CAD AND GIS INTEROPERABILITY - MYTH OR POSSIBILITY?

Norbert-Szabolcs SUBA, Ph.D, junior assistant - University of Oradea, suba_norbert@yahoo.com
Ştefan SUBA, lecturer Ph.D. - University of Oradea, stsuba86@yahoo.com

***Abstract**: This paper will discuss the aspects regarding the greatest challenge of system interoperability: data interoperability on a large scale. This can occur, for example, during a huge project, or when different user groups, public or private institutions etc., need to access the same, preferably unambiguous data. New data exploiting technologies bring new possibilities along, but they also bring new challenges, also due to the fact that local activities are losing ground to global concepts, activities, necessities and solutions.*

***Keywords:** GIS, CAD, interoperability, data integration*

1. Introduction

Interoperability is when two or more systems, having different characteristics and uses, work together (or complete each other) to assure a higher complexity, and also enhancing possibilities within a certain project, while producing standardized results, which are accepted afterwards by other systems, without unnecessary interventions (like data format changes etc.). Generally, in geodesy, interoperability can manifest in the following main activities, both on hardware and on software levels: data acquisition, data processing and data storage and usage.

A certain type of interoperability can already be observed at the level data usage, storage and visualization. This interoperability is mainly based on accepting some very usual data formats and existing data manipulating solutions. The problems start when less usual data formats are transformed into these usual formats, and there comes the possibility of data loss (either in quality or quantity). Also, when new problems arise, the tendency is to adapt the problem to the exiting solutions, offered by the existing systems, and not vice versa, as it should happen.

Users of these solutions can be split in two main categories: CAD system users, respectively GIS users. These two systems concepts are rather different, and if we mention that for both of them there are a large number of available software, we can affirm that assuring their interoperability is a great challenge indeed.

2. CAD and GIS program types

The different nature of the two program types can be observed from their very names: Computer Aided Design, respectively Geographical Information System.

CAD programs provide exact, engineering data; GIS programs use maps (geographical data), respectively metadata attached to these geographical locations. By using the geographical term, the lack of need for precise, geodesic positioning is exposed, the main attributes being the metadata. The two separate program types are recognized worldwide, from the academic medium to the industrial applications, and each type has its own powerful community of users and sustainers. Their evolution is quite similar: CAD programs represent the transition from technical drafts to computer design, whereas GIS represents a similar approach, in case of maps and charts. This parallel nature of the program types is unique in an era of convergent technologies.

Recent developments in IT, respectively the adaptation to different necessities extended the possibilities these software offer. The necessity for their interoperability has been identified years ago. However, most of the users still perceive CAD software being useful only for technical drawings, whereas GIS software only for mapping. In reality, things are different, respectively there is a possibility of data exchange between the two software types. But then again, there are also some conceptual differences between the two of them.

Leaving the terminology aside, we can affirm that the objectives laid out in the final product description will determine the nature of the software used. This decision can be made in different working phases:

- *at the level of an individual assignment*: depends on user requirement. The choice is simple, it is made by the "best tool for the current problem" principle. Generally, CAD software is suitable at high scale works (where details and precision is essential), whereas GIS programs are used for large scale works, where queries and thematic assignments over large areas are more important than the object level precision.
- *at project level*: the individual assignment loses ground in the favour of the working process, for which it contributes. Interoperability factors, as well as data transfer and integrity are becoming the main concerns. Users who contribute to the work process may have different qualifications and may use different programs, but it is important that they work at the same data resolution level, according to the product requirements.
- *at company level*: nowadays, no analysis can be considered complete without taking into account the economical factors [1]. CAD and GIS similarities may result in duplicate efforts of individuals or working groups within the same company. Without compelling monitoring, data may be created and stored in two separate systems (CAD and GIS). Moreover, these duplicate data may have different precision and level of detail. To avoid this, a data-centered approach is recommended during the working process.

From those mentioned above, the necessity of having a spatial database can be concluded. This will, on the one hand, assure the interoperability of these systems by offering a joint platform for the storage of geospatial data, and on the other hand, will prevent the existence of redundant and ambiguous data. The database then can be accessed by a standard program (usually a browser), which is available to each and every user (data access is done via intranet or internet), and it will provide the necessary data, no matter the working environment (CAD or GIS).

3. Geospatial databases

So there is a necessity to assure CAD and GIS interoperability. Besides the facts mentioned above, data integration had another huge advantage: the analysis and usage of precise CAD data using advanced GIS functions. The foundation of this interoperability is a complex database.

Naturally, creating and maintaining these databases raises a series of other problems:

- *data acceptance and data quality:* it is important to use standards for data input in the mentioned databases, in order for these to operate correctly. The development of open source GIS software encourages large groups of individuals to create their own databases, with the possibility to integrate their data in databases that already exist. This can result in multiple, ambiguous data existence, because only surveyor engineers need to justify their positioning precision, others don't (and an important data quality measure is the precision indeed). Setting standards for data creation and acceptance is a must, but it's not enough.

- *maintenance and actualization:* another important aspect is the temporary accuracy [2] of the data. In order for someone to be able to use the data provided by these systems, it is essential to maintain the actuality of the data. An old, outdated database is just as useless as a database containing erroneously positioned data.
- *integrating the data in other systems:* living in an era of globalization, it is necessary that the database to be interoperable with other existing systems, in order to efficiently respond to data and information queries, no matter the location or the system used by the user. This is possible using a common language between databases: SQL. Using this, data queries and filtering can be done in order to obtain the desired data, regardless of the database type. It is obvious that, from the users' point of view, formulating the correct query is just as important as the quality of the data obtained.

Ignoring those mentioned above, respectively failing to ensure interoperability can lead to disastrous consequences. Not having precision standards, respectively lack of data integration (or lack of information about existing data) can lead to commanding and executing the same projects by different enterprises or even governmental agencies. This will result, on the one hand, in an enormous dissipation of (quite often public) funds, and on the other hand, will create an enormous data quantity. Having additionally in mind that there are quite some differences in data collecting methods of different groups, respectively knowing that there are multiple preferences for precision and detail level, as well as multiple preferences for the working process (CAD or GIS), an urgent need for data standardization can be observed, as well as the need for interoperability, in order to avoid the useless storage of erroneous and/or duplicate data, and to avoid using further financial resources to correct these errors or to redo the projects (from the data collection phase).

A correctly created and used database has a series of advantages:

- reduces data search time (assuming that there is just one, correct dataset), which will contribute to the speed and accuracy of decision making
- reduces the necessity of data conversion (conversion can result in loss of details or can lead to inefficiency)
- provides relevant, correct and timely data
- enhances the possibility of taking advantage of the data by using intelligent data visualization and analysis techniques.

Data-centered approach, data standardization, as well as data integration are all very important aspects. CAD and GIS program solutions, concepts and possibilities will change (they appear or disappear), but what remains, is the geospatial database.

4. Data integrity - present and future

In the present, a huge number of practical examples of interoperability and data integration can be observed. The sad reality is, that interoperability often means just the usage of a multitude of layers for data presentation, respectively a failed attempt to maintain a single, correct and coherent data source.

Data integration is a common requirement nowadays. The preparations for the integration process must be made from de CAD/GIS data creation phase of the project, without expecting other interventions for this. Regardless of the aspects presented earlier, there still are CAD/GIS interoperability and data integration issues, mainly because of the following:

- *data problems*: usually, interoperability problems are caused by the different nature of the data contained. These differences can be because of using the projection system coordinates (CAD) or geographical coordinates (GIS); the need to use notations (CAD - dimensions, explicative texts) and topology (GIS); usage of complex geometrical figures (CAD - curves, 3D objects) and database storage limits for storing these types of data (GIS). At a certain extent, even data formats can cause problems, because their transformation can induce errors and redundancy in the working process.
- *structure of the organization*: a huge number of companies have the GIS positioning problems solved by their GIS department or a subdivision of the IT department, without them having the required knowledge from geodesic engineering. As a consequence, the GIS division doesn't understand the problems related to geospatial data usage in CAD software, and the CAD group doesn't understand the problems of using CAD type data in GIS software.
- *the "data silo" syndrome*: this is found in the case when different departments fail to communicate with each other. Each other of them is focusing on their part of the project, not on the impact their work has on the project. This can result in creating multiple copies of the geospatial database in order to complete the specific individual task, without sharing the results with the other departments, which will ultimately result in a huge data quantity and will make data integration almost impossible at the end of the project.

There are solutions to solve the interoperability and data integration problems (according to those mentioned earlier), but the real-life application of these solutions is still far away.

5. Conclusions

CAD sources remain the main tool for 3D data accuracy and convergence, and GIS will be used for spatial data analysis. The imminent emergence of new applications (for example BIM - Building Information Modelling) is a good example of for the sustainability of this concept. CAD programs will deliver the precise 3D datasets (from the construction project phase to the actual visualization phase), whereas the GIS component will be used for different spatial analyzes (work process planning, utility networks, economical analysis etc.). These new challenges will, hopefully, bring some changes in the problem solving manner of the situation, and not by adapting the problems to the existing solutions.

The interoperability at data visualization and usage level is an important aspect. Field data precision and accuracy, as well as the extended utility of the obtained data is losing its value if these data are not integrated correctly at the end of the project and if the results are not being delivered to the end-users or beneficiaries in the required format. At the centre of the integration stands the geospatial database - it's structure, accuracy and the utilization possibilities will mainly determine the success of a project. It can be said that the ideal candidate for managing the geospatial database is the surveyor engineer indeed. [3]

6. References

1. G. Shennacht (2011), Spatial Information for the Economy, gis.Trends+Markets, ISSN 1869-9286

2. Suba ŞT., SubaN.-SZ. (2010), Techniques of inspecting the quality of maps, Analele Univ. din Oradea - Fascicula de Construcţii şi Instalaţii Hidroedilitare, ISSN 1454-4067

3. I. Harper (2011), The challenges before surveyors and surveying, Coordinates magazine, ISSN 0973-2136, volume VII, Issue 9