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# Challenges and Opportunities for BIM-GIS Integration – BIRGIT Case Study

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**Abstract:** The integration of Building Information Modelling (BIM) and Geographic Information Systems (GIS) is becoming increasingly important in the construction industry and urban planning, helping to create smart cities and digital twins. The research, which involved expert interviews, and an online survey conducted among specialists from partner countries, shows that there is a significant skills gap, as many professionals lack expertise in combining BIM and GIS. It also indicates that while the integration of these technologies is advancing, it is still in the early stages. To tackle this issue, the BIRGIT project—featuring partners from Sweden, Italy, Spain, Belgium, and Croatia—aims to develop new educational programs that meet market demands. Ongoing initiatives like BIRGIT are vital for bridging the skills gap and ensuring that professionals are well-equipped to effectively implement these technologies, ultimately improving project management and decision-making in the industry.

**Keywords:** BIRGIT; Building Information Modelling (BIM); Geographic Information Systems (GIS); industry demand; integration; technical skills; training needs

## 1 INTRODUCTION AND LITERATURE REVIEW

As for the construction and urban planning industries today, specialists are commonly trained in BIM or GIS. BIM, being at the centre, is concerned with the creation, administration, and analysis of virtual models of buildings, while GIS is focused on the spatial data analysis and managing information concerning geographic locations.

Even though the two systems are crucial for effective infrastructure planning and management, there exists a huge gap among professionals. A great number of engineers and architects hold a solid understanding of the BIM methodologies, but they hardly have similar abilities in GIS. On the other hand, specialists of GIS, like geoinformatics specialists and urban planners, mostly stick to spatial data analysis but rarely know much about BIM tools and methodologies.

This knowledge compartmentalization might hinder the proper conversion of BIM to GIS and vice versa. Professionals focusing solely on one of the two technologies often experience limited communication and collaboration with their colleagues in other disciplines, which can be detrimental to the entire project and may lead to data integration issues.

The lack of specialists who possess skills in both areas further hampers the effectiveness of a functional team. In this regard, educational solutions that promote the training of specialists and develop human capital with expertise in BIM and GIS can help bridge this gap. Enabling professionals to acquire competencies in both domains facilitates the integration process, which can improve the efficiency and sustainability of construction projects

BIRGIT is a research project that is geared toward the integration of BIM and GIS for more efficient community planning and the optimization of construction projects [1]. This integration has its drawbacks, such as the lack of skills and the knowledge gaps of the professionals. However, to overcome these problems, the BIRGIT project will provide some interdisciplinary educational materials to give the professionals the competencies that they need to have a successful BIM-GIS integration.

Information, features and capabilities from BIM and GIS are combined to enhance built environment management and analysis. By integrating BIM data with GIS operations, GIS enables the viewing and analysis of BIM data within a geographic context. BIM-GIS integration is becoming more widely used globally, helping to build infrastructure and smart city projects that align with the objectives 2030 Agenda for Sustainable Development (SDG) [2]. The integration uses detailed geometric and attribute data from BIM and the spatial analysis capabilities of GIS to create a more comprehensive picture of the construction site and its environment. A recent study proposed a semi-automated process for a hybrid BIM-GIS model, which enhances information management from both infrastructure and environmental perspectives, thereby enabling informed decision-making throughout the lifecycle of the infrastructure [3].

The joint use of these complementary technologies facilitates the solving real-world problems, particularly in the development of smart cities and digital twins [4, 5]. Another important area of application is in the construction and urban planning sector.

Diverse national strategies for combining BIM and GIS technology result in differences in the application of BIM and its effects. Strategies include industry-driven projects, in which the industry itself drives BIM adoption but the government plays a less significant role, and government-driven programs with required BIM policies [6]. On the other hand, some countries have opted for the opposite approach, where integration is initiated by the state administration [7].

The foundation for integrated digital approaches in major infrastructure projects has been established in the UK, a pioneer in requiring the usage of BIM [8, 9]. Although there is no federal law requiring the use of BIM in the USA, several state governments have implemented BIM to be used in public projects, and large-scale infrastructure projects are increasingly integrating BIM with GIS.

Recent studies have also addressed the interoperability between BIM and GIS in the research on cultural heritage preservation, emphasizing the need for converting objects from BIM models into a standardized GML format. This approach facilitates the linking of BIM and GIS with databases, enabling efficient data management and comprehensive risk analysis within the fields of urban planning and cultural heritage preservation [10].

Encouraging the use of BIM has been a constant endeavour of the European Union thanks to several guidelines and initiatives. For the first time in a legal context, BIM was introduced to the Member States by means of European Directive No. 24 published in 2014 and served as a baseline for further, more progressive development of this strategy across the continent [11]. The directive addressed how the construction industry could benefit from the adoption of information technology in improving efficiencies, sustainability and lowering costs. Nevertheless, in several countries, there is a lack of satisfaction among the stakeholders as to the outcomes which BIM can achieve, as well as an imbalance in its theoretical and practical application [12]. This is mainly due to a lack of standards, and inadequate training on best practices that would help embrace BIM in daily routines and the reluctance of the different stakeholders involved in the management system to adopt these integrated models [13].

Asian nations like Singapore and South Korea are investigating the integration of GIS into urban planning and smart city development, and they have established strict regulations and guidelines for the use of BIM in public projects [14]. The adoption is growing but more scattered in other areas. Hong Kong, for example, has issued guidelines for the integration of BIM and GIS to facilitate urban planning and smart city applications [15].

The incorporation of BIM and GIS technologies in infrastructure management is becoming increasingly important, especially regarding to underground infrastructure, which often remains invisible during design and construction. The traditional reliance on 2D drawings does not provide sufficient information for construction managers to make effective decisions throughout the lifecycle of the project. Therefore, “an integrated framework is needed that is based on advanced technologies such as BIM and GIS, where all geometric and semantic information can be stored, managed, accessed, retrieved, and updated in a standardized manner at different project stages” [16].

Effective communication, data sharing, and coordination between architects, engineers, and other stakeholders involved in the design, construction, and operation of built environments are facilitated by BIM-GIS integration. The integration together with quantitative analysis, technology application, and urban management, greatly contributes to the development of smart sustainable cities [17]. Integration makes it possible to improve urban sustainability, rationalize resource management in construction projects, and enhance governance in smart cities.

New methods for urban planning, design, and asset management are needed in both the public and private sectors. Planning maintenance, asset tracking, and facility management are all made more effective by this connectivity. To leverage these benefits, it is crucial to have well-educated professionals who are adept in BIM-GIS integration. Therefore, developing high-quality courses and educational materials is essential to ensure that individuals have the skills and knowledge required to implement and manage these technologies successfully.

In construction management, BIM-GIS integration is a rapidly emerging technology that has advanced significantly in the last ten years [17]. However, organizational, cultural, technological, commercial, and practical limitations have frequently been surpassed by the conceptual comprehension of these promising notions [18]. BIM and GIS systems can communicate more easily thanks to common data interchange standards as Industry Foundation Classes (IFC) for BIM and Geography Markup Language (GML) for GIS. This promotes interoperability between the two technologies. However, compatibility issues and integration challenges across various systems and technologies continue to be major obstacles [19]. By expanding the application of BIM technology beyond individual buildings to larger city scales, current research, best practices, and technological improvements are opening the door for more thorough and effective industrial processes [4].

Data interoperability must be fully resolved before integration of BIM and GIS at the application level can be achieved. This is because integration involves multiple levels, including the application level and a more detailed data level, which comprises sublevels such as the geometry level and semantic level (Fig. 1) [20].

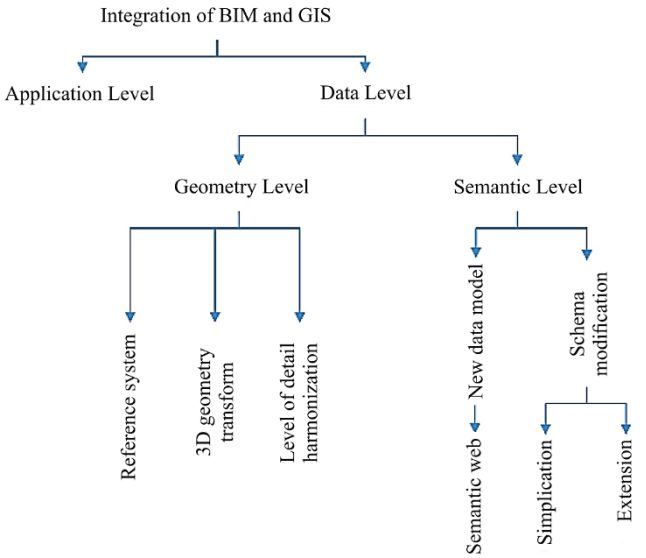


**Figure 1** Levels of integration of BIM and GIS

The complexity of integration is also linked to technical aspects; for example, certain functionalities, such as the scheduling tool, are not readily or fully adopted. Although this tool enables the planning of activities, it does not adequately address project complexity or the recurrence of activities [21]. Moreover, research into the integration of BIM and GIS has been insufficient. This gap exists at both the macro level—covering processes, project management,

and commercial and organizational dynamics—and at the micro level, which includes technical integration [5]. This indicates the need for more comprehensive research and development efforts to address both the macro and micro-level challenges to fully realize the potential of BIM and GIS integration in the AEC industry.

To address these challenges, the BIRGIT project has been initiated. BIRGIT is a three-year project funded by the Erasmus+ Programme, which runs from February 2022 to January 2025. Its mission is to bridge the gap between the growing demand for and the current supply of skills in BIM-GIS integration. To achieve this, BIRGIT focused on enhancing vocational education and training by creating new curricula and educational resources that provide people the know-how needed to integrate BIM and GIS effectively. The project's participants include the scientific community, BIM and GIS providers, public sector organizations, academic and research centres, EU networks of VET organizations, managers of technical education and training, trainers, trainees, and VET providers. The partnership includes seven organizations: University North (Croatia), Forma Azione s.r.l. (Italy), GISIG (Geographic Information Systems International Group) (Italy), Ocellus Information Systems AB and Novogit AB (Sweden), and EfVET (European Forum of Technical and Vocational Education and Training) (Belgium) [22].

The growing need for experts and education in the fields of architecture, engineering, and construction (AEC) has led to the creation of initiatives such as the BIRGIT project, which aims to close the skills gap in these rapidly evolving fields. The path towards successful BIM and GIS integration includes the technical complexities of aligning data from diverse sources, the lack of standardized practices across the industry, and the educational gap among professionals who are expected to navigate both BIM and GIS environments.

By integration real data with 3D city models, the integration of IoT, BIM, and GIS would significantly enhance the effectiveness and quality of urban administration [23]. Professionals in both fields must be well educated to integrate data. According to surveys conducted in Sweden, Italy, Spain, and Croatia, indicate a shortage of trained personnel and vocational programs that address the skills required for integrating BIM and GIS. GIS and BIM courses are typically offered within existing curricula; however, they are not integrated [20]. The labour market is necessary more and more BIM and GIS integration skills, which emphasizes the need for ongoing skill development and adaptability. Addressing these gaps through targeted educational programs and ongoing professional training is essential for meeting the growing demand and ensuring the successful application of integrated technologies across all areas of application.

## 2 METHODOLOGY

This chapter describes the methodology used for our survey of industry professionals, focusing on assessing knowledge and skill gaps in the BIM-GIS sector. The flowchart (Fig. 2) illustrates the methodology we defined and used for assessing knowledge and skill gaps in the BIM-GIS sector. The process begins with the Planning and Design phase, where we have defined survey objectives and created questions which could capture key skill areas. Following this, in the Data Collection and Distribution phase, an online survey targeting the BIM-GIS community was distributed to selected industry experts, and responses are monitored and collected for analysis. Next, the Data Processing and Analysis phase involves cleaning and analysing the responses to get to the important information which is then uncovered into current knowledge levels and required competencies. Based on these insights, the Insights and Recommendations phase focuses on summarizing the findings and proposing actionable steps to address identified gaps. At the end of the flowchart, there is the Development of E-Learning Materials phase which transforms the recommendations into structured e-learning modules designed to bridge the identified skill gaps. The materials are then deployed and refined based on feedback, ensuring continuous improvement in the sector's skill development.

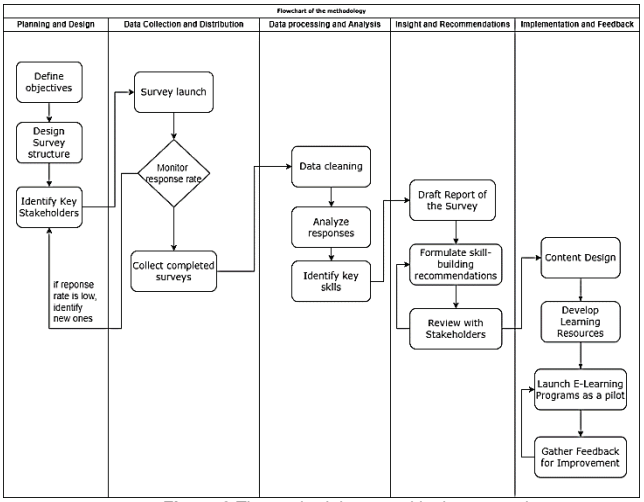


**Figure 2** The methodology used in the research

Beside launched online survey, and for the better understanding of the evolving needs and challenges of BIM-GIS integration, we also conducted further interviews with professionals in the BIM and/or GIS domain. Nine interviews were done, with two coming from Italy, one each from Spain, Sweden, and Croatia. The interview's focus was on the knowledge and abilities that are required for BIM and GIS integration. Despite having access to a list of suggested questions, the interviewers were allowed to assign more weight to some points based on the interviewee's profile and context, as well as the unique characteristics of the nation in which the interview is being conducted. The interviews are impartial considering the respondents' professional backgrounds (established experts in the BIM and GIS fields), but they also consider their individual opinions on the subjects and fields in which they use BIM-GIS integration. The online survey was created with the intention of gathering more precise and in-depth data regarding training needs, as well as to enhance the information already gathered with the

involvement of other specialists. 53 responses were gathered during the online survey, which was created using EUSurvey, the official survey management tool of the European Commission.

Most of the companies that took part in the survey are involved in the AEC industry (27), education and training (16), and software development/distribution (11). The questionnaire's questions are mostly divided into:

The questions asked in the questionnaire are classified into:

- General organisation information
- Demand for BIM-GIS integration skills in the industry
- Views on BIM-GIS integration process.

Within the methodology, a systematic approach was applied to assess current skill levels and identify gaps. By categorizing questions into general organizational information, the industry's need for BIM-GIS integration skills, and perspectives on integration, specific training needs and areas for development can be pinpointed, as shown in the next section.

## 3 RESULTS AND DISCUSSION

The largest response to the survey (47.17%) was from organizations of small and medium enterprises (SME). Also, a significant number of respondents come from the domain of education and research (18.87%) and administration and public bodies (15.09%). These results reflect the traditional usage of BIM primarily in the private sector, where it facilitates efficient project management and design processes, while GIS is more frequently utilized by public administration and government agencies for effective spatial planning and resource management.

As the professional profiles of the participants are equally divided between BIM and GIS (only 3.77% of the participants deal with both fields), analysis with professional profile and sector in which the organization operates was made. Participants identifying as BIM professionals predominantly work in the Architecture, Engineering, and Construction (AEC) sector, whereas GIS experts are spread across various sectors, varying by country. This research coincides with the previous ones, in which it was stated that many respondents use BIM in educational facility projects, and it was found that respondents with professional backgrounds in BIM are primarily engaged in the Architecture, Engineering and Construction (AEC) sector, which aligns with the predominant application of BIM in this sector [24].

### 3.1 Current Status of Integration

One of the most important questions that fully supports the necessity of tackling the problem of BIM and GIS integration is the question of the current status/maturity of the adoption of BIM-GIS integration (Fig. 3). A large percent of respondents think that the integration of BIM and GIS has not yet been fully implemented or it is at a certain stage of development (86.80%). Surveys reveal that respondents from Sweden and Spain tend to view the adoption status as "emerging/early adoption". In contrast, about one-third of respondents from Croatia consider the integration to be at the "growth" stage, which represents a more advanced phase. This view is even more prevalent among respondents from Italy. Although a smaller part of respondents (16.66%) believes that integration has not been adopted, the ratio of Emerging/early adoption and "In grow" phase is 50% - 50%. This implies that Italy may be a country where integration practices are further along in development, possibly resulting in greater efficiency and better collaboration among different sectors.

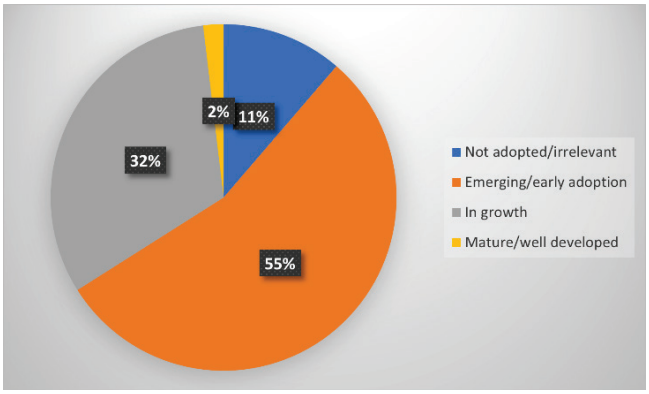


**Figure 3** The level of adoption of BIM/GIS integration

Even though a lot of technical challenges in integrating BIM and GIS have been tackled to some extent, there aren't many theoretical studies that look at how to effectively combine the strengths of both for deeper quantitative analysis. This indicates that while BIM-GIS integration has made significant progress, it has not yet reached full implementation, reinforcing the notion that its adoption is still evolving [25].

BIM/GIS integration is imperative in several areas in the construction industry as it provides effective data handling and representation through different phases of the project life cycle. There are different modes of this integration like migrating from BIM to GIS or from GIS to BIM or from both to another system [26, 27]. BIM and GIS are useful management information systems, providing managers with essential data, procedures, and total facility performance management software systems and decision supervision, providing data and metadata analysis for performance management and supporting analytical applications for internal and external building infrastructure management workflows [28].

The interviewee was able to choose several options to define the primary areas where BIM-GIS integration technologies are currently applied or hold potential for future application. Most respondents think that BIM/GIS integration technologies are mainly used in Land use and Urban planning (64.15%), Architecture (62.26%), Roads and highways (58.49%) and Smart Cities (52.83%). Use in Railways, Bridges, Utilities underground networks, Facility management also have a significant percentage (over 40%). When analysed by country, out of 14 respondents in Croatia, 12 of them decided on architecture. On the contrary, in Italy,

most respondents think that the application of BIM and GIS integration makes the most significant contribution in Land use and Urban planning and especially in the domain Utilities underground network which is not at all significant for Spanish respondents. They are most interested in the field of Land and urban planning, and Swedes in field Roads and motorways.

Given the opinions that the integration of BIM and GIS is in the early stages of development/early adoption or has not even started at all, the respondents' views on the current necessary skills for implementation are logical (Fig. 4). The general feedback is that the skills of current employees in the Geospatial and AEC industries only partially meet job requirements, which means they'll need more training and the acquisition of additional skills. 15.09% of respondents believe that current employees do not have the necessary skills to implement BIM/GIS integration, while as many as 56.6% of respondents believe that current employees need further training. What is also significant regarding this question is the significant percentage (22.64%) of respondents who did not know how to answer this question. The reason probably lies in the fact that many employers have not even begun to seriously consider integration.

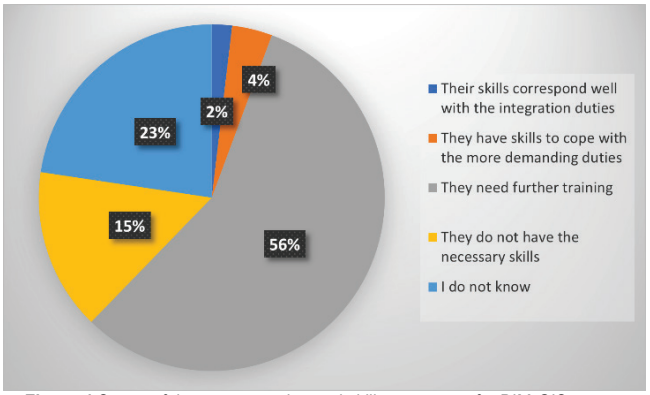


**Figure 4** Status of the competencies and skills necessary for BIM-GIS among current employees in the Geospatial and AEC industries

Such high percentages in certain areas define the starting point for competence research and identify the most common fields in which a suitable candidate for a BIM-GIS integration role should possess training (Fig. 5). Distinct hiring preferences favour candidates from the fields of Engineering (69.81%), Architecture (52.83%), and Geoinformatics. (56.6%). Participants also found relevant Computer sciences (45.28%), Data science and statistics (39.62%), Cartography (35.85%) and Geodesy (24.53%). Observing respondents from the two researched sectors separately, those with BIM-related backgrounds believe that having a foundation in Architecture and Engineering is ideal. On the other hand, GIS respondents stress the importance of training in Geoinformatics and point out that education in fields like Geodesy, Geography, and Cartography is relevant for BIM-GIS integration.

The BIRGIT survey focuses significantly on identifying and evaluating the specific competencies and skills necessary for BIM-GIS integration. Respondents were asked to assess their expertise in various competencies and skills as 'basic', 'intermediate', or 'expert'. Analysis of the required general competencies suggests that a strong foundation in both disciplines, particularly the fundamental principles, is essential for effective BIM-GIS integration work [16].

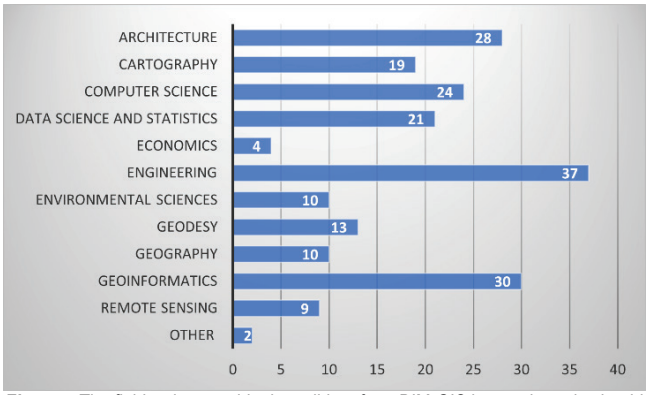


**Figure 5** The fields where an ideal candidate for a BIM-GIS integration role should be trained

### 3.2 Technical Skills

In the research, 22 software were offered, 9 from the GIS and 13 from the BIM domain. Additionally, the survey revealed that respondents tend to believe that having a solid understanding of both software tools is necessary. The survey indicates that knowledge of GIS software is regarded as necessary at an intermediate level. Additionally, research shows that both BIM and GIS professionals agree on the necessity of achieving an intermediate proficiency in tools from either domain to effectively tackle integration tasks. (Fig. 6).

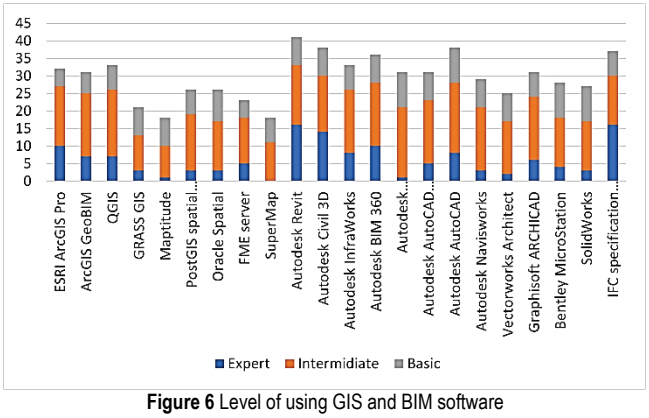


**Figure 6** Level of using GIS and BIM software

When analysing the total number of answers regarding the necessary knowledge of software, it is interesting that many respondents did not give their opinion about individual GIS and BIM software. This result indicates a notable gap in familiarity with these tools and suggests that certain software is used less or not at all.

Commercial ESRI's software and open-source software QGIS are regarded as the most significant. In terms of BIM software, Autodesk Revit stands out as the most recognized, which aligns with the findings from the interviews. Advanced proficiency in Autodesk Revit is viewed as the

most valuable skill. Autodesk software is heavily involved in commenting for a variety of uses. Emphasis should be placed on the fact that respondents, particularly BIM experts, place a high value on mastery of the IFC specification [5]. There is little to no focus on the other software items that are unrelated to Autodesk or ESRI. However, there are several obstacles in the way of a smooth BIM-GIS integration, such as standardization requirements and technical complexity [29]. To maximize the benefits of BIM-GIS integration and improve resource management and urban sustainability, it is imperative that these issues be resolved.

Regarding the category of BIM skills (Fig. 7), respondents in almost all categories opted for an intermediate or expert level of knowledge. 52.83% of the respondents believe that for the integration of BIM and GIS, competence related to BIM fundamentals is needed at the expert level, and 26.42% at the intermediate level. Significant emphasis is placed on tasks related to 3D modelling and the utilization of model-oriented software, with a summary indicating that this is important for both intermediate and expert levels (79.25%). Knowledge of data specifications and other standards (such as IFC) is also considered important (67,92%).

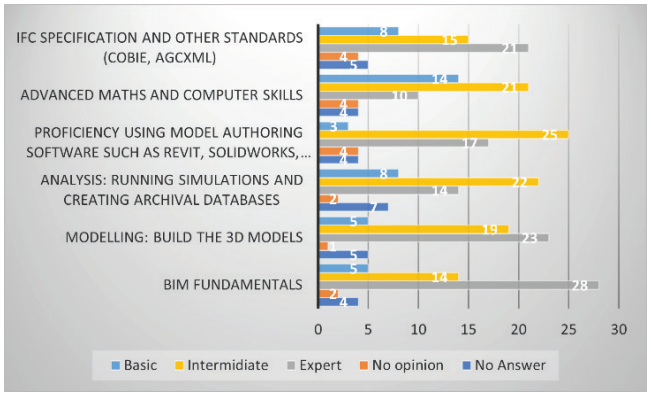


**Figure 7 BIM** skills set for a BIM/GIS integration job

Regarding GIS data skills (Fig. 8) 52.83% of the respondents believe that for the integration of BIM and GIS, competence related to GIS fundamentals is needed at the expert level, and 16.98% at the intermediate level. Skills in 3D GIS and data models can also be emphasized (summary for intermediate and expert levels: 69.82%), along with tasks related to georeferencing, map projections, and data resampling (71.7%).

These findings indicate that advanced skills in handling BIM and GIS data are essential, with the required skill level generally falling between intermediate and expert. Both BIM and GIS professionals acknowledge the necessity of intermediate skill levels, with many emphasizing the importance of advanced capabilities across nearly all areas. This indicates the increasing complexity of tasks related to BIM and GIS integration, which requires a high level of expertise. As a result, it's clear that BIM-GIS integration requires a variety of skills, with an advanced level of knowledge being important.

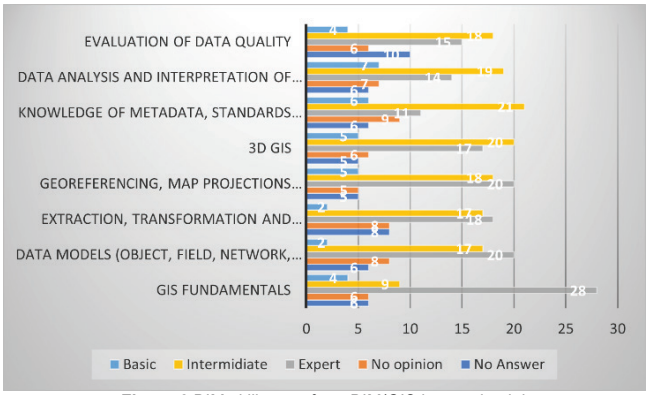


**Figure 8** BIM skills set for a BIM/GIS integration job

From an organizational and institutional perspective, there is significant emphasis on the importance of adopting GIS and BIM standards. It is recognized that without appropriate standards, successful integration may be hindered or even impossible. Even 56.6% of the respondents believe that it should be at the expert level and 18,87% on the intermediate level. This specific skill stands out as a major finding from the survey, highlighting the necessity of advanced knowledge in using and implementing standards, which play a crucial role in ensuring interoperability between systems. This skill not only enhances individual expertise but also encourages teamwork across various platforms, helping to create smoother and more connected workflows.

### 3.3 Education and Perspective

The last part of the survey focused on exploring trends and key aspects of education and training that need to be addressed for strengthening BIM-GIS integration in the future. Fig. 9 shows that respondents emphasize the significance of ongoing training investments for employees (39.62% of them considered this assumption as very important). Additionally, significant importance is given to practical experience through real-world business scenarios (case-based learning), with 28.3% of respondents highlighting this aspect.

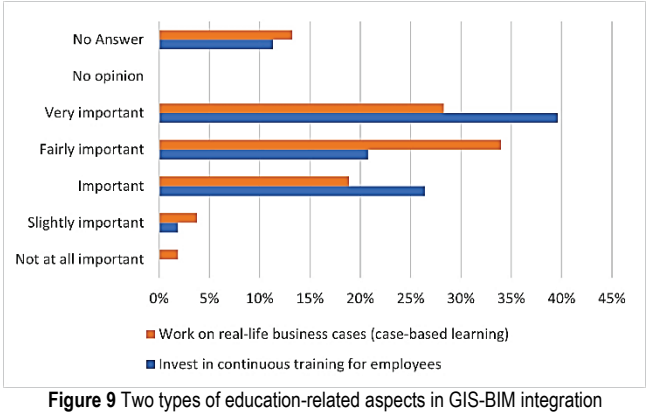


**Figure 9** Two types of education-related aspects in GIS-BIM integration

As per the suggestions made by the participants, enhancing the integration of BIM and GIS might be accomplished through staff training and support and by incorporating new technologies and procedures into

educational establishments. The need to create national standards and provide training that is accessible to all members is emphasized, with a focus on training for the most popular BIM and GIS applications. Furthermore, they advocate for GIS and BIM to be required subjects in civil engineering and architectural curriculum.

In addition, In the future, GIS-BIM integration will be more seamlessly integrated into larger information management systems, reducing the significance of discipline boundaries. Although there will be a rise in the use of integrated GIS-BIM, its ideal application may be limited by skill gaps, and its expansion into domains such as Life Cycle Assessment (LCA) and Environmental Impact Assessment (EIA) may be gradual. With prominent examples from nations like the USA, Singapore, and Germany, the integrated market is predicted to expand; nevertheless, it might take some time for Croatia and the EU to see comparable developments. It is expected that surveyors would produce extensive GIS databases that give builders and architects comprehensible, georeferenced project data.

## 4 CONCLUSION

The objective of the research describe in this paper was to investigate BIM-GIS integration by covering different aspects, namely:

1) Current status of integration
2) Technical skills needed for the integration
3) Education and Perspective

The method used was a combination of interviews and surveys in BIRGIT project partner countries.

While the studies mentioned in the introduction focused on the theoretical foundations and potential applications of BIM-GIS integration, our research shifts attention to the urgent need for improving education and skill development, particularly highlighting differences in professional competencies. Emphasizing regional variations in BIM and GIS integration techniques not only reflects the complexity of adoption but also underscores the importance of tailored educational programs, like those initiated by the BIRGIT project.

The results achieved through the interviews and surveys can be summarized as follows:

1) BIM-GIS integration is still in its infancy; 86.8% of respondents think it isn't being used correctly at the moment, and 47.17% stress the need for further training. Only 16.66% of respondents consider the integration complete, while 50% see it as either "early adoption" or "in progress."
2) Effective integration requires advanced BIM and GIS skills—52.83% of respondents noted the necessity for expert-level BIM skills, and 71.7% highlighted the importance of GIS expertise.
3) Addressing these needs through standardized methods and enhanced educational programs is crucial. Initiatives such as the BIRGIT project, which focuses on improving education and training, play a vital role in overcoming these challenges.

The findings presented in this paper should be combined with other studies to enhance synergy and a holistic view of the BIM-GIS integration. There are still issues that need to be tackled in future research.

The benefits of combining BIM with GIS include better resource management, increased sustainability in urban areas, and more effective planning and construction procedures. However, there remain challenges, including data compatibility and interoperability, scale and level-of-detail disparities lack of common understanding on type-appropriate variable formats issues regarding the volume problems with storing that much information having technical double-use criteria or software dependencies regulatory/standardization efforts. Addressing these challenges is crucial for reaping the rewards of BIM-GIS integration and take advantage of what it has to offer.

The integration of BIM-GIS is anticipated to be even better for project visualization, sustainability and cost savings. Its role in enabling smarter and more efficient urban and infrastructure planning will become increasingly important. The integration will benefit from advancements in AI and data analytics, providing deeper insights and predictive capabilities for urban planning. Digital twins and smart cities will benefit from real-time monitoring and simulation, while cloud computing and IoT will offer scalable and accessible storage solutions. Augmented Reality (AR) and Virtual Reality (VR) will facilitate immersive interactions with integrated BIM-GIS data, improving collaboration and project understanding. Additionally, stronger regulatory support will drive sustainable development by supporting environmental impact assessments and mitigations in public infrastructure projects.

The BIRGIT training materials for the integration of BIM in GIS is under development and testing at this time which will be further disseminated by conducting several multiplier events throughout partner countries stakeholders. These outputs are due to be made available, openly accessible and free of charge at the conclusion of the project — across all output formats — with a view to helping address current circumstances where actual expertise in this area remains rare or embryonic.

Further refining skills and adapting, will undoubtedly protect processes for urban planning and building whilst allowing for better resource management to improve the manner that cities are sustainably handled. In the end, BIM integrates with GIS to deliver modern urbanization through efficient expert collaboration and enhancing infrastructure administration across all segments.

### Acknowledgements

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## 5 REFERENCES


[1] https://birgitproject.eu/

[2] Liu, Z., Liu, Y. & Osmani, M. (2024). Integration of Smart Cities and Building Information Modeling (BIM) for a Sustainability Oriented Business Model to Address Sustainable Development Goals. *Buildings, 14*, 1458. https://doi.org/10.3390/buildings14051458

[3] Cepa, J. J., Pavon, R. M., Alberti, M. G. & Carames, P. (2023). Towards BIM-GIS integration for road Intelligent management system. *Journal of Civil Engineering and Management, 29*(7), 621-638. https://doi.org/10.3846/jcem.2023.19514

[4] Basir, W. N. F. W. A., Ujang, U. & Majid, Z. (2021). Building Information Modeling (BIM) and Geographic Information System (GIS) data compatibility for construction project. *Journal of Information System and Technology Management, 6*, 278-289. https://doi.org/10.35631/JISTM.624026

[5] Wang, H., Pan, Y. & Luo, X. (2019). Integration of BIM and GIS in sustainable built environment: A review and bibliometric analysis. *Automation in Construction, 103*, 41-52. https://doi.org/10.1016/j.autcon.2019.03.005

[6] Yang, J.-B. & Chou, H.-Y. (2018). Mixed approach to government BIM implementation policy: An empirical study of Taiwan. *Journal of Building Engineering, 20*, 337-343. https://doi.org/10.1016/j.jobe.2018.08.007

[7] Galić, M., Venkrbec, V., Chmelik, F., Feine, I., Pučko, Z. & Klanšek, U. (2017). Review of BIM's Implementation in some EU AEC Industries. *13th International Conference Organization, Technology and Management in Construction Conference Proceedings*. Zagreb: Hrvatska Udruga za Organizaciju Građenja, 462-476.

[8] Burgess, G., Jones, M. & Muir, K. (2018). BIM in the UK house building industry: opportunities and barriers to adoption. Cambridge University, Cambridge, March 1-8.

[9] Atkinson, L., Amoako-Attah, J. & B-Jahromi, A. (2014). Government's Influence on the Implementation of BIM. *Computing in Civil and Building Engineering*, 520-527. https://doi.org/10.1061/9780784413616.065

[10] Colucci, E., De Ruvo, V., Lingua, A., Matrone, F. & Rizzo, G. (2020). HBIM-GIS Integration: From IFC to CityGML Standard for Damaged Cultural Heritage in a Multiscale 3D GIS. *Applied sciences, 10*(4), 1356. https://doi.org/10.3390/app10041356

[11] Fiamma, P. & Biagi, S. (2023). Critical Approaches on the Changes Taking Place after 24/2014/EU in BIM Adoption Process. *Buildings, 13*, 850. https://doi.org/10.3390/buildings13040850

[12] Kolarić, S., Pavlović, D. & Vukomanović, M. (2015). Developing a methodology for preparation and execution phase of construction project. *Organization, Technology & Management in Construction: An International Journal, 7*(1), 1197-1208. https://doi.org/10.5592/otmcj.2015.1.4

[13] Matos, R., Rodrigues, H., Costa, A. & Rodrigues, F. (2022). Building condition indicators analysis for BIM-FM integration. *Archives of Computational Methods in Engineering, 29*(6), 3919-3942. https://doi.org/10.1007/s11831-022-09719-6

[14] Shafiullah, M., Rahman, S., Imteyaz, B., Aroua, M. K., Hossain, M. I. & Rahman, S. M. (2023). Review of Smart City Energy Modeling in Southeast Asia. *Smart Cities, 6*, 72-99. https://doi.org/10.3390/smartcities6010005

[15] The Government of the Hong Kong Special Administrative Region. Smart City Blueprint. Retrieved from: https://www.smartcity.gov.hk/blueprint/HongKongSmartCity Blueprint_e-flipbook_EN/mobile/index.html#p=2

[16] Sharafat, A., Khan, M. S., Latif, K., Tanoli, W. A., Park, W. & Seo, J. (2021). BIM-GIS-Based Integrated Framework for Underground Utility Management System for Earthwork Operations. *Applied Sciences, 11*, 5721. https://doi.org/10.3390/app11125721

[17] Song, Y., Wang, X., Tan, Y., Wu, P., Sutrisna, M., Cheng, J. C. P. & Hampson, K. (2017). Trends and Opportunities of BIM-GIS Integration in the Architecture, Engineering and Construction Industry: A Review from a Spatio-Temporal Statistical Perspective. *ISPRS Int. J. Geo-Inf., 6*, 397. https://doi.org/10.3390/ijgi6120397

[18] Sacks, R., Eastman, C., Lee, G. & Teicholz, P. (2018). B*IM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers*. John Wiley & Sons. https://doi.org/10.1002/9781119287568

[19] Shirowzhan, S., Sepasgozar, S. M. E., Edwards, D. J., Li, H. & Wang, C. (2020). BIM compatibility and its differentiation with interoperability challenges as an innovation factor. *Automation in Construction, 112*, 103086. https://doi.org/10.1016/j.autcon.2020.103086

[20] Zhu, J., Wright, G., Wang, J. & Wang, X. (2018). Critical Review of the Integration of Geographic Information System and Building Information Modelling at the Data Level. *ISPRS Int. J. Geo-Inf., 7*, 66. https://doi.org/10.3390/ijgi7020066

[21] Pedó, B., Tezel, A., Goethals, D., Koskela, L. J., Leaver, M., Victory, A., Vrabie, E. & Bocian, E. (2023). BIM and GIS integration: lessons learned from multiple case studies. *EC3 Conference 2023*, 4, 0. European Council on Computing in Construction. https://doi.org/10.35490/EC3.2023.248

[22] PR1 – Industry requirements on BIM-GIS training programs and courses. Birgit project. Retrieved from: https://birgitproject.eu/wp-content/uploads/2023/02/PR1_ Report-1.pdf

[23] Roumyeh, M. & Badenko, V. (2022). Integration between BIM and GIS for decision-making. *BIM Modeling for Construction and Architecture*, Saint Petersburg, Russia. https://doi.org/10.23968/BIMAC.2022.003

[24] Moreno, C., Olbina, S. & Issa, R. R. (2019). BIM Use by Architecture, Engineering, and Construction (AEC) Industry in Educational Facility Projects. *Advances in Civil Engineering*, 1-19. https://doi.org/10.1155/2019/1392684

[25] Song, Y., Wang, X., Tan, Y., Wu, P., Sutrisna, M., Cheng, J. C. P. & Hampson, K. (2017). Trends and Opportunities of BIM-GIS Integration in the Architecture, Engineering and Construction Industry: A Review from a Spatio-Temporal Statistical Perspective. *ISPRS International Journal of Geo-Information, 6*, 397. https://doi.org/10.3390/ijgi6120397

[26] Elsheikh, A., Alzamili, H., Al-Zayadi, S. & Shadhan, A. (2021). Integration of GIS and BIM in Urban Planning - A Review. *IOP Conference Series: Materials Science and Engineering*, 1090, 012128. https://doi.org/10.1088/1757-899X/1090/1/012128

[27] Wan Abdul Basir, W. N. F., Ujang, U., Majid, Z., Azri, S. & Choon, T. (2020). The integration of BIM and GIS in construction project – a data consistency review. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLIV-4/W3-2020, 107-116. https://doi.org/10.5194/isprs-archives-XLIV-4-W3-2020-107-2020

[28] Ismaeil, E. M. H. (2024). Asset Information Model Management-Based GIS/BIM Integration in Facility Management Contract. *Sustainability, 16*, 2495. https://doi.org/10.3390/su16062495

[29] Garramone, M., Moretti, N., Scaioni, M., Ellul, C., Re Cecconi, F. & Dejaco, M. C. (2020). BIM and GIS integration for infrastructure asset management: a bibliometric analysis. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 6*(4/W1), 77-84. https://doi.org/10.5194/isprs-annals-VI-4-W1-2020-77-2020

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