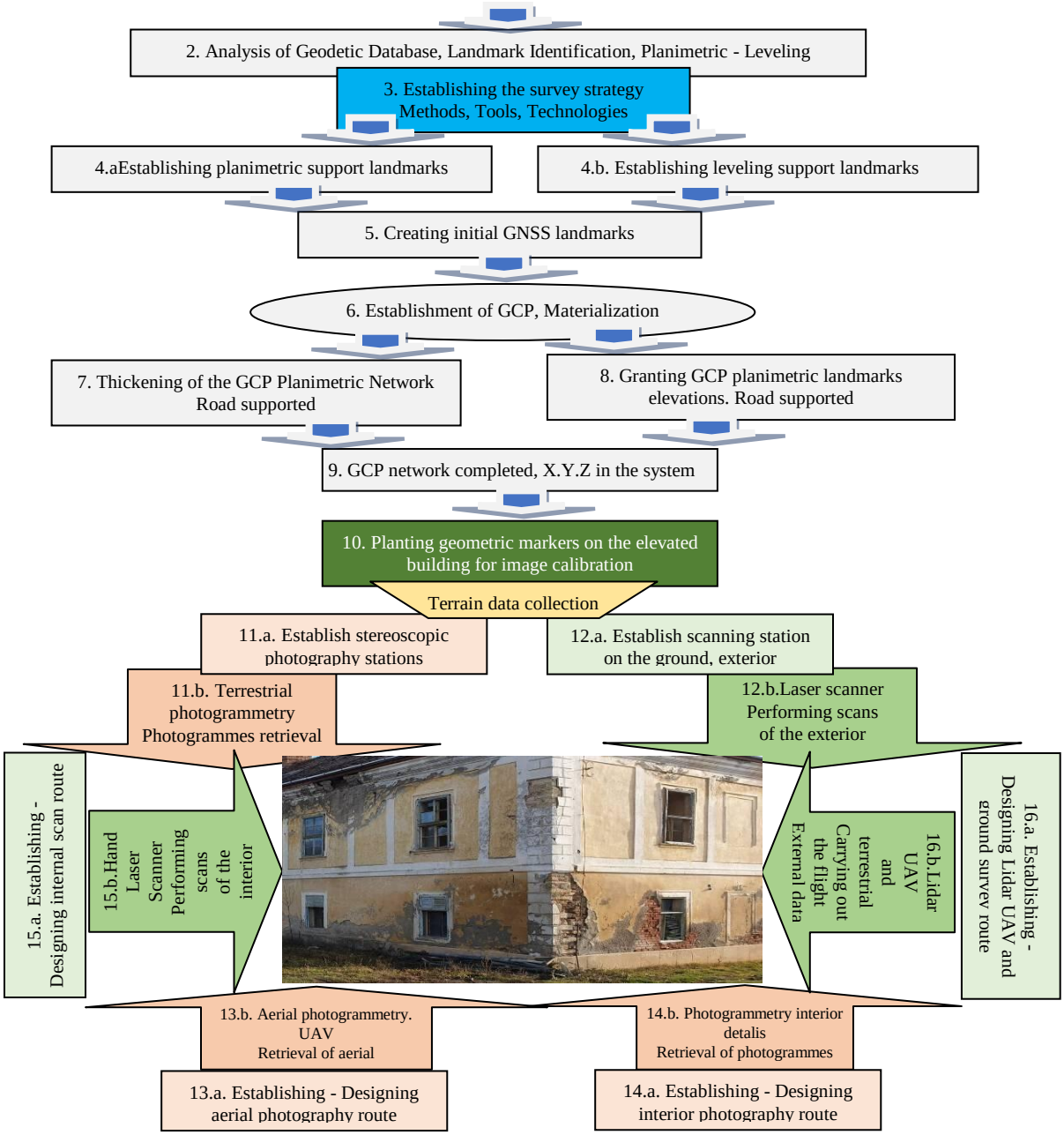


Figure 2. Field phase. Stages of preparation and materialization of landmarks and devices for georeferencing and calibration of field information, Application of Geomatic technologies for retrieving field information, part of the documentation activity

Starting from Stage 1, presented in Figure 2, one can define the quantity and quality of information needed by specialists in the reconstruction and conservation of historic buildings, and the technologies needed to be applied.

The survey project for the studied objective will have to be correctly connected to the established information requirement and will have to fit within a given budget.

Resuming the analysis of the workflow presented in Figure 2, it can be seen that stages 2-10 have the role of substantiating the georeferencing of all data taken in the field, by different techniques, presented in stages 11-16, either by creating GCP, landmarks or by planting geometric markers on the building for image calibration (so-called chessboards).

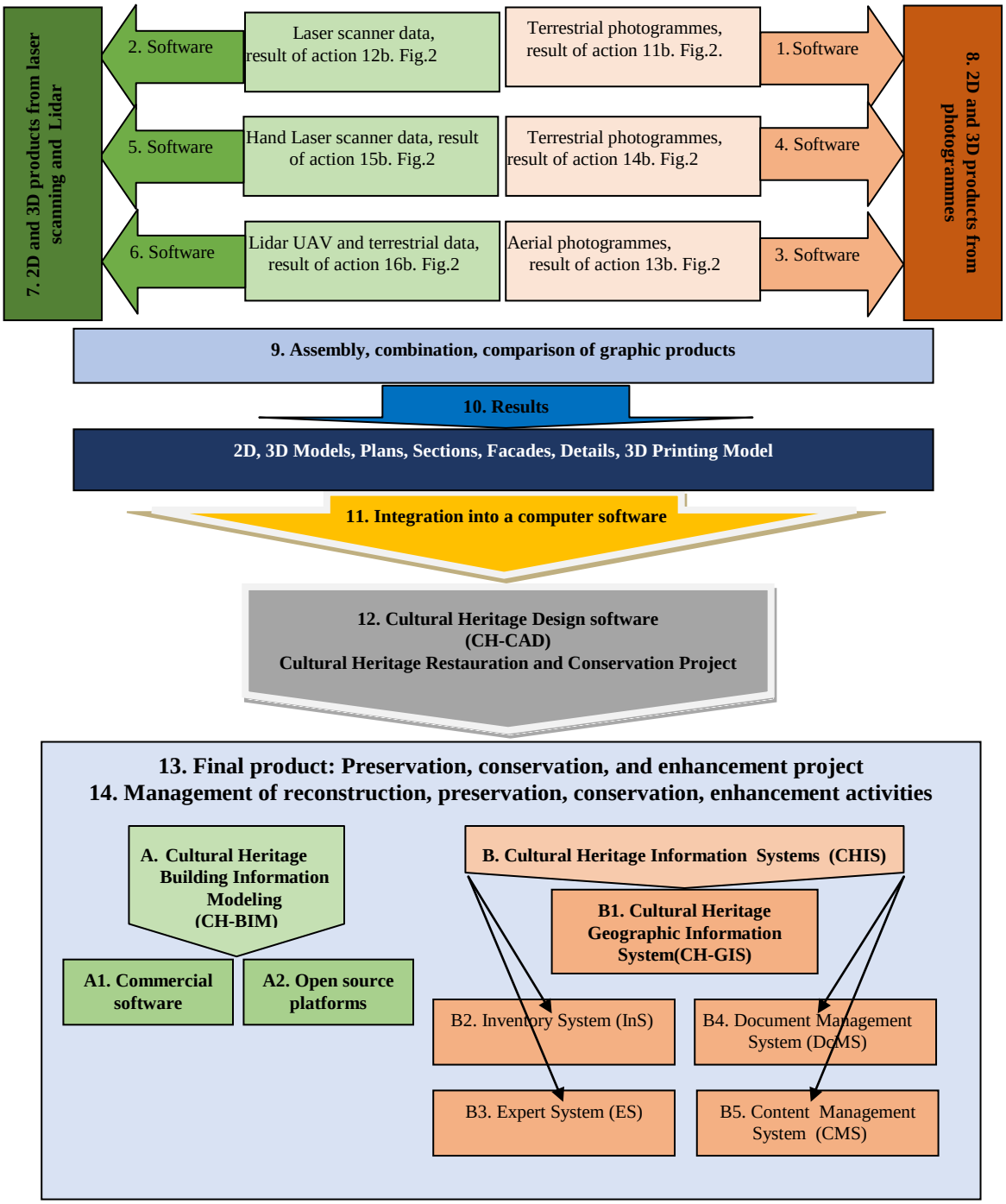


Figure 3. Office phases. The workflow of the integration of Geomatics-Geoinformatics Technologies in the activities of protection and conservation of the built cultural heritage

Thus, the technologies used can be chosen depending on the required-needed level of detail and the complexity of the analyzed assembly, currently having the following variants available:

A. Roof data and other height details:
- UAV aerial photogrammetry (13, in Figure 2),
- Lidar UAV remote sensing (16),

• Laser scanner with fixed stations located on platforms, at height (12); there is also the UAV-Laser scanner variant, such as RIEGL MINIVUX-2UAV

B. Data on the facades of the construction and other above-ground details:
- Digital terrestrial photogrammetry (11),
- Lidar remote sensing with fixed ground stations (16),
- Laser scanner with fixed stations on the ground (12).

C. Data on the appearance and condition of the interior of the building, including the basement:
- Digital terrestrial photogrammetry, preset photography path (14),
- Hand Laser scanner with mobile stations (15).

Figure Position	**Technology**			**Equipment**
Figure 2 11,14	Terrestrial photogrammetry Photogrammetry – interior details			Digital cameras: Kodak DCS420, Nikon D5100, Nikon D3X, Canon EOS 5D, Leica M-24MP, Leica Digilux 3, Sony Alpha 7R II, Olympus E5, Panasonic MC-LX5 , Leica BLK 3D
13	Aerial photogrammetry UAV			SenseFly eBee Plus UAS System, Aerialtronics Altura Zenith, Drona Parrot Bebop-Pro 3D, ANAFI WORK
12	Laser Scanner			Leica RTC360, RIEGL VZ-1000, VZ 400i, VZ 2000i, VZ 4000, VZ 6000, Z+F 5010x, Faro Focus 3D M70/S70 TELEDYNE, Optech Polaris
15	Hand Laser Scanner			ZEB-REVO RT, NUB 3D SIDIO Scanner, Breuckmann 3D scanner
16	UAV Lidar			Quantum Systems TRON F9 integrated with Yellow Scan LIDAR
16	Terrestrial Lidar			Leica ProScan,FARO Focus3D X 330
Figure Position	**Processed data**			**Software**
Figure 3 1	Terrestrial photogrammes Fixed stations, exterior			Aerial: IMAGINE Photogrammetry, Pix4D, SOCET GXP, WebODM, DroneDeploy, Correlator3D Aerial and Close-Range: COLMAP, Meshroom, MicMac, Multi-View Environment, OpenMVG, Regard3D, VisualSFM, 3DF Zephyr, Autodesk ReCap, Agisoft Metashape, Bentley ContextCapture, Elcovision 10, iWitnessPRO, LiMapper, Photomodeler
4	Terrestrial photogrammes Mobile stations, interior			
3	Aerial photogrammes UAV systems			
2	Date Laser scanner Fixed ground stations, exterior			ArcGIS-ESRI, Cyclone-Leica Geosystems, Geographic Calculator-Blue Marble, Polyworks-Innovmetric, RiSCAN PRO-Riegl, Teledyne Optech
5	Hand Laser scanner data Mobile stations, interior			FlexScan3D
6	Lidar data, UAV systems			LiDAR360 v4.0, FUSION/LDVv3.10, BCAL LiDAR Tools, FugroViewer, LASTools, MCC-LIDAR, Merrick's Mars Viewer
	Lidar data, Terrestrial systems			Terrasolid's software, VisionLidar 365, Lynx LMS Pro lidar
Figure Position	**Activity**			**System, Software, Platform**
Figure 3 11,12	Integration in to a computer software	Cultural Heritage Design software (CH-CAD), Cultural Heritage Restauration and Conservation Project		Computer Aided Design(CAD) Software, 3DStudio, AutoCAD, Rhinoceros
13,14	Management of reconstruction, preservation, conservation, enhancement activities	A. Cultural Heritage Building Information Modeling (CH-BIM)	A1.Commercial software	GraphiSoft ArchiCAD, Autodesk Revit, Bentley MicroStation V8i, Tekla Structures
			A2. Open source platforms	Edificius (Acca Software) Tekla BIMsight Autodesk Navisworks Freedom
		B.Cultural Heritage Information Systems (CHIS)	B1. Cultural Heritage Geographic Information System(CH-GIS)	ArchiBUS, Graphisoft ArchiFM, ESRI ArcGIS, Intergraph GIS
			B2. Inventory System (InS)	Almyta Systems, TradeGecko, Fishbowl Manufacturing Inventory Management System
			B3. Expert System (ES)	Caduceus, Mycin, Puff, Mistral, Eydenet, Kaleidos, Dendral, Mortgage Loan Advisor, R1 (DEC VAX Configuration)
			B4. Document Manag. System (DMS)	Legito, ClusterWall, eFileCabinet, M-Files, FileHold Express, Alfresco Content Services
			B5. Content Manag. System	

Table 1. Equipment, software and technologies used in the collection, processing, integration and use of field data for projects in the fields of Cultural Heritage

3. CONCLUSIONS

The technological explosion which took place in recent years in the fields of Geomatics and Geoinformatics has brought new opportunities and facilities in the field of taking geometric, graphic and analytical information on the conservation state of a built cultural heritage objective. Viewed in this context, the possible contribution of this real progress requires some clarification:

1. The existence of a very large number of technologies, some cheap, some expensive, requires knowledge and synthesis,
2. The above statement is reinforced by the possibly very large volume of activities of the kind specified, if the process of assessing the state of the historical monuments in the category mentioned in the paper begins,
3. The realization of certain models, flows, workflows is imperative.

The first part of the paper refers to all three previous aspects, presenting the vision of the authors, at the moment, for this particular field. In the second part of the case study, the authors applied part of the inventoried technologies, taking aerial and terrestrial photographic images and scanned data for a castle in Transylvania which is in an advanced state of degradation, but still recoverable. Given the large volume of work required to highlight hundreds of monuments in various stages of degradation we can consider that outdoor and indoor stereoscopic aerial and terrestrial photogrammetric technology can meet most specific information requirements, including 3D modelling or 3D printing.

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