An opportunity analysis on the future role of BIMs in urban data management

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ABSTRACT: In order to facilitate some urban management tasks, information regarding buildings needs to be represented in form of geospatial information. Some tasks in urban management such as indoor navigation, emergency response management, and processes in the construction life cycle e.g. site selection can be facilitated through the use of certain and sometimes high amount of, geometric and semantic information about a building. A Building Information Model (BIM) can be defined as a semantically rich shared 3D digital building model. Recent research has demonstrated that geometric and semantic information from BIMs can be transferred into the geospatial environment and CAD/GIS/BIM information can be integrated at web services level. This paper presents a comparative opportunity analysis on the future role of BIMs in Urban Data Management. The analysis presented was focused on exploring, the impact of progression in Building Information Modeling research, to the opportunities provided by the use of BIMs in Urban Data Management context.

1 INTRODUCTION

In AEC industry, tools to facilitate the design process have until the last decade been very much focused on automating 2 dimensional drawing board techniques. The emerging technologies in last 15 years focused on 3D modeling and facilitating collaborative design. In fact, most of the problems in the field have been related to insufficient interoperability and integration between different systems used, in the industry and throughout the lifecycle of an AEC project. In last 10 years Building Information Modeling have become a key research item in the global agenda to address the problems related to the inefficient sharing of information and collaboration throughout the lifecycle of an AEC project and the building (i.e. from feasibility and conceptual design stages through to demolition and re-cycling). The academic community has spent considerable time and effort in last 10 years for exploring the opportunities that these intelligent Building Information Models (BIMs) would provide to the industry. In late 1990s, the use of “Product Modeling” approach in AEC industry is defined as “Building Information Modeling” and at that time, BIMs were prescribed as a remedy for the illness of “Data Interoperability” in the industry. However, with the new interpretation of “Building Information Modeling”, it is now apparent that this ‘magic remedy’ has evolved to cure much more ‘illnesses’ than it was originally prescribed for.

Today the implementation of the Building Information Modeling paradigm is achieved by using several applications supporting an intelligent digital building model defined by the agreed schema standards such as IFC and CIS/2. Well-recognized applications used in the AEC industry are today capable of importing and exporting digital building models in form of BIMs, and few of them are also capable of acquiring information from BIMs through the use of a shared resource (such as a model server database). Building Information Modeling is applied in many different areas, for example either BIMs are used as a resource to enable interoperability or Building Information Modeling has been realized as a process of managing a project through a single shared information backbone. Recent research in the area also demonstrated how 4 to N dimensional simulation applications can be facilitated using BIMs (Rebolj et al., 2010; Spearpoint, 2010). Countries such as Singapore has used BIMs to validate that building models are compliant with national code and regulations. Research has also demonstrated that Building Information Modeling can facilitate the design of energy efficient buildings towards addressing sustainability and reduction in CO_2 emissions issues (Solis & Mutis, 2010; Bee Hua, 2010).

As stated in Isikdag & Zlatanova (2009) in order to effectively automate several urban management tasks, information regarding buildings needs to be represented in form of geospatial information. Several tasks of urban management such as, indoor navigation, emergency response management and some processes in the construction life cycle, like site selection (i.e. selection of the land plot for a designed project) can be facilitated through the use of certain and sometimes high amount of, geometric and semantic information about a building. Recent research efforts such as Isikdag (2006), OGC Web Services Phase 4 (OWS-4 Summary Document, 2007; Lapierre & Cote, 2008) and implementations in commercial software (i.e. IfcExplorer, 2008; Safe Software, 2009) have demonstrated that geometric and semantic information from BIMs can be transferred into the geospatial environment and CAD/GIS/BIM information can be integrated at web services level. In fact, as there are major differences in, geometric representation objects and semantics between the models in CAD/BIM and GIS domains, algorithms for seamless translation from BIMs into the geospatial environment are still in development.

In the provided context, this paper presents an opportunity analysis focusing on the future role of BIMs in Urban Data Management. The comparative analysis explained here has been completed based on two studies, first study was Isikdag and Underwood (2010) which underlined the current research directions and trends of Building Information Modeling in light of a recent edited book in the field, and the second one (Isikdag & Zlatanova, 2009) was a SWOT analysis about the implementation of BIMs within the Geospatial Environment. The comparative analysis was carried out based on a matrix defined for evaluating the impact of Building Information Modeling research trends on the opportunities provided by the use of BIMs within the Geospatial Environment. The paper starts with a background section summarizing the findings of the two studies which forms the background for the comparative analysis. The following sections provide the details on the comparative analysis performed and discuss the findings of the analysis.

2 BACKGROUND

2.1 *Research Directions in Building Information Modeling*

Isikdag & Underwood (2010) defined Building Information Modeling as

> *"the information management process throughout the lifecycle of a building (from conception to demolition) which mainly focuses on enabling and facilitating the integrated way of project flow and delivery, by the collaborative use of semantically rich 3D digital building models in all stages of the project and building lifecycle"*

From this perspective a Building Information Model(s) can be defined as

> *"the (set of) semantically rich shared 3D digital building model(s) that form(s) the backbone of the Building Information Modeling process"*

In addition to its well-recognized role in facilitating the design phase of the project life-cycle, Isikdag & Underwood (2010) argued that depending on the environment in which they are used, Building Information Models can have different functions such as being a Space Linker that links macro and micro urban spaces, an Interoperability Enabler which facilitates information sharing between various stakeholders and the software applications they use, a Data Store which stores the building information throughout the lifecycle of a building, a Procurement Facilitator that facilitates several procurement related tasks in the building lifecycle, a Collaboration Supporter through enabling the use and management of shared building information in real-time, a Process Simulator by facilitating the simulation of construction processes (i.e. nD), a System Integrator which enables the integration of several information systems across the industry, a Building Information Service which can serve real-time on-demand building information over the Internet, a Green Builder that enables advanced analysis supporting the design and construction of environment friendly/energy efficient buildings, and a Life Saver which facilitates emergency response operations.

Based on the 28 chapters of The Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies (Underwood & Isikdag, 2010), Isikdag and Underwood (2010) presented a research compass for Building Information Modeling. The research compass provided the future research directions for BIM that are derived from the perspective of the 50 authors of the handbook which include academics and industry professionals (i.e. the practical users of the BIMs). The following list summarizes 7 research directions for Building Information Modeling (that are relevant for this analysis) among 12 derived from the chapters:

1. Adoption: The implementation of product modeling approaches and Building Information Models has been a subject of research for nearly 20 years in the AEC industry. In fact, the low interest and investment on ICT and the lack of strategic perspective on the use and implementation of ICT has prevented the successful adoption of collaborative systems and interoperable information models within the organizations. Furthermore, the move from CAD based thinking to the vision of BIM is required but difficult as it involves the shift in fundamental data management philosophy. Thus, research towards facilitating implementation and use of BIM based information management tools and methods within organizational processes, is a requirement.
2. Standardisation: Early building product models made use of native ISO 10303 tools and methods to represent building information. Similarly, the BIM standard of today, such as IFC, is still making use of, i.) the geometric model (Part-42) of ISO 10303 in representing building elements, and ii.) methods of information sharing and exchange as defined in ISO 10303. As standardisation is viewed as a key enabler and facilitator of data level interoperability in the AEC industry, this area will continue to be a focus of BIM research.
3. BIM, Lean and Green: In recent years the construction industry has begun to adopt lean production principles that have been applied in the manufacturing industries. This approach to construction management is known as Lean Construction. As also overviewed by Solis & Muits (2010), the aim of Lean Construction is to enable continuous improvement of all construction processes in the building lifecycle (starting from design through the demolition of the building). On the other hand, the AEC industry now is taking the initiative to build more ‘environment-friendly’ buildings. The use of shared building models together with collaborative environments (i.e. based on Building Information Modeling methods) during design and construction process can contribute to leaner and greener construction (and buildings) by the use of intelligent BIMs for design optimisation (i.e. in CO2 emission analysis, etc.).
4. Construction Process Simulation and Monitoring: The approach to visual simulation of construction processes is known as 4D CAD. Analysis such as clash detection can now be completed using BIM software. BIMs are also used in monitoring the construction progress at the site. There is a strong research interest in developing BIMs to support and facilitate process simulation and progress monitoring.
5. BIM based Service Oriented Architectures: A current trend in the software industry is towards enabling interoperability over web services. The use of model servers is now increasing with open-source implementations such as BIMServer (BIMServer, 2010). The future Building Information Modeling approaches would require the shared models in model servers to be linked with external systems in a heterogeneous environment. The BIMs will form the core data component of the future model-driven service oriented architectures of the AEC industry.

6. Building and GeoInformation Integration: As mentioned by Peters (2010), there is a significant value in integrating BIM and GeoInformation Systems into a single system. The differences between CAD applications and GeoInformation systems have generated barriers of integration of different representations of buildings in AEC and urban models. Van Oosterom et al. (2006), Isikdag & Zlatanova (2008) draw attention to the need of integrated geometric models and harmonised semantics between these two domains in order to tackle the interoperability problems. Song et al. (2010) explained that a range of stakeholders such as building contractors, estate agents, city management, and public sector etc. will benefit from the integration of BIM and (3D) GIS. There is a major research interest for integration of building and geoinformation, and BIMs can play a key role in these integration efforts.
7. Supporting Emergency Response: Emergency response operations indoors, require a high amount of geometric, semantic and state information related to the building (and building elements) in form of geoinformation. Until very recently Egress Models used in building evacuation has mainly been based on 2D floor plans. This situation is now about to change as the required level and amount of information can now be transferred from BIMs into the geospatial environment. In addition, BIMs are now used in fire simulations. Thus, the representation of semantically rich digital building models (derived from BIMs) in the geospatial environment will bring significant opportunities for supporting Emergency Response operations.

2.2 *A SWOT Analysis on the use of BIMs in Geospatial Environment*

SWOT is an acronym for Strengths, Weaknesses, Opportunities and Threats, and is a well-known approach used prior to defining a strategy (Zach,1999). The technique is mainly used for a analyzing a company's internal capabilities (i.e. strengths and weaknesses) in relation to the competitive environment (i.e. opportunities and threats) (Avison & Fitzgerald, 2006). In the review presented in Isikdag & Zlatanova (2009), the SWOT analysis is used within a different perspective. The first stage of the analysis was focused on the technical perspective of the implementation of BIMs in the geospatial environment and evaluated the strengths and weaknesses which appear as a result of using BIMs in acquiring building information and transferring it into the geospatial environment. The second stage of the analysis, i.e. on the opportunities and threats explored the processes that can be facilitated by the implementation of BIMs within the geospatial context and the risks this implementation might bring. A list of opportunities risen by the implementation was determined as follows:

1. The implementation of BIMs in geospatial environment will facilitate the site selection process. For example, when the floor plan geometry, floor plan area (in sqm.) and number of stories is transferred into the geospatial environment, this information will help in finding out if the proposed building can be constructed over the -land plot in consideration- depending on the rules and regulations (such as, the maximum allowed value for -floor plan area / land plot area ratio-, maximum number of stories allowed for that land plot and so on.)
2. The implementation of BIMs in the geospatial environment will help in evaluation of the design proposals by answering questions such as "What windows have views of a particular spot?", "How will a design proposal affect views and shadows in an urban scene?" from multiple stakeholders' perspectives.
3. Conditions which affect both the lighting and thermal requirements of the buildings are related to the geographic location and orientation of them. Different elements of natural and built environment (i.e. hills, trees, buildings) can affect these requirements Developing geoinformation models (enriched by detailed building information) will facilitate the analyses on energy consumption and lighting requirements.
4. Logistics operations are usually managed within a geospatial environment, and if geometric and semantic information -representing the current state of the construction- can be transformed from BIM into geoinformation models, this up-to-date information

can facilitate the logistic operations in the construction sites (which occur at various stages of the construction).

5. The transfer of semantic information from BIMs into the geospatial environment will help in assessing the damage caused by a disaster (e.g. damaged electrical elements can be predicted by using the BIM in a flood situation).In addition, the assessment of the damage after a disaster will support the design of a renovation project.
6. The information transferred from BIMs can help in generation of building models with high Level of Detail (LOD) in 3D City Models.
7. The implementation of BIMs within the geospatial context will provide emergency responders with tools that will help in two aspects, i.) these tools will facilitate orienting (as, the response personnel will know the geometry of the construction and possible exits in advance) and ii.) these tools will also enable safer indoor navigation and evacuation as the response crew will be informed about the usage type of the different rooms (e.g.- a room might contain flammable chemicals), and materials of the building elements (e.g. a type of flooring might get slippery when its wet).
8. Efforts towards developing 3D (indoor) geo-coding systems have started to emerge in recent years. The implementation of BIMs in geospatial context will help in developing models and algorithms for automatic 3D geo-coding.
9. The transfer of information from BIMs into the geospatial environment can aid in registration of apartment rights and rights related to different spaces (i.e. shops, shopping arcades, garages) in 3D cadastral registries.
10. The need of collaborative environments in public participation is becoming apparent. The BIMs and 3D City Models, together with integrated building and geoinformation will act as key pillars of the information infrastructure for these collaborative environments.
11. In some countries, the property tax evaluation process requires geometric and semantic information on building elements/parts and furniture, such as the precise dimensions of the rooms, and the number and type of fixtures located within a house. In addition, any structural changes in the house or property also affects the amount of the tax. The implementation of BIMs in geospatial environment will facilitate the tax evaluation process as required information can be acquired from the digital model of the building.

As mentioned in Section 2.1, the developments as a result of research related to Building Information Modeling in 7 research directions may have various impacts on, i.)the use of BIMs in the context of Urban Data Management, and on ii.) the opportunities provided by the use of BIMs. In this paper we focus on the latter. The following section of the paper provides an opportunity analysis , in light of an "Analysis Matrix" developed for exploring the impact of progression in each BIM research direction to the opportunities provided by the use of BIMs in Urban Data Management context. The results of the analysis are expected to provide a projection to future use and role of BIMs in the Urban Data Management scope.

3 OPPORTUNITY ANALYSIS

The Table 1 shown below provides the Analysis Matrix used for evaluating the impact of advancements in Building Information Modeling related research to various opportunities provided by the use them in Urban (Built) Environment domain. Each column in the matrix corresponds to a research direction, which means either i.) the research on Building Information Modeling will support that direction/trend or ii.) Building Information Models will be evolved in a way that they will support that direction or aspect of design, management, or integration. Some research directions are more fundamental (Supporting the adoption of BIM into organizational processes ; Supporting the Standardization of BIMs), while others are more practice oriented (i.e. Developing BIMs that would support Lean Construction and Green Design; Developing BIMs that would enhance Process Simulation and Monitoring; Developing BIM based Service Oriented Architectures; Supporting Building and GeoInformation Integration; Developing BIMs that would facilitate Emergency Response Operations) .

Environment Opportunities for Urban	BIM Research Directions				
		Supporting the adoption of BIM into organizational processes	Supporting the Standardization of BIMs	Developing BIMs that would support Lean Construction and Green Design	Developing BIMs that would enhance Process Simulation and Monitoring
	Facilitating Site Selection	Moderate	Moderate	Low	Low
	Evaluation of Design Proposals within Stakeholders	Moderate	Moderate	High	Low
	Facilitating the analysis on energy consumption and lightning requirements	Moderate	Moderate	Major	Low
	Integration of logistics operations into large-scale 4D simulations	Moderate	Low	Major	Major
	Assessment of damage (and in support renovation projects)	High	High	Low	Moderate
	Facilitating 3D Modeling of Urban Environment	High	Major	Low	Low
	Facilitating Evacuation Activities	High	High	Low	Moderate
	3D Geo-coding	High	Moderate	Low	Low
	Registration of Ownership Rights in 3D Cadastre	High	High	Low	Low
	Public Participation	Moderate	Moderate	High	Low
	Property Tax Evaluation	Moderate	High	Low	Low

Table 1. Analysis Matrix.

Opportunities for Urban Environment	BIM Research Directions		
	Developing BIM based Service Oriented Architectures	Supporting Building and GeoInformation Integration	Developing BIMs that would facilitate Emergency Response Operations
Facilitating Site Selection	Moderate	Major	Moderate
Evaluation of Design Proposals within Stakeholders	Moderate	Major	Moderate
Facilitating the analysis on energy consumption and lightning requirements	Low	Major	Low
Integration of logistics operations into large-scale 4D simulations	Low	Major	Low
Assessment of damage (and in support renovation projects)	Low	Major	Low
Facilitating 3D Modeling of Urban Environment	Moderate	Major	Moderate
Facilitating Evacuation Activities	Moderate	Major	Major
3D Geo-coding	Low	Major	Low
Registration of Ownership Rights in 3D Cadastre	Low	Major	Low
Public Participation	Moderate	Major	Moderate
Property Tax Evaluation	Low	Major	Low

The rows of the matrix correspond to opportunities provided by the use of BIMs in Urban Built Environment domain. The following provides the details of the analysis.

3.1 *Research Direction 1 → Supporting the adoption of BIM into organizational processes*

In order for BIMs to become widely recognized and used in the industry, their adoption in the organizations will be supported by the Building Information Modeling research. As organizations adopt BIMs and integrate Building Information Modeling methodologies with their organizational processes the use of, shared information models and shared databases will increase and the esteemed vision of seamless data level interoperability will become a reality for the AEC industry. As site selection, evaluation of design proposals, energy consumption analysis, logistics operations based on current status of construction, proposal evaluation by public participation, and tax evaluation processes can benefit from a wide use of -commonly recognized shared models-, high adoption rate of BIMs in organizational processes will have a moderate impact on these processes. The impact would not be high/major as these processes can also be automated when the (organizational) BIM adoption rate is not very high. In fact, other processes such as damage assessment, 3D Modeling of urban environment, evacuation activities, 3D geo-coding and registration of ownership rights in 3D cadastres, will be significantly affected by the high adoption rate of BIMs in organizations. In other words, high availability of BIMs (as a result of high adoption rate and wide-use) will meaningfully help in these activities, as it will increase the reach to geometrically and semantically rich building information that will facilitate these processes.

3.2 *Research Direction 2→Supporting the Standardization of BIMs*

Although BIMs are -by definition- interpreted as standard means of exchanging information, many emerging applications now term their intelligent digital building models as the BIM. So, the research is still acting as a force driving the industry towards standardization and the use of recognized standards in sharing and exchange of building information. Industry Foundation Classes (IFC) is the widely recognized standard for Building Information Modeling.

Site selection, evaluation of design proposals, energy consumption analysis and proposal evaluation by public participation can benefit from a standard BIM, but more important issue in these is the requirement for an intelligent geometrically/semantically rich building model, thus the impact of standardization of BIMs to these processes would be moderate. The requirement for 3D geo-coding is similar, so the impact of standardization would not be high for this aspect as well. Damage assessment, evacuation activities, cadastral registration, property tax evaluation require up-to-date building information to be represented accurately in applications that are used in these processes. The standardization (on the source modeling domain) ensures that the information transferred to these target domains represents -agreed semantics-. In addition, as the applications on the receiving-end (target domain) would have developed tools for importing standard models, the accuracy in transferring information from a standard BIM would be higher than accuracy in transferring information from a regular digital building model. Furthermore, as the source model represents the building elements with agreed semantics, the representations on the target model can be validated by making use of the source models' schema. In summary, in the processes where information accuracy is important and model transfer is a requirement, the use of standard BIMs would be highly beneficial.

The use of standard BIMs as source models would have a major impact on 3D Modeling of urban environment, as standardization of the source models (i.e. BIMs) would serve to quick and batch transfer of information from multiple BIMs to geospatial environment, as it would be easy to develop interfaces (APIs) or Web Services for transforming information from a standard BIM (i.e. IFC) to a standard 3D City Model (i.e. CityGML). Otherwise, when the source models are regular digital building models (i.e. with different object schemas), a need for developing adapters and translators from each of them to the target Modeling domain would become inevitable, and this would negatively affect the performance/accuracy of information transfer from BIMs into the geospatial environment. Finally, the process simulation activities can also be performed by using non-standard BIMs. Thus, BIM standardization efforts will have a low impact on logistics operations (which are performed based on current status of construction), as building information in these operations will be obtained from process simulation applications but not from BIMs directly.

3.3 *Research Direction 3→Developing BIMs that would support Lean Construction and Green Design*

Currently AEC industry is focused on enabling and facilitating, lean construction (i.e. by applying the lean production principles to construction) and design/construction of environmentally friendly and sustainable buildings. BIMs -as being facilitators of all information management processes in the lifecycle of building- should also support lean construction processes and construction of environmentally friendly buildings. The geographic location and positioning of the building will have an impact on the energy consumption and this impact is seriously considered in evaluation of design proposals. Thus, BIMs providing more information for energy consumption calculations/analysis would be highly beneficial in evaluation of design proposals (with some stakeholders or with public participation). As aimed in this research direction, when BIMs contain more information regarding energy requirements and consumption, this would have a major impact for facilitating energy consumption analysis. Lean construction depends on lean supply and Just-in-Time (JIT) delivery of materials to the construction site. When BIMs are developed for providing support to enabling leaner processes (i.e. by use of process simulation tools) and (JIT) logistics operations, this would have a major impact on facilitating the logistic operations performed based on 4D simulations. Other opportunities in the matrix (not mentioned here) will not be much affected by the developments in this research direction (i.e. the impact level is considered as low for all other opportunities).

3.4 *Research Direction 4→Developing BIMs that would enhance Process Simulation and Monitoring*

Process simulation, visualization of construction based on process simulation, model based monitoring of construction activities are currently being accomplished by the use of semantically rich building models, and the use of BIMs within these simulation and monitoring applications is highly encouraged. This type of simulations is generally termed as 4D/nD CAD. If an emergency situation occurs during the construction of a building, information acquired from the 4D/nD Model (which is in-sync with the actual construction) can serve for assessing the damage in the building, and can assist to navigation and evacuation activities within the building, by providing information based on the current state of the construction. Information acquired from the 4D/nD model would enable routing and wayfinding within the building (based on the current status of the construction). For example, the navigation path from room A in first floor to room B in second can naturally be different depending on the current state of the construction (i.e. a staircase connecting floors might not have built yet at the time the emergency situation occurred, although it is represented in the architectural model of the building). Thus, information regarding current state of the building is of a key importance for evacuation processes and for accurately assessing the damage when a disaster occurs during the construction, and when required this information can be acquired from applications supporting process simulation and monitoring. For this reason, developments in Building Information Modeling towards enhancing process simulation and progress monitoring will have a high impact on, facilitating evacuation processes and damage assessment exercises. The major impact of developing BIMs that would enhance Process Simulation and Monitoring would be facilitating, the 4D simulations, and in consequence the logistics operations that acquire information from these simulations. Other opportunities in the matrix (not mentioned here) will not be much affected by the developments in this research direction (i.e. the impact level can be regarded as low for all other opportunities).

3.5 *Research Direction 5→Developing BIM based Service Oriented Architectures*

Although Building Information Modeling is interpreted as a model-based interoperability and integration paradigm, the use of model-driven service oriented architectures is highly encouraged by researchers and technology providers in the field. In the proposed model-driven web service architectures, a shared BIM forms the core of a web service, where multiple clients (or systems) can interact with -to acquire information from the shared model-. The use of BIM based web services would facilitate interactions on the 3D visual representation of the BIM in web-based collaborative environments. The use of BIMs in such environments would have a considerable impact on facilitation of, i)the processes in site selection, evaluation of design proposals and proposal evaluations by public participation and ii.) the communication and coordination in emergency evacuation processes. Furthermore, as shown in the OGC Web Services Phase 4 (OWS-4 Summary Document, 2007) service oriented architectures can have an impact on information integration towards representation of buildings together with (or within) a 3D City Model. The impact of this research direction to other opportunities mentioned in the matrix can be considered as relatively low when compared with the areas mentioned previously.

3.6 *Research Direction 6→Supporting Building and GeoInformation Integration*

BIMs are generated by using CAD systems. The approach to Modeling in CAD Systems and GIS are significantly different, and in consequence, the resulting information models have differences in representation of the buildings (Isikdag & Zlatanova, 2009). CAD systems are developed to model objects that do not exist prior to the generation of the model, and are designed for representing the maximum level of detail in terms of, geometry and attributes of the model. On the other hand, GIS are developed to represent objects that already exist around us, and geospatial data models are defined for representing the objects in a way that they can be recognized most easily. In addition, GIS highly require and make use of the geo-referenced geometries in representing the real-world objects. The differences in the representations of buildings in both systems (CAD/GIS) and in both information domains (AEC/Geo), together with the need for representing highly detailed building information in geospatial environment, have ignited the efforts towards enhancing BIMs for supporting building and geoinformation integration. This integration would have a major impact for facilitating all the processes (opportunities) mentioned in the impact analysis matrix (as all of them would be highly facilitated as a result of a building and geoinformation integration).

3.7 *Research Direction 7→Developing BIMs that would facilitate Emergency Response Operations*

A digital building model designed to support emergency response operations should provide, i.) detailed 3D geometric representation of building elements (which should be geo-referenced and compatible with GIS representations), ii.)semantic information regarding the building elements (i.e. including a clear definition and naming of objects and their relations), iii.)properties of each building element (such as material of the walls, opening directions of the doors, doors used as exits) and iv.) states of them(e.g. door can be ‘open’ or ‘closed’ at a certain point in time). In the first stage BIM based information management methods can be enhanced to provide geo-referenced and GIS compliant geometric representations of building elements when required. Once this achieved, the transfer of geometric information from BIMs into the geospatial environment will be a straightforward task. Furthermore, information regarding the object states needs to be stored in the BIMs. In this case, the (geometric/semantic) information transferred from BIMs (which also provide object’s states) into the geospatial environment will positively affect, the site selection activities, evaluation of design proposals (by stakeholders and public participation), and representation of 3D building information in city models. In fact, the major impact of this research direction would be on facilitating the evacuation activities -especially when the object states are stored in BIMs along with geometric/semantic information and transferred into the geospatial environment-. In fact, we view the impact of this research direction to other opportunities mentioned in the matrix as relatively low.

4 CONCLUSIONS

In recent years the vision of model-driven management of AEC processes is becoming a reality. Shared use of semantically rich building models (BIMs) which are defined by standardized schemas currently referred as Building Information Modeling. In fact, recent research and industry visions also regard Building Information Modeling as an information management process and strategy that spans along the lifecycle of a project and facility. In this respect, the shared information models (i.e. BIMs) forms the core of this new emerging information management strategy. This new strategy focuses on enabling seamless integration and interoperability between different applications used in automating the tasks in the lifecycle of a facility/building by the use of shared digital models.

Although this new strategy and shared digital models has been developed for facilitating the various tasks in the AEC industry, the use of them is now positively influencing several processes related to Urban Data Management. A SWOT analysis recently carried out by the authors has outlined the tasks that would be facilitated by this positive impact of implementation and use of the BIMs in Urban Data Management Systems. The results of the SWOT analysis demonstrated that activities including site selection, evaluation of design proposals, emergency response and post-disaster damage assessment, registration of ownerships in 3D cadastre and even tax evaluation will benefit from this implementation.

The analysis explained in this paper was focused on exploring, the impact of progression in Building Information Modeling research, to the opportunities provided by the use of BIMs in Urban Data Management context.

The analysis results indicate that BIM research towards supporting Building and GeoInformation Integration would have a major impact on facilitating all processes/opportunities in focus. Other research directions that would have a considerable impact on all opportunities in focus were found as, i.) research towards facilitating organizational adoption of Building Information Modeling and ii.)research towards facilitating standardization of BIMs. Developing model-driven service oriented architectures and developing BIMs that would facilitate emergency response operations will have an impact on half of the BIM related opportunities in focus. On the other hand, the impact of i.)research towards, developing BIMs for supporting lean construction and green design, and ii.)developing BIMs that would enhance process simulation and progress monitoring, found as relatively low. Further research will focus on exploring how this 7 research directions related to BIM research will have an impact on the opportunities related to UDM by via a series of surveys and one-to-one interviews with participants from the AEC industry.

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