POLITECNICO DI TORINO

Master Degree in
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Master Degree Thesis

BIM and GIS approach for industrial plants

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“ As Humans, when we say “I”, we mean our memory. Memory is soul. If someone loses his memory, he becomes like a plant. He hasn’t got any soul anymore. We are our own MEMORY. ”

Umberto Eco

Thanks

To my parents, which teach me each day should be better than yesterday, Trust on my capabilities, knowing my future is brightened by understanding myself, and never stop learning, for all caring and supporting me in all my choices and decisions. To my siblings and friends which try to do their best in my ups and downs, always caring and sharing love. To Professor Anna Osello and Matteo who know how to bring out the best skills from people and trust the way of each step for growing, to all the DrawingtotheFuture which share their information and knowledge with me with kindness. Thanks to Monica and Salvo, which supported me like two close friends during all time.

The integration of Geographic information system (GIS) and Building Information Modeling (BIM) is a new trend in architecture, engineering and construction (AEC). BIM is used as an intelligent 3D model-based that has a benefit of semantic and geometric information, while GIS is a tool of geospatial-based for analysis and data management. The combination of these two software can improve the capability of several kind of 3D representation and mapped demonstration with the support of organizing information in the smart city and urbanization. However, in the wider perspective the location-based studies can improve managing urban planning, public health, and social science specially, accurate mathematical modelling is required for the analysis and simulation of each step of AEC industry, quality, cost, progress, safety, contract and information management, and coordination of various sectors in the different level of detail (LOD).

The potential prospects, opportunities and drawbacks of this interoperability should be evaluated from the function of analysis. During the last two years the attention of the BIM-GIS integration is rapidly increasing between engineering, construction building technology and computer science. In this field there is a lot of capabilities of contributing to urban analysis and integrating it to the building with real features and decision making. As a result, the performance of energy assessment simulation is shown the influence of energy saving in the large scale buildings.

Integration of BIM and GIS can be leaded at many levels, grouped relevant studies into five groups, schema-based approaches, service-based approaches, ontology-based approaches, process-based approaches, and system-based approaches. (Amirebrahimi) The benefit of existing 3D models in the comprehensive of 3D city model with the details of BIM into the large scale spatial analysis.

The following thesis is concerning the case of the factory which was commissioned by Giovanni Agnelli, designed by architect Vittorio Bonadè Bottino (1889-1979) was built in 2 years and a half. The building arranged on a single floor, which managing the production phases of the factory of via Nizza (Lingotto), the new factory for production of cars, aviation engines and metal smelting which was inaugurated by Benito Mussolini on 15 May 1939. At the end of fifties the spaces were not sufficient, the Mirafiori South factories built and the second half of the twentieth century Mirafiori became the symbol of Turin. Between 1980's and the early 21st century the factory suffered a serious crisis as well as in 2005, 300,000 square meters of unused surfaces have been purchased by local authorities to be transformed into a developed center that combines production, research and development (Citta di Torino, 2000).

It is located in the place where the Castle of Mirafiori built by the duke Carlo Emanuele I of Savoy. In 1908 first Italian airfield was built in the area that was Turin Mirafiori airport. The history that behind the building and the affected of the city can be compared to Detroit, where the Ford Plant exists. “A large factory in the past with the industrial history and too large area, the city must ask itself the question of what to do? It is difficult to imagine the future today and a deserted area can damaged Turin” says historian Giuseppe Berta.

ABSTRACT

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Acronyms index

BIM	Building Information Modeling
AEC	Architecture Engineering Construction
CAD	Computer Aided Design
UTM	Universal Transverse Mercator
GML	Geography Markup Language
GPS	Global Positioning System
KML	Key Markup Language
2D	Two-dimensional
3D	Three-dimensional
IDE	Integrated Development Environment
IFC	Industry Foundation Classes
WGS	World Geodetic System
ISO	International Organization for Standardization
LOD	Level Of Detail/Level of Development

Acronyms index

GIS	Geographic Information System
VIN	Vehicle Identification Number
RDB	Relational Database
RDBMS	Relational Database Management System
CD’s	Construction Documentations
FME	Feature Manipulation Engine
OGC	Open Geospatial Consortium
IAI	International Alliance for Interoperability

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Introduction

Nowadays the European cities are facing a morphological dissolution and functional transformation due to the deindustrialization process, which has begun at the end of the last century. The big scale Industrial plants play a vital role in the future of the city in economic development, energy saving and social life of citizens. Each project identified properties including unique geographical condition and building project which requires various kind of data and information in order to surrounding environment. The purpose of combining BIM and

GIS is to take advantage the abilities of each software in the worldwide growth of cities with the quick urbanization and climate change which these days is the subjective matter. An important debate is improving quality of life of present and future generation under the condition of urban life in which need an immense sources for technology and managing. It is going to characterize the progress of application of BIM-GIS integration in the AEC industry and the deep understanding of proposing potential of BIM-GIS qualification in the building plants. There is a various aspects are discussed of the architecture and the city, especially for the city like Turin in the present century. Paying specific attention to strategic planning of a project like Mirafiori in Turin and the plan making of a large-scale project with a more flexible variant land-use as well as importance of the scale, position and where activity and values located. As the matter of the fact a building is not just a volume, it contains users, function and paths, and it is surrounded by some context which gives all the lines, shapes, system, material, and son on in special meaning.

Studying the use of BIM/GIS 3D integration management of historical buildings and spatial analysis can improve decision making more convenient in the field of architecture and urbanization. If BIM was born for the construction process of the building, its potentialities and its functionalities have, in recent years, extended its use to the management of the whole life cycle of the building itself (Charalambos et al. 2014, Eastman et al. 2011, Georgiou et al. 2014, Volk et al. 2014, Amirebrahimi et al. 2016). Moreover, spatial information is necessary in a BIM system for environmental evaluation, resource organization, and safety analysis (Yau et al. 2014). The integration of BIM with GIS can help to create a broader vision in the management of buildings by inserting, and in GIS, all the additional spatial information that falls within the territory relating to the infrastructures, to the sub-services and in general to all the buildings that exist within the area (Ebrahim et al. 2016, Irizarry et al. 2012, Isikdag et al. 2008). Accessibility of the information and open data in order to efficiency is important in the field of architectural and energetic, which concern more in this topic from the state of the consumption of the building in its life cycle and identify the features from model into the city.

The Mirafiori as the case study in Turin is the symbol of motorization of Italians, is 80 years old. There are millions of cars produces which some of them have become iconic. The building arranged on a single floor, which managing the production phases of the factory of via Nizza (Lingotto), the new factory for production of cars, aviation engines and metal smelting which was inaugurated by Benito Mussolini on 15 May 1939. At the end of fifties the spaces were not sufficient, the Mirafiori Sud factories built and the second half of the twentieth century Mirafiori became the symbol of Turin. Between 1980's and the early 21st century the factory suffered a serious crisis as well as in 2005, 300,000 square meters of unused surfaces have been purchased by local authorities to be transformed into a developed center that combines production, research and development (Citta di Torino, 2000).

The development of BIM-GIS workflow in data interoperability with the focus on their schemas in different sources which linking and concern the capability of each software to combine into a project for a definite goal for the case study. The different format like industry foundation class (IFC) and geography markup language (GML) can be joint to find a common data management for industrial section in the city. In this case the using of safe software data integration platform (FME) is supporting for spatial data and connecting systems, transform, and workflows. The approach of industrial infrastructure with the implementation of geographical planning by using the tools between BIM and GIS can allow to get an appropriate purpose of visualization in geological data of calculation and estimation large amount of time and effort which can be more accurate compare to traditional method.

The first part is about the problems and challenges behind the city of the case study, and the second part describes the workflow, that created a parametric model of building in Revit Autodesk software, then integrate it into 3D GIS-based with the ArcGIS Pro software with its errors and problem solving for well-develop of spatial analysis.

Chapter One

Case study

Few places are more representative of the modern Italian identity than is Mirafiori that can be considered the highest model of industrialization founded on the great factory that has perhaps pursued more than a century. A sort of mythical place of the Italian proletariat and of its struggle: the ideology of «worker centrality» has declined all its illusions, its hopes, defeats, projecting it into the background of a company town (Citta di Torino, 2000)

To make way for the factory the 'Generala estate' was partly sacrificed and the already mentioned stable built by Gualino was demolished between 1935 and 1936. The gigantic development of FIAT Mirafiori, which is linked to the birth of other industrial settlements such as the Carello lighthouse factory, has affected the entire surrounding area, transforming the area, especially between the 1960s and 1970s, into a real city. The centrality of the factory for the life of the neighborhood is also evidenced by the fact that some important streets of the district recall the pioneers of the automotive industry. In addition to Corso Giovanni Agnelli, founder of the company FIAT in 1899, the Via Biscaretti di Ruffia is dedicated to the scholar, journalist, humorist, and model maker who began collecting vehicles, memorabilia and documents in 1932, giving life to the first nucleus of the Automobile Museum (Citta di Torino, 2000).

Mirafiori south happens in other districts of Turin, does not lend itself to traditional walking. The extensive courses, the more recently built roads, and the housing complexes that testify to the industrial vocation of Turin impose faster means in harmony with the times. The inhabitants of the area have long since rediscovered the pleasure of riding the streets of the neighborhood by bicycle, thus reviving a tradition that has roots in the past. In 1931 Silvio Schierano had begun to build transport bicycles, giving rise to an activity then continued by his inheritors with patented products.

Today there are numerous shops and bicycle repair shops in the Mirafiori area. And yet until the second half of the nineteenth century this area was rather far from the city, as defined by the 1853 customs law. Except for the historical complexes, there were large expanses of agricultural areas interrupted by the farms built by noble families linked to the court. Before the construction expansion of the second post-war period took place, which radically changed its appearance, the district was the destination of the Turinese out-of-town trips that spilled over the meadows until the early years after the Second World War. The reason that the population increase from three thousand after World War II, reaching in the years of maximum expansion to sixty thousand, to forty thousand nowadays.

Mirafiori District

Entering the Mirafiori area from “Corso Agnelli” to then join the “Corso Unione Sovietica”, we find the FIAT plant which covers an area of about three million square meters of which half is covered, built on the area of the stables of Gualino(). The project of the building, which is a typical example of “Novecento “ style architecture, distinguished in its results by the FIAT Lingotto otherwise well inserted in the structure of the urban context, presents both traditional aspects and innovative aspects.

Continuing beyond the FIAT factory, you will go along the Città Giardino residential district, of which the original project in the Deco style has remained scarce evidence. Over the years, housing units belonging to different architectural typologies have been added to these and, in recent decades, entire residential districts, now fully equipped and therefore autonomous. At the same height, but on the opposite side of the “Corso Soviet Union” the aforementioned Villa Scintilla still offers, at the bottom of “Via Farinelli”, a well-preserved example of the appearance of the place at the beginning of the twentieth century (Citta di Torino, 2000).

Bending along the Drosso district, in the opposite direction to the one leading to the castle of the same name, we then return to Corso Unione Sovietica to continue along the road to the Mirafiori castle. Along the way you will find some memories of the past of the village, the Balbo farmhouse (former Cassotti farmhouse) which is located inside the Piedmont park and, next to it, the Visitation church with an neighboring convent restructured after the 1980 earthquake on designed by the architects Gabetti and Varaldo, the Margherita di Savoia nursery school of eclectic neo-Romanesque style, which was built in 1901 by Gastone di Mirafiori, son of the “Bela Rosin” on the grounds of the ancient palace (Citta di Torino, 2000).

On the opposite side of the road, towards the interior, there are some remains of the old village with the characteristic low houses. Continuing, we reach the mausoleum of the “Bela Rosin” for which a preparatory renovation project was approved. At about the same height the park dedicated to Gustavo Colonnetti, professor of mechanics and physics at the Polytechnic, of national and international reputation, died in 1968. It is a large expanse green area (326.000 m2), rich in fauna and flora, now the subject of interventions that intend to enhance all its potential, also recovering the ancient hunting routes they pushed up to Stupinigi. (Citta di Torino, 2000)

In addition to the insertion of new plants, there are areas equipped for children's games, visitors' stops, which are more used by residents of the area, and the distribution of material naturalistic Next to the Colonnetti Park there is the CNR institute of metrology and the national electrotechnical institute Galileo Ferraris, to underline the value of the future science teaching (Citta di Torino, 2000).

The "Via Artom" delimits the extension of the park, which has become almost synonymous with social housing aimed at solving precarious housing arrangements. The large housing complexes that sprang up throughout the surrounding area during the second half of the 1960s and which gave rise to the already mentioned M 22, M 23, M 24 districts mark an urbanization model forced, linked to a particular historical period. Socio-cultural aspects and problems connected to it have also involved literature and cinema, for example, we recall the novel by Nanni Balestrini We want everything, and the films Da Trevico in Turin directed by Ettore Scola and La ragazza di via Millelire by Gianni Serra, set in the homonymous street in the neighborhood. Walking and shopping are not the attractions of Mirafiori Sud. According to the new patterns of living and living in working-class neighborhoods, purchases are made mainly in department stores and markets (Citta di Torino, 2000).

The FIAT Mirafiori complex, subject between 1958 and 1970 to successive enlargements, is also important for the history of the labor movement: around this establishment, which has become almost the symbol of the conflict between advanced industrial capitalism and a working-class of a new kind, the struggles of the warm autumn developed between the late 1960s and the 1970s.

Mirafiori and its Economic Challenges

Mirafiori, as the new Fiat plant of the Lingotto in the 1920's representation of the rational industrial design, an order recovered and consolidated after the great growth in capacity productive occurred with the First World War and the violent social conflicts that had succeeded to it. Mirafiori was not born as a factory-manifesto of Italian industrialists. On an area of one million square meters there was a plant for the production of automobiles and aviation engines and the casting of cast iron and metals.

The front of the buildings extended for 500 meters and their length for over seven hundred. Below them a grid of 7 kilometers of tunnels departed around, railway tracks branched out for a total of over 11 kilometers. Next to the plant there was a test track of two and a half kilometers. Titanic dimensions of a productive organization that abnormally exalted by the 41,000 meters of water pipes intended to ensure a daily consumption of 26 thousand liters), from 70 thousand meters of pipes for compressed air and heating, from 85 thousand square meters of glass used to create lighting workplaces (Berta, 1998).

Everything had been designed to concentrate a working mass that no Italian factory had ever welcomed: 22,000 workers spread over two shifts. Finding even the way to mention the soul of Turin « as the essential elements of the success of the company, alongside the genius of Agnelli ». But he did this by following the "industrial Piedmont of the early "novecento" to the "derivation of military Piedmont organized and tempered in the sixth and eighteenth centuries", to enhance the feature of the "piedmont discipline" over the modern economic value (Berta, 1998).

It would seem that Mirafiori was raised first and leading to give shape to an environment capable of growing the workers' living conditions and enhancing their sociality, before to jump the industrial growth. The factory was justified in furnishing for the luminosity of its departments, well heated in winter and ventilated in summer, for showers with hot water, for the large refectory where they could eat together ten thousand people, using food warmers and refrigerators, noted "Gromo", for the park that was to build, with the stadium, the swimming pool, the bowling alley, the track for scooters and the fields for tennis, Everything had been conceived (Berta, 1998).

Between 1940 and 1945 the war economy, certainly not conducive to strengthening the industrial framework of the industry, threw the factory into chaos. First the conversion to the realization of armaments and war material and then the period of German occupation, with the parallel and underground activity of the resistance, they had to disarticulate its functional scheme, transforming it into a universe held together fundamentally by the search for a possibility of survival.

Both the workers and the top management saw in the continuity of the factory structure the guarantee of a condition of support exposed by the constant harshness of the time of war, with the dominant atmosphere of threat that it forced, through the diktats of the Nazi occupier as through the bombs of the English-Americans or the sheer daily battle to secure the vital minimum of supplies.

Mirafiori was the most powerful engine and the most visible center of the burning industrial modernization of the country. Those who, in the Turin of the early Twenties, had been impressed by the principles of organizational rationality codified in the Lingotto plant they had not been able to perceive how the production standardization stage of the new plant was; Moreover, the Lingotto was evident that is the most qualifying example of the organizational progress of Italian factories. This meant that the plant world continued to be characterized by highly common and effective procedures and methods. Mirafiori is still a crucial part of this story, without being the principal lead anymore. Certainly, it remains unique in its dimensions (its district now houses a working population of over twenty-five thousand workers), but those who visit its production organization cannot avoid the difference with the past. Along with the way of working and changed the entire nature of the factory, starting with the workers, often men and women over middle age, arranged along a production cycle that has nothing left of the crowded and noisy assembly line (Berta, 1998).

Despite the imposing proportions inherited from a story that runs from session year Mirafiori is a work environment more similar to the many others on which the homogenizing imprint of the information revolution was printed. It remains the largest factory in Italy, but its destiny is now more than ever tied to the prospect of European industrialization.

Mirafiori immigration impacts of the city

Turin has dealt with a social and economic change since the 1950s the city has distinguished itself like a company town. There were a lot of efforts to restructure the industrial urban plan and rethink urban improvement. The development of the city was destined to continue for ten years almost 1,200,000 inhabitants, and then to decrease massively during the 1980s and 1990s, 35 percent of the total population of Piedmont ended up being concentrated in a metropolitan area no more comprehensive than 2.5 percent of the regional territory. As has often been said, Turin was not prepared for this huge changes (Berta, 1998).

At the end of the war, it was a city of six hundred thousand inhabitants proud of its industrial identity, but certainly unaware of having to take into account, due to the acceleration of development, a change that had to adjust with territorial and social boundaries, also the conception and representation of it. From the mid-Sixties, Turin began to fallen characters and to lose its attraction but still refined of Italian modernity (Berta, 1998), buried under a migration so large that the original roots become irretrievable.

At the same time, the city was beginning to show its vision and ready to discriminate socially. In the longer term, Fiat played a vital role in these change, the emigration that took place in the fifties and early sixties has the features of an individualistic mobilization. Sixteen thousand workers in 1953, eighteen thousand in 1956 twenty-one thousand in 1959, thirty-two thousand in 1962 and then the great leap to over forty-six thousand at the end of 1967, this is the progression of the Mirafiori numbers, the growth-notes by Stefano Musso, the author of a particular sociographic survey of Mirafiori workers through a constant trend, periods of containment (1951-54, 1958) alternated with others of strong recruitment of labor, such as 1955 and 1959, which recorded an increase of between 15 and 20 percent of the workforce. However, the peak in recruitment occurred between 1961 and 1963, when approximately twenty-two thousand new workers were hired, almost all of them were young (Berta, 1998).

It was such a huge influx that it changed the expression of the factory was strengthening, as Musso writes: “The great transformation was concentrated in just four years, at the end of 1958 still made up 47 percent of the workforce, in 1962 they had fallen to 25 percent”. The numbers reflect the waves of migratory movement that Turin took as its destination.

Between 1951 and 1971, the population of the city and the twenty-three municipalities that formed its principal area doubled (Berta, 1998).

In the ten years between 1951 and 1961 the resident population of the Piedmont region grew by 42.6 percent, crossing the threshold of one million inhabitants in the anniversary of the unification of Italy was celebrated. In all, about 440 thousand people had arrived, more than one third of them had left, but among Italian cities was the highest migration rate (Adriana Castagnoli).

At the peak of its development, Mirafiori became a homogeneously strong creation because of a precise corporate directive in the hiring system, and because it was central in immigration the number of young adult males and also in the families of workers performed to support the whole family. On the side of the professional classification, the new workers were massively involved in the third contractual category, that of the "specialized laborers", that is, of the common workers assigned to the assembly or in any case to the mass production. At least three of the four rations machinery at Mirafiori were part of this group, says Musso, leading to a quantitative authority that necessarily took away the inspiration of that ethos founded on the mastery of professionalism and trade of the workers' movement of the industrial triangle. In fact, for a long time, it seemed that a work position poor in professional content was the matrix of the subordination of newly formed industrial workers to the policies and promises of admiralties. In reality, that concentration of men, affected by job's income, and age in a full production environment, was preparing together with the deterioration of the quality of urban life caused by the migratory spiral, the great confrontational explosion of the late 1960s, and continues with one of the areas such as the Vallette, to point out the urban decay to which it is subjected without a master plan of Turin, where the ancient Savoy center capable of the enlightenment but still a sorrow reflection of corruption happened (Berta, 1998).

This growth also meant environmental contamination (Prat, Mangili 2016). The huge flow of migrants and the demand for housing and services overwhelmed Turin's municipal authority, which adopted a laissez-faire attitude, thus giving free rein to property developers (Pinson 2002; Winkler 2007). For instance, residential developments that were mainly intended for workers were located in the peripheral areas surrounding the factories, mostly with sub-

standard housing and limited access to basic amenities. The workers generally lived along an axis from north-east to south-west, while the professional classes settled on the eastern side of the city and in the hills.

This axis corresponded to the railway tracks that divided the city into two parts and which played a key role in freight transport of the surrounding factories. Likewise, urban agglomeration grew around the city of Turin in several rings of bordering municipalities along the main communication routes, thus creating a monocentric shape. As in other "mono-industrial" cities, Turin's economic model has declined since the 1970s due to several causes, such as the energy crisis of 1973 and deficiencies in the Fordist model (Bagnasco, 1990)

Figure: 1: Mirafiori 1942

(https://www.panorama.it/economia/lo-stabilimento-fiat-mirafiori-compie-80-anni-storia-foto)

From a local crisis to an urban renaissance

In the mid-1990s, the city of Turin counted 2.5 million square meters of brownfields and its identity was wavering. However, it took several years for local politics and local society to change their perspective and accept the idea that the manufacturing sector could not remain the city's only driving force. The city and its local actors had to deal with a frail political system (Bagnasco, 1986), a weak cultural scenario (Bagnasco, 1990), and economic transition. There was limited capability to negotiate and create relations between industrial and political actors, but also a lack of management skills and administrative know-how within the political class (Berta, Chiamparino, 1986).

"In the 1990s, several political changes affected the national and local scene. Firstly, a notable unprecedented political crisis impacted the whole national system, resulting in several arrests for corruption – so-called Operation Clean Hands (Mani Pulite or Tangentopoli) – the collapse of public finance and the delegitimization of the traditional political party system (Bagnasco 1996). Secondly, Law No.81 of 1993 introduced the direct election of mayors by citizens. This reform increased the power of mayors, compared to the previous system, and allowed them to appoint their own executives"

The new political framework introduced an innovative urban agenda with the aim of fostering systemic change and a new image for the city (Vanolo, 2015b).

Italian public authorities had to deal with the new political and institutional framework: Turin, Milan, Rome and Naples, marked by political discontinuity, had to restructure their urban agenda and forms of urban development (e.g. the end of Fordism, management of dismissed industrial areas, strengthening the knowledge economy and solving infrastructural issues) (Amato et al. 2011). In Turin, the new administrator, and the hardness of the industrial crisis authorized leading local actors, that is to say public, private, cultural, economic, academic and entrepreneurial. They met around the mayor's table to improve relationships with neighboring municipalities: the Province of Turin and the Piedmont region. They also promoted a new urban renaissance (Rossi, Vanolo, 2013).

All the stakeholders were involved in the debate with a common goal: renew production goals and create more advanced social and territorial balance to compete with other European

cities (Belligni, Ravazzi 2013).

A decade later than other municipalities (Harvey 1989; Scott 2008), Turin discovered territorial marketing and the promotion of local heritage, developing communication to improve its image. The European Union was also part of the game, granting new learning opportunities and resources through urban renewal, economic and social programs. Innovative industrial activities (electronics, robotics, telecommunications, etc.) started to locate in the Turin area, moving towards the "knowledge economy" (Conti, Vanolo 2003), an acknowledged trend worldwide (Scott 2008). The new urban agenda presented contrasting elements and resulted in a combination of both social-centred and market-centered policies according to the public finds available over the years (Belligni, Ravazzi 2013).

All of this challenges for being focused on new technology and research of industrial activity and entertainment for enhancing social requires and making better the inequities which happened during the fast growth. The first step was working on the master plan which approved in 1995 in order to new analysis of urban regeneration programming from 1997 (with the new trends of the European structural funds) and the strategic plan. The Urban Master plan and somehow the land-use plan was the promoting of economic development and social policies of supporting role for the renewal of industrial sites.

The focus of zoning framework and infrastructure planning to achieve the aim of managing modernization and declining the city in order to adding railway stations in the big scale projects and connecting the city with subway line, which divided it in two parts. The plan considered this an extensive renewal project, but the financial crisis, bureaucratic procedures and expensive decontamination works have gradually reduced and modified the original idea.

In particular, the unexpected costs of polluted soil decontamination justified the increasing number of shopping centers and housing. Thus, the plan effectively removed industrial areas from the city, while the supply of new industrial areas reached 30 million square meters in the province municipalities and, in particular, those in the first belt (Davico 2009).

The plan set a framework for existing and projected recreation projects, with a willful cross-sector key to execute it. The points of the plan suggested an economic recovery based on promoting culture and tourism, also as a decision of the progression of mega-events, such as the 2006 Olympic Winter Games. The Plan's vision for the future was based on three theories: to be on the European scene, to improve competitiveness and innovation, and to enhance the quality of life. The general implementation of these strategies and projects have been supported by the political unity of administrators.

Chapter Two

BIM: Building Information Modeling

Building information modeling, (BIM) is a digital 3D representation of functional and more important physical characteristics of resources and creating facilities for knowledge information and decision making from the beginning, life cycle and demolish period of a building. Moreover, about all of this information the realistic model of data, financial, planning, logistic, environmental and geometric/graphical in the base of 3D model can be considered as an organization which produce information of decision making in many aspects.

Digitalization of information in architecture, engineering and construction (AEC) can be shared around the team and stakeholders, the way of producing the information for simulation and report can make the process accessible and simple the idea of understanding the project information flow, reduction of waste and risk, saving of time and effort. This is the eliminating of all potentials issues in the virtual environment before actual physical construction starts which all the clash detection strategies and construction problems can be solved. Living of digital lives could give us this possibility of digital information modeling environments, even it could be managed by different kind of building stage lifecycle, not only in 3D geometry, we would have a financial data model, maintenance, analysis and so on.

As early as about 1970 Nicholas Negroponte, at MIT in the USA, was talking about digital architecture. This is not new technology. Perhaps the most notable recent example of BIM technologies in an adjacent industry is the design, production and manufacture of the Boeing 777 airliner. Boeing assembled their supply chain in a digital environments to design, test and construct the aircraft (Eynon, John 2016).

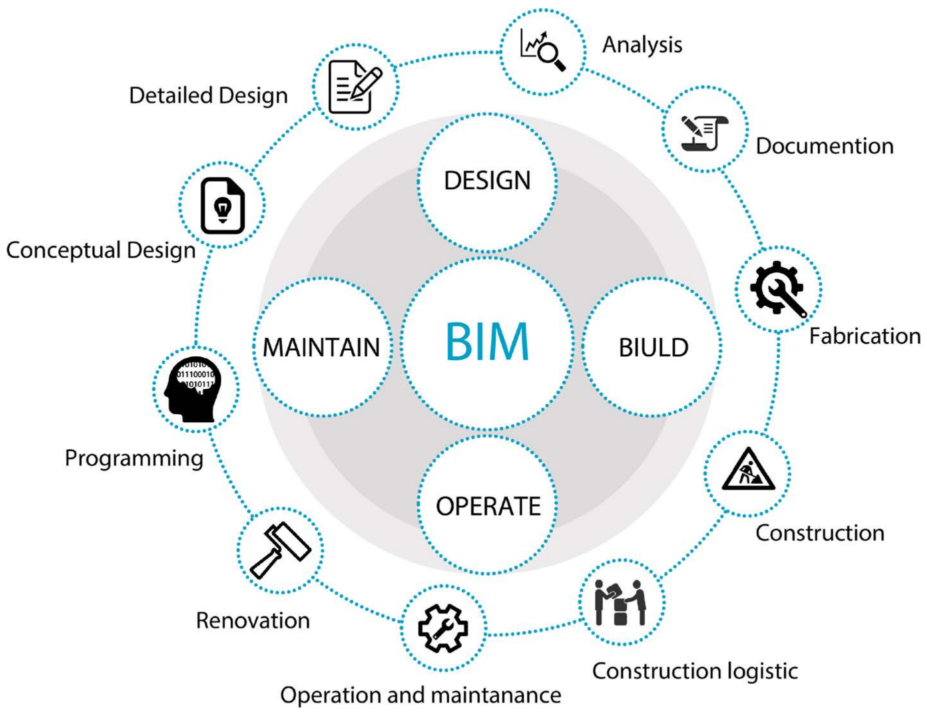

Figure: 2: Integration of BIM between various project's area

Visualization is one the most common aspects of the design model, using of cameras' view with different height around and inside the building can be useful for explaining the aim and future goal of the project. It should be added that BIM is more than a 3D modeling is about a creating, maintaining of information at each elements in the field of efficiently, environmental and lifecycle in a digital form. In the discussion of federation approach of BIM for the possibility of model making by different software in the use of packaging which will managing clash detection and visualization, like IFCs to use import a model into another format but it should know the report of how is successful can be this interoperability.

BIM and Infrastructure

Apart from dimensional using of BIM something that can be more precisely is the infrastructure side of application which is common syntax between vertical and horizontal assets in developing classification of understanding and use of BIM grows. It is perhaps unfortunate that BIM (Building Information Modelling/Management) includes the word 'building' and that much early discussion on BIM has concentrated on its use for design of 'buildings'.

If it is needed to realize the full benefits of BIM then its utilization needs to be seen in a much wider context, and the term 'building' viewed as the verb 'to build' rather than the noun 'building'. If we understand 'infrastructure' to be the physical structure needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function, then it is clear that 'buildings' are a subset of infrastructure as a whole and infrastructure gives the overall built environment context.

The often repeated adage that infrastructure is the horizontal rather than vertical aspect of the built environment is grossly incorrect and distinctly unhelpful in our implementation and use of BIM. Furthermore, linking infrastructure to just the civil engineering aspects of construction limits the application and use of BIM in the built environment. Infrastructure is the setting for the whole built environment and not just roads and railways (Eynon, John 2016).

With the conscious of interconnected the building with surrounded and entire interaction of environmental context and condition, rather than it is not necessary to start a new project with new assets, it can be started with existing assets and demands for improving its performance. This approach is supported the strategies of decision-making and data management which is not significantly resistance for those that have to fit into existing infrastructure.

To define of the landscape or also modify the existing landscape in many cases are needed survey and topological surface environment, geographical or prediction model. To modify geographical challenges accurate information modelling is required for measure quantity and performing of assets and volumes. All the components are affected by a wider network which is outside of the building which is connected to the site and underground assets with

a clash potential for the serious risks of existing facilities. While infrastructure has discrete components, these are often networked and continuous, requiring segmentation. The network aspect is important as it gives all components context, and actions on one element can impact others that are remote but connected.

A good example is track possessions for railway work or traffic diversions. In some disciplines, these networks are expressed as schematic diagrams rather than geometrically correct representations. These representations of components need to relate to the real world ones and connect to the same data. Typical of these might be signaling schematics.

Many deliverables are defined as polygonal features, such as land ownership, noise contours, planting, drainage and catchment areas, ponds, and environmental protection areas. Some of these component features are required for project delivery but are not physical objects as such, rather geographic features that hold essential delivery and permission information such as might be required during public participation exercises, environmental studies, traffic or water flow modeling, or simply for gaining access (Eynon, John 2016).

Infrastructure projects belong in features of the landscape including geography, landform, environmental, geological, utilities, and so on. While it can call it mapping which is essential segments of a foundation of BIM elements. Usually described as Geospatial Features in GIS, they are members of the model. Additionally, to make it more complex, some of these features are changeable that is they vary with time and conditions. While buildings do have to deal with the sever concerns, they are usually more a matter of preparation and authorization, introducing these infrastructure roles into BIM in understandable but not quite has a comprehensive base.

BIM Interoperability

The interaction between various software is the most commonly used method for collaboration in building projects, results and data interfaces, different formats, and inefficient collaboration. Industry Foundation Classes (IFC)-based data is expected that take place between heterogeneous BIM software. However, using IFC always has its analysis issues in the process of data in architectural, structural, MEP models to belong in fundamental causes of interoperability which cannot well interpret elements or objects of disciplines due to different domain knowledge.

It should be added that the consistent model data represent the same geometry, properties, and relation of the exchange and sharing, but it could use IFC- based BIM program for adjusting the bidirectional stage for receiving a proper outcome. As building projects become more complicated, the traditional method hardly meets the increasing needs of data sharing and exchange. For this purpose, BIM technology was introduced based on the concept of creating, storing and managing a great deal of information throughout the building lifecycle in an integrated way (Eastman et al. 2011).

BIM software tools from different disciplines are widely applied to building projects (Liao, Teo 2017). Due to multiple disciplines, data sharing and exchange between diverse software tools become an inevitable need, and a public and rich data format is necessary for data interoperability (Tolman 1999; Ramaji, Memari 2018).

Consequently, the IFC schema was developed to support data sharing and exchange. According to a non-exhaustive survey, over 200 software tools have import or export capabilities of IFC data models (BuildingSMART, 2013). After two decades of development, IFC has become a de facto standard for data interoperability between heterogeneous software tools (Olawumi et al. 2017).

Interoperability is the most promising potential of BIM and the basis for its development extensive. This occurs when BIM is understood and integrated as a design protocol and as a workflow management tool, providing support for the entire construction process. A fundamental requirement for the integration between the various contractors involved in the design is represented by the quality of the information contained in the model BIM. Therefore,

it needs to have a standardized arrangement to determine the best information content.IFC schema acts as a medium for bidirectional data sharing and exchange between heterogeneous software. Sometimes software tools require data models from other disciplines to fulfil their business tasks, and it inevitable that software tools import the required models created by other software. Subsequently, these imported models may be re-exported as new IFC models for other business tasks. For example, a structural engineer imports the architectural model for structural design and analysis, and then exports a new model to the architect for collaborative design. However, when the IFC data format is used for BIM interoperability in practical projects, interoperability issues (Kam et al. 2002; Oh et al. 2015; Taher 2016).

Each elements in IFC schema has its own rule which can make a managements of imported and exported in IFC different levels and formats under specific subset. LODs have been created to express the level of development that the model information must reach according to the final requirements. It should be added that “level of details” is different which refers to only graphic detail of the element which will explain more in chapter 4.

IFC Certification

BuildingSMART adopts IFC 2x3 Coordination View V2.0 as a benchmark template to validate the IFC import and export capabilities of software tools. To date, 30 software tools have been certified for IFC import, 23 tools for IFC export, and only 14 tools passed both import and export certification (BuildingSMART 2018).

Numerous software tools still need to pass the official certification for the effective support of IFC models. Furthermore, the IFC export certification can be divided into three aspects: architecture, structure, and mechanical, electrical & plumbing (MEP) (BuildingSMART 2010).

The official IFC certification process includes two steps (Lipman et al. 2011). Step 1 includes a range of object-level models, such as beams, columns, slabs, and walls. Due to the building complex, it is impossible for software tools to test all objects, so the most common objects are selected to test in the certification process. In Step 2, two or three project models, composed of most objects in Step 1, are used for further certification. The certification process is largely limited to "standard objects" (Kiviniemi 2008).

Open standards and workflows of the IFC tool may not support all the transfers and proves the variety of knowledge that transfers through the method this is the strength of evolution attempt to examine here to advance the capacity of relating to data exchanges. In the prevailing manufacturing become an attempt for obtaining the plan for decreasing obstacles and increasing the strength to use complex software tools for improving different kinds of inquiry principles visual review and some explicit critique tools throughout the advantage of utilizing application tools. Some researchers (Sanguinetti et al. 2012; Oh et al. 2015) point out that the cause of such issues is the incomplete mapping between software native models and IFC models. Hence, the quality improvement of IFC interfaces in software tools is recommended. Additionally, other researchers attempted to study how to improve data interoperability in specific domains. Karan and Irizarry (2015) extended the interoperability across the geospatial and BIM domains by using semantic web technology and ontologies of construction operations.

Ramaji and Memari (2016) developed an interpreted information exchange method to interpret the structural analytical model from the architectural model. Kim and Yu (2016) proposed a segmentation process to divide curved walls in IFC models into segmented straight walls for building energy analysis. Hu et al. (2017) utilized several solutions, such as the logic chain and a transformation algorithm from BIM to Geographic Information System (GIS), to promote interoperability between MEP-based documents and intelligent MEP models (Lai, Deng 2018).

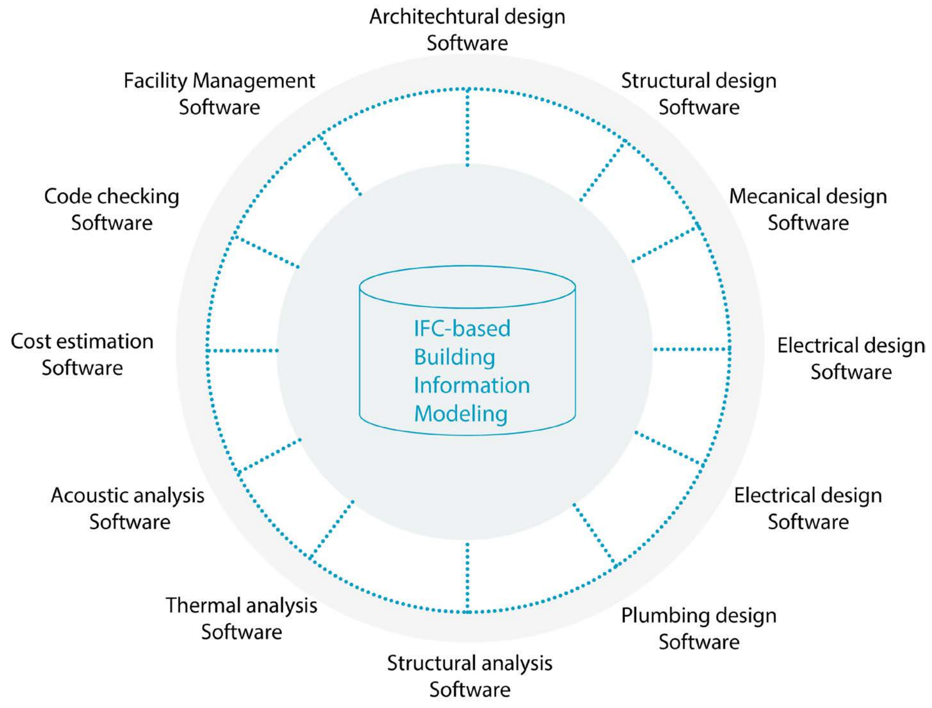

Figure: 3: IFC-based interoperability

Chapter Three

GIS: Geographic Information System

A geographic information system (GIS) is a computer program mapping to make software packaging, with a productive entity, created to support the resolutions, such decisions strength act like a simplistic and short-range as preparing an effective method to receive location addressing. Moreover; it can be more complicated like designing a light system for a city or describing flood plane, which is more intelligent for city obstacles. Geographic information systems are converting all the actions and developments that already adopted maps as the data foundation, with

the form of points, lines, and polygons. Most fields of human effort have extended affected by the digital network, accounting, statement taking, environmental abilities, and information in which all the spatial data are referenced to the earth and contained all the procedures of the site's place.

Working with symbols and numbers in the planning background that are easily switched to the other programming language that the computer understands. The spatial disciplines such as geology, planning, and land use management, that is connected with a chart, while maps also use symbols, a figure for each same as, navigation, resource allocation, lighting, and so on. Managing how to efficiently represent the real-world environment and keep all this information then developed complex data formations and efficient performance to describe the detailed environment, shapes, and real-world location of geographic features. The application of geodesic knowledge caused specific variations in the coordinates of that possible object which is relative to the latitude-longitude, which can use GIS as a powerful tool to make the analysis geographical data for making maps.

The problem is much easier than it might be, because the maps provided cover exactly the same area, have the same underlying assumptions regarding the shape and size of Earth, are at the same scale, and use the same projection of Earth's sphere onto the flat plane of the map. These benefits are often not available in the real world, where you frequently need a considerable amount of data preparation to solve such a problem (Kennedy, Michael 2013). For the imagination of solving the problems traditionally or using computer-based GIS of what is existed on Earth's surface or the flexible or movable activities is a big difference, Working with GIS has remarkable related characters like Coordinate systems, latitude and longitude, geodesy, geographic projection, scale, projected coordinate systems, UTM and state plane, physical dimensionality, global positioning systems, remote sensing, rational databases, and so on. Among the uses of GIS might be:

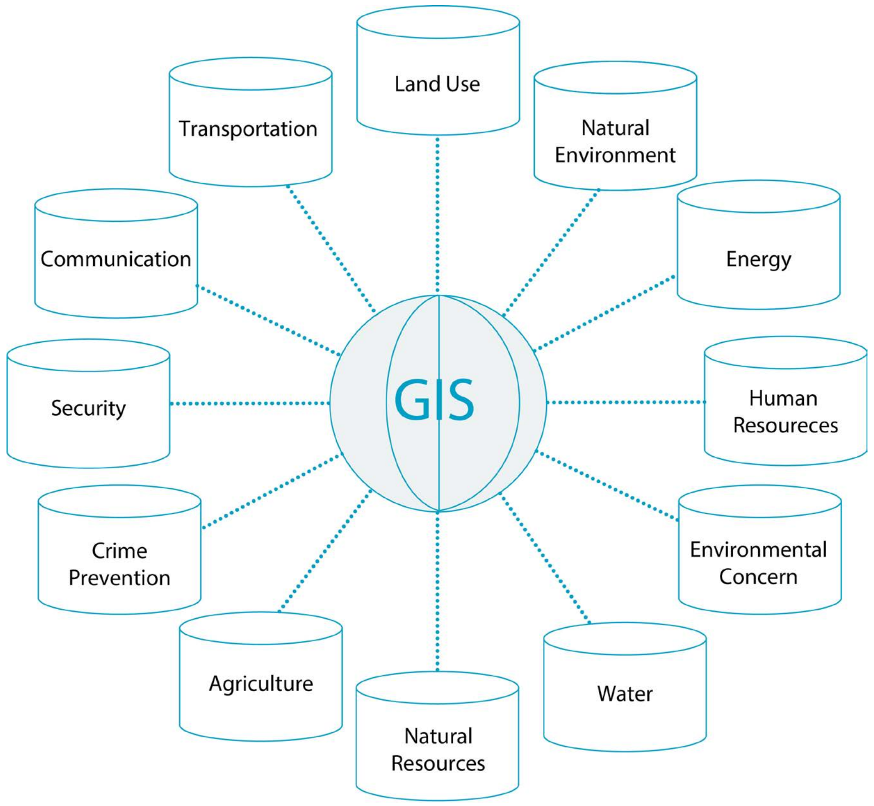

Figure: 4: 3D-based interoperability

The land advantage gives us the capability of zoning, analysis of environmental impact, location, and site analysis. On the other hand, the relational energy consumption in

determining the cost of energy and the investigation of different allocation schemes, reducing waste, and heat pollution for environmental impact assessment, distribution lines facilities, and development can be so beneficial. GIS plays a crucial role as a database in developing zones management, and urban planning.

Management zones represent the proper management and requirements in the specific area, providing a framework for an automated monitoring system that will appropriately classify modifications in conditions in order to spatial relationships. The geographic features allow the comparison of different types of data and connection of it with attribute data which has the information about spatial data inside by referred to the earth.at first glance where the project located, coordinate system, latitude and longitude, and scale, projected coordinate system, UTM and state plane, GPS and remote sensing then the relational databases in these aspects of GIS is important.

Coordinate System

It is a method that can be determined anywhere the point is located which in two-dimensional (2D), and three-dimensional (3D) space. Latitude-longitude is a reference enveloping in the globe based on the spherical coordinate system which is for the intention of Earth location issues demanded of navigation. It is called the coordinates of the point in which contained x-y planed which passes through Greenwich and the geometrical spherical coordinate system is explaining the source of the point, level and positioning. Three numbers qualified the parameters of the earth and surface that can be matched with the GIS data and combined with its standards. Many objects of the ground do not move to a position, therefore, this is the fundamental principle of geography and GIS, the object that is located on the earth belongs to that point which explains as three numbers, latitude, longitude, and altitude which classified the location, it is related to one spot distinct number and the characteristic of every single point from the earth's curves to a flat surface.

Figure: 5: World map in two-dimensional (2D) canvas

We should consider the human scale correctly, the earth is curved and it should be understandable for making it straight with the right measurement. Another barrier is that we should also describe the coordinate system in an irregular shape, it has ups and down with a shape of a sphere, mapping Cartesian coordinate systems is for defining that.

We should apply even the measurement and the shape of the earth which is sophisticated

from the position estimation and position changes during the time. Coordinate is working with numbers and describe the location that has x and y values or z values. This one can make the address unique with a set of measurements.

This is so important to know coordinate is dependent on a translation points from curved earth to a flat map, the coordinate has a point and calculating everything from that point so we have so many different choices which call it benchmarks for establishing location point. This is different kind of x and y coordinate due to the measurements on the earth for the spatial relationships between the other measured points.

Satellite and other observations are used by geodesists to develop geoidal models. These

Figure: 6: Eastern Hemisphere

Figure: 7: Western Hemisphere

support a series of geoid estimates, for example, by the U.S. NGS with GEOID90 in 1990, with succeeding geoid estimates in 1993, 1996, 1999, 2003, 2009, and one planned for 2012. These are called models because we measure geoidal heights at points or along lines at various parts of the globe, but we need geoidal heights everywhere.

Equations are statistically fit that relate the measured geoidal heights to geographic coordinates. Given any set of geographic coordinates, we may then predict the geoidal height (Bolstad, Paul 2016). A useful datum must include a set of points and lines that have been painstakingly surveyed, and that may be used as the starting points for subsequent, detailed, local surveys.

Some authors define the datum as a specified reference surface, and a realization of a datum as that surface plus a physical network of precisely measured points. In this nomenclature, the measured points describe a Terrestrial Reference Frame. This clearly separates the theoretical surface, benchmark reference system, or datum, from the terrestrial reference frame, a specific set of measurement points that help fix the datum. While this more precise language may avoid some confusion, datum will continue to refer to both the defined surface and the various realizations of each datum (Bolstad, Paul 2016).

The datum described as the World Geodetic System of 1984 (WGS84) offers the most recent, widely accepted view of where the center of the Earth is, its shape, and the location of its poles. The ellipsoid of WGS84 is virtually identical to the GRS80 ellipsoid. In the coterminous states of the United States, this datum is virtually identical (within millimeters) to the North American Datum of 1983 (NAD83), although they result from different approaches and calculations. According to the WGS84 latitude-longitude graticule, the object previously described would be at latitude 38.00007792° and longitude 84.49993831°.

The difference might seem insignificant, but it amounts to about 10 meters on the Earth's surface. Or consider it this way: According to NAD83, a second object placed in the ground at 38° N and 84.5° W would be 10 meters away from the first one. Given a latitude and longitude, a GIS must know the datum that is the basis for the numbers. Hundreds of datum exists, and many countries have their own (Kennedy, Michael 2013).

Geographic Projection

Sometimes is not convenient for using latitude and longitude for describing a set of points because of some boundaries like coastline or the country's boundaries on the earth's surface. There is a calculation between two distances on the Cartesian x-y plane. But these measurements on the geographic importance of latitude longitude do not work properly of many features of mapping if we assume to have many spots on the surface. This is symbolic of spherical coordinate system which is related to the length of an arc or degree from the north to south, the projected coordinate defines the spherical of location onto a plane.

The feature of the earth as a geographic projection on a flat surface in which it can be calculated easily and more realistic reason but in some cases, it must be an equivalent on the ground. Projection equations must also be specified in the "backward" direction, from projected coordinates to geographic coordinates, if they are to be useful. The projection coordinates in this backward, or "inverse," direction are often much more complicated that the forward direction, but are specified for every commonly used projection.

Most projection equations are much more complicated than the transverse Mercator, in part because most adopt an ellipsoidal Earth, and because the projections are onto curved surfaces rather than a plane, but thankfully, projection equations have long been standardized, documented, and made widely available through proven programming libraries and projection calculators (Bolstad, Paul 2016).

The computer engine calculator is so powerful in the complex computations for project data. Four-point that are the most important feature of analysis are size, distance, shape, and direction, the scale is the matter of positioning which defining database of the real-world coordinates that are called as final output. The State Plane Coordinate System is a standard set of projections for the United States (Bolstad, Paul 2016).

The place of definition for an individual state is State Plane coordinate system in Cartesian coordinate systems, one or more states in each zone by varying parameters in projection and for limited errors due to projection Multiple State Plane zones is useful and for surveying, mapping, and spatial data development especially about big-scale district. The State Plane system provides a common coordinate reference for horizontal coordinates over the county to multicounty areas while limiting distortion error to specified maximum values (Bolstad, Paul 2016).

The State plane has generally some error in the units from 1 unit in 10,000 but the possible error from the UTM coordinate system may be from 1 to 2500.

The Universal Transverse Mercator (UTM) coordinate system is another standard coordinate, distinct from the State Plane system. The UTM is a global coordinate system, based on the transverse Mercator projection. It is widely used in the United States and other parts of North America and is also used in many other countries (Bolstad, Paul 2016).

The UTM system divides the Earth into zones that are 6 degrees wide in longitude and extend from 80 degrees south latitude to 84 degrees north latitude. UTM zones are numbered from 1 to 60 in an easterly direction, starting at longitude 180 degrees West. Zones are further split north and south of the equator. Therefore, the zone containing most of England is identified as UTM Zone 30 North, while the zones containing most of New Zealand are designated UTM Zones 59 South and 60 South. Directional designations are here abbreviated, for example, 30N in place of 30 North (Bolstad, Paul 2016).

UTM is common for study areas and spatial data in big scale, like many state plane zones, using it is so easy in order entire state applies dominantly in one UTM zones, it should be added that all the data for analysis must be in the same coordinate system. Many European countries have standard map projections covering a national extent; for example, Belgium, Estonia, and France each have different Lambert Conformal Conic projections defined for use on standard nation-spanning maps and data sets, while Germany, Bulgaria, Croatia, and Slovenia use a specialized modification of the transverse Mercator projection. Some countries adopt specific Universal Transverse Mercator projections, including Norway, Portugal, and Spain. Specifications of these projection parameters may be found in the respective national standard documents.

Larger countries may not have a specific or unified set of standard, nationwide projections, particularly for GIS data, because distortion is usually unavoidably large when spanning great distances across both latitudes and longitudes on the same map.

There is simply no single projection that faithfully represents distances, areas, or angles

across the entire country, so more constrained projections are used for analysis, and the results aggregated to larger areas (Bolstad, Paul 2016).

Relational Database and Queries

Relational databases are created for giving information about the object and getting the report by picking subset which is a mixture from a total of attribute table, mathematics and rational operators, and utilities. For instance, a database can be examined by recording and updating data during a period by numbers and values. All of this knowledge is possible to manage by selection, subsets, and leading, the relational database is related to a table with all the information furthermore each of them contains a column with a unique identifier for each row of the table.

It is called a key field moreover this key if the reference to number should be identified this number is related to which field. This key code is a vehicle identification number (VIN), otherwise, it includes several tables that keeping the information and contents occur in a key field, so it is a suitable setup. This managing is useful for partitioning the information such as:

Figure: 8: Partitioning information in data

We can call this database a collection of symbols like numbers, letters, and particular types located in the right position and major underlying system or composition. The program or library in a new world with symbols and a user can explore, discover the subject of using the data with a substituted computer-based theme. Most of this information is about a particular part of the world that can restore in a "hard disk" that for example has shown the most common type of soil found. The disk is the physical medium, the codes assigned to a soil data, and the location of each acre-as understood from the position of each datum on the disk-could be the underlying structure (Kennedy, Michael 2013).

The general purpose of the database is usually from some consequences of the project

individually or in a team with a significant effort and need to be updated, modified, and corrected progressively that can be the process valuable. It can show errors depend on size, the problem of construction, the integrity of data, or the quality of physical use. Another sector that is so valuable in using datasets is the function with its method like the numbers, names for land use decisions.

Many schemes exist to store information in the memory of a computer or on its secondary devices, such as disk drives or tapes. The primary method used to store large amounts of information is called the "relational database," or RDB, developed by E. F. Codd.21 The software is described as RDBMS (relational database management system). The idea is simple: use a set of two-dimensional tables; for a given table there is a prescribed format in which the rows relate to entities (objects, people, things in general), while the columns relate to attributes (characteristics, properties) of entities. The intersection of a given row and a given column is a cell, containing a value, which defines the particular attribute of the particular entity database table that can be used to store names, occupations, and pay schedules of employees. The structure that contains the attributes, the column, is also called a field or an item (Kennedy, Michael 2013).

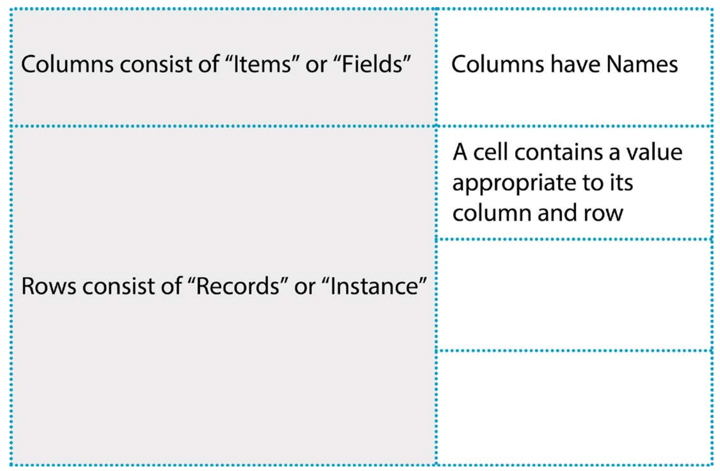

Figure: 9: Positioning table and its context og fields in the GIS

It should be noticed that the computer calculating program is so good for making the data separate and search the advantage of using the list is sorting with fast algorithms and can be run in a high efficiency if a new factor added to the list it can be located in the right place with editing and adding features. Database is referring to the idea, people, object, feature, some unique entity and so on. The GIS entity is a 3D spatial characteristic that presents it in points, lines, areas, and polygons that can be included in the classification of the features with attributes.

Role of GIS in Industrial location

Industrial location has a strategic decision of a critical role of a company and on a big scale inside a city that needs an optimal function on a broad location. GIS is useful for spatial analysis in the functionality of queries and analyze geographical information. The analysis of industrial location facilities is the most important of decision making in operational research, geographic information, and computer science that can be used in intelligent computer systems in micro-location and macro-location analysis.

The macro location is the geographical area, which can meet the basic requirements for the construction and development of the industry with minimal operating costs. The micro-location is the specific place in the macro location that meets technical, infrastructural, and working process requirements (Zelenovic, Djordje 2003).

The spatial decision making has direct contact with the landscape, economic, and social factors which play a vital role in appropriate strategic spatial analysis. The location analysis through the development of distance analysis, attribute data, and multi-criteria above the overall risk and industry advantage.

All the affected sectors like transport, taxes, pays are going to be under the influence of the industrial location. The desired requirements specified by the selection criteria in an investigator attempts to determine the optimum location of the associated possibility sites each has benefits and limitations, analysis of attribute data particularly plans for Multi-Criteria and Multi-Objective location analysis in GIS. Specific emphasis on the problems in combining subjective character, methods for the gathering of data in the appearance of differing terms of the trade-off among criteria; and procedures for dispute analysis and conflict retreat in positions of various scientific decision problems. The trouble of industrial sites is the large number of data that needed a quick decision proposes is necessary to develop a model.

In the past, site selection was based almost purely on economical and technical criteria. Today, a higher degree of sophistication is expected. Selection criteria must also satisfy a number of social and environmental requirements, which are enforced by legislation and government regulations. The process selection of industrial site means complex multi-criteria analysis which includes a complex array of factors involving economic, social, technical, environmental, and political issues that may result in conflicting objectives (Badri, Masood 2007).

One of the most important and far-reaching decisions faced by operations managers are deciding where to locate new industrial facilities. This is a strategic decision involving irreversible allocation of the firm's capital, and often has a crucial impact on key measures of the firm's supply chain performance such as lead time, inventory, responsiveness to demand variability, flexibility, and quality (Bhatnagar, R., & Sohal, A. S. 2005). The most commonly used spatial analysis in GIS are:

Analysis of attribute data,

Query of spatial data

Analysis of the distance,

Network analysis

Nonparametric techniques

Chapter Four

BIM and GIS

In the improvement the process of building construction and the complex of various standards and formats involved in the information of project management and decision making to share data connecting the architect, urban planning, construction manager, and so on. Developing a common model for participating documents and store information of current model is a new challenge, BIM represents a series of parametric objects of detailed geometric and semantic information, GIS achieves the information resources in the construction project.

The construction aims which is the main purpose of a systematic development can be maintained between the technique of construction application in terms of data sharing, integration, and management. Construction is a process of work by creating buildings or infrastructure to support the requirement of society.

This process starts with the planning, design, financing, and continues until the project is ready for use to include problem recognition to the implementation of a fully operational solution. Construction can be referring to the several sectors such as building (residential and non-residential), infrastructure (roads, bridges, public utilities, and dams) and industrial (process chemical, power generation, mills and manufacturing plants) (Abdul Basir, Majid, Ujang, Chong 2018).

Through construction documentations (CD's), the construction management team is able to gather information about the building (such as design information, geometric properties, etc.), add information related to constructability, resources, sequence of work, schedule, and document the construction process in fulfillment of the requirements of the legal contract (Dib et al., 2013).

The problem in the construction industry remains the need of connectively between several cooperators and functions which is developing with computer technology to overcome the graphical and non-graphical information's barriers in a single environment to make all layout, drawings and schedules together.

The main focus in BIM is on indoor planning tasks such as in relation to space use and energy consumption like heating, ventilation, or air conditioning. While Geographic Information System (GIS) facilitates mainly for outdoor planning tasks such as site selection, Jobsite planning, delivery of goods and services, and emergency evacuation operations (Barsal 2012).

BIM represents detailed geometrical and semantic information about building elements and their main emphasis is on interactive 3D graphical modeling to serve the needs of automated drafting and attribute linking with features. On the other hand, GIS has less emphasis on drafting and more on digital terrain modeling that facilitates spatial analyses and used to manage urban management tasks, disaster management, delivery of goods and services, and cityscape visualization. This is because of GIS provides high level and volume of geospatial information and can give the detailed geometrical and semantic information about the building in order to become facilitated through better automation.

There are certain functional overlaps between GIS and BIM technologies in the area of spatial information analysis, on the other hand, there are many differences such as in terms of visualization, geometry information storage, and 3D analysis performance (Bansal, 2011b).

The building has a crucial role in environmental impacts and climate change, for sustainable construction planning and urban environments, it needed a tool for simulation and evaluate different aspects of a project in construction industry in planning and location by GIS.

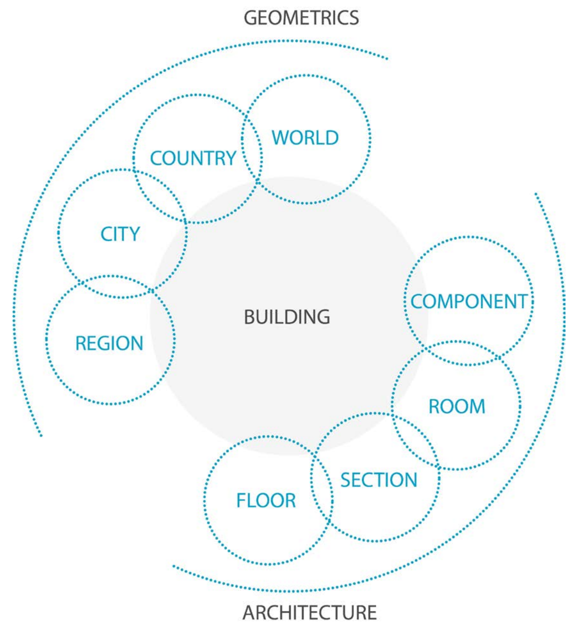

Figure: 10: Positioning table and its context og fields in the GIS

BIM and GIS Cooperation

The integration between two systems in one can perform various analyses in one platform like energy analysis and facility management in the climate adaption of many buildings to its environment according to visualization and attribute. Energy efficiency classes regarding building specifications, local climate, heating costs, lightning, hot water, renewable energy and urban heat canyons in a larger context. With a 3D model over a city, weather impact analysis can be performed by analyzing e.g. impact from wind and air pressure (Bengtsson, Gronkvist 2017). The new and existing buildings in the planning phase in the special district can help analyze and 3D visualization and locate assets of spaces and queries in 2D and charts at the same time. This city supported planning to the site selection and facility management of the 3D model estimate many procedures of a building in a city during a period and finding a specific solution in an emergency condition.

BIM and GIS integration also plays an important role in the creation of a 3D space model of smart cities. It allows the mapping of underground utilities, such as pipes and cable underground but also integrated with street level and above ground level data. The 3D city model could be visualized in a more interactive way and a larger context in both semantic and realistic views on desktops, web, or mobile, but also in real-time (4D) (Deshpande, 2017). The navigation of more complex topological and geometrics associations in indoor environments and indoor space has an accurate navigating in order to georeference of localization. The coordinate of z value can modify the spatial properties of elements of the model which is part of the city and routs and each element can be distributed into feature classes. Even in the complex building and structure the 3D visualization can correctly geoprocessing and accounting. Georeferencing an accurate, detailed, BIM-model gives the user the possibility to answer several environmental questions using a GIS. Examples of such analysis includes view quality, a measure of how obstructed the view from windows in a building is, and shadow volume, a visualization of where on a building's rooftop placement of solar panels would be most efficient dependent on shadows from the surroundings (Rafiee et.al., 2014). Through the conversion of a BIM-model from IFC into a geographical vector format (including the

semantic properties of the original model) GIS-analyses can be performed on the data set. The actual georeferencing, the process of transforming the local coordinate system used in IFC into a geographical one, has been one of the problematic processes with BIM- and GIS-integration. A possible solution for this issue is to use the attributes for longitude and latitude from the class IFCSite together with the one for north direction in the class IFCProject.

Combining these, an automated process for scaling, rotation, and translation can be created. Once georeferenced, the model can be imported into a GIS (Rafiee et.al., 2014). To perform a view analysis, all windows on the building in question should be selected. Then, a 3D solid consisting of the view from each window can be created. An analysis of how much of that solid that contains other buildings or vegetation can then be performed resulting in a ratio describing the view quality. For the shadow analysis, shadows from surrounding buildings and trees at a specific date and time can be obtained in the GIS. The intersection of these shadows and the building's roof then gives a map showing the best locations for solar panels for different periods (Rafiee et.al., 2014). The spatial types and operators that are available in all major GIS software today, are developed to function in 2D space.

The same concept could, however, be applied to geometric objects in 3D space for performing common spatial queries on BIM data or 3D city models in a GIS. In a BIM today, qualitative spatial relationships cannot be used as selection criteria, unlike within a GIS, since only alphanumeric comparisons on individual attributes are possible. The spatial objects in a BIM must first be abstracted into reduced dimensionality, from load points, power lines, plates, slabs, etc., into simple points, lines, and polygons, which the algebra in the spatial query relies on. The abstraction of the BIM then allows the user to perform several kinds of spatial operators; metric (distance, farther than, closer than, etc.), directional (above, below, north of, etc.) and topological (touch, within, contain, etc.) (Borrman, 2010 and Fosu et.al. 2015).

Relevant Collaboration

Cooperation means working together toward shared goals, while collaboration means working together towards common goals while respecting the contribution of each individual to the whole (Kozar, 2010; Kymmell, 2008). Coordination is given as to "first" bring the different elements of (a complex activity or organization) into an efficient relationship and second negotiate with (others) in order to work together effectively" (Oxford University Press, 2001, p.189). Collaboration is required to obtain the strategy of integrating BIM with GIS common goals especially when the project is huge the administration of collaboration becomes a crucial role in information management and decision-making. Different types of collaboration are needed based on situations (Bouchlaghem, 2012) has categorized the possible technologies for collaboration into four categories in relation to time and place:

1) Same time - same place,

2) Same place - different times,

3) Different places - same time,

4) Different places.

Furthermore, the capabilities of BIM are very limited concerning the "how" , and absent concerning the "why" , leading to inefficiency to solve the emerging problems within the BIM environment (Dossick and Neff, 2011). This is the reason of the flow of information among the professionals. Integrated Collaborative Technologies involve the following as mentioned by Stevens et al., 2009; Kapogiannis, 2014; and Kiviniemi, 2005):

- Collaborative software: Support sharing and information flow in order to improve the team's performance. It uses for collaborating in real-time, conferencing, and asynchronous.
- Workflow systems: Facilitating the automation and managing of business processes.
- Systems of managing documents: Manage documents during all the stages of its processing.
- Peer-to-peer collaboration software: To allow users to share files and communicate in real-time with no need for a central server.
- Systems of managing knowledge: Support the knowledge capture, organize, distribute (know-how). Also known as Information Technology (IT) systems.
- Systems for the social network: Are IT systems which link people that know each other

with people that their contacts know.
- Collaborative Design: enables stakeholders to design construction projects (collected or distributed).

Collaboration is a target which needed effective techniques to reach effective collaboration between BIM and GIS.

BIM and GIS Integration

The integration of BIM and GIS has its feature and capabilities of each factor, for example, GIS provides topological (georeferenced) data, which allows for 3D analysis, spatial analysis, and queries such as calculating the distance between two different points, calculating routes, and defining the optimal location (Irizarry and Karan, 2012).

BIM is incapable of such analysis, but it provides a detailed database of object-oriented parametric information for the building and represents it in a 3D model, a feature that GIS is lacking (El-Mekawy, 2010).

The data interoperability for BIM and GIS is different, GIS used CityGML while BIM used the IFC standard. The differences are in terms of the level of granularity, geometry, storage, and spatial scale. The three different kinds of integration with BIM and GIS is application level, process level, and data level. At the application level, the integration methods generally use reconfiguring or rebuilding (Kamari and Akinci, 2010).

Developed a BIM-GIS integrated model to improve the visual monitoring of construction supply chain management. In this study, BIM-GIS visual module was developed to represent the availability of materials. This application provides real-time quotes on doors and windows from different databases across the Internet. GIS-based spatial analyses such as network analysis and attribute analyses were used to provide an optimal solution to manage costs of supply chain logistics (Irizarry et al, 2013).

This multi-disciplinary method which displays the collaboration among the application and design rule in the areas where the procedures located can perform the research consortium and performance relationships between the partners. In the process level, methods that can be called web-based integration the responsibilities required the ability within the distinct of more flexible than application level, although in this method the integration is more challenging. But the goal is that the geometrical information from associated to related resources and transforming information from BIM to GIS which extract, transform and load.

Studied the uses of semantic web technology to ensure semantic interoperability between existing BIM and GIS tools. The advanced strategy is comprised of the ontology construction,

semantic integration through interoperable data formats and rules, including queries of various information sources. The integrated process relies on building information modeling (BIM) in the localization method providing an effective form of system for enhancement of integrated management in geometrical and alphanumerical data.

Reducing the time extensions can improve the process of change, repair, and damage with the knowledge that this information comes from other sources and tools. BIM can be shown as a new approach to the building process to a centralized information program for building data fragments linking different users. The influential elements are the result of time-saving among problems and bugs which the interface among open standards are linked to interconnected system programs for the identified the model information.

This BIM ontology provides a way for a combination of building and construction-related data that contains all IFC classes with different attributes. Using an instance-based method to generate mapping rules between IFC and CityGML based on the inspection of entities representing the same component in the same model. Four basic concepts were developed in the reference ontology which are building object, geometry, property sets, and inverse relationship.

The relationship between these four concepts was also developed by studying the schemes of IFC and CityGML (Deng et al, 2016). In the data level method, the facilities data transfer between two software is a translation/ conversion methods such as FME (Safe, 2013).

This data is translation the data between IFC and CityGML which transformation is both sematic and geometric of datasets with a different Level of Detail (LoD). The LoDs should be appropriately matched with the elements during transformation. To solve the geometry transformation problem, a non-semantic data schema, shapefile, is suggested, and Open-Source Approach (OSA) was developed to transform IFC into shapefile (Wang et al, 2019).

The conversion problems like using tools like Feature Manipulation Engine (FME) and data interoperability extension for ArcGIS (DIA) when semantic mismatching happened and reading IFC model have obstacles. Otherwise, the way of using customized algorithms for 3D presentation used by IFC has remained problems.

Using ArcGIS as a computer technology at a significant level that can get input, manipulate data and produce output that can read, stir and write to simulate reasoning and decision making with the ability to connect with other users and other computers by the internet and other networks. Working with applications with the set of software packages for conducting computers uses programming, GIS has a package from Esri that known as ArcGIS.

ArcGIS is an integrated GIS that consists of different principal parts. We are working with ArcGIS Desktop software, which is an integrated suite of advanced GIS applications. Esri also has interfaces for managing geodatabases in a database management system (DBMS). Also there is an Internet-based GIS for distributing spatial data and services (Kennedy, Michael 2013).

Output of GIS depends on the sizes and selection of spatial data scale without skills of editing or extensively analyzing that data options, also include systems of common functionality identified as workgroup GIS and function GIS. It is so useful for publishing map data. These days ArcGIS Pro make an advantage for project input into the GIS atmosphere with the interoperability between other software like Revit and interpret other tools as a shape file and extract the information into the geodatabase programming.

The critical components of the system were the links between the BIM design tool, a central model repository, and the Web portal for entering and viewing assessment data (Eastman et al., 2008). The open standards system based to support interoperability and integration has an information process workflows of Microsoft Excel for data entry as well. The benefit of shape and geodatabase in the workflow is the static model import and shape import; however, without indoor modeling and texture. The process of integrating 3D model into ArcGIS Pro

by Esri to develop the workflow, it should be created the model in REVIT and output files in .rvt to produce the geometric information in with attributes table with the complex database with a right parametric model.

CityGML and IFC

The format of GIS is CityGML furthermore BIM data have different concepts which are IFC and all the features are analyzed in this section. CityGML is an open standard data that has the capability of 3D city models and landscapes Geography Markup Language (GML) field and as classified by Open Geospatial Consortium (OGC) in Extensible Markup Language (XML) arrangement. The XML-based data model has attributes, connections, and substances of a city which is basic for the smart city and sustainability of the city 3D model.

CityGML has two sections the first one defines the documentation and the second part is the instance report of real data. In each model exists different Levels of Detail (LODs) describe the details of the elements that consist of LOD0 explained the footprint of the building in 2D, otherwise it is from LOD1 to LOD4. LOD1 models are referred to as the basic block model with flat roofs: LOD2 is also a basic block model with different roof styles. LOD3 and LOD4 models incorporate windows and doors which have close exterior views, while their internal components are quite different. LOD4 contains interior spaces (rooms) and internal walls, while the model in LOD3 does not. However, the building model in CityGML is less complete and mature as in BIM, even in LOD4 (Amirebrahimi et al., 2016).

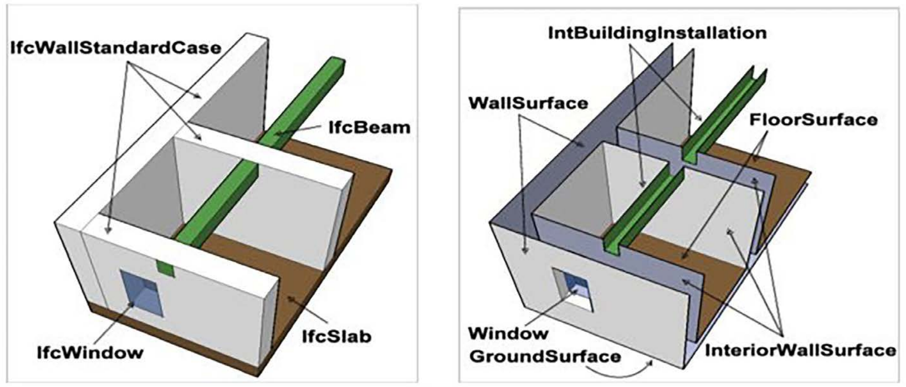

Figure: 11: Comparison of the IFC and CityGML of building component representation (Kolbe)

The Architecture, Engineering, and Construction (AEC) industry is divers therefore information demanding (Aziz et al., 2006), and there are various 3D data formats in existence from diverse vendors that deter information exchange in this field (Atazadeh et al., 2017). Although there are many open BIM standards, such as BIMXML and COINS

in existence, IFC is the primary open data schema used for information exchange within AEC/FM domains (Amirebrahimi et al,2016), and it is EXPRESS-based which is developed by buildingSMART (formerly: International Alliance for Interoperability (IAI)) in 1994 (Mignard et al,2016).

IFC describes the information schema in the EXPRESS language based on the object-oriented (OO) concept. Focusing on the interoperation of architectural information to enable the reuse of the information, it provides a total of over 700 objects, including various architectural elements, materials, and processes, which are mostly extended from the kernel objects (J. Sani, A. Rahman 2018). IFC is divided into Level of Development (LODs), from LOD100 to LOD400 which each increase in each step adds more detail to the building, for

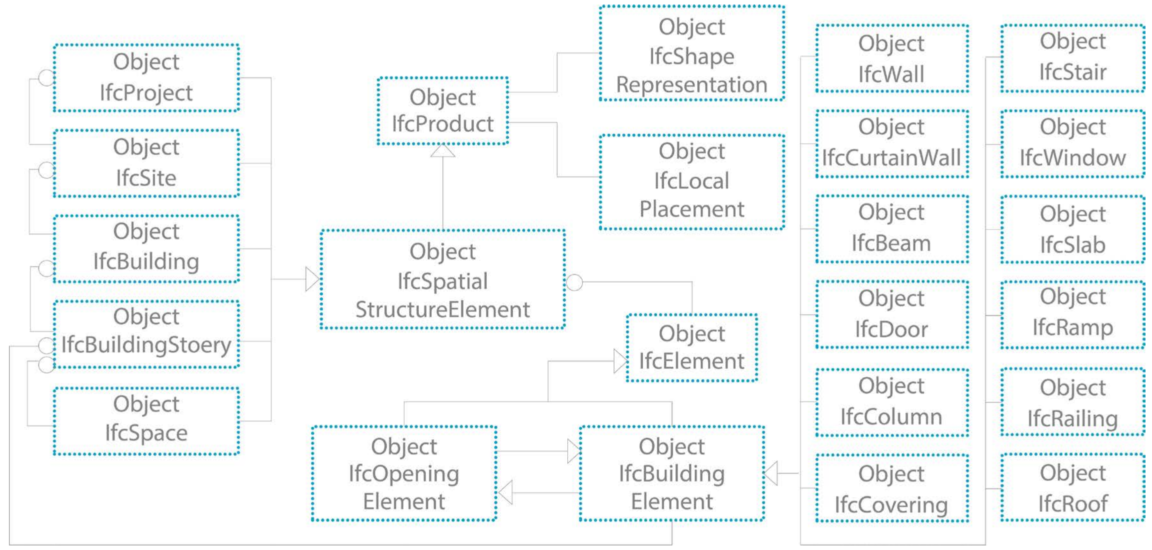

Figure: 12: UML model of IFC building model (El-Mekawy et al., 2012b)

instance, LOD100 is just only solid and LOD400 is more complex with various components like interior, furniture and so on.

The discussion is regarding to alteration between BIM and GIS in the connection of CityGML and IFC, in geometry level, while the semantic level is related to attribute data transform. There exist the issue of mismatch of semantic information between GIS and BIM, where the two domains have different definitions for the same object, for instance, a door in IFC is defined as "Ifcdoor" while it is just "door" in CityGML; and in some example, one of the schemas defines a component while the other one failed too, for instance, IFC defines beam, column, stair, and so on, while CityGML only generalized the component like "BuildingInstallation" (Donkers et al., 2016).

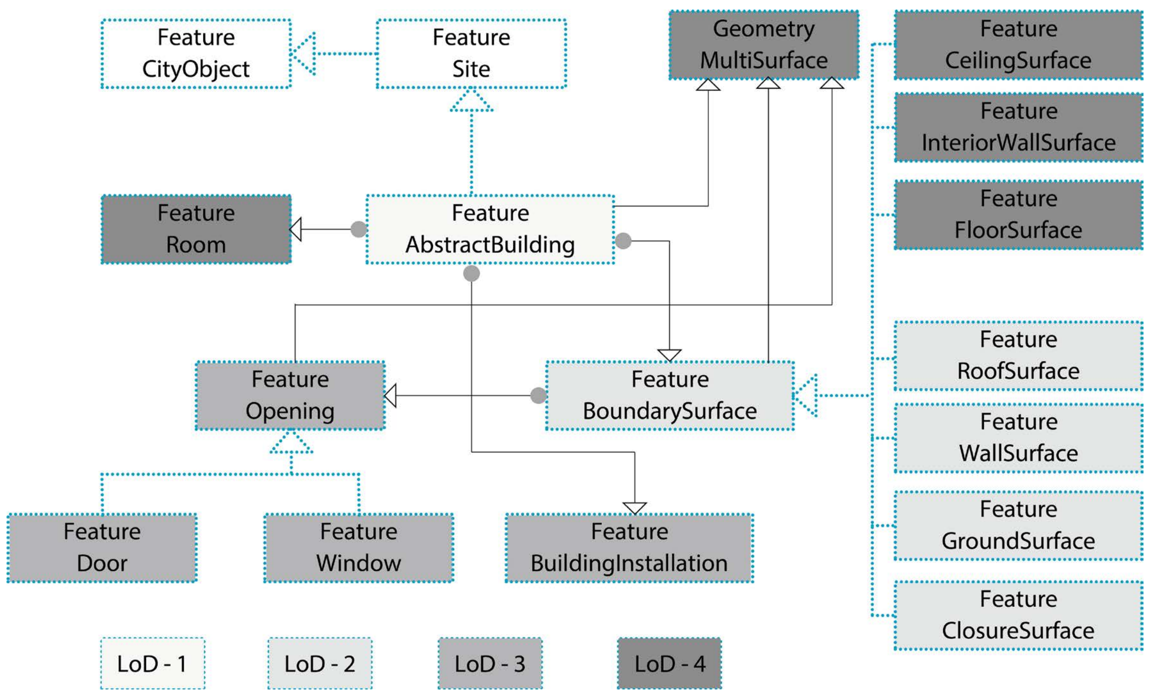

Figure: 13: UML of CityGML building model (El-Mekawy et al., 2012b)

Different LoD

Within the framework of the methodological and conceptual approach that characterizes Building Information Modeling (BIM), the concern of details level which is called LOD stands for Level Of Detail. LODs have the task of precisely defining the level of detail of the various types of information that are contained within the model. In this perspective, in particular, the Level of Detail represents a defined reference point that allows all the subjects involved in the project to define and explain the construction of a Bim model with a high proportion of evidence regarding its contents and maximum reliability.

Information relating to it along with all the different phases in which the process of conception and realization of the work is divided. The definition of the characteristics of each Level Of Detail concerning the type of element considered is a theme addressed by two important normative references, one of American origin and one of Italian origin. In the American context, the American Institute of Architects (AIA) has published a Level Of Detail framework for the AIA Protocol G202-2013 Building Information Modeling, where the term LOD refers to the level of development necessary in relation to the contents of the elements of the model, the choice to use the definition "level of development" instead of "level of detail" is motivated by the fact that an element, although it may appear visually detailed, could it be more generic.

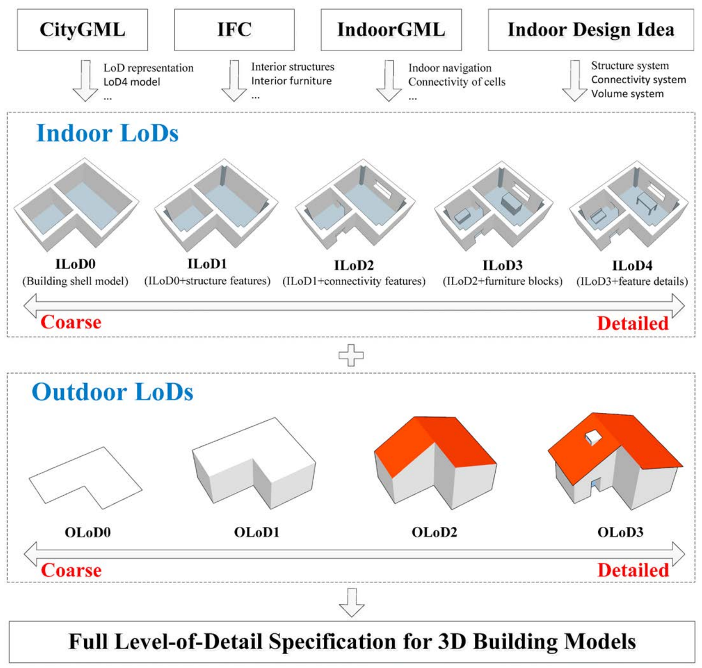

Figure: 14: Different Level of Details (Tang et el.,2018)

According to this documentation, the degree of development obtainable through the drafting of a building model defined through a Bim-like approach is explained into five levels:

• LOD100: the elements are generally represented by a symbol, not necessarily committed in form, size, and location;
• LOD200: the elements are described in an approximate form, size, and location, with the ability to act as a link to documents their attachments;
• LOD300: the elements are defined by shape, quantity, size, and position, maintaining the ability to act as links to documents attached to them;
• LOD350: the elements vary from the previous, LOD350 in the possibility to also integrate relationship parameters with other factions of elements present in the project; therefore, common distances, length of paths or components, constraints and respects can be quantified directly by the model, without referring to specific documents;
• LOD400: the elements include data on the shape, quantity, size, position, equipment details, installation instructions, and manufacturing characteristics;
• LOD500: the elements have been located on-site, confirming their data on the form, quantity, size, and position.

The Italian legislation that refers to the Level Of Detail is UNI 11337-4: 2017, which has among its assumptions the possibility of using any of the existing Level of Detail scales, without exclusions or priorities, according to the specific needs of the contract and provided that its specific references, logics, objectives, and structure are defined in advance for the purpose of maximum clearness for the individuals concerned.

UNI 11337-4: 2017, in particular, adopts the fundamental terminological distinction between LOD, LOG and LOI; in this perspective, the LOD, development level of digital objects, is made up of LOG, object development level - geometric attributes, and Level Of Detail, and in order to ISO 19650, object development level - information attributes. Concerning the definition of specific LODs, the legislation adopts the following general scale:

- LOD A: the entities are represented graphically through a symbolic geometric system or a gender representation taken as a reference without geometry constraint. The quantitative and qualitative characteristics are suggestive;
- LOD B: the entities are virtualized graphically as a generic geometric system or overall geometry. The qualitative and quantitative characteristics are approximate;
- LOD C: Entities are virtualized graphically as a defined geometric system. The qualitative and quantitative characteristics are generally defined in compliance with the limits of the current legislation and the reference technical standards and referable to a majority of similar objects;
- LOD D: entities are virtualized graphically as a detailed geometric system. The qualitative and quantitative characteristics are specific to a defined majority of similar products. The interface with other specific construction systems is defined, including the approximate overall dimensions of operation and maintenance;
- LOD E: entities are virtualized graphically as a specific geometric system. The quantitative and qualitative characteristics are particularly to a single production system linked to the defined product. The level of detail relating to manufacturing, assembly, and installation is defined, including specific maneuvering and maintenance dimensions;
- LOD F: the objects express the virtualization verified on the site of the specific production system executed/built. The quantitative and qualitative characteristics are those specific to the individual production system of the laid and installed product. The management, maintenance and/or repair and replacement interventions to be carried out throughout the entire life cycle of the work are defined for each product;
- LOD G: the objects express the updated virtualization of the factual state of an entity in a defined time. The management, maintenance and/or repair and replacement interventions to be carried out throughout the entire life cycle of the work are defined for each product.

Chapter Five

Method

After the industrial revolution in the world the shape of many cities change and in the future many industrial plants and spaces might be abandoned, the technological techniques for decision-making will be more trend in AEC. BIM and GIS with effective integration benefit of data from the conversion of sources in an appropriate format for involving municipal facility management is so useful in BIM/GIS-based information Extract, Transform, and Load (BG-ETL) of architecture with the appropriate features. This approach can be useful for reusability and extensibility of the

abandoned building to a new function inside a city by a researched base of information system management and beneficial studies of building management and spatial information. The aim of the discussion is the implementation of using the case of Mirafiori, which is the Lastratura 1 part to test the BG-ETL architecture and evaluate the utility of collaboration to have full information about building history and background of construction procedures and technologies during its lifetime.

All the information related to the case study was thoroughly collected in this phase and digitized to ensure a quick and simple consultation. Starting from the careful analysis of the propriety information, we proceeded with the selection of the subject for the parametric modeling (Vacca et al., 2018). The BIM model does not represent the entire receptacle for every type of information, but must be created inside a particular and focused program.

The work continued with the definition of a conceptual scheme for the decomposition of the building in categories of constructive objects with the choice of alphanumeric content to be capitalized for each one of them and; therefore, with the definition of the detail level of the model (Vacca et al., 2018). The determination of the parameters in which claims to notify the elements of the model, applying the representation of construction methods and materials, and the type of degradation can be mentioned in the software.

Beginning from 2D survey information and promoting the advancement of the parametric model with BIM Autodesk software, which developed the informative building project and the structuring of each data in the elements to determine the level of corruption and intervention.

Modeling in BIM can be so close to the real management of the building and taking advantage of collecting data detailing in each part as well as elements of architectural, structural, and so on can be so useful in GIS.

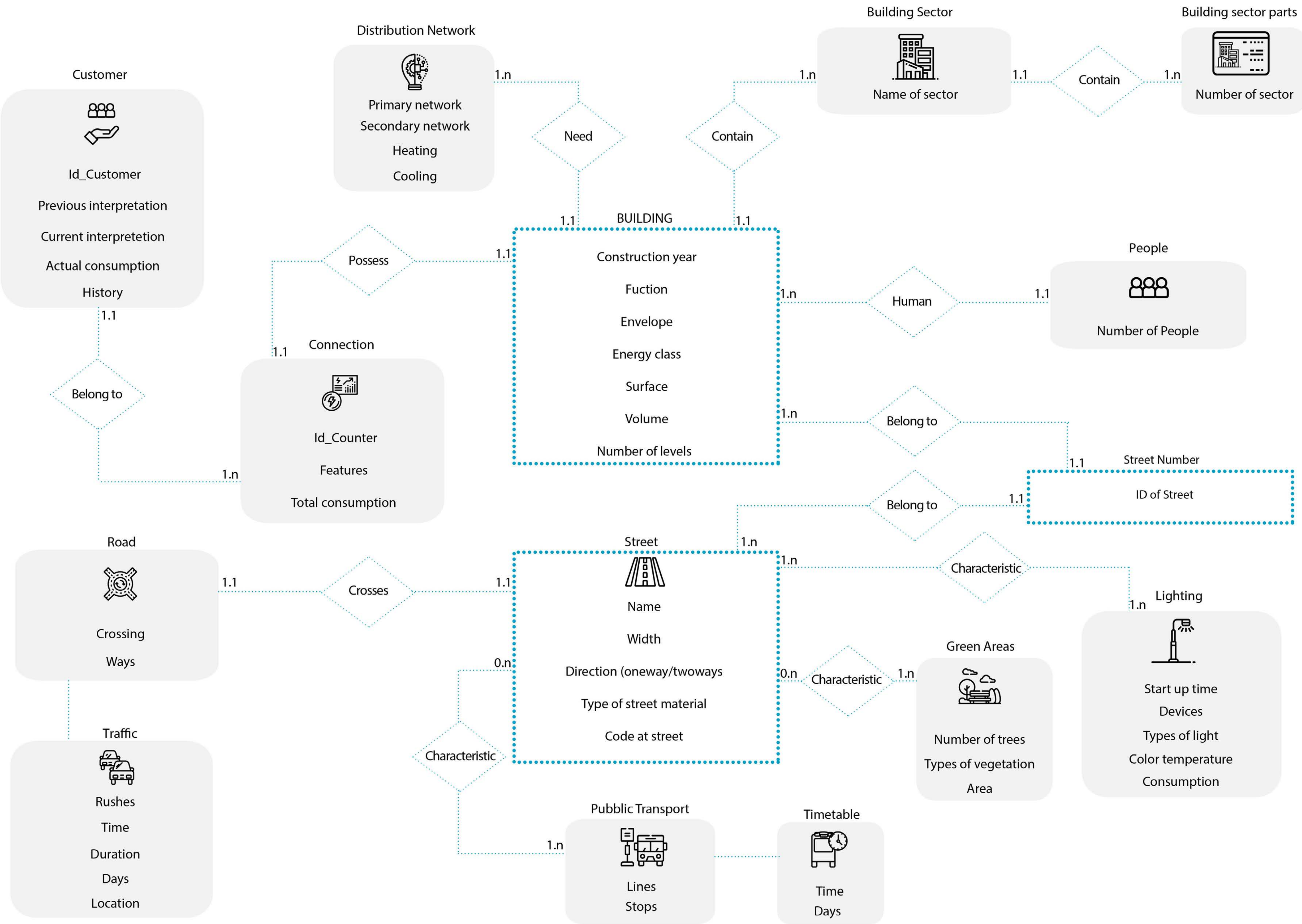

Figure: 15: Conceptual Model

BIM and GIS Workflow

The purpose of the research from creating 3D GIS protocol from the 3D BIM model with the idea of digitalization and optimization of the accurate process of management tools of modern software. The growth of GIS software into the use of ArcGIS Pro for various complex crossing enables us to integrate the 3D model of Lastratura 1 of Mirafiori into ArcGIS, which Revit created parametric data to convey into GIS.

There are 3 ways to get to the goal can be directly imported into GIS, can be chosen FME by Safe Software. FME can transform a parametric model of a building into GIS features, starting from two different REVIT output files: (.rvz) or (.ifc). Both paths produce the same geometric information; the difference is in the complexity of the related tables.

When converting from the IFC format, a smaller number of tables is created; starting from .rvz, the database is more complex but all the added fields are empty. For this reason, we proceeded by converting the .ifc parametric model (Vecca et al., 2018). At the end these two ways can be checked by FME Inspector application to make sure all the information correctly exported from Revit.

However, with FME Workspace application it can be converted into geodatabase (.gdb) for modeling the building into 3D GIS scene for visible interaction of other factors within the city and operating by other constituents of surroundings and producing geospatial or system queries.

The third and the way chosen in this research is directly from the Revit file (.rvt) into ArcGIS Pro then extracting information from the attributes table by data export features.

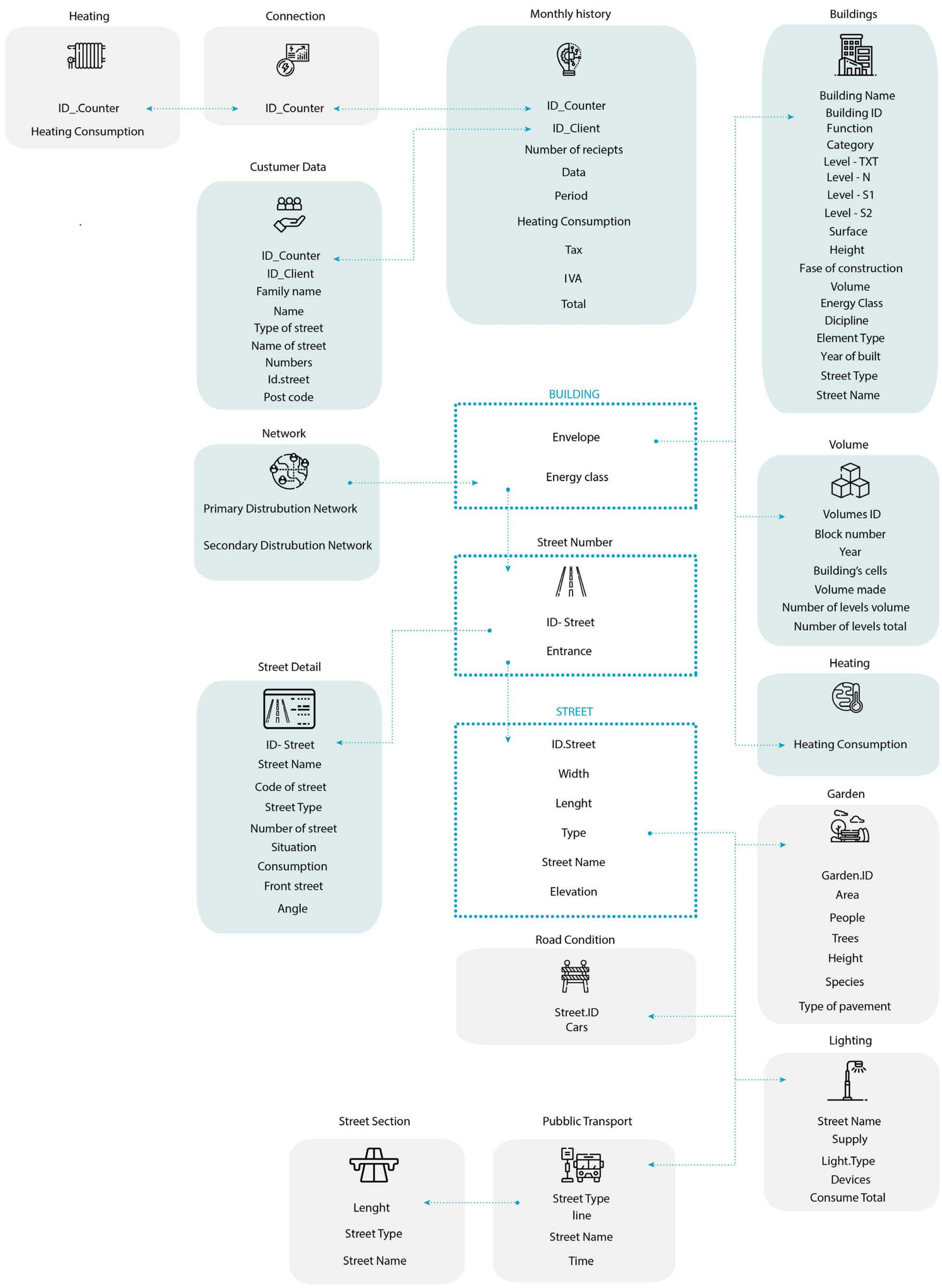

Figure: 16: Logical Model

The ability to identify on the parametric model and the related urban context the components that primarily need intervention allows us to consider and evaluate the important economic, logistic and operative aspects of the intervention, also optimizing the management of safety measures in the restoration work environment with a correct choice of the machinery, tools, temporary works and procedures to be employed (Vecca et al., 2018). All the database archive in GIS and allows to share in future and documentation project of the building.

The technical objects of the BIM with a significant feature of related virtual 3D models of the ground's surface which has different IFC classes that can transform to CityGML features. However, fundamental differences between BIM and GIS exist that preclude successful integration, also the study of spaces is key to understanding the topological layout of buildings (Boyes, 2015).

In the term of bordering space that is space-bound between floor cover and wall centerlines by the surface of the ceiling, this should be explained over the simplified BIM model for being understandable by GIS with layers in different level of details. In the Lod 2 of CityGML that is depend on complexity of the shape, can use "IfcSpace" and "IfcSlab" for transforming to

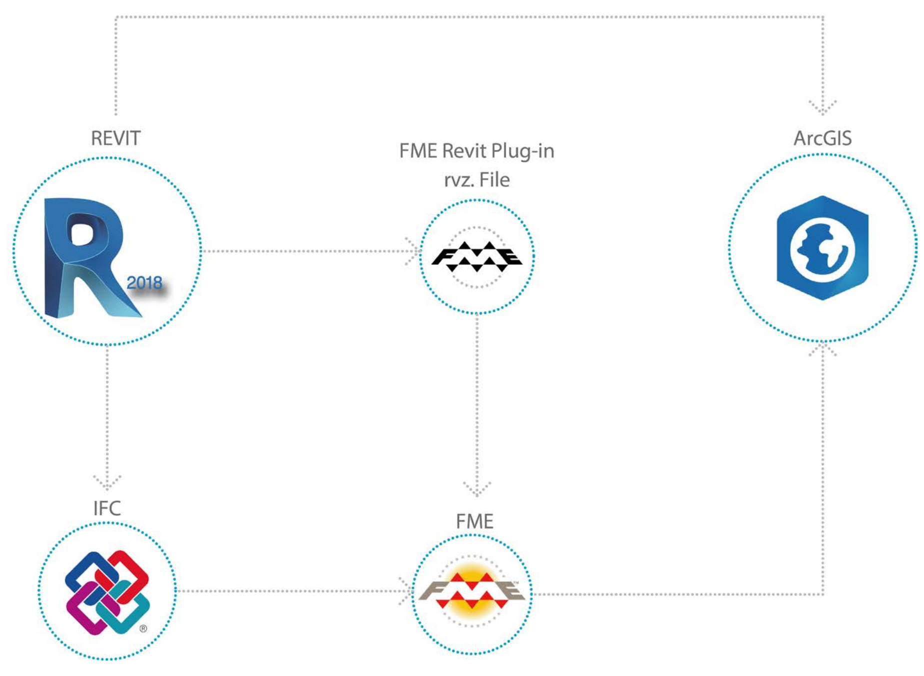

Figure: 17: Workflow Methodology

GIS that is represented object attributes related to the room like name, volumes and net of floor area in a one output that is building.

IfcRelSpaceBoundary is geometrically described as a collection of planar polygon faces. Each face relates to a particular building element that is stored as a boundary attribute (buildingSMART, 2014).

Exporting IFC space boundaries at different levels can be provided by Autodesk Revit and transforming it into FME Workbench for the geometry of space boundaries in different IFC classes. For the CityGML LoD-3, the workflow is describing in Revit FME exporter in "rvz." File with the connection with "IfcSlap" and "IfcSpace". The key to creating space objects efficiently in Revit is to start with a well-constructed model.

Wherever possible, floors should be continuous throughout a particular building level. Splits in floor heights, e.g. mezzanine levels, and stairwells must be contained by a wall or virtual boundary. These methods should stand as good practice for any modelers intent on using BIM data sourced from architectural design of a building (Boyes, 2015).

In the detailed level of LOD 3 the representation of design is based on location and survey and different classed output like FloorSurface and WallSurface which describes as LoD C. In the integration between Revit and CityGML in the FME Workbench environment as a hierarchical data structure, like basic feature, intermediate and advanced in which features are grouped differently when converting to CityGML.

Basic feature integration

The beginning point of performance data in the blank workspace canvas is to read IfcSpaces geometry type to read the parameters geometries, and the feature types are the two layers needed to create a simple solid geometry. The Ifcslab describes the floors and roofs; otherwise, the IfcSpace represents the space between these floors as surfaces.

The IFC features need to be merged into a single feature that represents the buildingtransformer to the canvas and connect it to both the IfcSlab and IfcSpace feature type. In the parameters, ensure that Aggregate Handling is set to Deaggregate. This transformer breaks the input geometry into a mesh for each of the flattened components. When we run this workspace later on, some of the features will be rejected, so to ensure that the workspace continues running we need to set the Rejected Feature Handling. Right-click on the <Rejected> output port on the Triangulator, expand the Workspace: Rejected Feature Handling, then click on Continue. The red dot next to the <Rejected> port will disappear when this is set correctly.

Now that the meshes have been created for each component we need to merge them so we can work with a single mesh. Add a meshmerger transformer to the canvas and connect it to the TINSurface output port on the Triangulator. This will merge the 59 individual meshes into a single mesh (FME community, 2019).

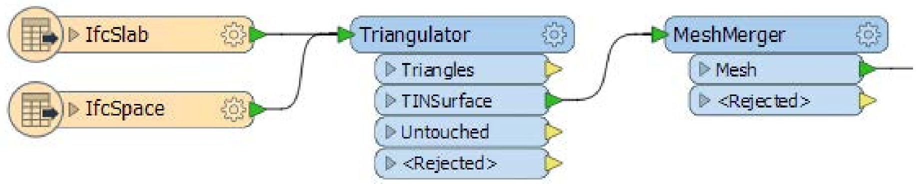

Figure: 18: Create a single mesh using the Triangulator and MeshMerger

Another step is setting the attribute of CityGML has specific standards for attribute naming for the file to be readable. Thankfully there is a custom transformer to create these attributes. Add a CityGMLGeometrySetter custom transformer to the canvas. In the parameters set the CityGML Lod Name to lod2Solid and the Feature Role to cityObjectMember. You could create these attributes using an AttributeCreator and a GeometryPropertySetter, but using this custom transformer prevents typos because these attribute values are case sensitive (FME community, 2019).

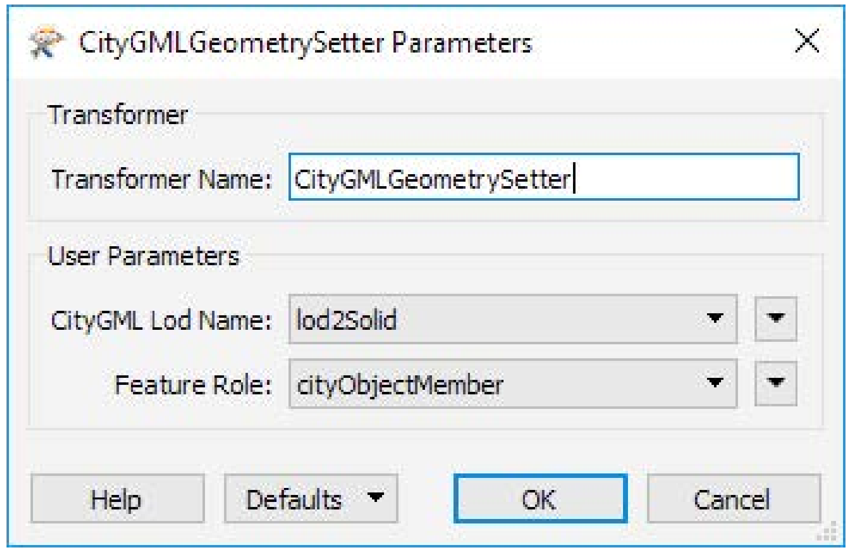

Figure: 19: Set CityGML Lod Name to lod2Solid and Feature Role to cityObjectMember

There is another attribute create that is created by the user with the information of transformer to connect to the CityGMLGeometrySetter in the parameters of AttributeCreater.

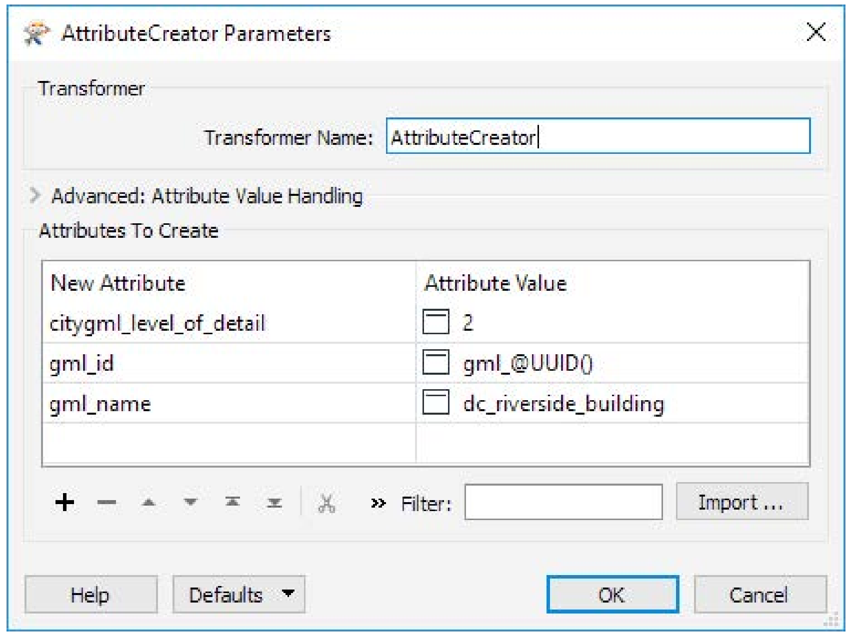

Figure: 20: Create citygml_level_of_detail, gml_id and gml_name attributes

There is no coordinate system information stored in the IFC model, there is need to scale the model maybe it is in millimetres. Add a Scaler transformer to the canvas and connect it to the AttributeCreator. In the parameters, set the Scale Factor for X, Y, and Z to 0.001 which will scale it to meters.

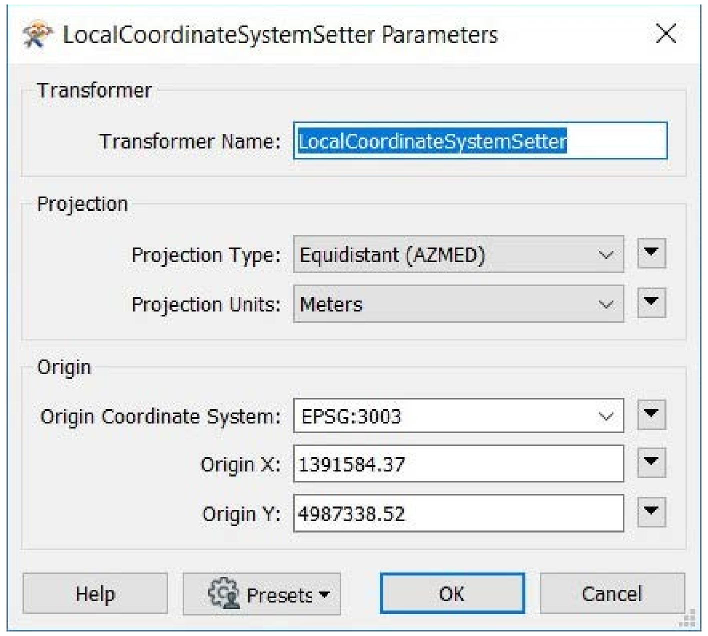

Figure: 21: Create citygml_level_of_detail, gml_id and gml_name attributes

Next, adding a LocalCoordinateSystemSetter transformer to the canvas, set the original X and Y which is related to the project and an appropriate coordinate system for the real location of the model. Add a CityGML writer to the canvas and name the dataset to set the Feature Type Definition to Automatic and then connect it to the CsmapReprojector. In the Feature Type parameters set the Feature Type Name to Building at the end it should be run the workspace and inspect the output (FME community, 2019).

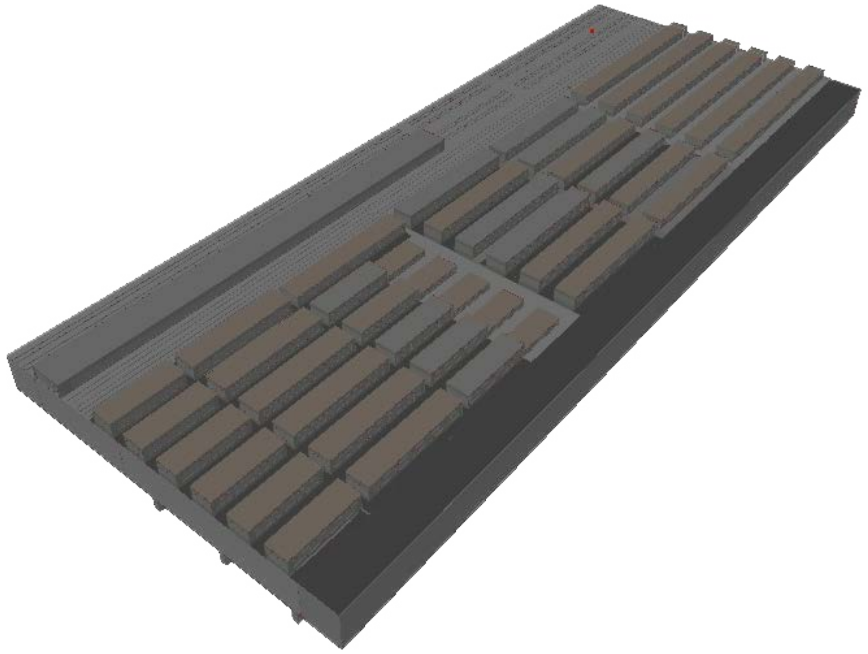

Figure: 22: Output CityGML viewed in the FME Data Inspector of Lastratura 1

Intermediate feature integration

This method of the level of detail C or LOD 300 contains the characters that not required in CityGML like IFC Doors in kind of Openings which is part of Walls, while in CityGML, Doors are part of Walls, and all the features are grouped individually, for instance, windows are part of contained in IFC Member feature and must be related to their referenced feature when transforming to CityGML. For the IFC feature in this level is needed more details, for example, the opening is referred to the more details behind IFC format.

Therfore; it is used two different IFC readers one of them is one step behind the features and the second one is two-step back to the IFC more details, because the first step doesn't carry on the IFC geometry.

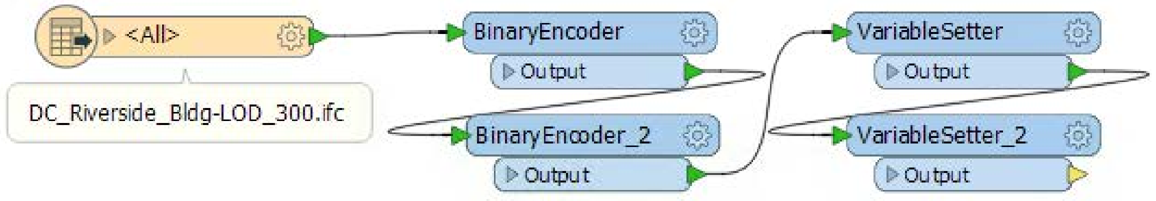

Figure: 23: Create a parent/child lookup table

The second IFC reader is used for the data conversion. The Building is a simple conversion to remove any geometry using the GeometryRemover transformer and then and AttributeRenamer transformer to set the ifc_unique_id to the gml_id (FME community, 2019).

All of the conversions will need to convert the geometry from a complex IFC solid to MultiSurface that can be written to CityGML, so a custom transformer called ConvertGeometry is created to quickly duplicate this process (FME community, 2019).

Within the ConvertGeometry custom transformer, the IFC solid geometry is separated from the property sets with a GeometryPartExtractor transformer, then converted to surfaces with a GeometryCoercer transformer. Then to flatten multi-level geometry, it was disaggregated using the Deaggregator transformer and setting the Mode to Flatten All. Then the geometry is re-aggregate into MultiSurfaces using the Aggrigator transformer with the Mode set to Geometry - Assemble One Level and a GeometryRefiner transformer (FME community,

2019).

Almost all features have their parent link set to the IFC Building Story, instead of the Building, so we need to move up one link to create the CityGML parent link to the Building, using the lookup tables stored in the variables. Since this will be repeated throughout the workspace, another custom transformer called GetGrandParentID is created (FME community, 2019).

A BinaryEncoder transformer is used with a User Parameter created for Attribute to Encode. Then a VariableRetriever transformer is added to set the _gparent_id. Finally, the _gparent_

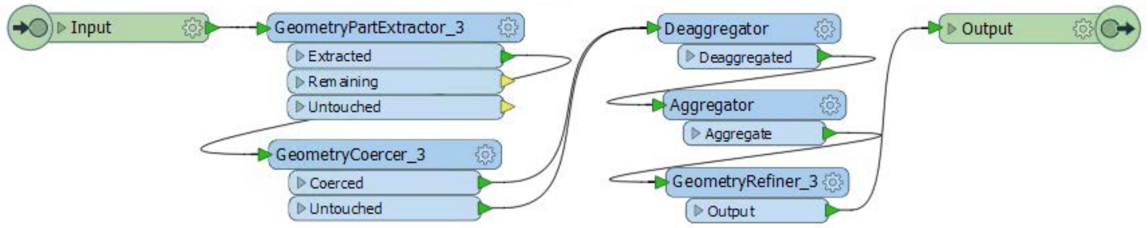

Figure: 24: ConvertGeometry custom transformer workflow

id is decoded, and another User Parameter is created for Destination Attribute using the BinaryDecoder transformer (FME community, 2019).

Before writing out to CityGML, a couple of attributes always need to be set following a strict naming convention. A CityGMLGeometrySetter custom transformer has been created to prevent data entry errors and can be found on the FME Hub. This transformer sets the CityGML Lod Name and the Feature Role (FME community, 2019).Simple conversions require minimal filtering if any at all before writing out to CityGML. The main workflow

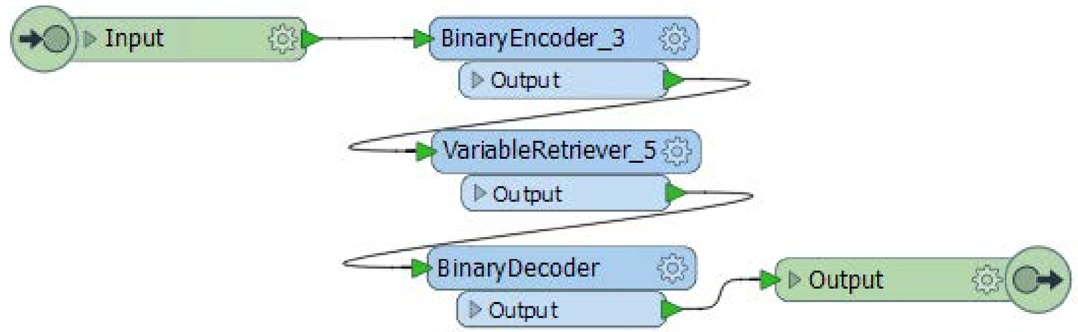

Figure: 25: GetGrandParentID custom transformer workflow

goes as follows:

1) Read in IFC data, 2) ConvertGeometry, 3) Set the gml_id, 4) GetGrandparentID, 5) CityGMLGeometrySetter, 6) Write out to CityGML.

CityGML BuildingInstallation and WallSurface features are made up of many IFC feature types, and some IFC features may be part of both. IFC Members, StairFlights, Slabs, and Railings are combined into Stairs, which are then written as BuildingInstallations, along with Columns and Beams. Other Members are combined into CurtainWalls, which are written

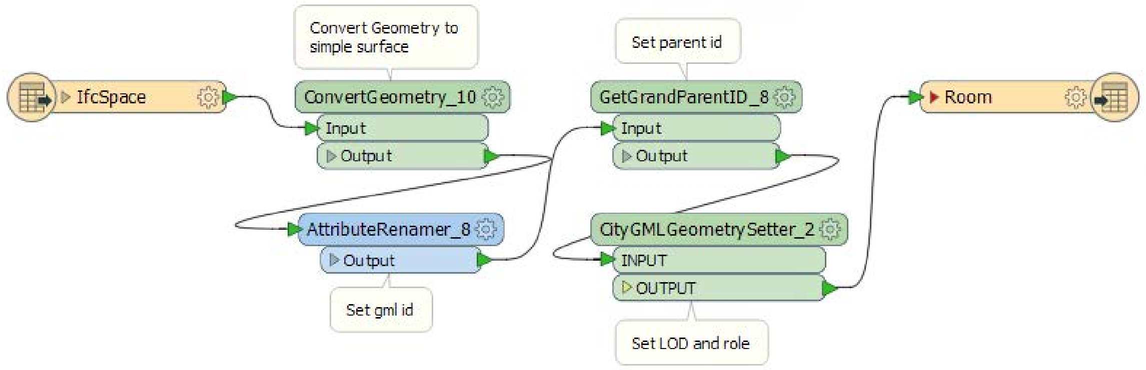

Figure: 26: Example simple conversion, converting IfcSpace to a CityGML Room

out to WallsSurfaces, as are IFC features Wall and WallStandardCase. These separations and combinations can require several lookups of parent type and grandparent IDs from the variables created by the first IFC reader (FME community, 2019).

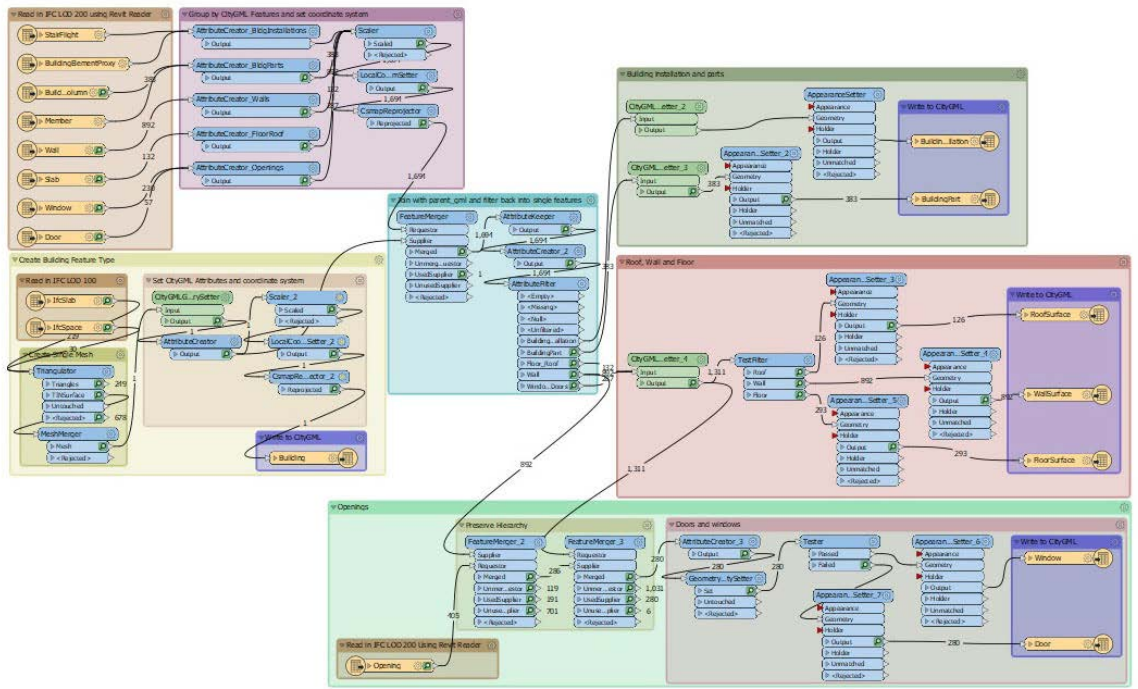

Figure: 27: Complete workplace of LOD 3

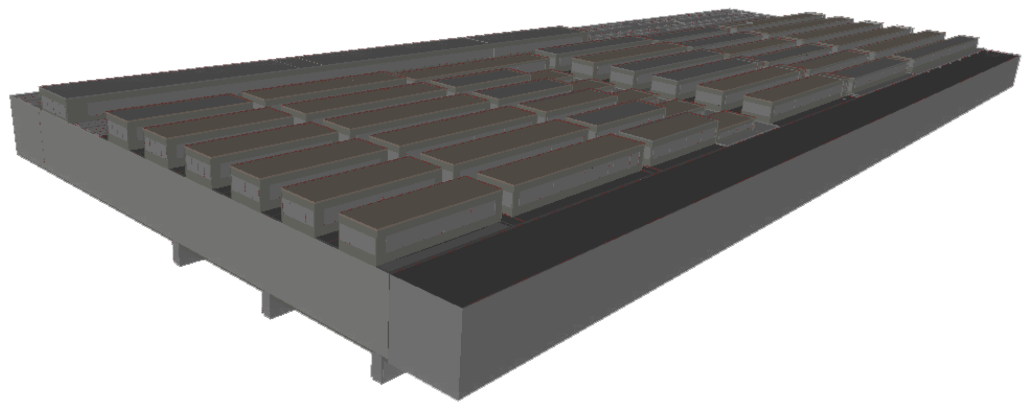

Figure: 28: Output CityGML viewed in the FME Data Inspector of Lastratura 1

Main feature integration

The method that more discussed is about directly interconnection linking Autodesk Revit to ArcGIS Pro, which in 2019 provides the opportunity for integrating BIM and GIS inside one 3D scene and 2D map with attribute and decision-making. To the complete informative model in the 3D GIS, it was necessary to export the virtual component schedules from REVIT and then to import and connect them, within the geodatabase, to the same virtual components, through the identification code.

In this way, the 3D virtual model created within REVIT was transferred completely and without loss of data to the 3D GIS. After importing the .gdb file into ArcGIS and integrating the data, in ArcScene, it is possible to navigate the 3D model of the building placed within its urban context (Vacca et al., 2020). The workflow is applied for the Lastratura 1 of Mirafiori, which throughout the years was influenced by various reconstruction and preservation interferences with a big scale building.

The essential for energy management, sustainability, and functionalization display the project involved in the modern world into a contemporary building. All this information for a historic building is vital for the workflow of typologies of existing building heritage to concern the historic knowledge and restoration progressively during the decades. In the

ArcGIS Pro the storing of all the maps, workspaces and data connection in one environments then it can be used by other users and managing data. In the scene, the member of ArcGIS Pro by combining data with Autodesk Revit file (.rvt) is readable in BIM file workspace and it presents Architectural, Electrical, Mechanical Piping, and Structural BIM file dataset. It should be added that the survey point and project base point which set in Revit is not in the proper place in ArcGIS, it displays 0 North and 0 East which means that in the project the using of Bench Mark is essential to find a point on the Earth with proper attitude and longitude.

The Bench Mark should be fixed in Revit coordinate for linking and specify it in a point on the Earth with a special attention to Coordinate System which is match with the location of the project.

The spatial reference is challenging for the connection between BIM and GIS in the correct position and area and for finding a proper coordinate system match with Bench Mark. Although, if it is not in the accurate point it would be managed by Georeference which can be scaled, moved, and rotated. The layer of properties can demonstrate the general information, metadata, source, and elevation which the height of features located and additional geometry z-values of the 3D model; moreover, all this knowledge exists in the ArcGIS environment with visual management and color definition.

Choosing Projection

The data location run into many datasets have different ways of describing the location on Earth, the issues during the displaying data with different coordinate systems or projection. There is a math involves in projection which in some way exists wrong math to converting projection in x,y coordinate for 3D surface on a 2S plane, it should be chosen property for a project. it should mentioned that the world is round and the maps are flat, for defining the 3D surface and the way of measuring and classifying it the geographic coordinate system in the properties of scene should define location right which is comprised of three elements like geoid, a spheroid (or an ellipsoid), and a datum (Rock, Malhoski, 2020) .Geoid represents a reference system for vertical measurement; although, spheroid represents a refrence system for horizontal measurement. Now that you have the geoid and spheroid, the last piece you need is a datum.

A datum is what puts a coordinate grid on top of the spheroid. Much like spheroids, many datums can be used. Some datums cover the whole world, like the World Geodetic System 84 (WGS 1984), and some cover smaller areas like the North American Datum 1983 (NAD 1983), which covers North America. Datums allow variation in topology versus a spheroid because a spheroid is smooth and the surface of the Earth is not (Rock, Malhoski, 2020).

The map should be created from the place where the project located from the North or South or from the web mapping around equator. If the projection of creating a map is not correct probably the building locates in Canada or Russia.

The state plane coordinate systems are favored by land surveyors because they break the surface of the Earth up into relatively small areas that produce an error rate of no more than 1:100,00. Cities and municipalities typically use the state plane zone that they are located in for their data for two reasons—the low error introduced, and because it's an accepted and well-known standard that makes it easy for an outsider to guess with high certainty what projection will be used. One other feature of the state plane coordinate system is there are no negative coordinates.

The origin, or (0,0) of each zone is outside the zone, meaning all coordinates will be positive, which makes calculations easier and less prone to error (Rock, Malhoski, 2020). However, choosing an appropriate projection is dependent on the scale and the shape of data and the purpose of the map, the best choice of the projection is the data which fits into it.

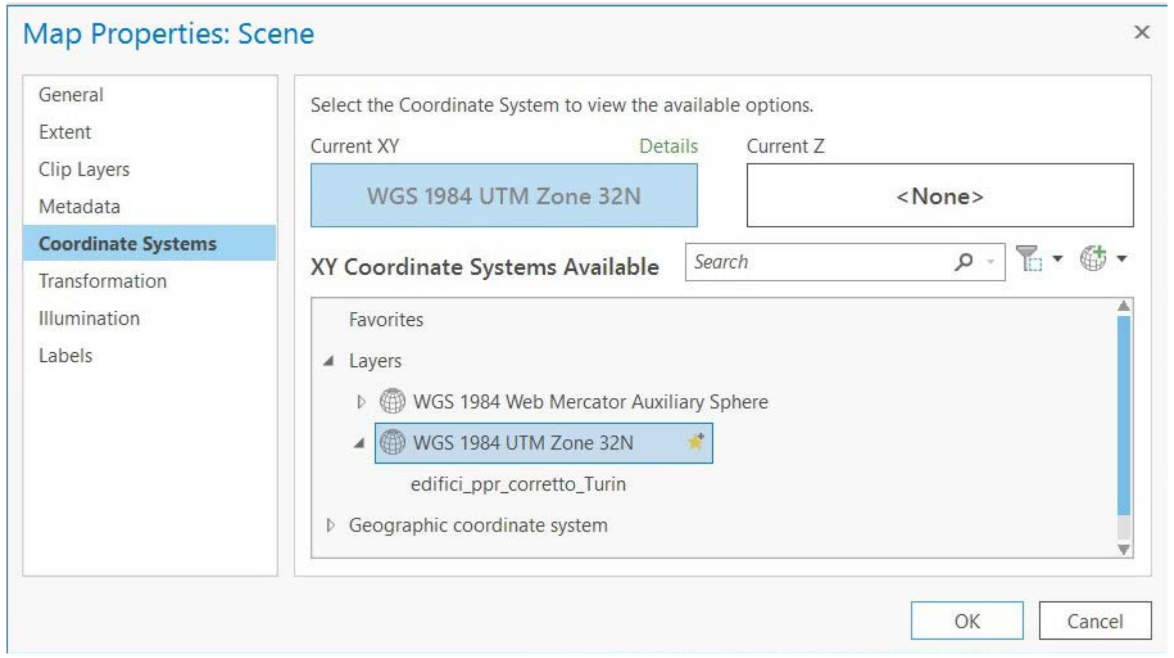

Figure: 29: Suitable Coordinate system for Turin

Export and editing features

3D layers of the scene and attribute of georeferencing are not able to edit or add field but it can be organized by feature export through the data management and extract data of the references which are in Revit (.rvt) format. The feature can be selected in the content of interface and functionality in choosing the parameters pick input and producing output where the file exists all in the same project for managing. The output file is saved in the project for editing, adding and calculating feature types, the shape is transforming like “Multipatch” with the category of use, different level and different phases of discipline with all the information of the building, the year of building, the year of modeled in Revit and all element’s data in the attribute table.

The Multipatch is the way of 3D managing and extruding of objective in the GIS environment for designing and describing the building’s surface. The layer can symbolize from one layer convert it to category or quantity for showing the difference by colors, comparing together and improving communication.

3D Smart Mapping

Displaying and storing the data platform have authored in GIS and can be shared by other users the ability of smart mapping can help to save time and effort in creating visually and accessing easily the features with symbology, labeling, and pop-up. Smart mapping is a tool for setting the cartography that is an automated tool for data and recognize the type of data and types of values for the data prepare cartographic symbology for the data-based on the scene.

It is a dynamic attribute change of symbology based tool suggested the symbology of 0 The story of the data tells by smart mapping in changing population, volume of traffic along a highway, zoning or showing the location and information of the data. The data can describe by different colors and choosing a correct methods in the section. Creating the feature layer with different function of using and information can be choose and edit.

It would be useful for showing the location like commercial buildings or roads, at this time in the integration of the building and attributes table the quality issues of location can be found; however, it can have the information within the attribute and optional style. The knowledge is used like numbers, charts, maps, and so on, depending on the specific values for the slider and classification of data. Using the geometry for different values and typologies in the big scale industrial plant into a city for knowing the energy consumption of the building compared to others.

Additionally, map managing for a primary result of facility management in order to general renovation of building for the aim of energy saving of a big factory which plays a vital role in a master plan of the city like Turin in function and the size. The forthcoming study of smart building and sustainability of the city and building for the linking outside and inside of an important building like Mirafiori for comprehensive the connection of other buildings and organs with their specific features of their own.

All the information in one platform can give the opportunity to take advantage of decision-making for the prospect arrangement. The destiny of industrial and residential buildings around the Body Shop of Mirafiori can be displayed by 3D modeling and the height managing of characteristics with colors in the layout by the high quality of mapping.

The extracting information from BIM to GIS demands suitable control for every element of the object which is related to an individual building, the attribute of the buildings can describe all the objects below the name of the building in which the knowledge comprises.

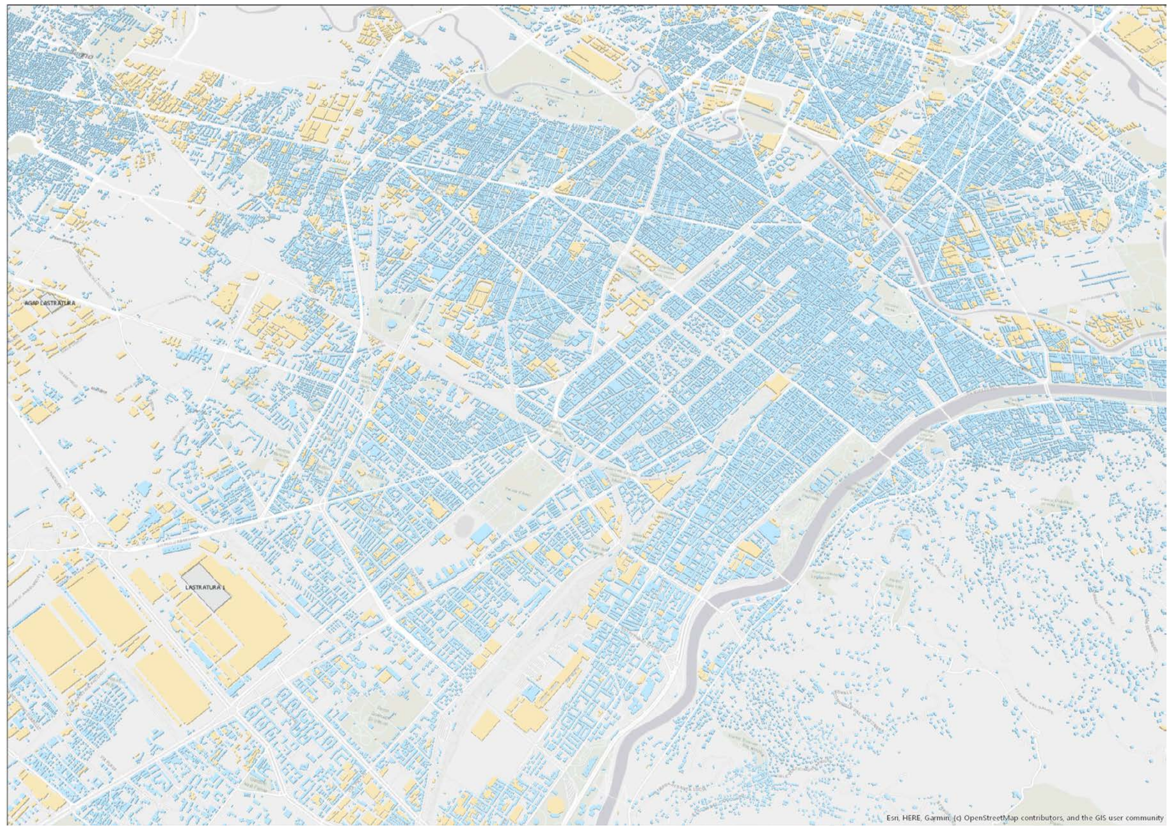

Figure: 30: 3D model of the buildings with different functions in Turin

Chapter Six

Results

The data exchange between the two systems in the way of remaining the information is a significant purpose which is discussed with a case study represented by an industrial infrastructure. Starting with the map of Turin and the building model from BIM with the data of building in the Mirafiori district is able to manage the ability of decision-making about managing the future of a big scale building. The address and function of the building in order to construction period and transformation during the time, size, types of system and many information which is related to the building and

stored in GIS with the help of BIM model by adding more precise information.

When the technical design model is developed, an environmental model is produced, where the spatial data needed for the environmental impact assessment have been collected. It has been useful to use inputs from various sources for the definition of the environmental model. Currently, Italy is trying to increase the use of open data, in particular, Public Administrations are making data available to be easily consulted and processed in order to realize territorial maps and improve statistical analysis (D'Amico et al., 2019).

The abandoned building in particular and big-scale industrial sites for two buildings of FCA group comparison Lastratura 1 of Mirafiori and Lastratura of AGAP for the energy analysis and consumption in a specific session.

Project Information

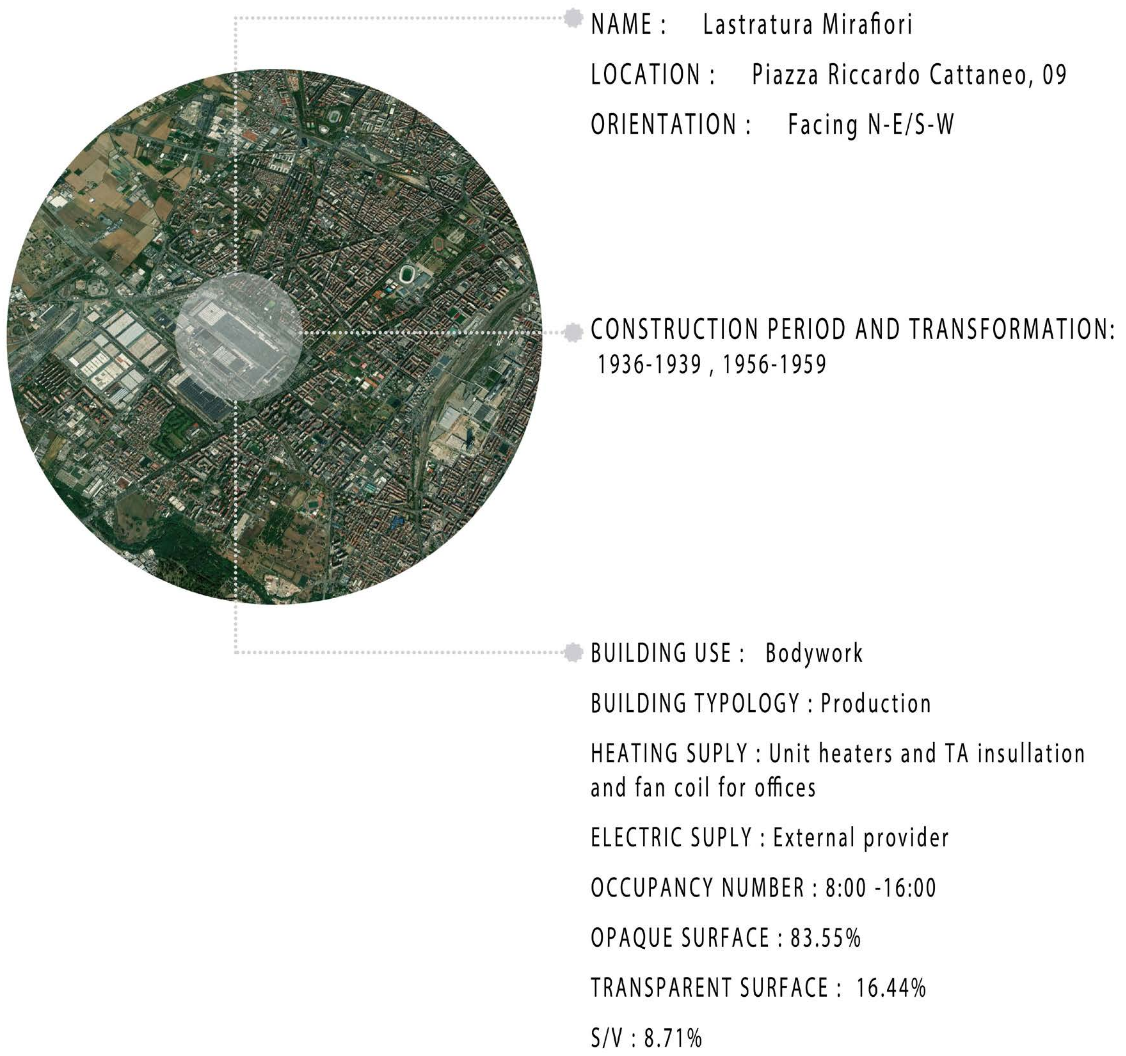

Figure: 31: Lastratura 1 of Mirafiori typology

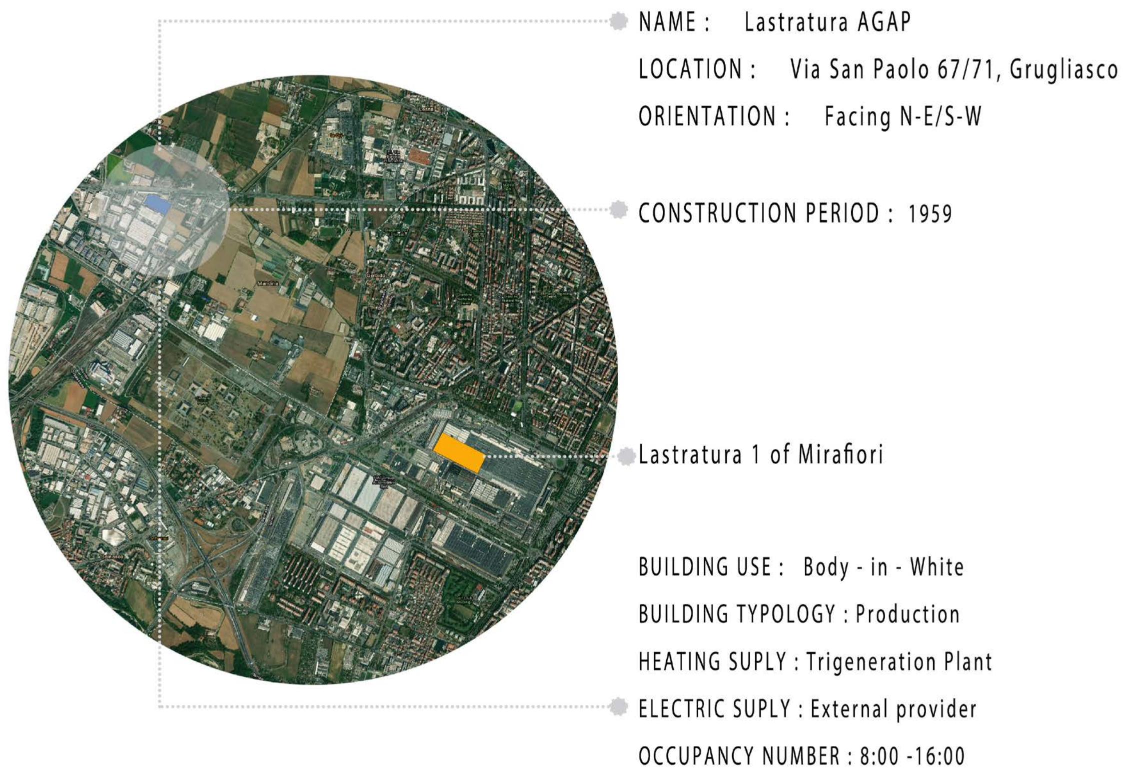

Figure: 32: Lastratura of AGAP typology

Data from BIM and GIS

The building's file and all the data flowing between two software is explicit information concerning especially in FME which is more complex and there is a translator in the middle; moreover, it should be transported to shapefile (shp) or geodatabase (gdb) for importing to ArcGIS Pro.

The data from Revit (rvt) directly to ArcGIS Pro with adding data in the 3D layer scene with the topographic and Ground information of GIS by default. The managing of Define Projection can be run in Geoprocessing by inputting dataset or feature class with the location of the file directly, in this point there is a precise perception of mapping and building elements together.

The building coordination should be so specific in UTM or State Plane including position; otherwise, it can be used by Georeference by managing in the display. This is the first step because here is merely expressing in GIS without any editing in attributes, extracting is the most important part of data selecting between BIM-GIS.

Figure: 33: BIM into GIS environment

In the data of the project the data should export features or attributes, with the name and location of output's file inside the GIS for getting the information in 3D scene as a geodatabase format in the geoprocessing of BIM parameters.

Figure: 34: BIM exported to the GIS parameters

The features symbolized by unique value like different levels, transparency, function, and so on with a particular field value that described specific information in the 3D model.

Figure: 35: GIS's transparent and opague surface unique value symbology

All the members of the information, which is selected can be supported by the name of building for managing better inside the city with more buildings, that will be extracted by GIS.

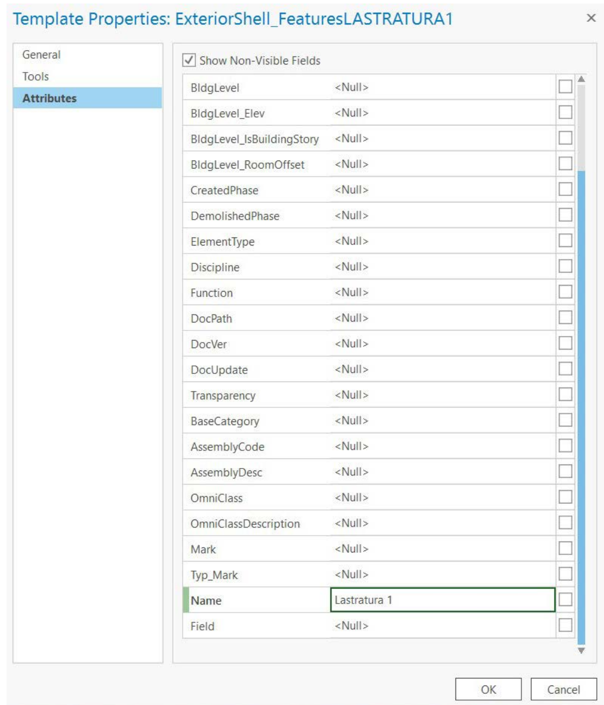

Figure: 36: Adding the name of building to the project from editing attribute

The open data of buildings typology of the city in different functions in residential and commercial buildings. The information can be associated inside the city by the appropriate data, also architectural value with the new requirement for functionalization and energy management. In this case, adding the parameters and values of 3D smart city for the existing building heritage is essential for method of integrating.

The city information can represent the building with BIM data, GIS data which extract from BIM with special category, and GIS feature with a specific format for achieving information that comes from other software like Excel for displaying the features.

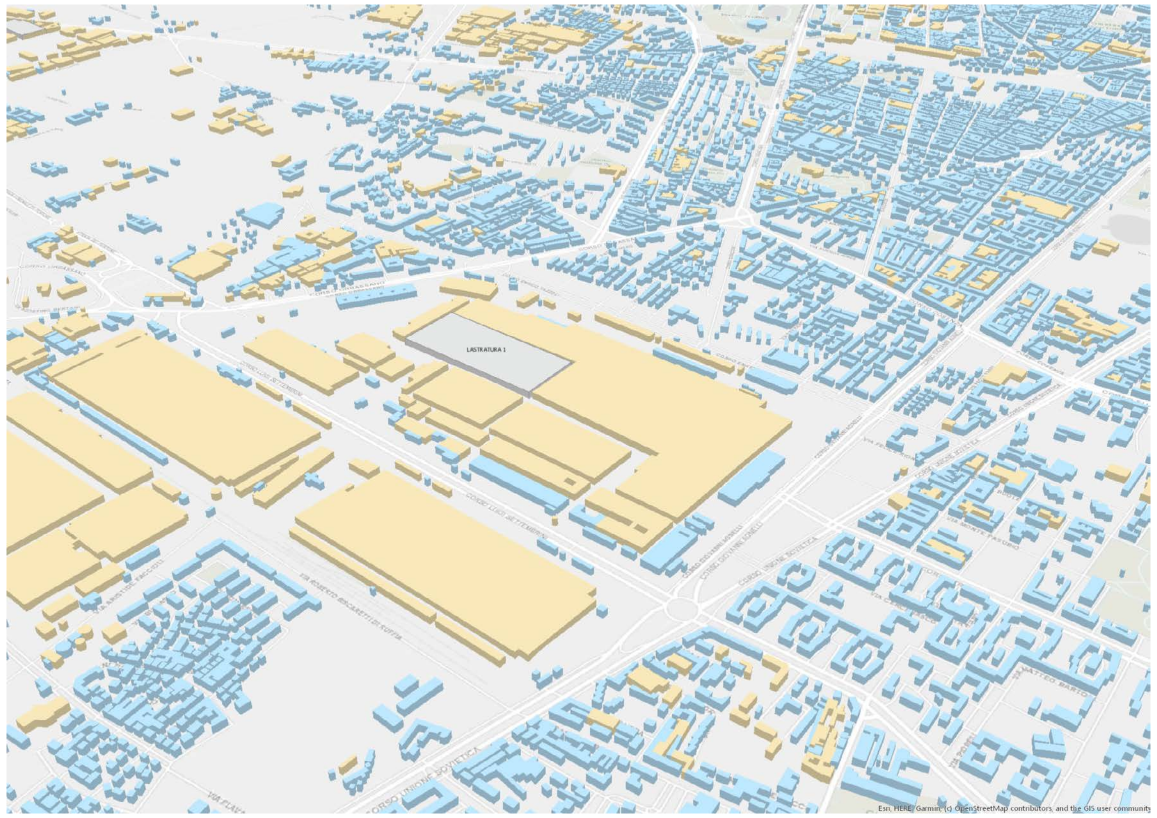

Figure: 37: Case study with the characterististic information of GIS inside the city

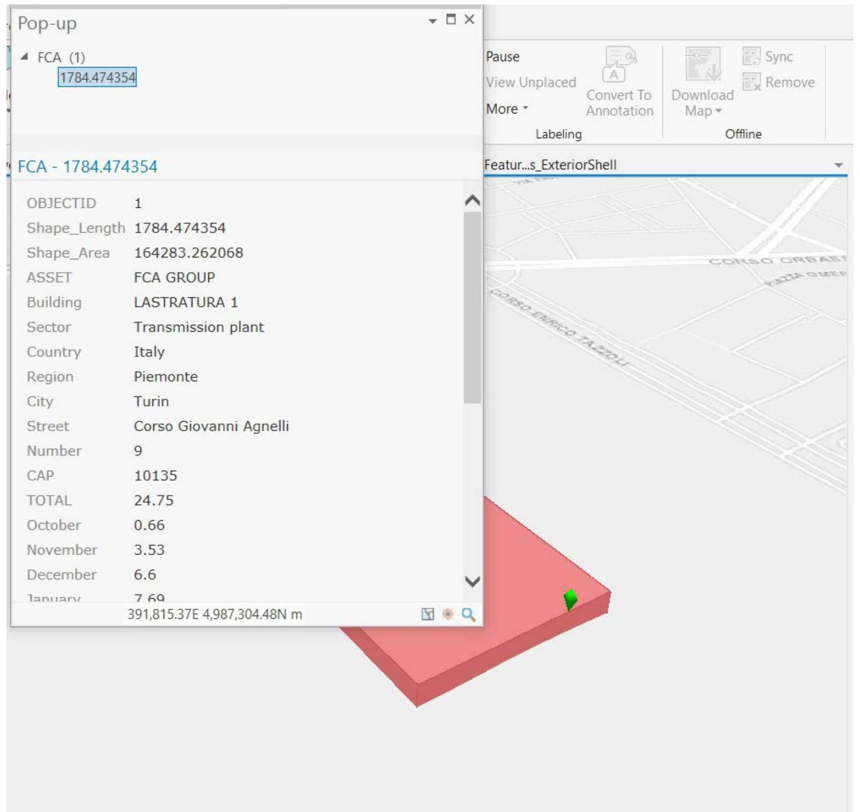

Figure: 38: Case study with actual information indise the GIS

Workflow Challenges

The interoperability process for exchanging data has some challenges which are discussed in this section. The possibility of getting files especially in Shapefile format (shp), with the database of properties in a required format in the BIM-GIS integration in order to exchange the data.

Identifying the errors in output of file the input as a dataset in the workflow exposing can have some issues which should be clued and fixed. In the FME workbench of procedures of datasets of managing workflow in the domains of information.

Obtaining information from 3 different methodologies provide a heterogeneous data for accomplishing, FME software, in this case, the specific errors of IFC-CityGML conversion in the longest way with some problem in adding two different numbers of x and y, which is not in the same place and in the high LoD datasets to the way of using different coordinate in the transformation can be not to join unitedly. This mismatching with the different feature type due to conversion process can be caused errors in complex model that validation of errors algorithms identification.

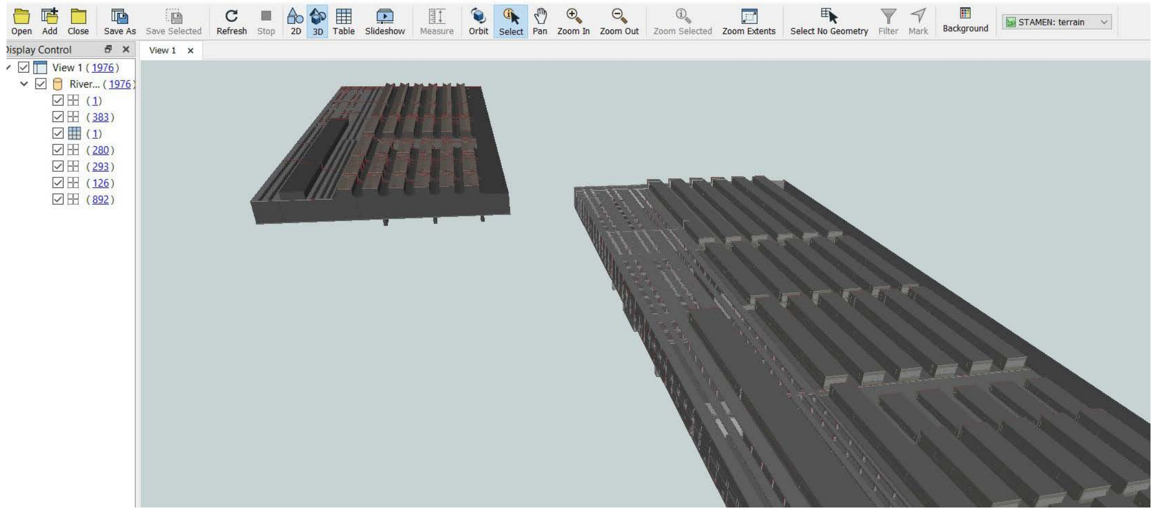

Figure: 39: FME Data Inspector with different number of coordinate system in LOD 3

The placement of the building should be attached to the Revit model as the benchmark, in order to survey point is not readable in GIS and shows the 0 N, 0 E point of the world.

The accurate position should be fixed in FME in coordinate system setter, especially for LOD 3, which is in the workflow of two coordinate system setters. The specification requires

a correct point of latitude and longitude of a building for setting in the right spot.

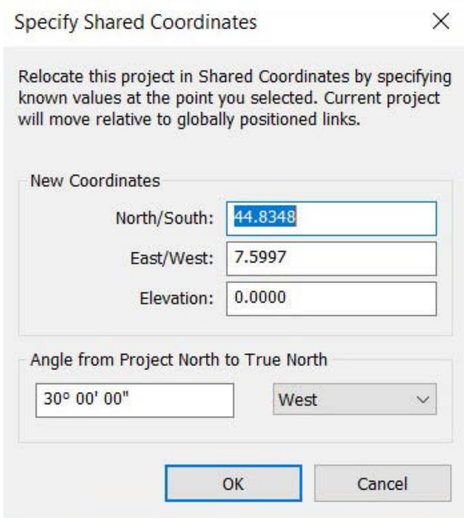

Figure: 40: Specify coordinate at point in Revit for Mirafiori Lastratura 1

When the coordinate system is for another part of world and not match with the placement of the building can have some errors in the building in order to not to match with the coordinating system of the point.

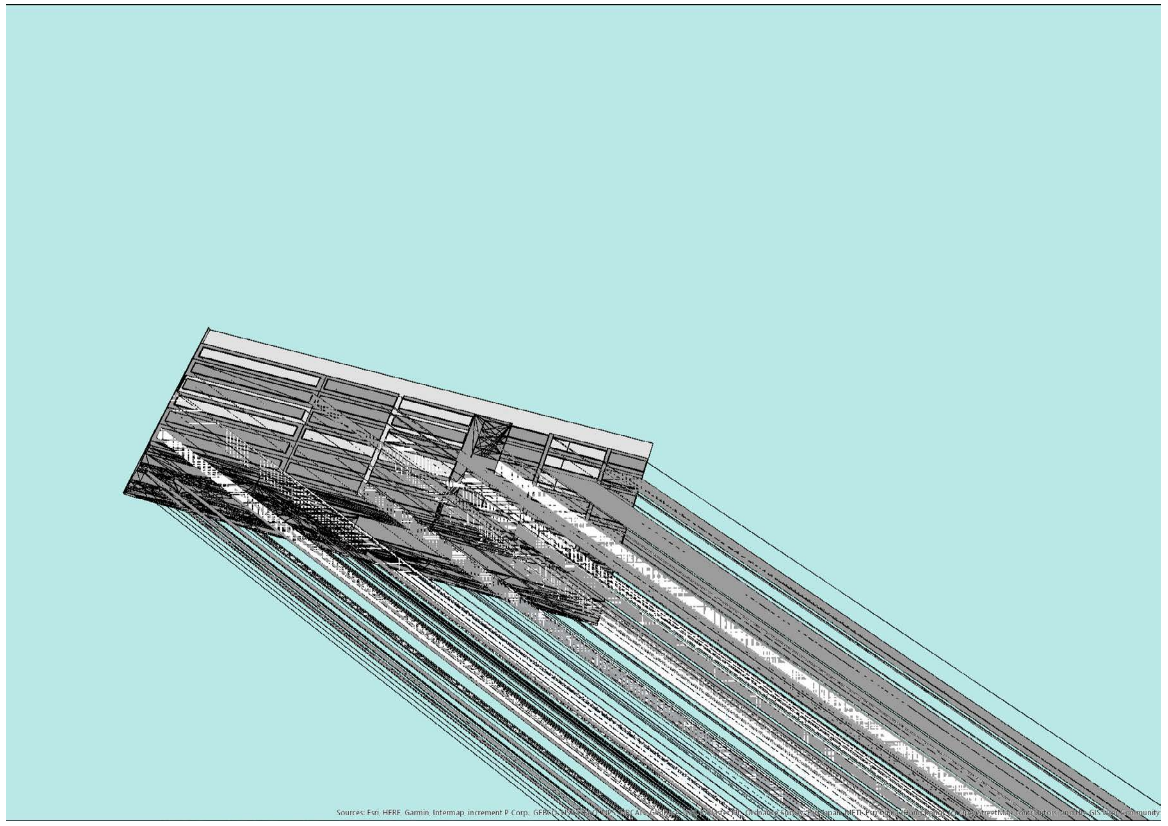

Figure: 41: Specify coordinate in the wrong system

In the properties of the exterior shell should be chosen in a right elevation on the earth; unless, the management of levels on the slope or surface can be disordered.

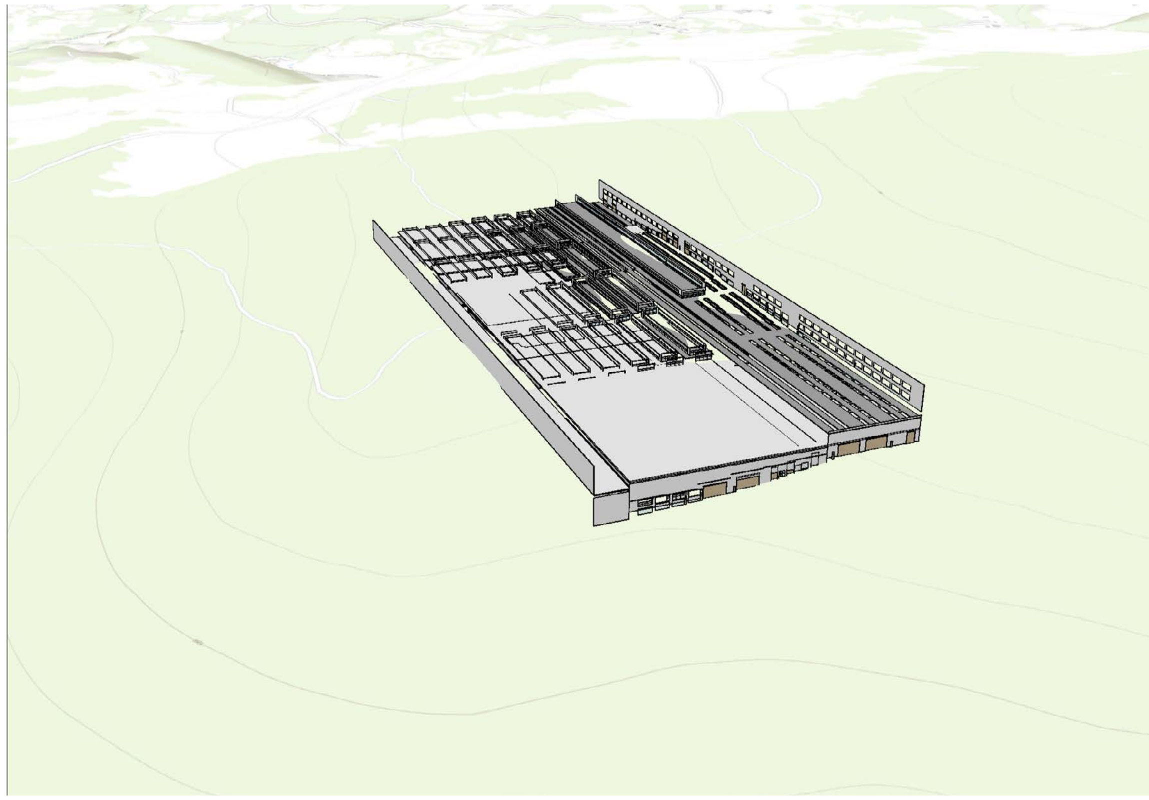

Figure: 42: The challenges of the building on the surface

Comparing Energy Consumption

The contribution of BIM-based energy analysis and GIS-base calculation in the way of the geometric and semantic, which extracted from BIM into the GIS city model for generating high accuracy and information source in the large scale building for energy analysis. The increasingly urbanizing density of the city in architectural complexity, energy consumption plays a vital role in urban planning management. The evolution of 3D geographic and 3D building information for the 3D smart city model can evaluate the energy performance of individual buildings in the city. The information of the 3D building of BIM can give a correct data display from the physical exteriors and surrounding environment through GIS. The general spatial analysis and suitability panning to relating items and integrating setting to support decision making.

The domain of BIM 3D model also utilization of 3D model for facility interoperability of urban planning, architecture designing, and environment specialist. The influence of potential in urban planning to achieve information integration in more detail energy analysis can be compared and converted to GIS. The information add to the feature and field to manage energy consumption during a specific time.

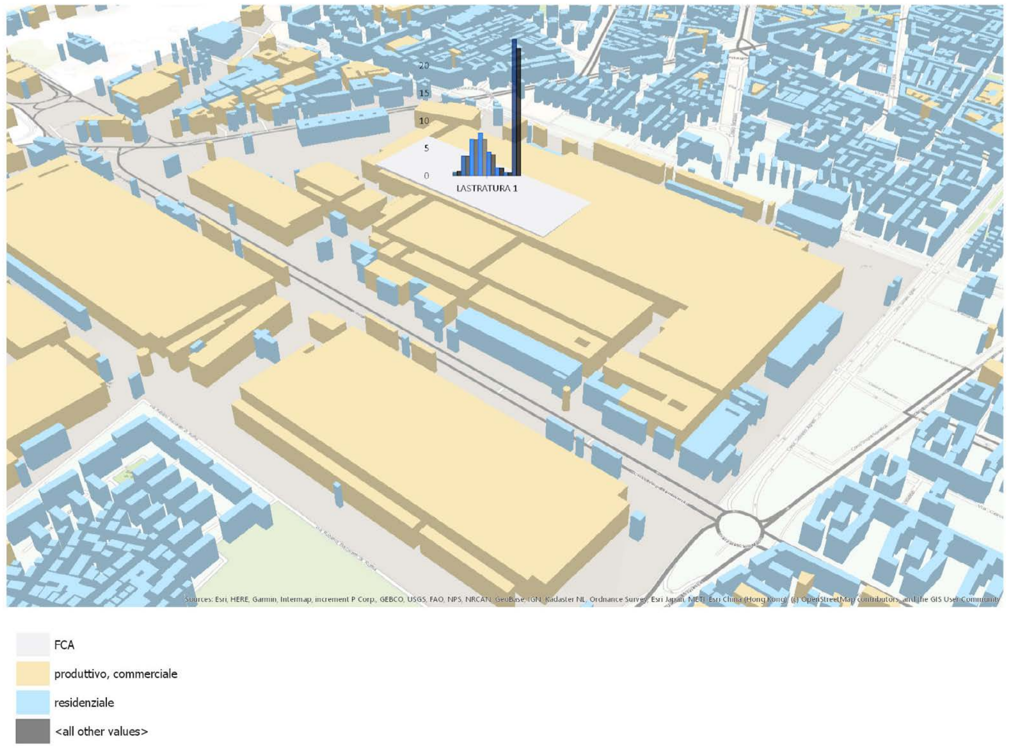

Figure: 44: Energy Consumption of the building 1 (Lastratira 1 of Mirafiori)

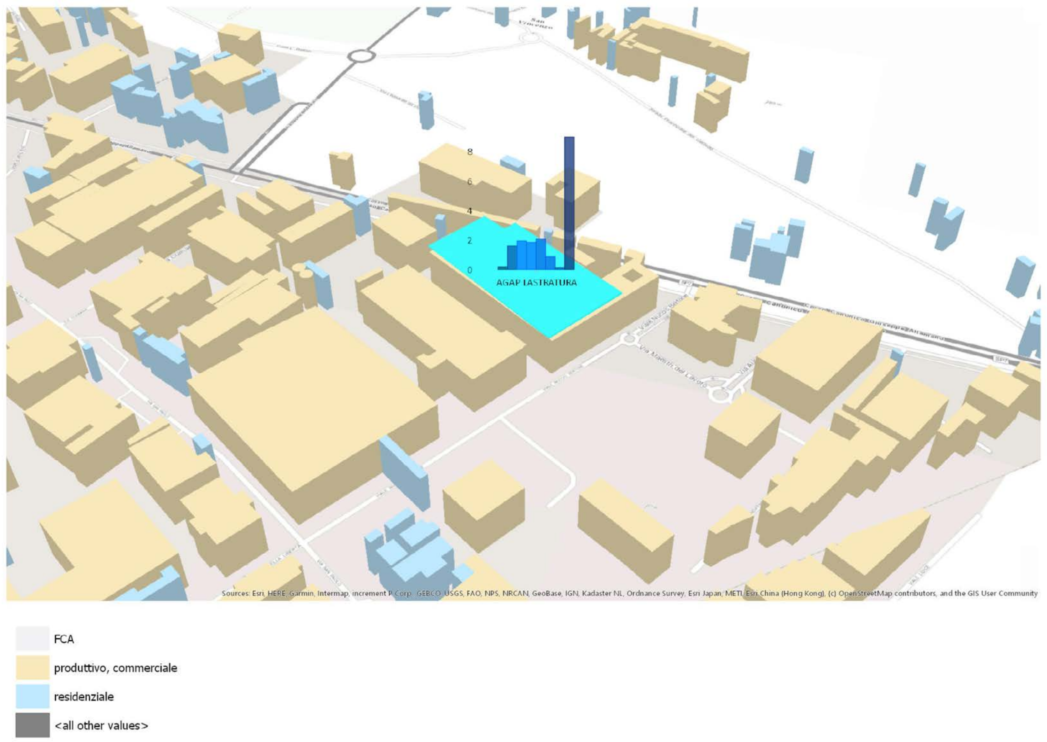

Figure: 43: Energy Consumption of the building 2 (AGAP Lastratura)

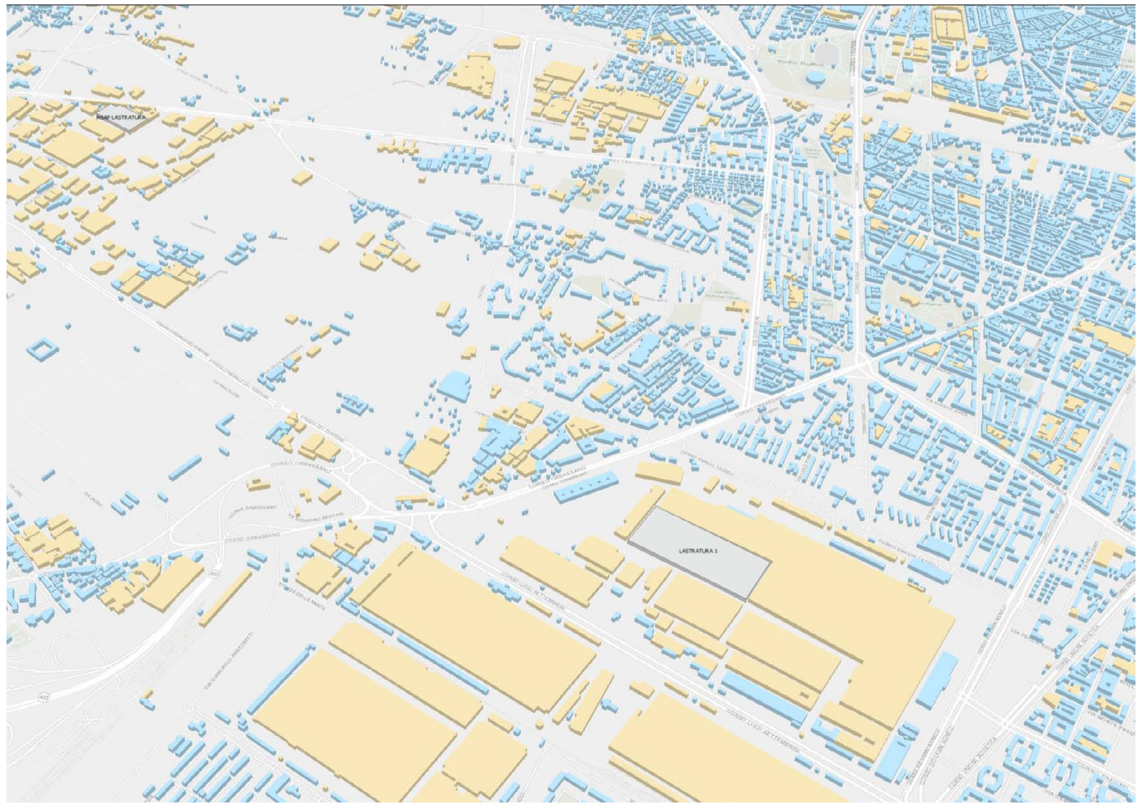

Figure: 45: Location of Lastratira 1 on Mirafiori and Lastratura of AGAP in the city

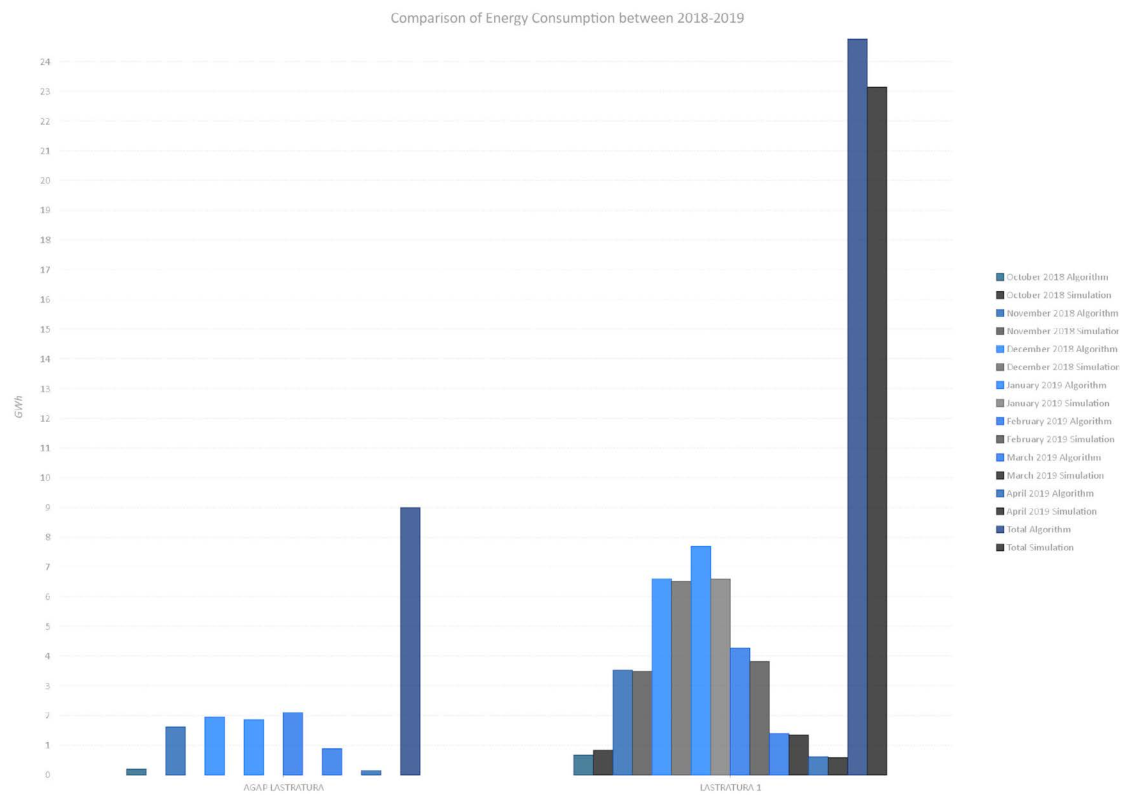

Figure: 46: Comparison of energy consumprion inside the City of two buildings during specific time

Conclusion

The complexity of big-scale projects for time-saving in the urban plan is the subjective point of interoperability between data. The proposed model improves the infrastructure planning and geotechnical analysis between BIM-based model and GIS-based 3D city model of semantic adoption of information flow. The proposed model can improve managing the project's energy consumption in comparison to other buildings for developing civil infrastructure systems in sustainability and improving the building's functionality for becoming acceptable in the modern industry.

The integration of BIM and GIS systems is developing in these days for data exchange of cooperation and interoperability in the capability of each system for simulation. Geological analysis in open sources and applied to the project, and uploading it to share with other users in the potential of automated process of alternative analysis in the field of construction and engineering.

The positive results of BIM in the design phase and developing the infrastructure in taking advantage of the design process from the information obtained in the BIM database for specific analysis like geotechnical, data extraction, and so on. The elements take control of qualify the project related to economic and environmental values. In the interoperability of data sharing concerning the implementation of GIS datasets of geographical knowledge from BIM context to energy analysis.

The novel benefit of using BIM for data management in storing data and on the other hand GIS allows us to analyze the geographic from symbolic point and geographic entities. Getting the information from BIM and applying it to the GIS with a complex technical point for maintenance process can allow to have a more sustainable approach in the future. The importance of industrial buildings in the thinking of future using of big-scale building which is part of the city's historical background.

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