ISSN 1828-5961

The centrality of Representation with BIM

La centralità della Rappresentazione con il BIM

The digital transition of the AEC sector is a requirement for all professionals involved in, for this reason the topic of Representation strengthens the centrality of its role related to the different involved field, thanks to data interoperability. BIM is the methodology that enables the sharing of graphical and alphanumerical information among different professionals. The developed methodology fitted during these years is described for several projects, and it is always composed by three phases: survey and documental research; digital modelling and data interpretation; data exploitation through interoperability. BIM process still does not reach an optimized interoperability level, but this represent the added value of technological innovation for construction industry, as a tool for information sharing.

La transizione digitale del settore delle costruzioni è un'esigenza per tutte le figure professionali, pertanto il tema della rappresentazione rafforza la centralità del proprio ruolo in relazione ai diversi ambiti coinvolti, grazie all'interoperabilità dei dati. Il BIM è la metodologia che consente ai diversi professionisti di scambiare informazioni grafiche e alfanumeriche. Si descrive la metodologia studiata nel corso degli anni per diversi progetti, composta sempre da tre fasi: rilievo e ricerca documentale; modellazione digitale e interpretazione dei dati; utilizzo dei dati grazie all'interoperabilità. Il processo BIM ad oggi non ha ancora raggiunto un grado di interoperabilità ottimale, ma questa rappresenta il valore aggiunto dell'innovazione tecnologica per l'industria delle costruzioni, come strumento di condivisione dell'informazione.

key words: BIM, HBIM, InfraBIM, Data Management, Energy efficiency.

ISSN 1828-5961

Anna Osello
Was born on 30.09.1967 a Locana (TO). She obtained her degree at Politecnico di Torino in 1992 and her PhD in 1996 at Università degli Studi la Sapienza in Rome. She is full professor at Politecnico di Torino where she leads the DrawingTOtheFuture LAB carrying out research on the issues of BIM and interoperability.

Luca Barone
Was born on 2.06.1990 in Savona. He graduated in Building Engineering on 2015 at Politecnico di Torino. He was a reseach assistant at DrawingTOtheFuture LAB, a research group led by Prof. Anna Osello at Politecnico di Torino, researching on the issues of BIM in order to realize the digitalization of the public buildings.

Sanaz Davardoust
Was born on 3.10.1981 in Iran. She graduated in Architecture at Politecnico di Torino in 2013. Currently she is a PhD student on Architectural and Landscape Heritage about "The BIM process to the architectural heritage: new communication tools based on Virtual Reality and Augmented Reality".

Daniela De Luca
Was born on 20.01.1991 in Turin. She graduated in Architecture on 2015. Currently she is a research fellowship at DrawingTOtheFuture LAB, a research group led by Prof. Anna Osello at Politecnico di Torino, researching on the innovative methodology of BIM for the energy efficiency with District Information Modelling (DIM).

Matteo Del Giudice
Was born on 21.12.1987 in Turin. He obtained his degree at Politecnico di Torino in 2011 and her PhD in Innovation technology for the Built Environment at Politecnico di Torino in 2016. He studied abroad in Malaysia for Erasmus Mundus in 2014. He is involved in a DrawingTOtheFuture LAB led by prof. Anna Osello.

Maurizio Dellosta
Was born on 18.07.1991 in Casale Monferrato (AL). He graduated in Architecture on 2015. Currently he is a research assistant at DrawingTOtheFuture LAB, led by Prof. Anna Osello at Politecnico di Torino, researching on the innovative methodology of BIM in building maintenance and management.

Arianna Fonsati
Was born on 29.02.1992 in Turin. She graduated in Architecture on 2015. Currently she is a research fellowship at DrawingTOtheFuture LAB, a research group led by Prof. Anna Osello at Politecnico di Torino, researching on the innovative methodology of BIM for the energy efficiency with District Information Modelling (DIM).

Greta Lucibello
Was born on 22.06.1991 in Turin. She graduated in Architecture on 2015. Currently she is a research fellowship at DrawingTOtheFuture LAB, a research group led by Prof. Anna Osello at Politecnico di Torino, researching on the innovative methodology of BIM in building maintenance and management.

Niccolò Rapetti
Was born on 1.02.1987 a Turin. He graduated in Architecture from Politecnico di Torino in 2014. He had a research fellowship on BIM and interoperability, with prof. Anna Osello in the DrawingTOthefuture LAB. He is a Phd student in Urban and Regional Development, about BIM and interoperability for infrastructure design.

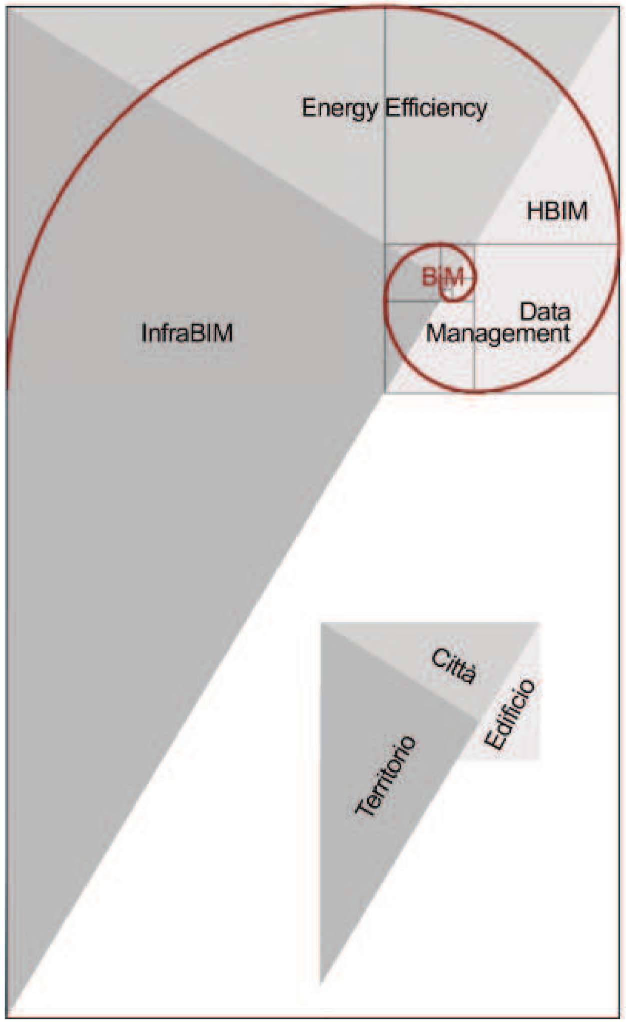
Francesco Semeraro
Was born on 14.04.1990 in Monopoli (BA). He graduated in Building Engineering on 2014. He had a research assistant at DrawingTOtheFuture LAB, working on BIM for building maintenance and management. Currently he is a Phd student in Urban and Regional Development, researching on BIM for infrastructure.

Francesca Maria Ugliotti
Was born on 19.03.1987 a Borgosesia (VC). She received a graduate Building Engineering degree at Politecnico di Torino in 2011. She was a Temporary Researcher at DrawingTOtheFuture LAB. She is a Phd Student on Urban and Regional Development at Politecnico di Torino.

INTRODUCTION

Human beings have always found several ways to communicate ideas, needs and projects. This process has always been enhancing in order to optimize the communication without lack of data. From this point of view drawing can be considered one of the most important instruments of communication using different "languages" that facilitate the users' awareness step by step.
In the last years new drawing tools that are able to improve the quality of representation have been provided by Innovation Technology (IT), extending the contents n the graphical, and especially in alphanumerical direction. In these terms, the role of information is becoming increasingly important especially relating to the topic of data-sharing.
This issue is an essential part of Building Information Modelling (BIM). In fact, in terms of data communication, BIM can be considered the connection between the different environments of the Architecture, Engineer and Construction (AEC) industry, dealing with the difficulty of data communication between professionals involved in construction, trying to solve redundancies problems and the inefficiencies in terms of time and costs.
As a methodology, BIM is based on a shared model that contains a large amount of information enabling each user to enrich or query the 3D parametric model for different types of simulations (energetics, structural, etc.). So, it is evident the importance of the data sharing that is enabled by interoperability, that plays a key role in the BIM process for the optimization of data management.
In these terms it is relevant to highlight how BIM methodology is strictly related to the management of the Information for different uses at different scales. The BIM process can be adopted at building, district and territorial scale; each of them is characterized by different Level of Detail and Development (LODs) related to the goals of each project.
It is clear that at urban and regional scale, a large amount of data needs to be managed through a framework or a common platform, enabling professionals to link different information stored in different databases using standard exchange formats. In these terms, interoperability is considered the milestone of the building process characterized by IT.
Relating to the actual environmental and economic conditions, BIM methodology could became the key to speed up the building process, enhancing the data sharing between the users through the standardization of a shared language.
This idea is represented in the Figure 1 following the Golden rectangle fundamental principles that appears in nature and is used by humans several times both in art and architecture.

Figure 1. The Golden rectangle BIM oriented.



In this way, BIM is compared to the Golden ratio; as the phi is considered a paradigm of the nature in term of proportions, BIM is considered the beginning of the building process where information is shared between professionals in the different representation scales.
From this point of view BIM should be considered as the archetype of the building process from which several fields, such as Data Management, Historical BIM, Energy Efficiency and InfraBIM, can exploit its benefits in their proper way. Obviously, each field requires different kinds of information basing of the objectives of each project; this means that the 3D parametric models need to be reached with heterogeneous data that determine a certain BIM level of maturity.
Some examples of the main application fields discussed above, are presented in the following part of the article. The objective is to demonstrate the central role of the drawing conferred by BIM in different interdisciplinary fields, starting from the documentation value of information.

ISSN 1828-5961

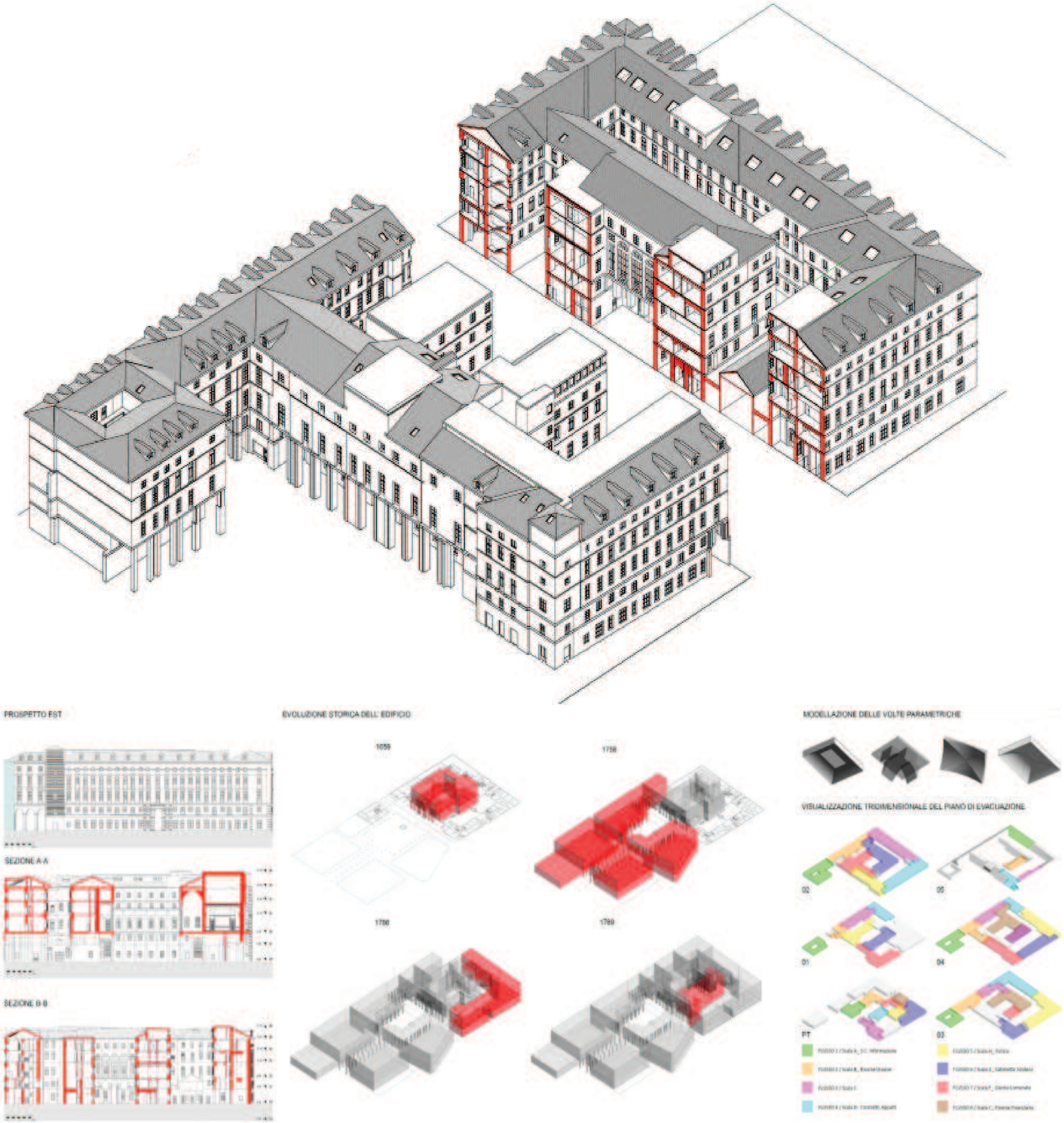


Figure 2. Digitization project of the public heritage for the City of Turin, Palazzo di Città.

EXAMPLE 1. HISTORICAL BIM FOR PALAZZO DI CITTÀ IN TURIN
by Sanaz Davardoust

The ongoing research project is a collaboration between Politecnico di Torino and the City of Turin for the digitalization of the public heritage with BIM.
The Palazzo di Città is a baroque building developed and transformed significantly up to our days. The different transformations occurred at the building and at the urban context over the years, were represented through the use of simplified masses. One of the main aspects of the modelling phase is the identification of rooms in Revit (the software chosen for parametric modelling) according to the purposes of the project, which is performing energy simulations for cultural heritage in order to define energy refurbishment strategies.
Palazzo di Città is characterized by a relevant number of irregular geometries, such as not orthogonal walls in plan, intermediate horizontal closures vaulted and made of masonry of various types like Barrel vault, Rib vault, Cloister vault, Keel vault, like in the most of the historic buildings. In the realization of this HBIM model, particular attention was paid to the correct definition of vaults families, in order to be able to describe the correct typology and to be "adapted" to the different dimensions and shapes of the
In this cases, it is really important the recognition of the essential data that must to be represented/modelled (for architecture, structure and system fields). Even if the architectural ornaments express the unicity of the single building rooms, however can be considered not essential for the development of the BIM model considering the objectives of the project. (Figure 2).

EXAMPLE 2. DATA MANAGEMENT FOR THE FACILITY MANAGEMENT OF REALE GROUP NEW HEADQUARTERS IN TURIN
by Francesco Semeraro and Greta Lucibello

The main objective of the ongoing research project started in partnership between Reale Immobili and Politecnico di Torinofor the construction of Reale Group new headquarters, is the realization of a BIM As-Built model for the organization of Facility Management (FM) operations, and in particular for architectural and systems building components during its Operation & Maintenance phase (O&M). It was designed the most appropriate strategy for the realization of a shared parametric model specifically for the attended objectives, starting from two-dimensional As-Built documentation shared by the work director, technical sheets of architectural and technological assets, and Reale Group corporate management standards.
The methodology pursued for the creation of a BIM model useful in the building O&M phase primary focused on the definition of a correct Level of Development (LOD) for each component realization, and it considered a LOD 500 for architectural and systems elements. Subsequently, the creation of a specific set of parameters characteristics of FM field, such as 'product data', 'location' and 'links' that integrate and complete elements information, and the 'maintenance' group used to define the strategy, the type, the frequency, the cost and the duration of an evaluating intervention. Moreover, to enhance the efficiency of the management process it was useful to adopt a building registry, based on a system of articulation, classification and coding of all its elements. In the end, worksharing was enabled to promote collaboration and information sharing among the team work by the Autodesk Revit workset tool.
The strength of the parametric model stands in the possibility to manage in an organized manner the large amount of heterogeneous information connected to the real objects through their tridimensional and scheduled representations, not only inside the BIM software environment, but also externally, exploiting data interoperability properties. In fact, the mainly attended results from this project is using parametric model data in Archibus, a facilities management software, and developing Augmented and Virtual Reality applications for maintainers' professional training and for data visualization in general (Figure 3).

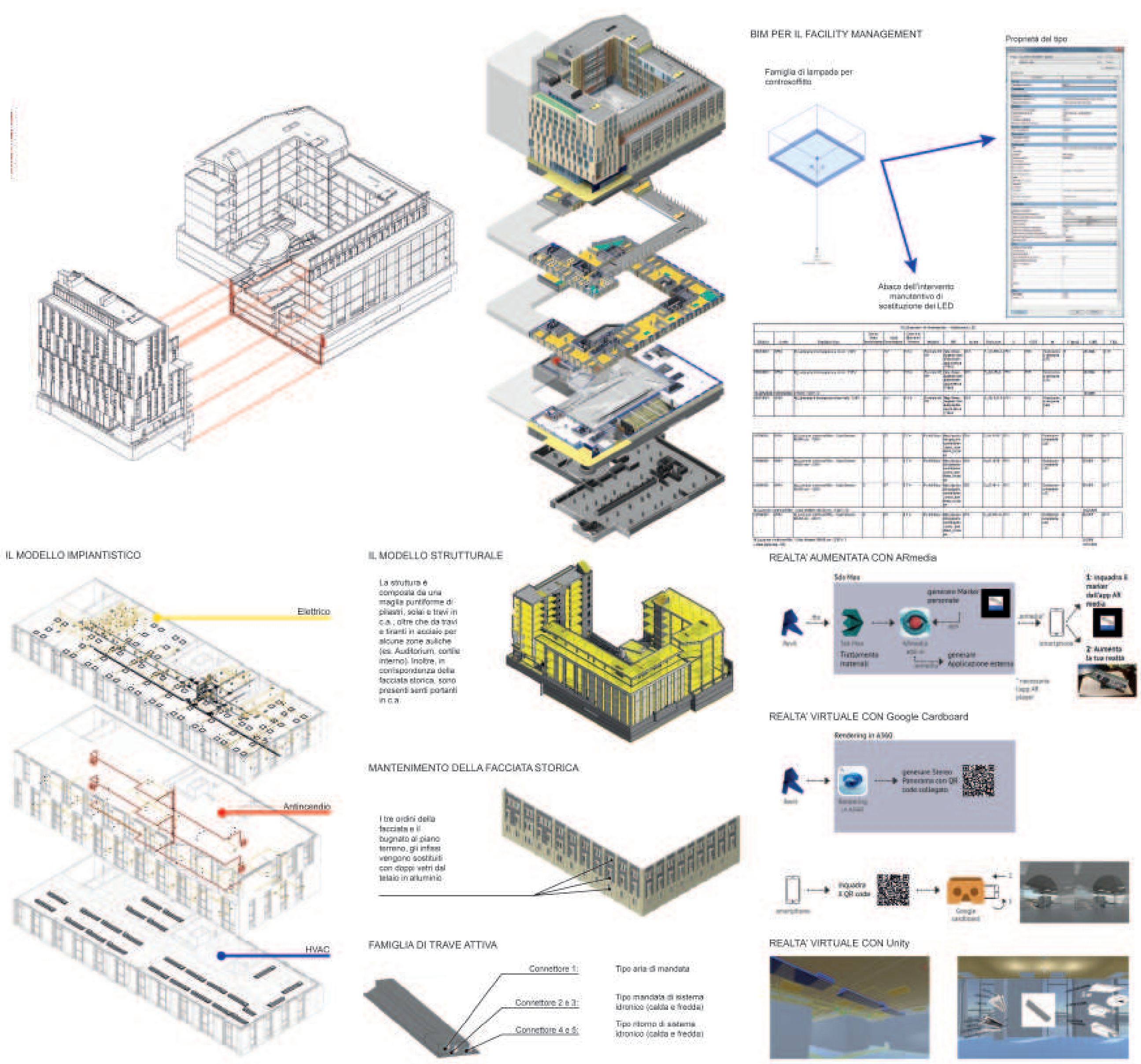
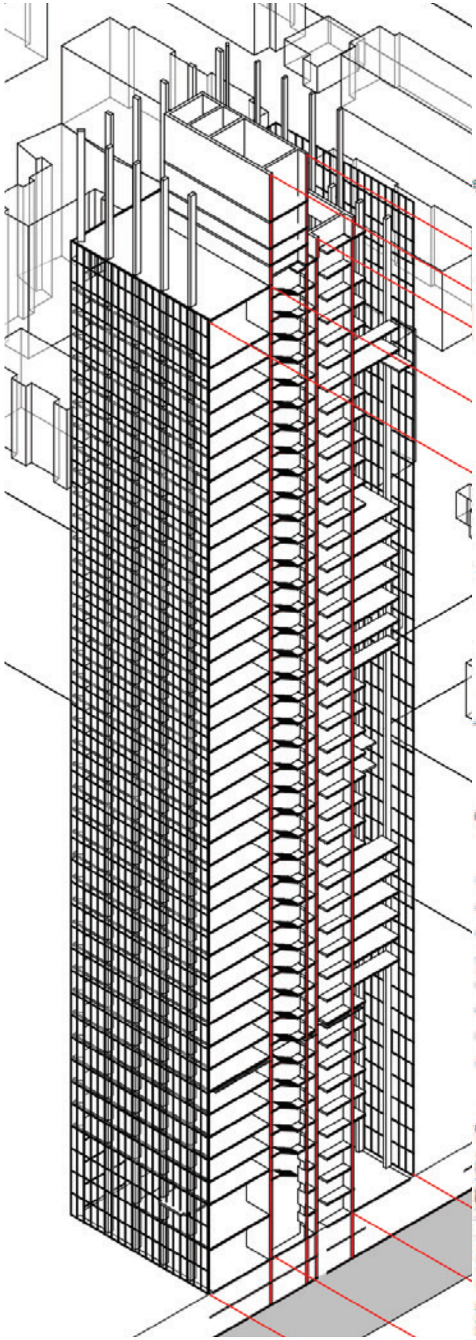


Figure 3. BIM for Facility Management: management and maintenance of Reale Group new headquarters.

ISSN 1828-5961

EXAMPLE 3. DATA MANAGEMENT FOR MEP SYSTEMS OF THE PIEDMONT REGION HEADQUARTERS IN TURIN

by Luca Barone, Maurizio Dellosta, Francesco Semeraro



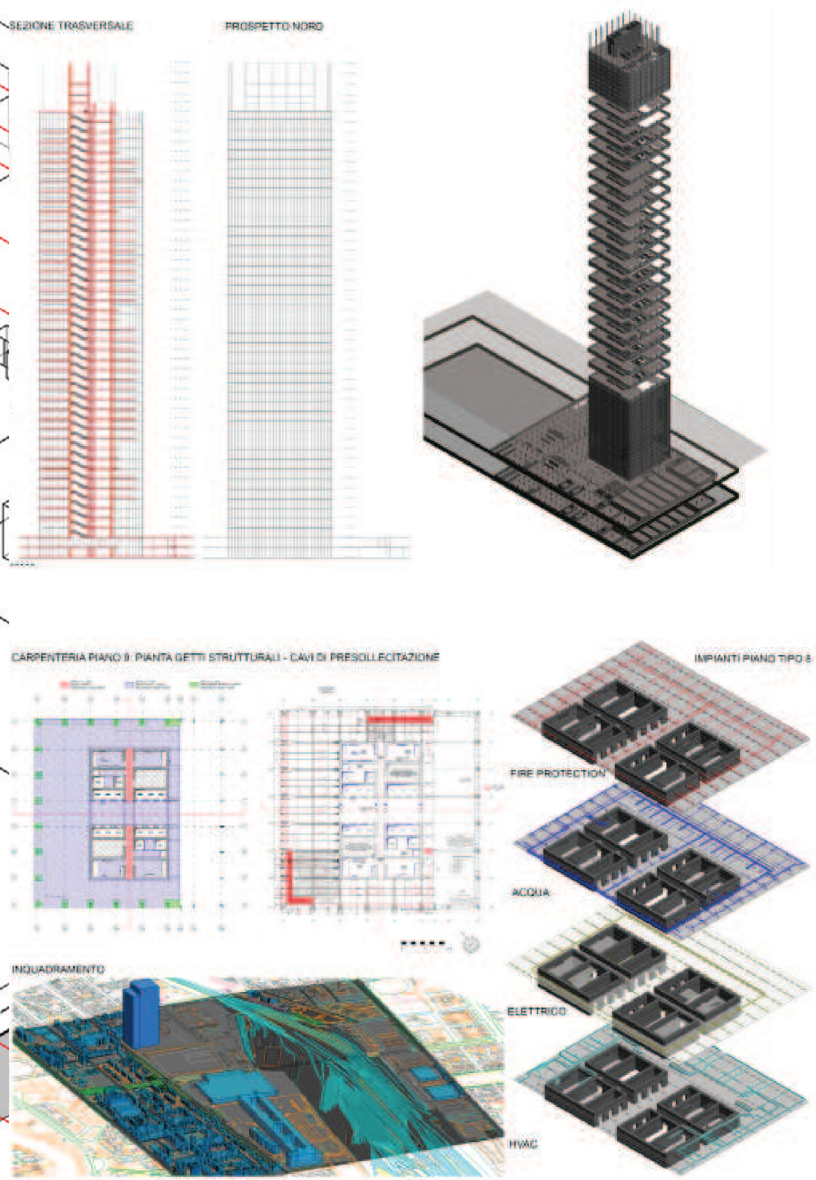
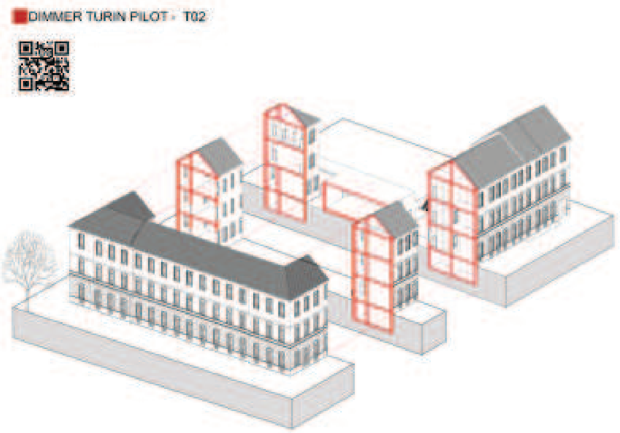


Figure 4. As-Built BIM model for the maintenance of the Piedmont Region Headquarters project.

The Piedmont Region is building in Turin its new headquarters, an office tower that consists of 41 floors for a total of 205 meters high which making it the highest building in Italy. This is the case study for the application of BIM methodology in the research project carried out in collaboration between the Region of Piedmont and Politecnico di Torino. The ultimate goal is the creation of an As-Built parametric model for the preparation of a manual for the maintenance of facilities and building management during Operation and Maintenance Phase. The work in progress research project started from the two-dimensional As-Built documents, provided by the constructor that allowed the knowledge of the building. The first operation is to define which is the level of development (LOD) to consider. Every model subject area has been developed at a specific LOD, and in particular it has been defined a LOD 500 for the MEP systems, composed by the HVAC plant, fire protection, plumbing and lighting system; a LOD 300 for architectural components and a LOD 200 for structural ones. The systems, components and equipment contained in the BIM model can be useful during maintenance if the initial parameters of the model elements were implemented by introducing a set of shared parameters selected with the future professionals that will manage the maintenance operations in order to align the efforts of parametric modeling for the implementation of the operation and maintenance manual. The realization of the model has seen the development of a strategy for setting the sharing of work, organizing the parts of the BIM model in collections, so that team members can work independently and simultaneously on different collections. The parameters set is constituted by the building registry of all system components (component ID, quantity, coding, localization, classification, etc.), the performance requirements, controls and interventions. The process result is a parametric model, which contains all the parameters necessary for an efficient interoperability to proprietary platforms towards the maintenance management of the plant systems and for visualization in virtual reality of geometric and alphanumeric information (Figure 4).



EXAMPLE 4. ENERGY EFFICIENCY WITH DIM – DISTRICT INFORMATION MODELLING

by Matteo Del Giudice, Daniela De Luca, Arianna Fonsati, Francesca Maria Ugliotti

The District Information Modelling and Management for Energy Reduction (DIMMER) project represents an evolution of the use of BIM, extending its use from buildings (building scale) to district (urban scale), simultaneously expanding the areas of study thanks an interdisciplinary use of ICT based on interoperability.
The basic concept behind District Information Model (DIM), introduced for the first time by the DIMMER European project, is to implement the BIM philosophy and extend it to a district level, using common data at both building and district scale, involving a plurality of users, starting from both technical and social aspects.
The main objective of the DIMMER project consists of the creation of a common platform where several information coming from different data source is collected, such as BIM (Building Information Model) service, GIS (Geographic Information System) service, SIM (System Information Model) service described with geometric and alphanumeric data. This platform is enriched by several data that come both from the real-time monitoring and digital data and it focuses on: 1) analysis of environmental condition due to geographic and morphologic characteristics at both building and urban scale; 2) interoperability between different data sources; 3) integration of real time data from building scale (BIM) to urban scale (DIM); 4) use of web-based interface to improve people's awareness on energy saving/efficiency, using virtual and augmented reality.
The BIM models were created to be used as a graphical datasource where data can be extracted in different ways depending on the specific objective such as the energy simulation, data visualization, etc.
In the DIMMER approach, the modelling of existing buildings within the district level is carried out using BIM by experts of Drawing sector. This methodology allows both the visualization of 3D models of buildings at urban scale and the management of related data concerning construction type, installed MEP systems, intended use and, as shown below, energy consumption by means of energy modeling. The aim is to to provide an integrated tool able to collect different types of information according to the end users' needs, such as for example the thermophysical properties of building components, as the U-value, for both transparent and opaque elements, allowing for the visualization of construction layers (Figure 5).

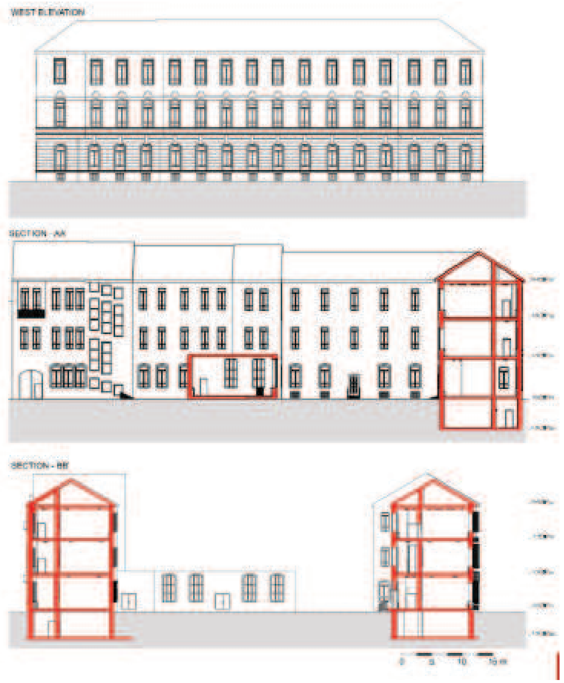


Figure 5. BIM use for data collection in the DIMMER Project: Primary school Coppino.

ISSN 1828-5961

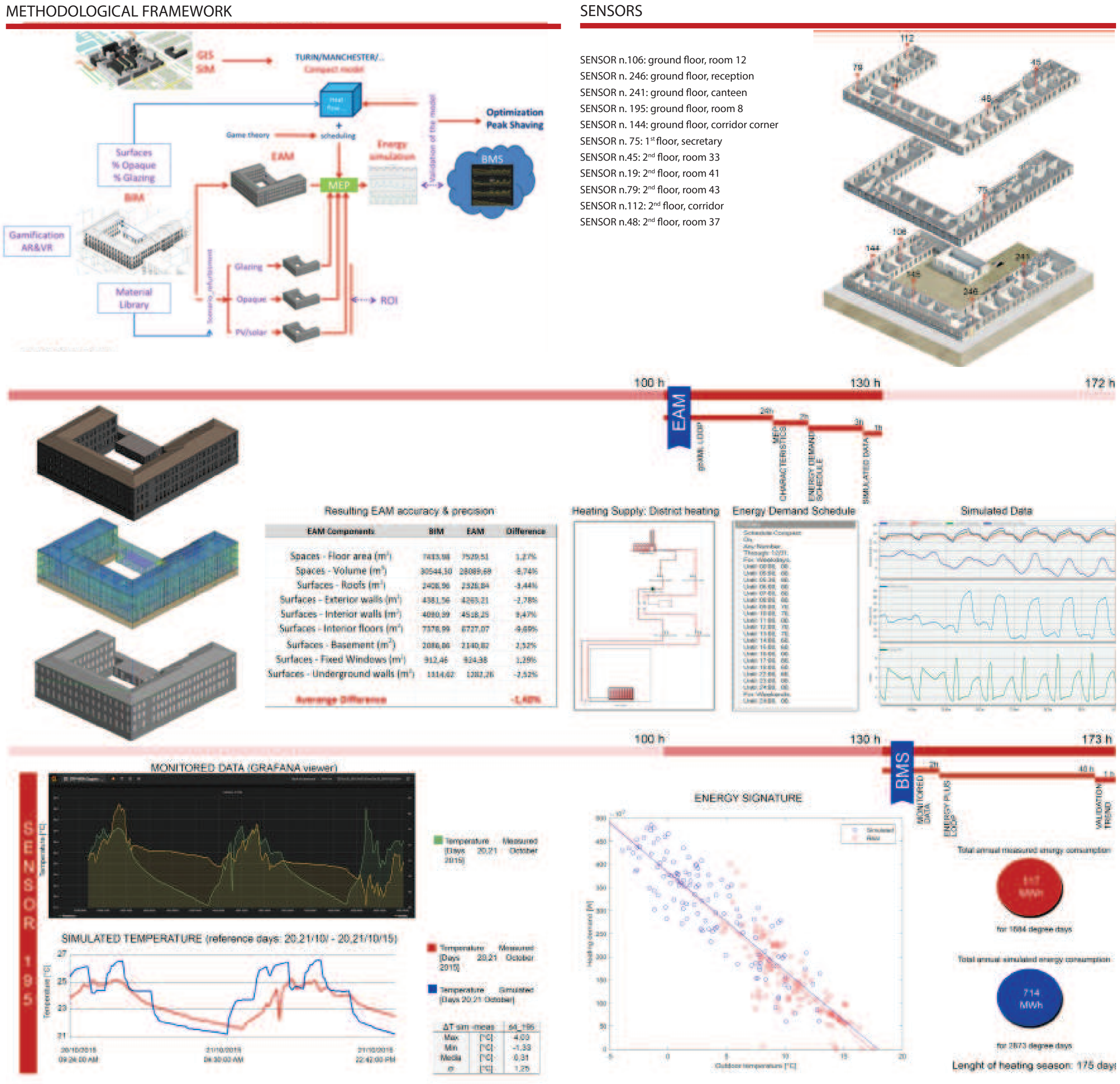
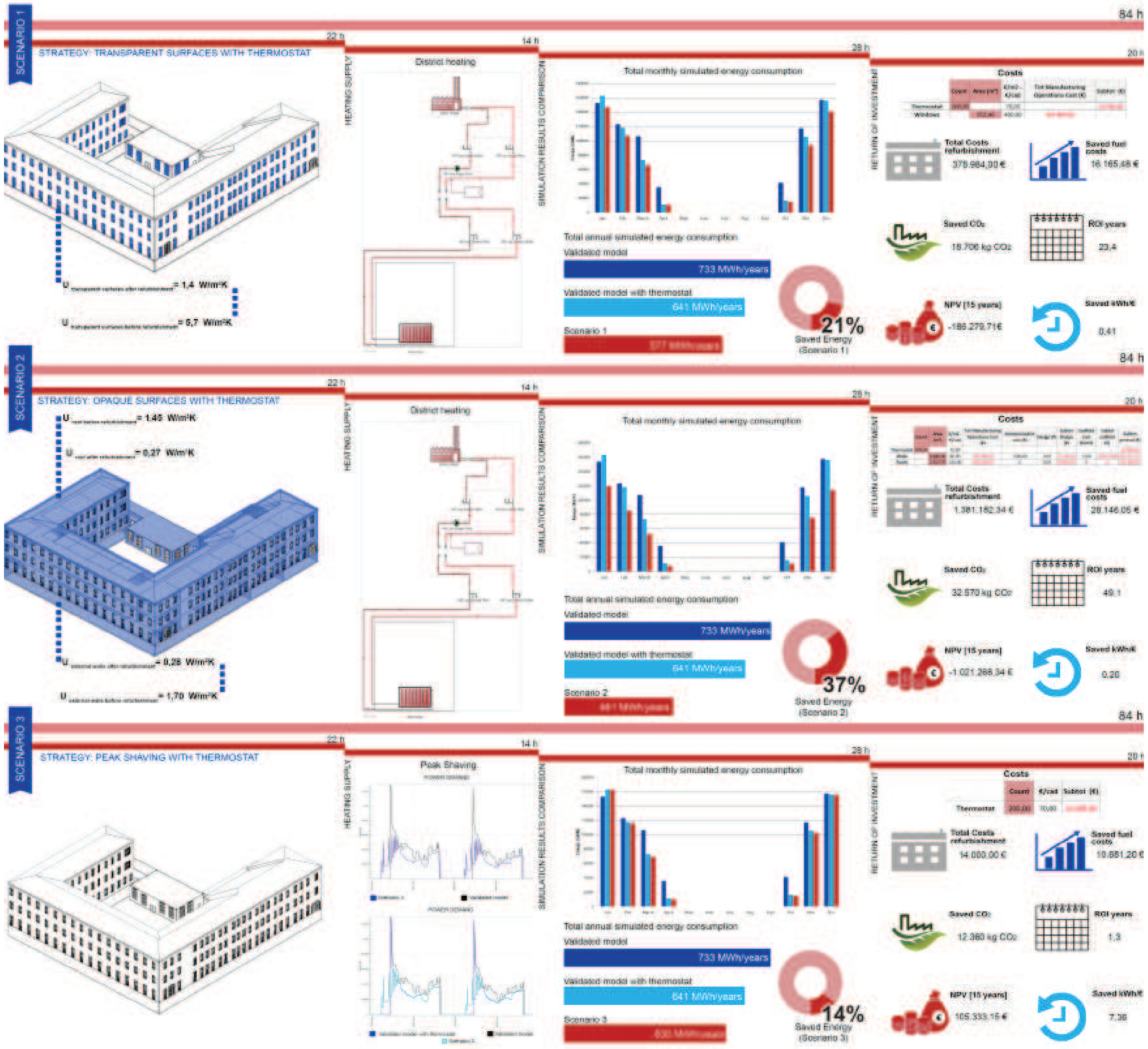


Figure 6. EAM and BMS domains and model validation: Case study Elementary School Michele Coppino, Turin.

Through the interoperable process BIM models generated the Energy Analysis Models (EAMs) in order to run energy simulation (performed by Energy experts) using different Graphic User Interfaces (GUIs) with different simulation engines.
At the beginning, after several interoperability tests, the choice fell on Design Builder that uses Energy Plus, as simulation engine. Design Builder provides advanced modelling tools, which enable energy simulation starting from a 3D parametric model. For the import/export process the gbXML format was used. Obviously, this step was not error free causing lack of geometrical and alphanumerical data.
Due to this loss of data, during the research, it was decided to change the software chosen for the energy simulation, working directly with Energy Plus: obviously, t these simulations are performed after having set the Heating Ventilation and Air Conditioning (HVAC) system. Here specific information is included, such as the nominal capacity and the water flow rate of the boiler or other system components. The obtained results are really accurate.
The validation of the model was achieved after several attempts of comparison between data measured through Building Management System (BIM) and simulation outputs. For this reason, the simulated temperatures and the measured ones have been compared, using as reference specific days. The end result of the process has been confirmed through the comparison between the energy signature (a graph representing the relation between the heating demand and the outdoor temperature) coming from the energy simulations and the real one (Figure 6).

ISSN 1828-5961



Furthermore, several scenarios of potential refurbishments aiming to increase efficiency have been hypothesized. The first strategy includes the addition of a thermostat and the substitution of windows, the second one includes the refurbishment of external walls and roof and the thermostat and the final one considers a better HVAC management (for example, peak shaving). In the end, it was possible to obtain as a result the total annual simulated energy consumption for each scenario and the related percentage of saved energy, calculated through comparison of the energy consumption before and after the application of the strategy (Figure 7). Finally, a Cost Benefit Analysis has been integrated (performed by Real Estate evaluation experts), in order to show the costs for each strategy and the following economic indexes: Return of Investment (ROI), Net Present Value (NPV) and Internal Rate of Return (IRR). In this way it was possible to check the efficiency of each strategy, in both energy saving and economic terms, thanks to an interdisciplinary collaboration where each one contributes with their own specific competence to manage a complex process, based on data sharing derived from BIM model.

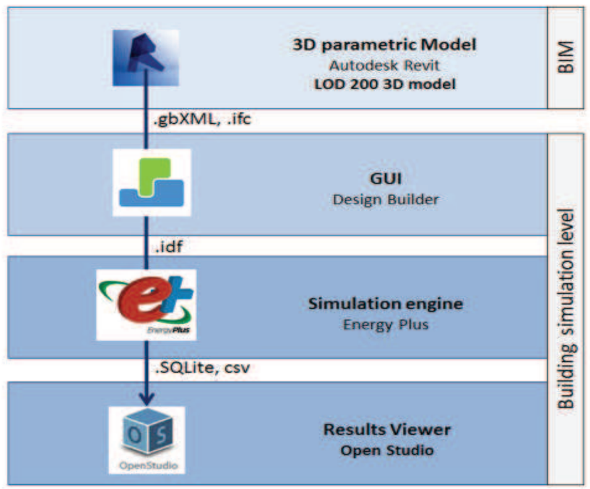


Figure 7. The three scenarios and the framework of software: Case study Elementary School Michele Coppino, Turin.

ISSN 1828-5961

EXAMPLE 5. INFRABIM FOR INFRASTRUCTURE MODELLING

by Niccolò Rapetti

Currently, the diffusion of BIM methodology is spreading also in infrastructure sector, thanks to the possibility to benefit from the BIM capability to manage a large amount of data and the possibility to share them among different disciplines, maintaining the information updated and reducing the redundancy of data.
The case study is referred to the collector tunnel of Peschiera's source complex, an hydric supply channel built in 1937 for Rome's municipality. The project expects the renovation of a piece of the canal length 244 meter. BIM workflow focuses on construction management and structural analysis.
Firstly, starting from CAD documents, it has been necessary to generate an appropriate parametric families and shared parameters. In fact, as is visible in Fig. 8, the tunnel geometry is composed by different part as side wall, lean concrete layer, water pipe, steel rib, etc.. Moreover, it has been generated a time schedule, where are indicated the construction phases, divided in construction processes and times.
The BIM model, according to the objective of the project, it has been developed at level of development and detail (LOD) equal to LOD400, to obtain executive information, constructive details and analysis of quantity take off. As a consequence of the large amount of data, interoperability process plays a key role in order to facilitate the exchange of data. In fact, it is necessary to choose the appropriate data exchange format.
For the construction management was chosen the Autodesk Navisworks software, which allows to manage information coming from different data sources. Therefore linking these information it is possible to control the construction process and the interim payment certificates. For the structural analysis at Finite Element Method (FEM) it was chosen the Straus7 software. Unfortunately, at the moment only the geometrical data are exported, with the loss of other information such as materials physical properties.
At the moment, BIM level of maturity of the infrastructure field, corresponds to an intermediate level, where the interoperability is still not error free and it is often necessary to replicate data. Furthermore, the main future challenge for a greater spreading of BIM in the infrastructure field, will be the capability to manage the complexity represented by georeferenced information, from regional scale to construction scale, via interoperability (Figure 8).

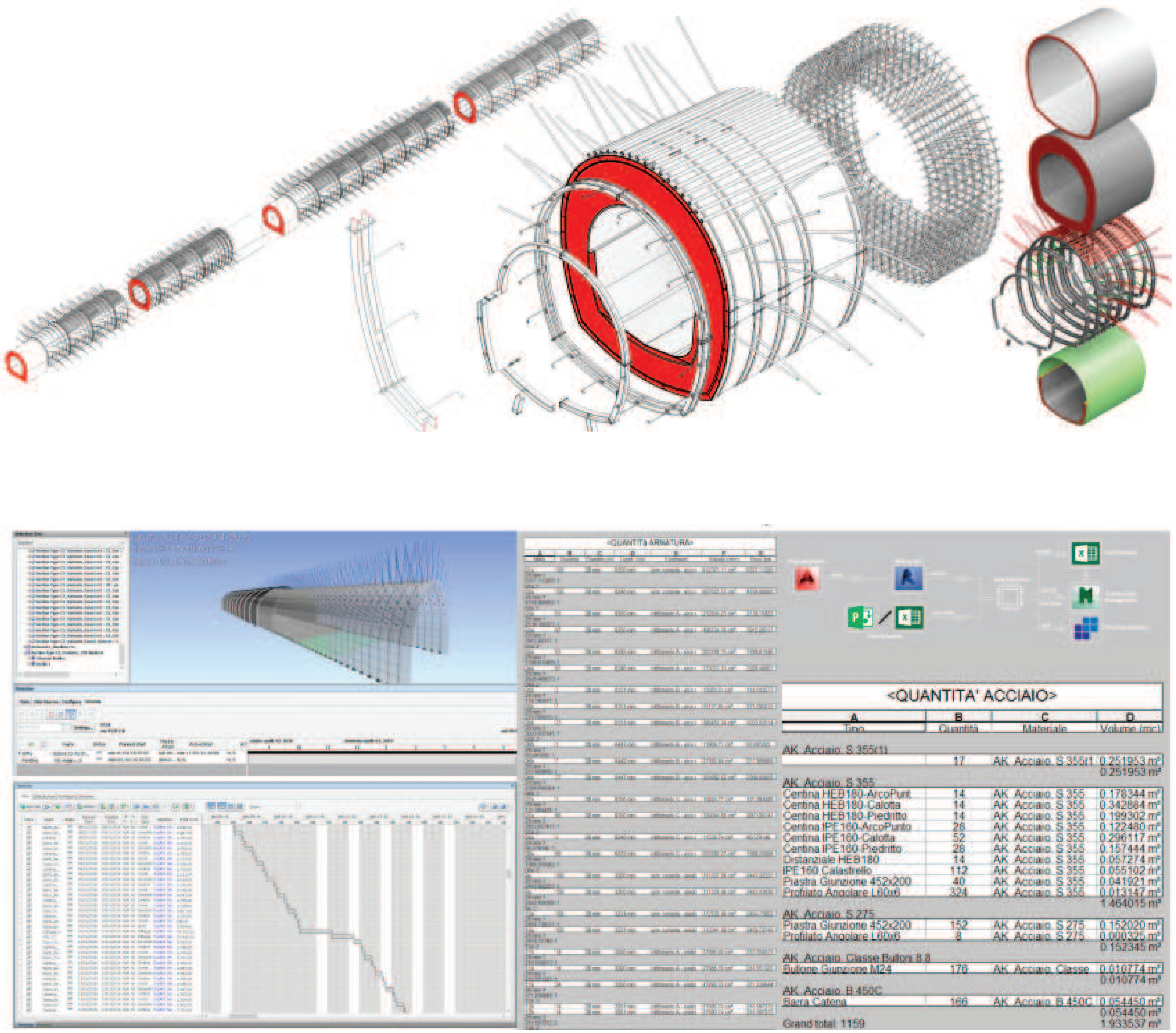


Figure 8. Renovation project of the Peschiera tunnel.

ISSN 1828-5961

CONCLUSIONS

The excursus of the case studies presented highlights several aspects faced by the research is in these years in the drawing area. The mile stone remains the representation as a communicative tool which it allows information exchange among different disciplines, instead the innovation takes place in an always more digital tools. As a consequence, what was a pencil line drawn, now is a parametric object containing the semantic abstraction of a wall, rather than another building component. If previously the communication was made through the use of paper, now it is made through the exchange of bytes strings. For this reason it is possible to image this research how the transition that it will carry out the revolution of traditional cadaster into “Future Cadastre” or “3D parametric Cadastre”. In fact, as is visible in the Figure 9 the map in the middle shows the border of Turin’s municipality and it is the cartographic regional representation currently adopted by the municipality, instead on the left it is possible to note some historical documents that represent an exemplification of the evolution of the representation. The innovation by using of IT, allows to query the map of the city, which are associated a series of information related to different stakeholders and different disciplines, from building scale to regional scale. Using applications of Augmented Reality, such as Aurasma, it is possible obtain a higher level of information than the one offered by a simple reading of the map, through the use of a smart device like a smartphone or a tablet. The data displayed could be of different typology and they can refer: i) to tridimensional model of the building; ii) to multimedia contents such as pictures and videos; iii) to digital work sheets; iv) to a link, etc. In this way the comprehension becomes faster and interactive, optimizing the whole process of data collection. Obviously, the “Future Cadastre” represents a possibility, but many issues remain to be defined.

Figure 9. Map of Turin municipality that represents the idea of ‘Future Cadastre’.

The other main topic, deducible from the case studies, is the BIM maturity level, which it is necessary valuate analyzing the various degree of collaboration among different disciplines involved in the projects and then analyzing the collaboration between different experts of construction field. On the basis of these two metrics the European project DIMMER represents the closest example to the third and the most advance level of maturity up to now defined This corresponds to a full cooperation between all disciplines through the use of unique and shared project model, stored in a central repository where all parties can access and edit the same model, deleting the huge risk of redundant information. In the other examples proposed, especially the ones in which professionals, that are far from research and innovation word, are involved, the level of maturity reached oscillates between first and second level. In fact, in the most cases there is not an open information exchange format, unique and accessible to all actors.
In the research that is taking place in the infrastructure fields, it becomes even more evident how it is necessary establish a more solid structure that it allows the interoperability of data and information at different scale of representation from regional to executive scale.
Therefore, digital transition of the AECO sector is now a requirement for all professionals involved in. The topic of representation strengthens its role in relation to the different fields, thanks to the data interoperability.
Unfortunally, nowadays the BIM process has not yet reached an interoperability degree able to share data without any loss at process, organizational and technological level, causing a necessary data replication. It is evident the importance of the research activity in this area. BIM and interoperability represent the added value of technological innovation for the construction industry, where the idea of representation is strictly connected to the idea of information as a database for different disciplines.

ISSN 1828-5961

AKNOWLEDGMENTS
We would like to express our appreciation for the collaboration in the research projects proposed above the Comune di Torino, the Reale Group, the Regione Piemonte, the EU 7th Frame Program of research and the DIMMER Project Consortium, AK Ingegneria Geotecnica Srl.
Furthermore we would like to thank Gloria Colombo, Daniela De Luca, Stefano Giovannitti, Giulio Di Vico and Marta Foschini for their collaboration in the realization of the pictures within their master degree theses.

BIBLIOGRAPHY

Osello, A. (a cura di), (2015), *Building Information Modelling – Geographic Information System – Augmented Reality per il Facility Management*, Dario Flaccovio Editore, Palermo.

Borrmann, A., Kolbe, T.H., Donaubauer, A., Steuer, H., Jubierre, J.R., Flurl, M., (2015) *Multi-scale geometric-semantic modeling of shield tunnels for GIS and BIM aplication*, Computer-Aided Civil and Infrastructure Engeenering, Vol.30, Issue 4, pp. 263-281.

Bornrmann, A., Flirl, M., Jubierre, J. R., Mundani, R. P., Rank, E., (2014), *Synchronous collaborative tunnel design based on consistency-preserving multi-scale models*, Advance Engineering Informatics, Volume 28, pp. 499-517.

Carmigniani, J., B., F., B., (2011), *Augmented Reality: An Overview in Handbook of Augmented Reality*, Springer.

Cigolini, R., Valentini, S., Villa, A., N., (2005), Facility Management e Global Service Integrato, in Facility Management Italia, Milano, Edicom Editore.

De Toni, P., (2007), *Open Facility management. Modelli innovativi e strumenti applicativi per l'organizzazione e la gestione dei servizi esternalizzati*, Il Sole 24Ore.

Eastman, C., M., (2008), *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*, John Wiley & Sons Inc., USA.

Erik, P., A., Daniel, F., Shery, S., F., (2014), *DIMENSIONS OF INTEROPERABILITY IN THE AEC INDUSTRY*, in Construction Research Congress.
European Commission Decision (2015), Horizon 2020: Work Programme 201-2015.

Guinard, D., Trifa, V., Karnouskos, S., Spiess, P., Savio, D., (2010), *Interacting with the soa-based internet of things: Discovery, query, selection, and on-demand provisioning of web services*, IEEE Transaction on Services Computing, IEEE.

IFMA, IFMA Foundation (2013), *BIM for Facility Managers*, John Wiley & Sons Inc., USA.

Oreni, D., Brumana, R., Georgopoulos, A., Cuca, B., (2013), *HBIM for conservation and management of built heritage: towards a library of vaults and wooden bean floors,* ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume II-5/W1.

PAS 1192-2:2013. Specification for information management for the capital/delivery phase of construction projects using building information modeling.

Patti, E., Acquaviva, A., Jahn, M., Pramudianto, F., Tomasi, R., Rabourdin, D., Virgone, J., Macii, E., (2014), *Event-driven user-centric middleware for energy-efficient buildings and public spaces*, Systems Journal, IEEE.

Talamo, C., (2014), *La gestione integrata delle informazioni nei processi manutentivi. Dall'anagrafica degli edifici ai sistemi BIM*, Techne 08, Firenze University Press, pp. 228-240.

The American Institute of Architects (2013), AIA Document G202-2013 "Project Building Information Modeling Protocol Form".