Importance of 3D Modeling Software in Urban Environment

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Abstract— In all big cities and not only in these exist a real need for urban development, because of the builded new residential areas. In all of urban decisions must be verified if all of these are designed in the same architectural style like the neighborhood: if are meeting the conditions of height, style facade, the materials and the design of the overall area, distance from surrounding buildings, not to encroach the urban rules. In Romania are very useful today these representations and to find practical possibilities for creating 3D models - with varying levels of detail. Creating of 3D urban models could be the basis of decisions taken in urban development, offering better details and informations about the real situation, being more suggestive and representing a start point to develop subsequent to 3D cadastre. All of these could not be created without a good and performant modeling software.

Keywords— cadastre, 3D urban model, ArcGIS, ArcScene, AutoCAD Map, Autocad Civil 3D, real estate, CityGML

I. Introduction

3D digital representation of the city [7] – a domain that has progressed rapidly in the last decade - are seen as a promising way to support the development and expansion capabilities for spatial and environmental planning, environmental analysis and emergency response infrastructure planning and last but not least promoting cities.

At national level there are not 3D models made for any city in the country. [6] In present 3D models are obtained relatively easy through laser scanner technology. [22]

At international level, the public administrations of cities meet a number of major issues such as unplanned urban development properly or illegal constructions, traffic congestion, pollution and environmental degradation. In recent years the necessary spatial information systems for the management of cities is increasingly.

Moreover, 3D modeling is not on photogrammetric principles because different companies offer design 3D graphic models of buildings based on public or private interest.

In the educational field - in the new curricula - are implemented these elements. [23]

For the 3D representations are used Geographic Information Systems (GIS) and dedicated computer-aided design (CAD). [24] There are fundamentally different technologies. CAD technology was originally designed to automate the process of making drawings and sketches, unlike GIS products developped having primary purpose the unified managing in a single database the graphical and tabular non redundant components.

Although they are complementary technologies, using them in the same organization has become a necessity.

This is the reason for major companies who are producing software design CAD programs have tried combining the two technologies. Such products are AutoCAD Map 3D and AutoCAD Civil 3D produced by Autodesk, the world leader in developing software solutions for 2D and 3D computer aided design. [1]

II. ArcScene

In ArcScene by ESRI the 3D symbols are a 2D symbols with extended properties. These properties are enhancing the 2D symbols so they can be viewed in 3D in an ArcGIS 3D application. It is possible to use 3D symbols to bring more realism for documents or help portray 2D map symbols in 3D. It is better to use 3D symbols to create geotypical worlds, geospecific worlds, or 3D maps.

While a 2D symbol has dimensions in the x and y directions, a 3D symbol has the additional property of a dimension in the z direction. Thus, a 2D point symbol is analogous to a 3D sphere symbol, a square-shaped 2D symbol is analogous to a cube-shaped 3D symbol, and a 2D line symbol can be analogous to a tube-shaped 3D symbol. [17]

Three-dimensional symbols can also be more complex than simple geometric shapes. A 2D picture fill symbol, whose pattern is applied as a fill to a 2D polygon, is analogous to a 3D texture fill symbol. A 3D texture fill symbol is a picture fill symbol that has awareness of its real-world size and can be mapped to a geometry with proper scaling.

It is possible to symbolize points by representations of real-world objects (3D models).

ArcScene allows to overlay [17] many layers of data in a 3D environment. Features are placed in 3D by providing height information from many possibilities like feature geometry, feature attributes, layer properties, or a defined 3D surface, and every layer in the 3D view can be handled in a different manner. Data with different spatial references are projected to a common projection, or data can be displayed only using the

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relative coordinates.

ArcScene is also fully integrated with the geoprocessing environment, providing access to many analysis tools and functions. Before the widespread use of computers, creating dynamic 3D views of the ground below was practically impossible. Today, earth scientists have more information about the underground. This has opened up new possibilities for generating 3D perspectives of the subsurface world.

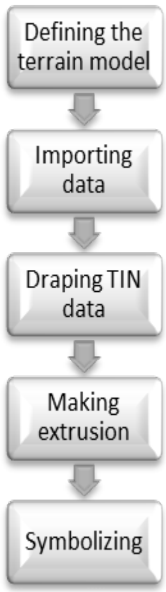

Fig. 1 – Steps for creating a 3D model

III. Comparative Study

The study area represents a zone of Brasov County, Romania. [25]

Brasov (Kronstadt in German language, Brassó in Hungarian language, Corona in Latin language, also on old maps Cronstadt, Brastovia or Brasov in Kruhnen Saxon dialect) is the capital and largest city of Braşov County, Romania. According to the 2011 census, has a population of 227.961 inhabitants, Brasov is one of the largest cities in the country (declining in the last two decades because the reduction of industrial activity). [19]

The study area is characterized by apartment buildings with up to 8 floors in the Craiter District and houses with a height generally P+1 Floors or P+2 Floors, in the neighborhood of Flowers District.

We used a topographical map of the area at 1/1000 scale (Figure 2).

Between the two Autodesk products there are not many differences in terms of 3D modeling, the differences are consisting in the purpose for which they were created. The AutoCAD Map 3D is designed for planning, design and infrastructure management compared to AutoCAD Civil 3D which is the solution for civil engineering and transportation. In the 2014 version, Autodesk dropped out at AutoCAD Land Desktop. In figure 3 are presented the main benefits of Civil 3D.

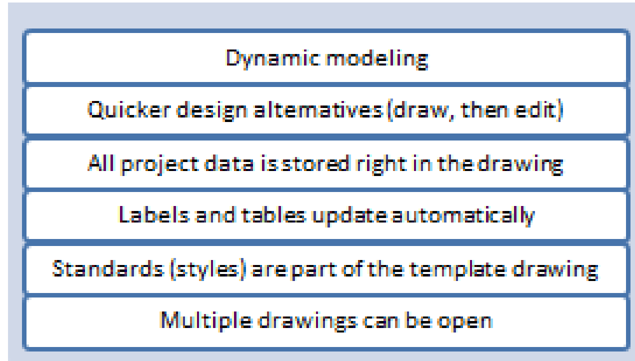

Fig. 3 – Civil 3D benefits
(adapted from www.agtcad.com)

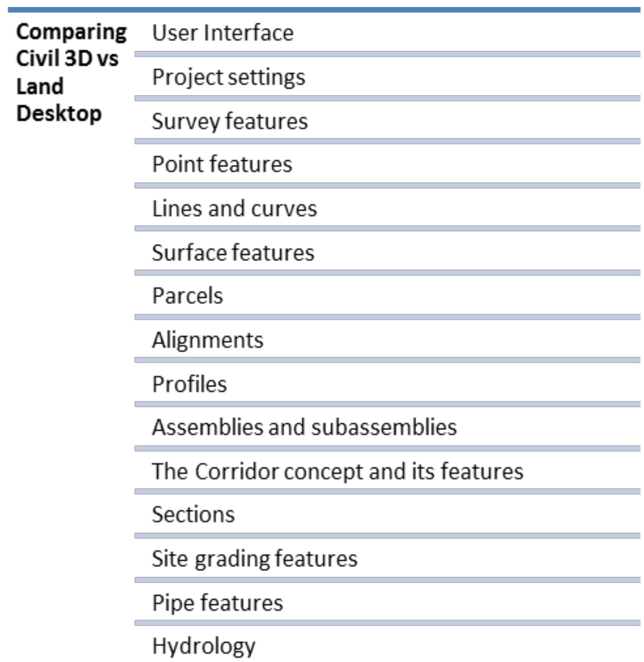

Fig. 4 – Comparison criteria
between Civil 3D and Land Desktop
(adapted from www.agtcad.com)

The main element that makes the difference [1] between the two Autodesk products and ArcGIS is the edit mode. ArcGIS graphical data editing process is more slow than using AutoCAD system software. In order to edit in ArcGIS should be started an editing session, then after this must select the shapefile and at finish must ended the editing session. Another difference is that there are constraints of shapefile's geometry for which the editing. Instead, by using AutoCAD editing mode is much faster and can enter commands from the keyboard, without having to be searched in the menus or toolbars. In addition, we can introduce elements on the layers that have different geometries and moving graphics data from one layer to another is very easy, just by selecting the item's intended to be moved and select that layer.

Another plus for AutoCAD programs is given by the wide range of editing tools.[16]

About the textual database in AutoCAD it is an easier working possibility with external databases, which leads to maintaining a low content of the drawing because it contains only links to information from the database. The types of external databases recognized being attached to a drawing represents an advantage. It could be attached to a Dwg drawing tables from a database of Microsft Excel, Microsoft Access, Oracle, ODBC, dBase, Paradox type. In ArcGIS, the desired attachment of the external database [27], can be achieved by creating a JOIN attribute tables in the tables in the database, including the need to have a common field. AutoCAD allows to release memory, disconnecting the external database, while remaining attached to the project and can reconnect to it only when necessary.

The dizadvantage of these external databases is the way for linking them to elements of design. Binding can be done automatically or manually, but regardless of method, this link is costly in terms of time to perform, but also the resources used by the PC.

In ArcGIS this step's is performed automatically by attaching one attribute table for each class of items in the design, which leads to reduction of the time to achieve a design since it is necessary to develop a database, and possible links between database tables.

Another disadvantage of using foreign databases is that if another user wants to send the drawing he must send the database also with the drawing, which in a project with ArcGIS is not required, the database being integrated into the design file.

Regarding the query of information for spatial analyzes, working with ArcGIS seems easier because the query is applied directly on the elements of interest, by defining in a relatively simple and logical way. [15]

With AutoCAD products achieve query is a more laborious process as the query can not be done on a design already open. In order to achieve such analysis, the drawing must be attached as an external source, which slows mode.
Another aspect is that if a drawing was attached database and definitely made the connection with graphic objects, when the drawing is attached to the application of a query, the connection between graphical objects and textual data is not longer active. If the drawing is normally opened by the Open command from the File menu, the link is read under normal circumstances, but we can not apply queries. [1]

Therefore, if we desired query graphical objects using Autodesk products is compulsory that the relationship between external database and graphic objects to make under an attached drawing, then over the same drawing can be assigned to the desired query.

From the application of conventional signs viewpoint there is a difference between the two software, ArcGIS having a wide variety of useful ways of representing 3D shape.[1]

In ArcGIS we cannot make a change to a symbol in terms of color or angle of rotation because the change will affect all items that are included in the class.

Fig. 5 – Modeling with ESRI ArcScene

Compared with ArcGIS, software AutoCAD [15] do not have such a wide range of special symbols refer to materials that characterize objects that asphalt, brick, wood, glass, and so on, but their application can be made on each object in part, the only condition is to be characterized by a certain height.[8]

ArcGIS manages to make the 3D representation using TIN model, representing the source of the z coordinate. After this the objects are represented by their high relative to TIN.[10]
Instead of this, AutoCAD provides a representation only using information from the database without a reference surface. This is the reason why when we want to apply a material to an object, it must have a certain height in the database. This is an inconvenient because there is a need to introduce the height of objects in all database tables. [14] Every software has its advantages and disadvantages and their use should be chosen according to the desired project. Thus, if the work is mostly based on spatial analysis then ArcGIS is the solution, but if the purpose of the project involves more edits than analysis, the AutoCAD Civil 3D or Map 3D should be used. [1]

Fig. 6 – Modeling with AutoCAD Map 3D

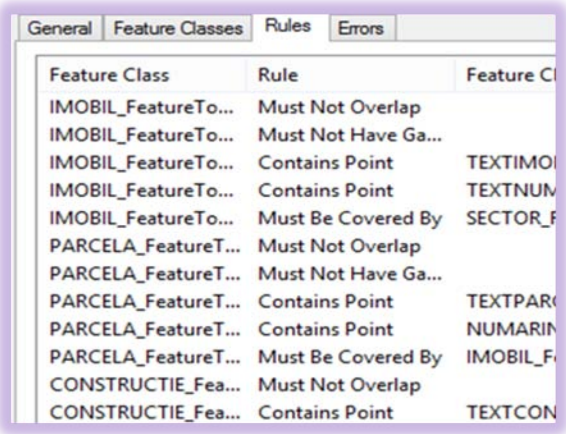

Fig. 7 – Establishing the topological rules

IV. 3D Data Integration

For CAD system

- The mathematical description of the design object is well known;
- Well-known, simple-shaped objects, with a corresponding efficient mathematical descriptions, are often used in the modelling process to build more complex structures (for example, in Constructive Solid Geometry - CSG);
- The final object is well defined, to any required degree of precision.

(a)

For GIS system

- Requires to build statistical description of object with not well known shape;
- Linkages must be maintained between the spatial and the non-spatial data;
- A degree of uncertainty is always present both in the initial data and in the result of modelling process, so the final object is not necessarily well defined and is subject to further analysis, simulation, and interpretation;
- Many models may be created for a particular project, and they should be filed and managed with their respective source data and modelling parameters

(b)

Fig. 7 – Comparison between CAD (a) and GIS (b) systems (adapted from [4])

3D CAD has been identified with powerful precision data entry and editing tools. [11] These tools enable users to create precise geometric objects which can be moved and edited with no loss of precision.

Because 3D CAD comes from a world where engineering tolerances of fractions of a centimetre or an inch are important, full attention is given to manage data without losing precision [4].

GIS system was primarily aimed at mapping a and spatial analysis, [9] not precision design for construction and management of real-world objects. If a GIS system is to be used as a CAD system, the models in GIS can approximate the geometry of designed objects, e.g. building, tunnel [22], cavern, but it is difficult to represent them with the geometric precision required of by engineers.

In figure 7 are made a comparison between the two types of systems.

Currently, CAD-GIS integration projects tend to be project specific and case-by-case. But model conversions are seldom based on pure geometric “translations”, so semantics is important. One of the efficient solutions to integrate two different systems is to achieve interoperability between them.

V. CityGML

After we made a discussion about the software for a relative simple 3D modeling, it is interesting to identify the main possibilities to go to a more complex representations, like 3D city model. To realize this we can use different data models. There are several data models to model a 3D city [5], [6] which in also is included the CityGML, too.

The OpenGIS® Geography Markup Language Encoding Standard (GML) The Geography Markup Language (GML) is an XML grammar for expressing geographical features. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet. As with most XML based grammars, there are two parts to the grammar – the schema that describes the document and the instance document that contains the actual data. A GML document is described using a GML Schema.

CityGML uses CSG (Constructive Geometry) that means to ombine multiple shapes with set of operations (intersection, union, deletion) to construct new shapes.

This allows users and developers to describe generic geographic data sets that contain points, lines and polygons. However, the developers of GML envision communities working to define community-specific application schemas [en.wikipedia.org/wiki/GML_Application_Schemas] that are specialized extensions of GML. Using application schemas, users can refer to roads, highways, and bridges instead of points, lines and polygons. If everyone in a community agrees to use the same schemas they can exchange data easily and be sure that a road is still a road when they view it. [26]

CityGML is an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is an application schema for the Geography Markup Language version 3.1.1 (GML3), the extendible international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and the ISO TC211. The aim of the development of CityGML is to reach a common definition of the basic entities, attributes, and relations of a 3D city model. This is especially important with respect to the cost-effective sustainable maintenance of 3D city models, allowing the reuse of the same data in different application fields. [26]

It had emerged as a method for modeling 3D objects and urban structures. It defines the classes and relations for the most relevant geographical objects cities, respecting their geometry, topology, semantic and appearance properties. Topographical objects include not only buildings but also the building height, vegetation, water, roads and more. CityGML has been designed as a data model based on XML and is implemented as an application GML schema. [12]

Are used various approaches to create CityGML ranging from manual to automatic ones. Mainly manual methods implies buildings extrusion fingerprints in 2D vector files or creating systematic 3D geometry of buildings using CAD or GIS technology. Semi-automated or automated methods are using photogrammetric methods such as extraction constructions orthophotos or satellite imagery. [5]

At a basic level, a 3D urban model is the digital elevation model (ground height) and 3D building models. [4] Since both are given in the 3D space, LIDAR data were found to be a good source for collecting this information. LIDAR data provides accurate information for surfaces and 3D objects.

CityGML is in fact an XML-based model for storing and exchanging urban 3D virtual models. This is an application schema based on Open Geospatial Consortium Geography Markup Language 3 (OGC GML3). Geography Markup Language (GML) is a standard language for modeling, storage and transport of geographic information. GML is based on eXtensible Markup Language (XML) the best Internet standard from the distribution of World-Wide-Web Consortium (W3C) viewpoint.

In present the 3D city models are constructed from laser data such as LIDAR and terrestrial laser, photos, and terrestrial images, satellite or aerial, orthophotos or cadastral maps for example.[5] Therefore, 3D urban models are increasing and more and more cities have been or are shaped around the world.

CityGML supports five different levels of detail. These are needed to reflect the independent processes of data collection with different application requirements. Moreover, these levels make easier the effective data visualization and analysis. In CityGML data set, the same object can be represented on several levels simultaneously, which allows us to analyze and view the same object at different degrees of resolution. In addition, two sets of CityGML data containing the same object in different levels of detail can be combined and integrated. In Figure 8 are presented the levels of detail [12].

CityGML data model is composed of different classes [25] that belong to the most important types of objects in the 3D city virtual models. CityGML data model is decomposed from terms of theme viewpoint in a core module and thematic extension modules. The basic module includes basic concepts and components of the CityGML data model. Based on the core module, each extension covers a specific thematic virtual 3D city models. CityGML introduces the following eleven thematic extension modules: Appearance, Building, CityFurniture, CityObjectGroup, Generics, Land, Relief, Transportation, Vegetation, Water-Body and TexturedSurface.

VI. Area of Applicability

Moreover, in large cities, at the international level [4] were developed numerous 3D cadastral systems. Unlike 3D rendering, 3D cadastral systems have associated records related to the legal status of the buildings, which implies a juridical harmonization.

The 3D cadastral object has a broader sense, may refer to volumes whose projection on the ground does not necessarily coincide with the limits of the earth's surface parcels. This approach is somewhat similar to that of the vision 'Cadastre 2014', namely 'territorial legal object ".

3D real estates are not being formed in Romania at this moment. The cadastral system is today a two-dimensional (2D) system projected to the ground level. Real estates are legally formed in cadastral surveys and it is not possible to form a three-dimensional (3D) real estate.

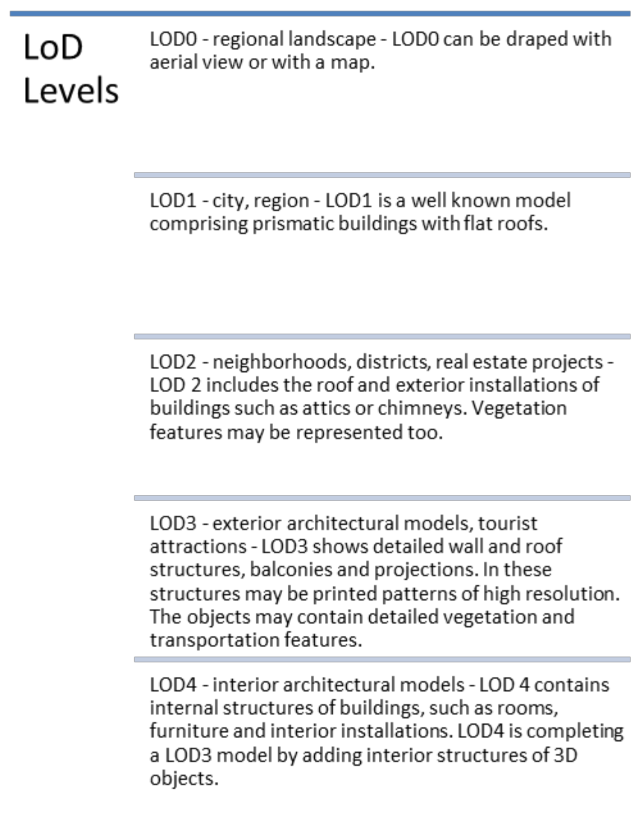

Fig. 8 – Levels of Detail in CityGML

The lack of possibility of 3D property formation has lead to various substitute solutions such as leased area, encumbrance and company form arrangements and shareholding contracts based on joint ownership. [20]

The current cadastre does not fulfill the reliability requirements: 3D property formation is needed especially in large-scale construction works including spaces over- and underground. The basic problem in the current situation is that the legislation, and thus property formation and registration, do not recognize [20] other measures than those falling on the ground level.

Therefore, different means for obtaining ownership and possession rights and mortgageability for overground and underground spaces must be searched in each separate case making use of the existing judicial mechanisms and sometimes even the “grey-areas” of the legislation. [20]

Case-specific proceedings lead to in coherent practices and uncertainty considering the possession of the real estate, real property formation, maintenance of the cadastre, title registration and granting of mortgages.

In Romania there are several reasons why the big cities [13], especially in central areas and in areas with large height differences would be necessary to develop pilot projects to create 3D cadastral systems. Thus, the existence of complex construction undertaken on several levels and potential projects on modern communication pathways, car parks, leading to such systems. When the details of the 2D representation is not sufficiently clear and suggestive we can use 3D solutions. We must also take into account that in financial terms must have allocated significant amounts, according to experiences of other countries.

Some of the cases in which are required suggestive 3D records [2]:

- buildings that are extending above a road. In this case, 2D cadastral system should allocate separate cadastral numbers on the same surface and recognize two different owners. 3D representation shows suggestive real estate, situated one above the other, they may even be ways of communication;
- construction above an arch (in areas of medieval towns like Sighişoara, Sibiu, and so on, where real estate property needs to be protected and restored);
- construction above or below the bridge;
- underground buildings (shops, garages, warehouses, tunnels, subways, and so on). Each of these constructions can be extended under one or more parcels, the owners may be different, requiring more cadastral numbers. Piata Unirii in Bucharest is an example of intersections and overlapping trails: metro network undercrossing the Dâmbovița River and the main sewer box with road passage, the passage of correspondence between the two underground stations, input / output for two subway lines. All these big investments we can add urban networks of all kinds, and on the Earth surface is a major road junction which raises due to heavy traffic. For the metro area are projects and plans for other facilities are other beneficiaries and therefore need further cooperation and prospects of the center of Bucharest;
- underground construction with surface entrance;
- construction of settlements with significant height differences, carried out mainly in hilly and mountainous areas.
- similar cases are found in the University Square (metro, retail, underground parking) in Victoria Square (road passage, two underground metro stations and underground parking perspective), in the North and Basarab Railway Station and in the future Bucharest needs bolder projects.

Fig.9 – Areas of interest in Bucharest where is justified to create a 3D system

VII. Conclusions

Several urban municipalities decide nowadays to build 3D models in order to clearly understand the real situations of cities. They use these models for many purposes, such as urban planning, emergency pollution problems, etc.. The most important thing is to collect information correctly. Objects in the city about that are collecting information is directly determined by the coordinates and characterized by several properties such as height, type, use, etc.. Such modeling can be achieved more easily by using CAD or GIS products available, or you can choose the more complex approach such CityGML. The concept of CityGML can also be used to simulate the consequences of floods or natural and technological hazards. It may be useful for civil engineering construction because the actual building heights might be compared with the maximum permitted building height. It can also be used for real estate, but also for marketing and advertising as it can encourage the visual impact of a new project, triggering potential buyers.

In Romania, the areas in that CityGML would find best use are tourism and history. There is a connection between them: whether it would create urban models for historic areas, highlighting modeling cities in past centuries, it would greatly improve the tourism, because it would create landmarks for visitors.

If we talk about the realization of a 3D cadastral system, this requires resolving preliminary legislative issues, the choice of appropriate methods of representation and integration with traditional cadastral system.

As main advantages we can mention:

- real situation no longer refers to the projection surface, so 3D properties that are not related anymore to traditional 2D parcel;
- properties can be represented as a projection intersecting

other properties on the ground and to be defined in a transparent manner;

• 3D information enables the construction of topology (depending on the chosen representation model) being directly connected with DBMS approach;

• 3D situation therefore supports DBMS queries;

• 3D properties can be viewed simultaneously with the 2D parcels.

In conclusion, in addition to traditional cadastral system, developed in major cities based on real estate cadastre and made as a spatial information system [28] will be required a three-dimensional management of properties, buildings, communication ways and public utilities [18].

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He is involved as teaching activity – being Associate Proffesor - at three remarkable universities from Bucharest: Technical University of Civil Engineering, Bucharest, "Ion Mincu" - University of Architecture and Urbanism and University of Bucharest, in five faculties.
Of the most relevant teaching courses we mention: General Cadastre, Information Systems Specific to Activity Fields, Surveying, Cadastral Database in Urban Areas, Specific Information Systems, Urban Cadastre, Methods of Real Estate Recording, Landscape Design and Planning, Cadastral System in Local Government.

He is author and coauthor of many scientific papers, studies and presentation of scientific papers at national and international events.From the resarch activity can be mentioned that he acts as Expert at strategic project co-financed by European Social Fund, "Development of an Operational System of Higher Education Qualifications in Romania (DOCIS)" - beneficiary National Agency for Higher Education and Partnership with Economic and Social Committee (ACPART), as Project Manager of the researh project “Techniques, Technologies and Ontologies for Data Portals and Spatial Data Services”, as Project Manager at strategic project co-financed by European Social Fund “Online University Collaboration Network in Order to Develop the Ability to Provide Superior Competences in Geodesy”.

Assoc. Prof. Dr. Badea is Member of the Surveyors Union of Romania, Founding Member of Surveyors Order of Romania, Member of National Society Photogrammetry and Remote Sensing. He holds an Authorization to achieve and verify works in the field of Cadastre, Geodesy and Cartography. He was Official Referee in the Scientific Board for Evaluation of PhD thesis in "Engineering Sciences" and “Civil Engineering”; he was President of the organizing committee of the Faculty of Geodesy Scientific Symposium with international participation GEOPREVI2011,. He also presented papers in WSEAS and NAUN conferences, being WSEAS Reviewer and member of the Scientific Committees.