

## CAD-GIS INTEROPERABILITY

*Assoc. prof. PhD. TUDOR BORȘAN, Prof. PhD. LEVENTE DIMÉN  
“1 Decembrie 1918” University of Alba Iulia, Romania*

*ABSTRACT: Through this paper we want to show the ways in which we can exploit the CAD data model in the GIS environment. Knowing that in the GIS environment we also work with vector graphics in addition to raster graphics, it is visible the resemblance to computer-aided design (CAD), the editing aspects of digital geometry being similar. On the other hand, it is known that these formats that contain vector graphics and are accepted as a global exchange standard (DXF, DWG - promoted by AutoCAD / Autodesk) or (DGN - promoted by MicroStation / Bentley) can be an important primary source for processes and modelling highlighted on GIS platforms. The basic idea of the paper is created on the CAD model's residence in the native environment on the one hand, but also its relocation in the GIS environment, demonstrating portability through import-export operations.*

*Keywords: CAD dataset; DXF; DWG; GIS; shapefile; interoperability; Layers;*

### Introduction

The topic addressed is part of the geomatics issue, being related to the establishment of ways that can offer solutions in CAD-GIS convergence. The relationship between these structures is obvious, which is why many have considered that they can use CAD platforms to solve problems specific to the GIS environment. Often the simple idea that at the level of the CAD environment there are protocols that facilitate the binding and encapsulation of spatial data to external databases, leads us to believe that the project developed on the CAD platform to which the descriptive component was added has GIS valences. On the contrary, work environments should be treated independently, each with its own capabilities, so it is favorable to consider only the portability attribute. Currently there is a wide variety of CAD data structures, which although far from being considered geographical structures, cannot be ignored. A CAD layer has a different connotation than the one in GIS, but we will resume this aspect during the study in our article.

### CAD data resident in the CAD environment – export shapefile

The problem of export to the GIS environment can be done using three directions: global export, layer export and object export.

The global export is performed without first making a selection of graphic primitives or an identification of objects resident in distinct layers, which is why the GIS environment will perceive an amalgam of non-belonging elements, in other words, a mixed structure of "spaghetti" type (fig. 1).

The export directed to the belonging of objects to a certain layer and at the same time following the selection of a graphic primitive with which the elements resident in that layer were defined (in this case - polygons) will be conditioned by a verification and validation action – as appropriate, by which the layer in question (CONSTRUCTIONS) contains only objects rendered by closed polylines, only in this way will they be perceived as polygons in the GIS environment (fig. 2).

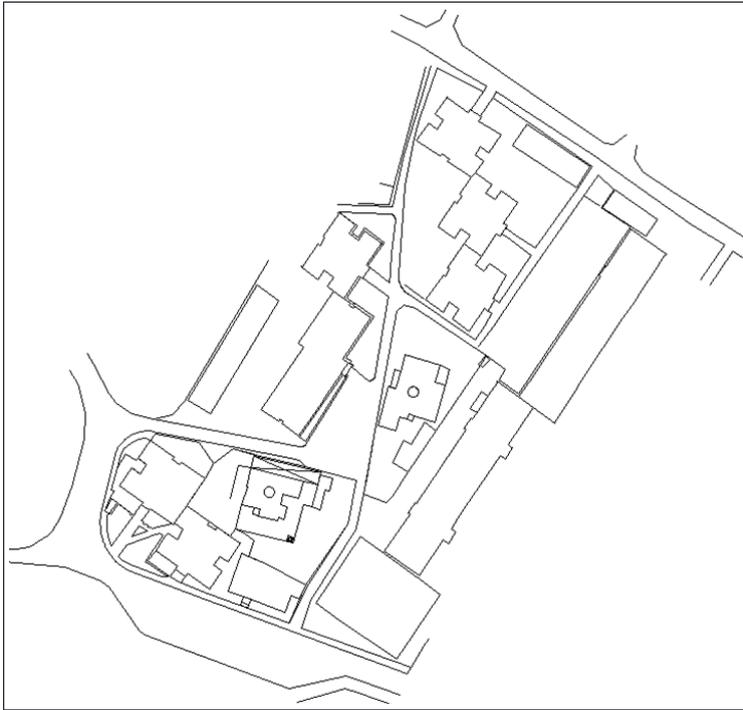


Fig.1. Global export

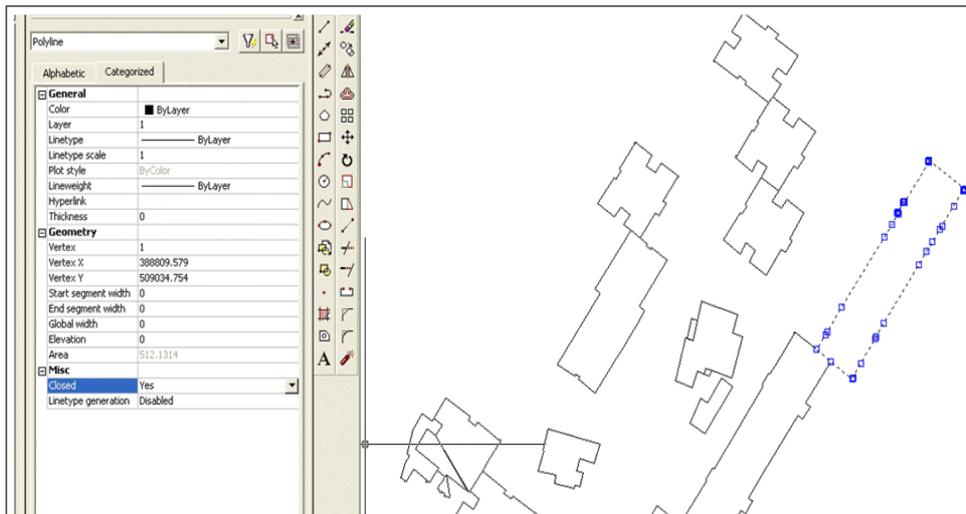


Fig.2 Layer export – checking the closure of polylines

The export directed on a manual selection of objects is also conditioned by the presence of the unique attribute of the

graphic primitive in the elaboration of the drawing (fig. 3).

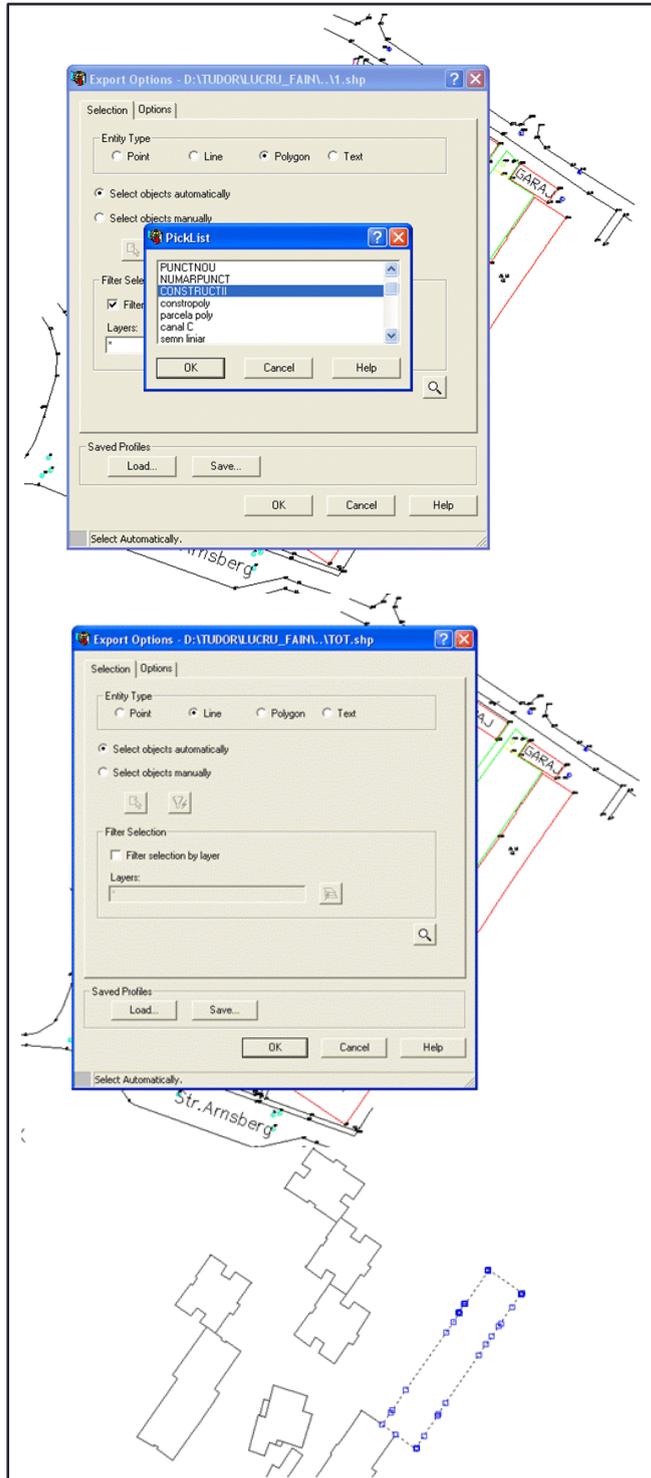


Fig.3 Object export – selection of the graphic primitive

### CAD data resident in the GIS environment - DXF/DWG import

First, we need to see how the presence of a CAD data model in the GIS environment is perceived, so when we import on the GIS platform (Arc GIS Desktop) a native CAD representation in DWG or DXF format we will distinguish a collection of graphic primitives that assemble all Layers for

Next there is the problem of obtaining shape models, native GIS amid the exploitation of the native CAD format integrated in the GIS environment. A first way that will take into account the entire representation is the so-called "manual" vectorization, a not very complicated operation, but time and energy consuming, which will capture stages such as the conceptual and physical design of all layers



Fig.4. The structure of a DWG file visible in the GIS environment

points, lines, polygons and annotations. Moreover, the GIS environment will not automatically recognise the coordinate system in which the drawing was represented, even if it has been defined. Once the referencing has been applied in the CAD environment, GIS will recognize the plane coordinate system "on the fly" (fig. 4).

that will enter the cartographic composition (either using the CAD organization template, or we will impose a new classification) the use of cumulative capture elements that allow the "magnetization" of nodes and edges in both structures. It should be mentioned that the CAD structure functions as a kind of background in the

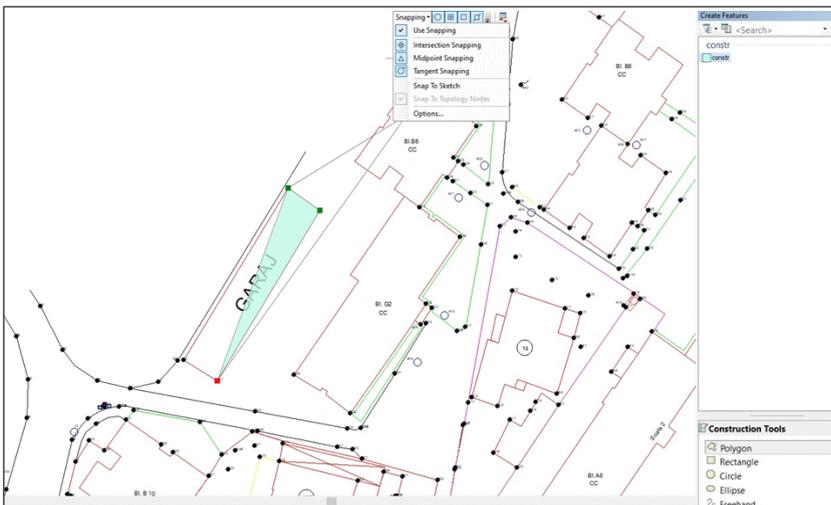


Fig.5. Manual CAD model vectorization

composite formula, respectively as a structure over which it will be vectorized, the GIS structure is new and brought to vectorization over the CAD one, and the common denominator, which will recognize the nodes and edges in both structures in the drawing process, is the Sketch (pencil) (fig. 5).

Another way of vectorization, in other words reconfiguration on shape background is the automatic drawing or vectorization valid only in the case of polygonal geometries, if and only if the objects in the CAD environment have been defined as closed polylines. Vectorization is performed automatically by recognizing and activating nodes (vertices) in the researched surface (fig. 6).

The most suitable option in obtaining shapefiles is the export itself directly performed on graphic primitives from the

collection of the DWG / DXF structure. In case you want to store objects that belong exclusively to a certain layer, you can proceed to query the database, implicitly to highlight the records found on the applied syntax (fig. 7).

### Gis-cad conversions

Another aspect that concerns us is the one related to the conversion of native GIS (shape) structures into CAD structures (DWG / DXF).

A simple export that offers the only possibility to transform the representation from GIS formula into CAD formula can be achieved either by acting from the context menu of the layer thus releasing only the layer in question with intrinsic elements, or by acting multilayer using the geoprocessing tree (fig. 8, 9).

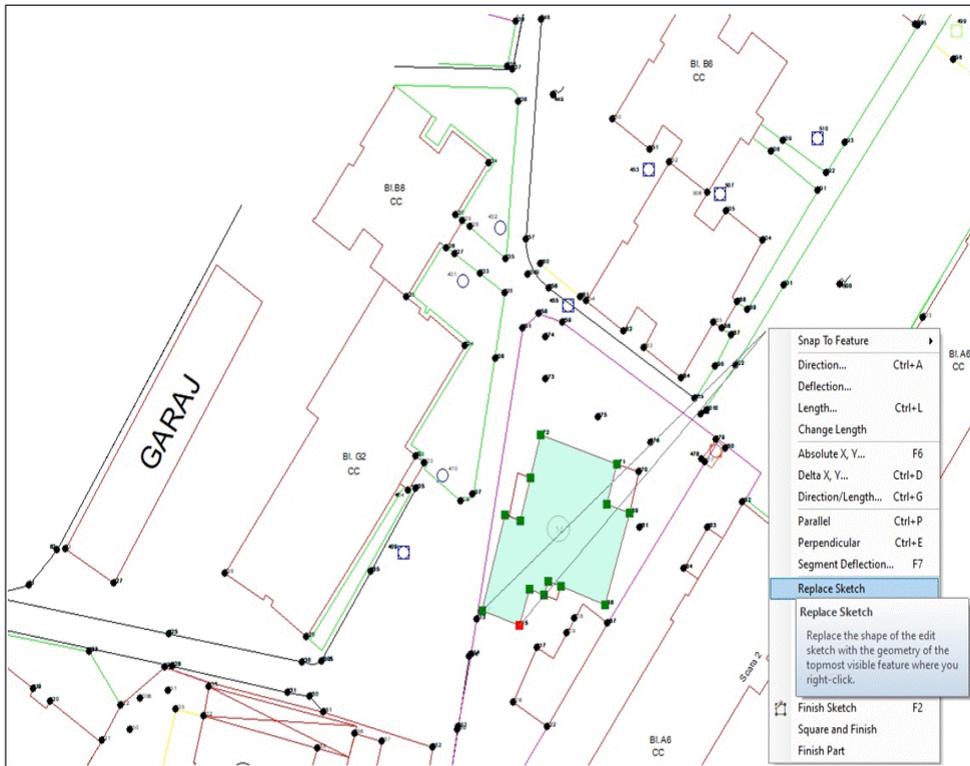


Fig.6. Automatic CAD model vectorization

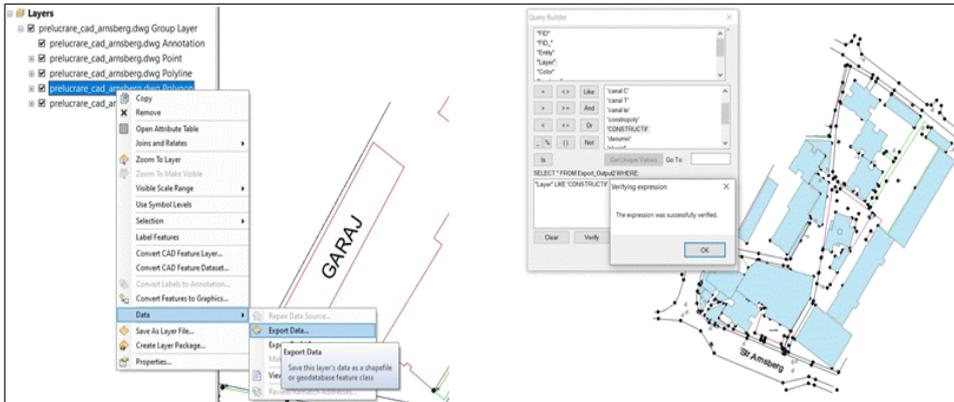


Fig.7. Export shapefiles and extracting objects resident in the layer

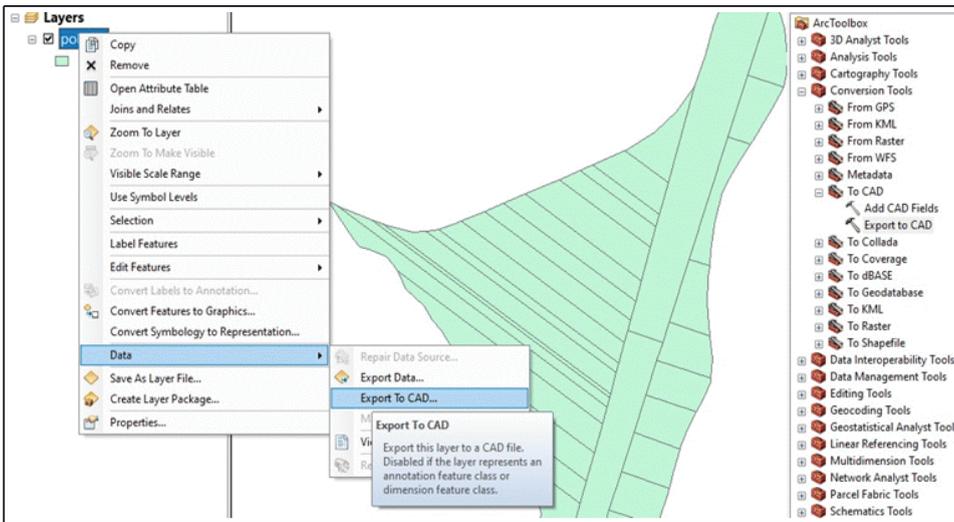


Fig.8. DWG / DXF export possibilities - layer and multilayer

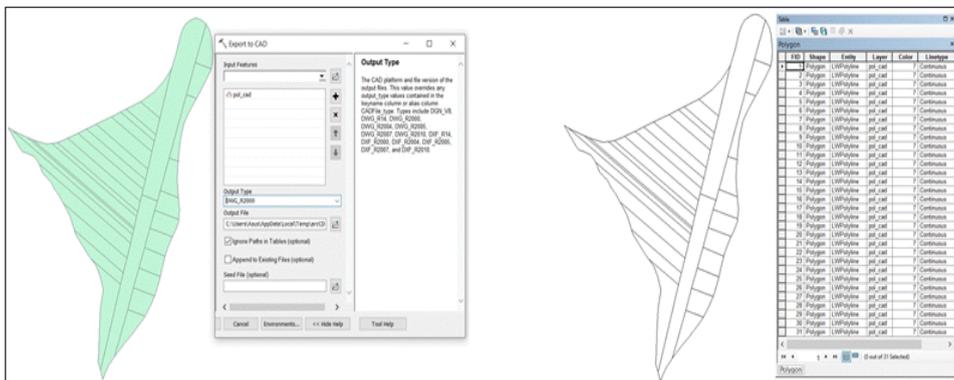


Fig.9. DWG/DXF export

### GIS-CAD conversions – particular cases

Special situations require special actions - if for example we want to have in the CAD environment a representation with objects framed in distinct layers we can use the

descriptive component of the GIS format as a basis for generating and sampling Layers in the CAD environment.

This involves a special construction in the attribute table, the strategy being to apply a template field specific to the CAD (Layer) environment that allows populating with repetitive attributes (Fig. 10).

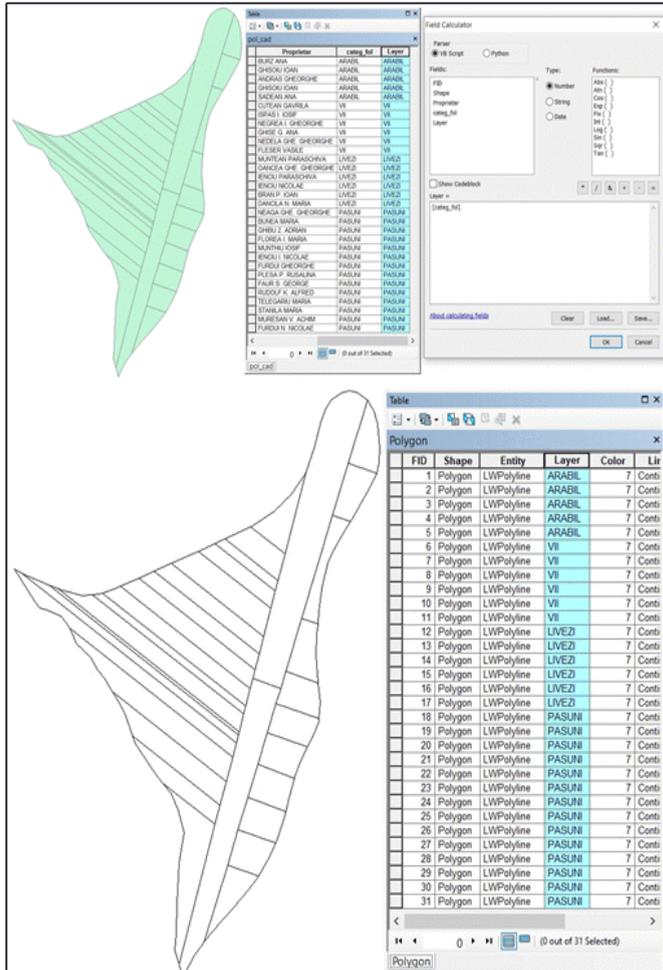


Fig. 10. Premises in obtaining the DWG/DXF structure with multiple layers

The last example refers to the export of texts or values associated with entities, under the conditions of applying two template fields, the first folded on “CadType” encoding, the second on the population with attributes that keep the “TxtValue” encoding

imprint. An artifice that should be made is outlined on the action of converting the polygons that abstract the plots into points that will be defined as centroid and on which the annotations will be applied, visible in the CAD environment (fig. 11).

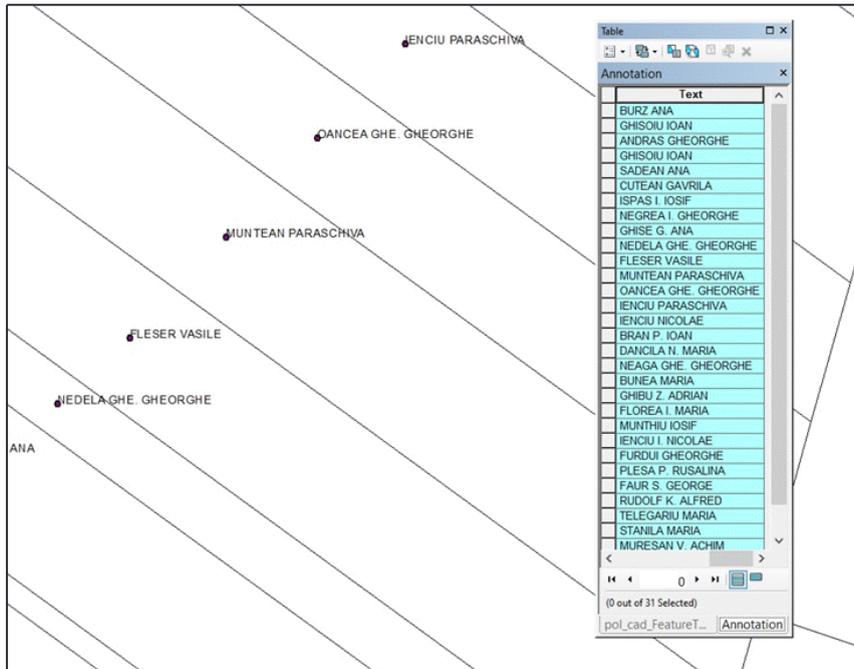


Fig.11. CAD export - annotations

## Conclusions

In 1998, William Wittreich, in his presentation of "Beyond CAD into GIS" stated that the difference between the two products, processing media and data formats, is visible through "drawing" on the one hand and "spatial database" on the other. In the same way, CAD shapes things in the real world, while GIS shapes the world itself. GIS uses the system of geographical coordinates and projections around the world, while CAD uses plane coordinates that are closely related to the object being

modeled, not being in a connection with a global spatial context.

In this paper we have managed to classify some import-export procedures of CAD and GIS data and to offer some explanations regarding the migration and manipulation of these related formats with alternative residence. As we have seen, Arc GIS does not offer many procedures for processing CAD files. For proper processing of these files, it is necessary to convert them to shapefile format - for less complex operations, or to object classes residing in GDB containers - for elaborate processing.

## References

1. Băduț M., *GIS - Sisteme Informatice Geografice - fundamente practice*, Editura Albastră, Cluj Napoca, 2004.
2. Borșan T., *Sisteme Informaționale Geografice – Fundamente teoretice și practice*, Ed. Aeternitas, Seria Didactica, Alba Iulia, 2013.

3. Borșan T., *Topografie arheologică și GIS. Fundamente teoretice și aplicații practice*, Editura Risoprint, Cluj Napoca, 2015.
4. Dimen, L.; Borșan, T.; Vințan, I.; Găban, L., *Creating and managing a database for planning and monitoring the achievement of the objectives of sustainable development in Zlatna Locality, Alba County*, Journal of Environmental Protection and Ecology, 2015.
5. Dimitriu, G., *Sisteme Informatică Geografice GIS*, Editura Albastră, Cluj Napoca, 2001.
6. Imbroane, A.M., *Sisteme Informatică Geografice, Vol. I Structuri de date*, Presa Universitară Clujeană, Cluj Napoca, 2012.
7. Karimi, H.A.; Akinci, B., *CAD and GIS Integration*, CRC Press, New York, 2010.
8. Popa, D.; Borșan, T.; Popa, M.; *Functional and aesthetic optimisation of urban space*, Journal of Environmental Protection and Ecology, 13 (4), 2012.