BIM, GIS, and the Possibilities

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Dec 05 2010

Abstract: Geospatial tasks and questions can be solved or answered with the help of Geographic Information System (GIS). Building Information Model (BIM) has been used by various disciplines to design and manage the interior and exterior of buildings. The merger of BIM and GIS would break the limitation of each application individually. This paper will present the status of GIS and BIM as one application or in conjunction with each other.

Introduction

Building Information Management (BIM) and Geographic Information System (GIS) are two terms that might not have had a lot of association in the past, but today these two terms and their associated applications can complement each other rather well for solving complex task that might be limited by either BIM or GIS individually. GIS as an application can store, manipulate, and display geographic information well. The observed weakness of GIS in comparison to BIM is its lack of ability to manage a building's interior data (Deren *et. al*., 2004). BIM on the other hand has emerged as the application to use for creating, storing, and managing buildings.

BIM and GIS individually will be presented and described initially. The major topic that will be explored in this paper is the current state of BIM and GIS as a whole. The research that I have conducted has shown that there are currently very few applications that support both BIM and GIS together fully. The existing applications that do support BIM and GIS integration are found to be very ad hoc in their operations. Although this is presently the case, recent developments between BIM and GIS have shown a promising outcome for their integration.

Building Information Model

BIM is a class of application that is commonly used in the architecture and construction field for designing and modeling perceived structures. Although the term BIM might be used often to describe an application that is capable of creating and managing a building's attributes, a clear definition of what BIM technology actually is has not been established (Eastman *et al.*, 2008). In fact, the term BIM was not coined until the early 2000's by the design, construction, and management community (Jernigan, 2007). The work environment of a BIM application is commonly in a three dimensional (the use of length, width, and height), but a BIM should not be defined by the third dimension according to Jernigan (2007). BIM also features 'intelligent' in its building model (Elvin, 2007; Eastman, 2008). This means that a BIM should not only have attributes linked to a feature, but the features should be linked to each other as well, allowing scenario and analyst to be run on the building.

The origin of BIM can be linked back to Computer Aided Design (CAD), (Dzambazova et. al., 2009). From an architectural stand point, CAD is a computer application that allows for computerized drafting of structures. CAD took rise in the 1960's (Kasik, 2000) and revolutionized how building plans were being produced by architects and designers (Gorman, 1998). When defining BIM, a lot of authors have referenced BIM to CAD. In the publication *Revit Architecture 2010: BIM for Beginners*, the authors define CAD as "a 2D technology that outputs a collection of lines and text on a page." The authors further states that "there is little to no correlation or intelligent connection among them", them are the drawing documents that a CAD application produces. In example, a building might have many

documents associated with it, but none of the documents interact with each other. In a BIM, different views and documents of the same building will function together, uncommon for older CAD application. The example below shows how a BIM (Autodesk Revit Architecture 2010) deals with deleting an element in multiple views. Figure 1.1 shows four views (top, west, north, and a 3D perspective) of a simple house. Figure 1.2 shows the same house without the roof, in this instance, the roof was only deleted in the top view and the deletion was applied to all of the other views associated with the house.

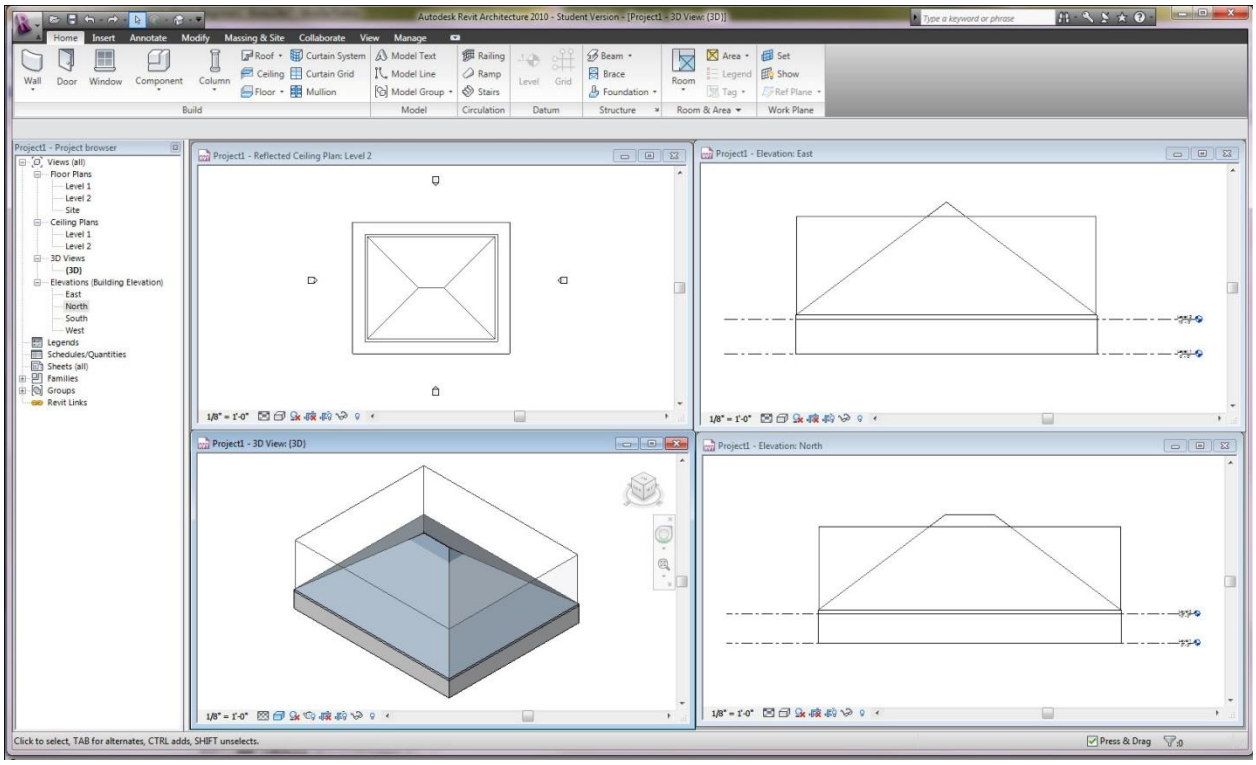

Fig. 1.1

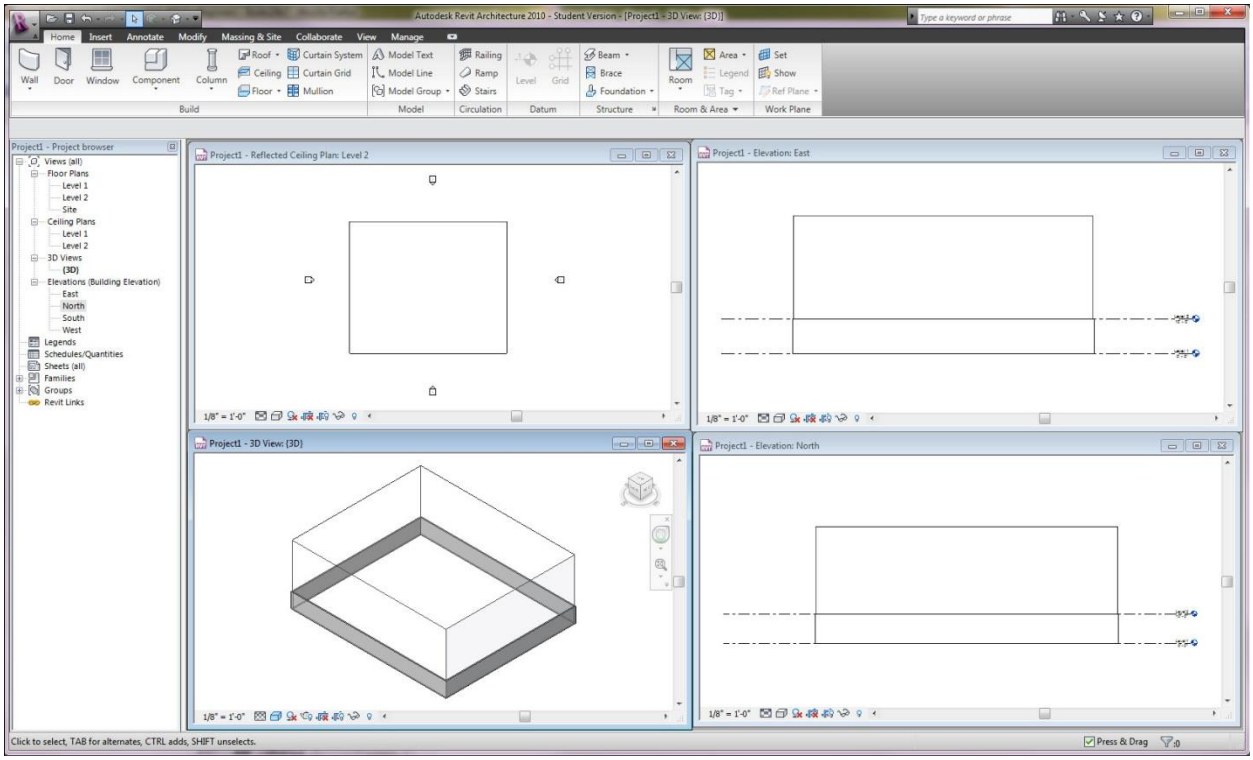

Fig 1.2

The *design-bid-build* delivery system that is currently being used in building construction practices explains how a BIM application is used in the architecture and construction industry. According to the Construction Management Association of America (2010), a client using the *design-bid-build* delivery system approach would hire two types of firms, architecture and construction. The architecture firm is responsible for designing and drawing the plans for the development while the construction firm has the responsibility of building the development from the produced documentations. Thus if the documentations are poorly produced by the architecture firm, miscommunication between the architecture and construction firm could occur. The benefits of BIM over CAD have been addressed by Stine (2010). In the article Stine proclaims Revit (BIM application that was used in Figure 1.1 and 1.2) over AutoCAD as a better tool for representation and presentation of a structure. The ability to render images and animate a movie in Revit allows for better visual understanding of a structure by the construction firm from the architecture firm. Another strong point about Revit over AutoCAD that Stine made was the opportunity to make endless amount of plans from one building model; this is because unlimited amount of 2D sections cut can be performed on a 3D model. The superiority of BIM over CAD has led many authors to describe BIM as an evolution of CAD (Holness, 2008; Glen, 2005).

Geographic Information System

The origin of GIS can be rooted back to Canada in the 1960's, the Canadian Government at the time needed a system that could manage land use change (Peuquet and Marble, 1993). Further development of GIS can be attributed to the Harvard's Laboratory for Computer Graphics, here Howard

Fisher developed Symap, a revolutionary computer application that can process geographic information and produce line maps from a plotter (Chrisman, 2006). The United States Geological Survey defines GIS as "a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system (USGS, 2007)." This is a formal definition of GIS. In this paper, GIS will be regarded as a computer application, in the sense that BIM is also just a computer application.

The two main principles of GIS in context to BIM and GIS are data creation and data processing. Figure 2.1 shows a simple rectangle polygon created in ESRI's ArcMap 10. While figure 2.2 shows a simple buffer process done on the rectangle.

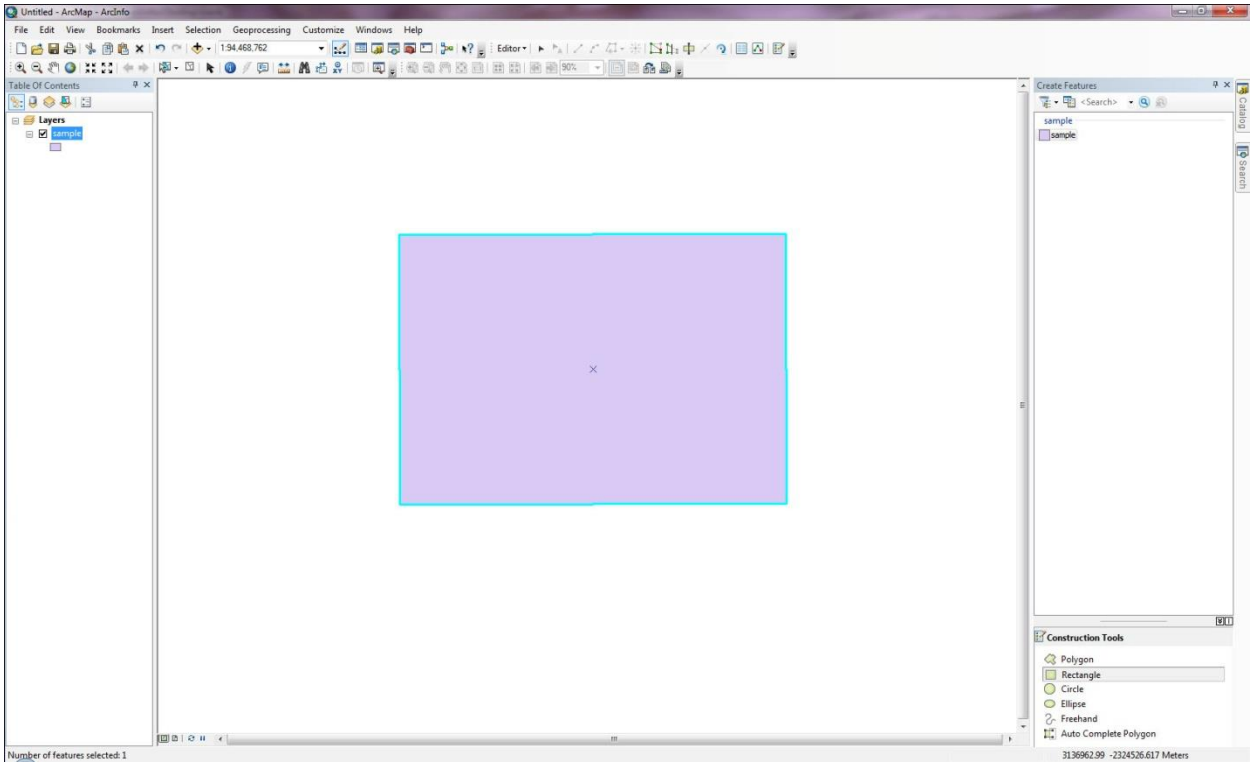

Fig 2.1

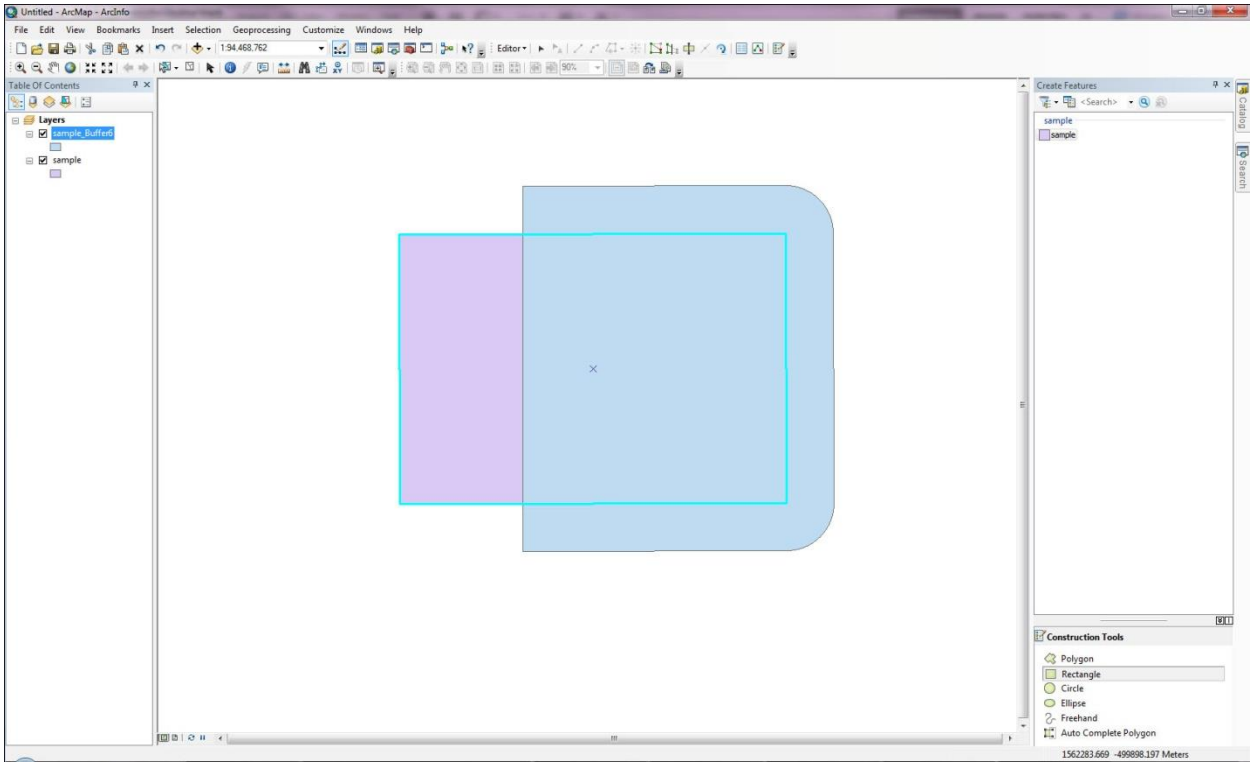

Fig. 2.2

BIM versus GIS

When using GIS in context of BIM, the vector format was the major form of data used between the two applications. Both BIM and GIS should be regarded as more than a simple vector drawing application such as Adobe Illustrator, a vector drawing application that is used by the graphic design community to render illustrations. While I found that the 3D environment in Revit was exceptional, this BIM application lacks simple analysis tools that are found integrated inside of a GIS application such as ArcMap.

Although different BIM vendors might provide different analytical tools for their BIM application, I found with Revit that most post production processing was done with additional software from either Autodesk or third party developers. An example of a post production processing application produced by Autodesk for their Revit application is the Green Design Studio. Green Design Studio is a web-based application where a Revit file can be uploaded to for evaluation of energy use or production from the model. This is similar to a geo-processing tool that would be found inside of a GIS.

This process of modeling and analyst in two different applications has given rise to the idea of using BIM and GIS in conjunction of each other. One of the major conflicts with BIM and GIS is the amount of dimension that each application supports; BIM is in three dimensions, while GIS is two dimensions (Isikdag and Zlatanova, 2009). Isikdag and Zlatanova found that the current GIS applications were not sufficient enough to handle the three dimensional models that were being created in BIM applications. At the time of writing I found that there were various discussions concerning the use of

extract transform load (ETL) application to allow for the derivation of 3D BIM data to be placed inside of a 2D GIS application (Cervosek, 2010). The current state of CAD and GIS can help explain how BIM and GIS might operate in the future. I discovered that a CAD files can be extracted, transformed, and then loaded into ArcGIS quite smoothly. Figure 3.1 shows a CAD derived floor plan of a building of inside of ArcMap, while figure 3.2 shows the same floor plan in a 3D environment created with ArcScene (ArcScene is an application inside of the ArcGIS suite for creating 3D GIS data).

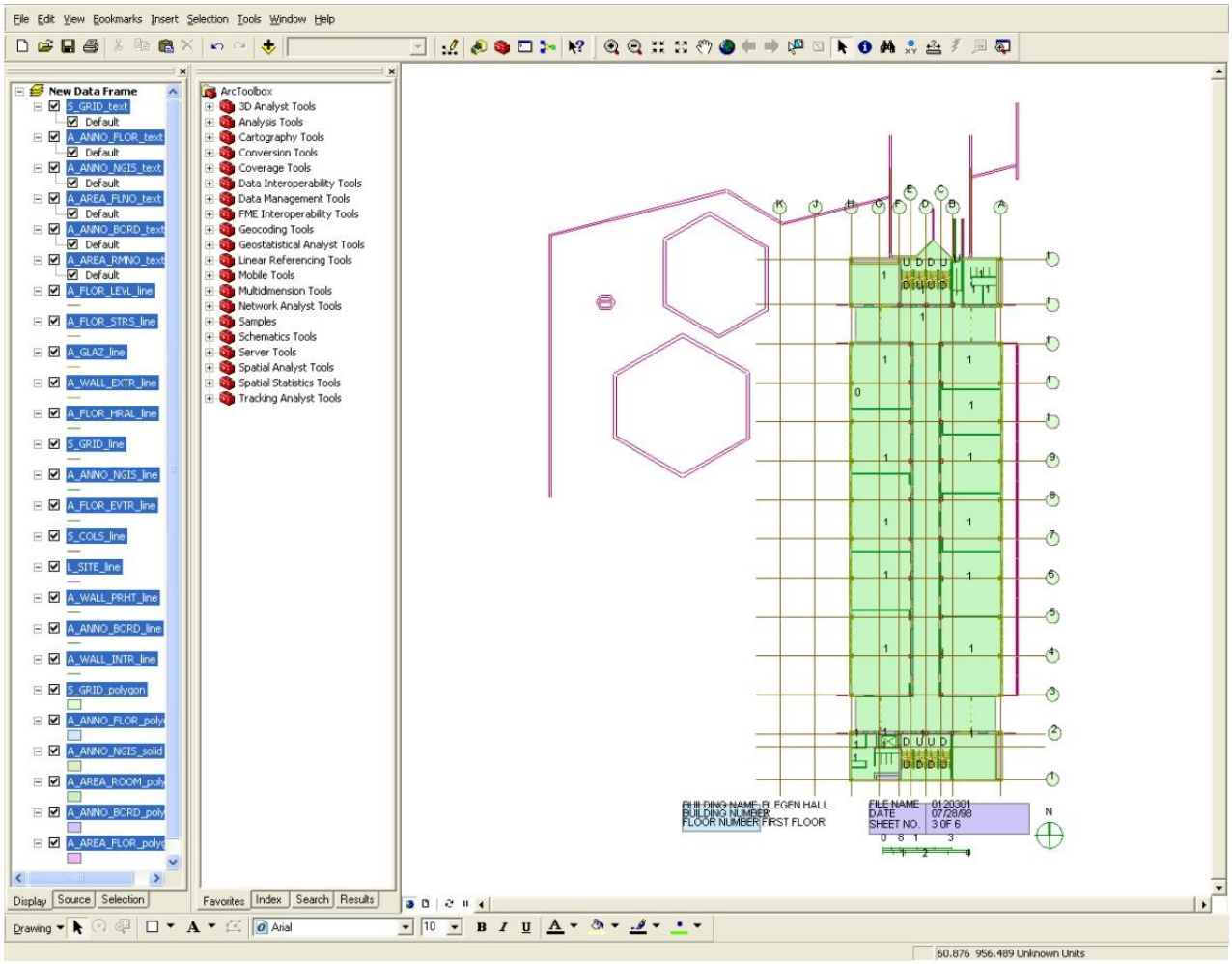

Figure 3.1

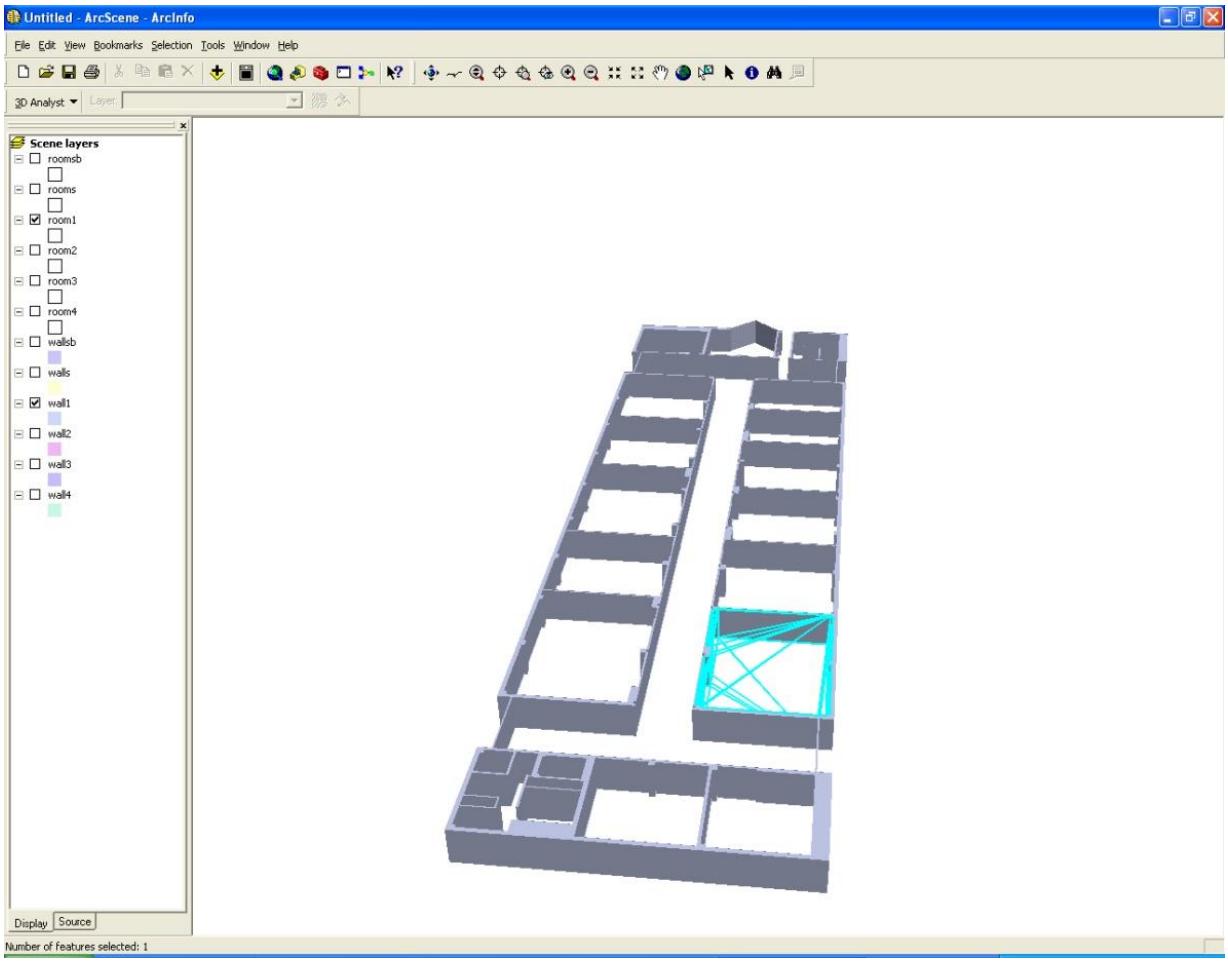

Figure 3.2

Visually, CAD data can be sufficiently viewed in a GIS application, but a key element (attributes) in both BIM and GIS are missing. As mentioned previously, CAD drawings were not designed to contain attributes, so the CAD files carries little attributes when being loaded into ArcMap with an ETL application. A big problem that I found with incorporating CAD into a GIS application was the use of proper projection. Without proper projection the size and scale of the building are arbitrary. This appears to be a major problem for CAD at the moment, and BIM in the future, but little to no literature has specifically stated how the problem should be solved. Without proper attributes or spatial component, there is very little geo processing that can happen in ArcMap directly from a CAD file.

An issue that I found to be a very important topic between BIM and GIS in the current literature is the governing organization that is issuing the standards for BIM and GIS applications. Technically there are no standard laws that are enforced on BIM and GIS developers to how their files should be structured. There are however individual organizations that produce recommended standards for both BIM and GIS software. BIM currently has two major organizations that have established BIM file standards, the International Alliance for Interoperability (IAI) and the Building Smart Alliance (BSA).

Currently most developers are abiding by the IAI (Kymell, 2008) who are the governing body over the standards of the Industry Foundation Classes (IFC). It should be clear that the BSA is a supporting organization in North America and not an opposing organization to the IFC. GIS has the Open Geospatial Consortium (OGC) which runs the OpenGIS standards and specifications, supported by major GIS vendors such as ESRI (ESRI, 2008).

The use of BIM and GIS files in conjunction of each other might appear to be daunting at the moment, but very recently, the BSA has attempted to establish open guidelines between BIM and GIS application through the GIS/BIM IFC based information exchange initiative. The goal of the BSA in this attempt is to establish guidelines that both BIM and GIS developer should follow for interoperability between their applications. On the GIS side, OGC supports the City Geographic Markup Language (CityGML) standard. CityGML is a web standard that is used for the exchange of 3D structure associated with geographic context (OGC, 2010). Under the standard of cityGML, Léon van Berlo of the Netherlands Organization for applied Scientific Research has developed GeoBIM. GeoBIM allows for the transformation of BIM/IFC file format to cityGML. Although in early development, the process was demonstrated in his presentation *GeoBIM extenstion for CityGML and IFC BIM.* Figure 4 shows the biggest problem he found in the transformation from the two formats, solid geometry and boundary representation.

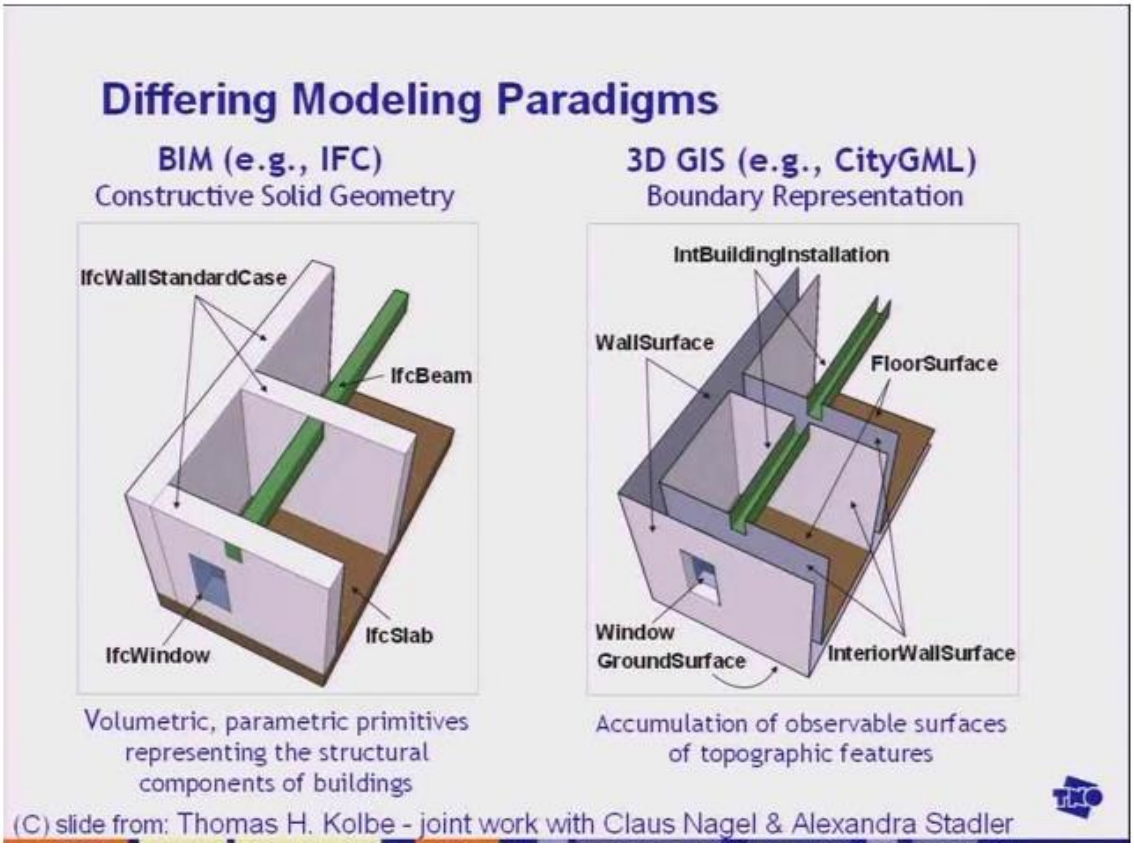

Figure 4. *Image taken from GeoBIM extension for City GML and IFC BIM presentation* (Berlo, 2010)

BIM and GIS, an outlook of possibility

I have found a few examples of BIM and GIS working in conjunction with each other. Below will be a short description of a few of these examples. Building Information Spatial Data Model (BISDM) has been a well documented process of GIS and BIM in one application by ESRI and Penoscobay. There have also been many ad hoc approaches to BIM and GIS integration implemented by the facility management industry. Facility management is defined as "A profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology" (IFMA, 2010). Theoretically, researchers have found usage of GIS and BIM integration in fire rescue planning and within the design community.

BISDM is a process of incorporating BIM inside of a GIS (ESRI, 2008; Young, 2008; Rich, 2008). Because BISDM is developed on a GIS platform, it will have the ability to work on both the large scale (country, state, and city) that GIS is accustom too while being able to zoom in to the small scale (building, room, furniture) that BIM provides. In a building information management pilot, BISDM associated software was used to store and process building data from the Smithsonian Institution in Panama (Kendra *et al.,* 2009). Before the pilot study, building management was done with AutoCAD drawings and multipurpose facilities database. An issue that the Smithsonian Institution had before the implementation of BISDM is the lack of advance processing tools that is currently supplied with their CAD application. A problem that was presented to the Smithsonian Institute was assigning attributes to the building, floors, and room. As mentioned earlier in the definition of BIM, CAD files normally have no attributes associated with them. The lines in a CAD file are simple lines, unlike a line in a BIM and GIS application which might be a road, river, or boundary depending on how it was assigned in the database. The process of adding attributes to CAD data has not been fully established as of writing. ESRI (2008) has proposed two types of attribute incorporation; the split and merged structure.

Rich and Davis (2010) have demonstrated several implementations of BIM in conjunction of GIS for facility management. The problem that appeared the most throughout the case studies was incorporating building information data into a GIS application for facility manager to access and use. The solution to a few of the cases were to create a web application (middleware) that could manage the GIS and BIM application in conjunction of each other, this allowed individual application to access proprietary data of each specific software. Once the facility manager had access to both exterior and interior data, new operations could be executed for the better use resources.

GIS and BIM integration is believed to be able to help with emergency response organizations by providing crucial data in one application. Isikdag (2008) and his colleague proposed the integration of BIM data into GIS software for fire fighters to better respond to a burning building. By displaying building information in a GIS, the fire fighter will know where the entrance of the building is and be more prepare to extinguish the fire, the use of route analyst inside of the GIS was also proposed to support in the shortest path to the fire from the current location of the fire fighting squadron.

Designers are another group of people that can benefit from the GIS and BIM incorporation. The rise of GeoDesign (the use of Geography for design profession) has also pointed out the need of BIM and GIS integration. At the GeoDesign Summit in 2010 Karen Hanna the dean of the college of design at California State Polytechnic University pointed out that one of the challenges that faces GIS at the moment is "BIM, integrated practices" for design professional. Hanna further explains that once BIM is more integrated inside of GIS, more individual from different disciplines can congregate in a meeting, thus allowing the opportunity for better decision making.

Conclusion

After reviewing literature on both BIM and GIS I found that they both share a lot of similar traits. From a user stand point, both GIS and BIM can be regarded as a graphic application that allows user to link attributes to specific objects in the geometry. Currently there are several major distinctions found between BIM and GIS applications. BIM lacks spatial context that is critical to the processing ability of a GIS. While using BIM (Revit) for the purpose of building design, it was found that no specific projection or coordinate system were required. This is not to say that there is no unit of measurement inside of a BIM, the use of imperial (English System) or Metric is established before any designing begins. Also the lack of integrated processing and analytical tools within BIM was found to be a major disadvantage to the application compared to the robust set of tools found in current GIS application. The current BIM application appears to serve the purpose of a 3D renderer that is capable of storing and linking attributes, as an analytical applications, it appears to be slowly progressing (Kymmel, 2008).

Ideally BIM and GIS would work in conjunction of each other to answer complex questions that requires data from both interior and exterior spaces. After research, I have found that the merger of BIM and GIS was not without conflict. The two major problems with compatibility are file formats and dimensionality. The building data from a BIM file cannot be loaded into a GIS without proper transformation from the extracted BIM file. Even when extraction is successful with a BIM file, GIS has difficulty in displaying 3D properties of a BIM model. The popular solution at the moment is to convert the 3D file back to 2D, and eliminate the z or height factor of the building.

The progress being made between BIM and GIS was found to be very GIS oriented. It appears that the merger or use of BIM into a GIS was found to be more common, specifically in BISDM. As the merger of BIM and GIS progress this might change, the marriage of BIM and GIS is still in its infant stage. There are already questions that BIM and GIS can answer as a whole, now it is just a matter of time for BIM and GIS to become one seamless application.

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