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The BIM process for the architectural heritage: New communication tools based on AR/VR

Case study: Palazzo di Città

By

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Declaration

I hereby declare that, the contents and organization of this dissertation constitute my own original work and does not compromise in any way the rights of third parties, including those relating to the security of personal data.

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Acknowledgment

And I would like to acknowledge ... I wish to thank to my friends, to professors who impressed me with their huge knowledge during my research, I sincerely appreciate the support of Professor Bernardino Chiaia who helped me to resolve some of the important issues at the beginning of my PhD course and finally i feel highly indebted to them.

Abstract

The present study aims at presenting the application of the Building Information Modeling methodology to the case study of Palazzo di Città, the Turin City Hall, investigating the possibilities of integration of new technologies in Cultural Heritage preservation and valorization. From the survey phase to the communication of the CH to end-users, BIM methodology, combined with the latest digital innovations (AR, VR, 3d Laser Scanner and much more), allows a fast and highly communicative representation of buildings to both professionals and common visitors who interact with the building life-cycle.

An important objective of this work is moreover to demonstrate the advantages of adopting and integrating this technologies in Real Estate Management at a national scale, fully testing the adaptability of parametric software and Virtual Reality modeling to complex and highly decorated buildings, confirming the potentiality of BIM software upon an uncommon field: the historic buildings. The case study is in fact Palazzo di Città, the baroque, seventieth century City Hall of Turin.

The research fully meets the latest directives of European Union and other International Organizations in the field of digitization of archives and Public Property management, participating to the international community effort to overcome the contemporary deep Construction Field crisis. In particular, the methodology has been focused and adapted to the protection and management of our huge Heritage, founding its objectives on the quest of cost-saving processes and instruments, applied to the management of a CH. Through BIM it is in fact possible to increase the communication and cooperation among all the actors involved in the building life-cycle behaving as a common working platform. Draws, 3D model and database are shared by all the actors and integrated in the same digital structure, where control tools and cooperation can prevent the designers from errors, saving time and money in the construction phase.

The particularity of the case study, Palazzo di Città, being contemporarily a CH, a public asset and a working space, allows a deep study of the possibilities of BIM applied to a complex building, touching very important aspects of a historic building management: digitization of the historic information, publication of modeling techniques of complex architectonical elements, transformations reconstruction, energy consumption control, Facility Management, dissemination, virtual reconstructions of the lost appearance and accessibility for people with sensory and motor impairments.

Moreover, the last chapters of the study focus on the fruition of this paramount Turin CH, making available for all kind of people interesting and not well known aspects of the history of the building and of the city itself. This part of the research suggests a methodology to translate static 2d images and written descriptions of a CH into living and immersive VR environment, presenting in an interactive way the transformation of the Marble Hall, once called Aula Maior: the room where the Mayor meets his citizens.

Besides the aspects related to the valorization and preservation of the CH, the study reserves considerable space to the deepening of technical aspects involving advanced parametric modeling techniques, use of BIM software and all the vital procedures necessary to the generation of an efficient management informative platform. The whole work is intended as a guide for future works, structuring a replicable protocol to achieve an efficient digitization of papery resources into a 3d virtual model.

Introduction

In the last two decades, Cultural Heritage (CH) constantly increased the integration of digital technology in all the activities that are essential to the conservation process. From the survey phase to the communication of the CH to end-users, the use of many digital tools is more and more widespread. Laser-scanners are emerging as a fast and effective technique in collecting dimensional information of complex objects, the growth of digital libraries are allowing a wider access to usually hidden information, the realization of 3D models and the consequent use of Virtual Reality (VR) grants an effective communication of the buildings to both professionals and common visitors.

This technological evolution knew an important acceleration during the Construction Field crisis. In fact, the lack of economic resources in the building sector, obviously affected the protection and restoration of our huge Heritage too. The construction market reacted with an increasing demand for cost-saving methodologies and instruments in all the phases of the building process, providing a great impulse to International Organization, such as European Union, in enhancing the research upon such problematic.

The research promptly reacted to these questions, activating many projects focused on construction process efficiency and building performances. This led to the born of a methodology whose purpose is to increase the communication and cooperation among all the actors involved in the building process: Building Information Model. BIM emerged as a great solution to create a common working platform where draws, 3D model and database are shared by all the actors and integrated in the same digital structure. Moreover, any BIM software is provided with control tools, which can prevent the designers from errors, saving time and money in the construction phase.

EU co-founded and monitored the impact of 110 projects under the 7th Framework Program (FP7), which are leading to ready-to-market innovations, and

BIM is one of the 7 technology-clusters investigated by the studies: Design, Technology Building Blocks, Advanced materials and nanotechnology, Construction process, Energy performance monitoring & management, ICT and BIM. The EeB PPP Project Review 2016 highlights the importance of embracing all aspects of the building and construction sector, in order to achieve important results in term of process efficiency and sustainability.

CH undoubtedly derived many advantages from this line of research, exploiting all the new technologies normally applied to Real Estate Management, building efficiency improvement, work sharing, projects representation and communication, advanced structure analysis and security planning. Of course the translation from contemporary architecture to complex historic buildings is not always automatic and requires further investigations; in particular, BIM software were for nowadays buildings, slowing down for many years its application to extremely decorated monuments or irregular surfaces.

The following lines aim to reconstruct the extremely variegated mosaic of the state of art of BIM applications to both Cultural Heritage and Built Heritage, in particular in the research field, starting from the works born inside Polytechnic of Turin.

Our city is in fact involved in an intensive process of digitization of the building documentations, and it is currently investing important resources to establish a working methodology to manage the large information flow related to existing buildings. In this operation, the Polytechnic was involved as a role partner, starting a cooperation with Torino Smart City, to study the possibilities of BIM applied to cities' conservation, particularly within the Italian Real Estate. The research path is focused on Facility Management and the promotion of effective and less expensive actions of refurbishment, optimization and energy efficiency.

Every building was accurately studied and provided input to further investigations: The Piedmont Region Headquarters (Grattacielo della Regione Piedmont) was treated in a thesis (G. Di Vico) which verified the actual benefits of BIM in a building construction and management process. In particular, the work focused on the mechanical project and maintenance, highlighting the differences between traditional and parametric model based design. Another topic of the work was the application of VR devices (Google Cardboard) for training maintenance technicians.

Another crucial aspect brought to light by Turin researches is the recovery of the school building heritage, which constitutes a relevant percentage of the Municipal properties. “Building Heritage Information Modeling Management” (BHIMM), a project beneath PRIN (Programma di Ricerca di Interesse Nazionale (PRIN) 2013, gave a deep insight on the theme of interoperability between BIM parametric software and structural (SAP), lighting and thermic calculation software. The 3D model of Primo Liceo Artistico of Turin constituted the database from which extracting the needed information, testing the best modeling techniques to grant a complete data exchange between the programs. The theme of interoperability is essential for all the subjects involved in building construction, and all these studies gave over considerable space to this topic testifying the great attention of the Research community to the need of the world of work. Interoperability is in fact the crucial feature, which made the success of BIM methodology and it was particularly tackled in BESTEST ASHRAE 140. This model was the main case study of application of INNOVance, an Italian research project carried out by Milan and Turin Polytechnics, which led to the creation of the first Italian open-source construction "unified database", shared by all stakeholders: public and private clients, construction companies, professionals and manufacturers.

The goal of this experience was the optimization of data exchange process between architectural and energetic analysis software. The components used in the 3D model were derived from INNOVance, while the energy calculations were carried out on Energy Plus. Polytechnic of Turin led many other studies on this field; for example Archimede Library EEB Project, which explored the role that BIM plays in energy modeling practices and the issues that should be considered to make the process of data sharing effective.

Energy issue turns out to be essential for a sustainable exploitation of the public heritage; besides, as pointed out by Patti et al. and Ronzino et al., the energy analysis integrated in the construction process is moving from the building to the urban and district level, integrating digital models with the Information and Communication Technologies (ICT). Following this statement, the City of Turin went a step forward in the use of BIM for Real Estate, activating with Polytechnic two researches. The first, SEEMPubS project (Smart Energy Efficient Middleware for Public Spaces), which ended in August 2013, investigated the theoretical and operational possibility of using a network of sensors to monitor energy consumption and raise awareness of this issue among end-users in academic and working places. Its natural continuation, the DIMMER project (District Information Modeling and

Management for Energy Reduction), ended in September 2016, extended the study from buildings (building scale) to the neighborhood (urban scale), integrating it with BIM. In this work, many crucial points were touched, in particular the development of a sustainable workflow in energy analysis for Real Estate Management and energetic urban strategy planning. Besides, the potentiality of BIM and Augmented Reality (AR) were explored in a field, which is crucial in CH: the awareness rising of end users. Thanks to interoperability and ICT, the 3D parametric models constituted a basis for dissemination activities to sensitize citizens and actors involved in Real Estate, to the theme of energy saving.

Most of the buildings involved in the presented projects were born in the last 70 years and don't constitute a CH; nevertheless, some important historic buildings are part of this variegated scenery, giving the possibility of applying the BIM methodology to a baroque Palace, which is the main object of the present study.

To understand the value of the present study, another term must be introduced: Historical BIM. HBIM, is the common BIM methodology applied to historical building. Because of its nature and complexity, this kind of constructions must be often simplified, in the modeling phase within the BIM environment. Nevertheless, in the last years, many groups of research approached the problem, trying to enhance the complexity of the data stored inside a HBIM model, by the use of innovative tools like laser point clouds and photogrammetric data.

A group of research of Polytechnic of Milan demonstrated on the case study of Castel Masegra (Sondrio) that a complex HBIM can store useful information, which can be easily communicated not only to expert operators, but also to a wider user community interested in cultural tourism. Despite a not complete interoperability between BIM software and AR software, which leads to some data loss, the study highlighted that a relevant amount of time can be saved, since the research group did not need to redraw the model for AR, but just had to implement some information which were lost in the translation of the model for mobile devices. Another important study on this theme is "HBIM in the Cloud", which concentrates on the availability of the in mobile devices to bridge the gap between office and construction site. Through AR, it is possible to obtain information directly in the worksite, exploring the invisible part of a building (foundation, river bed etc...) or the removed elements used to support the construction phase (roof sticks, scaffoldings, cranes and other used machines).

The BIM can be therefore intended as a central tool for the accurate investigation of any kind of building. It can beside interact with different software to obtain sub products without splitting data processing into different modelling projects for different purposes.

The research by Polytechnic of Milano is not an isolated case: as illustrated in the study by S. Logothetis, A. Delinasiou, E. Stylianidis of the Thessaloniki Aristotle University, the use of Building Information Modelling (BIM) in the field of culture heritage documentation is rapidly spreading. Many architects, archaeologists, conservationists, engineers noticed BIM potential in changing a cultural heritage structure management and documentation. This disruptive technology and methodology is helping designers in the process of conservation of old buildings, for example supporting the stages of simulation of structural behavior, analysis, economic evaluation of the project, and restoration.

A Bim model can as well store the information about the main transformations and chronological phases of a CH, reconstructing and visualizing all the stages, from the first brick to the latest interventions, integrating the available historical documents with the data derived from the latest technologies (laser scanning, photogrammetric surveys). To help professionals and accelerate the modeling phase, the first prototype libraries dedicated to HBIM objects were born in 2009 (Murphy et al.), following the so called HBIM approach: "the parametric objects are built from historic data (surveys, assays and literature) and layered in plug-in libraries aimed to map the elements onto point clouds data and image survey data" (Dore and Murphy, 2012). Unfortunately, these elements have limited capabilities of changing, preventing their use in other models or the visualization of different states of conservation.

Among the different use of BIM in CH, one of the most relevant is undoubtedly the structure analysis. This application consists in the realization of complex and realistic geometries of the structural elements, substituting the traditional and less reliable wireframe models. Thanks to BIM and dense point clouds, it is possible to obtain reliable results without losing the efficiency of the data exchange between modeling software and analysis structure software. Complex models can not only generate more accurate results in term of data analysis, but also they can facilitate the communication between professionals.

This point is the basis of another European Project: "INCEPTION - Inclusive Cultural Heritage in Europe through 3D semantic modelling". This study shows how, through BIM, it is possible to stimulate and facilitate collaborations across disciplines, technologies and sectors; besides this methodology is based on cost-effective procedures which can enhance onsite 3D survey, helping the reconstruction of cultural heritage buildings and sites. This objectives can be obtained thanks to the development of an open-standard Semantic Web platform, where the resulting interoperable digital models can be easily accessible, processed and shared. The application of this methodology can help in protecting the CH of seismic areas, with scopes of classification, prevention and reconstruction. As shown by the recent earthquakes of Accumoli, Amatrice and Norcia, the speed, cheapness and accuracy of surveys could enhance the quality of the intervention on many beautiful historic realities, saving both buildings and many lives.

Besides this vital questions, other studies show how the use of HBIM really goes beyond the structural and restoration issues, embracing other important aspects involving CH communication. DICE (Digital Immersive Cultural Environment) is one of those, and it consists of a VR/AR (virtual & augmented reality) platform, a CMS (Content Management System) and a GIS (Geographic Information System) for geo-referencing both space and content and for providing immersive navigation in the VR/AR space. The project aims at enabling these VR and AR environments, to augment the capabilities in education, training, entertainment, content creation, etc.

Among the different applications generated in the DICE project, PYRONES was born. This is an innovative platform developed for modeling and simulating large structural fires, which is already integrated within existing engineering BIM workflows and serves as a building performance assessment platform, able to evaluate fire protection systems. In addition it penetrates the building security management market, being a holistic training platform for specialists in evacuation strategy planning, firefighters and first responders, both at a Command & Control and at an individual trainee level.

As already explained, BIM, combined with AR and VR, thanks to the high level of comprehensibility of a 3d model, allows an enhancement of the communication between the different actors involved in any kind of the building operations. The dissemination among common people of the meanings and historic information of a historic building is obviously one of the paramount objectives for any CH professional. For this reason, BIM is rapidly spreading in many project whose purpose is that to investigate and share the transformations and the values of a monument. Milan Cathedral, one of the most important symbol of its city and of

Neo-gothic movement, has become, since 2008, an object of study of a research group inside Polytechnic of Milan and it has been modeled in BIM environment. In particular, its main spire, which is closed to visitors since early XX century, can be now visualized, navigated and used by different kind of users: from tourists, thanks to a high-appeal visualization system, based on a VR environment, to the Veneranda Fabbrica technicians, that will use the model as an info-data catalogue, through a common web browser connected with the remote BIM System Server and the modelling software where ad hoc Input/output plugins are implemented. The resulting view is a sort of “augmented reality system in a virtual environment” where technicians can easily identify the state of conservation, as well as current and past maintenance activities.

The present research perfectly nestles into the just depicted panorama, taking advantage of BIM, as well as innovative AR and VR solutions. Furthermore the case study Palazzo di Città, being the seventieth century City Hall of Turin, whose rooms are still used as offices, allows a deep investigation of a very important topic, especially in Italy: the management of a historic building, being contemporarily a CH and a working space. This characteristic shaped the research as an interdisciplinary study of the possibilities of BIM applied to a complex building, touching very important aspects of a historic building management: digitization of the historic information, publication of modeling techniques of complex architectonical elements, transformations reconstruction, energy consumption control, facility management, dissemination, virtual reconstructions of the lost appearance and accessibility for people with sensory and motor impairments.

In particular, the adopted methodology, which is well illustrated in BIM GIS AR (A. Osello, 2015), aims at enhancing the fruition of this paramount Turin CH, making available for all kind of people interesting and not well known aspects of the history of the building and of the city itself. These kind of data, which have been extracted, selected and interpreted from many different archives and historic resources (some of them being 2d static draws or Latin words), have been translated and then stored in a 3d model, becoming a new and fresh source for both AR and VR devices, becoming available through different user-friendly devices (tablet, smartphone, computers and VR devices). The rich bibliography includes all the major historians (Cravero, Cibrario, Zaccaria, etc.) who have treated the enthralling transformations of the Center of Turin, which symbolically shaped its streets and buildings around its City Hall of Turin. Among these texts, a 17th century original book by Thesaurus emerged for its unicity in the telling of the lost original appearance of the Aula Maior, becoming the starting point and main inspiration for an immersive VR tour inside the room.

The methodology which guided this and many other researches in the process of transformation of papery resources into 3d digital models inside a BIM environment, is based on a replicable protocol synthesizable in 5 fundamental steps:

- Geometric survey of the building.
- Historic research.
- Modeling phase (intended as the translation of the geometric information inside a BIM environment).
- Translation of the historic information into a digital management informative platform, which is functional to the sharing of the information between all the actors involved in the process.
- Dissemination and realization of different kind of technical activities through VR and AR.

The study has been structured in 8 Chapters, beginning with a necessary and in-depth panoramic about BIM possibilities and evolution, as well as its applications and future developments – especially in the field of public procurement – to which follows the presentation of the Project "Digitization of the buildings of Turin". The second chapter treats the Turin state of art and the issues in the field of public Real Estate management, introducing the case study and the methodology adopted for its digitization. Then, the historic research will be tackled, retracing the most important steps of the growth of Palazzo di Città as a symbol of Turin and as an important public office district. The following parts will introduce the reader in the fascinating world of the BIM methodology, approaching the topic of the state of facts analysis – the phase in which both tangible and intangible aspects are collected in a hierarchical informative structure – the implementation of the management informative platform, and the most technical section: the creation of a parametric model in a BIM environment.

Finally the reader will be able to appreciate the applications and impacts of this complex process, both from the technical (FM) and CH fruition points of view. In particular, the last three chapters will show how the BIM model, thanks to its interoperability, can interact with different software, being the central basis for different sub-products such as a FM 3d model database, a VR immersive environment for a museum virtual tour and many AR applications for historic data reading, modeling techniques dissemination and maintenance operations.

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List of abbreviations

Acronym	Full Name
3D	Three- dimensional
.3DS	3D Studio max format file
3DX	The World 3D Format
AEC	Architecture Engineering and Construction
AIA	American Institute of Architects
AR	Augmented Reality
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigerating and Air- Conditioning Engineers
BEIIC	Built Environment Industry Innovation Council
BIM	Building Information Modeling
CAD	Computer Aided Design & Drafting
CIFE	Center for Integrated Facilities Engineering

CH	Cultural heritage
CMMS	Computerized maintenance management system
COBIE	Construction Operations Building Information Exchange
CoreNet	Construction and Real Estate Network
CNR	National Research Council
CRC	Cooperative Research Centre
CRESME	Economic Social Research Center of the market for Construction
DDS	Data Design System
DIMMER	District Information Modelling and Management for Energy Reduction
.dwg	AutoCAD drawing
EUPPD	European Union Public Procurement Directive
.fbx	Filmbox
FM	Facility Management
.gbXML	Green Building eXtensible Markup Language
GIS	Geographical Information System
GPS	Global Positioning System
GSA	General Service Administration

HBIM	Historical Building Information Modelling
HMD	Human Mounted Display
ICT	Information Communication Technology
IFC	Industry Foundation Classes
IFMA	International Facility Management Association
IPD	Integrated Project Delivery
ISO	International Organization for Standardization
ITIIC	Information Technology Industry Innovation Council
LOD	level of detail and development
MR	Mixed Reality
NATSPEC	National System Specification
NBS	National Building Specification
NIBS	National Institute of Building Sciences
OCA	Office of the Chief Architect
P.A.	Public Administration
Pc	Personal computer
PSBS	Public Building Service
QrCode	Quick Response Code
SEEMPubS	Smart Energy Efficient Middleware for Public Spaces

SWOT	Strengths, Weaknesses, Opportunities, Threats
.txt	Text file
UI	User interface
UNI	Ente Nazionale Italiano di Unificazione
USACE	U.S. Army Corps of Engineers
VR	Virtual Reality

Chapter 1

Chapter 1

The use of BIM in the management of existing buildings

1.1 BIM definition

The building information modeling (BIM), is today the most common methodology in the market of software for engineers and architects. Despite the relative youth of this concept, the spread of BIM programs in the AEC sector has been grown at exponential levels thanks to the important innovations in all stages of the life cycle of a building. To understand the scope of innovation, just think that the BIM methodology allows, through a unique three-dimensional model, to manage the whole multitude of information and operations normally divided into several files and folders. Born initially as a simple data container, in the form of 3d model, from which the definition Building Information Model, BIM methodology to today makes use of a real digital network, capable of integrating all the disciplines involved in the design and management of a building, until its demolition. In addition, BIM allows to extract in an automated way and at any time every architectural aspect normally necessary in the presentation phase of a project, eliminating at the base the probability of inconsistencies between the various technical drawings or tables where the architectural elements are listed (for example in the calculations). This possibility can be quite useful also at the stages of study such as the energy and structural analysis, which can be performed by the program or deepened inside dedicated software, thanks to the high interoperability of formats normally used by BIM.

For this reason with the BIM acronym is not intended just the image (model) of a building, but also the design methodology (modeling) through which optimizes the entire building process due to the high possibility of cooperation offered by the software to all actors involved in the project.

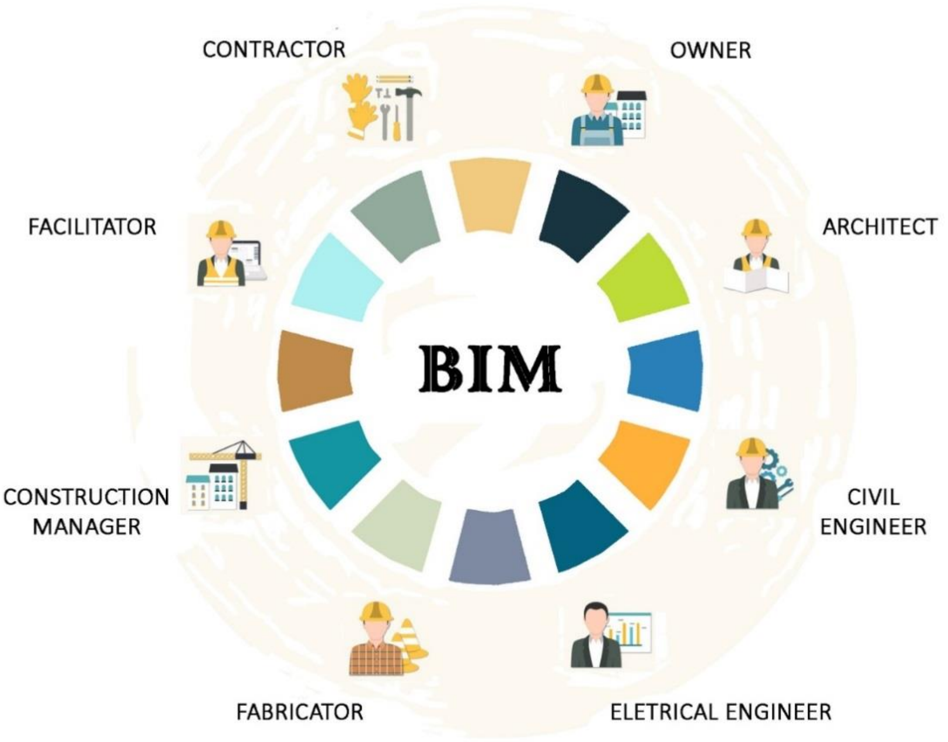

Figure 1: Cooperation between All the Parties Involved in the Construction

1.2 The evolution of BIM compared to a traditional 2D drawing

Architecture and construction have trusted from the beginning on the drawing to represent the necessary data for the project both in the design and construction phase. The computerization in the second half of the XX century and particularly since the end of the 70s, has allowed the development of CAD[1], enough to be used and developed by the industrial sector (aerospace and manufacturing in particular), in collaboration with the software company. The subsequent adoption as part of

[1] The acronym CAD - Computer Aided Design & Drafting - distinguishes between a computer's use for graphing (Drafting), or else using of computer to replace the drawing board, rather than to a real-aided design (design). With the passing of time this term places the attention on the design, using an electronic instrumentation for the creation and management of the project.

building constructions for architectural design allowed the birth of AutoCAD, opening up the path for all other 2D drawing software. However, the increasing demand for three-dimensional models has drew more and more attention to the 3D virtual graphics processor technologies. The development of CAD building models was introduced in the '80s. However, some major limitations of these applications, and in particular of 2D modelers, made the birth of parametric software essential, the use of which is at the base of BIM methodology.

In parallel, the aerospace and manufacturing industry adopted systems able to process integrated analysis and reduce errors; in particular, these sectors started to work on the objects for mechanical installations projects, and significant developments related to the design process were realized. This new approach gradually pushed the construction industry toward the parametric modeling. The first attempt, which dates back to 1986, is the Graphisoft: ArchiCAD (or Virtual Building Solution). It allowed for the first time to represent an architectural project through a three-dimensional virtual model, integrated thanks to the possibility to input data and geometric information, property and quantity of used elements.

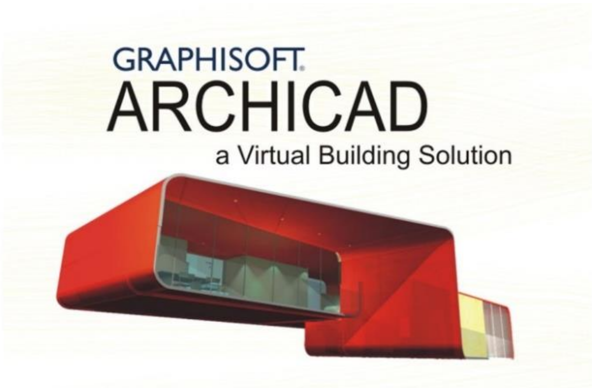

Figure 2: Symbol of parametric modeling software Archicad

The adoption of BIM methodology is a revolution of perspective compared to traditional CAD-based design. The traditional approach (CAD) provides a static representation of the various drawings and descriptive of the project such as vertical and horizontal sections, technological details, bill of quantities etc…

Making possible to meet the need for communication between the designer and any other actor involved in the project. The purpose of BIM design, by contrast, is the creation of a three-dimensional graph database in the form of virtual building, from which each user who gets involved in the life of the building, can automatically extract all the necessary information as well as the final work itself.

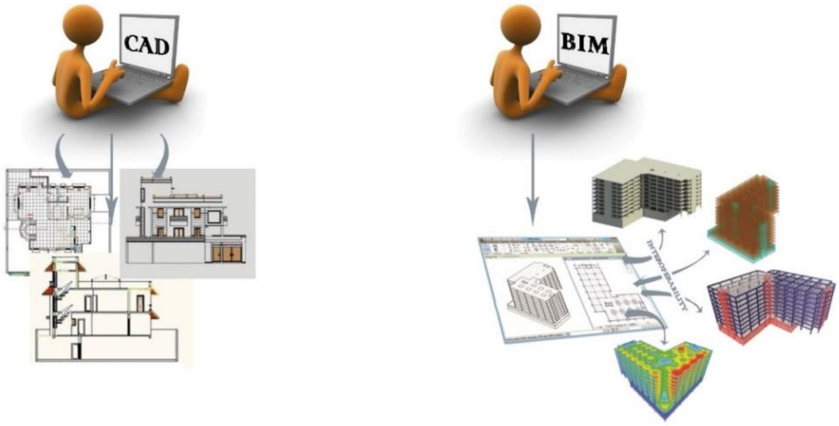

Figure 3: Building Process from CAD to BIM

The parametric software also allows to catalog and classify all the elements establishing a project in a much more systematic way as compared to the two-dimensional CAD LAYERS. In CAD technology this tool behaves exactly like a sheet of tracing paper, allowing overlapping and hierarchical arrangement of the drawing through the grouping of homologous objects (structure, systems, finishing, and glass elements). There are also historical attempts to facilitate communication between professionals by creating standards able to unify the methodology of development and reading of the sheets, such as the model of the American Institute of Architects, widespread in the United States, or European examples such as BS 1192 (Great Britain) and the "Sistème Unitarie de Communication" (France). Besides, the attention to design archives organization, standardization of graphics and symbols to represent real objects have increased.

The revolutionary feature of this software is the storing of data and the use of pre-packaged items, providing designers an alternative to the traditional two-dimensional drawing realized in AutoCAD or by hand. Also compared to traditional 3D CAD design made of solid elements, ArchiCAD was beginning to think in terms of architectural elements, provided with typical properties, called parameters, which allow to create a real database of information, in parallel to the virtual 3D model. In addition, the breaking point with older technologies consisted in the automatic updating of all views and sheets where modified elements appear.

This new tool has initiated a structural process of technological innovation which culminated in the birth of the BIM methodology. This step was not immediate, and in spite of its launch in 1986, the BIM began to become very popular only in 2003 thanks to the debate organized by Jerry Laiserin[2], in which the term was promulgated and consistently used by the two most popular American software company: **Autodesk and Bentley**. The debate had the merit to show and convince the experts that it was possible to achieve effective and collaborative design even between different software, providing benefits to the construction industry.

In parallel, more and more BIM software were created, which based their working methodology on the possibility to create database and 3D digital models suitable for simulating the virtual building construction analogous to the construction site reality: just to mention a few of the main ones Allplan, Archicad, Autodesk Revit, Bentley Building, VectorWork.

1.3 Introduction to BIM and parametric software

Comparing a BIM software to a traditional 3D CAD software, the first noticeable difference at a first glance to the interface is the difference in modeled objects: if the traditional CAD works in terms of lines and basic geometric shapes, in the case of a parametric software designed for the building industry, it will be possible to find the classic architectural elements: door, window, walls, roof, etc.

The models generated by these software will display typical attributes of the elements they are associated with, providing information to all actors involved in the project and allowing the integrated collaboration of various professionals due to the identification of building subsystems.

In a concrete example, it is possible to intuitively understand the difference of approach between BIM and CAD and therefore, the importance of this technological innovation in the building sector: in the CAD philosophy, each object, such as a door, must be represented in each view or table according to the graphic and theoretical conventions of the drawing. It is therefore the lines that will be grouped together in a layer, allowing the identification as "door element", thanks to color, thickness and graphical notation. In the case of the BIM, on the contrary, such object is modeled only once in 3d, realizing a sort of virtual “alter ego" of a

[2] Jerry Laiserin is an analyst in the industry that focuses on technologies of the future for the company and building and on the collaborative technologies for work on the project.

real door. This object is automatically identified as the door, assuming properties, graphic notations and technological information in every view in which the element needs to be visualized. In this way, the element behaves like a door and it must be linked to the wall on which it is inserted. Eliminating the wall eliminate the door as well, exactly as it would be in the project reality. In CAD methodology instead, the door would still exist in any view, despite the elimination of the wall, requiring additional operations on each graphic art in which it appears. This means that the entire building, represented as a set of "alter ego", is an alter ego itself: it is therefore a real digital model of an actual building, from which it is possible to get all necessary elaborates and data to draft the explanatory documentation of the project (sections, elevations and floor plans of the graphic tables, but also calculations and checking of the laws).

Indeed, the essential point of a BIM software is the connection of various technical drawings and tables which, having no relation in CAD, involved a greater attention by the designers and more chances of contradiction between the files and drawings related to the same subject.

In the BIM methodology a parametric three-dimensional digital model is modeled and framed by cameras: it is therefore possible to set a certain type of view rather than another, but as a matter of fact, it is as if the object was simply framed by x-ray "cameras", which merely "observe" and return what has been previously modeled. When an element of the construction gets modified inside a particular view, it gets actually modified in the model, and consequently the other views and schedules are automatically updated, eliminating the possibility of error instantly.

Along with BIM, the previously mentioned software are also called "parametric software". The root of this term was born in computer language, where the "parameter" term indicates a value to be assigned to a function so that it can complete a certain action. In BIM, “to parameterize” means representing an entity using numerical values assigned to certain features or attributes. Considering a roof as an example, the BIM software will need for instance the "slope" parameter, in order to independently and correctly generate the design of the roof on the basis of a certain perimeter. Besides, it will be required to insert thickness, stratigraphy and then the materials which compose it. In this way, the parametric software realizes the design according to the values that the user must merely select or type, without the need to represent them manually.

Subsequently, it is possible to change such information on a single element so that, as previously said, all of the views that frame the homologous roofs are automatically and instantly updated. Also, if the documentation includes schedules concerning the roof or its materials, they will be changed as well, in parallel with the views. The advantage for designers, all views being linked, is the possibility to choose the most comfortable view to make adjustments and obtain a response from the program without the need for manual intervention on the rest of the documentation.

The building itself is progressively modeled on the basis of these views, which can then be replicated and organized with schedules within descriptive tables needed in the project documentation. Another important point concerns the parameters language which, resulting from the construction industry, represents the common language between the designer and the software, as well as one of the basic tools in the BIM process.

Figure 4: The BIM process

The use of BIM is appropriate in particular for the construction and building management phases, due to its ability to store information on structural components and external environments elements in each of the steps relating to the construction and life of the building, allowing to retrieve in a few moments any data useful to the maintenance or, for instance, to monitor the energy consumption.

Besides the parameters and attributes related to individual elements, it is possible to insert the information concerning the building as a whole, such as geographic coordinates, address, energy class, or those relating to specific moments of its life, such as the work progress phases and the scanning of maintenance operations, by planning as best as possible the management of the site.

It can therefore be concluded that BIM works as if the model was much more than a number of vector elements, but an actual digital prototype building, with a digital archive from which to obtain the specific documentation related to any moment of the product lifecycle: preliminary, final and executive design, management and possible demolition. In particular, in the case of historic buildings, it allows to bring together in a single file all documents related to the successive stages of development, accelerating the building survey thanks to the digitization of any images and historical information. The BIM software can also perform test to identify errors and inconsistencies between the elements, thanks to intelligent objects that establish a relationship with the other components of the project, exactly like the real ones used in the construction. In order to facilitate the collaboration between professionals, each modification performed by a user is reported to the other members involved in the execution of the model, highlighting inconsistencies and incompatibilities and increasing reciprocal communication with the aim to reduce the possibility of error. A concrete example of the usefulness of this function is offered by models in which different users operate on structures and installations: if the introduction of a new bearing element is in conflict with a previously installed system, or vice versa, the program reports or prevents insertion, providing, in some cases, possible alternatives. The phases of the construction site are therefore less susceptible to changes during construction due to incorrect interpretation of technical drawings executed by the partners, facilitating compliance with the time and the budget.

1.4 Data exchange and interoperability

One of the reasons that are allowing the parametric software to establish itself on the market is the possibility to increase collaboration between different professionals working on the project.

Because of the interoperability of these software with other applications, such as those of structural, energy and technical nature in general, it is possible to perform in-depth analyzes by exporting all the necessary information directly from the model and evaluating the economic sustainability, energy efficiency, resistance of the elements and compliance with the regulations in force.

Among the various tools available in the BIM software, the schedules is one that definitely sets the basis for such communication. These are tables in which every technical element (roof, walls, columns, floors, glazed areas, panels, doors, etc.) is automatically sorted in its own group; it is possible to highlight the surface, the volume and other dimensions, as well as the costs, which are calculated automatically by the software, highlighting both partial and total values, making it ideal for operations such as computation, structural analysis, and much more.

It follows that the amount of information stored in a single file can actually also be useful after many years and even throughout the manufactured lifecycle. It is therefore possible to preserve the memory of all previous phases and allow the next steps optimization and organization, ensuring significant time savings, especially when BIM methodology is adopted from the initial design stages. According to studies conducted on various projects, thanks to BIM, compared to traditional design, it can be saved up to 30% of the labor time normally used in editing operations. Despite the lack of BIM entirely self-sufficient and integrated solutions, many software developed the possibility of interaction and collaboration with the BIM applications. Moreover, building SMART[3], an international association committed to the BIM regulation, offered further impulse to this process by certifying the interoperability of software through ISO 16739:2013[4]; the Italian section was prepared by Professor Stefano Della Torre. The association's official

[3] http://www.buildingsmart.org/ International Alliance for Interoperability (IAI)

[4] http://www.iso.org/iso/iso_catalogue/catalogue_tc

website provides a complete and exhaustive list of IFC worldwide spread certified applications, such as those mentioned above.

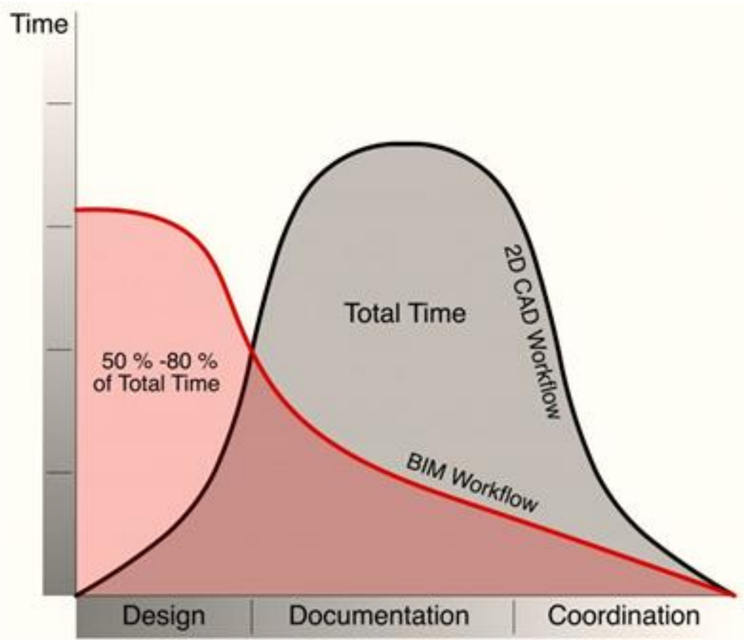

Figure 5: The amount of time taken working with the BIM software

The current limit of such applications is the incapacity to complete all actions and analyzes needed to bring a project to fruition. However, thanks to export opportunities into highly interoperable exchange formats, the BIM methodology can overcome the limitations of dedicated software through the integration with other essential applications in the realization of an architectural project.

The integration of the BIM software and other applications is guaranteed by the IFC (Industry Foundation Classes), worldwide spread for its ability to guarantee the reading of data and the interchange of information between the majorities of software used by all actors involved in the project.

This involves the ability to model the building according to the needs and the specific phase of the project, so as to facilitate the workflow and collaboration between the various users, adding each time the necessary information to characterize the virtual model for new uses, without having to start from scratch.

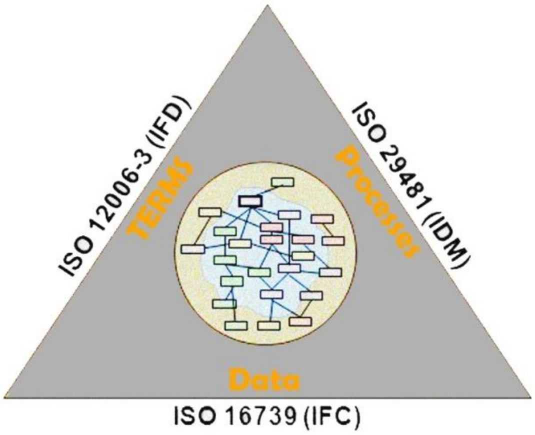

Figure 6: Triangle of Building Smart standards

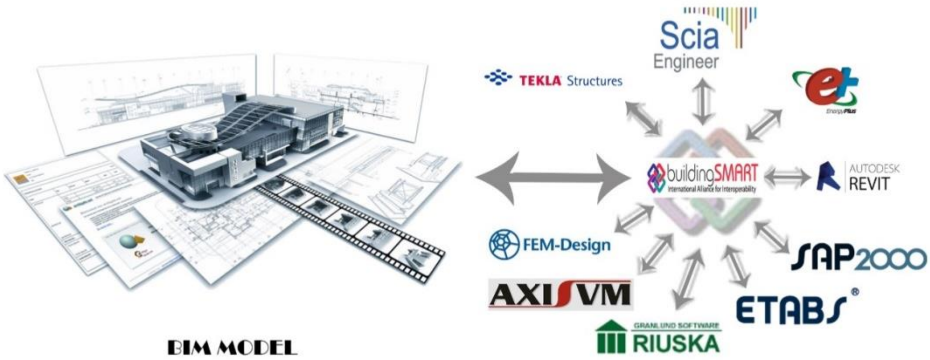

Figure 7: Interoperability between different software

1.5 3D, 4D, 5D BIM. Geometry, Time, Cost

"The acronym BIM is historically linked in the minds of many to 3-dimensional and now 4D (time) and 5D (cost) virtual modeling of buildings. BIM, however, has the capability and even the responsibility to be much more". In these words, the National Institute of Building Sciences (NIBS)5, explains how the 4D BIM

[5] The National Institute of Building Sciences is a nonprofit, non-governmental organization that brings together representatives of government, the professions and industry, labor and consumer interests to study and solve the problems that hinder the safe construction, the construction of facilities to make affordable housing, commercial buildings and industries in the US. In addition, the Institute offers an authoritative source and a unique opportunity for the free and frank discussion between the public and private sectors within the built environment. The mission of the Institute of serving the public interest is achieved by supporting the progress in the construction of science and

modeling consists in integrating within a 3D model the ability to monitor and analyze the construction time; in parallel, it defines the 5D BIM (as) the capacity of the cost management of building process.

Also the international company ASHRAE[6], in "An Introduction to Building Information Modeling" deals with the theme of costs and time analysis and management, relating it explicitly to the interoperability between the software "A 3-D BIM that has objects and assemblies that have a cost dimension added to them. The cost information can be contained in the BIM or can be linked or otherwise associated to the building objects"; “A 4-D BIM that has objects and assemblies that have schedule and time constraint data added to them. The information can be contained in the BIM or can be linked or otherwise associated (integrated and/or interoperable) with project design and construction activity scheduling and time sensitivity estimating and analysis system”[7].

By automating the update process of the documents extracted from BIM, it is possible to characterize the virtual model of a building in parallel with the detail level increase even in terms of time: 4D models can thus analyze the times both in the preliminary stages of design and in the more complex and precise ones as during the detailed coordination of subcontractors in the implementation phases.

Characterizing and increasing the detail degree of the building elements, and adding them in the time tables, in addition to the model updating, will also increase the detail degree of the timing analysis. It can be noted , even in this case, there is a direct link between the time attribute and the components connected to it, establishing a direct relationship between the elements of the 3D model, the construction activities necessary for their implementation and tables that show the beginning and end dates of such operations, displayed in 4D model. In this way, BIM allows to easily monitor compliance with the program and easier updating of the table if something unexpected occurs. Besides new construction projects, the

technology in order to improve the performance of buildings, by reducing waste and saving energy and resources.

[6] ASHRAE, founded in 1894, is a global company that supports and intends to increase the well-being through sustainable technology for the built environment. The Company and its members focus on building systems, on energy efficiency, indoor air quality, refrigeration and sustainability in the industry.

[7] https://www.ashrae.org/about-ashrae

4D modeling can also be used in renovation. During the renovation or modernization of a manufacture, the management of material and equipment needs to be dealt with in order not to obstruct the works or slow them down. Space becomes therefore a very fluid, provisional element, in which are to be designed repositionings, storage, special activities, transport, loading and unloading of materials. In certain cases the users of the building can even continue to use some zones while waiting for the works to be completed in certain environments, posing a difficult challenge to the designer at the temporary space level. Through a 4D model, the temporal scanning of each single phase, the accessible spaces and those reserved to the authorized personnel and areas that are temporarily designated for specific activities which are normally carried in process areas can be communicated to tenants[8]. The intuitiveness of a 3D model, combined with the high detail of temporal tables can be very helpful in explaining every modification to customers. Obviously, this tool is indispensable even for the scratch projects, where it is necessary to manage construction programs, to coordinate the various work teams and monitor day-to-day progress. Indeed it is possible to predict and avoid any interruption and to evaluate any possible overlapping, organizing and optimizing a rational sequence of all activities. The images extracted from the 4D model can also be used during the construction phase by supervisors as well as by the superintendents to progressively illustrate short-term objectives for the crew.

Usually, 4D modeling provides for four specific steps that cover the entire lifecycle of the project[9].

• Pre-design: it allows to study the feasibility within the strategic planning. For example, it is possible to identify different sequences and analyze their timings to select the one with the best phases and provisional spatial configurations, allowing buyers and designers to reduce the costs of analysis because of the employability of this model even in later stages.

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[8] Dana K. Smith, Michael Tardiff , “ Building Information Modeling, a strategic implementation guide for architects, Engineers, Constructors and Real Estate Assett Managers” - Wiley, Maggio 2009

[9] Chuck Eastman, Paul Teicholz, Rafael Sacks, Kathleen Liston, “BIM Handbook - a guide to building information modeling for Owners, Managers, Designers, Engineers and Contractors” - Wiley, Luglio 2011

• Design development: by entering into the substance of the different manufacturing processes, it is possible to evaluate their temporal impact, identifying advantages and problems and optimizing the construction schedule.

• Offer Construction: the contractor may use 4D models also during the offer to show his own work programming capabilities, especially when works need to be carried out in presence of users. The 4D models can help to give full explanation about space and constraints, highlighting zones and activities sequence, increasing the offers accuracy during the tender.

• Construction: as noted above, the 4D models become particularly effective in the construction phases management and communication. They can direct operators, managing the area and working schedules, as well as flows and site security in case different teams are working. The progress reviews of the construction programming can be easily compared with the real progress in the construction site allowing immediate and extremely communicative highlighting of the extent of any delays and / or unexpected events. As a result, it is possible to take necessary countermeasures by analyzing the feasibility and impact of changes.

In conclusion, since the necessity of costs monitoring has recently increased and noting that the schedules have a direct impact on the economic aspects, 4D modeling presents undeniable positive aspects: the greater collaboration between stakeholders through a more immediate communication and a better comprehension of the phases, based on images and tables; a simplification of the identification on a preliminary basis of successive phases of the construction site and the possibility of temporary spaces through the management of flows and spaces users. Therefore, it is possible to optimize the coordination of subcontractors and a detailed summary of the constructive sequences, and because of these timing analysis, costs and economic aspects can be more easily identified l, including in relation to the expected duration of the site in all its activities. The model, thanks to the enclosure of costs, is hereby defined 5D and allows to immediately obtain the bill of quantities, which is linked to the construction objects and the schedules in the model. Any modification and updating of these elements will produce updates on both the time scale and the bill of quantities, allowing continuous monitoring and rapid evaluation of design alternatives.

1.6 6D, 7D BIM. Sustainability and Facility Management

In a building lifecycle, in the design stage, the phase in which the manufacture consumes more economic resources, i.e. the management after construction, is often neglected. Energy consumption has a considerable impact on the costs that the customer has to face, it should therefore be considered and taken into account already in the preliminary planning stage to ensure sustainability of the building in the long term. 6D modeling refers to a specific type of virtual modeling that deals with the analysis of this aspect, since it allows designers and installers to perform precise analysis and simulations of building energy behavior at an early stage of the design process[10].

The performances of the building-plant system can also be simulated with features that take into account environmental factors: solar radiation; exposure of transparent surfaces; building orientation and shading provided by buildings or other external obstructions; climatic conditions provided by a global archive of weather information to get simulations on a daily, monthly, and yearly basis; information on internal equipment, medium ranges of use and occupation of the environments to take account of internal earnings and evaluate energy and water consumption.

These calculations can be the basis for an additional level of study and design of the building: the Facility Management (FM), i.e. efficiency of the workplace designing, as it ensures comfort and safety of users and workers, can be represented through 7D modeling. If the main tools of the Facility Manager are interoperable database and can provide a high level of detail of consumption, uses and wear of the building elements, the BIM environment allows to combine all of this to the three-dimensional graphical representation and the possibility of interaction with more sophisticated and precise analysis software. The accuracy and completeness of data that a parametric software guarantees since the early stages of design and construction, also provides in a second moment, and therefore in FM, high accuracy and accessibility of information; data without which it is likely to exceed the expected costs and waste valuable resources, causing difficulties during the search for alternative solutions. For this purpose, it can be useful to make an "as built" of the building, updating the model since its construction phase to provide a basis for

[10] http://www.energygroup.it/Aree- Application / Design -BIM.aspx

accurate information to maintenance operations. Maintaining a single archive and concentrating the data in the same file, can also solve contradictions and building data dispersion and redundancy frequently recurring in the traditional archives. This methodology can in fact avail the utilizing of a BIM software as an archive of equipment and parts lists (through schedules) and a CMMS, a computerized maintenance management system.

Figure 8: BIM 3D, 4D, 5D, 6D and7D

1.7 BIM in the world

Since 2000 it is possible to count numerous attempts by the international community to facilitate the transition from CAD to BIM. The UK was one of the pioneers of this process, trying to understand the meeting points between these two worlds, using shared standards and promoting the management and exchange of information from one system to another by intervening at the base of its production process. Indeed, in 2000 was born the AEC[11] (UK) CAD Standards Initiative, re-formed in 2009 to accommodate new instances of BIM, in fact, including professionals experienced in this new methodology for the implementation of its encoding. In 2011 it was the turn of the National Building Specification (NBS), an initiator of a free digital objects library, the National BIM Library for the construction industry in the United Kingdom, easily accessible by professionals of the construction world. Also, a plan was launched to make the use of BIM compulsory at the legislative level, at least in the public sector, from 2016.

[11] The AEC (Architecture Engineering and Construction) is an organization that deals with coping with the need to a standard in the British construction industry for a BIM environment.

Research Centre (CRC) for Construction Innovation, which aims to improve the construction industry through the development of technologies, tools and management systems.

In Asia, Singapore is the most active State in terms of BIM, through the Construction and Real Estate Network (CoreNet), an organization that is implementing this methodology in governmental projects. Through state funding the organization was able to start the CoreNet e-Plan Check system. This project aims at complementing the transition from 2D to BIM design, to deliver value and to improve management through a virtual model that acts as a database. Thus the electronic archive, in the form of three-dimensional model, can gradually be enriched with new information throughout the life of the building, from design to construction, until demolition. In this way paper archives will be streamlined; thanks to the digitization of the technical documentation, the delivery of modules and designs takes place online through a service available twenty-four hours a day, simplifying the work of approving authority and facilitating the communication of the state practice through a simple consultation of the online bulletin board. The increased speed in the development of practices involves shorter response times and a more efficient and productive public service thanks to the computerization of the delivery procedure. However, the full integration of BIM in daily planning is still in the testing and development stage, through a collaboration between governmental and public bodies, industry and educational institutions.

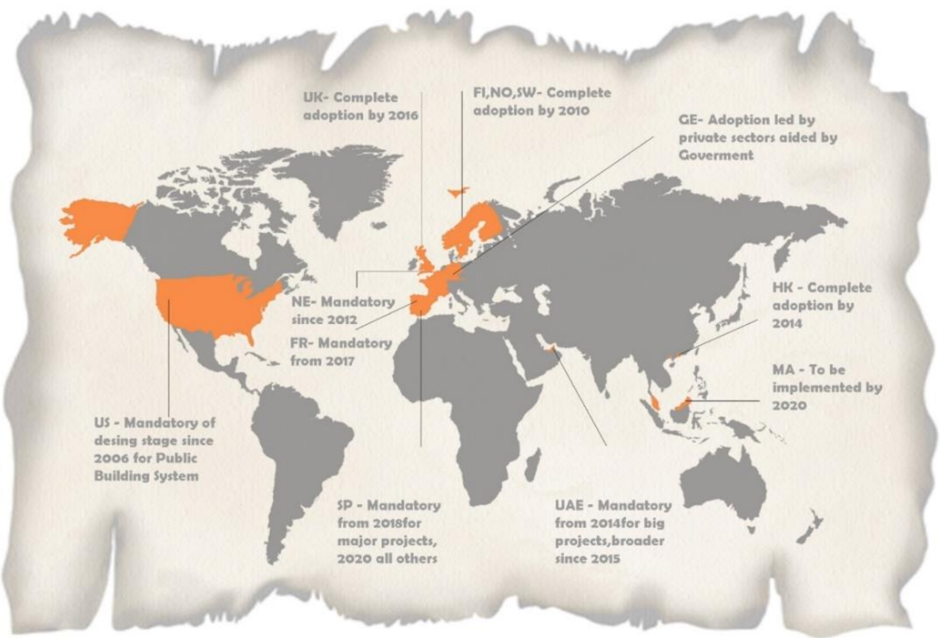

Figure 9: The BIM methodology in the world

1.8 BIM in Italy and the importance of its placement in the field of public procurement

As we have seen, the Scandinavian countries, Britain, the United States and many others, have already reached important milestones in the implementation of BIM methodology in daily practice of the construction industry, specifically in what concerns the sphere of public works. In Italy, by contrast, the ICT (Information Communication Technology) and their technological potential is still much disregarded, particularly in the building sector. The verification processes, control and management of building production based on building information modeling, which have firmly established in other states, are proving their effectiveness in achieving high quality and security standards, compliance with deadlines, optimization of resources, compatibility and integration with the environment in work realization.

The Italian construction sector, one among the most affected by the global economic crisis, can therefore greatly benefit from the use of these technologies and innovation, as also highlighted by the XIX economic report CRESME[12] (Economic Social Research Center of the market for Construction and the Territory). The industrial system of constructions needs to be revolutionized by developing new strategies to redesign both the processes and the final products (buildings, cities, infrastructure), without neglecting the offer models.

The XX economic report CRESME, (November 2012) recommended the US model and many others due to their ability to integrate people, systems and affairs optimizing the results and increasing the value of assets, as well as the ability to reduce waste and maximize efficiency and sustainability in all stages of design (from construction to management). This particular system, called Integrated Project Delivery (IPD) [13] indicated by CRESME as "target", cannot ignore the BIM

[12] CRESME (Center for Economic Research of the Social Market for 'Construction and Land) is an' association founded in 1962 that conducts research and promotes meetings between public and private operators. In recent years it has information systems that can constantly monitor the progress of the various construction markets, from real estate to the new building production, to maintenance and recovery, public works, the individual products and materials, giving operators the industry an indispensable strategic tool for knowledge.

[13] IPD is the design approach that integrates people, systems, structures and business practices within the process that collaboratively uses the talents and insight of all participants to achieve an optimal result of the project. Increase the value for the owner, and helps reduce waste by maximizing efficiency through all phases of design and construction.

Building Information Modeling as its specific "technology." The public sector can play a significant role in spreading and implementing this technology and methodology approach to construction and renovation / management of buildings, starting from public procurements.

The insertion of the use of building information modeling among the requirements of tender offers, can definitely involve the private sector too, both because it would require the adoption of parametric software by many professional firms, and because, once implemented, this technology would certainly also be used for the private sector projects. The majority of companies is in fact reluctant to invest in this system, especially fearing that the initial difficulties during the transition from CAD to BIM may excessively protract design time. Also, the presence of a myriad of small and medium-sized companies that would undoubtedly encounter difficulties in covering the initial costs must not be underestimated.

After all, the investment is considerable: starting from the purchase of the software, and continuing with the necessary training or recruitment of specialized staff in the use of BIM. Focusing on the study of the Stanford University Center for Integrated Facilities Engineering (CIFE), based on the analysis of 32 projects in the field of BIM, it is possible to overcome many hesitations and understand the quality of the benefits arising from the adoption of this innovative work system in terms of compliance with deadlines and reduction of errors. The analysis found the following percentages:

• -40% design changes on the site

• 3% margin of error in the estimates of costs

• -10% of the total cost by analyzing the interferences.

Some examples of adoption of BIM in the public sector is actually already implemented in Italy. Among the most significant ones it can be mentioned the Police Station "Lancers of Montebello" of Milan, a residential building under new construction.

The project, an important element within a large plan to support compliance with standards of the Milan police station complex of buildings(53,450 square meters in total) dating from the late XIX century, is conducted by various partners: professionals of the interregional public works of Lombardy and Liguria, the University of Brescia, through the team led by Professor Angelo Ciribini, Professor of civil Engineering and architecture, and finally the ICT company Harpaceas, who participated in the project as a technology partner[14].

As declared by the engineer Baratono in the journal IL Sole 24 Ore: "BIM represents a long-term investment capable of enabling, on the one hand, to shorten the time through the efficiency of the construction process and the manufacture management, and on the other hand, to ensure greater effectiveness of the control systems. For this reason it has been decided to start the experimentation. In addition, BIM, fostering a dematerialization of processes aimed to the investigation of the projects, would allow a significant reduction of administrative time. It would undoubtedly enable the rationalization of expense ". It should be emphasized the precious help of Luca Ferrari from Harpaceas[15], also interviewed in the article, who provided the software tools, assisting the team and providing advice in all phases of the project, supporting the realization of individual models associated with them. The BIM software used, Allplan, belonging to the German company Nemetschek, has been the main instrument for the realization of the architectural and structural design, as well as for the parametric design of the technical, ventilation, water-sanitary and electrical installations; also belonging to the Nemetschek group is the Norwegian company Data Design System, which produced the DDS-CAD platform used in the project. Solibri Model Checker has instead made a checking tool to verify congruity with the regulations, while the 4D model, and therefore the time schedule and monitoring of implementation times, were made by Synchro.

1.9 BIM for the control of retrofit designs

The intervention on the existing real estate is a particularly complex and varied field of the construction sector, and begins, in its simplest form, in the daily maintenance. This activity, which undoubtedly represents the most significant element of the useful life of a building, consists of the necessary operations to keep the functioning of the organism in operation, replacing or repairing the damaged and the obsolete parts.

[14] http://www.ingenio-web.it/Notizia/3417/BIM:_applicato_in_un_APPALTO_PUBBLICO

[15] Harpaceas born in 1990 in Milan, thanks to a strong group of engineers significant design experience at the engineering firm Finzi & Associates, and at the company's software development and structural analysis CeA.S., to present itself to the construction sector as technological excellence partners. The Harpaceas activities, initially oriented in the proposed solutions in the field of structural analysis, has rapidly expanded going to cover the fields of architectural and civil engineering design, plant engineering and infrastructure.

The recurring operations in this phase are:

- Organization of operational management
- Programming of the exercise management
- Ethnical-functional control of building organism
- Execution of ordinary maintenance works
- Organization of extraordinary maintenance
- Execution of extraordinary maintenance works.

However, in the likely event that the manufacture has to change destination or has to adapt to new requirements, the necessary operations take other names: renovation, alteration, rehabilitation, recovery or retrofit, depending on the extent of the work carried out on the building. Keeping a close eye to this matter, it will be possible to note that the common denominator of all these interventions is certainly the adaptation of the object performances to new or old requests and needs of end users, with particular attention to the provisions of the building and any new economic, cultural and social contexts.

The term "restructuring" refers to the most common operations, whose aim is for example the only correction of deficiencies in construction system, often due to aging, wear or accidental external agents; in other cases this kind of intervention is necessary because of new requirements of the users, which involve a functional-spatial adjustment. Among the most recent of the introduction terms, in the lexicon of the construction, it is possible to find retrofit or retrofitting. It is a type of very recent intervention and peculiar of its kind, as it arises from the need to adapt the energy performance of the building to current standards. It can be easily understood how this specific approach is the product of both the introduction of new technologies and a greater awareness of environmental issues, particularly spread in the second half of the ‘900, which result in a demand for very high energy performance compared to the medium quality of building which lacks control and attention to energy issues.

This type of intervention obviously differs from the simple maintenance because it adds technologies that do not exist in the period of the project with the aim of raising the performance of the building to extraordinary levels, even before the natural obsolescence. This concept is well expressed by Rinaldi A .: "retrofit is not part of the view of maintenance as it represents an update, an adjustment, an adaptation of the building, specifically in relation to the energy efficiency, but also, by extension, other functions / functionality related to environment and sustainability "[16].

In addition, the retrofit term deviates even further from the concept of 'requalification', since it raises the emphasis on some specific arguments related to environmental sustainability, thereby adding an aim matured in the light of a particular cultural context and in a debate that has particularly characterized the last 50 years of history in the construction industry.

This approach has obvious repercussions on the process design as well, as the implementation of innovative technologies, an essential tool of any retrofit, requires analysis and preliminary experimentations to simulate and anticipate the effectiveness of transformations. It is a complex and nonlinear process, where knowledge must be integrated: structure, system and architectural design combine together from the early design phases, to search for a compromise that can ensure the maximum efficiency, both at the building and the construction site level, reducing the possibility of error.

Therefore, checkpoints are becoming necessary within each decision-making stage, using innovative technologies and software able to represent and manage this complexity, showing the potential impact of any technological and architectural solution thus controlling the effects and being able to review the design choices ongoing. In the building, this methodology is defined integrated design and was conceived and adopted in the industrial field even before that in architecture. The successful point of integrated design lies in the ability to put together the various actors involved in the process, advancing in parallel every aspect and every design level, examining the interaction between all the of composition, distribution, technological and economic aspects of the system.

It is evident that BIM is particularly suited for retrofit projects, using a technology that can bring together all the efforts of various professionals in a single file, due to the use of intelligent 3D elements able to interact with the other objects in the model. Parametric software provide important tools for control and analysis

[16] Rinaldi A., "The redevelopment of the basic historical context: the project for Brennone 21 in Reggio Emilia" - Intervention presented at Cersaie, Bologna, 2009.

(site characteristics and utilized elements, energy and lighting simulation, computational tools in the quantities of materials used, cost estimation etc.), which may be important suggestions since the modeling and the state of fact analysis phases. The survey can avail 3D laser scans, providing a much deeper level of detail than traditional system; energy analyzes can be carried out already in the early phases of concept to exclude some of the alternative solutions, evaluating costs and benefits immediately. Thus, any decision can be taken on the basis of economic feasibility, without neglecting the technological efficiency of possible solutions and their impact on the long term.

Chapter 2

Chapter 2

Project "Digitization of the buildings of Turin"

2.1 Project description

- The Real Estate management

The real estate assets in Turin, a city rich in history and prestige since antiquity, consists of numerous historic and recent buildings, in which several crucial activities for the economy and society of Turin, as well as for the entire region, take place. The management of this multitude of artifacts is certainly one of the most delicate activities because of their great impact on the expenditure of the municipal budget; its effectiveness depends on an integrated process: a complex and articulated operation that cannot be separated from the intelligent use of data concerning the building.

This interdisciplinary collaborative process is based on analysis that can integrate very different aspects and knowledge, whose ultimate objective is the achievement of determinate performance (e.g. high interior comfort, affordability, functionality, zero-energy balance etc.). The process of determination and selection of the most convenient solution can use innovative tools to develop an information platform, interactive and coordinated with the different systems, making available to clients and designers all the information necessary to evaluate the economic aspects and to simulate the final results and the calculation of the impact on the building and on end users.

- Project state of the art

Analyzing the current situation, numerous inefficiencies of maintenance operations and consequent waste of public funds can be noticed, mainly due to the lack of links between the many data and documentation existing in the municipal archives and owned by the various agencies.

Before each operation, drawings are performed continuously to illustrate the necessary work which, despite being passed on to contractors, do not negate the necessity of each company to draw up their own plans and their drawings that can generate contradictions between a work and another.

As well as within the building field, even the surveys provide for the compilation of files, but not for the updating of the old ones, producing a data redundancy and continuous renovation of all of the census operations.

For this reason, the project "Digitization of the buildings in the city of Turin, started in 2014, aims to create a new digital archive model upgradeable and integrated to simplify the management of real estate assets of the Public Administration, so as to provide for an unique tool for the Facility Manager to control costs and study solutions for efficiency of buildings. This will also mean eliminating the need to update every single CAD files and documentation of the case studies, i.e. public buildings with different uses (public offices, building archives, elementary schools etc.).

- Partners and project activities

The main project partners are the "Torino Smart City" foundation and the Polytechnic of Turin which are the actual perpetrators of this digitization process, extremely important to develop a BIM methodology to rationalize, update and share the multitude of information related to buildings, once scattered in several archives.

Thanks to the BIM technologies, it is possible to reduce or even totally remove some of the recurrent inefficiencies in the construction industry, innovating both the production process and the built management one. The informative flows that are produced at all phases of these processes and by different actors, can also be simplified, standardized and collected in a single archive, by creating catalogs aimed at modeling in the BIM environment, using a common language for all buildings of real estate assets.

Firstly, it was therefore identified the most effective tool in transmitting information, paying close attention to the concept of interoperability: the IFC standard, open interchange format internationally recognized, and consequently the technologies which are based on it, set out the safest means to guarantee a complete and correct transmission of data between software. The use of these tools is the basis for the methodology of the Building Information Modeling and Management, trough which is possible to improve the quality of the process, by the identification of responsibilities and the consequent transparency of individual operations that may reduce the possibility of corruption, additional costs and poor quality, in compliance with the requirements of Community legislation.

In concrete terms, for each building a single three-dimensional virtual model is realized and, thanks to the BIM technology, it can store all the numerical data and drawings relating them, since the construction and plant components are themselves characterized by both numerical and graphical attributes. Such metadata, exportable through the IFC standard, also allow the interaction of the model with other interoperable software, providing greater depth of analysis and continuous updating of the central database.

That is how the BIM model is not only a three-dimensional representation of the building, but rather a collaborative platform in which data are queried and extractable, providing further valuable material for various activities such as, for example, energy efficiency and user awareness.

To proceed with the creation of a BIM model, the preliminary stages consist of an architectural survey, to realize the CAD as-built tables and then perform a detailed three-dimensional model which is closer to reality. Concurrently, the survey of all supplied devices is run, with particular attention to thermal and electrical systems.

The IREN[17]technicians, partner company in this project, are involved in this phase of the project, making available modelers their skills in the electricity sector (production, distribution and sale), the thermal energy for district heating (production and sale), gas (distribution and sales), the management of integrated

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[17] Iren is structured as an industrial holding company with headquarters in Reggio Emilia, operating offices in Genoa, Parma, Piacenza and Turin, and company managers of the individual business lines. The holding Iren S.p.A. are the following strategic activities, development, coordination and control, while the five operating companies ensure coordination and development of the business lines: Iren Acqua Gas in the integrated water cycle, Iren Energia in the production of electricity and heat and technology services, Iren Mercato in the sale of electricity, gas and district heating, Iren Emilia in the gas sector, in waste collection, environmental hygiene and the management of local services, Iren Ambiente in the design and management of treatment plants and waste disposal and in the renewable sector.

water services, management services (collection and waste-disposal) and services for Public Administrations.

After the expeditious survey, the BIM model, performed by Polytechnic of Turin team, is carried out by using the Autodesk Revit software in such a way that the elements and data can be exported to the other software, such as Archibus for space management (space planning) and Design Builder for energy analysis.

This technology can also be used and continually updated to manage the future maintenance and / or organize larger interventions, such as those needed to improve energy efficiency.

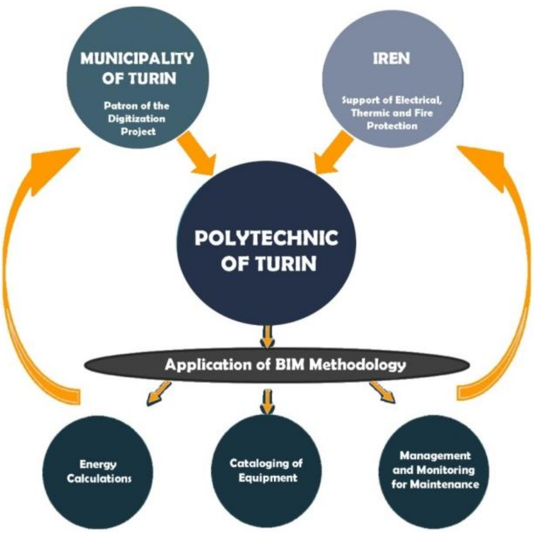


Figure 10: Project management among companies

- The European context and of Turin

The European Directive of 15 January 2014, European Union Public Procurement Directive (EUPPD) proposes the encouragement, the specification or imposition of BIM use for civil engineering projects financed with public funds in the EU starting from 2016. Some of the 28 member countries are already ahead in this process, having already reached the obligatoriness of BIM for national projects financed with public funds: these are England, the Netherlands, Denmark, Finland and Norway.

It is thanks to a study conducted on these countries and released by the European Commission in 2012, that a 5% to 20% saving was highlighted in contract costs of public bodies that have already implemented e-procurement solutions. Closely observing at the turnover generated by the contract European market, estimated at more than 2 trillion euro, 100 to 400 billion euro per year could be saved- which, at worst, is equivalent to the construction of over 150 large hospitals[18].

The adoption of BIM for public contract procedures depends on the degree of maturity reached by the BIM tools and the guarantees of effective control of information at all stages of the building lifecycle which, even in the private sector, have generated remarkable savings and design quality. The attention of the major industrialized countries governments towards BIM, for all these reasons, is steadily growing, particularly for what concerns public contract procedures, where the high-quality final product and better control of costs results into benefits for the whole society.

The European Union has lately been making great progresses on energy efficiency and energy savings related to construction both in normative and legislative field and in the research. In the myriad of projects concerning this subject and Smart City, which are funded by the European the project launched by the Public Administration of the municipality of Turin and the Turin Smart City Foundation. The latter, born precisely within the municipality of Turin in 2011, is an entity involved in the management and coordination of initiatives for sustainable development, and in this five years of life has put much effort on projects to raise Turin's livability standards, by lowering emissions, adopting advanced technologies and improving public governance attention on the quality of citizen's life. Within this framework is born the collaboration with Polytechnic of Turin, one among the most advanced institutions on the use and research on parametric software and BIM methodology in Italy. In this field, the faculty has a considerable experience, thanks to numerous research papers on the integral design, based on interoperability between the used software.

"Interoperability is therefore an essential requirement because, in a growing number of projects, BIM is actually used as a methodology and not only as a

[18] Font: Smart Market report, 2014, The Business Value of Bim for Construction in Major Global Market

building information model simplified for utilization during the design phase. The automatic exchange of models and other data between different software is one of the main changes required to the construction industry for a complete integration and collaboration between the different actors of the building process[19]."

This project aims to demonstrate how the academic and the business world can collaborate together and combine their experiences to innovate facility management and, consequently, to ensure significant savings in terms of time and cost.

The project consists therefore in the creation of a unique database, upgradeable and interchangeable between the actors involved in each case study. Due to the interoperability of the software utilized in the BIM methodology, it is possible to perform all functions relating to the design and analysis of the various levels (structural, energy and management) maintaining a single dynamic model, shared as a reference point for interaction between various parties. In addition, during the facility management phase, this model can ease the review of tenders and the facilities contracts, making them more consistent with the real requirements of the territory and with the actual possibilities of the building.

The benefits of this technology also concern other important fields, such as tourism and education, due to the possibility of interaction with software for augmented reality, a particularly effective tool in raising awareness on sensitive topics such as history, culture, sustainability and energy saving. In parallel, this project represents an opportunity to start an advanced, ambitious program for digitization and dematerialization of Public Administrations, launching and feeding into the process for the creation of a unified digital archive, thanks to the finding of dedicated EU funding.

2.2 Goals

In the national scene, that of Turin is the first case of integrated project of real estate management, based on the adoption of the BIM methodology and initiated by a Public Administration. The project described so far has the main objective of developing guidelines for the application of an efficient work methodology,

[19] Font: Smart Market report, 2014, The Business Value of Bim for Construction in Major Global Market

sustainable and replicable on a large scale, by identifying reference Best Practices at a national level.

The achievement of these goals involves the use of cutting edge technologies, related to modeling in the BIM environment and able to exchange data with software for in-depth analysis in the structural, energy and management fields.

More deeply, the objectives are summarized below:

- The use of GIS software for the realization of an energy model on urban scale by integrating the individual building with its context to carry out territorial surveys useful to planners and decision makers.
- Recovery of real data from the records of technical registry data for the study of selected assets and the estimate of management optimizations, so as to adjust the energy contracts in favor of the administration.
- The creation of a "unified digital archive", in ideal continuity with the 3D cadaster realization project for Italian cities, to establish instant revisions and facilitate the operation of checking and updating parameters also in terms of time.
- Reaching an advanced management level of the facilities, and so allow to have univocal information in real-time, common for all services of the same administration, and ensure optimization of operative flows between the various offices involved in the management through the exchange of homogeneous information.
- Facilitating the immediate use of information through web services and intuitive portals, speeding consultation and simplifying design operations and update.
- Implementing the possibility of analysis for the facility management and space management, through Archibus software. This tool has been proved essential for space planning analysis and verification of saturation, allowing the planning of optimization, lease or sale intervention in the light of active or abandoned buildings evaluations.
- Managing planned maintenance activities (e.g. environmental hygiene, six monthly review forms etc.) and improve performances on demand.
- Identifying and planning the best design solutions and the priority activities through simulations for the investment return valuation.

- Providing public administrations all the necessary data and tools to analyze the state of affairs and adopt the best intervention strategy at energetically level. The information on energy consumption of buildings, plant documentation, quantities and dimensions of space and the information on thermal properties of opaque and transparent surfaces of the buildings can be used in the production of energy audits.
- Providing the P.A. with all the actual data of consumption and interior comfort (temperature and humidity) recorded by the installation and reading of sensors. These data will be used both in the study of energy efficiency strategies and for raising awareness and informing the users of each building.
- This management system, tested during the project, will have the chance to become operational for all the buildings of the public administration, and could be extended to large private urban contexts.

Figure 11: BIM potentialities

2.3 SWOT analysis of the project

A preliminary and fundamental step to start this project is the SWOT Analysis: a valuation of the Strengths, Weaknesses, Opportunities and Threats of each context, whose aim is to achieve a conscious and effective strategy.

This tool is suitable for any context that requires a rationalization of decision-making process and consists in the recognition of the strengths and weaknesses that characterize the project, i.e. internal factors that concur positively or negatively to build the value of the project itself. These consist for example of internal resources, such as the performance levels, and, if measured, they can be used to evaluate the improvement of activities and business processes. These tests, which are defined benchmarks, can be performed before the start of the project and allow the quantification of a strategy benefits. "Opportunities" and "threats" mean instead all uncontrollable external factors which, during the project implementation, can speed up or slow down the process of accretion of the asset value. They are for example Political and Legal, Economic, Social and Demographic, Cultural, Technological (Innovation) factors, which are summarized by the acronym "PEST":

The strengths of the project, already widely described and anticipated in the project description, are summarized as follows:

- The digitization of the real estate through intelligent dynamic models and the subsequent dematerialization of archive documents.
- The usability and uniqueness of the data, followed through an interactive data platform.
- The high exchange of data related to the building between specific software (structural, energy and management) guaranteed by the interoperability of BIM software.
- The innovation introduced in the facilities management system through the integration and synergy between the scientific and operational academic experience.
- The elaboration and extension of Best Practices in both the Public Administration and the private sector, to initiate the regeneration process of buildings rationalizing the scarce financial resources available in periods of crisis.
- The introduction in the tender notices of a tool and a process control informative system based on reengineering process of activities related to the management, commiserating the amount of the contracts with actual identified needs.
- The high degree of communication at all levels guaranteed by the use of the BIM tools which, compared to traditional CAD, can rely on technologies such as augmented reality and virtual reality to communicate to citizens and raise awareness on energy saving issues.

- The correspondence of this project compared to many European funding calls to support the digitization and dematerialization interventions of Public Administrations[20].
- For what concerns the weaknesses, found in particular in the times and costs of project execution, it was necessary from the outset to concentrate the resources involved on an appropriate number of buildings to catalog and model. In order to reduce the execution time, it is in fact necessary to increase the number and the variety of involved actors, which can facilitate the acquisition of information, especially during the census of buildings, and expedit the implementation of the model and the analysis. Moreover, thanks to a structured organization, helped by the use of collaborative software, the collected data can help to improve the quality and to speed the execution of work. The programs, in spite of their weight in terms of costs, particularly in what regards the licenses and integration activities of the different systems, are in fact an essential encouragement for promoting collaboration between stakeholders and automate or streamlining the ordinary management activities related to the building.
- The main obstacles to the success of the project, however, are those of cultural sort, such as resistance to change. It is, therefore, essential an engaging communication with all stakeholders that highlights, from the early stages, the positive effects in short, medium and especially long term. Among the various threats which may affect the credibility of the project, the most dangerous is undoubtedly the lack of following up at the conclusion of the project.
- For this reason, during the growing and development stages, it is necessary to strengthen and organize the activities, forming a management structure able to keep the information system updated, following project management and coordination activities. For each building, it will be necessary to designate a representative provided with local vision who can guarantee the data reliability and a constant updating in terms of variations and changes of spaces and staff.

[20] F.M. Ugliotti, documentation on “data collection and expeditious survey of existing buildings for the management of large estates ", in January 2015.

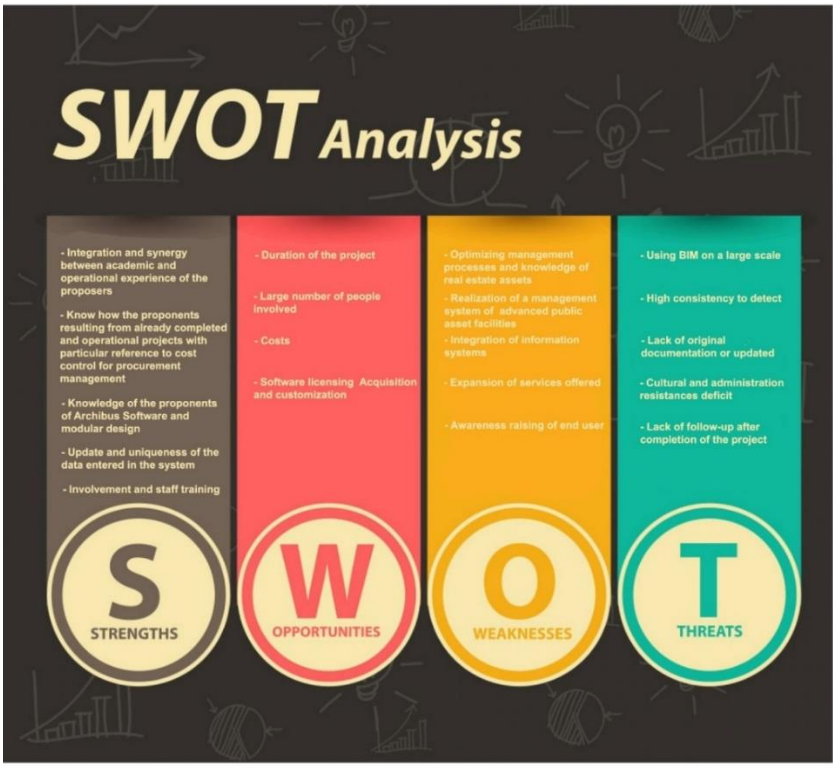


Figure 12: SWOT analysis

2.4 Methodology

The project, due to its complexity, has been structured in successive steps, outlining a common working methodology to all the buildings taken into consideration.

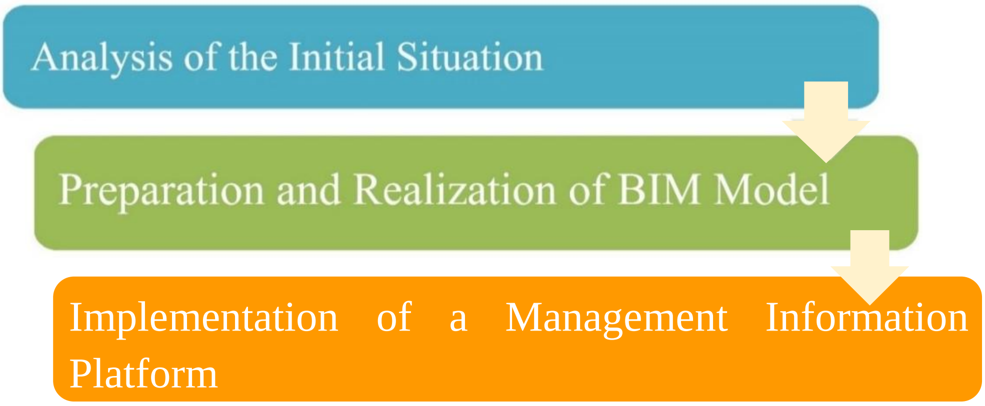


Figure 33: Methodology of the project

- Analysis of the initial situation

RECORDED DATA
Reference structure
Intended use
Occupants
Workplaces
Terminal equipment
Photographic survey
Data for 3D modeling
Energy characterization
PERFORMED ACTIVITIES
SURVEYTEAMS: 3 persons- Survey, Form, Photographs
RETURN: 1 person- 3D Modeling

- Analysis of the used applications
- Analysis of buildings types records
- Definition of the information hierarchy and the priorities
- Definition of local survey sheet
- Formation for the survey
- Campaign of the survey
- Definition of existing floor plans

The first step, i.e. the analysis of the initial situation, consists in the essential retrieval of documentation of the buildings archive.

This involves both various types of IT applications, used by the entity which manages the building, and papers stored in building and historical archives, as in the case of the most ancient artifacts. In this phase all the drawings normally used by the Agency in the performance of its activities (human resources, organizational structure, intended use, occupied terminals, work stations, any energetic characterization, data modeling 3D) are evaluated and compared.

The comparison between these elaborates, as well as analysis of the same, are crucial to highlight any contradictions and inconsistencies, lacks or out of date changes, integrating the elaborates with the missing information and classifying and organizing them in such a way to subsequently realize the different investigation plans (economic, energy and architectural). From a technical, systems and management point of view, it is also necessary to perform an expeditious visit to census spaces and equipment, avoiding data overload. Moreover, it is necessary to standardize the type of information for all buildings included in the Digitization Project, using the specific data sheets for the survey and arrangement of all the necessary information. This phase is carried out after establishing of a survey team of three figures, which will define a hierarchy of information and priorities on the basis of major technical sheets made from the start. This phase is very delicate because it allows the identification of the essential elements to pursue the aims (e.g. space management, energy aspects and operations). Each building kind is a response to specific requirements and activities to perform; for the municipality of Turin, the case studies mainly belong to the category of buildings like office space and schooling considered as a priority because they are the most common and therefore particularly affecting urban strategies, but libraries, residences and sports centers were also considered for a more complete and accurate system setup in view of its replicability. The intended use of each building will require a different hierarchy of information and must be taken into account in the identifying of the successive information necessary to perform the specific activities of each typology.

Figure 44: SWOT analysis of the project

Once the survey sheets are defined, it is possible to proceed with expeditious survey aimed at identifying and cataloging three main aspects: geometric, management and photographic. At this stage it is recommended to use tools to speed up and optimize transcription operations and cataloging of management information: during the visit, data can be sorted in excel sheets or simple Access databases. Further arrangement shall be identified and structured to store different files in such a way as to make them easy to read and to elaborate, for example by dividing the files into folders dedicated to the photographic documentation, to the survey sheets, to planimetry, and finally to Revit model.

- Setting and implementation of parametric model: BIM

The setting of the parametric models of buildings mainly depends on the purposes underlying the project. Therefore, it is necessary to identify the starting requirements, the individuals who will use the model, the output that they will achieve; only then it is possible to use unified standards for all buildings, by setting a real modeling methodology. Despite the architectural components normally used in the modeling phase are always the same, the parametric software allows to define a different level of detail and development (LOD), which may vary according to the model. Level of detail and level of development are in fact indicators that allow every individual involved to measure the degree of certainty or confidence of the information contained in the elements.

The level of development determines the accuracy of the information contained in the model, as well as the reliability of the elements relating to the specific use for which they are intended (analysis, cost estimating, schedule and coordination). Usually, a low level of development can be found in the conceptual representations; instead it will have to be much higher while getting closer to the elaborate construction and documentation of as built. The level of detail, refers instead to the amount of graphic definition with which the element is represented. As an example, on a home, we will have a LOD0 in case of simple polygon of the planimetry, a Lod1 if the polygon is extruded, providing the information on the height of the building, a LOD2 if a roof with all its slopes is specified, a LOD3 if windows are defined and a LOD4 if the interiors are also modeled. It follows that the levels of development and detail are closely related since the graphic elements, in a parametric model, often go hand in hand with the information they contain.

However, the same model, may contain several LOD depending on the various fields of interest. Due to the possibilities offered by the BIM software, objects can be modeled in fact in the readily distinguishable strands; usually the most used are the architectural, structural and plant engineering (fundamental in FM operations), energy efficiency and seismic and structural safety. The level of detail used in a strand may be higher or lower than the other depending on the intended use; making a practical example, in the case of the schools, crucial aspects such as improving the safety and efficiency of the institute from an energy point of view, will be deepened. On the other hand, in the office buildings, spaces and plant section will be shaped in greater detail to evaluate possibility of optimization of work and energy consumption. It will also be possible to entrust every strand to different subjects, due to the ability of BIM software to work by worksets.

It is important, however, that the team in charge of expeditious survey is aware of the ultimate goals even in the long term, so as to individuate its existing documentation, arranging at an early stage all relevant information. Only in this way it will be possible to gather the needed data to build the common reference base for any other aspect that one might want to deepen in the future, without having to repeat the survey phases on the site. Consequently, in this project, particular attention was focused on the phase of identification of objects and three-dimensional processing functional to the FM and the energy simulations and analysis. To define the recommendable detail degree of the elements which are to use in a certain type of activity, it is possible to use a particular standard: the AIA Document G202-2013 Project Building Information Modeling Protocol Form.

Without this important step for the organization and definition of work and objectives, it cannot be possible to set an interdisciplinary workflow in the BIM environment where it would be easy to respect the roles and responsibilities of the parties and, therefore, the requirements of modeling content, completing the intended uses of the model.

In the specific case of this project, the range of the level of detail reached in the modeling of the elements is between the LOD 200and the LOD 300. This refers to graphical representations of specific systems in terms of quantity, size, shape, placement and orientation, with associations of non-graphical information for the general coordination of the elements and approximate cost analysis. The difference of levels mainly depends on the availability level of the starting documentation provided by the institutions and by the Municipality of Turin.

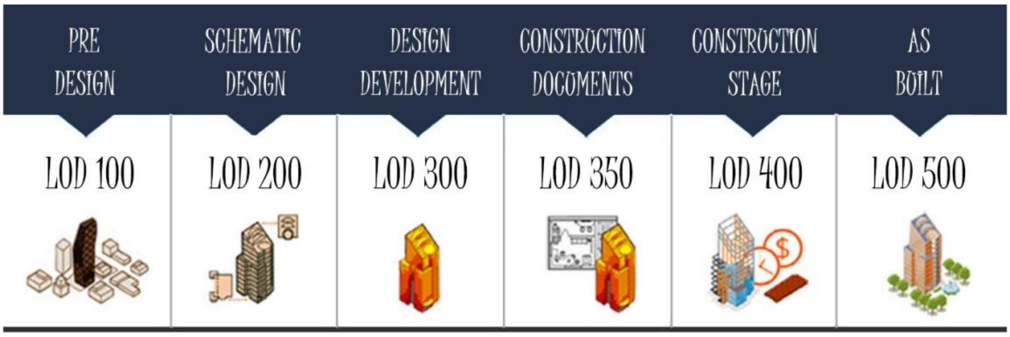


Figure 55: Descriptive diagram of the LOD concept

• Implementation of a management information platform

In building management phases, the information platform is an indispensable tool to analyze the state of affairs and identify possible changes in the organization of space, or to schedule maintenance activities. All information relating to issues of registry data and inventory, the active cycle (rent payment management) and to passive cycle (facilities management) are in fact collected here, becoming organized, identifiable without waste of time, easy to read and mixable, ensuring a more detailed analysis.

This phase is structured in two consequential steps:

- Space classification
- Insertion of management information

2.5 Case studies of the pilot project

The City of Turin has started this experimentation acting on 30 case studies which are public buildings with different uses: public offices, archives building, elementary school etc.

P.zza Palazzo di Città 1	P.zza Palazzo di Città 7
Palazzo San Giovanni 5	Meucci 4
Via Giulio 22	Via Giolitti 42
Torino Smart City	Corso Ferrucci 122
Via Bologna 74	Lingotto , Corso Racconigi

Via Barbaroux 32

Via Consolata

Guido Reni 102

Stradella

Coppino

Abeti15

Braccini 63

Casteldelfino 30

Fleming

Bologna 77

Via Garibaldi 25

Bertolotti

Servais 5

Corsica 55

Biblioteca Italo Calvino 94

Abeti13

Galvani

Casteldelfino 24

Torrazza

Figure 66: List of the digitization project buildings

2.6 The case study: Palazzo di Città

- Reasons for the choice

Palazzo di Città is one of the office buildings of the project "Digitization of the buildings of the city of Turin", and the subject of the case study of present work.

Previously mentioned in the list, this case undoubtedly represents the most related to the research of the Doctoral Program Cultural Heritage and Landscape, resulting in fact the most emblematic and comprehensive from the historical point of view, offering interesting inspirations both from the point of view of good management and the purely addressed to redevelopment strategies in tourism. This building also offers an interesting opportunity to test the interoperability of the BIM software with other analysis programs, highlighting important aspects related to the translation of a complex building, articulate and highly decorated in an integrated virtual database and complete with all the information necessary for the management of City Hall.

In this sense, the case study allows us to explore concepts such as the level of detail and Development (LOD), setting the modeling of each element on target to meet specific requests from the buyer and users engaged in the protection and management of the good. To ensure the fulfillment of this requirement, the research was therefore focused on finding and inserting data which are functional for very different operations (energy analyzes, facility management, tourism communication). Such information can be extracted by simple questions from any actor that will be involved in the conservation process of the building.

Figure 77: Palazzo di Città

Chapter 3

Chapter 3

Historical and architectural analysis

3.1 Palazzo di Città- historical introduction

Figure 88: D. Hieronymus Righettinus, 1583, Perspective Plan of Turin and the Savoy lands crown with Charles Emmanuel I companies

The history of the town hall began in the middle Ages, in the XII century, with the need to host the duties performed by the consuls. At that time, the city of Turin was a small nucleus characterized by very rural traits together with a typically Roman road system; the downtown area, characterized by a beating heart identifiable in the market, was continually crossed by flows of people and therefore would be the most suitable for the realization of a municipal palace where the citizens could easily come together and make decisions on public issues.

However, the first historical documents (first half of the XIII century.) refer to the imperial palace as the location of meetings, where Frederick II and Henry IV also dwelt. It was presumably a palace on the outskirts of the town and was soon abandoned for contingent political events; in the years following the fall of the Hoenstaufen, the palacium comunis abandoned the imperial seat (the last documented meeting in the old Imperial seat dates back to 1257).

In these years began a phase of constant movement of the meeting place. Some documents explicitly refer to a porch near the grain market ("subter voltis curie grains ubi ius reditur et consilia celebrantur"), while others to the sun and even in the halls of noble homes which were rented.

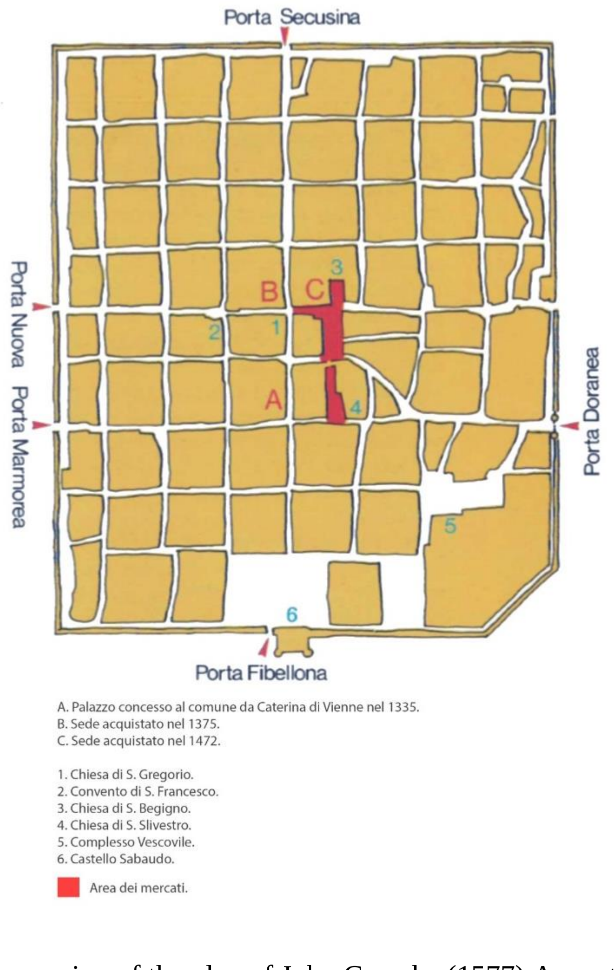


Figure 99: Reprocessing of the plan of John Caracha (1577) Augusta Taurinorum, deletion related to the sector of the ancient Square of Herbs

The Porcelli, Borgese and Ainardi families offered from time to time the possibility of hosting the vicar and the Council. Obviously, this situation did not allow a municipal organization worthy of a national center of increasing importance and the Council strove constantly in the search for a permanent location. The possibility came in 1335, when Catherine of Vienne offered Turin the possibility to settle for seven years in a building which was confiscated to the Grassi family.

First of all, it is necessary highlight the location, particularly favorable to make a show of itself. Placed in contiguity with public street, in San Simone block, a point of transit for the major internal and external commercial routes and situated halfway between the Savoy castle and the market, the palace then represented an opportunity for the municipal body to increase its importance, so much that the new occupants decided to invest in the development of facilities and building functions.

A gallery was erected on the main street for the public reading of the judgments and to perform guard duty, and the erection of a Belfredo was approved to house the municipal bell; the meeting room was equipped with benches along its perimeter.

However, already in 1346 a document clearly shows that the Council had started to rent again other spaces, a sign that Grassi Palace was still insufficient for the most crowded meetings or still too tied to a very strong central power, particularly that of the Prince of Achaia, who appointed a citizen judge and a foreign vicar. The situation did not improve particularly in the immediately following years, when even the municipal bell coincided with that of the noble Palace of Borgesi.

This family, in addition to being one of the major guests of the Board's meetings, was particularly active in the political life of the city, so much that its members often covered important institutional positions. From this point of view, Turin falls behind the developments in comparison to the major Italian lordships, like Milan and Florence, where the civil power could act as a counterpart and operate independently from the aristocratic power.

It was on the occasion of another political upheaval that the municipality of Turin was able for the first time to free itself from the noble power: due to the consolidation of the Savoy power and the end of the Acajas influence on the city, the possibility to act independently of the power to Amedeo VI arose: he agreed to recognize municipal bodies, giving them more freedom and authority to nominate the most important appointments.

In 1375 the merchant Giovanni Rivalba bought a house in the city's beating heart, right next to the Borgesi building with the tower, designating it as a permanent headquarters for the execution of public meetings and activities. The civil functions finally free themselves from the protection of the aristocratic families, beginning a path of independence and progressive autonomy. The building location, as always, is close to the commercial center and the new occupants immediately strive for the building of a bell tower, the first step to show the prestige and the new prominent role in city life. Hence there has been a modification of the urban fabric, starting from the beating heart of civic life.

After the years immediately following the plague of 1349, the major changes began to outline: a demographic and economic recovery, the renewed strategic importance of the city in Piedmont after the annexation of the region to the Savoy Kingdom, the University of Turin founded by Ludovico of Acaja in 1405. Also at the building and urban level, new typologies began to appear, more prestigious, resistant and larger in size. The wooden porches, in the market area, left room for those bearing walls, spreading throughout the city center and defining a large porticoed square with shops at the ground floor.

The central streets were paved and the elements or functions that characterized the rural buildings within the city walls were banned and gradually replaced, giving way to more decent materials, more commercial activities and prestigious buildings (the University and the Ducal Council). The huge costs and the Duke interference in decisions on public land didn't go down well with the population, as well with the municipal council members, who saw their building ousted from its role of driving center to a new urban model but then again, the municipality of Turin did not hold adequate resources to its ambition. Consider that that the purchase of the building costed a third of the city economic resources and that every subsequent change, aesthetic beautification and repair affected much the financial asset.

Despite the works of adaption of the building purchased by John Rivalba in 1375 and the consequent achievement of a level of decorum sufficient to ensure recognition of the building within the urban fabric, in 1472 the city was able to become the owner of a seat that was a relatively prestigious and adequate to its role as the capital of the Savoy dynasty: Scrivandi palace.

The location in the heart of the Market and in the city center and the purchase of the building by the municipality, marked the will of Turin population to free themselves from the central power and to start an autonomous path of self-determination. The ground floor of the building, intended for shops, was rented to merchants and craftsmen ensuring consistent revenue. The decor was still affected, because of malodorous commercial activities, such as the butcher, and so began to emerge the first demands for the building expansion over the entire block; however the building began to take on the characteristics that distinguished it from the rest of the urban structure, making it stand out in all its importance: the paintings on the facade, the destination of some rooms to a caretaker for the maintenance of the building, the will to adapt the aesthetics of the building to its institutional value, as requested in the past by the nobles.

Since 1500 the city of Turin begins a path of major urban transformations that can turn it into a European capital. The Roman setting based on the thistle and the decumanus are reinterpreted in modern and Baroque style as a symbol of a rational central government planning the expansion of the city, despite the resistance of the local population.

On the contrary, the building of the municipality lied in an area of still medieval sort in the city center, in a context that would ll undergo, from the middle of the XVI century, remarkable changes to adapt the center to the new ducal ratio progressively abandoning the area’s commercial mold. This area was extended in fact from the town hall to the space in front of the Basilica of Corpus Christi and was divided into areas called Squares, whose name identified the goods sold: square of Wheat, square of Herbs, square of Fish etc...

3.2 The Lanfranchi project – 1659

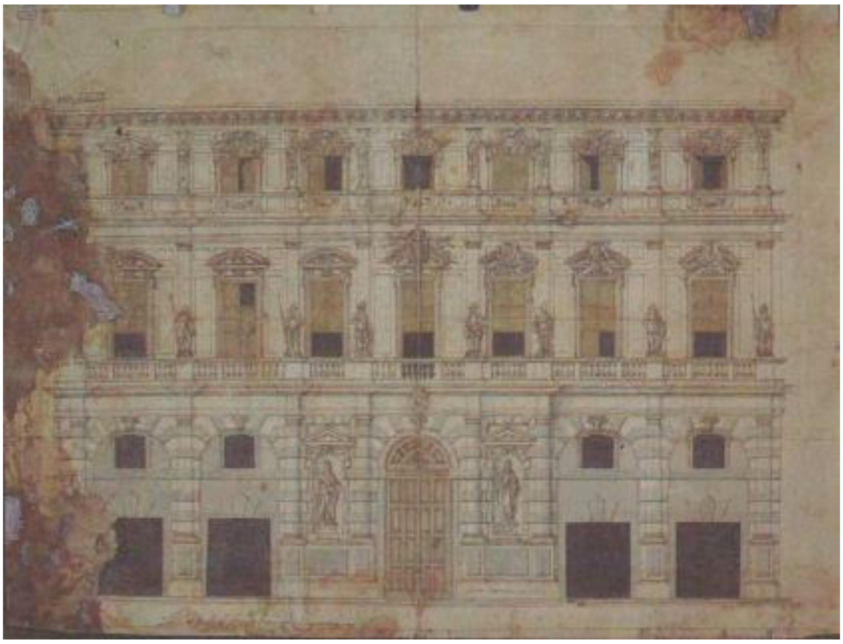


Figure 20: Francesco Lanfranchi (1659): project design for the facade of Palazzo di Città

In 1658 began a further process of building transformation that revealed a unity of purpose of dukes, mayors and settlers, to give the building a European capital worthy prestige. The Town Hall was indeed preparing to become the showcase and theater of the upcoming wedding of Carlo Emanuele II and the Duke began to promote and encourage the resolution of the rents of the ground floor to start the building and its façade modernisation, in order to "make itself noble" *("riducesse nobile")*.

The ducal architect and engineer, Francesco Lanfranchi, was then appointed head of the project for the facade and the lobby-staircase-hall of honor system, i.e. the two focal points to communicate the building relationship with the city and the hierarchical one between institutions and sovereign.

The person in question, professionally mature and well placed in the circle of Turin court, was undoubtedly a respectable interpreter of the architectural and urban currents of his time, as well as fully conscious of the architectural and cultural experimentation lines for big works.

The main theme underlying lanfrachi’s idea is the formation of an attractive building (as not so subtly suggested by Duke Vittorio Amedeo I of Savoy). The main aspect of the project is in fact the distribution organization, which follows the typical sequence of the palaces built by aristocrats: lobby, porch, staircase, loggia and hall of honor. The connections with contemporary references are quite explicit in this regard: the Castle of Valentino, Beggiami Palace (later Lascaris), Cisterna Palace and many others of Piedmont territory as well as Turin one, particularly the new buildings under construction in those years and then in the eighteenth century, on the now demolished fortifications ruins. Just as those urban buildings, the Town Hall presents shops at the ground floor, which were used for trading and detached at the distribution level from the rest of the building; also the courtyard honor square, placed on the symmetry axis of the building, is a clear reference to the aforementioned typological model.

One aspect that distinguish the Lanfranchi’s design by private noble buildings of its time is the terrace at the first floor, whose sophistication and representative function are clearly underlined by the statues. The open porch and the front building supported by twin columns also mark the balcony, increasing its size at the hall of honor. Therefore, it is an explicit reference to a typological model that refers to the Court, to parties, to parade view.

The square becomes the population gathering place on important occasions, such as that of 14 May 1663, when the people of Turin, who was gathered in the square around a large machine with fireworks, got to applaud the couple, finally overlooking the new City Palace loggia, recently finished. The spectacle was renewed in 1665 when Carlo Emanuele II, a widower after only a year since his first marriage, married Giovanna Battista of Nemours.

However, in addition to the image of elegant “city lounge”, or scene for public performances and important religious celebrations, the square continued to hold the appearance of swarming and tidy market, with well-placed benches, provided with any food gender and craftworks. Throughout the '600, this space will be repeatedly evoked in numerous paintings and enthusiastically described, even becoming an eloquent symbol of Turin in handbooks and guidebooks.

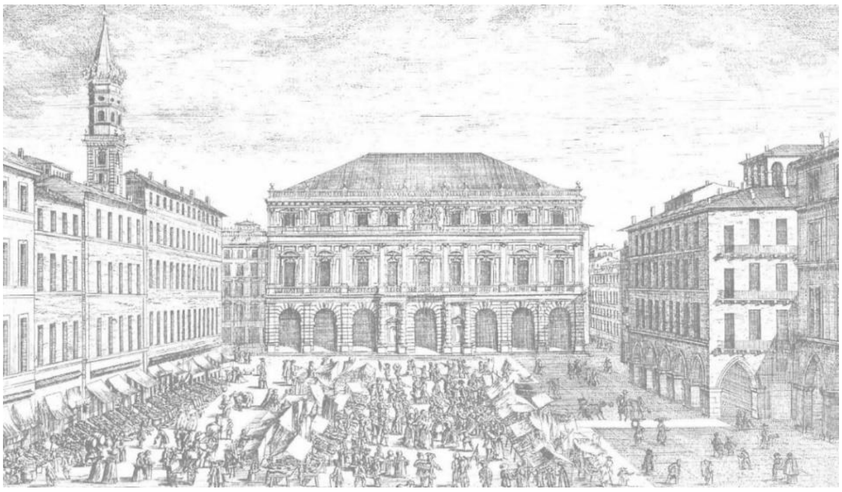


Figure 21: Major views of Turin (1749): the ancient tower of San Gregorio in the background of present via Milano not yet rectified and a well-proportioned view of square of Herbs

The insertion of aforementioned staircase in the palace, planned to stop at the main floor, produced a functional problem: the impossibility to access the upper rooms from the main staircase. This first issue shows the predominance of the Duke’s will in relation to the functional requirements of the municipality, especially in the solution proposed by the architect, which envisaged the inclusion of a convenient scale instead of a wardrobe in the back, affecting the aesthetics of the archive. As a result, the facade is disconnected from the back of the building, leaving a body merely designed to carry a role of appearance.

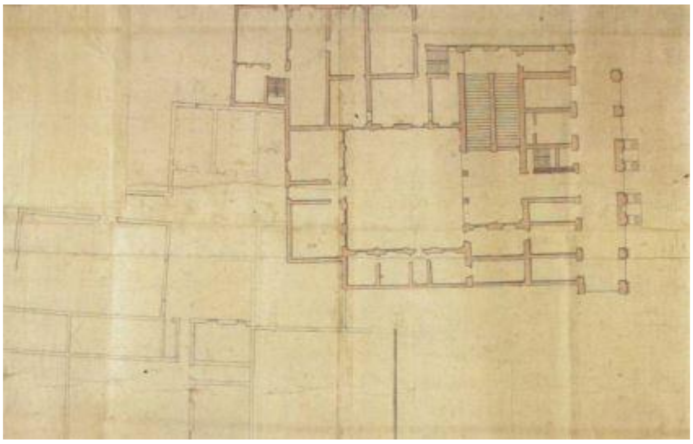


Figure 102: Francesco Lanfranchi (1659): definitive framework of lanfranchi works with survey of adjacent houses

Analyzing the plan of Lanfranco project, the advancement of the porch compared with the land plot of the City is immediately evident; this change was the cause of conflicts with neighboring residents, influencing subsequent expansions of the building and changes of the block.

Since the beginning of the work, in 1659, the Municipality began to take action to buy the surrounding buildings, particularly those stranded by the new configuration on the square, bordering to the south with the Palace. For the same reason, negotiations were started to purchase the buildings on the north side of square of Herbs.

The architect's activity will continue until his death (in 1669), presenting also other interventions, such as the nearby Town Hall tower and the expansion to south of the city, in the Mirafiori area.

Subsequently, the role of trusted architect of the Municipality passed to the captain, engineer and architect Rocco Antonio Rubatto, but the work had to be interrupted because of the siege of the city of Turin, in 1706.

The Palace, during the conflict, was transformed into the headquarters of the Marquis A. C. M. Isnardi of Caraglio and underwent modifications to limit the damages caused by nearby enemy artillery, reducing fire hazards and damages from bombing.

The cobblestoned coating of the square was temporarily removed so that artillery shells could sink in the sand; also, a gallows was erected next to a pre-existing well, in order to discourage thefts, desertions and attacks. The palace was rapidly cleared out by the Directors, who moved into a convent in the Po district, while the rooms became the army headquarters under the command of the Governor.

After the war and once war damages were repaired, the building factory was able to resume expansion works.

3.3 Palace of Lodgment– 1714

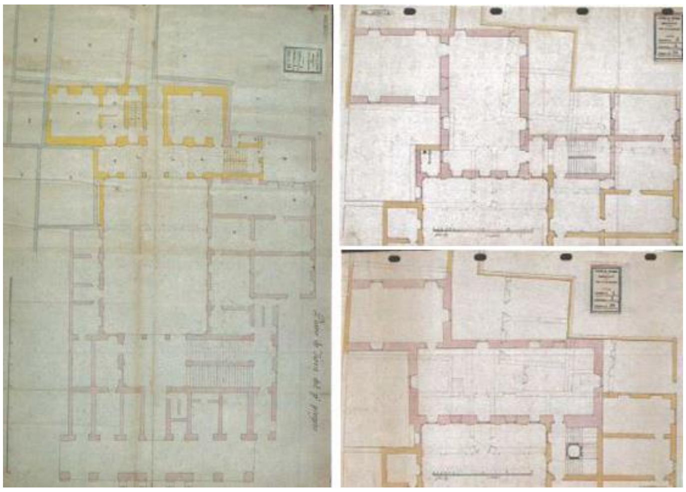


Figure 113: Alessandro Ludovico Emanuelli (1714), the Project for the lodgement Vase

In this phase of the construction site it was necessary to complete the back of the honor hall with a hall that in public documents is called "the lodgement Vase".

The City Hall, in 1713, designated Antonio Bertola, the first engineer of H.M., to choose the best project among various proposals: in addition to the previously studied by Rubatto, were also examined those of Charles Jerome Re, Gian Giacomo Plantery, Alessandro Ludovico Emanuelli and finally that of Giovanni Antonio Sevalle, which was actually executed starting from1714.

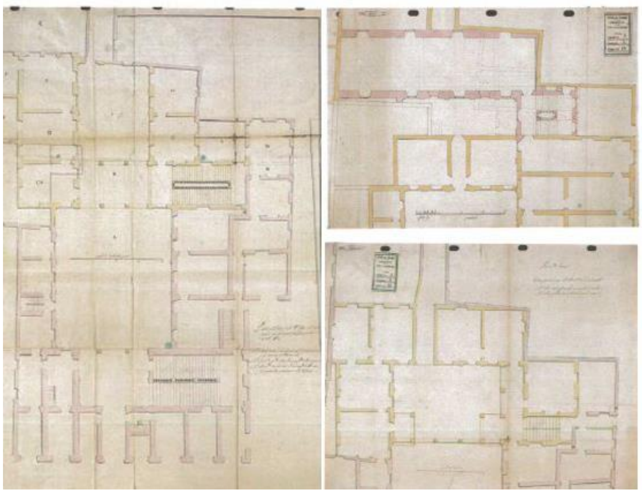


Figure 124: Giovanni Antonio Sevalle (1714), the Project for the lodgment Vase

The main change made to Lanfranchi project was the widening of the honor hall, whose squared plan was abandoned in favor of a rectangular golden section. This choice influenced the final scan of the windows and perimeter loggia, as well as the porch-loggia solution in the backdrop.

The project raised the opposition of Count None, due to the right of way reduction relating to the nearby house owned. The proposal elaborated by the the count's entourage was, however, rejected because of higher execution costs and the impossibility to guarantee a future symmetry of the building.

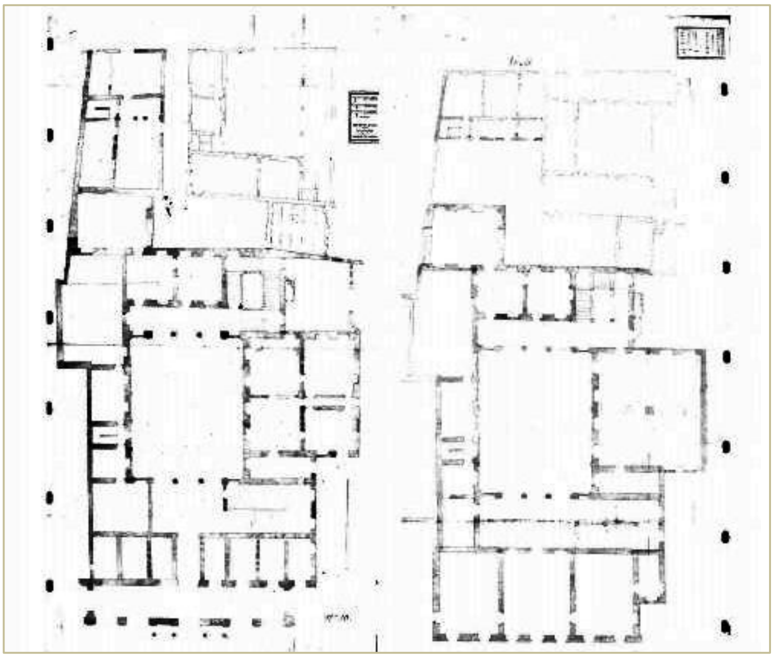


Figure 135: C.G Framework, L.A. Guibert, A. Rome (1714) Project for the limited expansion to west of the lodgment Vase

3.4 Expansion of Palazzo di Città– 1728

This new urban structure influenced the evolution of the Town Hall as well, bringing the City Hall to incorporate another neighboring house, in 1728, in view of a future lateral expansion of the building, already prefigured years before the Lanfranchi project. The aim of these expansions was obviously to make a uniform institutional Square, as a final vanishing point of axis that connected the center of royal power with the civil administration, which would give greater prestige to the city.

To achieve that, however, it was necessary to revolutionize the size and aspect of the whole fabric of the center, still of medieval mold.

As easily deducible from the ancient place names, the squares of Contrada di Porta Palazzo and Dora Grossa were the beating heart of the trade activities, and continued to oppose great resistance to the ducal projects of rationalization of the center. The first and long-standing matter was the destruction of the Red Vault, a medieval arch in brick placed along the axis that linked the Town Hall Square with the Ducal Castle and which interrupted the view of the palace itself, separating square of herbs from square of Corpus Domini.

Figure 146: Pietro Domenico Oliviero (1753) Depiction of Corpus Square, where is possible to seize the vanishing point of the "strada nova" of 1619 attested on Town Hall through the Red Vault

The project, promoted by the various Dukes since the beginning of 1600, was finally brought to completion only in 1722 with the support of the municipality and a considerable outlay to refund the owners of the demolished houses.

The King Vittorio Amedeo II of Savoy intervened more directly on the center, urging the realization of the parade ground in front of Porta Palazzo, as defined by Juvarra's project. In the same announcement in which the Turin vicar communicated such royal will, were also dictated other important information for the homogenization of Contrada Porta palazzo, setting a single tranche which new realisations had to align with. The obligation was also dictated for the interventions on the existing one, though without imposing uniformity on the facades, as it happened in the parade grounds. However, this freedom was not enough to stimulate and speed up the works on the existing one, as it was the result of a decision that came from above, rather than an actual necessity of the neighborhood or the expression of a real motivation of trust fund requalification.

3.5 Straightening of contrada Dora Grossa – 1736

This stalemate was overcome in 1736 by contingent political and economic motivations that saw the emergence of a new middle class and a newly appointed nobility, who could finally buy the fiefs that were not supported by a demonstrated legitimate purchase.

An 1736 edict for the straightening of Contrada Dora Grossa successfully tried to intercept the possibilities offered by the development of the tertiary sector, encouraging anyone who had the means and desire to quickly realize large blocks by adhering to the aesthetic and functional canons of a metropolitan city and forcing anyone who opposed against such transformations to sell.

After an initial period of adjustment, also due to a contingent period of war, work resumed with greater vigor in the mid-eighteenth century, according to a diagram demolition of the medieval system and its reconstruction in large cells merging the old ones. Each new realization on a same block, according to a 1939 integration promoted by the king's architect, Benedetto Alfieri, also had to be aligned with the first building made therein. This indication will shape the current conformation of Via Garibaldi and give life to a building typology based on apartments overlooking the interior gallery which will inspire subsequent achievements until mid-nineteenth century.

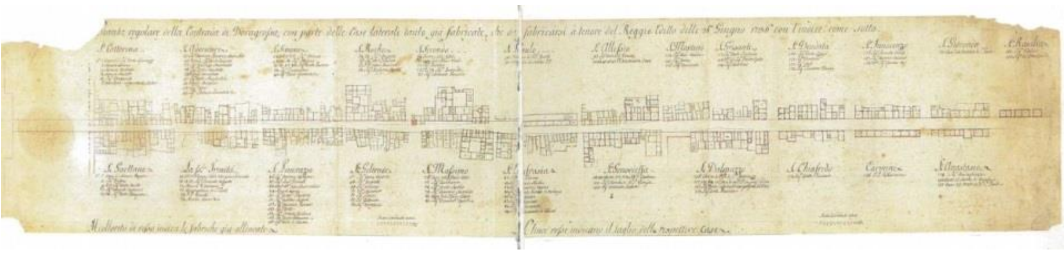


Figure 157: The particle Survey of urban restructuring of Contrada Dora Grossa (1750)

3.6 Benedetto Alfieri's project for Palazzo di Citta' square – 1760

The success of the regulatory experiment on Via Dora Grossa brought the municipality to extend these directives also to contrada of Porta Palazzo and Porta Susina. In addition, in 1756, the reconstruction of Contrada and Town Hall Palace was decreed.

The project, entrusted to Benedetto Alfieri, was prepared by the architect Carlo Emanuele Rocca's studies and surveys, which also had the task of calculating the quantity data relating to the St. Gertrude block reconstruction and to the extension of the Palace towards Via Dora large, to provide the municipal building with new and larger offices.

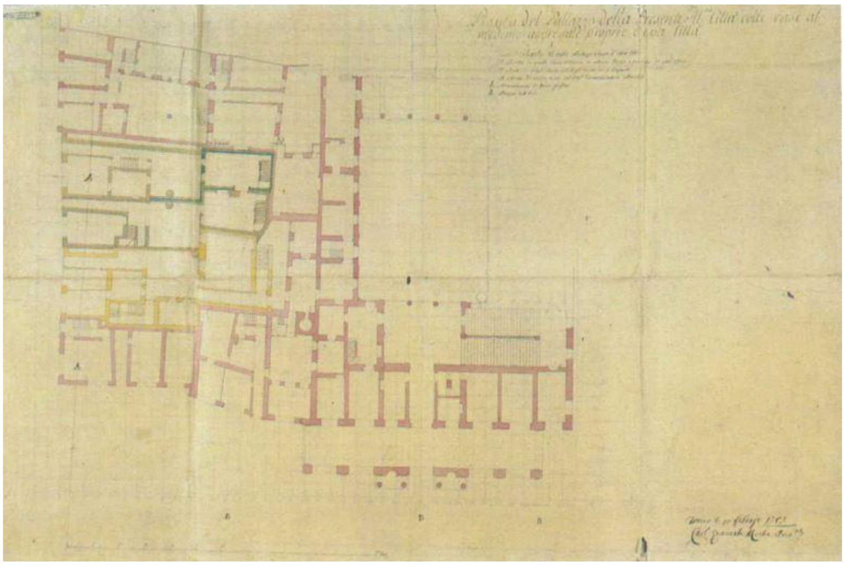


Figure 168: Carlo Emanuele Rocca (1757) Plan view survey of Palazzo di Città and the houses neighboring to Contrada Dora Grossa

The works were started in 1758, after the purchase of the houses located south interfering with the alignment of the square of herbs with Via Dora Grossa. In addition, the properties of the municipality previously purchased and located in proximity to the Palace, began to be transformed according to Lanfranchi's project.

Shortly after, the same process involved the block of St. Bonaventure too, located in the northern side of the square, closing the reorganization work of Contrada Porta Palazzo.

This process on the one hand confered to the public space the role of primary element of urban space organization, subordinating to it the shape of the surrounding buildings. On the other side it permanently rejected the original plan of a municipal building detached from the urban context, being its height constrained to that of the surrounding buildings.

Alfieri therefore contributed decisively to define the current appearance of the square, accepting the requests for rationalization and straightening of Juvarra, Bertola and Plantery's projects and bringing them to fruition in the institutional center of the city. The work of fusion of the Palace with these interventions was made possible thanks to a compromise reached by combining the finishes of the buildings delimiting the new square with the module Lanfranchi adopted to space the windows on the Palace facade.

Figure 179: Photo of the building on the front of Via Garibaldi, flyovering Via Milano

After the closing of the square towards Dora Grossa was brought to completion in 1758, Alfieri conducted the project for an equivalent operation on the opposite side, to the north, along the St. Bonaventure block.

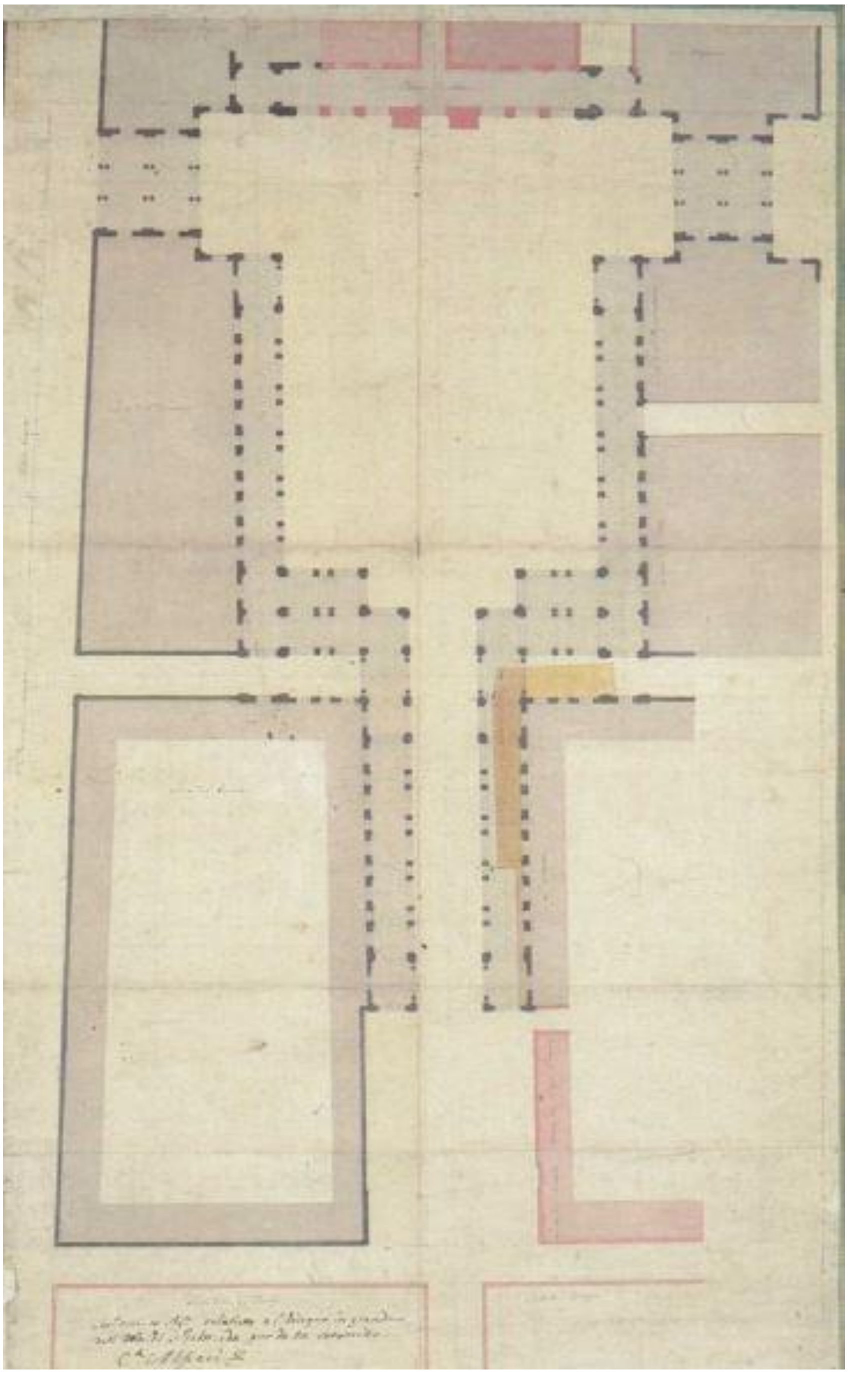


Figure 30: Benedetto Alfieri (1756) Project for via and Town Hall Square

However, after the acquisition of the houses adjacent to the Palace and their demolition, the Municipality was not temporarily able to pursue the aim of closing the square on the face opposite to that of Dora Grossa.

The reshaping of Alfieri’s project, allocating the square to a more evidently residential function, began to unsettle the city primacy of the herbs market, which, however, would retain its primitive vitality until the early decades of the 1800s.

3.7 Dellala and the enlargement on via Dora Grossa – 1773

In the second half of the eighteenth century, thanks to a new period of peace for the then Kingdom of Sardinia, Turin knows a new phase of urban development, in which the purposes accrued in the first half of the century are brought to completion. The innovation of the morphological and ornamental variation on the facades within a context of typological iteration, which was born thanks to the Edict of 1736, led to a continuous research for compositional variations on the theme of continuous curtain.

From a socio-economic perspective, this instrument had stimulated investments from many private citizens, bringing to a phenomenon of enlargement of blocks and densification of the center, but also to a progressive moving of the less well-off social classes as well as the less decorous trading activities toward the extra-urban areas. It also began to spread the practice of subletting, leading to a charges increase and the subsequent intervention of the central government as a supervisor.

In this context, it is therefore understandable that the incomplete districts surrounding the City Palace were sought-after. The first case of dispute was that relating to the district behind the Palace and involved a group of houses called "the Griotta" that overlooked Via Dora Grossa. The Marquis Operti, owner of some neighboring houses, made a proposal relating on the existing buildings on the corner of Via Garibaldi and Via Bellezia, which would severely limit the possibility of the Town Hall expansion.

The architect Francesco Valeriano Dellala from Beinasco was then immediately instructed to study the project for the Vicariate wing and the Lodgement expansion in place of the houses "of Griotta”.

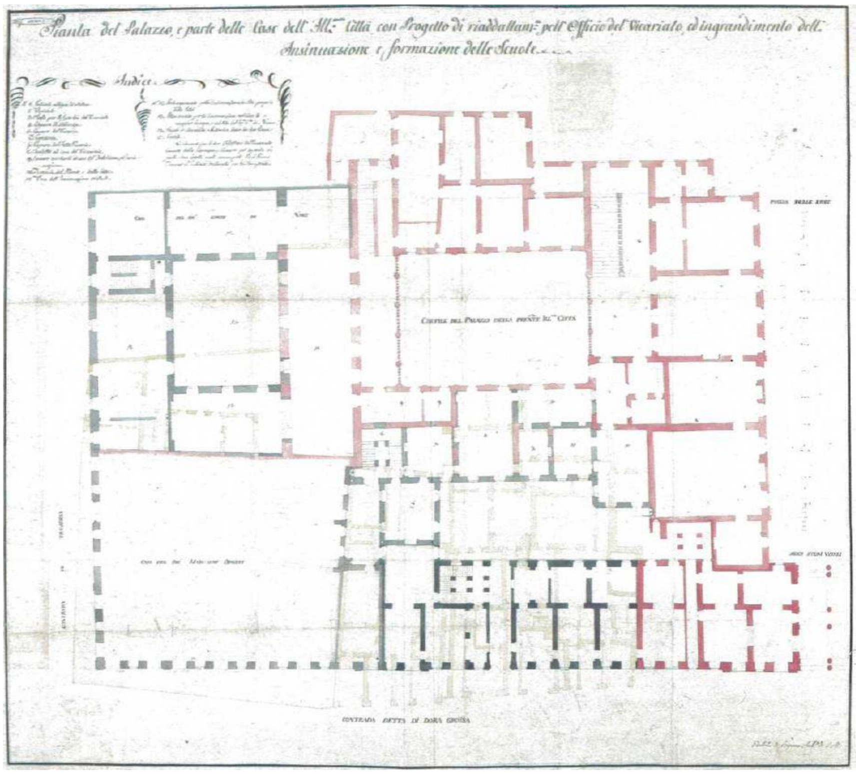


Figure 31: Francis Valeriano Dellala Beinasco (1773) Project for the renovation and expansion of the Town Hall, with an alternative solution for the reconstruction of the rental wing on Contrada Dora Grossa.

In 1773 Dellala presented a proposal project including civic tower, located near the Marquis of Operti home. However, for static reasons, it was built in the corner of the present Milan Court of Appeals streets.

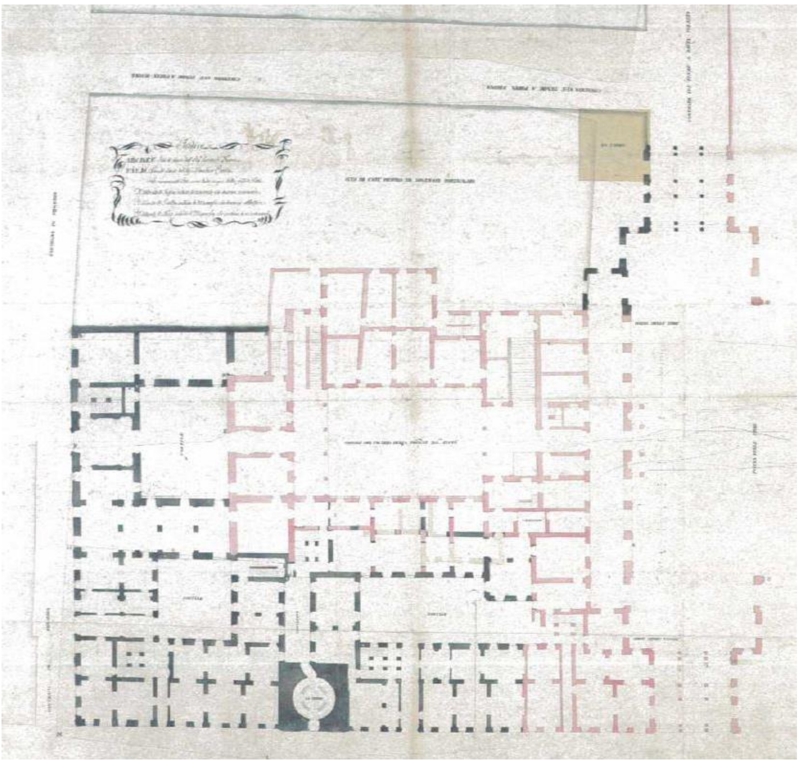


Figure 182: Francis Valeriano Dellala Beinasco (1773) Project for the renovation and expansion of the City Palace in the entire block, with details of two alternative sites for the new Civic Tower.

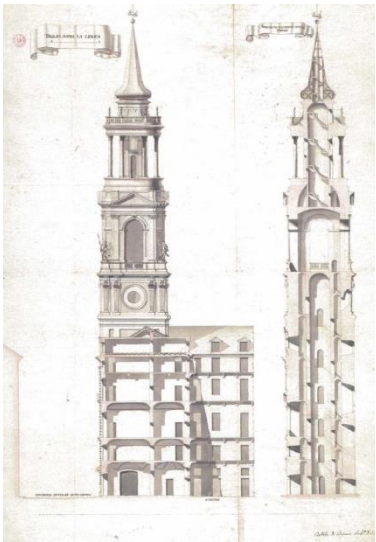


Figure 193: Francis Valeriano Dellala Beinasco (1773) Project for the new Civic Tower on the front of the contrada Dora Grossa. Lateral sections and elevation.

3.8 The district of St. Maximum – 1788

Having started in the 70s the purchase of some houses on the district of St. Maximus not to run the risk of losing an important expansion of the building area and to lay the foundations of the building completion project, the City Hall continued this completion process even in the following decade.

After detecting and calculated the benefits of the implementation of rental houses owned by the municipality, the Council commissioned again Dellala to also design the new complex. The drawings subsequently passed into the hands of the architect Luigi Barberis, who revived the ideas of the predecessor setting a project of strict symmetry and three axes going through the whole block, from east to west, thanks to the opening of symmetrical doors on all opposite sides of the block.

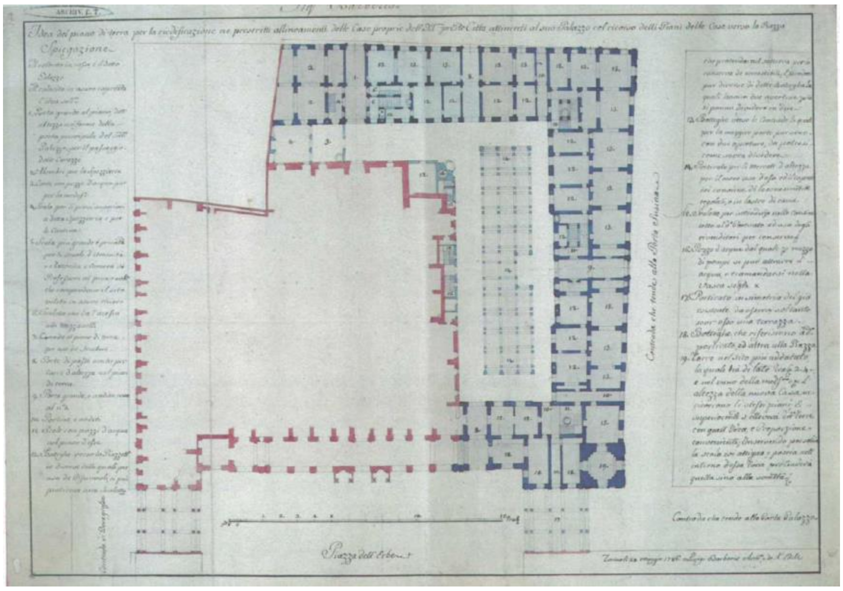


Figure 204: Luigi Barberis (1786) Idea of the ground plan for the rebuilding in prescribed alignment.

In 1786 Filippo Castelli's project, who essentially resumed those of his predecessors, was finally brought to the construction site stadium, thanks to the demolition of all the old houses and their reconstruction. In 1788, due to the acquisition of the Marquis Operti's home, it was finally possible to complete the entire block, by then become civic property in its totality.

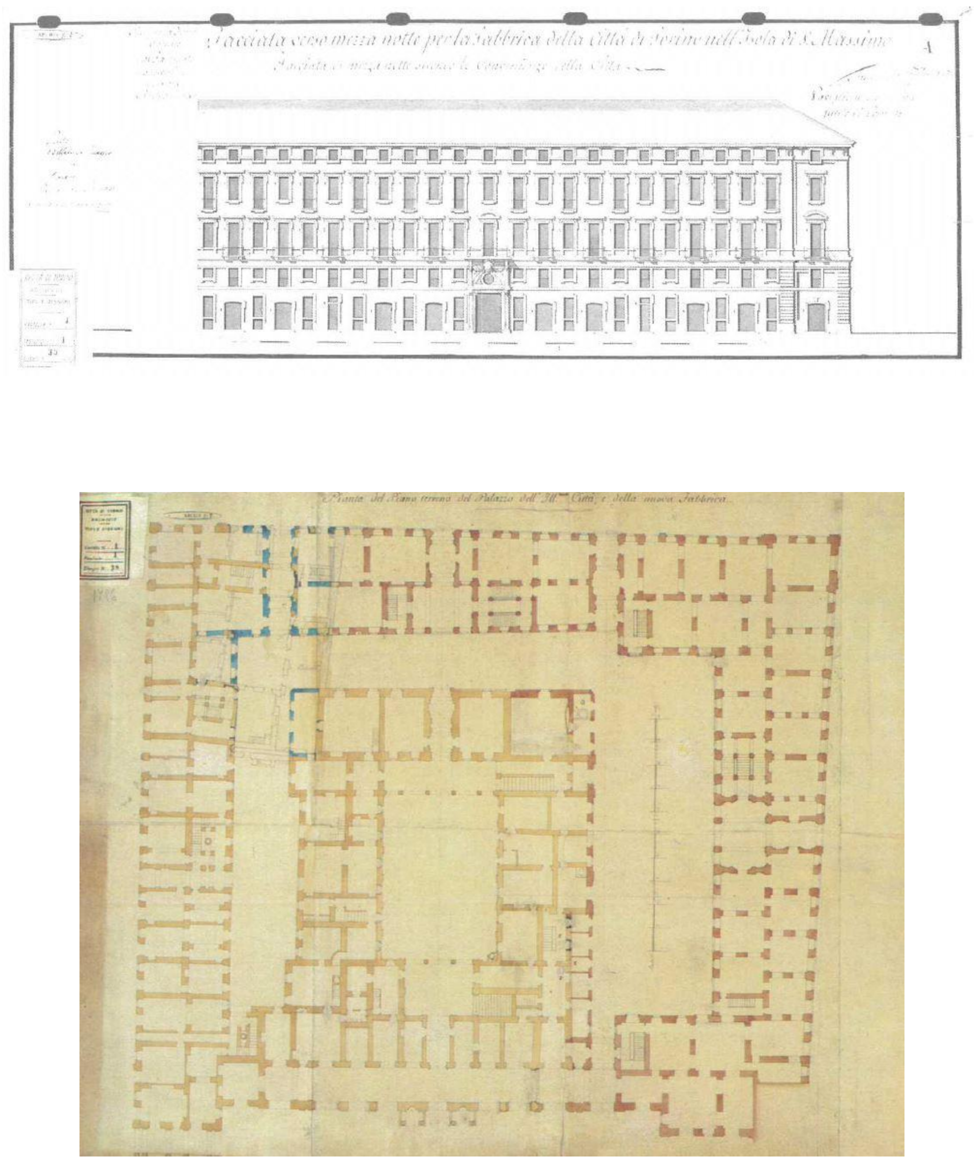


Figure 215: [Francesco Valeriano Dellala of Beinasco, Luigi Barberis, Carlo Andrea Rana, Filippo Castelli], plan and elevation design for <<the new factory S. Massimo>> 1786.

3.9 Turin in the early '800: Napoleon, Restoration

At the end of eighteenth century, the rationalization process of the city of Turin and its transformation into enlightened metropolis undergoes a further acceleration after great political disorders.

It is indeed the 7th of December 1789 (or 7 firmaio), when Palazzo di Città Square watches helplessly the French revolutionary troops entrance.

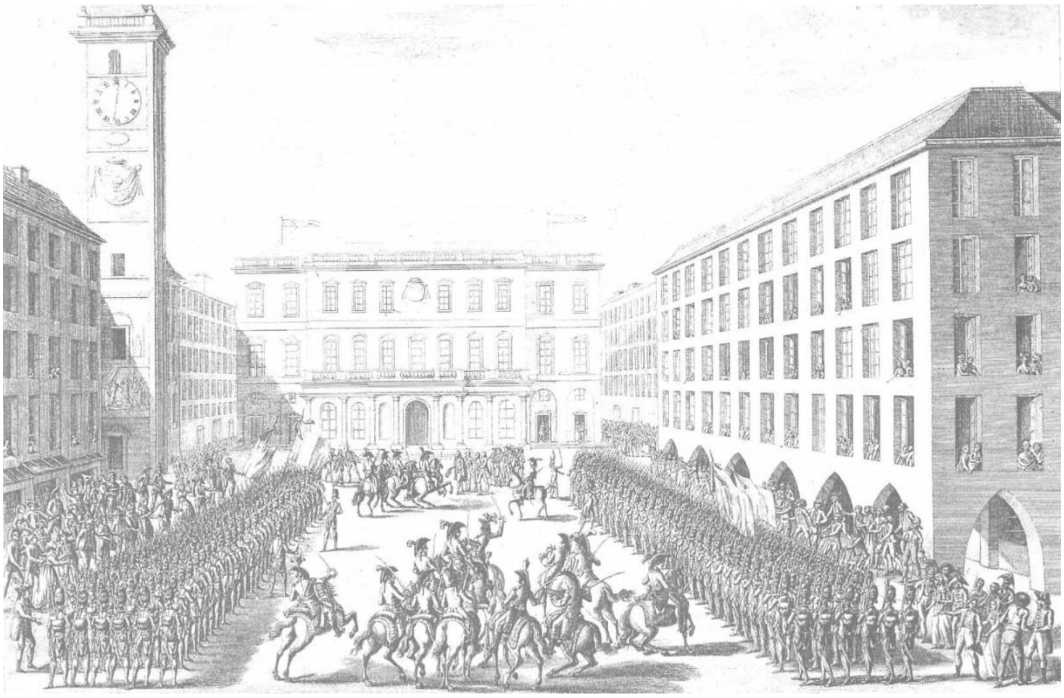


Figure 226: The french troops of general Joubert entrance in Turin, on 7th December 1798.

At the center of the Alfieri's basin, the Turin citizen erect their "liberty tree", the first of many other rites and events in the revolutionary mould. The Palace is stripped of the royal Savoyard effigies and turns finally in a laical Hotel de Ville, also housing the old clock of the demolished town hall tower.

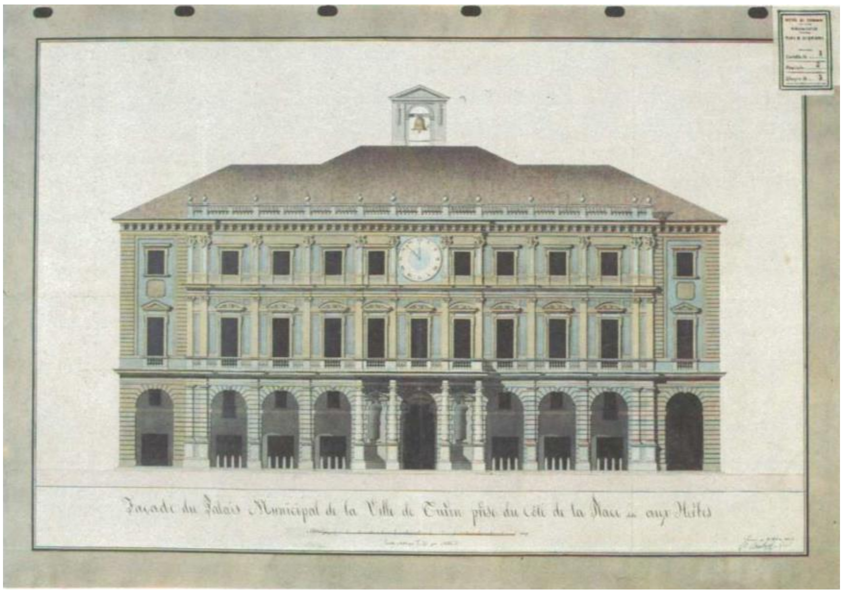


Figure 237: Gaetano Lombardy (1813) Façade du Palais Municipal de la Ville de Turin

But the transformation of the city did not only concerned the secularization of the Savoy power symbols; it was in fact the whole urban model of Turin to undergo significant revisions during the years of French’s domain and in particular in the Napoleonic period.

Firstly, with the change of the war techniques and since the new powerful means of siege, the walls became an out-of-date defense system and were largely demolished. The new urban spaces generated by their abatement were transformed into opportunities for self-promotion of the Napoleonic government.

The new projects of the French and Piedmontese architects reflect the Enlightenment culture of the dominant ideology, having a much more open overview on the territory rather than a focused on strategic buildings one. Turin becomes the center of a planning program for the entire Piedmont, which takes on the new role of France's open door and the projects related to the city fully incorporate the idea of a political-administrative and morphological structure provided with a global vision.

The result of these background is the creation of new bridges on the Po River and other communication structures at a local level: *promenades and grandes places* become the dominant themes for preparatory projects. The adoption of a

Plan général d'embellissement, as well as the insertion of a national English garden, demonstrates the innovative spirit the town expansion is planned with.

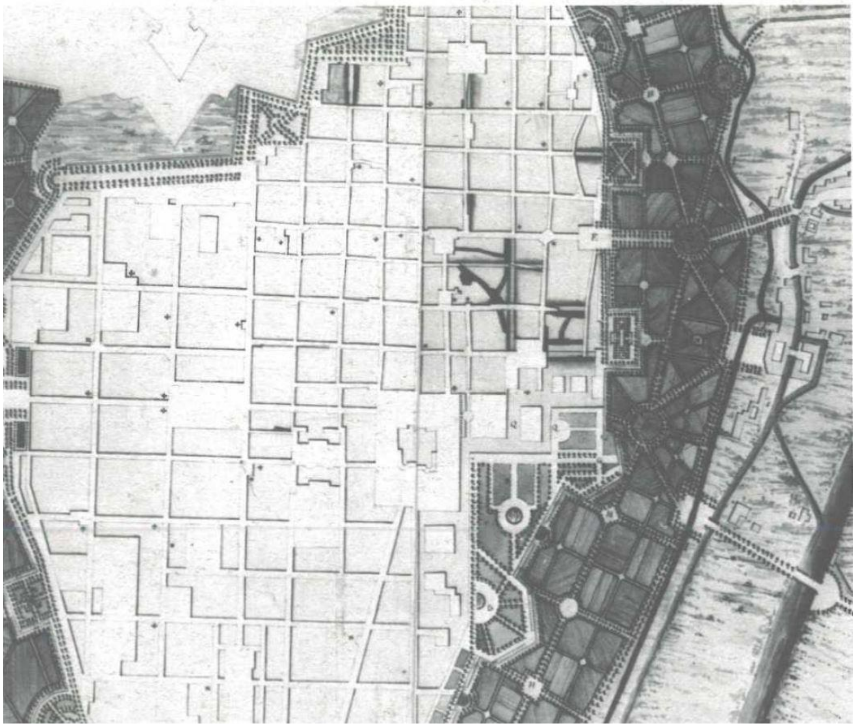


Figure 248: Ferdinando Bonsignore, Michelangelo Boyer, Lorenzo Lombardi (1802) new demonstrative plan of distribution and destination of fortification sites

The work done by Bonaparte is essentially resumed also during the restoration by implementing urban plans with more specific interventions in the royal city, this time in a neoclassical mould. The existing structures are decorated with statues and monuments and the new rationality resulting from Boullé’s theories becomes the interventions and projects trademark of this period.

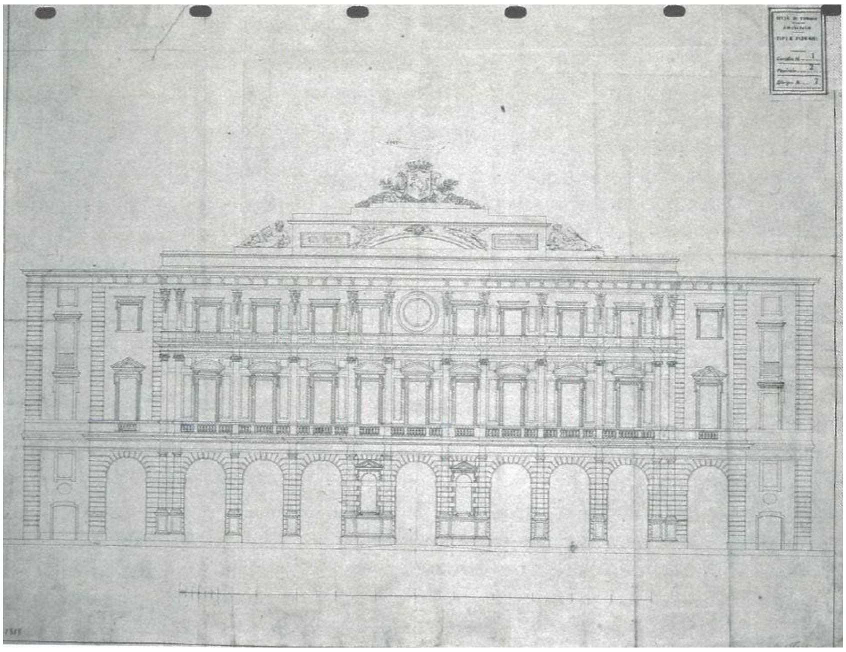


Figure 259: Giuseppe Barone (1818), project for the neoclassical upstanding of the Town Hall for the formation of the library.

3.10 Palace of the City in the nineteenth century

In this area lies the insertion of royal statues in the niches on either side of the door and the porch of the Town Hall, as well as the monument dedicated to the Conte Verde at the center of the square. The façade is enriched with a new iconography that expresses the bourgeois institutional power on the Palace façade.

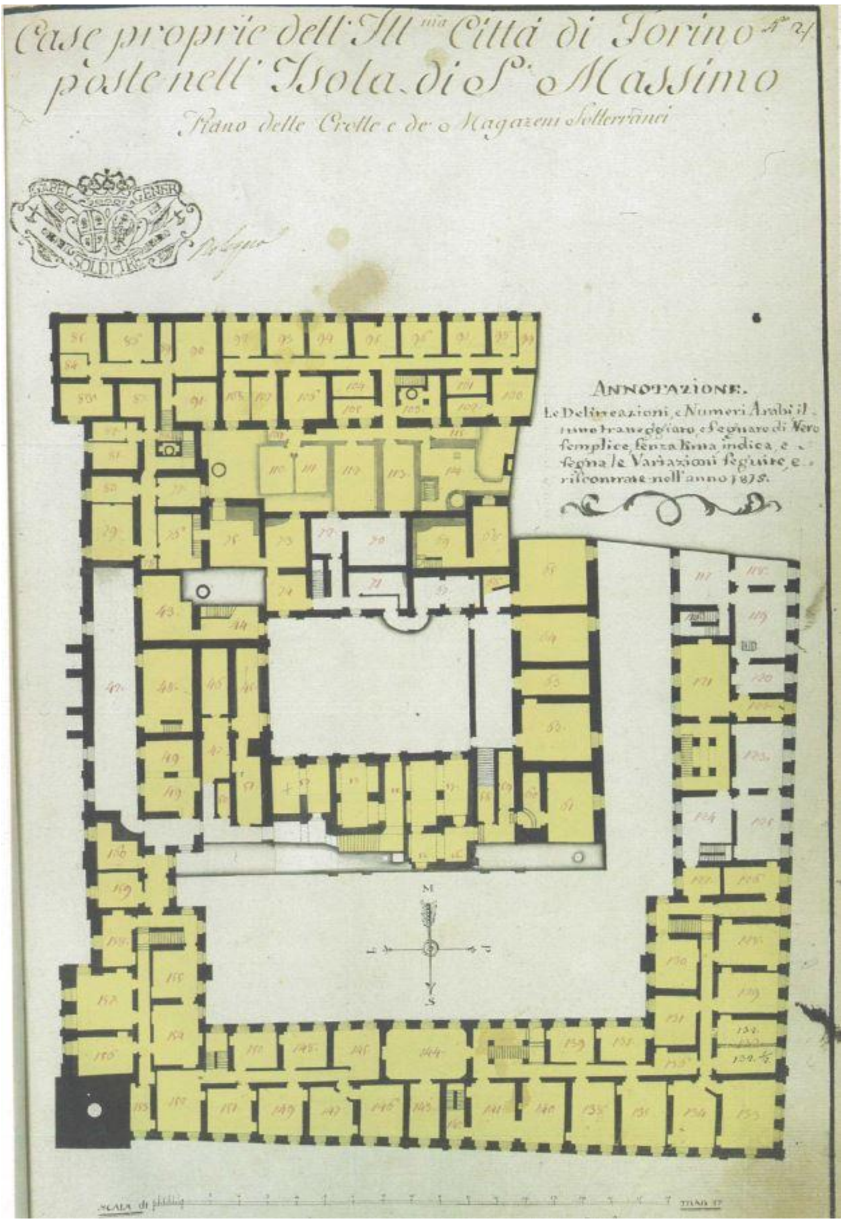


Figure 40: Identification of the areas of Palazzo di Città leased at the end of eighteenth century. Ground floor

In 1817 a fire lays the foundations for the reconstruction of the north wing of the Honor Court, according to a plan to rationalize the functional and distribution system.

Along with that, is raised the Consulate old wing, equaling the height of the adjacent buildings and giving the court of honor an even more closed aspect.

During the first half of the nineteenth century the Palace undergoes some interventions aimed at improving the architectural quality, both replacing some decorative elements in the porch and the façade and adapting some residential areas for the use of offices, reaching the conformation admirable in the 1868 survey carried out by Art Office. The planimetric and functional structure is now settled, and all plans and almost all the places are now used as a municipal office or uses annexed with the institution.

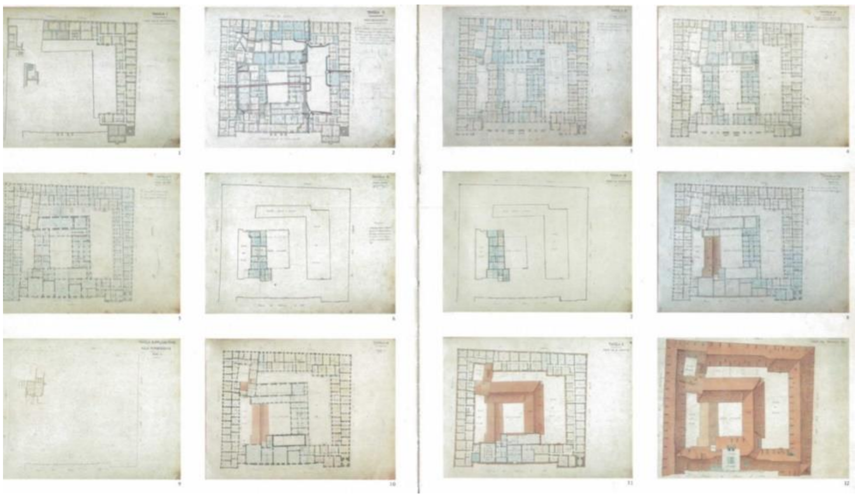


Figure 41: City of Turin. Office Art, plan survey of the S. Maximum block to all feasible parts

3.11 The second half of '800 - Turin national capital

The Napoleonic period ends with the great defeats of French Emperor in the Russian land and in Leipzig, giving the opportunity to the old rulers to regain their thrones. For Turin, the Restoration officially begins on 20 May 1814, with the return of Vittorio Emanuele I of Savoy, crossing the bridge that today bears his name, but built indeed by the French.

But the revolutionary seed planted across Europe will soon sprout, bringing the middle class to gain important political and institutional recognitions in later years.

On 8 February 1848, the constitutional proclamation is published and Town Hall Square becomes the scene of spontaneous celebrations, dances, parades and a riot offlags. On February 27, following a big national holiday in honor of Charles Albert for the granting of the Albertine Statute, which involves the whole population, including the poor, invited to take exceptional edible ration.

For the occasion, the king gives the city the monument to the Conte Verde, by Pelagio Palagi: the group of bronze statues that recalls the then young Amedeo VI's businesses in the East of the then young AmedeoI, renewing the bond between the city and the regent who had inspired celebrations of great significance and started the process of gradual growth of public institutions.

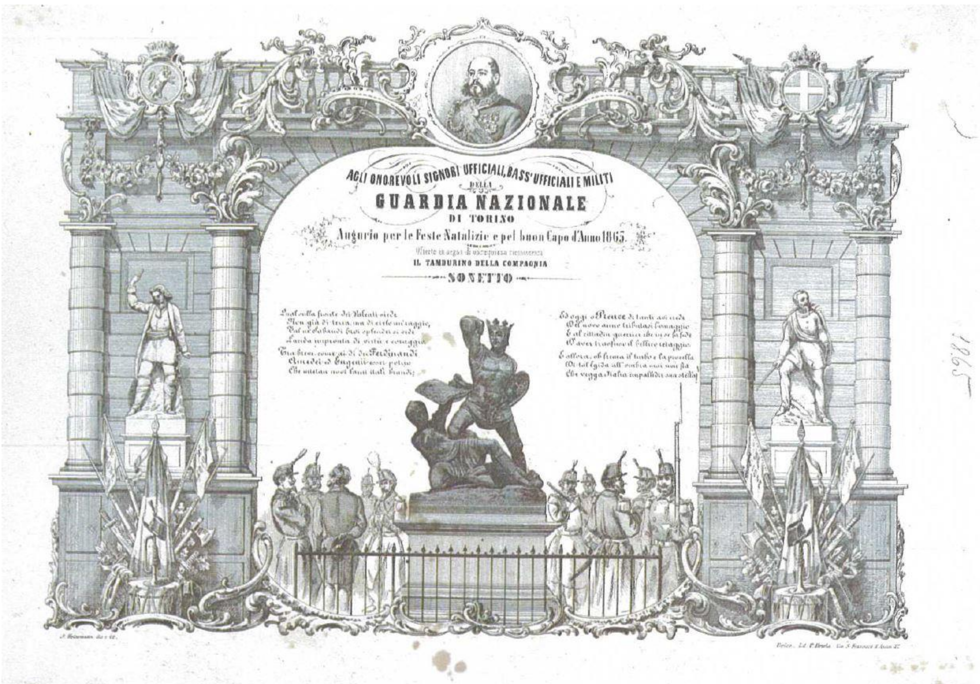


Figure 262: Monument to the Conte Verde

The monument was inaugurated in the Town Hall Square only in 1853, with an experiment of electric light that made both the monument and the town hall shine in a suggestive manner, stunning the bystanders and filling the institutions with pride.

In parallel, the upgrading process of the center residential area continued quickly, thanks to the push following the Plan for the capital expansion by Carlo Promis (1852).

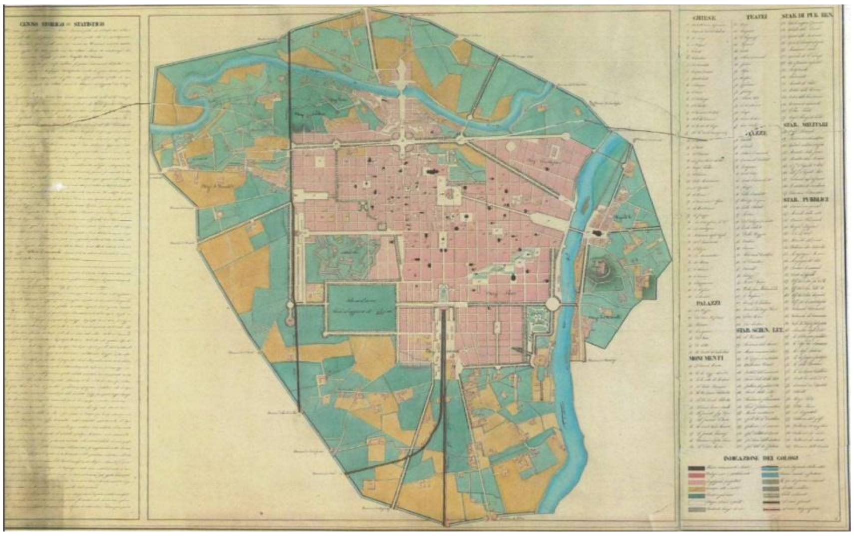


Figure 273: Representation of the city of Turin at the end of the pre-unification period, according to the blocked configuration derived from the enlargement Plan of the Capital by Carlo Promis (1850-52)

The intention of the municipality was to maintain a certain physical and formal continuity, as well as ideological, with the old proposals on which the city was grown; from that setting, Turin has inherited the resulting homogenization of new and existing residential fabric and the substantial affirmation of building typology in closed court. The other consequence was, at urban level, the connection of new rectors axes of nineteenth-century expansions to the old ones defined by the seventeenth century onwards, until the restoration.

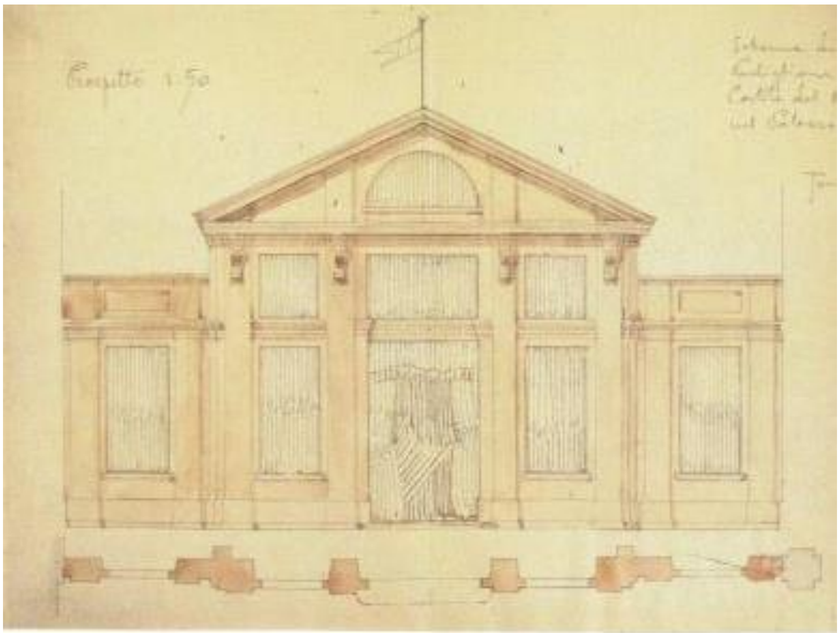
This illusory uniformity masks a strongly hierarchized city through urban polarizing hubs coinciding with streets, squares, public and relation spaces.

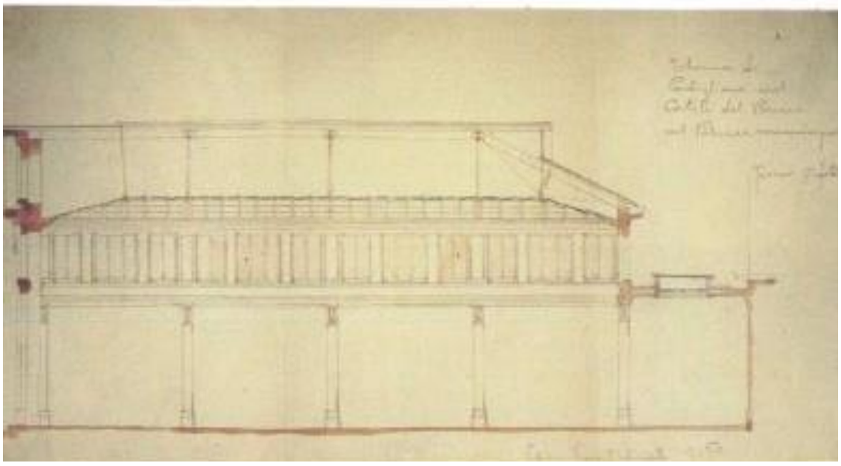
Starting from the 70's of the 19th century, after the election of Turin as the national capital, a phenomenon of bourgeois reappropriation of the old town center has developed, due to investments in large real estate and financial groups. The antique aspect of the oldest districts was in fact rejected by the high bourgeoisie since both the old and the eighteenth-century buildings did not hold the uniformity and quality construction that instead distinguished new interventions.

The progressive vision, as only restricted to the field of new building materials (iron and cement), as well as the need for financial power to conquer central places, led to a series of debates to establish new lines of action on minute tissue; these considerations took shape in the early decades of the 900 with Plans regulators and urban growth linked to the development of the industrial sector, and the consequent centralization of financial offices.

3.12 Palazzo di Citta' (Turin Town Hall) - historical archive

After a few decades without any substantial morphological changes, the Town Hall was again at the center of debate in 1913 because of the proposal of the construction of a new building, to be used as rooms for the public.





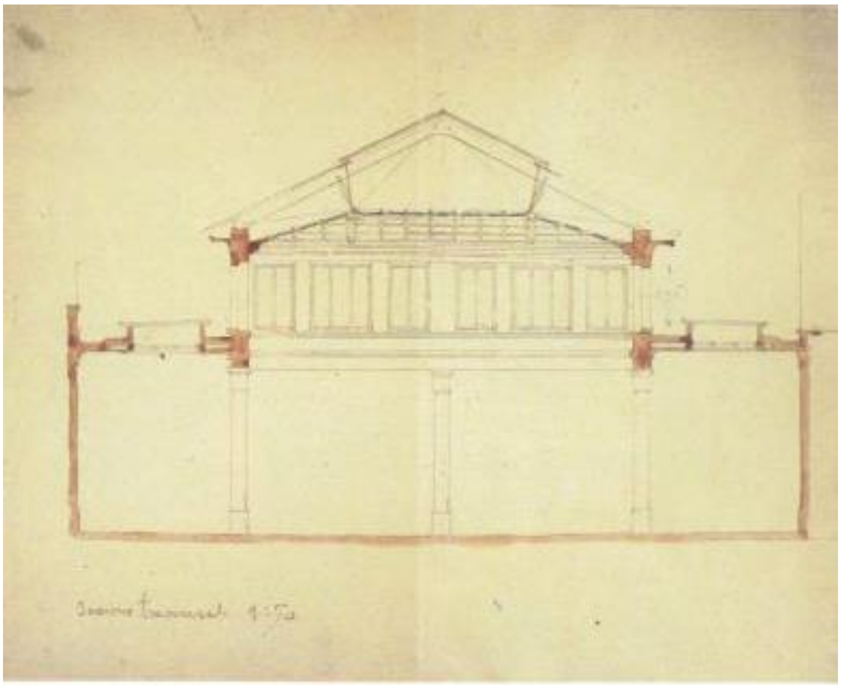


Figure 284: City of Turin. Public Works Office, Project for the Pavilion in iron and glass to be erected in the so called Butter courtyard.

3.13 1900: The square valorization

In the late 90's the building did not undergo further substantial changes; however, the technological upheavals brought by industrialization and motorization, had also affected the complex Turin center.

The use of Palazzo di Città Square and the subsequent design of the floors covering were adapted to the need of connecting the center public road system with the suburbs, upsetting the splendor of Alfieri’s plan. Tramway lines on Via Milano and within the same square, had dictated the directors axes of the pavement so that it could withstand the pressure of heavy vehicles passing by, generating an irregular and chaotic design. In addition, the halt and traffic necessity made the Town Hall Square a large car park for the neighborhood offices.

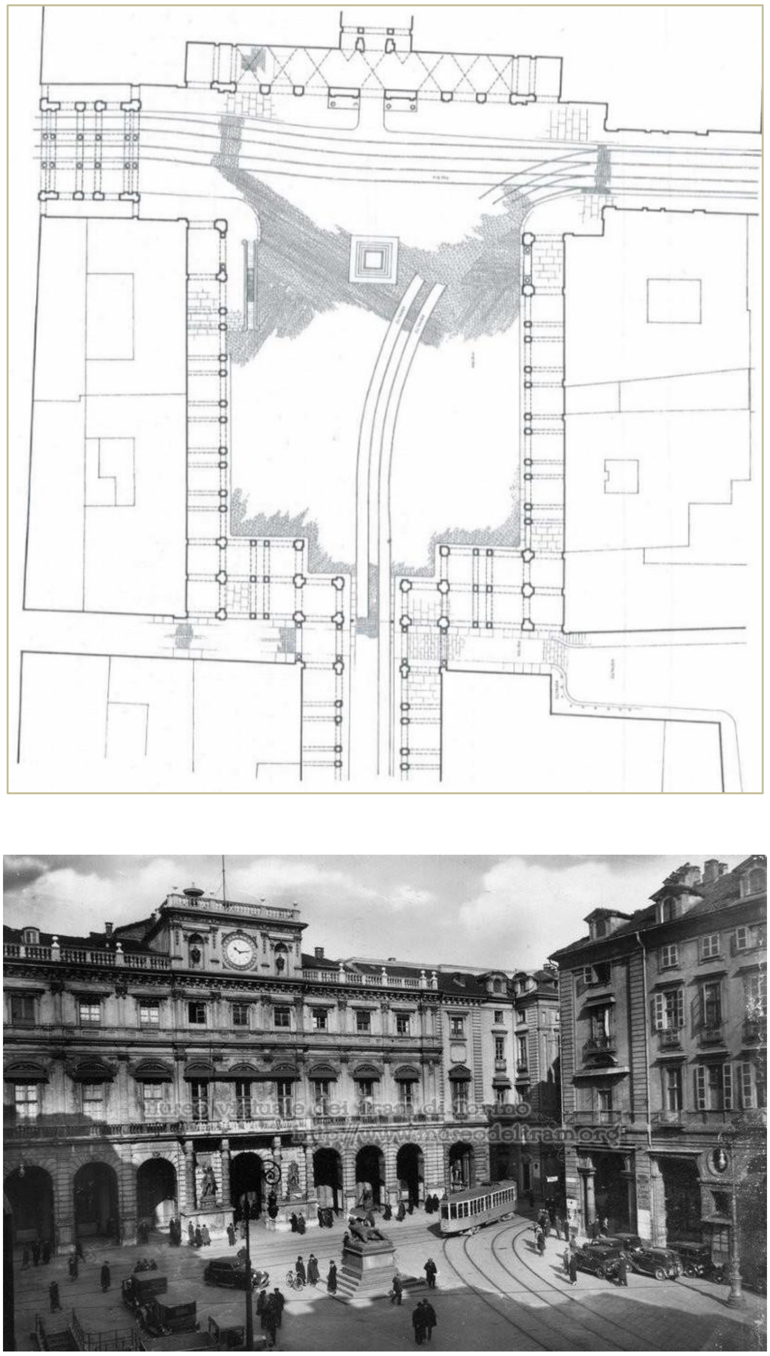


Figure 295: Tramway lines on via Milano and within the square

Only at the end of the twentieth century. In the 90's, the gradual dismantling policies of Turin industrial, brought to the redevelopment of the center, through the area pedestrianization and other important interventions. The new function of museum center, as well as institutional center, is made explicit both in urban design and in the upgrading of the pavement according to the Alfieri's project modules, where the volumes were valued in parallel through the rethinking of the square and the palace lighting. In addition, the monument to the Conte Verde was restored in order to bring it back to its former splendor, also surrounding it with a fence to better preserve it. The project was completed by a few simple elements of public furniture, not to burden the design and to allow a better reading of the new image of the Palace City square.

3.14 Description of the current architectural situation

Palazzo di Città, the current seat of the Municipality of Turin, is located in the old town center and mostly presents the original features of 1659 Lanfranchi's Baroque project. The building has six different levels and two underground floors and houses the state and meeting halls of the mayor and councilors, but also the municipal offices, circuits, archives, stores and workplaces of about 5,000 employees.

The survey made it possible to model the spaces, whose surface is approximately 87,700 m2, while the volume exceeds 137,000 m3.

The palace was built in different stages and has seen the original nucleus expanding over two centuries, and was partly rebuilt after the bombings of World War II, but the technique used to realize the bearing structure remained the original one, i.e. solid masonry. The outer casing has no insulation, as well as the sloped roof. The windows, made in wood, mainly hold a single glass, but some frames inserted in more recent restorations have a double glass.

The heating of the spaces, generated by a natural gas boiler, is entrusted to normal water radiators or, alternatively, to water fan coils which also provide the cooling in the summer months.

The modeling phase involved both the square-shaped building and the across square, as well as the whole system of porticoes and buildings designed by Alfieri.

Figure 306: Front view of Palazzo di Città

Figure 317: View of Palazzo di Città

Chapter 4

Chapter 4

Analysis of the initial situation

4.1 Introduction to survey techniques

An analysis performed on the building cannot be separated from a whole series of practices commonly defined as a survey, namely the scope of descriptive geometry whose objective is the transfer of the fundamental characteristics of a building or urban object to a graphic system of representations (mainly two-dimensional). In today's common practice, after manual measurements on the site, the drawings are reported on AutoCAD, obtaining plans, elevations and sections etc., which constitute the basis for the description, analysis, building conservation and for the design of interventions on the assets.

"It is necessary to know first what you have to draw and keep in mind that it is not the elevations, the plan and the section, such as images, you want to achieve in the first place, but rather the representation of the physical space, of the architecture quality and of the structural transformations occurring in the work itself (...) the architectural survey is an operation aimed at understanding the work as a whole (...); detecting means therefore to firstly understand the work before your eyes, to get all its values, from the dimensional to the constructive ones, from the formal to cultural ones[21]. "

There are different methods and measuring instruments, but their choice should be subjected to the type of information you need to obtain, defining an acquisition process, based on the latest survey purposes. The common measurement methods can be divided into three main groups: direct (survey meter), instrumental (topographical), indirect (photogrammetry).

In metric survey, the operator performs operations through the use of simple measuring instruments, such as the meter, the metric poles, plumb line, etc. It is undoubtedly the most used method, as well as the oldest one, and is indispensable

[21] M. Docci, D. Maestri, Manuale di rilevamento architettonico e urbano, Laterza, 2009.

in certain conditions where other methods encounter obstacles that preclude their use.

The topographic survey is named after the instruments, indeed topographic, such as total stations, tachometers, levels, distance meters, etc. As suggested by the same name, its use arises in the context of precision detection of planimetric developments of great extent, in particular for the inaccessible areas. Currently, it is also used in the urban survey, to determine the planimetric and elevation tendency of the streets and it is essential to contextualize the work to be detected on its territory, connecting it to the national topographic network.

Finally, the photogrammetric survey, the most recently born, employs cameras (cameras system, stereometric cameras and so called restitution instruments). The images extracted through these systems allow to extract the information necessary to the tracking of the surveyed object.

4.2 Significant Preliminary Activities

In the case of Palazzo di Città the manual survey was carried out on the basis of plans, elevations, sections and construction details provided by the City of Turin in .dwg format.

The coursework in question consisted of elaborate architectural graphics, the security plan, plans with the intended use of the spaces, electrical system.

File DWG		SI/NO
Plan	Masonry type	NO
Plan	Destination of use of rooms / encoding	YES
Plan	Beams / furnishings	NO
Plan	Lighting system	NO
Plan	Electrical system	YES
Plan	Heating system / distribution radiant panels	NO
Plan	fire-fighting devices	YES
	Typologies of switchboards	NO
Constructive details	Stratigraphy of slab / stratigraphy of vertical envelope	NO
Sections		YES
Elevation		YES
Details		

Figure 328: Dwg files provided by Turin Municipality

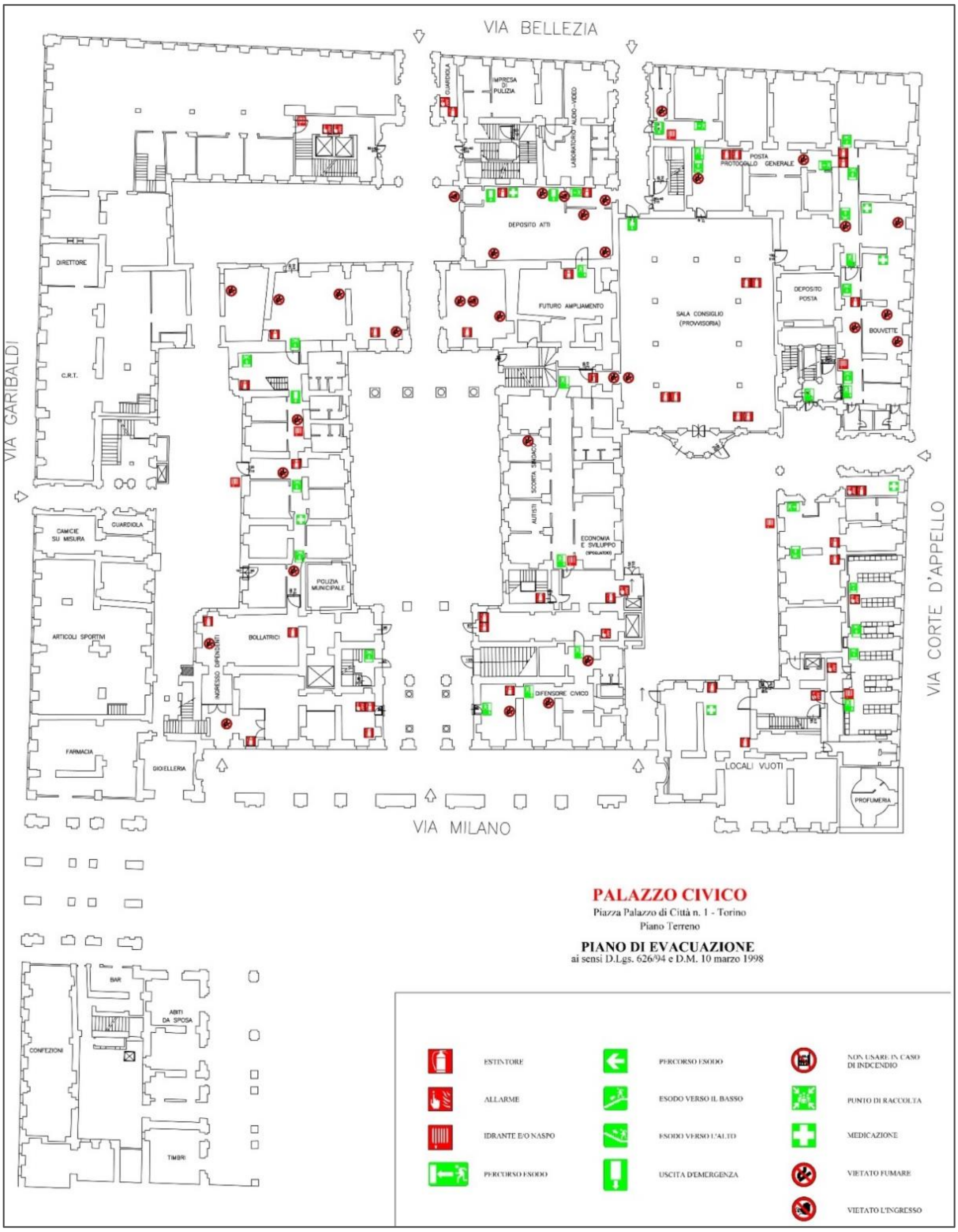


Figure 339: Dwg file provided by Turin Municipality- evacuation plan

Moreover, these elaborates were provided with the intended use of the rooms, electrical systems, fire-fighting equipment. For this reason, the manual survey operations have consisted of the verification of this information, paying particular attention to typological details of windows, walls and vaults, which were not shown in the drawing and which would have affected a correct three-dimensional modeling of detail.

Before beginning the survey operations, as well as for the other case studies of the City of Turin, a common coding was adopted, which will put the public administration in the optimal conditions to read the information, update the management database and facilitate communication with the various parties involved.

The elements of the building, were associated with a common code; the identified elements to detect are as follows: Levels, Room and Equipment.

- Levels

Town Hall is on six levels above- ground: ground floor, mezzanine level, and four levels which were associated with the codes PT, AMT, 02, 03, 04, 05.

REFERENCE LEVEL	CODE
GROUND FLOOR	PT
MEZZANINE FLOOR	AMT
SECOND FLOOR	02
THIRD FLOOR	03
FORTH FLOOR	04
FIFTH FLOOR/ ROOF	05

Figure 50: Building levels and associated codification

- Room

The Room Encoding consists of two parts: the first 2 numbers identify the floor numbers (PT, AMT, 01, 02, 03…)

After the symbol "-" other 3 digits represents the progressive number associated with a single space.

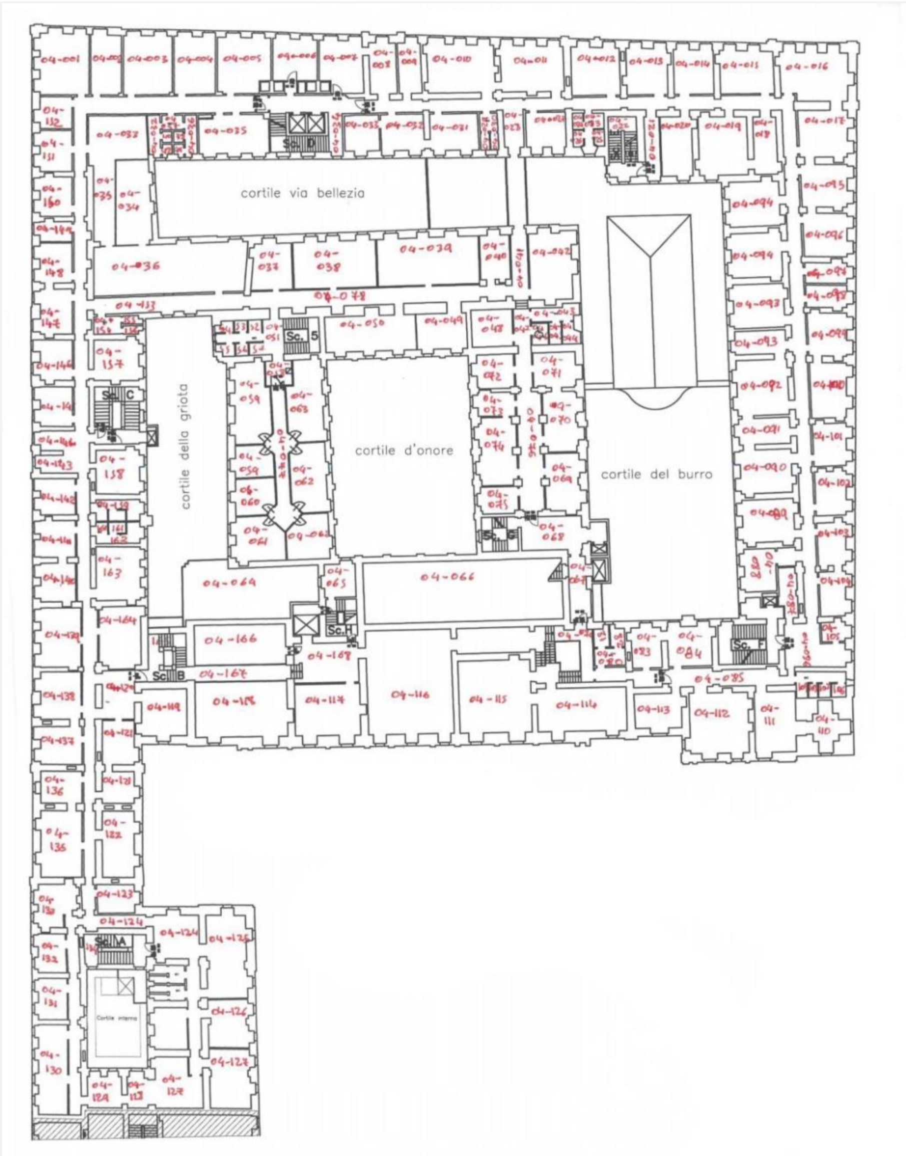


Figure 51: To the each room was assigned a code (4° plan)

•Complex code	• Building Scope	• REI
• Denomination	• Usage	• Door
• Proportional	• Category	• U.S.
• Accessible	• Typology	• Heated
• Public	• managerial Area	• Conditional
• Net Height	• Service	• Heat Meter
• Final Code	• Extension	• Electric meter
• Building	• Capacity	• Vault
• Plan	• Occupants	• False ceiling
• Room	• Primary air	• Floating floor
• Existing code	• Compartmentalization	• glazed surface

Figure 342: List of present characteristics in the files of the Room

- Equipment

In parallel with the architectural survey, took place the counting and identification of all plant elements specified in the following figure.

HEATING SYSTEM	Emitters (radiators, fan coils, fresh air) Room controller ACS (boiler) Utilities of water (taps, showers, toilets) Heat meter
FIRE SAFETY SYSTEM	Fire extinguishers Hydrants Siren / Alarm Manual alarm button Optical acoustic alarm Smoke detectors Door magnets Fire control Sprinklers
AUDIOVISUAL	Computer Printers / Photocopy machines Fax / Scanner LIM Whiteboards Projector
ELETRICAL SYSTEM	Ambient lighting Emergency lighting Switchboards Significant electrical loads Electric meter
SENSORS	Antintrusion Video surveillance loudspeaker Fixtures magnets Generator Ups Presence Sensors Lamp Dimmer

Figure 353: Devices detected in the spaces

During the survey phase, this information have been inserted into present excel tables so as to organize activities on the field and accelerate the digitization of data, eliminating the traditional transcription of paper-based data.

4.3 Metric and photographic survey

Once the authorizations to enter the spaces were granted, the Municipality of Turin informed the various offices, which offered total availability in the phases of survey.

• The direct metric survey, through laser distance meter, TAPE MEASURE and LINEAR METER;

• The survey of the devices, supported by major sheets shown in figure 53.

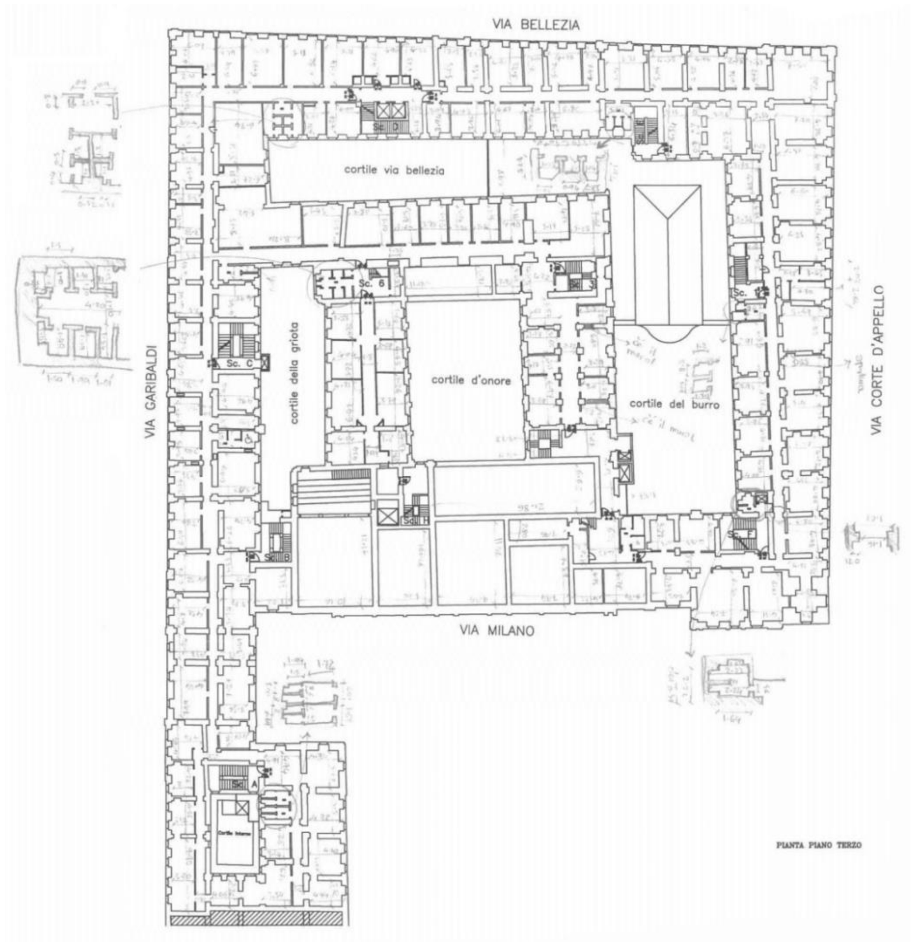


Figure 364: Geometric elevation of third floor

In addition, a photographic documentation was produced to document the state of art of the spaces and to support the following stages of modeling, by solving future necessity for additional visits. The photographs constitute a fundamental document, both to complete the survey graphics a posteriori and to obtain possible measurements, after correct positioning of the camera in relation to the plan of the object to be measured. The proper photographic survey provides reference points to later categorize the photos, for example, dividing them into folders related to the different places and different plans, saving a lot of time in the research of specific images even after a long time since the survey; also, it is an indispensable resource for the following description and documentation of technological details, finishes, equipment positioning, opening direction and type of indoor and outdoor fixtures.

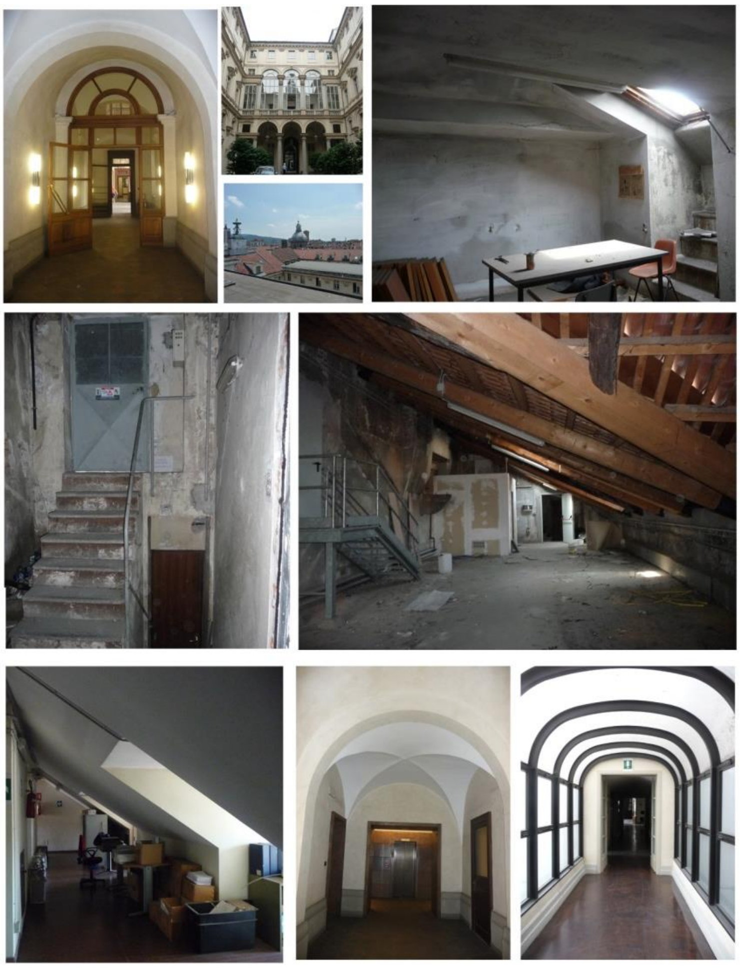


Figure 37: Photographic campaign

Chapter 5

Chapter 5

Setting and implementation of the parametric model

For accurate modeling of a BIM, particularly in the management of a multitude of buildings which constitute a Real Estate, it is necessary to set a workflow based on specific objectives determined with the customer.

In the case of the Town Hall you can recognize six successive steps:

- The definition and implementation of a template
- The setting of the parametric model
- The modeling of the architectural elements
- The implementation of customized parametric families
- The rendering of views
- Use of the schedules

5.1 Definition and implementation of a template

Once all the information required for the implementation of the Building Information Model have been obtained and organized, it can be possible to launch the parametric software and start the modelling process. As it occurs in standard practice when 2d or 3d drawing programs are used, even BIM software allow to organize a new model from the predetermined settings. This operation is performed thanks to the template: it is an actual file in which it is possible to find settings, families, views, tables, tags and other preloaded objects. In this way, it is possible to start modeling optimizing time, increasing the efficiency and the quality and standardizing the different projects within the same office or Public Administration, making it easier to read and use them. It therefore means to define standards shared by all involved actors, organizing teamwork optimally. Revit allows to create a new template, but it can also be possible to select one of those supplied with the software, perhaps adapting it to the needs of the working group.

After creating the template (.rte extension), via the function 'template files' of the 'New Project' dialog, it is possible to modify most of the settings from the ribbon "manage."

I will now show how the template was organized for the project of the City Hall of Turin primarily by focusing on four main settings for the projects standardization and the objectives achievement: levels (reference levels), local labels, schedules, and views.

5.2 Creation of the starting levels and relative nomenclature

To standardize the various projects, a shared nomenclature of levels was agreed, namely the infinite horizontal planes that act as a reference for all the elements housed in the same levels. The level defines what quota the object will be placed to (such as a roof or a wall) and for this reason it is preferable to make them correspond with the planking level of floors, the various floors, or set plane of roofs. Actually, objects such as walls or roofs can be comprised between two plans, then, it is possible to set reference levels even to quotas that will simply act as the upper and the lower limit, as in the case of the top of a roof or on the lower floor of a foundation.

This operation is performed in elevation or section views according to the nomenclature in the chapter 9.2.

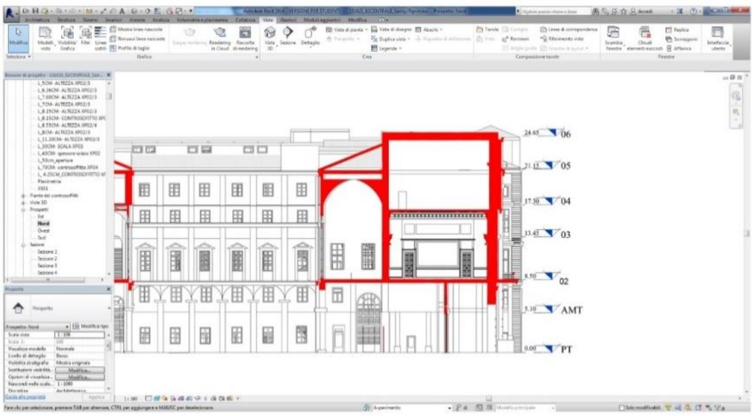


Figure 386: Reference levels

5.3 Creation of local custom tags

The “Room” function of Revit allows to associate a tag and a pattern to a certain space in order to facilitate its identification. These tags are simple 2D annotation symbols whose scale is linked to that of the tables for printing, so their dimension automatically adapts depending on the view variation. Despite being related to the rooms, these tags are associated with the same view were they were positioned; as a consequence, in case of duplex spaces or of greater height, it will be necessary to show a tag in every view of each level, without however redefine the local.

The tags, as well as all the other standard families of Revit, are subject to customization: in addition to geometric and chromaticity features of the pane, it is possible to select the information to display in plans (such as square footage and room code, or intended use). These data are automatically filled by the software that derives the information from that room according to the relative schedule.

The project template contains a custom tag whose creation process is summarized in the following points.

- Choice and definition of the most interesting information to be shown in plan

In the City Hall of Turin projects, the data appearing in the tags are three: the room final encoding, Category and Type.

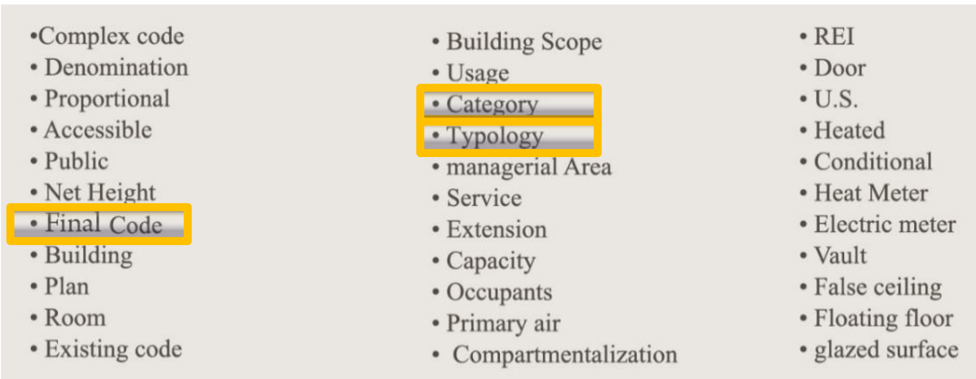


Figure 397: Information collected during the survey with highlighting of the values chosen to be used in the custom tag.

- Creation of shared parameters related to selected information

In order to incorporate in a family certain parameters, the latter must be shared. Therefore, the information that will be shown on the tags will have to first be created as shared parameters within an ASCII file with a .txt extension created by Revit itself, containing a list of all shared parameters of all families and their description; the user would then have to name the file and select a folder for saving, making sure to indicate that when he will want to share parameter in the project, and checking to always have it available on the computer.

For the Town Hall model, the following shared parameters were created: “Area Code” (data coming from the final encoding in the survey phase), “Room Category” and “Room Type”.

- Creation of the design parameters on the basis of above shared parameters and their association to the Rooms category.

After creating a shared parameter, it is necessary to specify which family or category should be involved: in this case the Rooms. Entering in the design parameters section, will be enough to assign the shared parameters to Rooms category.

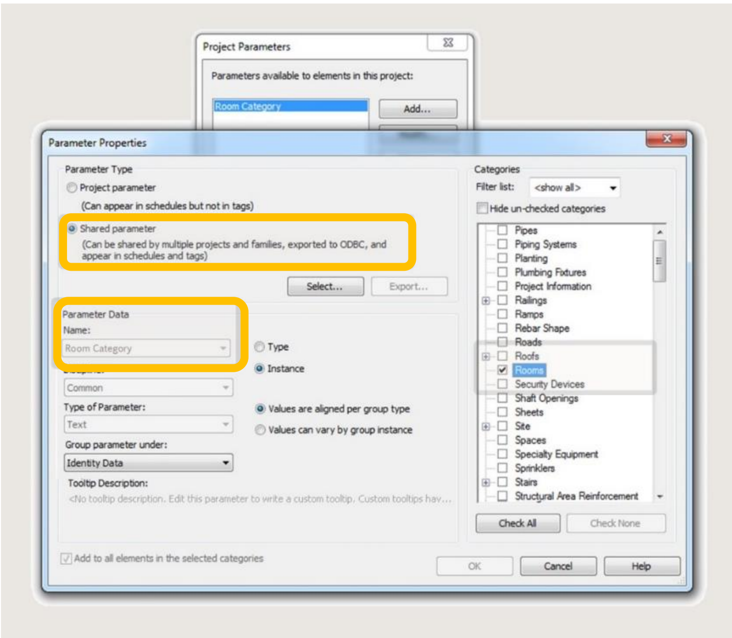


Figure 408: Creation of a project parameter, starting from a shared parameter

- New family of metric Room Tags creation

After this stage it is necessary to create the customized annotations family (tag), to which the three previously illustrated parameters will be added.

This involves the creation of a new family “metric Room Tag”.

- Insertion of label text

Before inserting the label texts to view, it is necessary to recall the shared parameters using the "Add parameter"; only then it is possible to select the previously shared parameters appeared in the list activated via the Create / Text Label button.

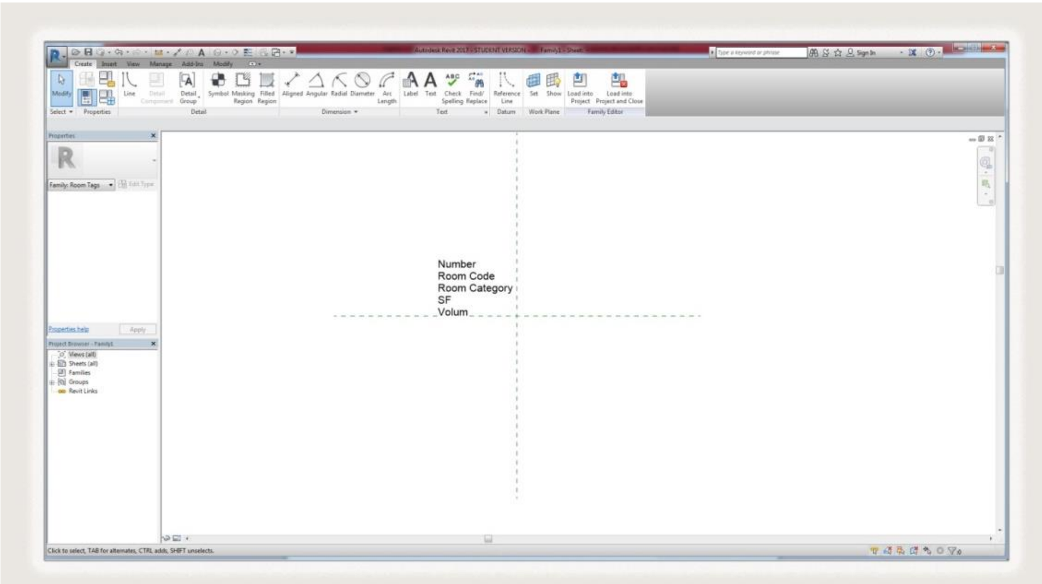


Figure 59: Custom label used for the Case Study

- Loading of Family label into the project

Thanks to the definition of the label it will be possible to load it into the template to be used for the design. From this point forward, each created room will be displayed with its label including the previously added parameters.

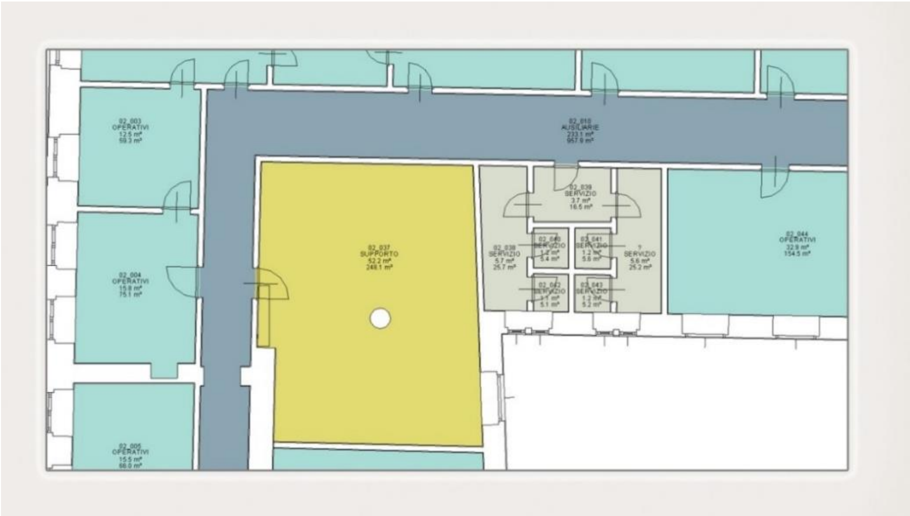


Figure 60: Excerpt of the case study plan 02. It highlights the use and results obtained from the customization of Room Tags

- Definition and preset of the main schedules

The project template also includes the setting of the desired schedules, i.e. tables, lists, and schedules automatically generated (and with considerable saving of time and energy) by the Revit model elements and their properties (type and family, materials, quantities, areas, volumes etc.). The more the model is accurate, the greater will be the amount of extractable information from schedules. As well as plans, elevations, etc., also schedules are project views that can be inserted in the tables and that update in tandem with the evolution of the model. Deleting an element from the schedule, this will also disappear from the other graphical views. Not surprisingly, the creation and management of schedules can be carried out from the view tab of the Ribbon.

Each schedule can be set as desired, by selecting the items to show and their order; in case of quantity (surfaces, volumes, unity) it can be possible to make totals and subtotals, useful for the quantities bill.

For the case study it was decided to standardize schedules, defining what would be those common to all projects and accordingly putting them in the template.

Below are outlined the steps to create the schedule.

Entering the project browser and selecting the Schedules / Quantities option with the right mouse button will activate a drop-down menu that enables the creation of different types of schedule.

New Schedule / quantity ... it will be possible to access to the window of schedule creation.

It is possible to create a schedule related to a specific category of elements to be cataloged or, with the Multi-category option, to group into a single list more items belonging in different categories (doors, walls, windows, locals, furniture etc.). The name automatically assigned to the schedule is, of course, modifiable.

The schedule organization is in turn editable at any time thanks to the Schedule Properties dialog box, inserting new entries, or by changing the grouping of the existing ones and acting on the table appearance.

The created schedules are the following, whose image containing the inserted entries is reported:

- Rooms schedule
- Windows schedule
- Enlightenment devices schedule
- Mechanical equipment schedule
- Walls schedule
- Mass pavements schedule
- Doors schedule
- Roofs schedule

Figure 61: Schedules fields of project

5.4 Parametric Model Setup

The digital model of a building is the result of continuous choices mainly based on the LOD defined at the beginning of the project. It is therefore crucial to define the goal of the model, so that the setting of the LOD and the subsequent choices in modeling phase are always consistent and optimized on the final target of the project.

In the case of the Town Hall, the subsequent use of the model for the FM addressed the setting of local tags.

As for monitoring and energy data management, it was decided to enrich with physical / thermal data all the elements that contribute to energy consumption: the vertical and horizontal opaque surfaces, windows and plants. These data are being hypothesized on the basis of regulations dedicated to calculation methods for energy analysis and information obtained in the survey phase, also by consulting the existing documentation provided by the Municipality.

- Reading of the DWG file in Revit

If in the case of ex novo design, parametric software allow to realize the project without the use of .dwg files, in the case of intervention on the existing one, the AutoCAD files corresponding to the realized design are the most important of work basis. Thanks to importation of .dwg in plan views, it is possible to extrude the walls and place openings and windows quickly, accelerating the three-dimensional modeling phases. For this reason, the 2d files are updated after the running survey, photographing the actual state of the manufacture and the position and actual consistency of each individual element. At this stage it is also necessary to skim all the superfluous information to implementation of the BIM and integrate those missing, keeping in mind the ultimate goal of this activity.

Figure 62: Palazzo di Città plan, axonometric projection and North elevation

Even though simple and immediate, the import of the .dwg file in Revit can hide a hidden danger: consistency between the units of the 2D and BIM should be checked in advance to avoid inconvenience based on wrong reading of the imported file size.

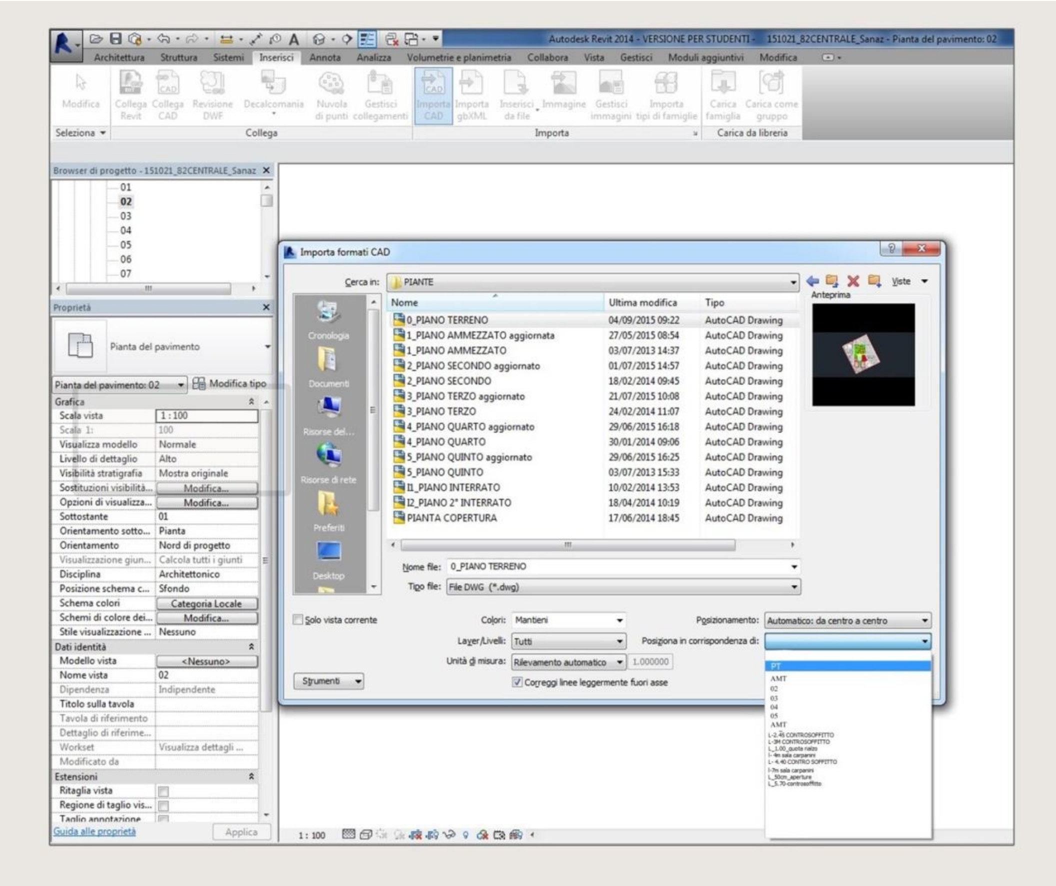


Figure 63: Windows importing CAD format showing how to set the unit of measurement

5.5 Models of custom views

On Revit, each view can be modified according to overall settings able to act on the totality of the elements which shall be displayed. This operation is managed via the view templates, i.e. a set of properties, instantly adjusting the scale, discipline, detail level, and visibility settings for the particular of a certain table. In addition, by setting the view templates in the previous modeling phases, it is possible to define and respect corporate standards that have been previously agreed, as well as to ensure better communication between the parties involved in the modeling process. The opportunity to act on the visibility of the individual categories, allows who is modeling to conceal or to highlight particular objects, eliminating the risk of overabundance of information.

The creation of models of view, is obviously subsequent to the determination of specific purposes of the real views, defining one or more styles to be used for each life. For example, an architect may display the same plan in many different styles, or show the partitions, the table of the demolitions, the plan of the furnishings and the enlarged view.

For each created view template it is in fact possible to control the settings for Visibility / Graphics replacements in each category, as well as the view scale, level of detail, graphic display options and so on.

Figure 414: Excerpt of 2° floor which regards to two different views of models, in the above shows the numbering of the windows and in the below, Rooms are colored according to their type and highlight only the scales windows.

Specifically, for each view it is possible to modify different parameters. In the following table are reported the parameters that can be customized and the relating description.

The created view models are the following:

- 1-100 Section directions
- False ceiling spaces
- Perimeter wall
- Plan 1-50
- Plan 1-100 Architectural
- Plan 1-100 Architectural_Spaces
- Plan 1-100 Architectural_Doors
- Plan 1-100 Architectural_Category
- Plan 1-100 Architectural_Direction
- Plan 1-100 Architectural_Safety

5.6 Workset

Revit 2014, the BIM software used for the Town Hall modeling, allows the use of worksets, a tool that allows to break the project down into sections, which can be modeled by multiple users connected to the same model. The modeling phase of the City Hall, however, was made by a single person. In this case worksets increase computer's performance by deactivating unused sections and reducing the amount of data that the graphic card has to process. The workset used for the Town Hall model, relating to categories such as interior walls, windows, vaults etc., or to working basis (such as .dwg of plans), are reported in the table below.

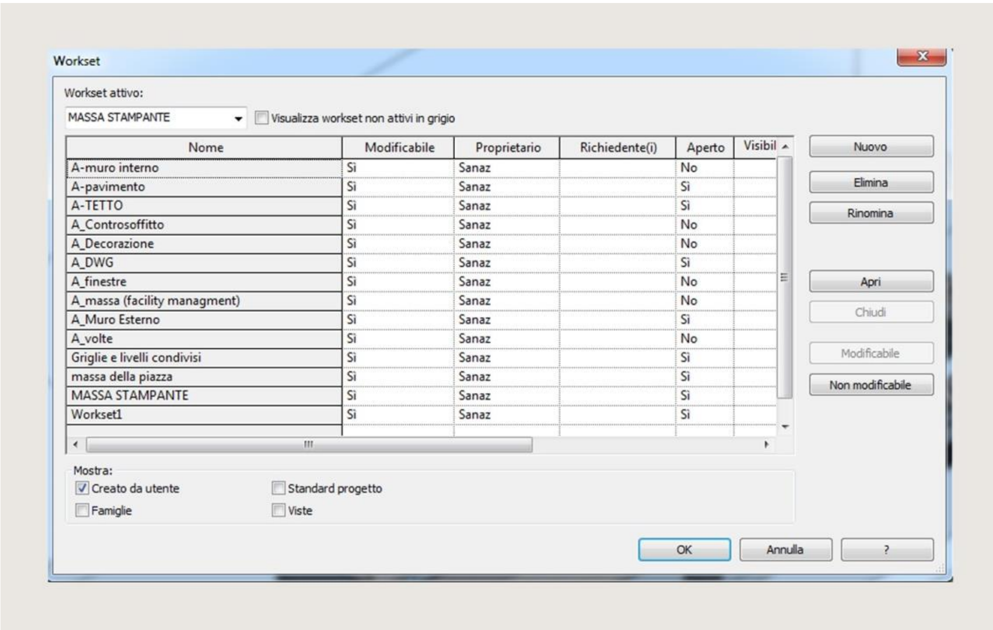


Figure 65: Workset used for the Town Hall model

5.7 Modeling

In this thesis, the modeling phase is a very expanded section, both because it is the longest phase of the whole project, and because it wants to be helpful in future similar works by illustrating the steps required to model advanced objects, avoiding the repetition of mistakes and showing the most appropriate solutions.

We will now examine the modeling procedures of some of the various architectural elements that are essential parts of the building, in particular walls and vaults, as regards the structural elements, but also phases and masses, concerning visualization of the historical data or relating to Facility Management.

- Components of the casing

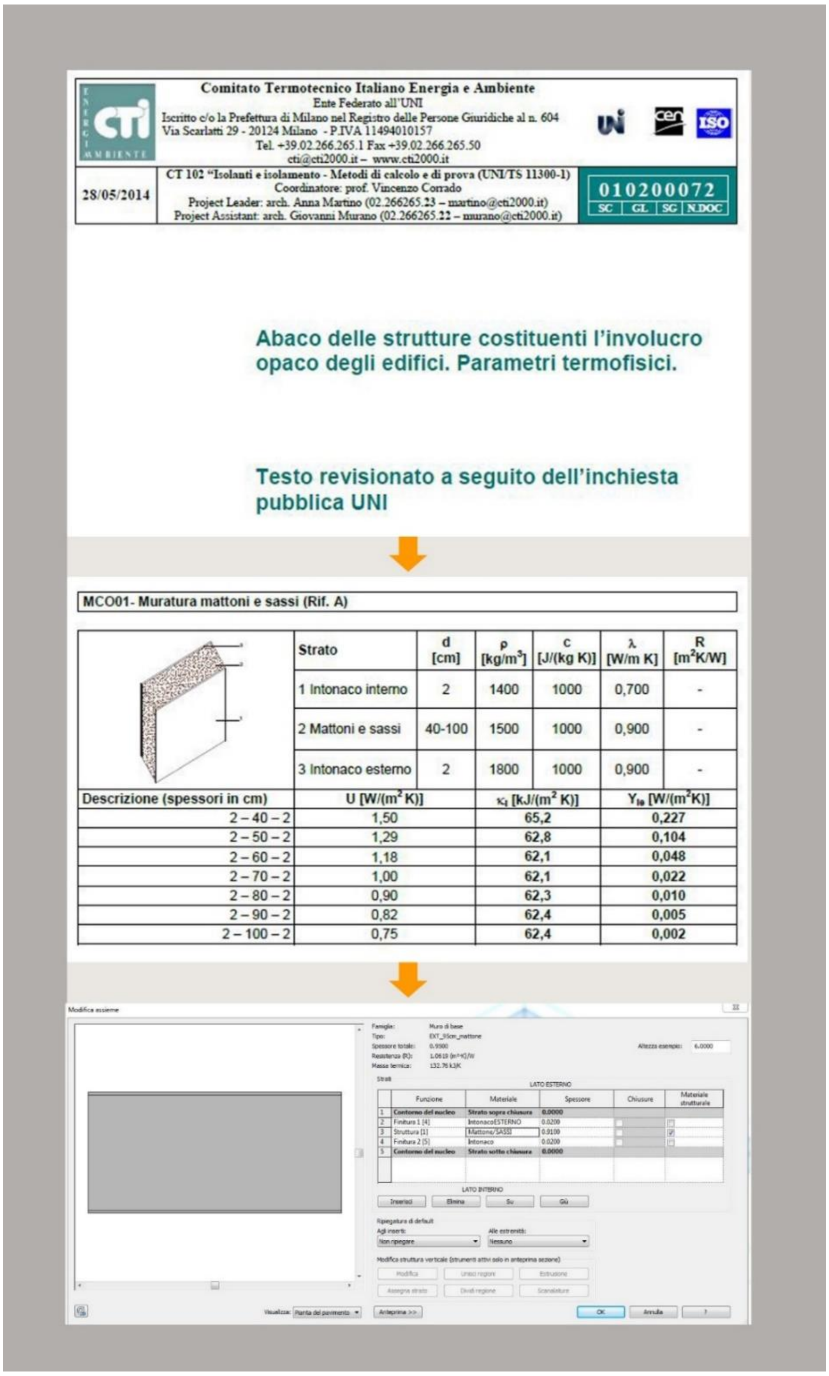
As previously seen, to use the virtual model as a working basis for energy analysis, the opaque elements and outer casing glass were characterized from the physical / thermal point of view.

Town Hall was built as a whole before the twentieth century, so there are no data sheets of the used materials for the construction of the walls. Therefore, it was necessary to use the UNI / TS 11300_1 of 05.28.2014 schedule prepared by prof. Vincenzo Corrado that allows to deduce the thermal characteristics of stratigraphy due to very extensive studies on techniques and materials used in different historical periods in Piedmont.

After the definition of the levels, .dwg files, previously updated during the survey phase, were imported, and the modeling started from the interior and exterior walls, starting from the ground floor and going up gradually to the sixth floor above ground.

After defining the outer shell and interior partitions, the parametric families of fixtures were modeled.

Palazzo di Città, due to its importance from the historical-cultural point of view, also has an important potential from the tourism point of view. For this reason, the virtual model was characterized by a high degree of detail in terms of graphics, with particular care for formal details, for example, in the case of different types of vaults. To avoid unnecessary burdening of the file it is preferable not to characterize all environments presenting complex finishes such as marble, frescoes and bas-reliefs, conducting instead further analysis on some symbolic spaces through other modeling and rendering software, so as to obtain immersive virtual reconstructions that can be used for tourism. This part will be further explained in fourteenth chapter of this work.



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Abaco delle strutture costituenti l'involucro opaco degli edifici. Parametri termofisici.

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MCO01- Muratura mattoni e sassi (Rif. A)

Strato	d [cm]	ρ [kg/m³]	c [J/(kg K)]	λ [W/m K]	R [m²K/W]
1 Intonaco interno	2	1400	1000	0,700	-
2 Mattoni e sassi	40-100	1500	1000	0,900	-
3 Intonaco esterno	2	1800	1000	0,900	-

Descrizione (spessori in cm)	U [W/(m² K)]	κ₁ [kJ/(m² K)]	Y_{ie} [W/(m²K)]
2 – 40 – 2	1,50	65,2	0,227
2 – 50 – 2	1,29	62,8	0,104
2 – 60 – 2	1,18	62,1	0,048
2 – 70 – 2	1,00	62,1	0,022
2 – 80 – 2	0,90	62,3	0,010
2 – 90 – 2	0,82	62,4	0,005
2 – 100 – 2	0,75	62,4	0,002

Figure 66: UNI/TS 11300_1 of 28/05/2014 schedule elaborated by prof.Vincenzo Corrado to deduce stratigraphy's thermal characteristics

- Vaults

The building in question is characterized by irregular geometries and, like most of the historic buildings, not orthogonal walls in plan. In the same building, all the intermediate horizontal closures are turned and made of masonry. Specifically, it is barrel vaults, cross vaults, pavilion vaults, Keel vaults, and often lunettes.

In the realization of this BIM model, particular attention should be paid to the correct definition of all objects and components of the three-dimensional processing necessary to the energy component, it is therefore extremely important to model the vaults not only from the architectural and volumetric point of view, but also structurally and in terms of allocated materials.

An important aspect of the performed modeling concerns the identification of the rooms in Revit.

Although there are different ways to model a vaults with Revit, not all methodologies are correct, especially from the latter point of view. For example, modeling using masses does not adequately identify the locals of the building.

But let us proceed in an orderly fashion, describing one by one all attempts before finding the correct methodology, and proceeding with the modeling of all the vaults of the building.

a. Barrel Vault

- Material: yes
- Room: yes

Let us start from the modeling of the simple vaults covering regular form environments.

To model, for example, a barrel vault on a rectangular room, it is possible to create a local model, choosing “roof" as the family category. Click on solid extrusion and once set the work plane on one of the vertical walls, and drawn the profile of the barrel vault, it is possible to enter the parameters so that the same vault can be reused for other regular form environments. In fact, at the conclusion of the solid extrusion of the local model, it is possible, using the "copy to clipboard “control, to reuse the same vault and reset the parameters to create the coverage of similar environments but with different sizes.

The advantage of modeling through local models is that the volume is the correct one, and there are no troubles in the Rooms delimitation in Revit.

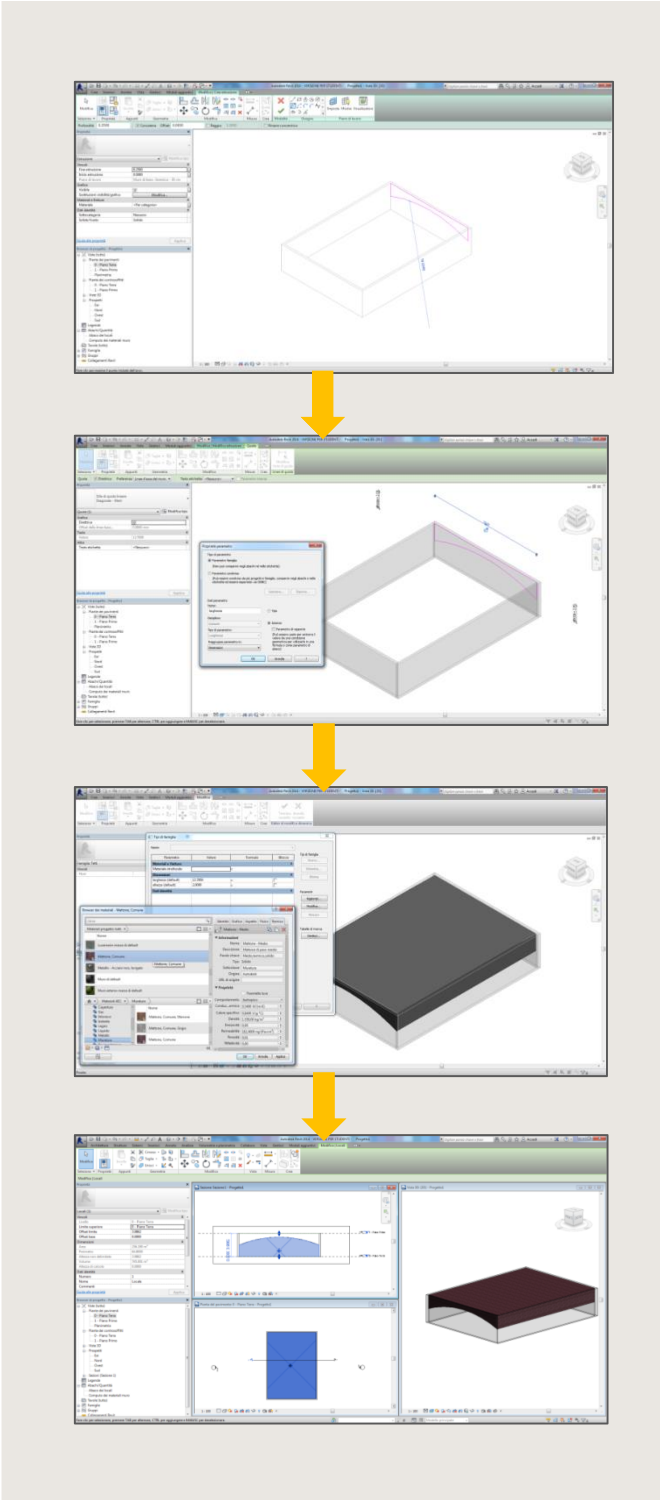


Figure 67: Modality of Barrel Vault modelling

b. Pavilion Vault, Keel vault and barrel vaults on the irregular plan

- Material: yes
- Room: yes

To model composed vaults, such as the pavilion vault, or keel vault, even on irregular plane, or simply to create a barrel vault on irregular plane, it is possible to proceed in a similar way, still from the local model, but creating an extrusion sweep. For the modeling of the pavilion or keel vault, it must be first defined the path, which coincides with the perimeter of the environment to be covered, and secondly it must be defined the profile to be extruded, by drawing it on a plane perpendicular to the path. Depending on the chosen profile it is possible to obtain, once the extrusion is completed, a keel vault if the arch drawn as a profile is smaller, or a pavilion vault if the arc reaches its maximum size, in other words, if the radius of the arch is half of the side of the environment to be covered (in the case of a square plan). To model a barrel vault on the irregular plane, the path along which to extrude the profile coincides with the center line of the environment in the plan, while the profile must be drawn by setting the working plane along one of the vertical walls and will have an arch shape.

For the modeling of more complex vaults, in this case composed with lunettes, have been carried out several attempts before finding the optimal method that suited both the volume point of view, the identification of the local model, and the materials.

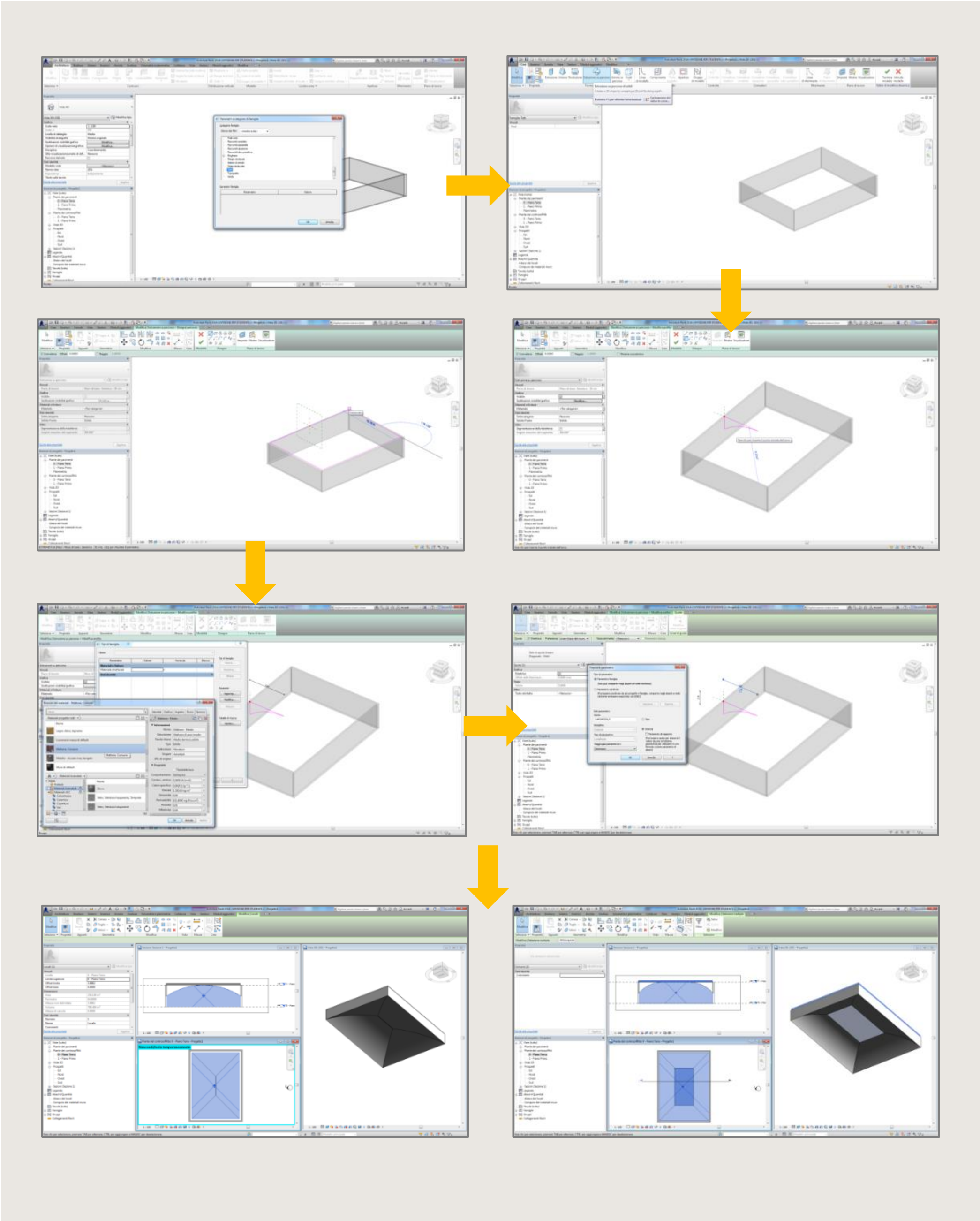


Figure 68: Modality of Pavilion, Keel and barrel vaults on the irregular plan modelling

c. Vaults with lunettes

- Material: yes
- Room: yes

The second attempt consisted therefore in the implementation of different local models, all made as a solid extrusion and not as empty. This procedure is particularly useful when the vault has a complex intrados, i.e. if it has a lunettes shape. Creating solid extrusions it is possible to parameterize the geometry to be extruded, for example specifying for a barrel vault, a parameter for the width and a parameter for the keystone height.

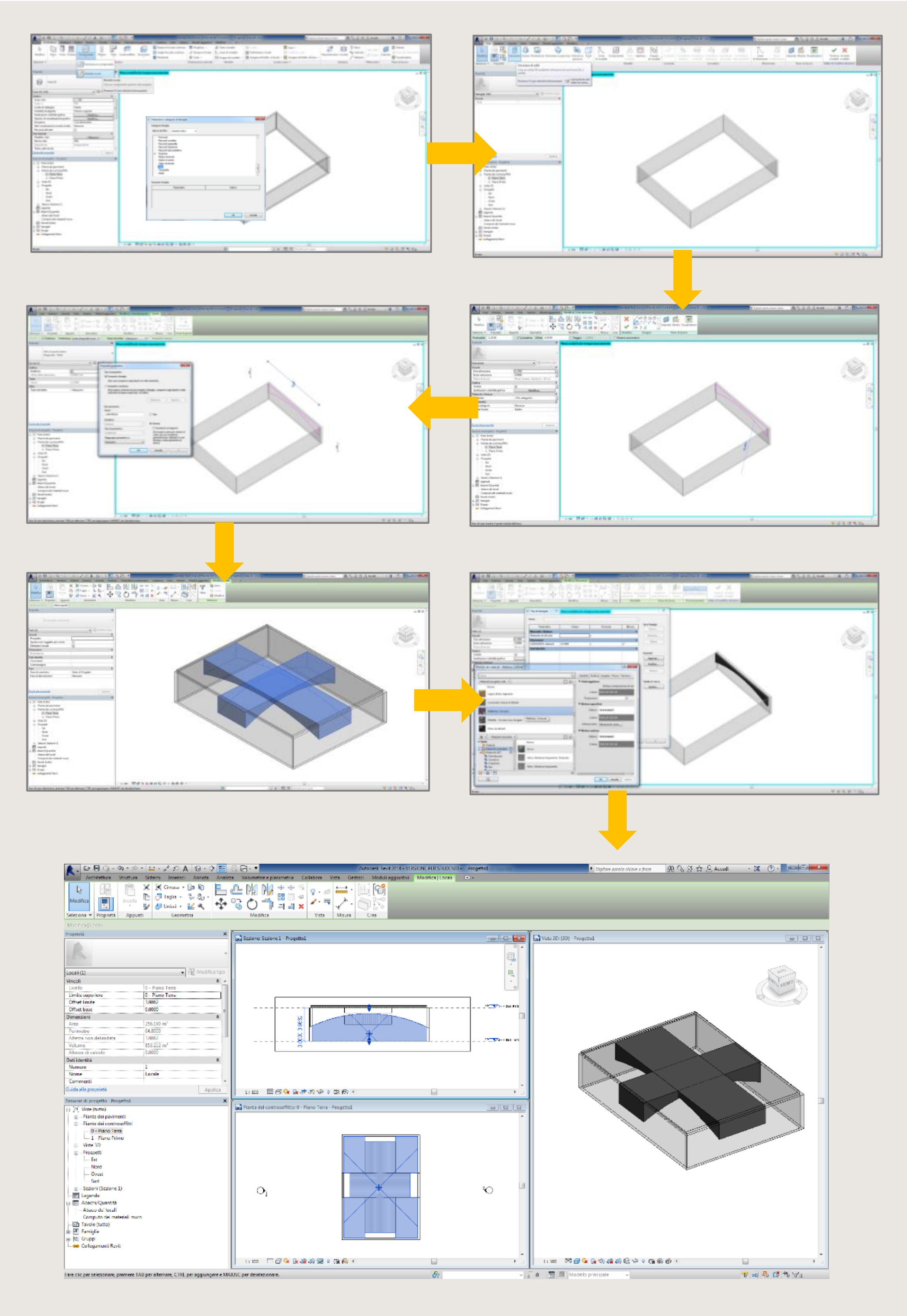


Figure 69: Modality of Vaults with lunettes modelling

d. Cross vault and groin vault

- Material: yes
- Room: yes

The third attempt consisted in the modeling of the vault as a local model belonging to the Roof category, as in the two previous cases, with the difference that within the same local model it is created the geometry, both solid and empty, to subtract.

The modeling of the vaults in this case followed these steps:

1) Creation of a local model, choosing the Roof category.

2) Setting the work plan on which to draw the solid shape to be extruded. In the case of a cross vault, it is a parallelepiped of which the base is extruded, coinciding with the sides of the environment that is intended to be covered.

3) Before finishing the local model, create empty volumes to be subtracted which determine, in fact, the vaulted roof. In the case of a cross vault it is two cylinders with horizontal axis, placed orthogonally to each other. To model, from the ribbon "create", it is necessary to select "empty" and then "extrusion". By setting as a reference plan one of the vertical walls, the circumference to extrude is drawn. By repeating the same procedure on another vertical wall, it is possible to get a unique local model cut by two empty semi-cylindrical, so a cross vault.

Deciding to shape the vaults through local model it is possible, at any time, to assign a material to each model. It is sufficient, through the "dynamic change" to select from the properties of the model the structural material chosen, which is possible to specify in the "Family Types" section.

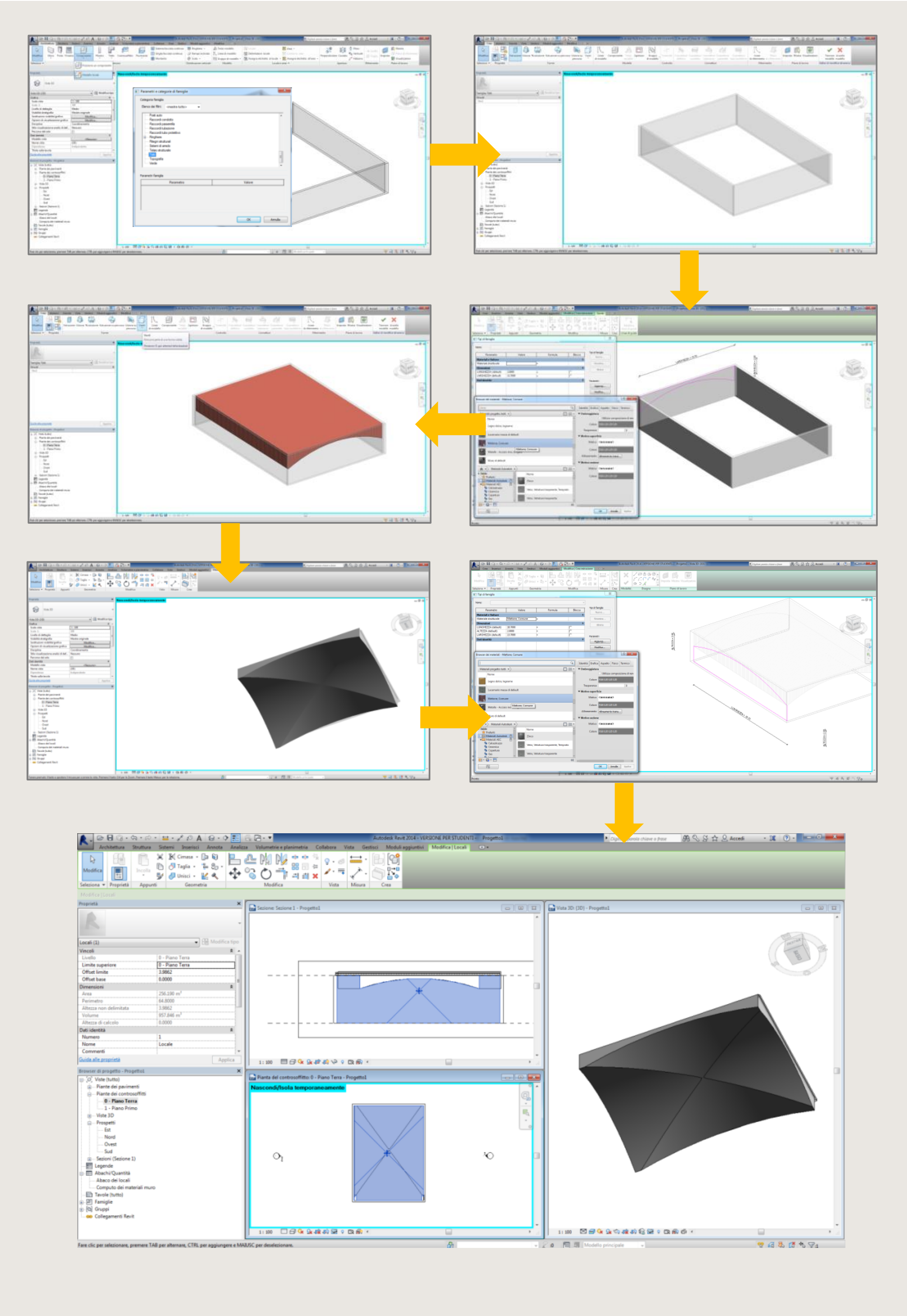


Figure 70: Modality of Cross and groin vault modelling

The following pages will be showing some attempts of vaults modeling often inadvisable in case of energy analysis because they do not guarantee or do not allow the correct reading of the material and the space data by the software.

1) Modeling using local model "roof"

The first attempt was to create a local model, which had as "Roof" category.

Therefore, it was created a parallelepiped as a solid extrusion, first setting as a reference plane a horizontal plane, starting from the polygon coinciding with the perimeter of the room to be covered.

After finishing this local model it was created a second local model, not as solid extrusion but as empty one, in the case of the barrel vault, it is a semi cylinder, to be subtracted from the first local model (solid extrusion). To realize the empty in question, you need to selected once again the "roof" category and to set as the reference plane a vertical plane, coinciding with one of the walls of the environment that is intended to be covered. The issue coming out of this type of procedure is the following: once the empty is realized and the second local model is finished, trying to subtract the two local models (the empty from the solid extrusion) the program does not give the possibility of subtraction between them.

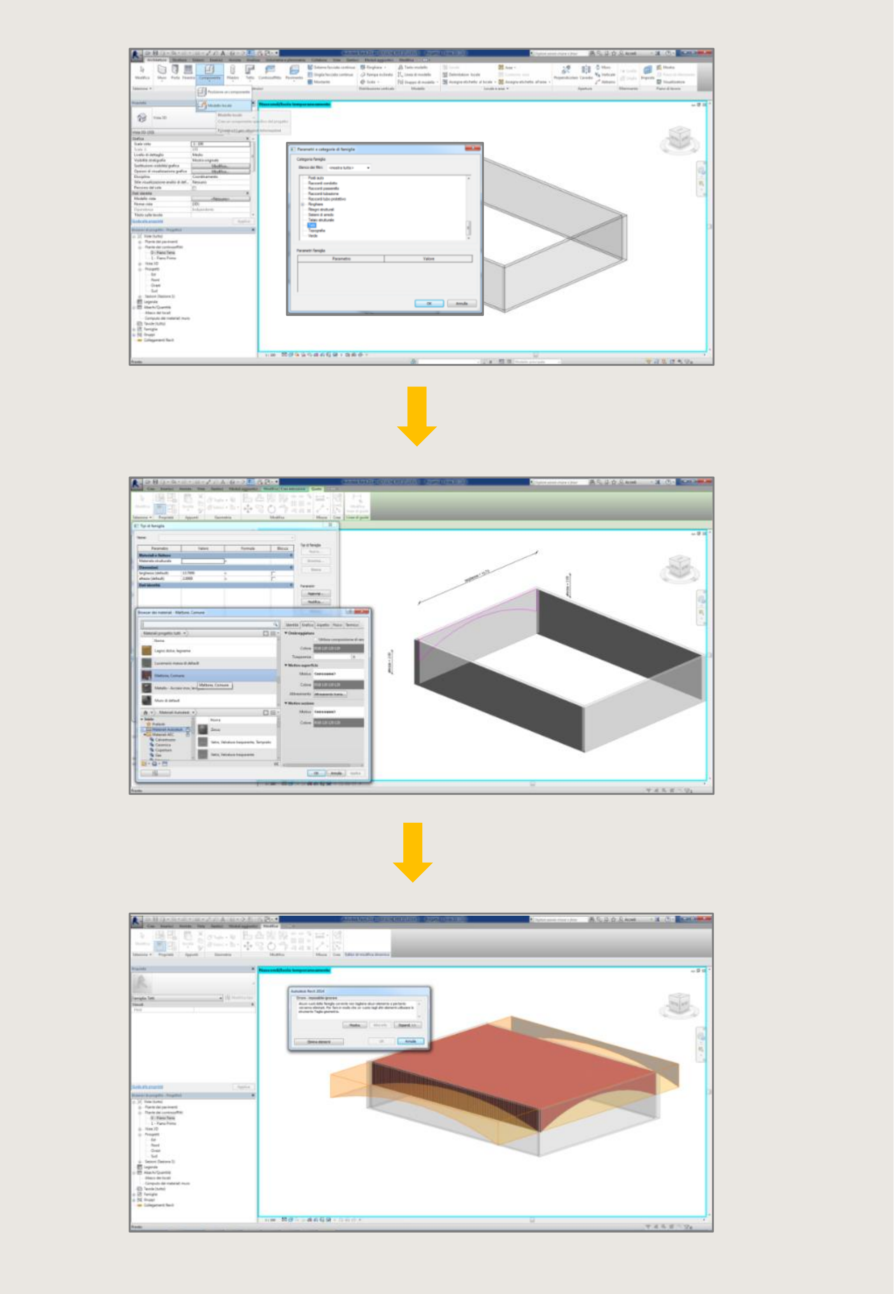


Figure 71: Modality of modeling using local model "roof"

2) Modeling by "masses"

Other attempts for modeling of the building vaults have been conducted, in particular with the modeling using masses. It is possible to use the masses in two ways: by exploiting them as solid geometry, or exploiting them as empty geometry.

In all two cases, clicking on "Massing & Site" tab, then "In-Place Mass ", a name is given to the mass and, after setting up the work plan, for example on one of the vertical walls of the environment, it is possible to create the profile to be extruded and then with "Create solid / void form", the mass is extruded.

The modeling using masses, as much as versatile, is not useful for the purposes of this project for a particular reason. In fact, it is not possible to assign a material to the solid geometry, and therefore no parameter type, whether it is a thermal or a resistance one.

The only way to assign a material using the masses is to create a surface of the roof.

Once the modeling of the mass is completed, a new roof is created in the “Massing & Site” tab, selecting the face of the mass where you want to create the turned surface. Once the roof has been created, i.e. our vault, it is possible to attribute a definite stratigraphy of materials, but it is just a layered and shaped surface. There's no guarantee that in reality the structure is actually empty in the flying buttresses. However the advantage of using this method is that, effectively creating a roof, it is possible to properly delimit the space.

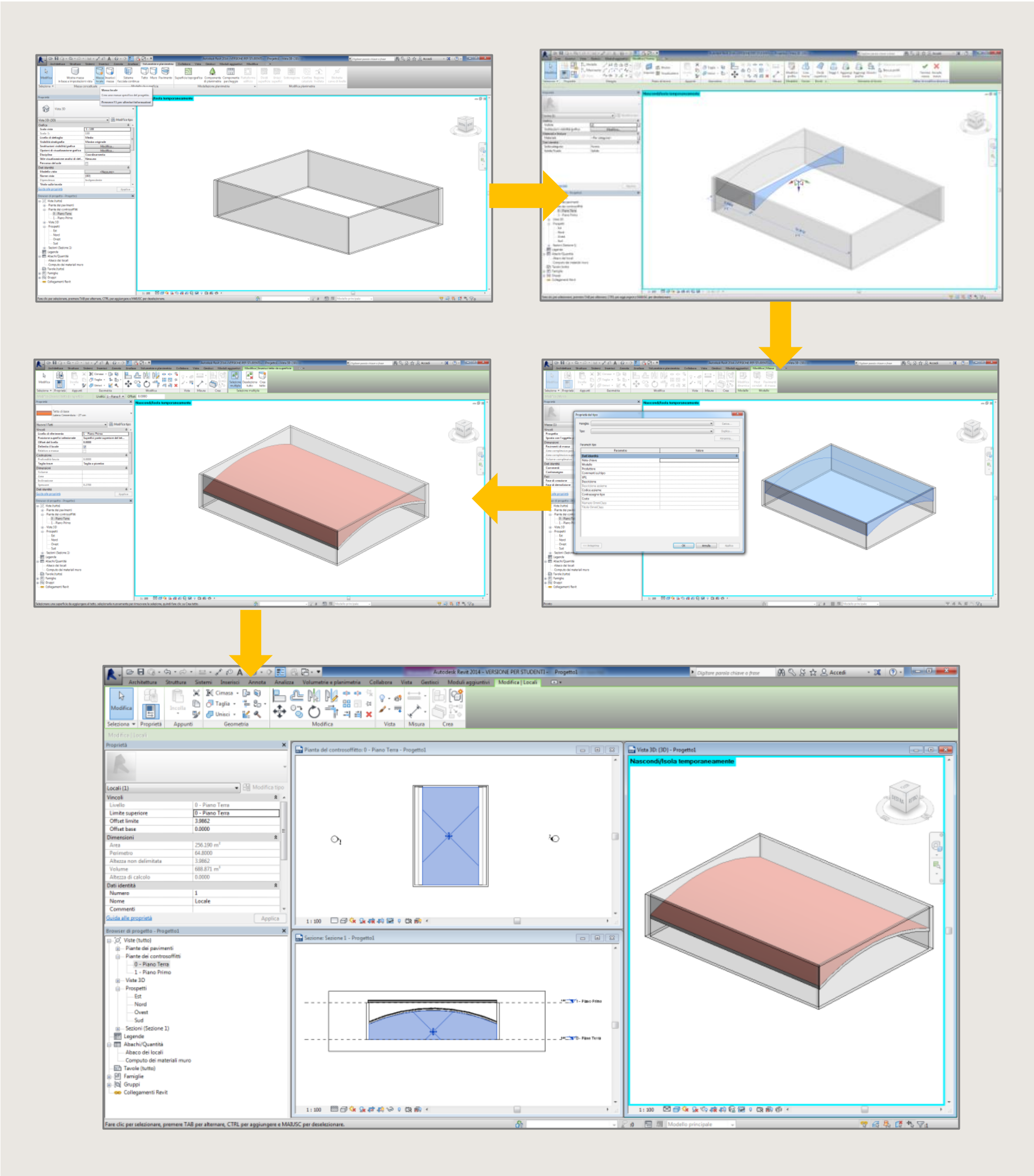


Figure 422: Modality of modeling by "masses"

5.8 Phases

An important aspect of the City Palace, considering its gradual realization that invested four centuries of history, is undoubtedly the distinction of the various construction phases of the original architectural structure. From intervention in the asset is indeed important to provide designers and actors involved in operations with all the information relating to the period of any environment realization, both to better understand the cultural heritage which the rooms preserve within their walls, both to immediately recognize the used materials age and the techniques adopted in the realization of every architectural and structural element.

Revit, as well as other parametric software, allows to insert information on the relative phase of realization in all the modeled elements; this means that it is possible to isolate and show only one or several steps at a time, temporarily excluding the objects related to unwanted periods. To provide an immediate glance on the enlargement process of the building over the years, especially for tourists but also for future designers who will interact with the asset, a volumetric model was then made through simplified masses, which displays very intuitively the entity and position of the various interventions related to specific construction years, both on the building and on the adjacent square.

In case of future intervention on the building, the updating of the model will be carried out specifying the year of implementation of the new interventions. In this way, it will be possible to see the initial conditions of the work at any time, quickly rebuilding the context in which the design choices matured.

The phase tool is also essential for the realization of the construction and demolition tables, visualizing in red the new constructions, in yellow the demolished parts, and in gray the existing ones.

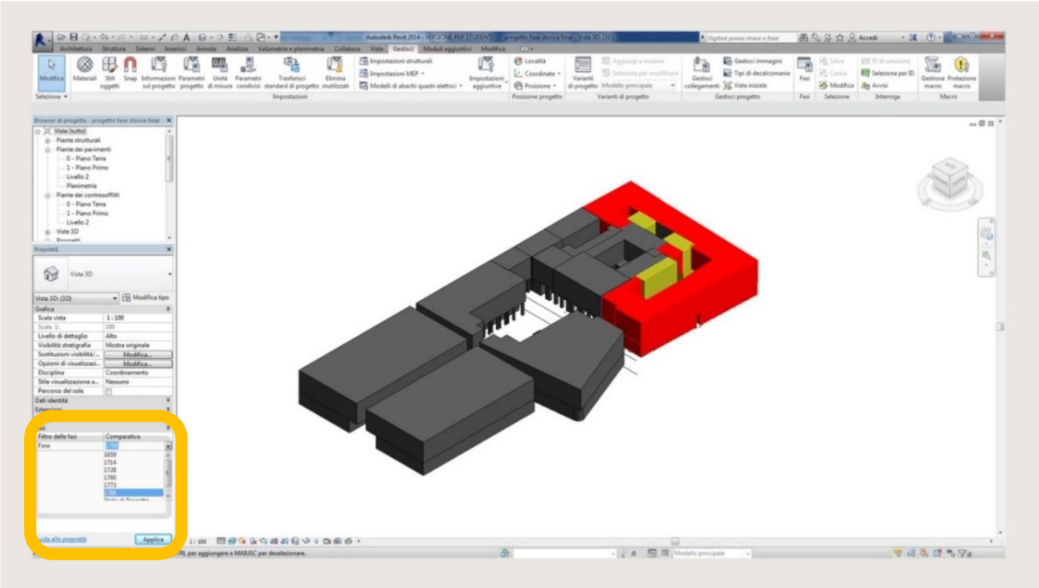


Figure 433: Various construction phases of Palazzo di Città

5.9 Masses

Possessing evacuation plans, based on the activities identified within the Facility Management, it was decided to create through the mass tool, colored volumes that identify each group for volume level. The rooms are then grouped in flows by color facilitating the identification of its escape route and the stair that is used in case of emergency.

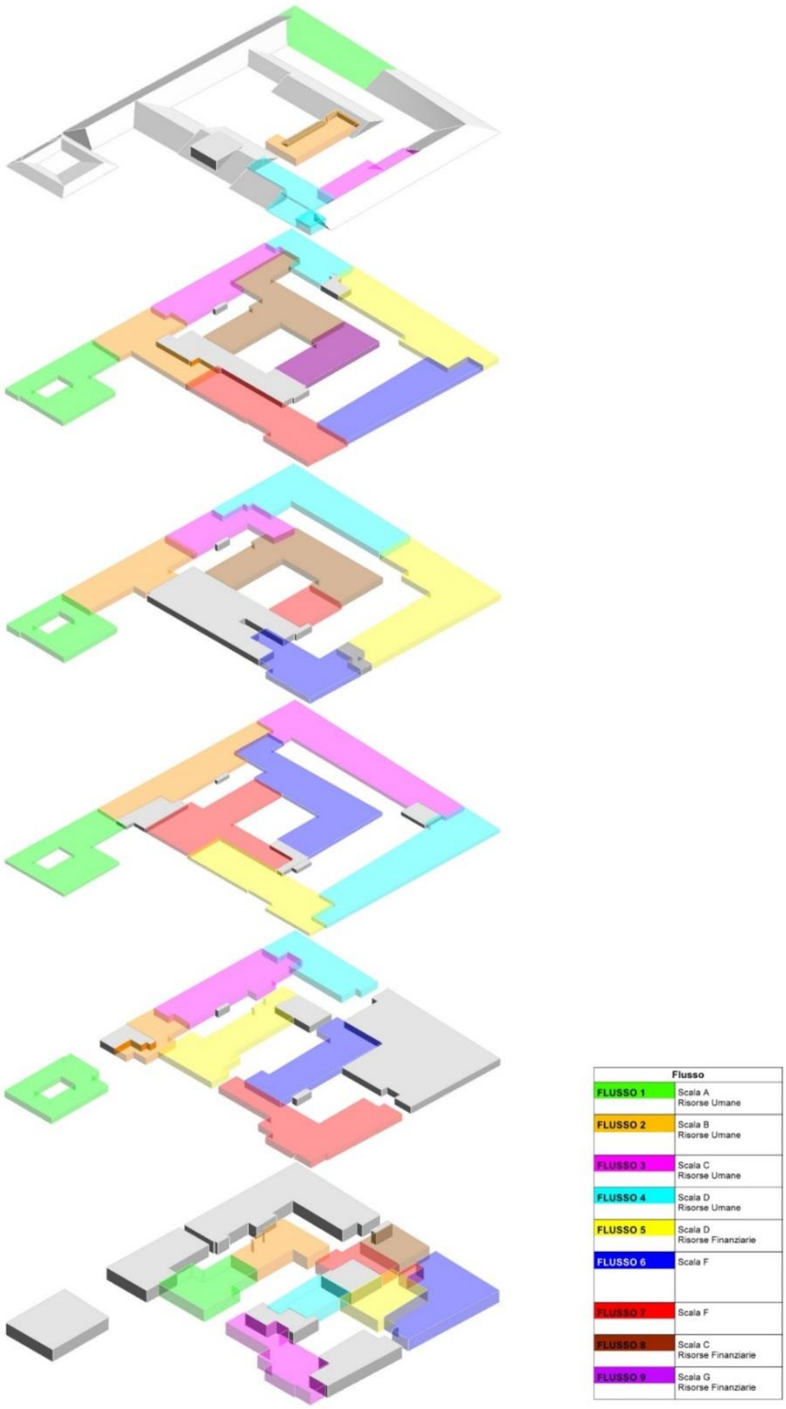


Figure 444: Colored masses based on various flows

5.10 Parametric Families implementation

To obtain faithful images to reality, as well as to characterize model for the future uses (see FM) several information should be added to the modeled objects. These data (e.g. materials) are defined “parameters” and are customizable information attributable to the families.

In the realization of a BIM model, the modeling of parametric families is an as delicate as crucial phase. In the case of the Town Hall, the most emblematic example is that of the fixtures: all interior and exterior fixtures in fact include this category.

In the realization of a parametric family, the first step is to choose a specific category (in the case cited the "windows" category). A specific modeling session will be then opened in which the parameters can be entered, in order to simplify the modeling phases of similar objects. In case, for example, of size or color variations, being the structural components the same, in fact will be sufficient to model a single family, characterize it on the base of parameters (i.e. the characters that will vary) and subsequently, in the model, specify the consistence of these properties, changing the appearance through the simple compilation or selection of a certain parameter, without modeling from scratch the whole element.

- Family typology

Revit uses three different typology of families: **system families** are those made available by the program, and usually consist in: walls, roofs, floors and stairs. The **loadable families** are provided in the libraries, which are the ones downloaded automatically together with Revit, or those downloaded or purchased on specific websites, recognizable from their file extension: .rfa. They can also be created by the user from the editor Families. The **in-place families** as a customized items, are created in the context of a project. It is recommended to create in-place elements when, in a project, it is necessary to have a particular geometry that will unlikely be reused, or a geometry that must maintain one or more relations with the geometry of another project. Since in-place families are designed for limited use in projects, they contain only one type. In the projects it is possible to create more in-place families and insert copies of the same element of an in-place family. Unlike standard component and system families, it is impossible to create multiple types by duplicating the type of an in-place family.

There are different ways to model the windows within a project: it is possible to choose from the default library of Revit a window that reflects the characteristics of the concerned door/window frame, or it is possible to create from scratch a new family, with all the desired characteristics. During the modeling activity of the case study, custom loadable families were created from scratch, since Palazzo di Città presents complex decorative door/window frames, which are incompatible with Revit default windows families.

The realized parametric family belongs to the following category:

- Fixtures

- Fixtures

As already said, the fixtures were realized as custom loadable families, to grant the highest fidelity to the real ones. The survey phase of the external doors/windows frames was carried out in an accurate and scrupulous way since, for each of them, certain characteristics were recorded to allow the successive energetic analysis of the building, which will be conducted by the Torino Smart City Foundation. The information useful for this purpose were collected in paper sheets created specifically.

The parameters obtained for each door/window frame, after the survey, are the following:

- Height
- Width
- Thickness of the Frame
- Width of the frames (both fixed and mobile)
- Material
- Width of the two mullions

• Width of the two transoms

• Number of any horizontal and / or vertical dividers

• Width of the dividers

• Sill height and thickness of the wall in correspondence of the window.

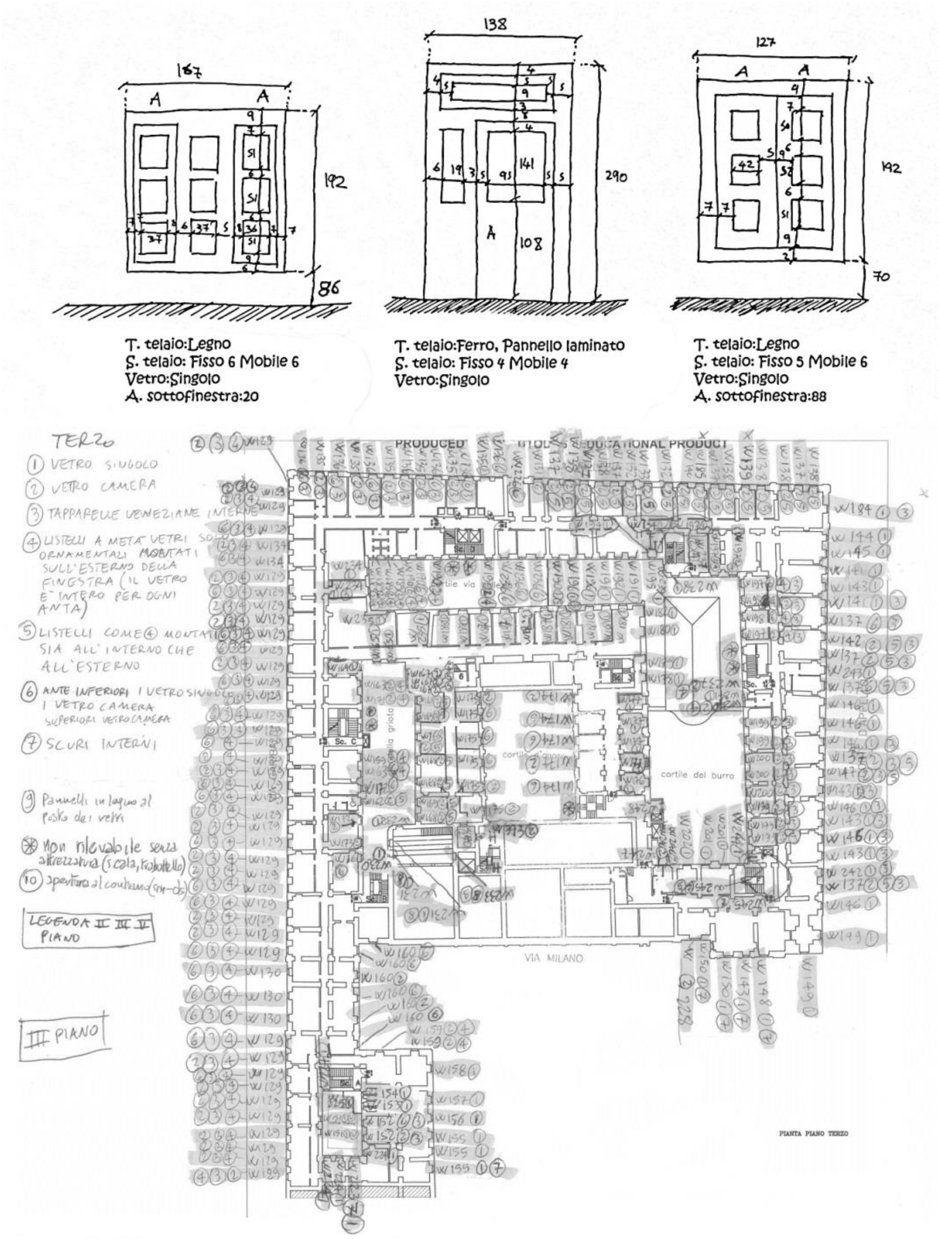


Figure 75: Survey of door/window of reference plan

Once all this information for each door/window frame was collected, the modelling could start. For uniformity and consistency it was decided to use a single source file. From Editor Families, selecting the "Window Metrics" category, several shared parameters were specified and named in accordance with the data obtained in the survey phase; the procedure consists in the drafting of a list inside a .txt file.

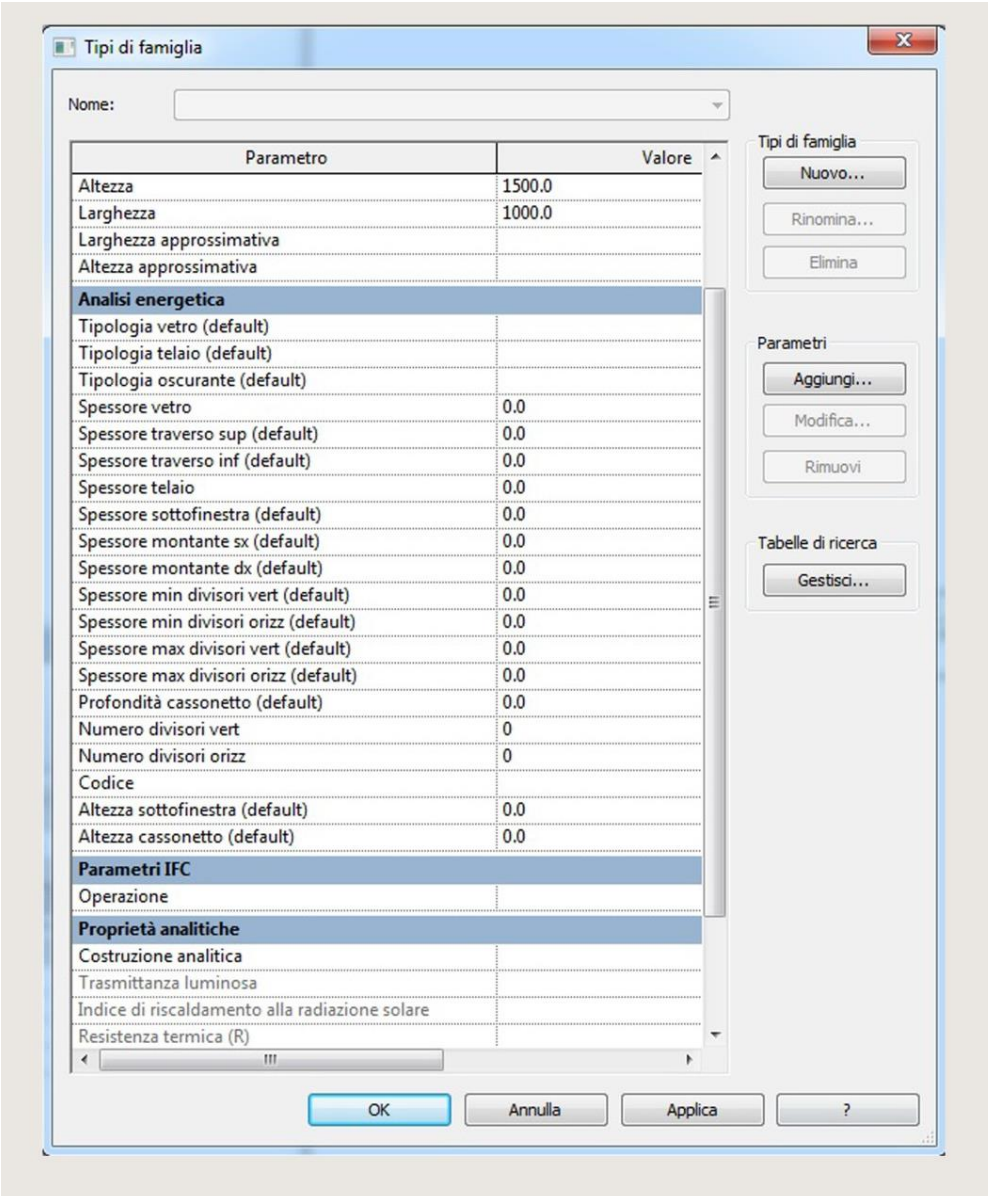


Figure 76: Drafting of a list inside a .txt file.

At this point, the .rfa file contains two dimensional parameters, width and height of the opening, and shared parameters that were inserted, but which are not yet completed.

Hence, the modeling of fixed and mobile frames began. They were created separately as two extrusions, and represented, in a simplified way, with rectangular section. Similarly, the glass, even when it was a frames with double- glazing, has been represented in a simplified way, as a single parallelepiped.

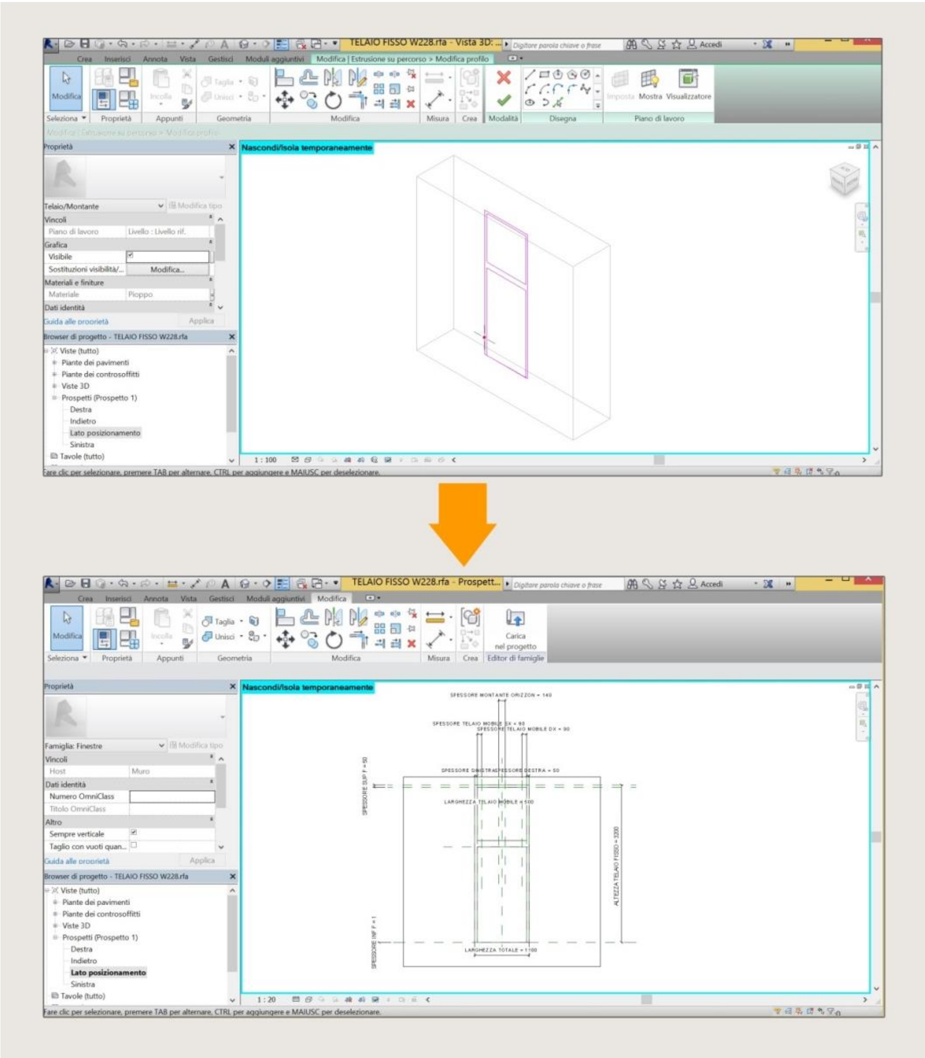


Figure 77: Modeling of fixed and mobile frames

To assign the materials to the various extrusions, the material parameters were created and associated to each element.

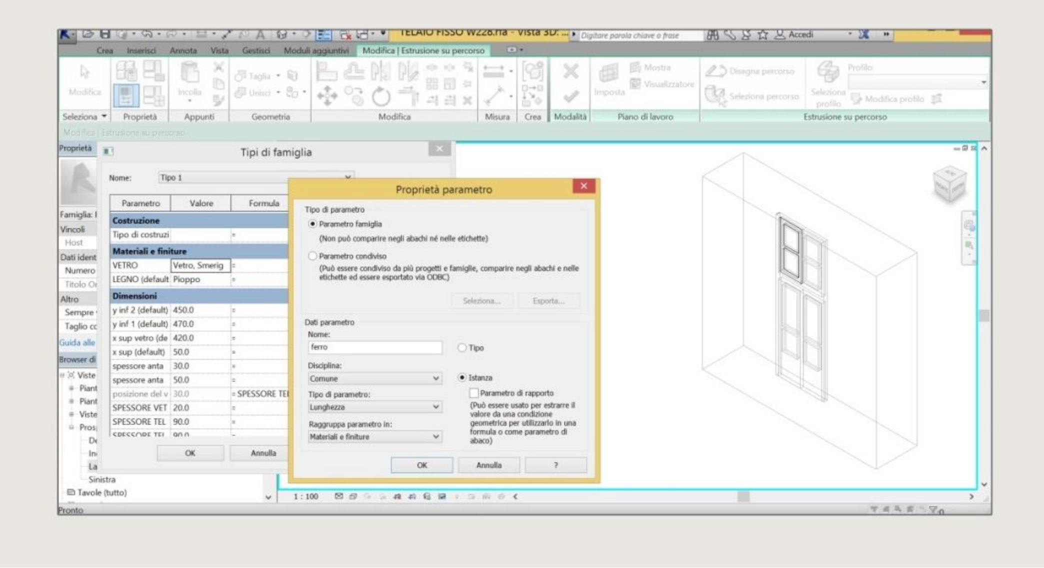


Figure 78: Assign the materials to the various extrusions

In addition, for each element a reference sub-category was selected, choosing among from:

Opening, Hidden Line, Threshold /Extremity, Frame /Mullion, Glass.

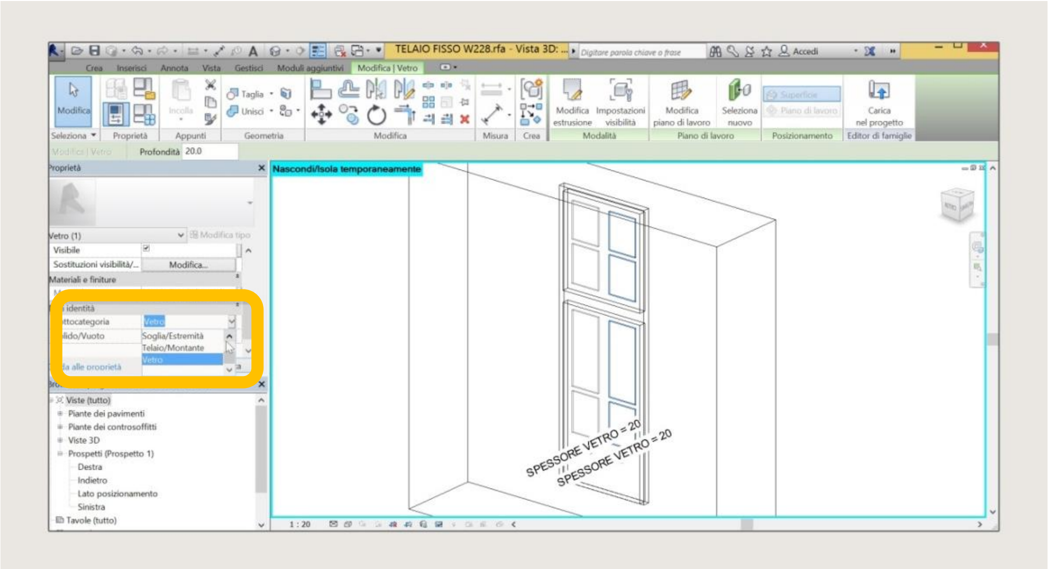


Figure 79: Assign the sub- category to each element

The modeling and the creation of various extrusions occurred by entering different reference planes, with relative annotations and parameterization, so that, in addition to the two dimensional parameters of opening height and width, other new parameters have been introduced to make the family more editable, creating different types.

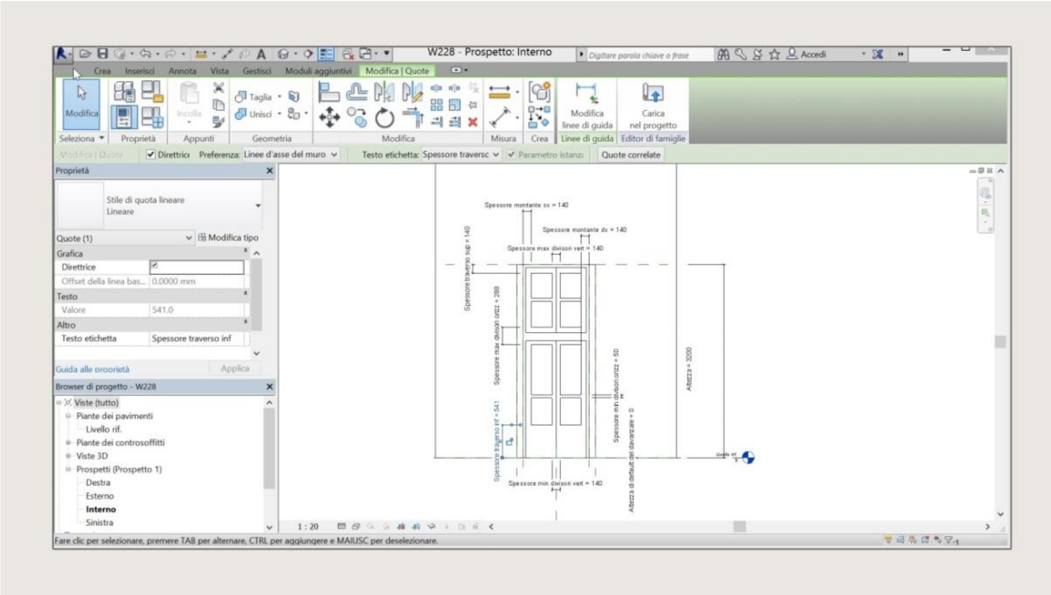


Figure 80: Creation of opening parameters

In fact, once that the various parameters are created, it is possible to edit the window and, under "Family Types" tab, we can create new types clicking on "New" and changing the parameters, obtaining the same kind of the starting window but with different dimensions, without any modeling phase.

After the geometric modeling of the above mentioned doors and windows, it is possible to fill the shared parameters introduced at the beginning (with .txt files) and grouped in the ensemble of the parameters related to the energetic analysis of the windows. Some of these parameters, such as the code, the type of blind, the glass type and the number of intermediate dividers, are text parameters that must be manually compiled from the “Properties” tab. Other, such as the thickness of the mullions and of the transoms, the frame thickness, the dividers thickness, the sub-window thickness and height, must be quoted as an instance and reporting parameters that means that Revit reads these values from a certain annotations.

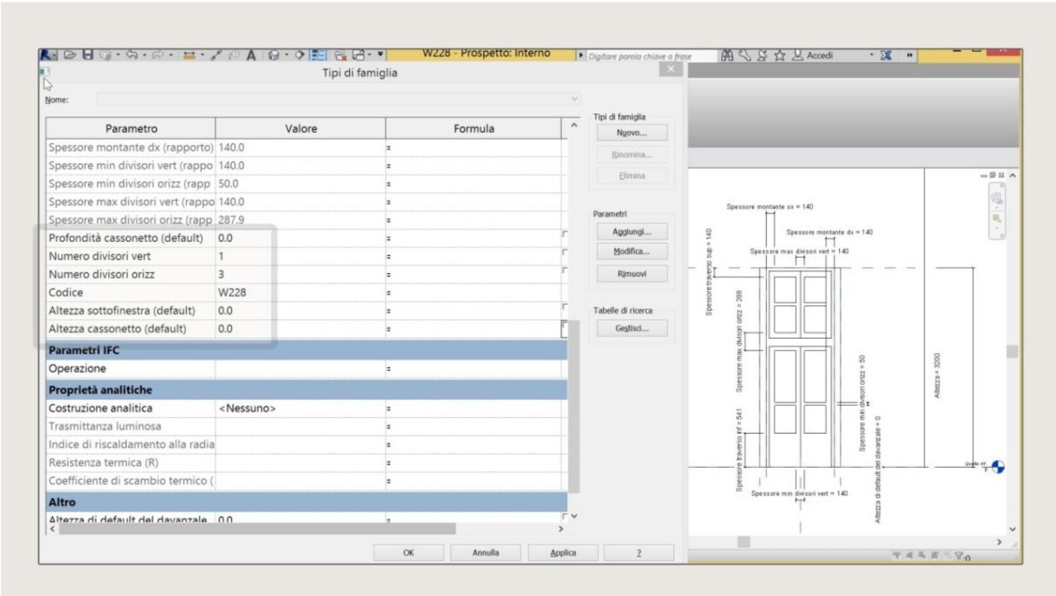


Figure 81: Manually Compilation of some parameters

To make the window and door frames properly readable after they are loaded in the model, it was chosen to assign to each component a specific visibility type, in accordance to the various levels of detail (high, medium and low). For example, the glass extrusion is not displayed at a low detail level.

Going on the Properties tab, replacing the Visibility / Graphics is possible to put or remove the tick corresponding at the level of detail that user wants or does not want to consider for the visibility of a particular element.

To finalize the modeling of the family, it is also necessary to introduce the detail lines in plan view, such as the centerline of the window/door frame, so that it is visible once imported in the project.

5.11 Rooms

Once the modeling of the components required for energy analysis is completed, the virtual model was characterized with the information necessary for the FM operations, as requested by the Public Administration. Thus the rooms were added to the model, building both a table form information database (the Rooms schedule) and graphic sheets (plans with information on the intended use of the spaces).

It will be sufficient to click on the Room button, select a point within any space and, automatically, the software should delimit and color the whole area encompassed by the walls delimiting the environment, as long as they are united. It should also be noted that the delimitation height, a default value which is normally applied automatically by the software on the base of the last insertion, can be modified at any time in the property panel.

For special cases of rooms with not delimited openings or particularly complex environments, it is possible to use the command "Room Separation Line", and define manually one or more lines of the perimeter through polylines.

When the room is created, it is necessary to manually insert the information, or fill out parameters relating to the room tag family, which has been previously loaded and activated. Then the Room Code, the Existing Code, the Room Category, the Room Use and the Room Type will be specified. To complete this phase it is necessary to take this data from the survey, respecting the chosen encodings. When a room is created, also it is possible to place the tag in the plan and fill out some of the information listed above directly in the plan view; for the other data will be necessary to operate on the room properties by selecting it in advance or inside the schedule.

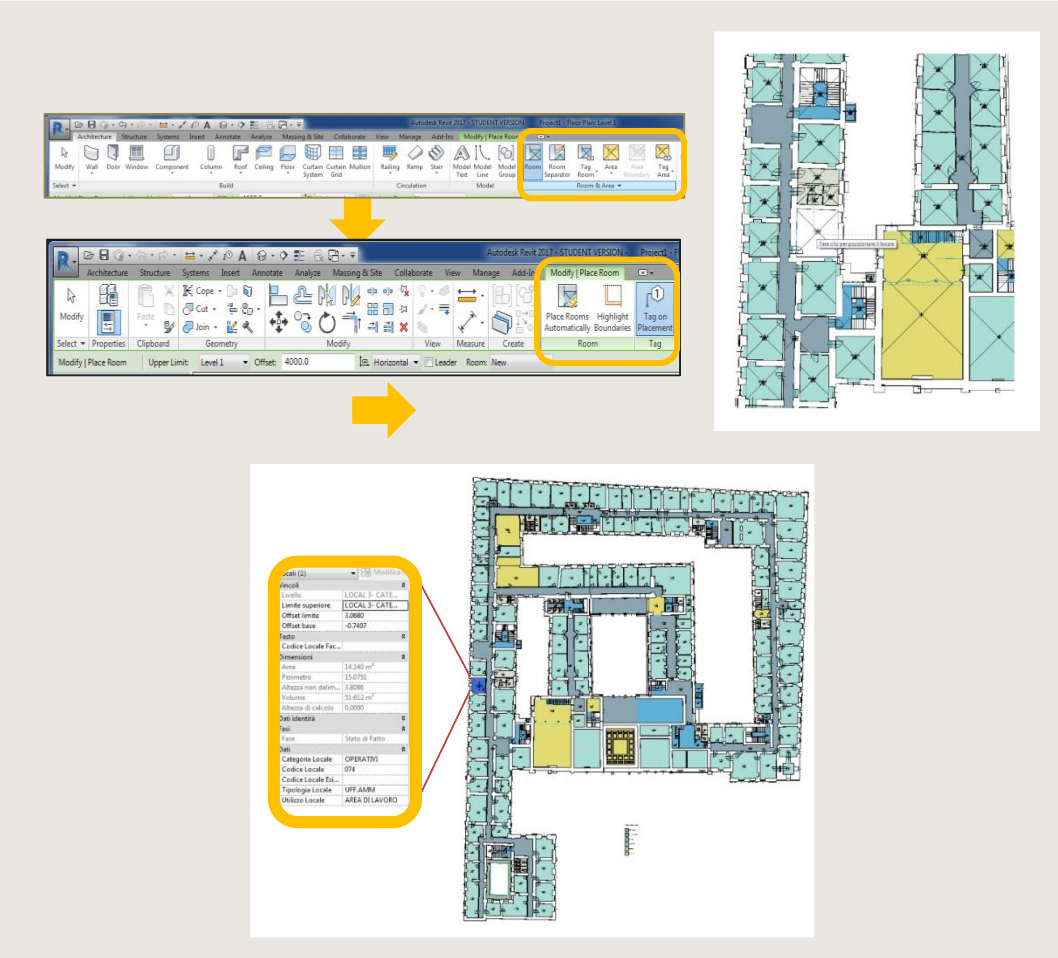


Figure 452: Room positioning and corresponding label

To insert a tag at a later time, for example in a vertical connection space which was already delimited in another plan, it is necessary to use the command "Assign tag to the room" or "Not Tagged" that automates this operation in all the plans which present rooms already established but unlabeled.

To select the information shown on the tag, instead, it is necessary to enter the menu in which all active parameters are listed. It will be sufficient to highlight the legend and click on “edit scheme” in the toolbar.

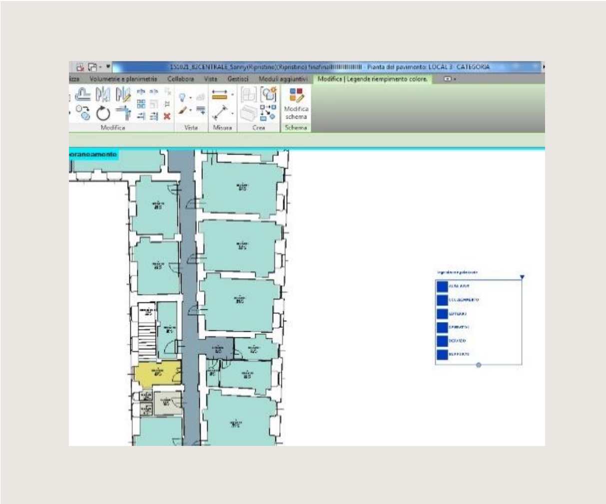


Figure 463: Edit room scheme

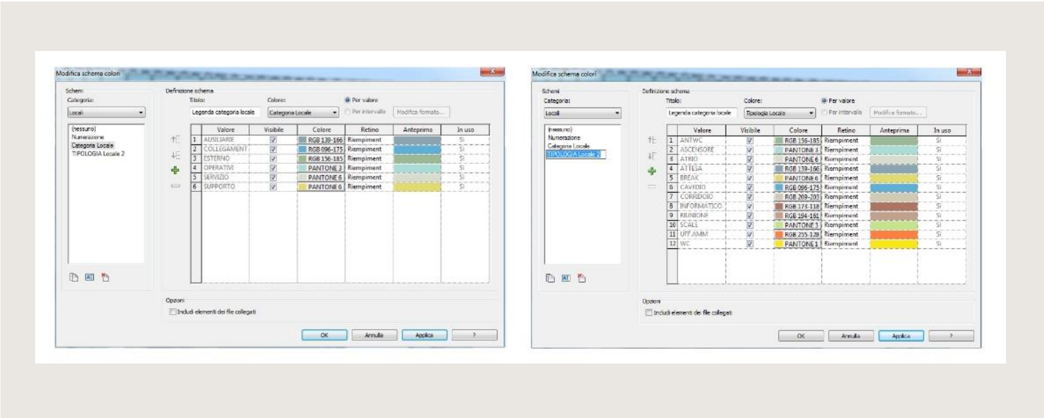


Figure 474: Room cataloging change

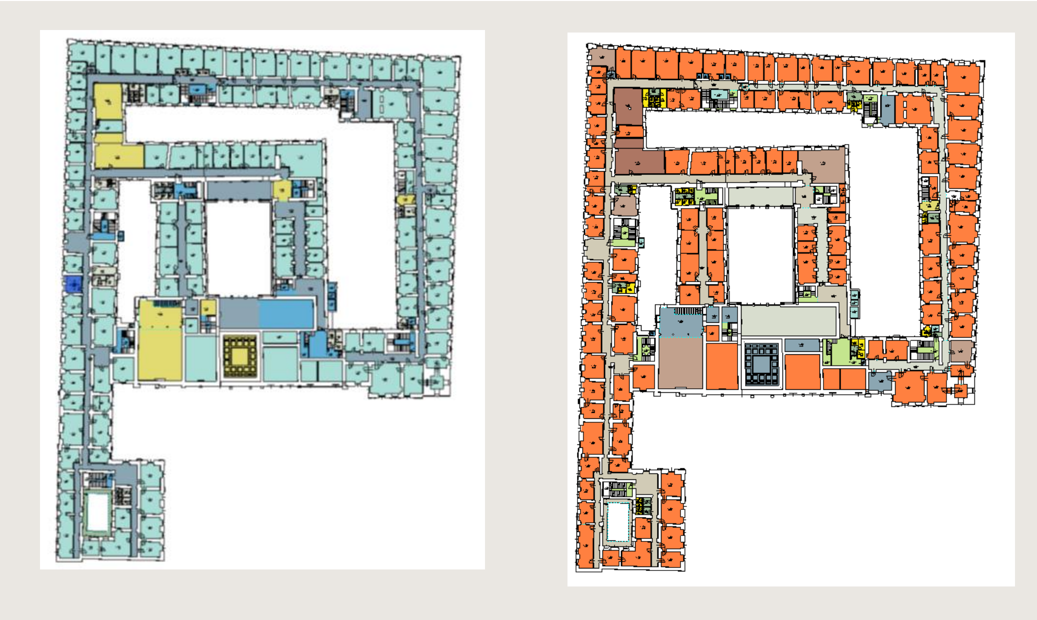


Figure 85: Thematic plan 04: Room Category, Room Typology

5.12 Definition of views

Once all the properties previously listed are defined, it is possible to proceed to the render stage, which is able to show the building in its entirety with high quality images. In addition to the standard images, which are defined in advance and constitute the working basis for the modeling, for example the floor plans, it may be ultimately possible to carry out particular views as axonometric sections, rendering of the internal parts in perspective and exterior views of the building as a whole.

This phase involves the setting up of cameras and environmental parameters, such as lights and shadows, the degree of cloud cover, the time of day and so on.

Revit also has an online rendering engine which avoids the complex and heavy calculations operations for the graphics card of the pc. This phase is run entirely by Autodesk360, a cloud service that can drastically reduce rendering times from many hours to few minutes.

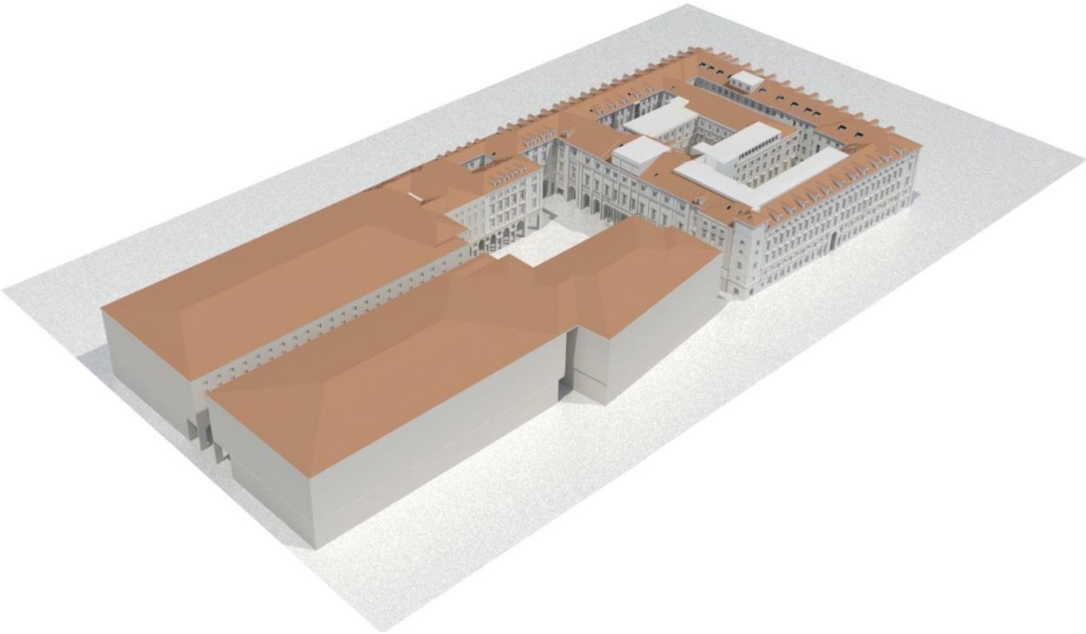


Figure 86: Perspective rendering of Palazzo di Città and its square and its surrounding buildings

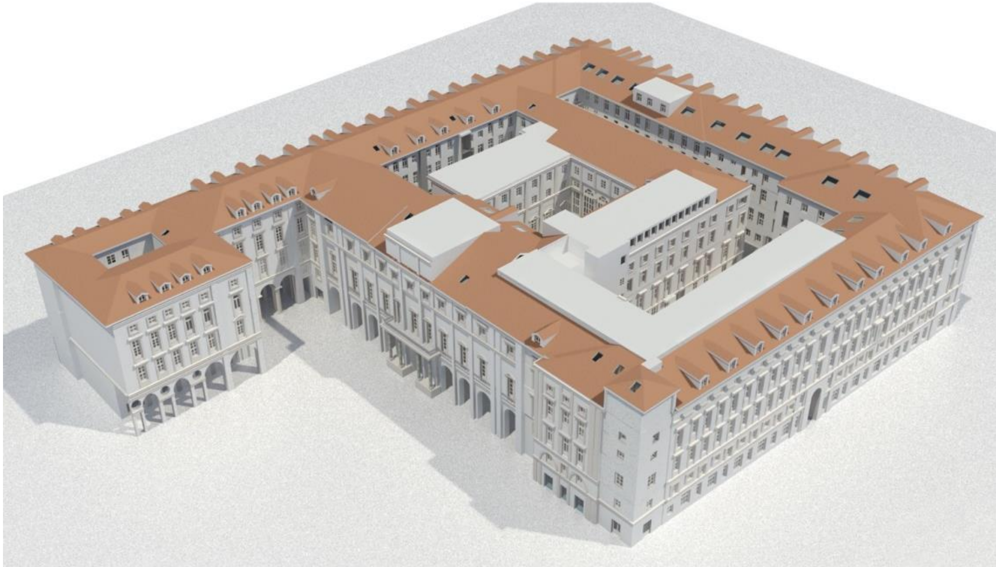


Figure 87: Perspective rendering of just Palazzo di Città

Figure 88: Rendering of the façade of the Palazzo di Città

Figure 89: Rendering of North elevation of Palazzo di Città

Figure 90: Rendering of west elevation of Palazzo di Città

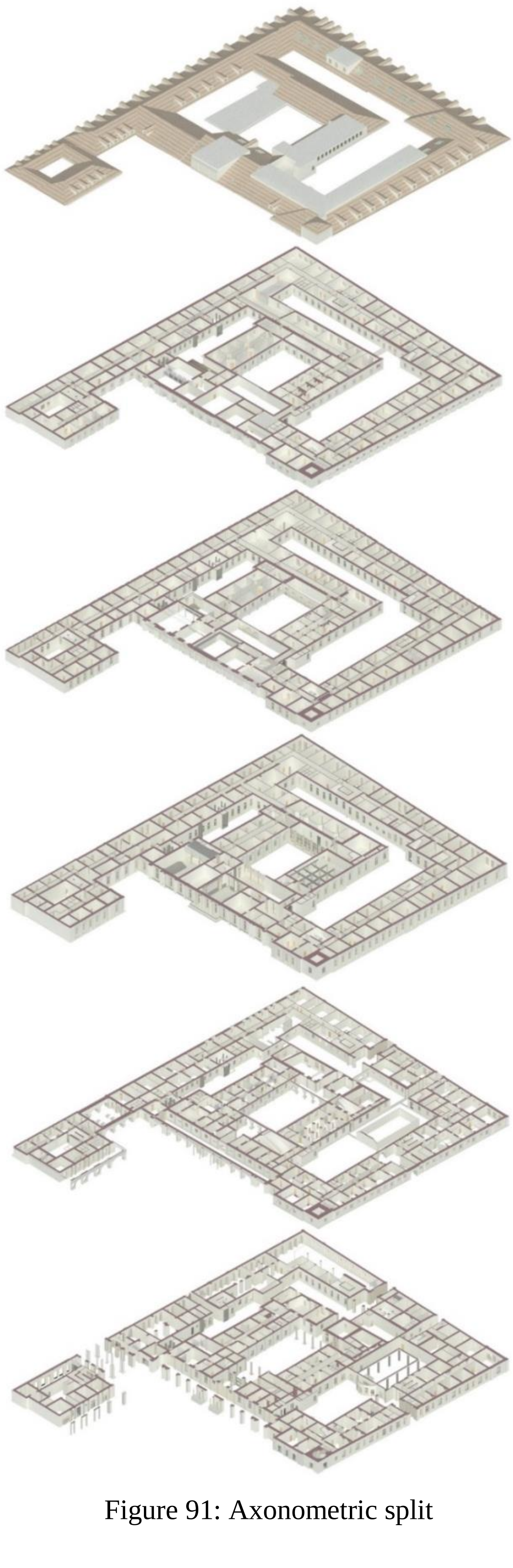


Figure 91: Axonometric split

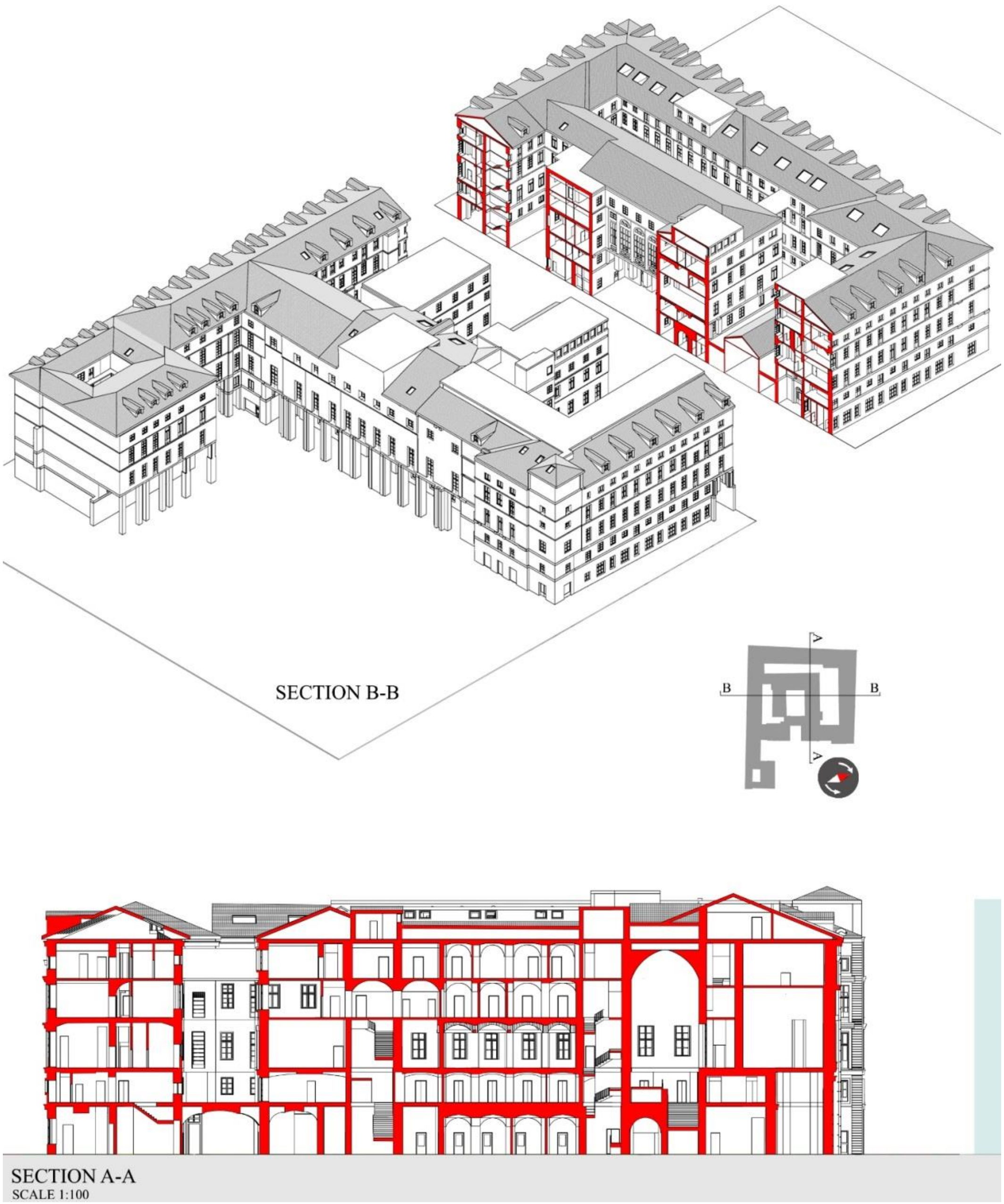


Figure 92: Transversal and longitudinal section (A-B)

5.13 Use of the schedules

As previously mentioned, the schedules constitute one of the Revit tools, fundamental in the optimization and acceleration of the operations relating to the computation of the elements, facilitating in parallel the subsequent management activities of the building.

Furthermore, it is possible to use schedules as any other view in Revit, making changes on the already modelled elements from the tables, which are in fact connected to the two-dimensional and three-dimensional views. Intervening for example in the schedule of the walls, it is possible to change the size, the height or thickness of an internal partition, simply by changing the family of the listed wall.

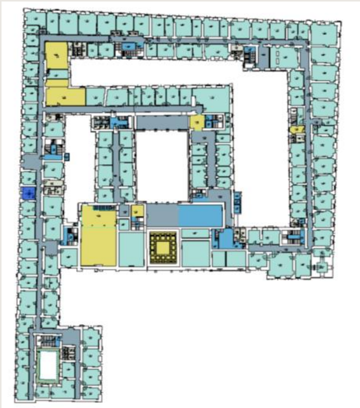
Once the modeling phase is completed, schedules become precious allies for Facility Management: programmed and manageable activities which can be executed in the virtual model thanks to the introduction of specific parameters inside the elements or the insertion of control instruments based on formulas. In this way it is possible to carry out management activities of the rooms, ensuring an optimal exploitation of the areas or making sure that rooms comply with the regulations. Taking advantage of the tools provided by the shared parameters applied to the rooms, it is possible to create both schedules and thematic plans that accelerate the reading of different information.

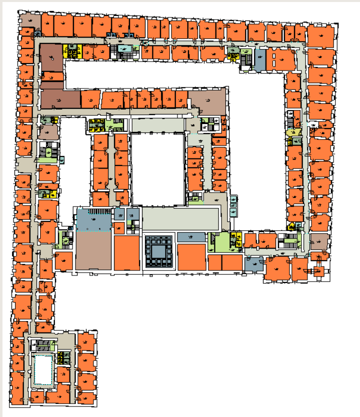
Thanks to interoperability, these lists can be exported to other dedicated software, implementing the FM and performing specific analyzes through more accurate instruments.

The goal of inserting rooms was to get a thematic plan like the one shown in the figure 92, in which is possible to see the different rooms whose different colors identify the different typology and category of the spaces of the Turin City Hall.

The piece of the room schedule shown below contains all the required information that the user created and associated with each instance through the use of shared and project parameters, directly linking the schedules with the thematic plans.

The following images are examples of the schedules created inside the model.





<Abaco dei locali>							
A	B	C	D	E	F	G	H
Livello	Codice Loc	Utilizzo Locale	Categoria Locale	Tipologia Locale	Direzione	Area	Volume
LOCAL 3- CATEGO	074	AREA DI LAVO	OPERATIVI	UFF.AMM		30.91 m²	101.94 m³
LOCAL 3- CATEGO	075	AREA DI LAVO	OPERATIVI	UFF.AMM		7.07 m²	23.98 m³
LOCAL 3- CATEGO	076	AREA DI LAVO	OPERATIVI	UFF.AMM		12.18 m²	40.93 m³
LOCAL 3- CATEGO	077	AREA DI LAVO	OPERATIVI	UFF.AMM		2.96 m²	9.73 m³
LOCAL 3- CATEGO	078	AREA DI LAVO	OPERATIVI	UFF.AMM		35.45 m²	121.65 m³
LOCAL 3- CATEGO	079	AREA DI LAVO	OPERATIVI	UFF.AMM		25.56 m²	81.37 m³
LOCAL 3- CATEGO	080	AREA DI LAVO	OPERATIVI	UFF.AMM		25.09 m²	82.90 m³
LOCAL 3- CATEGO	081	AREA DI LAVO	OPERATIVI	UFF.AMM		23.12 m²	73.52 m³
LOCAL 3- CATEGO	082	AREA DI LAVO	OPERATIVI	UFF.AMM		22.58 m²	74.71 m³
LOCAL 3- CATEGO	083	AREA DI LAVO	OPERATIVI	RIUNIONE		23.34 m²	77.06 m³
LOCAL 3- CATEGO	084	AREA DI LAVO	OPERATIVI	UFF.AMM		12.03 m²	38.31 m³
Non posizionato	085	AREA DI LAVO	OPERATIVI	UFF.AMM		Non posizionato	Non posizionato
LOCAL 3- CATEGO	086	AREA DI LAVO	OPERATIVI	UFF.AMM		29.35 m²	90.49 m³
LOCAL 3- CATEGO	087	AREA DI LAVO	OPERATIVI	UFF.AMM		45.59 m²	148.02 m³
LOCAL 3- CATEGO	088	AREA DI LAVO	OPERATIVI	ATTESA		20.72 m²	75.64 m³
LOCAL 3- CATEGO	089	AREA DI LAVO	OPERATIVI	UFF.AMM		35.54 m²	129.02 m³
LOCAL 3- CATEGO	090	SERVIZI ALL E	SERVIZIO	WC		3.83 m²	11.48 m³

Figure 483: Visualization of room in schematic and tabular form (top left refers to category/ top right refers to typology)

<Abaco delle finestre>																
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Famiglia	Tipo	Da locale: Livello	Da locale: Codice	Altezza	Larghezza	Altezza cassonett	Altezza sottofines	Numero divisori ori	Numero divisori ve	Profondità casson	Spessore max divi	Spessore max divi	Spessore min divi	Spessore min divi	Spessore montant	Spessore montant
W598	W598	0		3.12	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.09	0.09
W599	W599	0		3.25	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.04	0.04
W600	W600	0		1.57	1.40	0.00	1.10	3	1	0.00	0.04	0.13	0.04	0.13	0.14	0.14
W601	W601	0		1.95	1.40	0.00	1.10	2	1	0.00	0.06	0.14	0.06	0.14	0.10	0.10
W602	W602	0		2.60	1.40	0.00	1.10	1	0	0.00	0.07	0.14	0.07	0.14	0.06	0.06
W602	W602	0		2.60	1.40	0.00	1.10	1	0	0.00	0.07	0.14	0.07	0.14	0.06	0.06
W604	W604	0		2.66	1.40	0.00	1.10	2	1	0.00	0.15	0.12	0.07	0.12	0.06	0.06
W607	W607	0		2.77	1.40	0.00	1.10	2	1	0.00	0.15	0.12	0.07	0.12	0.04	0.04
W1414	W1414	0		2.88	1.40	0.00	1.10	4	1	0.00	0.30	0.14	0.05	0.14	0.13	0.13
W 405	W 405	0		1.70	1.40	0.00	1.10	1	0	0.00	0.07	0.14	0.07	0.14	0.15	0.15
W 407	W 407	0		1.91	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.18	0.19
W 407	W 407	0		1.91	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.18	0.19
W 418	W 418	0		3.03	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.28	0.27
W 427	W 427	0		2.59	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.05	0.05
W 428	W 428	0		2.51	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.07	0.07
W 428	W 428	0		2.51	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.07	0.07
W 429	W 429	0		2.32	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.04	0.04
W 431	W 431	0		2.49	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.16	0.15
W 432	W 432	0		1.48	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.12	0.11
W 434	W 434	0		2.30	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.05	0.02
W 435	W 435	0		2.30	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.03	0.04
W 438	W 438	0		1.92	1.40	0.00	1.10	2	1	0.00	0.06	0.14	0.06	0.14	0.14	0.14
W 438	W 438	0		1.92	1.40	0.00	1.10	2	1	0.00	0.06	0.14	0.06	0.14	0.14	0.14
W 438	W 438	0		1.92	1.40	0.00	1.10	2	1	0.00	0.06	0.14	0.06	0.14	0.14	0.14
W 470	W 470	0		6.95	1.40	0.00	1.10	4	2	0.00	0.36	0.23	0.61	0.16	0.11	2.68
W 475	W 475	0		6.54	1.40	0.00	1.10	5	2	0.00	0.18	0.12	0.12	0.12	0.10	0.10
W 475	W 475	0		6.54	1.40	0.00	1.10	5	2	0.00	0.18	0.12	0.12	0.12	0.10	0.10
W 494	W 494	0		2.63	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.07	0.07
W 496	W 496	0		2.80	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.07	0.07
W 497	W 497	0		2.82	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.04	0.05
W 497	W 497	0		2.82	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.04	0.05
W 499	W 499	0		2.65	1.40	0.00	1.10	2	2	0.00	0.19	0.16	0.05	0.10	0.15	0.18
W 499	W 499	0		2.65	1.40	0.00	1.10	2	2	0.00	0.19	0.16	0.05	0.10	0.15	0.18
W 503	W 503	0		4.40	1.40	0.00	1.10	2	2	0.00	0.26	0.44	0.05	0.44	0.26	0.21
W 513	W 513	0		2.63	1.40	0.00	1.10	1	1	0.00	0.09	0.14	0.09	0.14	0.13	0.13
W 514	W 514	0		2.63	1.40	0.00	1.10	1	1	0.00	0.05	0.14	0.05	0.14	0.09	0.09
W 515	W 515	0		2.63	1.40	0.00	1.10	1	1	0.00	0.05	0.14	0.05	0.14	0.09	0.09
W 516	W 516	0		2.54	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.04	0.04
W 522	W 522	0		3.70	1.40	0.00	1.10	1	2	0.00	0.36	0.23	0.61	0.16	0.11	0.10
W 544	W 544	0		2.80	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.10	0.10
W 549	W 549	0		3.10	1.40	0.00	1.10	2	1	0.00	0.13	0.13	0.13	0.07	0.12	0.04
W 551	W 551	0		3.70	1.40	0.00	1.10	1	1	0.00	0.13	0.14	0.13	0.14	0.16	0.16
W 551	W 551	0		3.70	1.40	0.00	1.10	1	1	0.00	0.13	0.14	0.13	0.14	0.16	0.16
W 558	W 558	0		1.74	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.05	0.05
W 562	W 562	0		3.63	1.40	0.00	1.10	0	1	0.00	0.04	0.14	0.00	0.14	0.09	0.09
W 562	W 562	0		3.63	1.40	0.00	1.10	0	1	0.00	0.04	0.14	0.00	0.14	0.09	0.09
W 562	W 562	0		3.63	1.40	0.00	1.10	0	1	0.00	0.04	0.14	0.00	0.14	0.09	0.09
W 563	W 563	0		3.62	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.07	0.07
W 568	W 568	0		3.64	1.40	0.00	1.10	0	0	0.00	0.04	0.14	0.00	0.14	0.08	0.08
W 571	W 571	0		3.50	1.40	0.00	1.10	1	1	0.00	0.22	0.14	0.22	0.14	0.15	0.15

Figure 494: Schedule of the windows

<Abaco dei muri>

A	B	C	D	E	F	G	H	I
Famiglia	Tipo	Funzione	Larghezza	Lunghezza	Volume	Coefficiente di scambio termico (U)	REI	Esposizione
Muro di base	EXT_75 cm_ma	Esterno	0.75	0.34	0.87 m^3	1.1909 W/(m^2·K)		OVEST
Muro di base	EXT_65 cm_ma	Esterno	0.65	0.20	0.44 m^3	1.3725 W/(m^2·K)		OVEST
Muro di base	EXT_50 cm_ma	Esterno	0.50	0.17	0.28 m^3	1.7797 W/(m^2·K)		OVEST
Muro di base	EXT_75 cm_ma	Esterno	0.75	0.44	2.67 m^3	1.1909 W/(m^2·K)		NORD
Muro di base	EXT_40 cm_ma	Esterno	0.40	3.69	5.44 m^3	2.2183 W/(m^2·K)		SUD
Muro di base	EXT_65 cm_ma	Esterno	0.65	0.80	1.77 m^3	1.3725 W/(m^2·K)		SUD
Muro di base	EXT_75 cm_ma	Esterno	0.75	2.72	0.73 m^3	1.1909 W/(m^2·K)		EST
Muro di base	EXT_15 cm_ma	Esterno	0.15	1.30	0.58 m^3	5.7798 W/(m^2·K)		EST
Muro di base	EXT_15 cm_ma	Esterno	0.15	1.74	0.51 m^3	5.7798 W/(m^2·K)		EST
Muro di base	EXT_65 cm_ma	Esterno	0.65	1.82	2.74 m^3	1.3725 W/(m^2·K)		NORD
Muro di base	EXT_75 cm_ma	Esterno	0.75	1.09	3.46 m^3	1.1909 W/(m^2·K)		OVEST
Muro di base	EXT_85cm_mat	Esterno	0.85	37.16	68.61 m^3	1.0518 W/(m^2·K)		EST
Muro di base	EXT_100 cm_m	Esterno	1.00	81.07	173.48 m^3	0.8949 W/(m^2·K)		SUD
Muro di base	EXT_95cm_mat	Esterno	0.95	12.49	31.73 m^3	0.9417 W/(m^2·K)		EST
Muro di base	EXT_90cm_mat	Esterno	0.90	9.10	19.22 m^3	0.9937 W/(m^2·K)		NORD
Muro di base	EXT_65 cm_ma	Esterno	0.65	0.64	0.85 m^3	1.3725 W/(m^2·K)		OVEST
Muro di base	EXT_65 cm_ma	Esterno	0.65	0.66	0.98 m^3	1.3725 W/(m^2·K)		OVEST
Muro di base	EXT_65 cm_ma	Esterno	0.65	0.66	1.00 m^3	1.3725 W/(m^2·K)		EST
Muro di base	EXT_65 cm_ma	Esterno	0.65	0.66	0.92 m^3	1.3725 W/(m^2·K)		EST
Muro di base	EXT_65 cm_ma	Esterno	0.65	0.66	1.00 m^3	1.3725 W/(m^2·K)		EST
Muro di base	EXT_65 cm_ma	Esterno	0.65	9.36	17.07 m^3	1.3725 W/(m^2·K)		NORD
Muro di base	EXT_83 cm_ma	Esterno	0.83	8.70	15.66 m^3	1.0769 W/(m^2·K)		EST
Muro di base	EXT_70 cm_ma	Esterno	0.70	13.02	19.52 m^3	1.2753 W/(m^2·K)		EST
Muro di base	EXT_55 cm_ma	Esterno	0.55	3.70	4.92 m^3	1.6195 W/(m^2·K)		OVEST
Muro di base	EXT_95cm_mat	Esterno	0.95	14.62	40.29 m^3	0.9417 W/(m^2·K)		OVEST
Muro di base	EXT_30 cm_ma	Esterno	0.30	1.42	1.45 m^3	2.9439 W/(m^2·K)		EST
Muro di base	EXT_120 cm_m	Esterno	1.20	3.80	10.38 m^3	0.7464 W/(m^2·K)		EST
Muro di base	EXT_55 cm_ma	Esterno	0.55	0.80	0.37 m^3	1.6195 W/(m^2·K)		EST
Muro di base	EXT_55 cm_ma	Esterno	0.55	0.58	0.43 m^3	1.6195 W/(m^2·K)		NORD
Muro di base	EXT_80cm_mat	Esterno	0.80	2.33	6.07 m^3	1.1170 W/(m^2·K)		NORD
Muro di base	EXT_25 cm_ma	Esterno	0.25	1.34	1.09 m^3	3.5196 W/(m^2·K)		NORD
Muro di base	EXT_80cm_mat	Esterno	0.80	5.35	13.27 m^3	1.1170 W/(m^2·K)		NORD
Muro di base	EXT_140cm_m	Esterno	1.40	0.71	2.18 m^3	0.6402 W/(m^2·K)		SUD
Muro di base	EXT_70 cm_ma	Esterno	0.70	0.18	0.43 m^3	1.2753 W/(m^2·K)		SUD
Muro di base	EXT_60 cm_ma	Esterno	0.60	0.60	1.22 m^3	1.4858 W/(m^2·K)		SUD
Muro di base	EXT_50 cm_ma	Esterno	0.50	1.18	2.00 m^3	1.7797 W/(m^2·K)		SUD
Muro di base	EXT_70 cm_ma	Esterno	0.70	0.64	1.52 m^3	1.2753 W/(m^2·K)		SUD
Muro di base	EXT_80cm_mat	Esterno	0.80	0.62	1.69 m^3	1.1170 W/(m^2·K)		SUD
Muro di base	EXT_70 cm_ma	Esterno	0.70	0.32	0.76 m^3	1.2753 W/(m^2·K)		SUD
Muro di base	EXT_83 cm_ma	Esterno	0.83	0.60	1.69 m^3	1.0769 W/(m^2·K)		SUD
Muro di base	EXT_70 cm_ma	Esterno	0.70	0.68	1.62 m^3	1.2753 W/(m^2·K)		SUD
Muro di base	EXT_35 cm_ma	Esterno	0.35	1.29	1.53 m^3	2.5301 W/(m^2·K)		SUD
Muro di base	EXT_70 cm_ma	Esterno	0.70	0.58	1.38 m^3	1.2753 W/(m^2·K)		SUD
Muro di base	EXT_80cm_mat	Esterno	0.80	1.05	4.47 m^3	1.1170 W/(m^2·K)		SUD
Muro di base	EXT_120 cm_m	Esterno	1.20	3.01	6.38 m^3	0.7464 W/(m^2·K)		EST
Muro di base	EXT_140cm_m	Esterno	1.40	0.64	3.05 m^3	0.6402 W/(m^2·K)		EST
Muro di base	EXT_30 cm_ma	Esterno	0.30	1.60	1.63 m^3	2.9439 W/(m^2·K)		EST
Muro di base	EXT_120 cm_m	Esterno	1.20	0.76	4.23 m^3	0.7464 W/(m^2·K)		EST
Muro di base	EXT_55 cm_ma	Esterno	0.55	4.44	3.84 m^3	1.6195 W/(m^2·K)		SUD
Muro di base	EXT_120 cm_m	Esterno	1.20	0.63	4.04 m^3	0.7464 W/(m^2·K)		EST
Muro di base	EXT_60 cm_ma	Esterno	0.60	0.75	0.30 m^3	1.4858 W/(m^2·K)		EST
Muro di base	EXT_80cm_mat	Esterno	0.80	18.16	38.31 m^3	1.1170 W/(m^2·K)		SUD

Figure 95: Schedule of the walls

<Abaco masse>			
A	B	C	D
Area complessiva superficie	Famiglia e tipo	Famiglia	Volume complessi
	Massa 2: Massa 2	Massa 2	
25436.99 m²	Massa 1: Massa 1	Massa 1	34302.27 m³
7035.35 m²	Massa flusso 1: Massa flusso 1	Massa flusso 1	12613.63 m³
5017.42 m²	Massa flusso 2: Massa flusso 2	Massa flusso 2	11351.42 m³
9014.15 m²	Massa flusso 3: Massa flusso 3	Massa flusso 3	13595.24 m³
8957.03 m²	Massa flusso4: Massa flusso4	Massa flusso4	13653.38 m³
9344.12 m²	Massa flusso 5: Massa flusso 5	Massa flusso 5	15276.60 m³
4210.65 m²	Massa flusso8: Massa flusso8	Massa flusso8	7505.22 m³
9012.13 m²	Massa flusso6: Massa flusso6	Massa flusso6	15457.57 m³
1236.12 m²	Massa flusso 9: Massa flusso 9	Massa flusso 9	1682.88 m³
8410.58 m²	Massa flusso 7: Massa flusso 7	Massa flusso 7	11807.15 m³
2476.97 m²	Massa 3: Massa 3	Massa 3	3949.37 m³
3176.75 m²	Massa 4: Massa 4	Massa 4	4891.92 m³
2910.69 m²	Massa 5: Massa 5	Massa 5	4756.65 m³
1896.78 m²	Massa 6: Massa 6	Massa 6	3071.87 m³
1648.38 m²	Massa 7: Massa 7	Massa 7	2569.83 m³
1059.48 m²	Massa 8: Massa 8	Massa 8	1662.55 m³
1180.13 m²	Massa 9: Massa 9	Massa 9	1876.56 m³
5222.27 m²	Massa 10: Massa 10	Massa 10	6486.77 m³
2290.62 m²	Massa 11: Massa 11	Massa 11	2761.24 m³
3389.60 m²	Massa 12: Massa 12	Massa 12	4210.06 m³
1139.05 m²	Massa 13: Massa 13	Massa 13	1435.00 m³
85.91 m²	Massa 14: Massa 14	Massa 14	44.58 m³
132.16 m²	Massa 16: Massa 16	Massa 16	46.25 m³
12817.26 m²	Massa 15: Massa 15	Massa 15	36885.46 m³
4691.69 m²	Massa 17: Massa 17	Massa 17	11703.64 m³
1350.81 m²	Massa 18: Massa 18	Massa 18	3120.81 m³
71.15 m²	Massa 19: Massa 19	Massa 19	12.09 m³
3109.00 m²	Massa 20: Massa 20	Massa 20	8858.74 m³
1280.04 m²	Massa 21: Massa 21	Massa 21	2747.30 m³
1253.17 m²	Massa 22: Massa 22	Massa 22	2957.94 m³
327.10 m²	Massa 23: Massa 23	Massa 23	258.77 m³
1221.88 m²	Massa 24: Massa 24	Massa 24	1213.20 m³
729.35 m²	Massa 25: Massa 25	Massa 25	760.65 m³
141.57 m²	Massa 26: Massa 26	Massa 26	112.09 m³
190.78 m²	Massa 27: Massa 27	Massa 27	165.42 m³
141467.11 m²			243804.13 m³

Figure 96: Schedule of the masses

Chapter 6

Chapter 6

Management of a building design and control process

6.1 Introduction to Facility Management

The term Facility Management means the integrated management of services dedicated to space (space planning), people (caretaking, cleaning, porterage) and things (plants), that do not fall in the core business[22] of an organization, i.e. all those activities necessary to the operational maintenance of the building and the optimization of the related work. The IFMA argues that "the business discipline that coordinates the physical space of work with human resources and the company's own activities." "Integrate the principles of economic and financial management of business, architecture and the behavioral and engineering sciences"[23]. The IFMA - Italy has identified three main areas in which it is possible to classify each of the FM activities: building, space and people services:

- Services to the building: it consists of ordinary and extraordinary maintenance activities to be performed for the maintenance of the structure and property plants. These services are aimed at maintaining the continuity of the building operation - real "container" of the

[22] The company's core business is the main enterprise activities of an operational nature which determines the fundamental task in charge for the purpose of creating a turnover and a consequent gain. Usually the core business is supported by other business activities that determine the organization, planning, the strategy and the tools with which the same company is committed to its fundamental task.

[23] IFMA Italy is the Italian Chapter of the International Facility Management Association, a non-profit association founded in 1980 in the United States in order to promote and develop the Facility Management, discipline defined as the management strategy of operating property company and services to the basis of the business, divided into building services, space and people.

company's activities - ensuring compliance with health and safety rules of the workplace as well as the rational use of energy resources.

- Services to the space: the purpose of this macro-areas is the optimization of the workspace in its value creation, communication, socialization and creation and circulation of knowledge functions. This are therefore very complex services to be organized, but essential to the working of the company and its users.
- Services to the people: in this vast macro-area are located catering, document management, reception, environmental health, security, etc. The purpose of these activities is to increase the workers' comfort, with a view to increasing of productivity but also to the loyalty of company employees.

The Facility Management is therefore a real design process, which is developed through the identification of "facilities" (buildings and services necessary for the company survival and productivity), their planning and delivery in the building. Of course, in this process, are considered the benefits in economic terms and the investment that these facilities involve, so as to optimize the expenses necessary to the increase of the working environment quality.

These activities, if carried out correctly and through the use of digital database, also allow the company to adapt to rapid changes in market, reorganizing the interior with the lowest possible consumption of resources.

The FM is characterized by three main aspects: strategic, analytical and managerial- operational.

The strategic aspect concerns all decisions on the management policy and services retrieval, the distribution of resources to be used to support corporate objectives (preparation and management of the budget, allocation of costs, etc.), the choice of supplier, etc.

The analytical aspect identifies the needs of the Internal Clients relating to services, by monitoring the effects and quality of the results of the operations that have been carried out, evaluating the efficiency in service delivery and identifying possible new techniques and technologies in support of the company. This area is the most linked to the company's core business and is the main means by which the FM contributes to the achievement of the company.

The managerial-operational aspect gives the view of all the services taken as a whole and it is necessary to ensure an optimal coordination: these activities are necessary to define the systems and procedures in addition to the delivery processes implementation and reengineering.

The first two areas are strategic for the company, those to which the Facility Manager dedicates more time and energy; the Facility Manager is a professional with a high level of managerial skills, with a profound knowledge of corporate strategies and objectives in order to organize the internal activities making it possible to adapt to changes with no loss of productivity. The tasks carried out within a day from the Facility Manager are often integrated with one another:

- Relational and decision-making activities, i.e. meetings with the Top Management and / or with the Manager of the different Business Units. In such moments, strategies and management policies of the facility as well as associated service needs are identified and defined.
- Economic and financial management, in which the economic aspects of the services to be performed are evaluated (expenditure forecasts, drafting budgets, benchmarking, analysis of budget-balance deviations, definition of cost sharing mode and so on.)
- Control, the final phase of the process in which the operating results are analyzed and the quality of services is monitored. In this phase, the used instruments are reports provided by the service providers and direct inspections visits.

Figure 97: Classification of each FM activities

6.2 The market of Facility Management in Italy

In Italy there are three types of operators that the market makes available to companies wanting to implement the Facility Management:

Single and multi-service providers: they develop a relationship based on individual performance, delivering one or more services exclusively in their operational part. It is the most common figure in our economic landscape, and this category includes many companies that provide high-labor content, such as cleaning, but also those with a high technological content, such as maintenance. Both small businesses and large ones use such services; this situation has engendered providers operating locally or, in the case of larger operators at a national level, usually acquiring a sub-supplier role. In addition, many single service companies are growing by size, often through mergers or acquisitions, to increase their economic weight on the market.

Managers of specific services: these are specialists in the management of a specific service able to provide an integrated service, starting from delivery until the reporting for control phases. These companies, thanks to this structure, usually mature more quickly strong skills and expertise, resulting particularly competitive on market.

6.3 Management of the building through the Revit software

In conclusion, schedules allow the elimination of those long phases of components and spaces lists filling, quickly providing all data necessary to costs estimate, a particularly long and monotonous activity. The Facility Manager can resort to Revit as an integrated three-dimensional database, where updating ease combines with the information visualization immediacy and clarity through intuitive and complete graphics. Through the use of Archibus, or other FM software, the Facility Manager of Turin Public Administration will be able to query the digital database inside the BIM model.

Chapter 7

Chapter 7

Virtual and augmented reality in BIM (ex: interoperability between parametric software)

7.1 Introduction to Virtual and Augmented Reality

In the current commercial world, the product communication cannot be separated from the image itself; for this reason, companies have developed tools, methods and increasingly complex strategies, varied and effective, incredibly diversifying the methods of presentation of the goods in order not to ever prove banal. In the advertising world often innovative and forefront communication modes are used, aiming at the involvement of the consumer, making the good to sell a "familiar" and reassuring object.

Virtual Reality (VR) and Augmented Reality (AR) technologies are nowadays among the most adopted and rapidly developing, especially in the architecture sphere. This section will therefore examine them in depth, identifying their links with BIM and their potentialities in the different areas a building can be involved in.

7.2 Virtual Reality Definition and areas of application

Virtual Reality stems from the necessity to faithfully "replicate" the reality, returning the visual, auditory and, in more advanced cases, even the tactile and olfactory sensation, which one would naturally perceive physically being in a certain space, allowing the user a certain degree of interaction with the virtual space, by mitigating physical, economic and security limits. The Virtual Reality therefore consists in an artificial reality (or e-reality), realized through the computer in the form of virtual world whose purpose is to simulate the real space.

In more extreme cases, the goal is to persuade the user to believe to be in a real space, isolating him from the outside world through the use of specific devices and immersing him into the simulated environment. This involves the use of helmets with stereoscopic vision[24], motion detectors (motion tracking, or head tracking) and delta glove[25], i.e. gloves that can relate the user's movements with objects in the virtual world.

To get a deep credibility of the model, it is necessary to recreate the reactions of objects and things to certain actions, incorporating in the model the laws of physics, like gravity or the properties of water and other materials. This involves the use of software and devices that can perform real-time complicated numerical calculations, so that the movements and reactions of objects are as faithful as possible to reality.

In its most common form, the VR appears in the form of static or animated 3d models, with which it is possible to interact via very popular devices such as mouse, joysticks and keyboards. Therefore, communication has made extensive use of this technology in various fields, from security training, especially on particularly expensive and dangerous activities (flight simulators and driving), to entertainment (videogame), sales (presentations of objects or buildings in navigable and searchable 3d), medical field (simulations of surgeries and rehabilitation activities), culture and tourism (virtual museums)[26].

[24] http://www.realtavirtuale.net/

[25] http://www.wareable.com/vr/manus-machina-wireless-gloves-hand-tracking-oculus-rift-gear-vr-htc-vive-osvr-1517

[26] http://www.vrs.org.uk/virtual-reality/how-is-it-used.html

Figure 98: Using virtual reality in various areas

Virtual Reality also allows the reconstruction of lost or imaginary environments, providing a unique tool in intuitive communication of a place, a civility or a building history in tourism or educational fields. Not surprisingly, disciplines such as history, architecture and archeology, since the 90s, have become protagonists of numerous experiments of the VR application, rebuilding contexts no longer visible but imaginable from artifacts and reports from written sources.

7.3 Augmented Reality definition and areas of application

Augmented reality is a technology that connects the real world with virtual objects. This bridge is realized through devices capable of projecting virtual images by overlapping the real ones and synchronizing them in 3dimensions.

Therefore, augmented reality does not replace, but rather enriches the commonly perceived space, through the display of additional information linked to a real object, and made easily utilizable.

To achieve this action, the AR uses a combination of technologies: a camera, a computer and software for data processing and, finally, a viewer for displaying of images or videos overlapped on reality.

The devices commonly used to display the data are often simple tablet, mobile phones or computers that incorporate these technologies into a single element. The operating mechanism is actually very intuitive and involves the reading of the real context via the camera, in such a way as to identify the object the data are connected to. The AR software recognizes the object thanks to a symbol superimposed to it, a very simplified and easily identifiable by the software graphics called "marker". Once identified the marker, the software traces and renders the virtual images, projecting on the device screen the overlay of this layer of information on the real world.

The potential of this technology lies in the economy of the required tools, and in the high flexibility and adaptability to any type of application. This technology can definitely play an important role in increasing awareness and collective knowledge, with the now total circulation of devices such as tablets and smartphones.

Among the various fields of application in which the augmented reality has already been applied. It is possible to find a variety of areas, among which the medical, commercial, cultural and entertainment ones.

In the medical technology it is already widely used; just think of the simple withdrawal score sheet QR that allows to view 2d TAC or MRI previously produced images. The currently under development projects are intended to compensate some perceptual deficits for specific patient groups (blind ones in particular) or to facilitate the intervention of doctors and surgeons in diagnostic and intervention stages.

Figure 99: Using augmented reality in medical field

In the commercial sector, where it has been in recent years demonstrated the importance of the message rather than the object to sell itself, the QrCode are becoming more widespread due to the ability to make additional information available any time and in any place in the form of video or virtual images able to excite the target user.

Figure 100: Using augmented reality in commercial field

In the cultural field, a sector that has always exploited the potential of this technology, exhibitions and interactive audio guides have long-established, such as those experienced in Ubiquitous project Pompeii[27] or at the Ara Pacis[28].

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[27] http://artisopensource.net/pompeiAR/?page_id=49

[28] http://www.arapacis.it/servizi/news/ara_pacis_al_via_bando_per_valorizzazione_multimediale

Figure 101: Using augmented reality in cultural field

Other examples at landscape and urban level are represented by Wiki-tude and Layar: two interactive guides that show information on the mobile phone display by combining GPS, Internet, Compass and Camera.

In the end, the entertainment industry, the field where it is possible to highlight more freedom in testing of AR technology, has already made available to the whole world users some very popular applications: Shazam, for the recognition of music) or Google Earth, Navigator 3DX, Wikitude Android, Nokia City Lens, for satellite navigation and use of information on rest areas, activities and their opening hours.

Figure 502: Using augmented reality in entertainment field

7.4 Differences between Virtual Reality and Augmented Reality

The fundamental difference between Augmented and Virtual Reality consists in the concept of simulation used. Virtual reality leads us, through a more or less immersive system, to think of living a certain reality deceiving our senses; this reality is completely computer-generated. So the VR stands between us and the real world, breaking at several levels sensory communication with it and replacing it entirely with a fictional environment.

Augmented reality, on the contrary, takes advantage of the real world as the basis on which to add information layers. “Augmented” refers to the feeling of "enhancement" of perception, understood as an expansion of the information that we would normally perceive using our senses. This technology is achieved in each case creating virtual content which, exactly as in virtual reality, aims at providing visual, auditory and even olfactory and tactile data, integrating them in the commonly perceived real space.

The study of Milgram & Kishino, the Reality-Virtual Continuum (Continuous reality- Virtuality), illustrates the connection between Virtual Reality and Augmented Reality. The experiment conducted by the two scholars consists of a "mixed reality" in which graphics and additional text information are mixed, immersing the user in an environment where the real and the virtual are two indistinguishable entities. The effect is achieved thanks to handling of the displayed objects (both real and virtual) and their continuous and accurate synchronization using a powerful rendering engine.

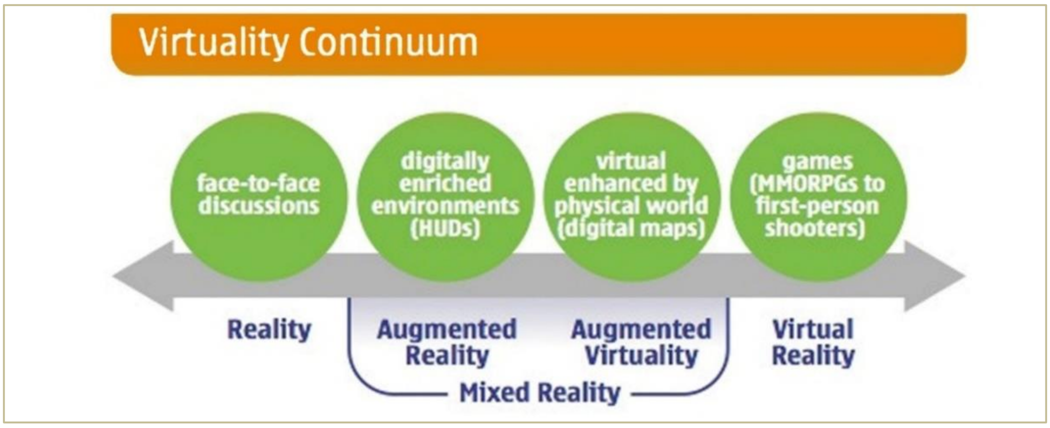


Figure 513: Continuous reality- Virtually

7.5 History of Virtual Reality and Augmented Reality

- 1957

Inventor H. Morton made the first successful attempt in the field of VR. The Sensorama Machine, the name of his most famous invention, a simulator that uses a 3-D motion picture with smell, stereo sound, vibrations of the seat, and wind in the hair to create the illusion of reality.

Figure 524: Sensorama Machine by H. Morton in 1957

- 1966

Harvard professor Ivan Sutherland and his student Bob Sproul, created the Human Mounted Display (HMD), the first real AR system integrating a small optical display on a helmet, covering one or both eyes. This system, called "the sword of Damocles" presented quite primitive interface and realism, since it simplified the rounding environment. Thanks to the marker on the head, the system could in fact interpret the position of the user and reproduce the prospect standing in front of his eyes.

Figure 5305: Human Mounted Display (HMD) by Ivan Sutherland in 1966

- 1975

Myron Krueger created Videoplace, an artificial reality surrounding the user and responding to his movements. The interactive environment was created through projectors, video cameras, special purpose hardware, and shapes of the screen. The system enabled interaction between users who were positioned in separate rooms of the laboratory. The first user's movement were recorded, analyzed and translated into graphical representations, and shown to the second user through environment simulation.

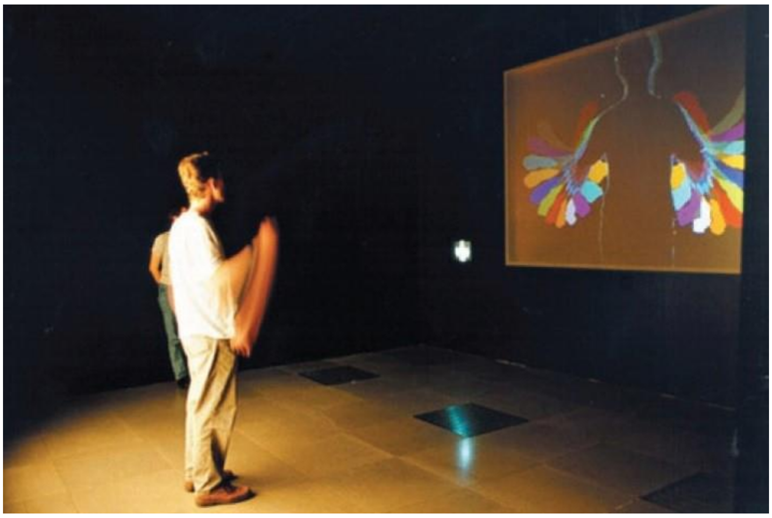


Figure 5406: Videoplace by Myron Krueger in 1975

- 1990

The term Augmented Reality was introduced for the first time by researcher of Boeing, Tom Caudell, in the description of a digital display used by aircraft maintainers. The system mixed virtual electronic graphics with a physical reality.

Figure 5507: Digital display by researcher of Boeing, Tom Caudell in 1990

- 1992

“Virtual Instrument (virtual fixture)” is the term coined by   to identify the overlap of abstract sensory information to a real a working space. Telepresence and remote handling are used in order to improve the execution of a task.

Figure 5608: Virtual fixture by LB Rosenberg in 1992

- 1994

Julie Martin made possible the interaction between her dancers and acrobats into a virtual world, giving life to Augmented Reality Theater Production.

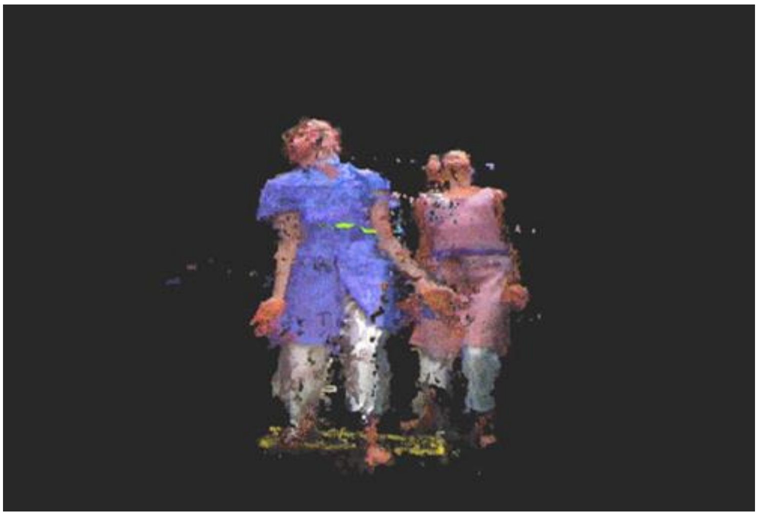


Figure 5709: Augmented Reality Theater Production by Julie Martin in 1994

- 1999

Hirokazu Kato created ARToolKit, a library which recognizes images and can be used in applications for augmented reality. This tool is currently supported on Android, and allows new and interesting AR applications in modern smartphones, Adobe Flash, that bring augmented reality in the web, and many other platforms.

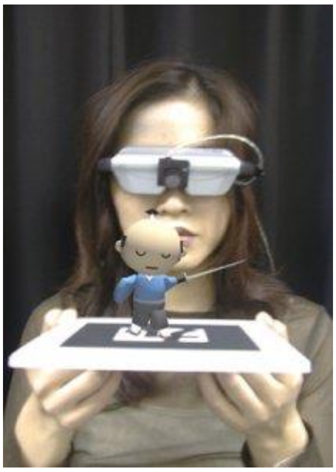


Figure 5810: ARToolKit by Hirokazu Kato in 1999

- 2002

The very first outdoor mobile augmented reality video game was released by Wearable Computer Lab demonstrated, thanks to his creator, Bruce Thomas.

The first game was called ARQuake and all you needed were a computer backpack and gyroscopes, enabling walk around without joysticks or handheld controllers. The view of the game was based on user's current physical location, enabled by this a head-mounted display.

Figure 5911: ARQuake by Bruce Thomas in 2002

- 2007

The first testing to interpret reality without any need of marker are made. These studies aimed to free AR from software to be installed on the computer, substituting them through simple smartphone application for augmented reality data visualization.

Figure 602: Augmented reality without marker in 2007

7.6 Augmented Reality and Virtual Reality in the architecture and cultural heritage

The use of AR and VR in architecture invested most of the activities in the building process: from the digitization of archival data, through the creation of virtual models for the simulation of the working environments to maintain, useful in the training phase of the technical staff employed in ordinary and extraordinary maintenance of complex systems. These technologies also represent the basis of the projects communication, in particular those of public interest, thanks to the ability to show future users the final appearance of the property that is intended to be accomplished.

As previously seen, AR and VR have constituted for some time two precious allies in the preservation of historic and artistic heritage, by binding to the tourism and developing its great economic potential.

This topic particularly affects the old continent and Italy in specific, given its history stretching back centuries and the inexhaustible amount of information and written and physical documentation, which unfortunately presents many management, degradation prevention and communication issues. The economic sustainability of the investments in this area is often linked to the management difficulties that are encountered in the maintenance of the assets and museums preserving their memory.

The very quick and constant development of information technology consistently provides new solutions to both facilitate search operations, and to develop new perspectives for the enhancement and preservation of this boundless asset.

In recent years, for example the BIM technology is increasingly imposing; thanks to its ability to manage heterogeneous information, and the cataloguing, quick consultation and improvement of the communication between different professionals ability, it now allows the creation of historical, architectural, plant and other database integrated into three-dimensional models. In this sense, the use of BIM in the field of protection of Historical Heritage is fairly recent and still experimental. In Milan it was realized a project that lasted eight years, regarding the modeling in BIM environment of certain parts of the Duomo, in order to organize maintenance and create virtual tours of inaccessible parts of the building.

The three-dimensional restitution of historic buildings can then become the basis for work on virtual and augmented reality projects, two innovative technologies whose development is making the immediate and effective display of any kind information more reasonable and sustainable.

Virtual reality can for example artificially reconstruct the lost environments by developing very realistic or even immersive graphic rendering, while the augmented reality, can definitely improve access to historical information which are often very complex to understand for the average user, making palpable and immediately usable the content of old and hardly procurable manuscripts.

In this sense it is possible to mention several examples, starting from the Italian ones. Among the most active entities we find the Visual Computing Lab[29] of Pisa belonging to the CNR (National Research Council)[30]. This laboratory, active since more than 25 years, has developed a number of projects regarding virtual museums such as the Tiber Valley and the Scrovegni Chapel of Giotto, virtual reconstructions as Estruscanning, Casal de 'Pazzi and Teramo Virtual City and in-depth virtual evocations like the fresco of the Basilica of Assisi, showing the hidden secrets of the pictorial technique of Giotto.

[29] The history of the Visual Computing Lab of CNR-ISTI began more than 25 years ago, with the friendship and collaboration of Claudio Montani (formerly CNR-IEI, now CNR-ISTI Director) and Roberto Scopigno (formerly CNR-CNUCE, now head of the VClab). http://vcg.isti.cnr.it/

[30] The Consiglio Nazionale delle Ricerche (CNR) or National Research Council, is an Italian public organization set up to support scientific and technological research. Its headquarters are in Rome.

Figure 613: Various virtual reconstructions of the CNR

The archaeological area is the one that has been able to exploit in the first place the potential of these technologies, reproducing civilizations and environments which are now lost. Another emblematic case study in this respect is the Golden House of Nero; destroyed, stripped of the rich coatings and buried by the emperor's successors, it was brought to light in the Renaissance and, thanks to the digs and restorations, carried on to the present day, it is now possible to admire it again in its original splendor thanks to a virtual rebuilding. Also at international level, the ICT has already become an integral part of cutting-edge tourist paths that use VR and AR to immerse visitors in suggestive and, at the same time, complete with information on the visited asset environments. The protection, in this case, rang from prestige buildings (Casa Batllo in Barcelona), in lost landscapes (Virtual Museum of the West Han Dynasty in Xian, China), with elements of ancient culture (the Virtual Paul's Cross Project, London)

The digitization of the Town Hall, although falling within a project related to the management of public heritage, offered the opportunity to apply the VR and AR in the protection of a complex and emblematic building as the seventeenth-century Town Hall of the City of Turin.

In the next chapter we will see how two of the best capabilities of these technologies were exploited to get the user excited and inform the actors involved in the protection of the good.

Figure 624: Casa Batllò, Barcellona

Figure 115: Virtual Paul’s Cross Project, London

Chapter 8

Chapter 8

Application of VR and AR on Palazzo di Città, its square and marble hall for displaying of intangible information

Town Hall, as seen in the historical introduction, has known various stages of expansion and significant upgrading to the needs of each era, from the late seventeenth century to the present day. The transformations, rather than consisting of additions, have often hidden the original Baroque style by drawing a veil of mystery over some rooms of the building.

We have touched upon the idea that, in the panorama of cultural heritage, there are many projects in which lost assets are brought to light thanks to the use of the most modern technology of scanning and three-dimensional visualization. The innovative element of the project investigated is the development of these technologies from a BIM base, taking advantage of the possibilities offered by interoperability between parametric software and those dedicated to AR and VR.

The goal of this work is in fact to provide the PA a tool that can support the activities required to ensure efficient use of the asset, safeguarding the history and the cultural elements that have made Town Hall one of the symbols of Turin.

In this regard, three areas of important interest have been identified in particular: tourism, maintenance and management of the building as office building.

To ensure the proper performance of such activities, it is necessary to communicate the asset peculiarities to all involved users. In this context, BIM fulfills the function of database, while the communication of the information contained in the parametric model is entrusted to specific AR and VR software. The development projects realized through this methodology are three:

- Communication in technical and tourism sector, through AR, of the evolution of the block on which the Palace is erected.
- Sharing of advanced techniques of vaults parametric modeling for energy analysis of historic buildings, by using of AR.

3. Virtual Tour of the Marble Hall, with related display in full immersion VR and guided narration of the Town Hall Square evolution.

In the following chapters we will analyze the techniques used to allow optimal and immediate views of all the intangible information related to the Palace and its history.

8.1 Application of Augmented Reality for Town Hall. Communication in technical and touristic field of the evolution of the block area on which the Palace is erected

From historical research carried out for modeling in the BIM environment of the Town Hall, has emerged a history as troubled as it is fascinating, that deviates greatly from the Renaissance municipal offices of cities like Milan or Florence. In fact, the Public Administration of Turin found a permanent establishment only in 1472, but the little economic autonomy brought about a need for comparison with the Dukes of Savoy and a slowdown of the development of the Municipality. The Palace, as seen, was built only in 1658, by the ducal architect Francesco Lanfranchi, and was in danger several times: the sieges that threatened the city of Turin, the economic crisis also due to the numerous wars of the XVII e XIX centuries and the Napoleonic army entering the capital of the Savoy State, had a negative impact on the municipality treasury, often making the original plant maintenance work difficult. In some rooms the degradation reached such an extent that a radical intervention was required, which did not always turn into a simple restoration, but rather, in some cases, a deeper transformation.

The history of the Town Hall, in this project, was then translated into intangible information within the three-dimensional model, associating each made element to its construction phase. The actors involved in the ordinary and extraordinary maintenance of the Palace will thus find all the necessary information for aware and respectful interventions, in the full knowledge of the used techniques and the historical period in which the environments were realized.

- Display in AR of the building evolution (AR-media - with AR marker)

The first experimental activity is directed to the touristic / historical field and aims to show the phases of construction and demolition of the block parts of the Palace, in the form of volumetric 3D.

To each year is associated a marker, i.e. a two-dimensional image similar to a QR code, which, framed by the camera of devices such as tablets and smartphones, allows to view a three-dimensional image of the Palace appearance at that particular moment in history.

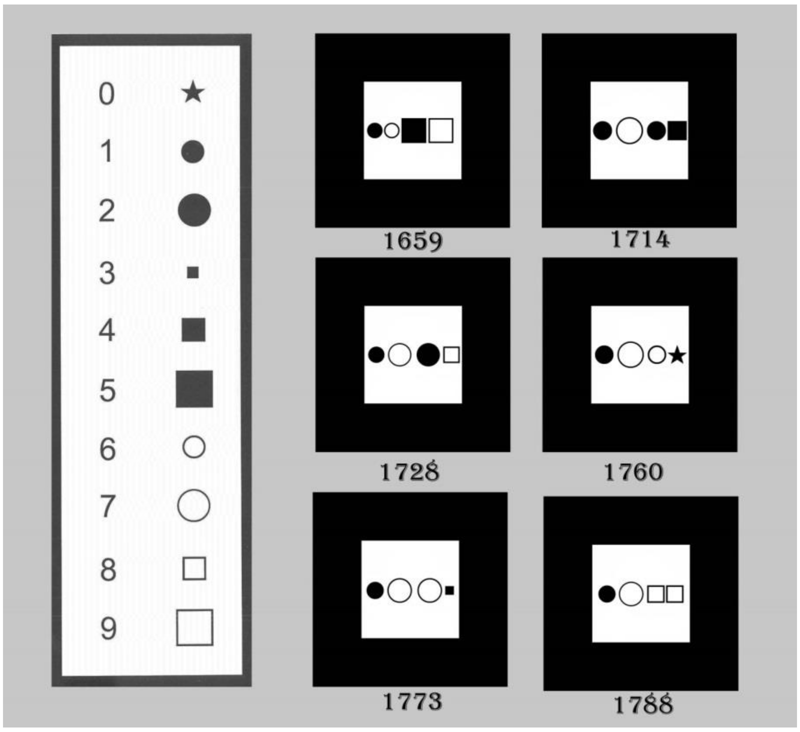


Figure 6316: Costumed marker refers to the phases of construction and demolition of the block parts of the palazzo di città

Entering into technical details, the software that was used in the visualization process of the building evolution was AR MEDIA[31], a plug-in for 3D Studio Max which enables the selection of certain views of the model and the creation of an associated marker.

To bring the parametric model from the BIM environment in 3DS Max was sufficient to export the masses we discussed in Chapter 10 in .fbx format (Filmbox). The interchange file, in the transferring from one software to another, however, loses the parametric data and information associated with individual elements.

[31] http://www.armedia.it/

Therefore an additional step was necessary for the association of materials. Each mass was in fact colored in yellow (for the demolition), red (for the construction) or gray (for the existing). Exemplifying the procedural scheme, the steps are as follows:

- Isolation of masses on Revit relating to a specific year, for example 1773

This operation is performed thanks to the filtering tools of Revit, which allow to select all elements on the basis of a shared parameter, in this case the year of realization inserted in the masses.

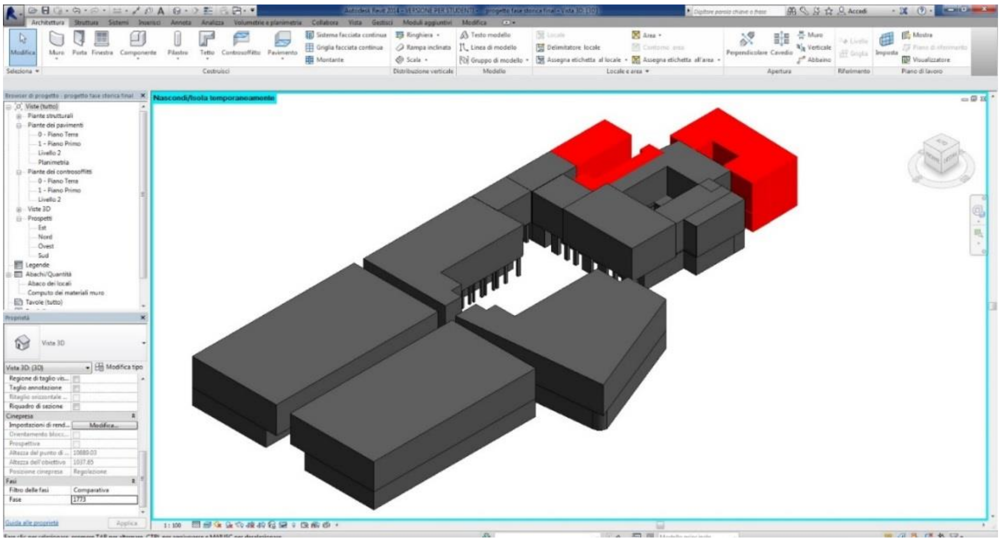


Figure 6417: Filtering of masses

- Exportation in .fbx format

This format is the only one that allows to exchange geometries between Revit and 3ds Max; the export phase does not require the use of dedicated plug-in, as it is already a basic function of Revit.

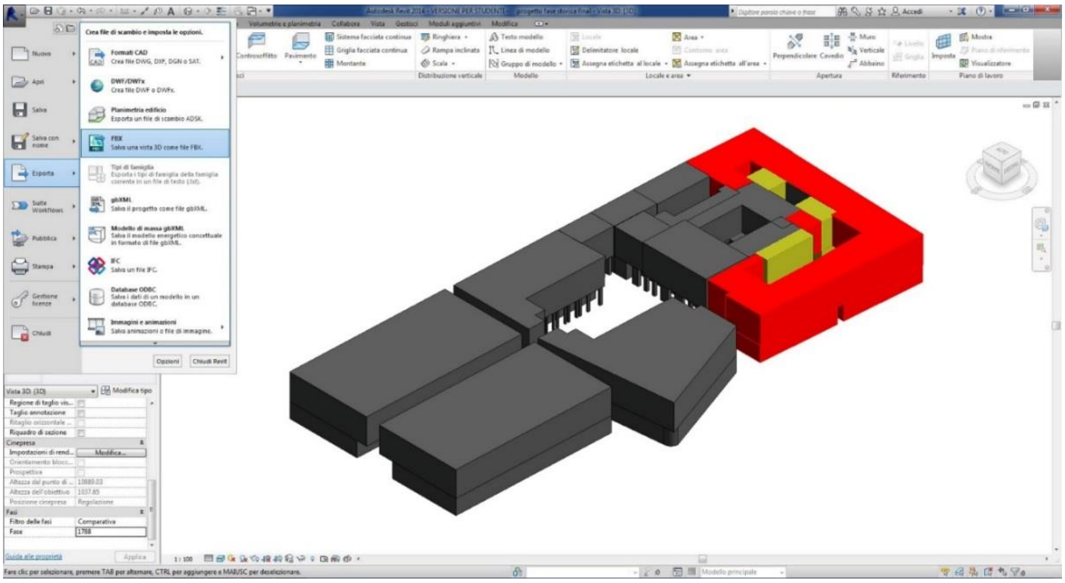


Figure 6518: Exporting to 3dsmax in .fbx format

- Importation of the files in 3DS Max and association of the material to the masses

At this point, the file is imported in 3DS Max. It is possible to notice the loss of attributes and shared parameters, such as the materials or other information about the year. The masses, all displayed in gray, will be characterized again, by coloring in red those realized in the reference year, in yellow those demolished in the reference year and in gray those previously realized. For this reason an .fbx format was exported from Revit to 3DS Max for each year.

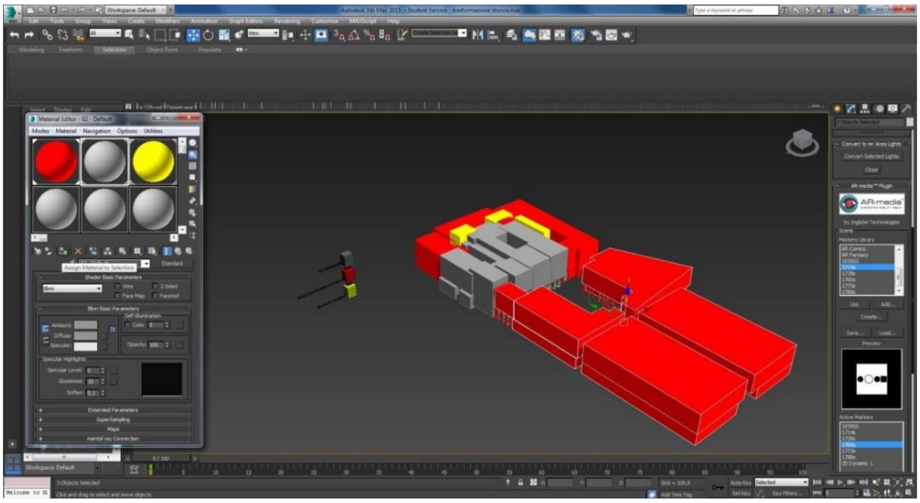


Figure 6619: Association of the material to the masses in 3d studio max

- The creation of custom marker using AR-Media

AR-Media provides predefined and customizable images to be exploited as a marker. Once images in jpeg format are defined, they are renamed with the specific name of the year and are transformed in marker (.arpattern format) via the AR-media tool "marker generator".

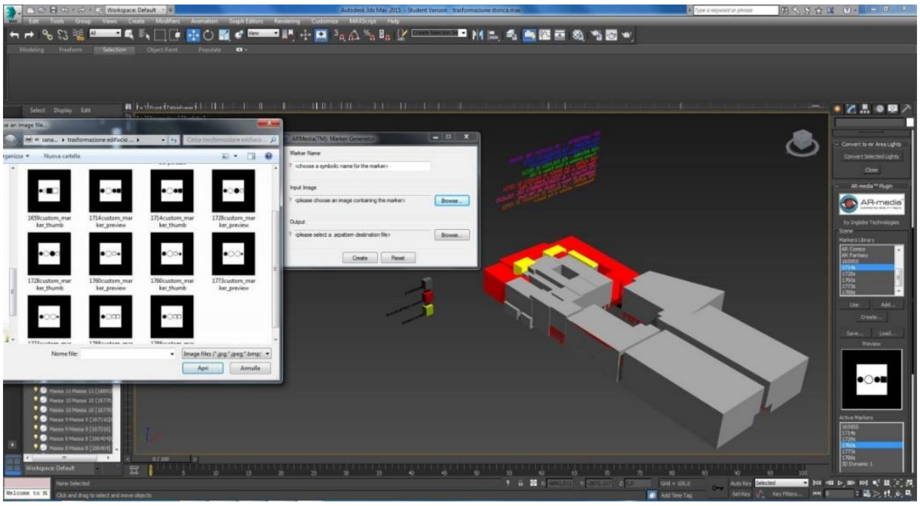


Figure 6720: Creation of marker

- Association of marker to the masses

This operation consists in associating the marker with all the masses to be displayed. In the attached object section it is possible to view a list of associated objects, while on the configuration marker it is possible to view the marker related to the specific year and by “include“ will be linked together.

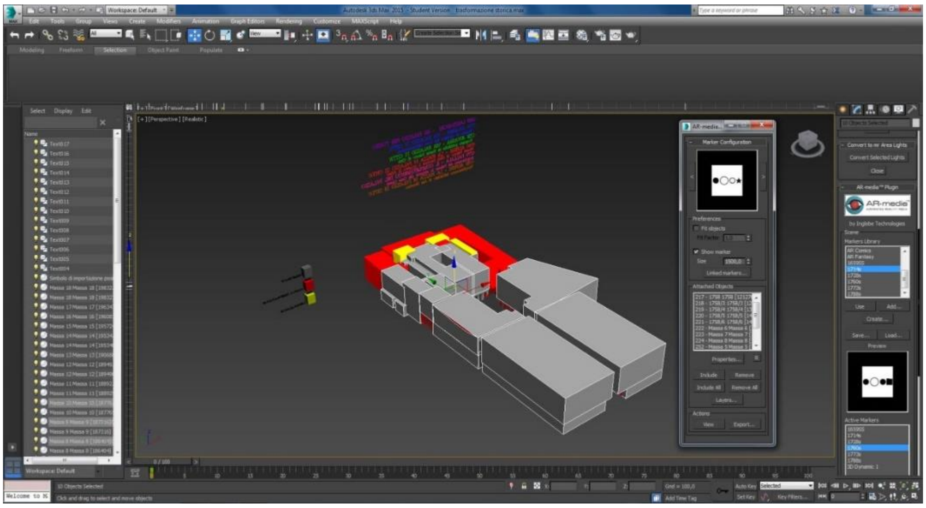
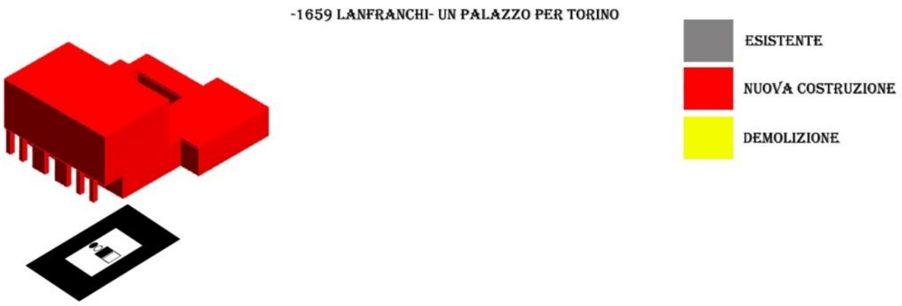


Figure 6821: Association of marker to the specific year of mass

The markers thus generated can be framed using a camera-equipped device and AR-Media application. On the device screen, the marker will be covered from the relative virtual image, showing the information on the construction year, the type of intervention, the name of the designer and the virtual model which is colored on 3DS Max.

The final effect allows visitors to have a quick perception of the building evolution over the years, showing the extent, the size and the typology of operation, year by year.


-1659 LANFRANCHI- UN PALAZZO PER TORINO
ESISTENTE
NUOVA COSTRUZIONE
DEMOLIZIONE


-1659 LANFRANCHI- UN PALAZZO PER TORINO
-1714 JUVARRA- VIA PALAZZO DI CITTA'
Progetto di modofica del Vaso dell' Insinuazione
ESISTENTE
NUOVA COSTRUZIONE
DEMOLIZIONE


-1659 LANFRANCHI- UN PALAZZO PER TORINO
-1714 JUVARRA- VIA PALAZZO DI CITTA'
Progetto di modofica del Vaso dell' Insinuazione
-1728 JUVARRA- VIA PALAZZO DI CITTA'
Proprieta' pubbliche in Piazza Palazzo di Citta'
ESISTENTE
NUOVA COSTRUZIONE
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-1659 LANFRANCHI- UN PALAZZO PER TORINO
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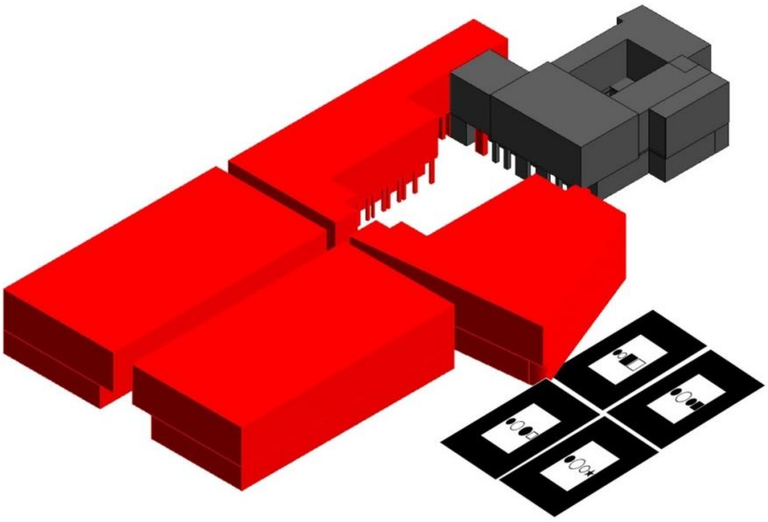
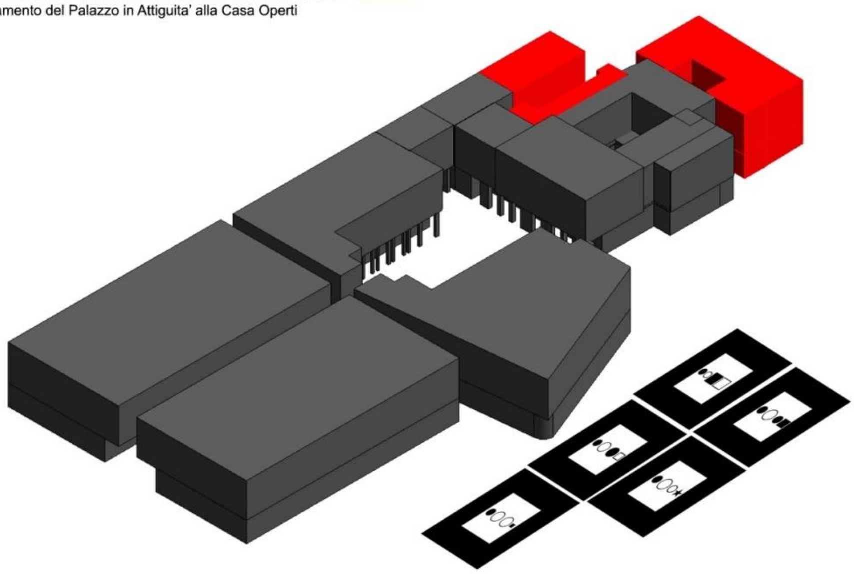
-1728 JUVARRA- VIA PALAZZO DI CITTA'
Proprieta' pubbliche in Piazza Palazzo di Citta'
-1760 ALFIERI- LA PIAZZA DI PALAZZO DI CITTA'
Piazza Palazzo di Citta' Secondo il Progetto di Alfieri

ESISTENTE
NUOVA COSTRUZIONE
DEMOLIZIONE



-1659 LANFRANCHI- UN PALAZZO PER TORINO
-1714 JUVARRA- VIA PALAZZO DI CITTA'
Progetto di modofica del Vaso dell' Insinuazione
-1728 JUVARRA- VIA PALAZZO DI CITTA'
Proprieta' pubbliche in Piazza Palazzo di Citta'
-1760 ALFIERI- LA PIAZZA DI PALAZZO DI CITTA'
Piazza Palazzo di Citta' Secondo il Progetto di Alfieri
-1773 DALLALA- IL COMPLETAMENTO DEL PALAZZO
Ampliamento del Palazzo in Attiguita' alla Casa Operti

ESISTENTE
NUOVA COSTRUZIONE
DEMOLIZIONE



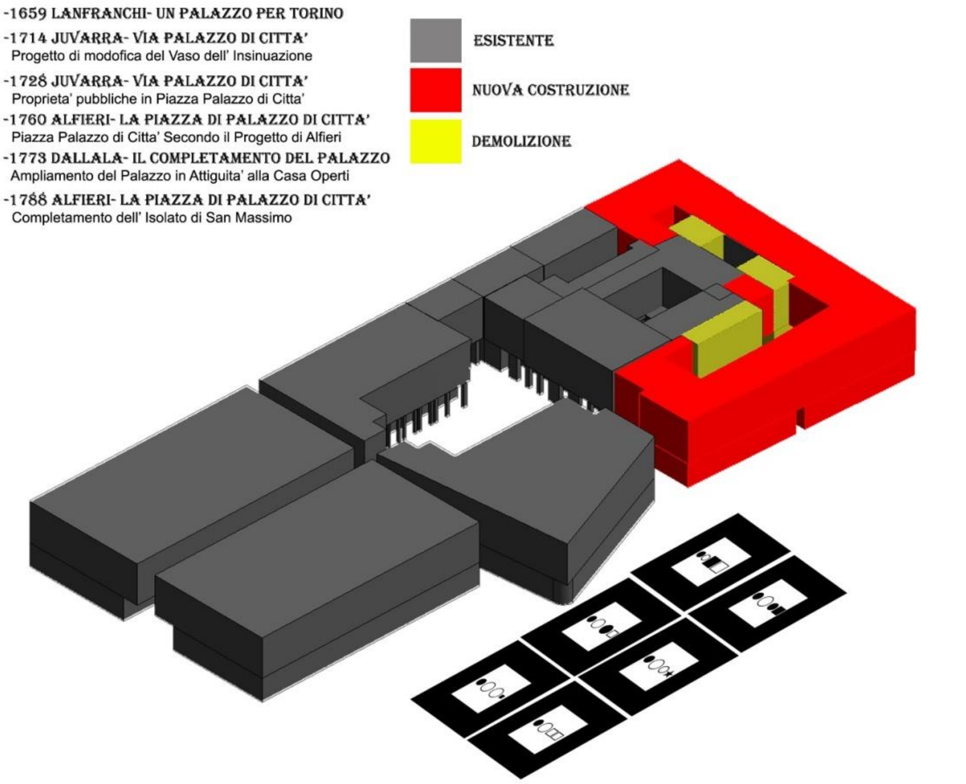


Figure 692: Visualizing of the building evolution and its transformation over the years by AR-Media application

-1659 LANFRANCHI- A PALACE FOR TURIN

- 1714 JUVARRA- PALAZZO DI CITTA STREET
The modification project of the lodgement Vase

- 1728 JUVARRA- PALAZZO DI CITTA' STREET
Public property in palazzo di citta'

- 1760 ALFIERI- SQUARE OF PALAZZO DI CITTA'
Square of palazzo di citta' second project of Alfieri

- 1773 DALLALA- THE COMPLETION OF THE PALACE
The extension of palace in adjacency of Operti's house

- 1788 ALFIERI- SQUARE OF PALAZZO DI CITTA'
Completion of San Massimo block

- Display in AR of the building evolution (Aurasma Studio - AR without marker)

As part of this experimental activity of the Town Hall evolution communication, it was adopted one of the most modern techniques of AR; it is a particular type of technology that allows to associate the additional information (images, text, links to web pages, video, audio, 3D models, ecc ...) to any image, without the use of markers. The program is in fact to recognize shapes and specific colors, thanks to refined methods of reading.

The program adopted to accomplish the activity is Aurasma[32] and the procedure is summarized in the following phases:

  - Creation or selection of the image "trigger"

In the specific case a color axonometric of Palazzo di Città was made (fig.122) that will act as "target image."

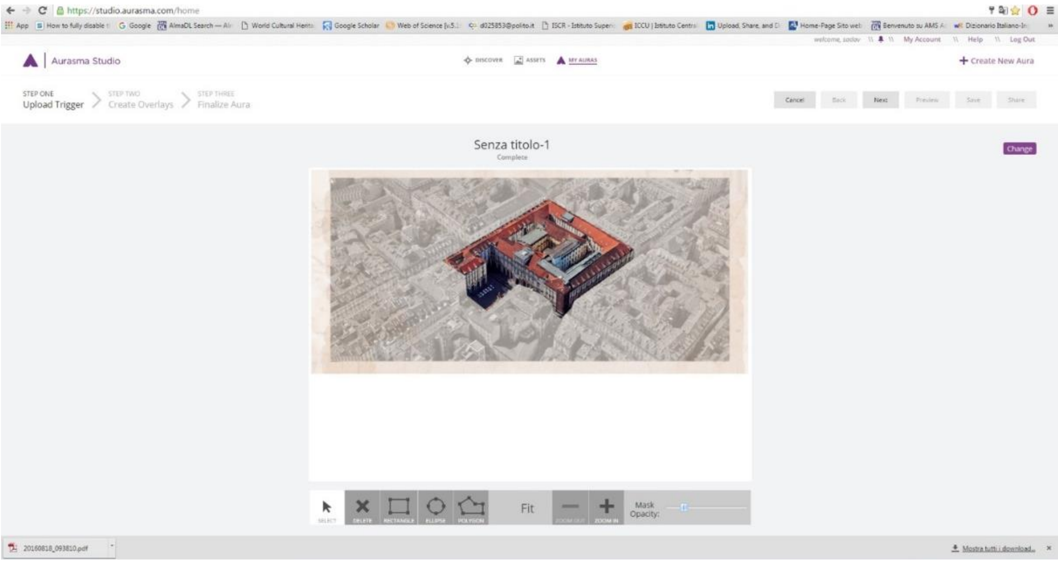


Figure 703: Target image: Palazzo di Città

[32] https://www.aurasma.com/

- Association of the overlay to target image

Overlay means the added content that will be displayed on the tablet when the camera is focused on the target image. In the discussed project, it was created an image showing the intervention phases with their years of construction. A video was also realized to show the visualization in the augmented reality via AR-Media, previously illustrated.

These contents have been associated to the image "trigger" of Aurasma as seen in the picture (fig. 125)

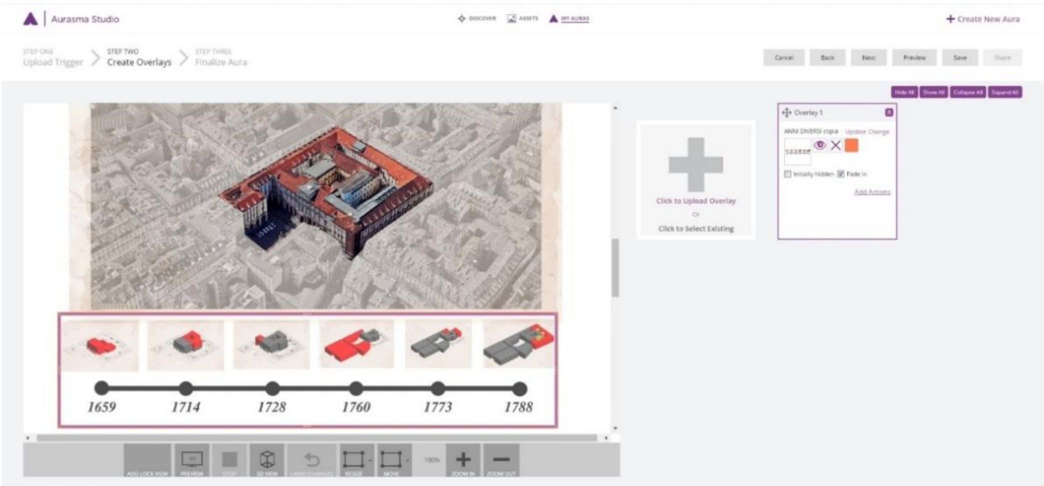


Figure 714: Association of an image showing the intervention phases to the trigger

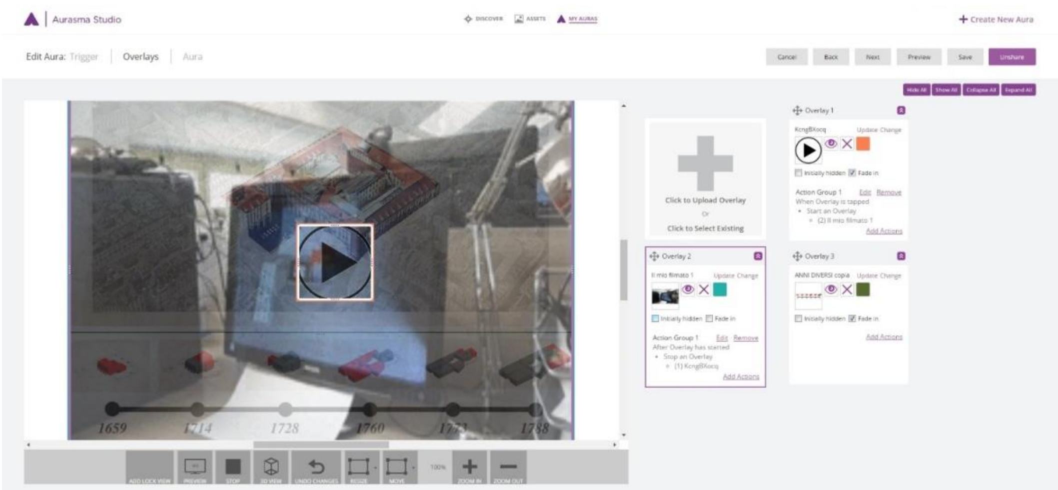


Figure 7225: Association of a video showing the augmented reality via AR-Media to the trigger

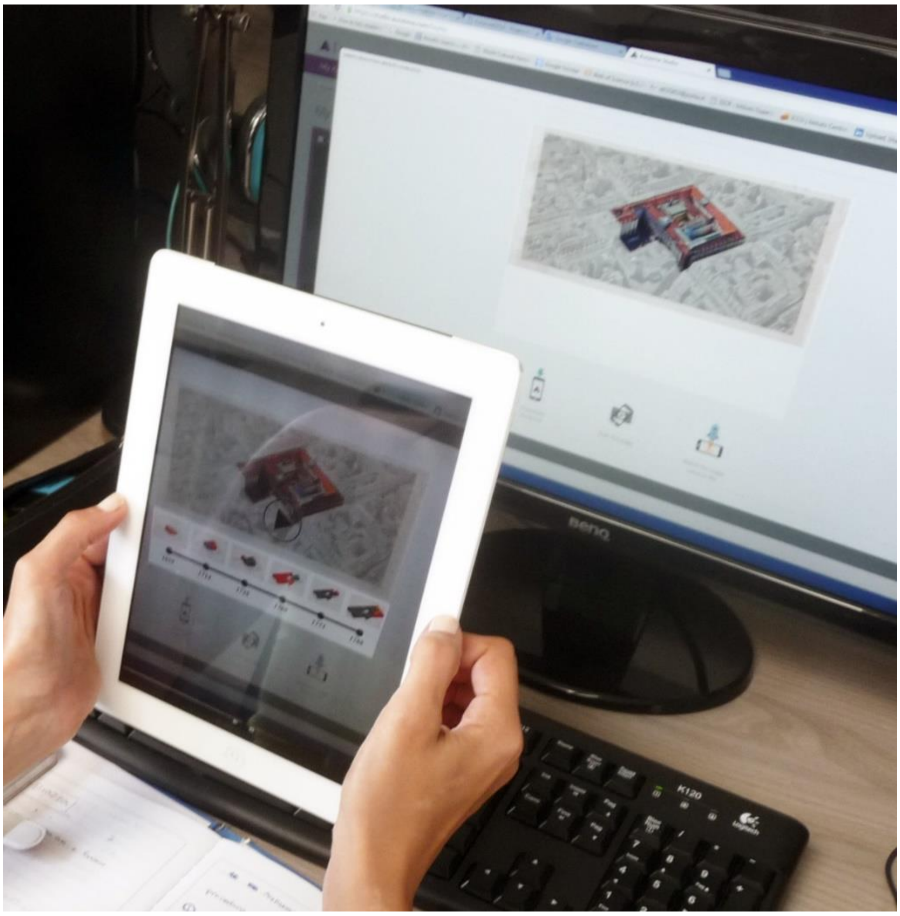


Figure 7326: Augmented reality of Palazzo di Città by AURASMA and visualizing of its historical evolution

This technology could be used not only in tourism, but also in other sectors, to reduce the times and the costs of intervention and investigation:

- Maintenance (on-site display of the special equipment data sheets)
- FM (displaying of data and schedules of the cleaning of the spaces)
- Renovation / restoring (visualization of stratigraphic or structural details of walls or other inaccessible elements).

- Display in AR of parametric modeling techniques of the vaults (Aurasma Studio - without marker)

Revit is a program born in the Anglo-Saxon areas, to facilitate the design of buildings from scratch and implement the part of management within the 3d models. This research field of the present work is instead deepening the BIM application to historic buildings, whose construction techniques do not correspond to the present ones. In practical terms, this situation is translated in a parametric software equipped with little automated tools for modeling of the complex elements, such as decorations or vaulted systems. The complexity of such elements not present in the system families, therefore, requires the use of particular modeling strategies.

The main difficulty is to create suitable objects for the data entry and the capability to export to other software, such as those of energy analysis.

These techniques, developed within the research area, can undoubtedly prove to be a valuable support for future projects; it has therefore been decided to divulge the tutorial of the vaults drawing phases to facilitate those who will continue researching on BIM applied to CH.

Such guides, made in video format, are shown in AR through Aurasma, framing the whole image of the Digitization project of Public Buildings in Turin that is in the application's public database and can be shared on the web by link, email and social networks.

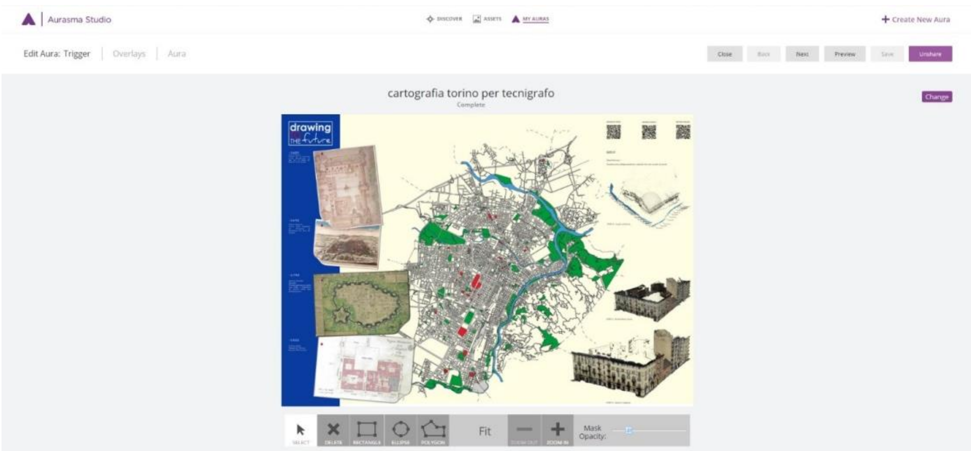


Figure 7427: Target image: the Digitization project of Public Buildings in Turin

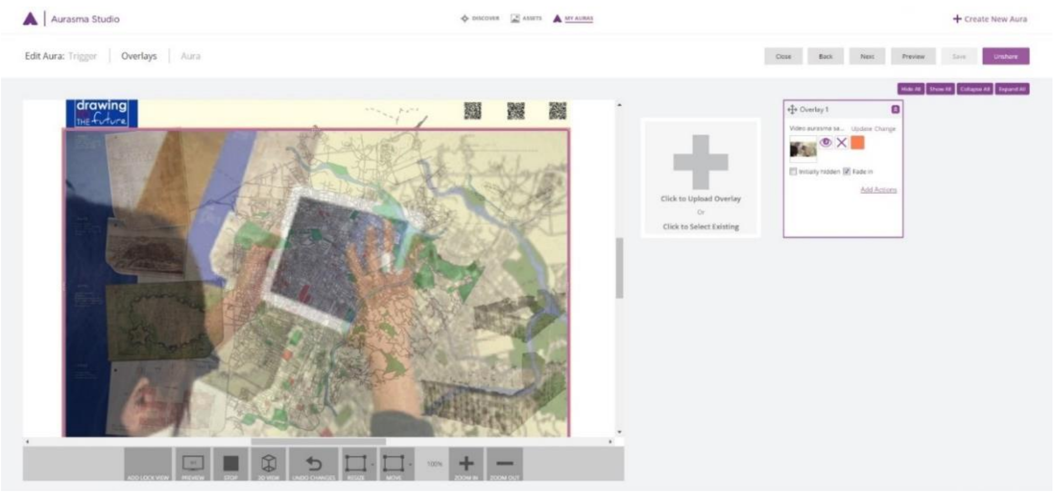


Figure 7528: Association of a video showing the parametric modeling techniques of the vaults via AR-Media to the trigger

Figure 7629: Augmented reality of Palazzo di Città by AURASMA and visualizing of the parametric modeling techniques of the vaults

8.2 Reconstruction Project of the Maior Hall and Palazzo di Città Square in VR

It was described in detail how the VR allows to reconstruct and show imagined or no longer existing environments. Also the Town Hall has a hidden history and by now lost original environments, because of the well-known wars and managerial affairs. The Marble Hall, used today by the Mayor to receive citizens, embodies the most significant example in this regard: the current aspect derives from a reconstruction in neoclassic style occurred in the early nineteenth century, to compensate for the damage, now irreparable, due to roof leaks. The lack of funds in the '700 did not in fact allow the necessary restoration work in the then Maior Hall, leading to the loss of valuable paintings on the ceilings and walls, made by the Flemish Jean Miel.

Wood finishes and the ancient frescoes were replaced by precious marble (which the room is named after) and wooden ceilings that simulate the stone because of the gray pigmentation.

The seventeenth-century image of the Hall, buried by the burial and dignified atmosphere of the Marble Hall, however, is kept in the written descriptions of Count Emanuele Filiberto Thesauro. The erudite belonging to the Turin aristocracy and very reputed in the Savoy court, was a leading figure of the seventeenth-century society and was indicated by Duke to choose the themes of the frescoes that would adorned the halls of the Palace. Also, he personally took care of the Latin didactic mottos writing, present in all the depicted scenes.

The Royal Library in Turin still preserves these recordings in the collection "Inscriptiones", written by Thesauro himself, forming the only basis used in the reconstruction process of the Hall image.

The absence of iconographic documentation, can therefore be circumvented through the use of written sources. However, this situation has led to the definition of a purely narrative character, rather than reconstructive, bringing about to the creation of a telling of the aspect preceding the nineteenth-century intervention through the use of VR and the production of a suggestive and evocative environment with a strong visual impact on the visitor.

This objective cannot be waged without a careful historical research phase which, in the case of this work, is part of the survey phase of the BIM methodology (see chap. 9).

The case study of Palazzo di Città, inside the Digitization Project of Public Buildings in Turin, has elements that distinguish it clearly from the other buildings, as its ancient origin. The normal survey was therefore accompanied by in-depth historical activities that have brought to light numerous documents concerning the events and the stories of Turin and its town hall. This information forms the work basis on which the virtualization and reconstruction project of the Maior Hall is created.

In addition, for a better understanding of the seventeenth-century context, it was necessary a comparison of the descriptions of Thesauro and similar seventeenth-century models come to the present days, allowing evocative development of the lost image, able to give the feeling of entering into the original environment.

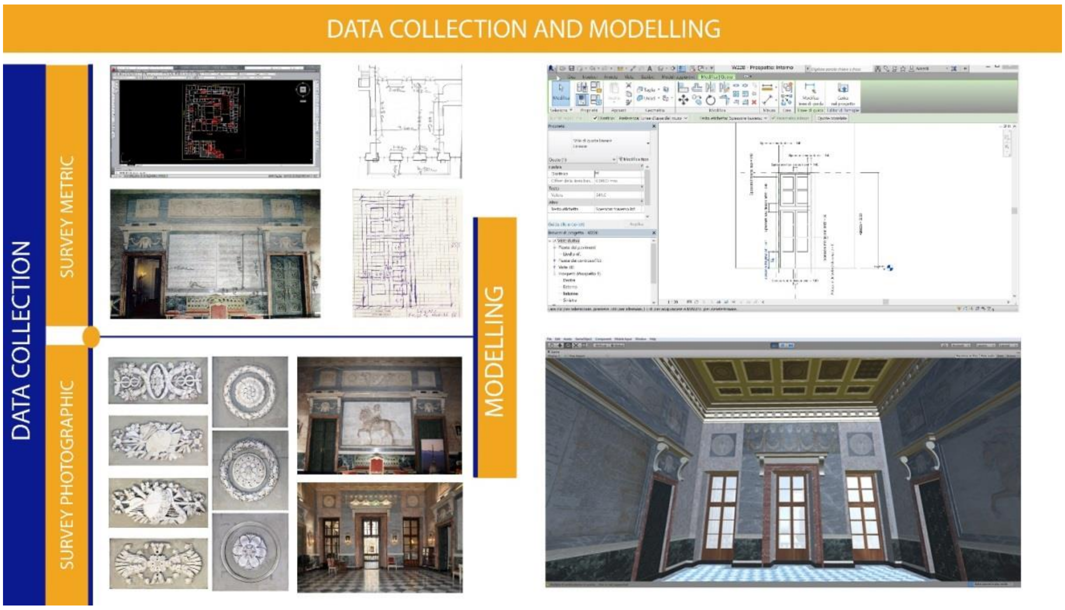


Figure 7730: Data collection and modelling of marble hall

- The Maior Hall in the words of Tesauro

The reading of Inscriptiones text and the comparison with the architectural character carried out on the Hall, have highlighted a possible images disposal scheme. The great details used by the erudite makes it possible to identify three distinct areas: the ceiling, the parietal top end and the parietal low end.

On the ceiling are indicated 5 stories on the origins of Turin: the myth of the Egyptian prince Phaethon in the middle and, on the corners, four legendary episodes belonging to the Roman period.

On the parietal upper part were 10 tables of important episodes in the history of Turin, while in the lower one appeared the figures of 8 emperors who were important for the city, framed by columns according to a widespread agreement in the Baroque period.

The height of the parts has been hypothesized by referring to the color change of the marbles, in today's room, which still maintain a division at the doors level. Among the possible various hypotheses, inspiration was drawn as much as possible from other seventeenth-century rooms still present in the Town Hall and other buildings constructed by the Savoy in the same years.

As regards the paintings, since there is no other frescoes come to the present day depicting the same episodes, a philological reconstruction was discarded, and it was preferred the evocative character, based on chromatic analogy with other paintings of Miel. These tables, which are still preserved in Turin museus, were therefore used as the finish of visible walls in VR, blurring the features and bringing the descriptions of Thesauro back.

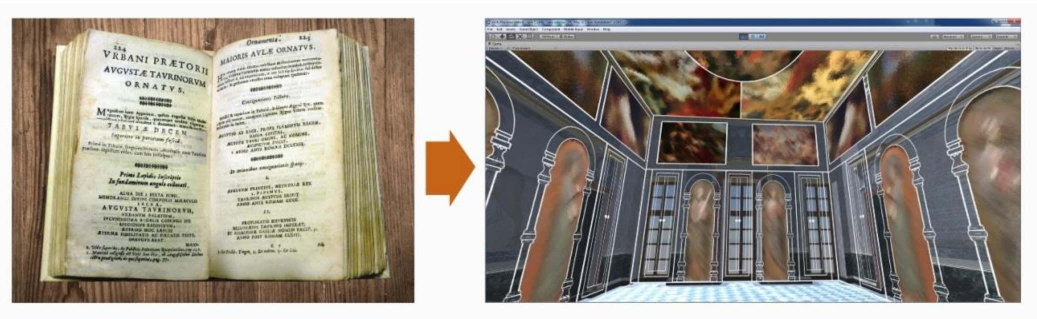


Figure 7831: Construction of The Maior Hall by the words of Tesauro

- Project of reconstruction in VR of Palazzo di Città Square (formerly square of herbs)

Thanks to the realization of the Maior Hall in immersive VR, it is possible to have a privileged point of view on of the opposite Palazzo di Città Square. The evolution and the now lost aspect of this space may in fact be described and admired from the balcony of the hall, using the same starting model used for the story of Thesauro paintings.

It becomes possible to go through the main stages of the history of Turin starting from the heart of his public life, observing the changes in uses and customs. The consistent iconography apparatus on the square makes it possible to faithfully show the aspect of the Savoy capital center and its public life from its medieval character.

In order to, through this virtual story, describe the colors and sounds that characterized the ancient square of herbs, the beating heart of commercial life since middle age, going over all the salient stages of its transformation: the creation of Lanfranchi palace, the dignification process , started in 1756 with Alfieri's square, the Napoleonic domination, the Restoration, the social transformation of the center based in the upper bourgeoisie, the definitive elimination of the commercial activities and the laying of the monument to the Conte Verde, the designation of the square as an administrative center of the nascent Italian State, the twentieth-century industrial infrastructure and the final redevelopment of the '90s.

Thus the visitor of the Town Hall can suggestively comprehend the history of Turin, thanks to functional analysis and comparison with the current uses. Moreover, thanks to the VR, it is possible to learn and to deepen in an involving and user friendly way the complex economic, social and political aspects that have characterized the growth of Turin in the national and global scene.

- Creation of VR through Unity

The evocation of marble hall and of the square in the VR exploits, such as occurred in AR, the interoperability between BIM and dedicated software. Obviously, the LOD used in the hall is considerably higher than that applied to other areas of the palace, reaching a level of detail 1: 1, achieved thanks to a very accurate survey which concerned every decorative element, at both metric and photographic level.

The provided information on Revit were then exported to 3DS Max and, later, in Unity, a software used for gaming capable of implementing advanced features such as animations, navigability of the model and automatic appearance of pop-up audio-text information.

With these tools and a dedicated modeling, it was thus possible to better characterize the environment intended for the immersive visualization, achieving a suggestive model in which the user can move, see, hear and read the information in the order he prefers. The operations to obtain this result are summarized in the following points:

- Modeling in BIM environment

The modeling phase, as in previous cases, requires special procedures, which need to be aware of the final objective. In this case, the model to be exported was characterized by detailed elements for the decorations, made by local model, but left without texture, as 3DS Max was unable to import them properly and allow their modification.

In addition, the modeled environment is that of the Marble Room, while reconstructions of the seventeenth aspect were subsequently realized as semi-gloss screens that overlap the existing, creating two specific virtual tours.

- Export and characterization in 3DS Max

This operation is necessary because Revit is not able to export the geometries in a format readable by Unity. For this reason it was used 3DS Max which also allows further characterization of texture. It is necessary to point out two fundamental aspects: the files must be imported through the .fbx option (Generic) files, which allows to manage all the elements separately. In this way it is possible to intervene on every single element with specific settings. Alternatively, similar elements (such as ports) would all be characterized by the same decoration, without the possibility of showing them the way they actually appear in reality.

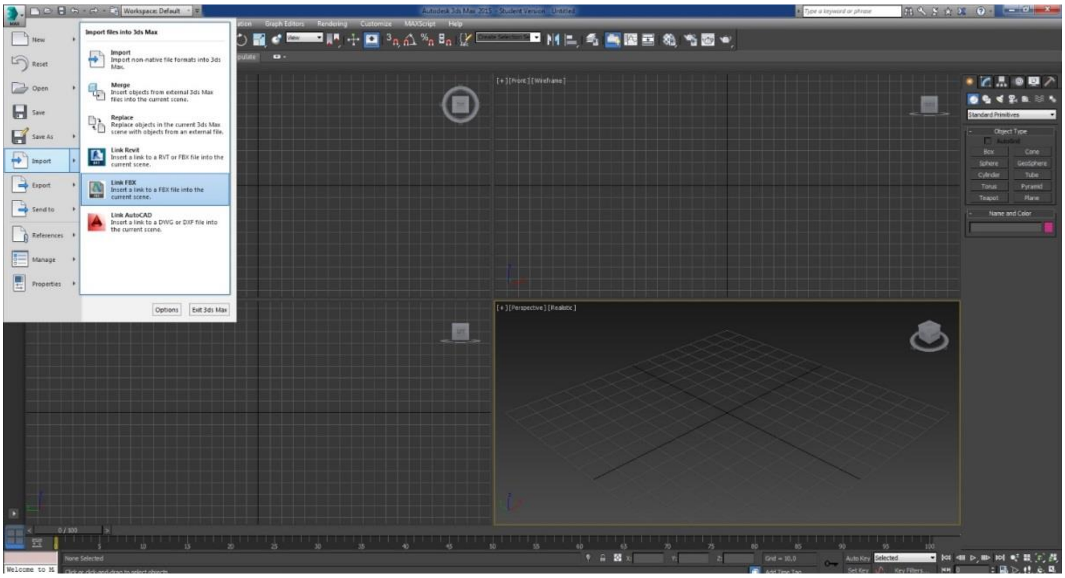


Figure 792: Exportation of model from Revit to the 3d studio max by .FBX format

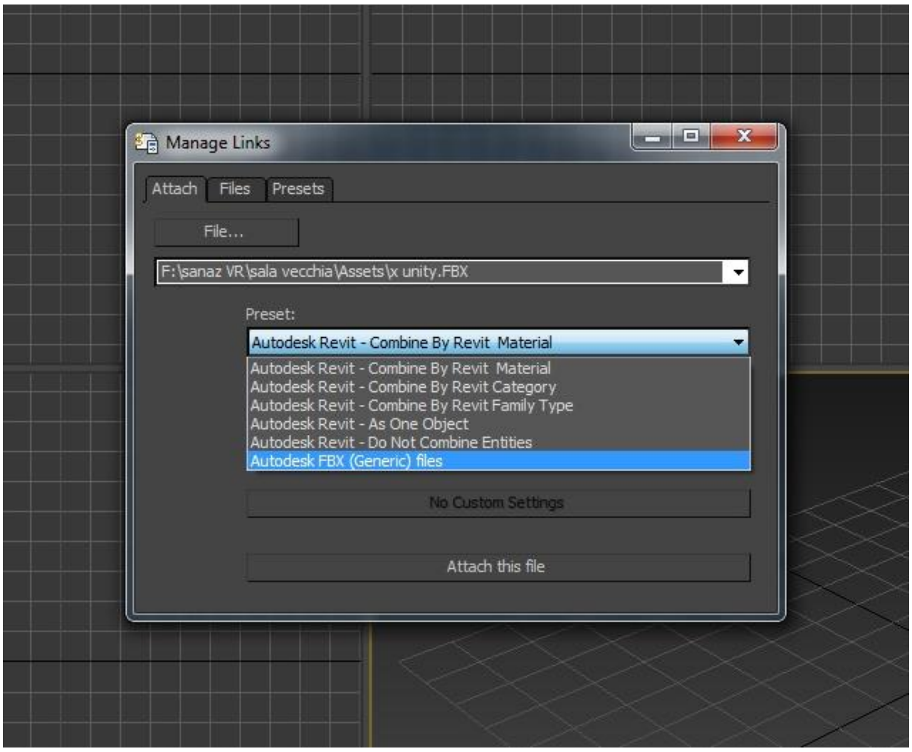


Figure 803: Selection of just generic file

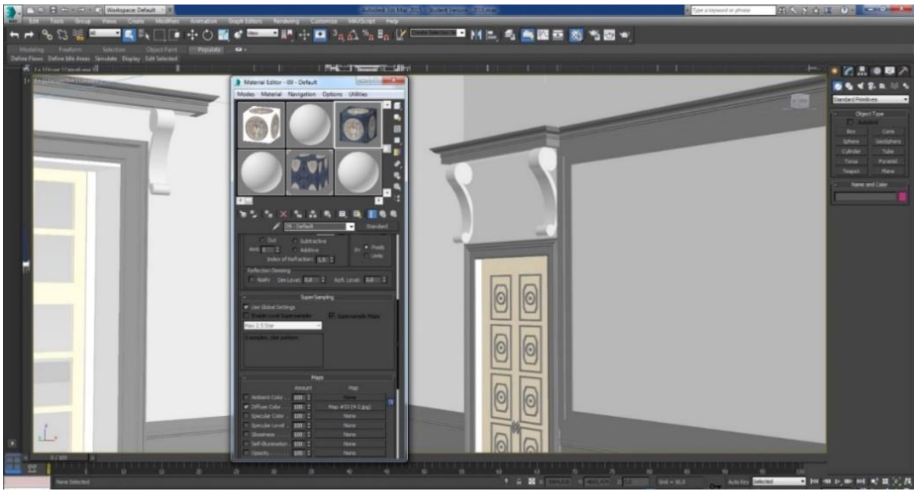


Figure 814: Customizing and Association of materials to each element

- Export and modeling in Unity

Once the 3DS Max model are imported in Unity, specific functions can be implemented for VR: real-time graphics rendering, light effects, soil creation, physical simulation (ex. gravity), sound effects, options for customizing the project (systems scripting).

First, it is necessary to tick the "collider model" option, through which the floor is identified as soil, avoiding that the model, in the animation process, falls by effect of gravity.

Figure 8235: Importation of model to unity and implementation of specific function

At this point imaginary buttons were added (Game Object) within the virtual environment to allow the appearance of images, video and other formats. This feature, called "scripting", associates the Game Object with the pop-up information uploaded on a particular object UI called Canvas.

This procedure allows, in strategic points, the automatic appearance of images related to the pages of the book by Thesauro whenever the user will move the mouse on them.

For virtual tour of the Marble Hall and the Square, the information are displayed through interactive totem to which is enough to get close.

The tour has also been studied for blind people thanks to impressive audio tracks that tell the transformations of the square and describe the subjects of the paintings, via the words of Thesauro. This function is also allowed by a script that can be activated with custom buttons on the physical keyboard.

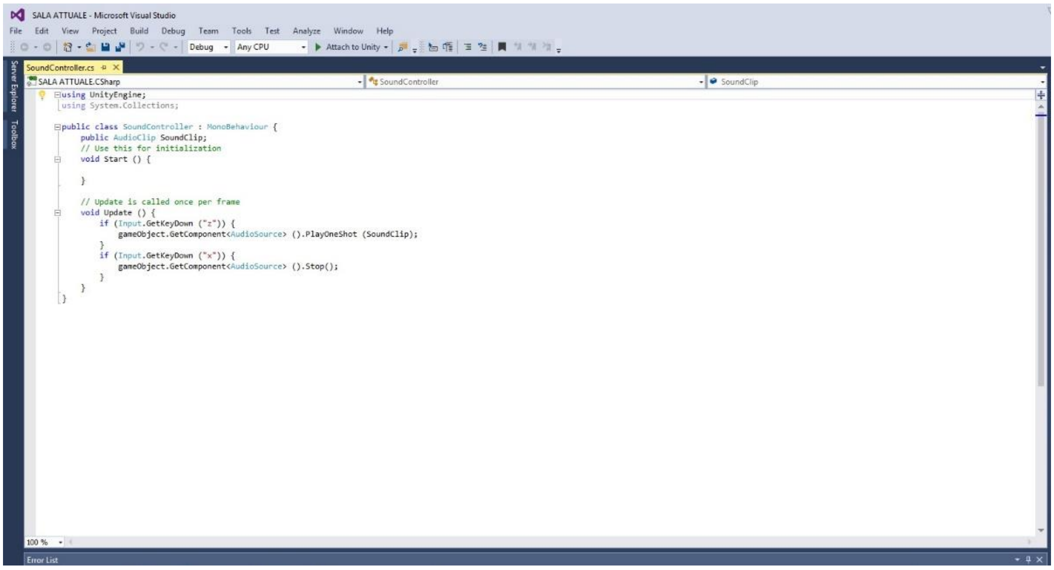


Figure 8336: Creation of specific script of audio tracks for storytelling of each painting

In addition, the Game Object in the room were characterized by lights of different colors : yellow for the introduction of the Hall, green for the paintings on the ceiling, cyan and orange for the tables respectively arranged on the upper and bottom of the walls.

The immersive visualization is achieved through dedicated devices like Oculus Rift[33].

8.3 The final effect with three virtual tour (Maior hall, current Marble hall, Palazzo di Città Square)

- Virtual tour in Marble Hall and its descriptions

Figure 8437: Virtual Reality of Marble hall by Oculus

[33] https://www3.oculus.com/en-us/rift/

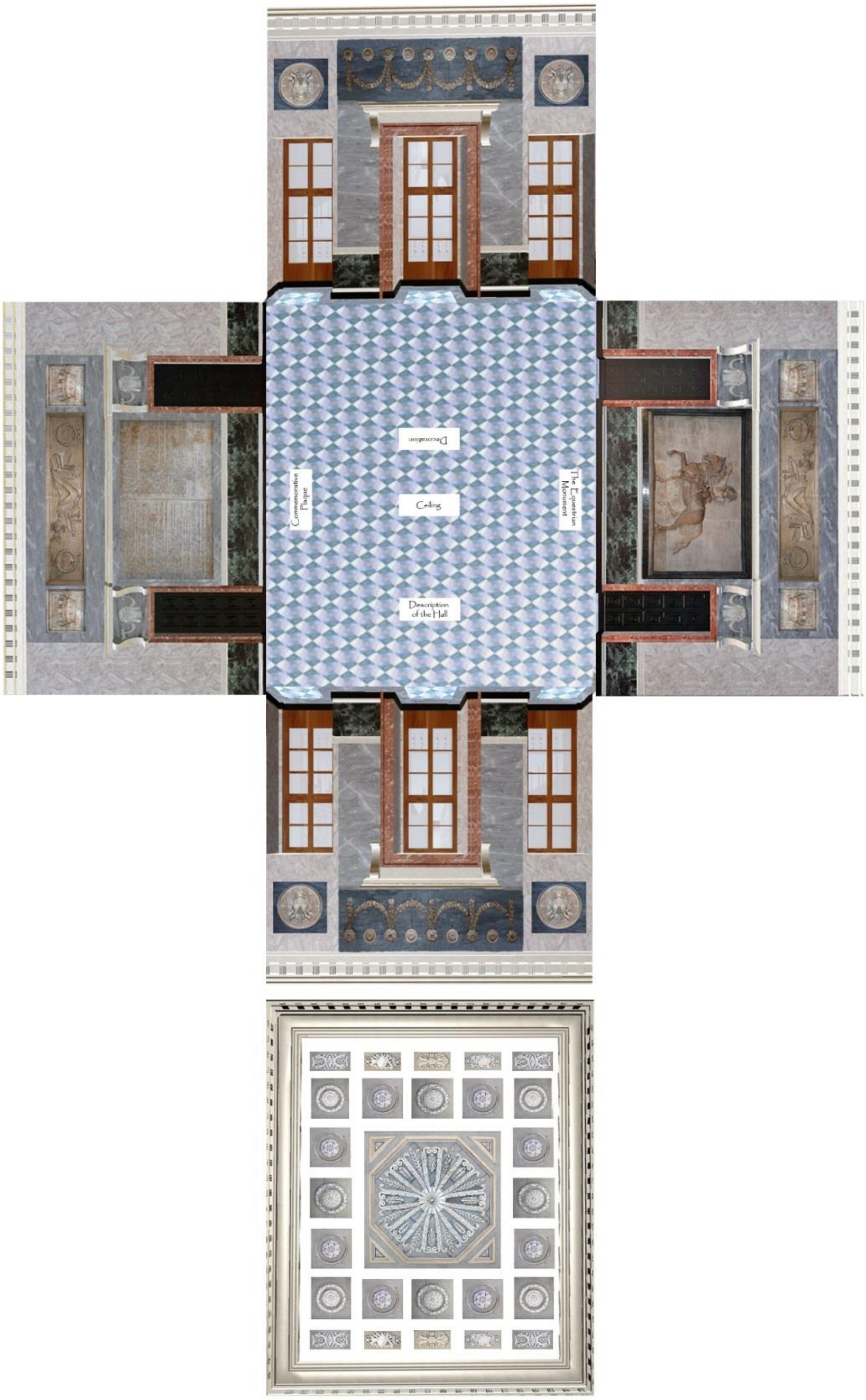


Figure 8538: Inside of the marble hall and placement of the various totems

- Brief description of the actual hall (totem placed at the entrance of the hall)

BREVE DESCRIZIONE DELLA SALA

il salone dei marmi (1816-1825).

Questa è la Sala dei Marmi, luogo di riunioni e ricevimenti ufficiali, in cui è possibile incontrarsi col Sindaco. Come lascia intuire il nome stesso, la sala è contraddistinta da finiture marmoree verdi, bianche e d'alabastro, oltre ad una lapide commemorativa e un altorilievo equestre raffigurante Vittorio Emanuele I. Il progetto nacque dall'esigenza di restaurare l'antica sala seicentesca, realizzata da Lanfranchi. I bassorilievi e le decorazioni che è possibile ammirare oggi furono curati dall'architetto Lorenzo Bonsignore, sviluppati in seguto dall'architetto Lorenzo Lombardi e scolpiti dallo scultore Giacomo Spalla, in quello stile neoclassico che sicuramente aveva caratterizzato il gusto del regno di Vittorio Emanuele I.

I marmi da utilizzare per il rivestimento delle pareti furono indicati nel documento dl 16 gennaio, giungendo ad un grande compromesso tra i sostenitori dei marmi locali e tra quelli dei marmi toscani. Se per i pavimenti, furono utilizzati principalmente i marmi di Carrara bianchi e neri, sulle pareti assistiamo ad un netto predominio di quelli piemontesi (Alabastro di Busca, Verde di Susa, rosso della valle del Tanaro, bianco di Frabosa ecc.). La composizione definita nel documento fu la seguente: nero per lo zoccolo, bianco per la cornice sopra lo zoccolo, verde per il basamento, bardiglio Vandiver per tutta l'impiallacciatura, bianco per la cornice sopra il basamento, alabastro di Busca per gli stipiti, bianco per la grande cornice superiore.
I lavori di rivestimento delle pareti risultano ultimati a regola d'arte il 28 ottobre dello stesso anno, anche se il basamento, in marmo di Carrara, fu successivamente sostituito con marmo di Saltrio a metà del 1817 a causa di danni dovuti all'umidità della calce e al fumo del camino. I pavimenti a scacchiera, invece, furono posati soltanto nel 1825.

Figure 8639: Description of the marble hall

The Marbles Hall (1816-1825)

This is the Marble Hall, a place of meetings and official receptions, where it is possible to meet with the Mayor. As suggested by the name, the area is characterized by green, white and alabaster marble finishes, as well as a commemorative plaque and an equestrian statue portraying Vittorio Emanuele I. The project was born because of the need to restore the ancient seventeenth-century hall, designed by Lanfranchi. The bas-reliefs and decorations were cured by the architect Lorenzo Bonsignore, later developed by architect Lorenzo Lombardi and sculpted by sculptor Giacomo Spalla in the neoclassical style, which has definitely characterized the taste of Vittorio Emanuele I's reign.

The marbles to be used for the covering of walls were pointed out in the 16 January document by reaching a great compromise between the supporters of local marble and those of the Tuscan marble. If to realize the floors were mainly used white and black Carrara marbles, on the walls it is possible to notice a clear dominance of the Piedmontese ones (Alabaster of Busca, Green of Susa, Red of Tanaro valley, white of Frabosa, etc.). The composition defined in the document *was the following: black for the baseboard, white for the frame above the baseboard, green for the basement, bardiglio Vandiver throughout the veneer, white for the frame above the basement, Busca alabaster for the jambs, white for the large upper frame.*

The wall covering works were accomplished on 28 October of the same year, even if the basement, made in Carrara marble, was later replaced with Saltrio marble in mid-1817 because of the damage caused by lime moisture and the smoke coming from the chimney. The checkerboard floors, however, were placed only in 1825.

- Description of the celling (totem placed at the center of the hall)

I SOFFITTI

Nel 1818 iniziano invece i lavori nella parti alte di alcune sale: il salone d'ingresso, la sala del Consiglio e della Congregazione. L'esecuzione dei lavori fu affidata ancora una volta allo scultore Spalla, oltre che allo scultore Giovanni Battista Ferrero e la progettazione, ancora una volta, a Bonsignore. I lavori entarono nel vivo solo nel 1822, anno a cui risale l'ultimo disegno firmato dall'architetto. Rimossi i dipinti seicenteschi, ormai troppo danneggiati per essere restaurati, i soffitti furono cassettonati e realizzati in legno, ma dipinti e intagliati in maniera tale da mimetizzarsi con i materiali lapidei della sala.

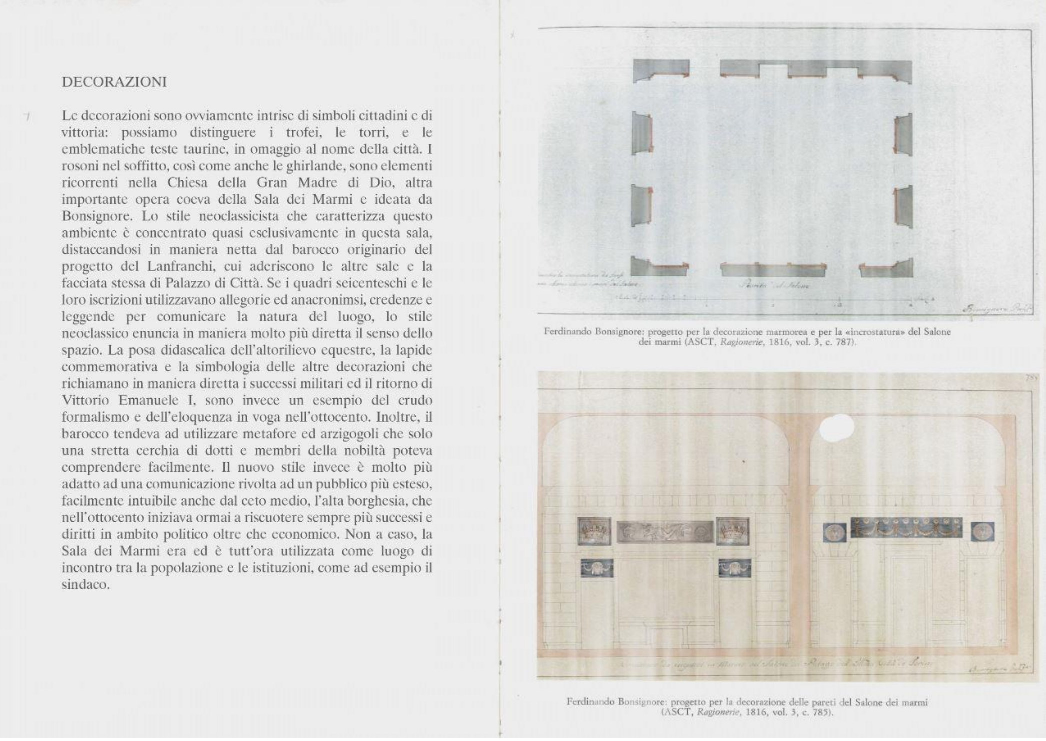
Ferdinando Bonsignore: disegno per il soffitto in legno del Salone dei marmi (ASCT, *Ragionerie*, 1822, vol. 47, c. 537).

Figure 8740: Description of the celling

The Ceilings

In 1818 had instead begun the works in the upper parts of certain rooms: the entrance hall, the hall of the Council and Hall of the Congregation. The works execution was entrusted once again to the sculptor Spalla, as well as the sculptor Giovanni Battista Ferrero and design, once again, to Bonsignore. The work came alive only in 1822, same year to which dates back the architect last design. The seventeenth-century paintings were removed because of the amoubt of damages to *be restored, and paneled ceilings were realized in wood, but painted and carved in such a way to mimic the hall stone materials.*

- Description of the decorations (totem placed at the upper-centeral of the hall)



DECORAZIONI

Le decorazioni sono ovviamente intrise di simboli cittadini e di vittoria: possiamo distinguere i trofei, le torri, e le emblematiche teste taurine, in omaggio al nome della città. I rosoni nel soffitto, così come anche le ghirlande, sono elementi ricorrenti nella Chiesa della Gran Madre di Dio, altra importante opera coeva della Sala dei Marmi e ideata da Bonsignore. Lo stile neoclassicista che caratterizza questo ambiente è concentrato quasi esclusivamente in questa sala, distaccandosi in maniera netta dal barocco originario del progetto del Lanfranchi, cui aderiscono le altre sale e la facciata stessa di Palazzo di Città. Se i quadri seicenteschi e le loro iscrizioni utilizzavano allegorie ed anacronimsi, credenze e leggende per comunicare la natura del luogo, lo stile neoclassico enuncia in maniera molto più diretta il senso dello spazio. La posa didascalica dell'altorilievo equestre, la lapide commemorativa e la simbologia delle altre decorazioni che richiamano in maniera diretta i successi militari ed il ritorno di Vittorio Emanuele I, sono invece un esempio del crudo formalismo e dell'eloquenza in voga nell'ottocento. Inoltre, il barocco tendeva ad utilizzare metafore ed arzigogoli che solo una stretta cerchia di dotti e membri della nobiltà poteva comprendere facilmente. Il nuovo stile invece è molto più adatto ad una comunicazione rivolta ad un pubblico più esteso, facilmente intuibile anche dal ceto medio, l'alta borghesia, che nell'ottocento iniziava ormai a riscuotere sempre più successi e diritti in ambito politico oltre che economico. Non a caso, la Sala dei Marmi era ed è tutt'ora utilizzata come luogo di incontro tra la popolazione e le istituzioni, come ad esempio il sindaco.

Ferdinando Bonsignore: progetto per la decorazione marmorea e per la «incrostatura» del Salone dei marmi (ASCT, *Ragionerie*, 1816, vol. 3, c. 787).

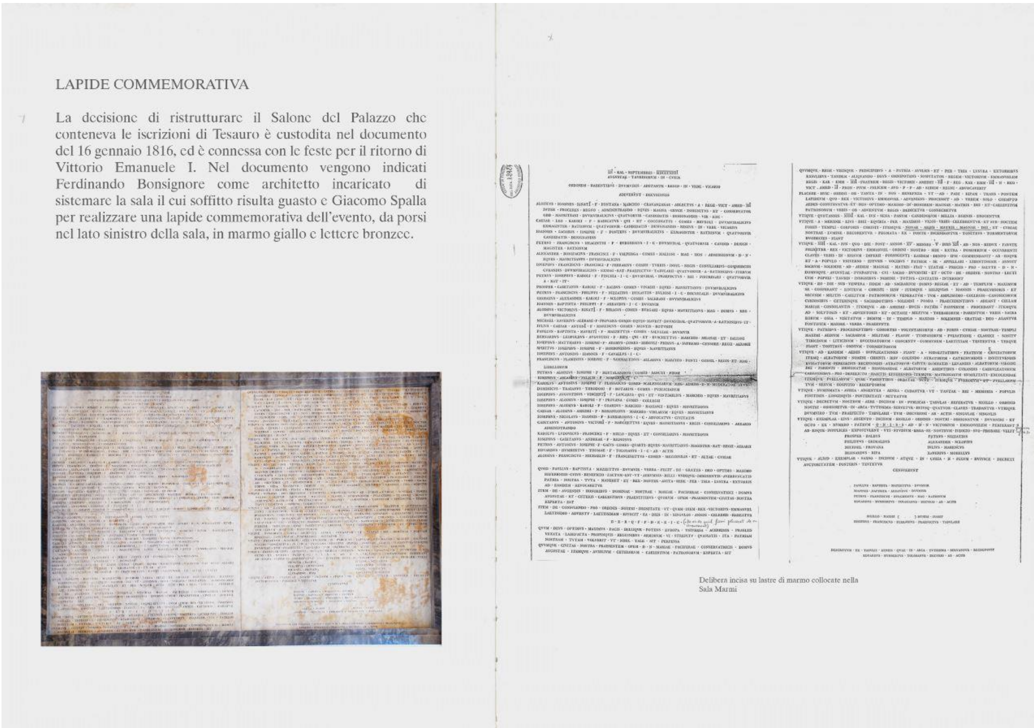
Ferdinando Bonsignore: progetto per la decorazione delle pareti del Salone dei marmi (ASCT, *Ragionerie*, 1816, vol. 3, c. 785).

Figure 8841: Description of the decorations

DECORATIONS

The decorations are obviously filled with citizens and victory symbols: it is possible to distinguish the trophies, the towers, and the emblematic taurine heads in homage to the city name. The wheels in the ceiling, as well as garlands, are recurring elements in the Gran Madre di Dio, another important work contemporary to the Marble Hall designed by Bonsignore. The neoclassical style which characterizes the space is concentrated almost exclusively in this hall, fully separating from the originally Baroque project by Lanfranchi, to which adhere other rooms and the façade of the Town Hall. If the seventeenth-century paintings and their inscriptions used allegories and anachronisms, beliefs and legends to communicate the nature of the place, the neoclassical style sets in a much more direct sense of space. The didactic pose of the equestrian high relief, the commemorative plaque and the symbolism of the other decorations directly recalling the military successes and the return of Vittorio Emanuele I, are in fact *the example of raw formalism and eloquence which were in vogue in the nineteenth century. In addition, the baroque tended to use metaphors and round-about expression that only a small circle of scholars and members of the nobility could easily understand. The new style is instead much more suited to a communication which is addressed to a wider public, easily deducible even by the middle class, the upper bourgeoisie , which in the nineteenth century began to collect more and more successes and rights in the political as well as the economic field. Not surprisingly, the Marble hall was and is still used as a place of meeting between people and institutions, such as the mayor.*

- Description of the commemorative plaque (totem placed at the left of the hall)


LAPIDE COMMEMORATIVA

La decisione di ristrutturare il Salone del Palazzo che conteneva le iscrizioni di Tesauro è custodita nel documento del 16 gennaio 1816, ed è connessa con le feste per il ritorno di Vittorio Emanuele I. Nel documento vengono indicati Ferdinando Bonsignore come architetto incaricato di sistemare la sala il cui soffitto risulta guasto e Giacomo Spalla per realizzare una lapide commemorativa dell'evento, da porsi nel lato sinistro della sala, in marmo giallo e lettere bronzee.

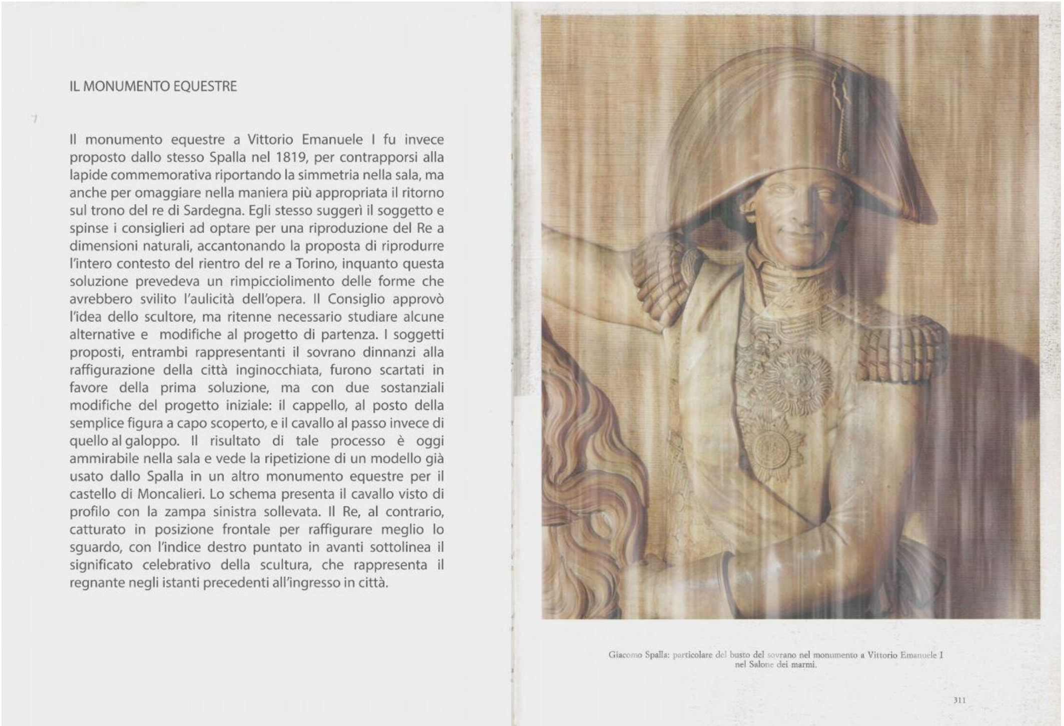
Delibera incisa su lastre di marmo collocate nella Sala Marmi

Figure 892: Description of the commemorative plaque

COMMEMORATIVE PLAQUE

The decision to restore the Palace Hall that contained Tesauro inscriptions is kept in the document of 16 January 1816, and is connected with the celebrations for the return of Vittorio Emanuele I. In the document are listed Ferdinando Bonsignore as the architect in charge of arranging the damaged ceiling of the hall and Giacomo Spalla to realize an event commemorative plaque to be placed in the left side of the room, in yellow marble and bronze letters.

- Description of the equestrian statue (totem placed at the right of the hall)



IL MONUMENTO EQUESTRE

Il monumento equestre a Vittorio Emanuele I fu invece proposto dallo stesso Spalla nel 1819, per contrapporsi alla lapide commemorativa riportando la simmetria nella sala, ma anche per omaggiare nella maniera più appropriata il ritorno sul trono del re di Sardegna. Egli stesso suggerì il soggetto e spinse i consiglieri ad optare per una riproduzione del Re a dimensioni naturali, accantonando la proposta di riprodurre l'intero contesto del rientro del re a Torino, inquanto questa soluzione prevedeva un rimpicciolimento delle forme che avrebbero svilito l'aulicità dell'opera. Il Consiglio approvò l'idea dello scultore, ma ritenne necessario studiare alcune alternative e modifiche al progetto di partenza. I soggetti proposti, entrambi rappresentanti il sovrano dinnanzi alla raffigurazione della città inginocchiata, furono scartati in favore della prima soluzione, ma con due sostanziali modifiche del progetto iniziale: il cappello, al posto della semplice figura a capo scoperto, e il cavallo al passo invece di quello al galoppo. Il risultato di tale processo è oggi ammirabile nella sala e vede la ripetizione di un modello già usato dallo Spalla in un altro monumento equestre per il castello di Moncalieri. Lo schema presenta il cavallo visto di profilo con la zampa sinistra sollevata. Il Re, al contrario, catturato in posizione frontale per raffigurare meglio lo sguardo, con l'indice destro puntato in avanti sottolinea il significato celebrativo della scultura, che rappresenta il regnante negli istanti precedenti all'ingresso in città.

Giacomo Spalla: particolare del busto del sovrano nel monumento a Vittorio Emanuele I nel Salone dei marmi.

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Figure 903: Description of the equestrian statue

THE EQUESTRIAN STATUE

The equestrian monument to Vittorio Emanuele I was instead suggested by the same Spalla in 1819, to contrast with the commemorative plaque and thus bringing symmetry in the room, but also to pay homage in the most appropriate manner to the return on the throne of the King of Sardinia. He proposed the subject and persuaded the councilors to opt for a full-size reproduction of the King , setting aside the proposal to reproduce the entire context of the king's return in Turin, as this solution involved a resizing of forms that would have debase the nobility of the work of art. The Council approved the sculptor's idea, but it was considered necessary to study some alternatives and modifications to the original project. The proposed subjects, both representing the sovereign in front of the kneeling cities depiction, were discarded in favor of the first solution, but with two significant changes to the initial project: the figure wearing a hat, instead of simply being bareheaded, and the horse walking instead of galloping. Today; the result of this process is admirable in the room and presents the repetition of a model already used by the Spalla in another equestrian monument for the castle of Moncalieri.

This scheme depicts the horse in profile with his left leg raised. The King, by contrast, captured in a frontal position to better represent his look and with his right index finger pointed straight ahead, emphasizes the celebratory meaning of the sculpture, representing the reigning the moment before his entrance in the town.

- Virtual tour in Aula Maior and its descriptions

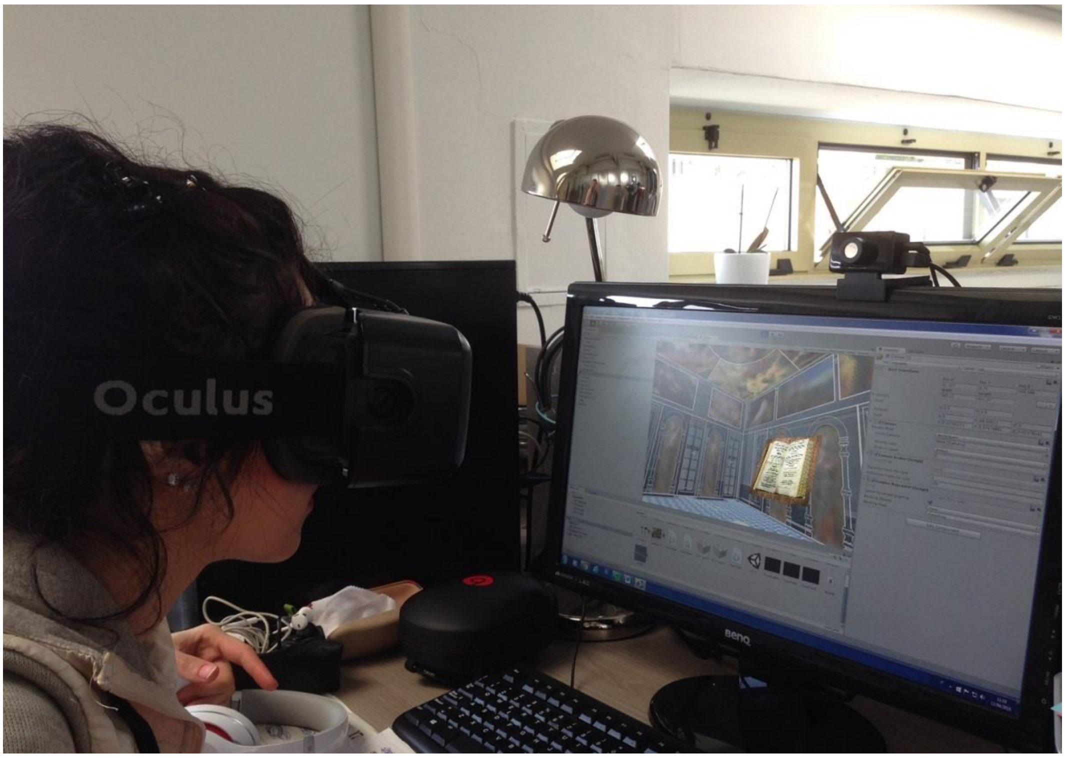


Figure 914: Virtual reality of the Aula Maior by Oculus

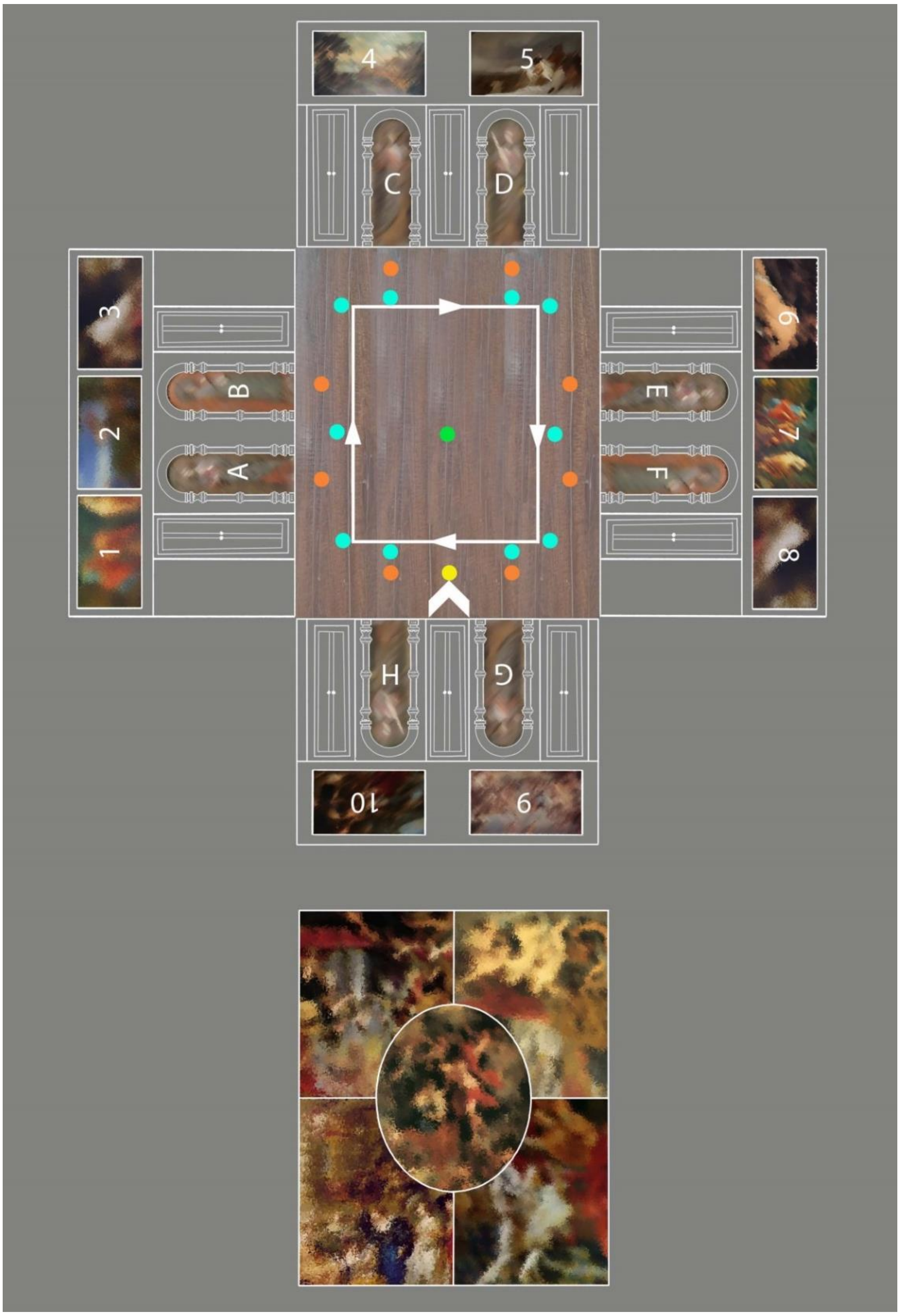
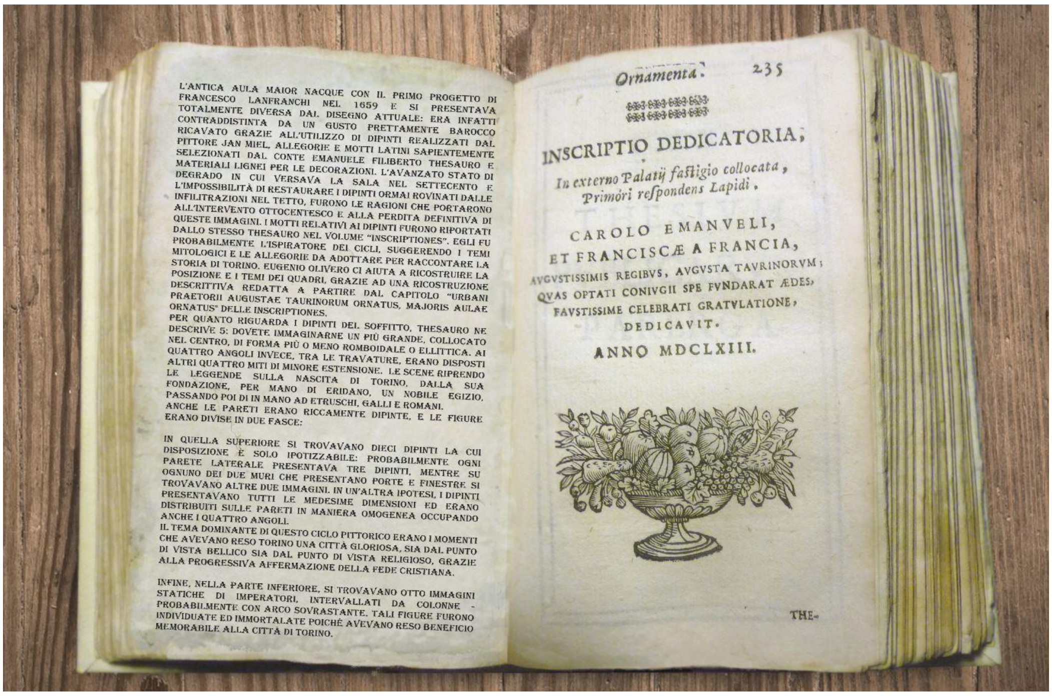


Figure 9245: Inside of the Aula Maior and placement of the painting descriptions

- Aula Maior and transformation to Marbles Hall description (at the entrance)



L'ANTICA AULA MAIOR NACQUE CON IL PRIMO PROGETTO DI FRANCESCO LANFRANCHI NEL 1659 E SI PRESENTAVA TOTALMENTE DIVERSA DAL DISEGNO ATTUALE: ERA INFATTI CONTRADDISTINTA DA UN GUSTO PRETTAMENTE BAROCCO RICAVATO GRAZIE ALL'UTILIZZO DI DIPINTI REALIZZATI DAL PITTORE JAN MIEL, ALLEGORIE E MOTTI LATINI SAPIENTEMENTE SELEZIONATI DAL CONTE EMANUELE FILIBERTO THESAURO E MATERIALI LIGNEI PER LE DECORAZIONI. L'AVANZATO STATO DI DEGRADO IN CUI VERSAVA LA SALA NEL SETTECENTO E L'IMPOSSIBILITÀ DI RESTAURARE I DIPINTI ORMAI ROVINATI DALLE INFILITRAZIONI NEL TETTO, FURONO LE RAGIONI CHE PORTARONO ALL'INTERVENTO OTTOCENTESCO E ALLA PERDITA DEFINITIVA DI QUESTE IMMAGINI. I MOTTI RELATIVI AI DIPINTI FURONO RIPORTATI DALLO STESSO THESAURO NEL VOLUME "INSCRIPTIONES". EGLI FU PROBABILMENTE L'ISPIRATORE DEI CICLI, SUGGERENDO I TEMI MITOLOGICI E LE ALLEGORIE DA ADOTTARE PER RACCONTARE LA STORIA DI TORINO. EUGENIO OLIVERO CI AIUTA A RICOSTRUIRE LA POSIZIONE E I TEMI DEI QUADRI, GRAZIE AD UNA RICOSTRUZIONE DESCRITTIVA REDATTA A PARTIRE DAL CAPITOLO "URBANI PRAETORII AUGUSTAE TAURINORUM ORNATUS, MAJORIS AULAE ORNATUS" DELLE INSCRIPTIONES.

PER QUANTO RIGUARDA I DIPINTI DEL SOFFITTO, THESAURO NE DESCRIVE 5: DOVETE IMMAGINARNE UN PIÙ GRANDE, COLLOCATO NEL CENTRO, DI FORMA PIÙ O MENO ROMBOIDALE O ELLITTICA. AI QUATTRO ANGOLI INVECE, TRA LE TRAVATURE, ERANO DISPOSTI ALTRI QUATTRO MITI DI MINORE ESTENSIONE. LE SCENE RIPRENDO LE LEGGENDE SULLA NASCITA DI TORINO, DALLA SUA FONDAZIONE, PER MANO DI ERIDANO, UN NOBILE EGIZIO, PASSANDO POI DI IN MANO AD ETRUSCHI, GALLI E ROMANI.

ANCHE LE PARETI ERANO RICCAMENTE DIPINTE, E LE FIGURE ERANO DIVISE IN DUE FASCE:

IN QUELLA SUPERIORE SI TROVAVANO DIECI DIPINTI LA CUI DISPOSIZIONE È SOLO IPOTIZZABILE: PROBABILMENTE OGNI PARETE LATERALE PRESENTAVA TRE DIPINTI, MENTRE SU OGNUNO DEI DUE MURI CHE PRESENTANO PORTE E FINESTRE SI TROVAVANO ALTRE DUE IMMAGINI. IN UN'ALTRA IPOTESI, I DIPINTI PRESENTAVANO TUTTI LE MEDESIME DIMENSIONI ED ERANO DISTRIBUITI SULLE PARETI IN MANIERA OMOGENEA OCCUPANDO ANCHE I QUATTRO ANGOLI.

IL TEMA DOMINANTE DI QUESTO CICLO PITTORICO ERANO I MOMENTI CHE AVEVANO RESO TORINO UNA CITTÀ GLORIOSA, SIA DAL PUNTO DI VISTA BELLICO SIA DAL PUNTO DI VISTA RELIGIOSO, GRAZIE ALLA PROGRESSIVA AFFERMAZIONE DELLA FEDE CRISTIANA.

INFINE, NELLA PARTE INFERIORE, SI TROVAVANO OTTO IMMAGINI STATICHE DI IMPERATORI, INTERVALLATI DA COLONNE - PROBABILMENTE CON ARCO SOVRASTANTE. TALI FIGURE FURONO INDIVIDUATE ED IMMORTALATE POICHÉ AVEVANO RESO BENEFICIO MEMORABILE ALLA CITTÀ DI TORINO.

Ornamenta. 235

INSCRIPTIO DEDICATORIA,

In externo Palatij fastigio collocata, Primòri respondens Lapidi.

CAROLO EMANVELI,
ET FRANCISCÆ A FRANCIA,
AVGVSTISSIMIS REGIBVS, AVGVSTA TAVRINORVM;
QVAS OPTATI CONIVGII SPE FVNDARAT ÆDES,
FAVSTISSIME CELEBRATI GRATVLATIONE,
DEDICAVIT.
ANNO MDCLXIII.

THE-

Figure 9346: Description of Aula Maior and its transformation to Marbles Hall highlighted by yellow light

The ancient Aula Maior rose up from the first project of Francesco Lanfranchi in 1659 and appeared totally different from the current drawing: it was marked by a typically Baroque style obtained through the use of paintings made by the painter Jan Miel, allegories and Latin mottoes wisely selected by Count Emanuele Filiberto Thesaurus and wood materials for decorations. The advanced state of degradation of the eighteenth century hall and the impossibility of restoring the paintings already damaged by leakage in the roof, were the reasons that led to the nineteenth century intervention and the permanent loss of those images. The mottoes related to the paintings were quoted by Thesauro in the book "Inscriptiones". He probably was the instigator of the cycles, suggesting mythological themes and allegories to be adopted to tell the story of Turin. Eugenio Olivero helps us reconstructing the position and the themes of the paintings, thanks to a descriptive reconstruction drafted from the chapter "Urbani Praetorii Augustae Taurinorum ornatus, Majoris aulae ornatus" of Inscriptiones.

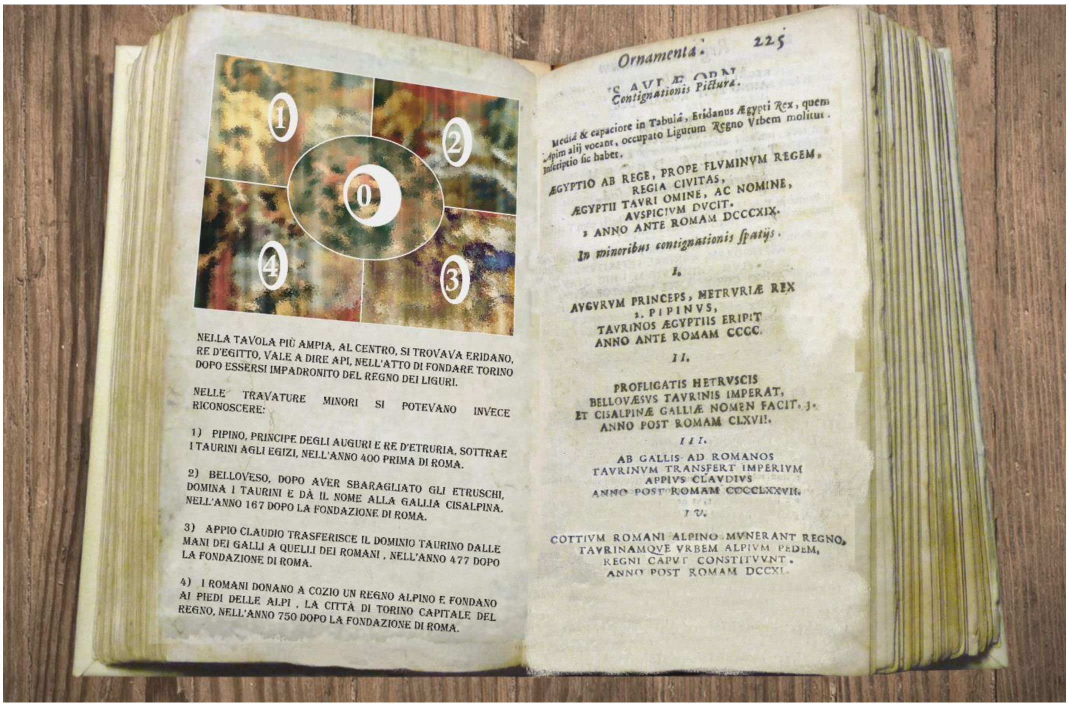
As regards the ceiling paintings, Thesauro describes 5: you need to imagine a larger one, placed in the center, more or less rhomboidal or elliptical shaped. In the four corners instead, between the trusses, were arranged four other smaller area myths. The scenes referred to legends about the birth of Turin, since its foundation, in the hands of Eridanus, a noble Egyptian, and then passing into the hands of the Etruscans, Gauls and Romans.

Also the walls were richly painted, and the figures were divided into two areas:

On the upper one were ten paintings whose arrangement is only conceivable: every lateral wall had probably three paintings, while on each of the two walls having French windows were two other images. In another hypothesis, the paintings all presented the same size and were homogeneously distributed on the walls occupying the four corners as well. The dominant theme of this cycle of paintings were the moments that made Turin a glorious city, both from the point of view of war and religion , due to the progressive affirmation of the Christian faith.

Finally, in the lower part, were eight static images of emperors, interspersed with columns - probably with the overlying arc. These figures were identified and immortalized because they made memorable benefit to the city of Turin.

- Ancient paintings on the ceilings description (in the middle of the hall)



Nella tavola più ampia, al centro, si trovava Eridano, re d'Egitto, vale a dire Api, nell'atto di fondare Torino dopo essersi impadronito del regno dei Liguri.

Nelle travature minori si potevano invece riconoscere:

1) Pipino, principe degli Auguri e re d'Etruria, sottrae i Taurini agli Egizi, nell'anno 400 prima di Roma.

2) Belloveso, dopo aver sbaragliato gli Etruschi, domina i Taurini e dà il nome alla Gallia Cisalpina. Nell'anno 167 dopo la fondazione di Roma.

3) Appio Claudio trasferisce il dominio taurino dalle mani dei Galli a quelli dei Romani , nell'anno 477 dopo la fondazione di Roma.

4) I Romani donano a Cozio un regno alpino e fondano ai piedi delle Alpi , la città di Torino capitale del regno, nell'anno 750 dopo la fondazione di Roma.

Ornamenta. 225

Contignationis Pictura.

Media & capaciore in Tabulâ, Eridanus Ægypti Rex, quem Apim alij vocant, occupato Ligurum Regno Vrbem molitur. Inscriptio sic habet.

ÆGYPTIO AB REGE, PROPE FLVMINVM REGEM,
REGIA CIVITAS,
ÆGYPTII TAVRI OMINE, AC NOMINE,
AVSPICIVM DVCIT.
ANNO ANTE ROMAM DCCCXIX.

In minoribus contignationis spatijs.

I.

AVGVRVM PRINCEPS, HETRVRIÆ REX
PIPINVS,
TAVRINOS ÆGYPTIIS ERIPIT
ANNO ANTE ROMAM CCCC.

II.

PROFLIGATIS HETRVSCIS
BELLOVÆSVS TAVRINIS IMPERAT,
ET CISALPINÆ GALLIÆ NOMEN FACIT.
ANNO POST ROMAM CLXVII.

III.

AB GALLIS AD ROMANOS
TAVRINVM TRANSFERT IMPERIVM
APPIVS CLAVDIVS
ANNO POST ROMAM CCCCLXXVII.

IV.

COTTIVM ROMANI ALPINO MVNERANT REGNO,
TAVRINAMQVE VRBEM ALPIVM PEDEM,
REGNI CAPVT CONSTITVVNT.
ANNO POST ROMAM DCCXL.

Figure 9447: Description of the Ancient paintings on the ceilings highlighted by green light

In the wide board, in the center, was Eridanus, the king of Egypt, namely Bees, in the act of founding Turin after the Ligurian Kingdom.

In the smaller trusses could instead be recognized:

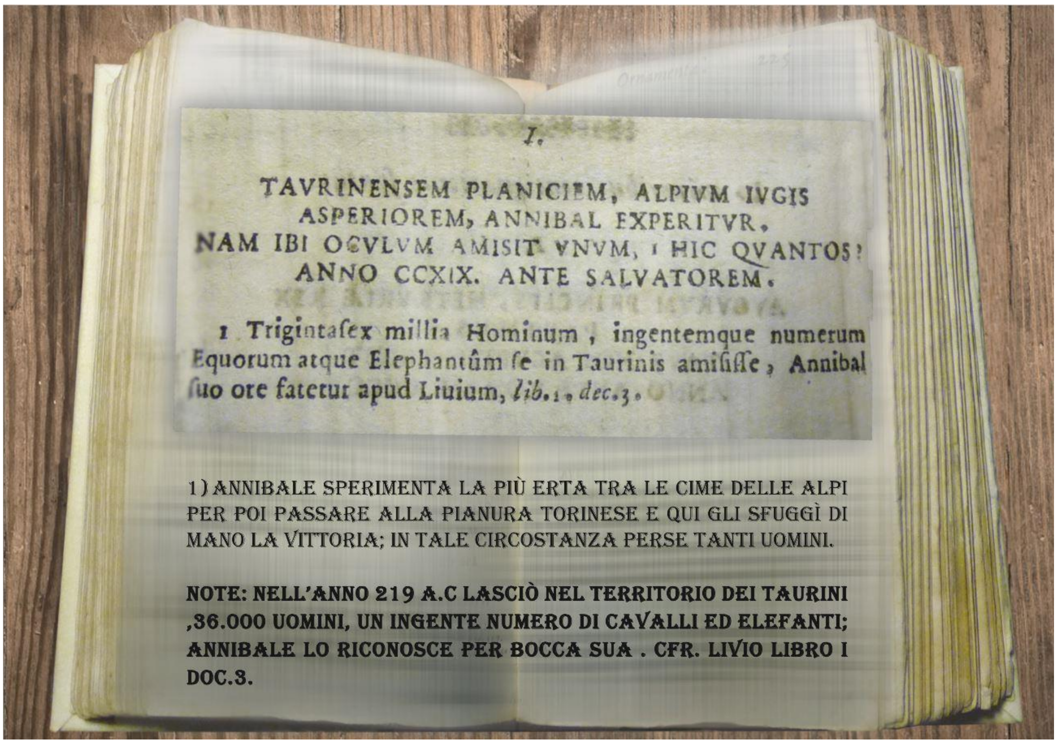
1) Pippin, Prince of Auguri and King of Etruria, subtracts Taurines to the Egyptians, in 400 before the founding of Rome.

2) Belloveso, after defeating the Etruscans, dominates Taurines and gives its name to Gaul. In the year 167 after the founding of Rome.

3) Appio Claudio transfers the Taurine domain by the Gauls hands to those of the Romans, in the year 477 after the founding of Rome.

4) The Romans give to Cozio an alpine kingdom and found at the foot of the Alps, the city of Turin, capital of the kingdom, in the year 750 after the founding of Rome.

- Cyan path over the perimeter with description of the upper area (1 to 10 tables)



I.

TAVRINENSEM PLANICIEM, ALPIVM IVGIS ASPERIOREM, ANNIBAL EXPERITVR.
NAM IBI OCVLVM AMISIT VNVM, I HIC QVANTOS!
ANNO CCXIX. ANTE SALVATOREM.

1 Trigintasex millia Hominum, ingentemque numerum Equorum atque Elephantûm se in Taurinis amisisse, Annibal suo ore fatetur apud Liuium, lib. 1. dec. 3.

1) ANNIBALE SPERIMENTA LA PIÙ ERTA TRA LE CIME DELLE ALPI PER POI PASSARE ALLA PIANURA TORINESE E QUI GLI SFUGGÌ DI MANO LA VITTORIA; IN TALE CIRCOSTANZA PERSE TANTI UOMINI.

NOTE: NELL'ANNO 219 A.C LASCIÒ NEL TERRITORIO DEI TAURINI ,36.000 UOMINI, UN INGENTE NUMERO DI CAVALLI ED ELEFANTI; ANNIBALE LO RICONOSCE PER BOCCA SUA . CFR. LIVIO LIBRO I DOC.3.

Figure 9548: Description of the 1° painting placed in the upper area of the hall highlighted by Cyan light

1) Hannibal experiences the steepest among the Alps peaks before moving to Turin plain and here got victory out of his hand; in this circumstance he lost many soldiers.

Notes: In 219 B.C. he left into Taurines territory 36,000 men, a large number of horses and elephants; Hannibal himself admits it... Cfr. Livy Book I doc.3.

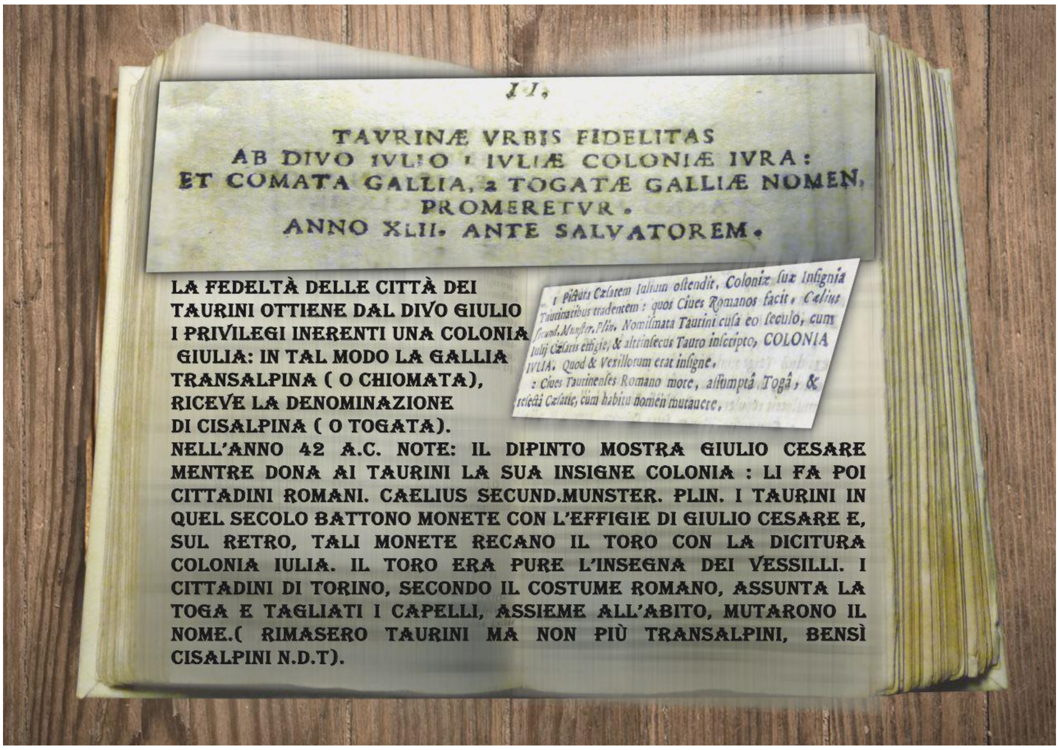
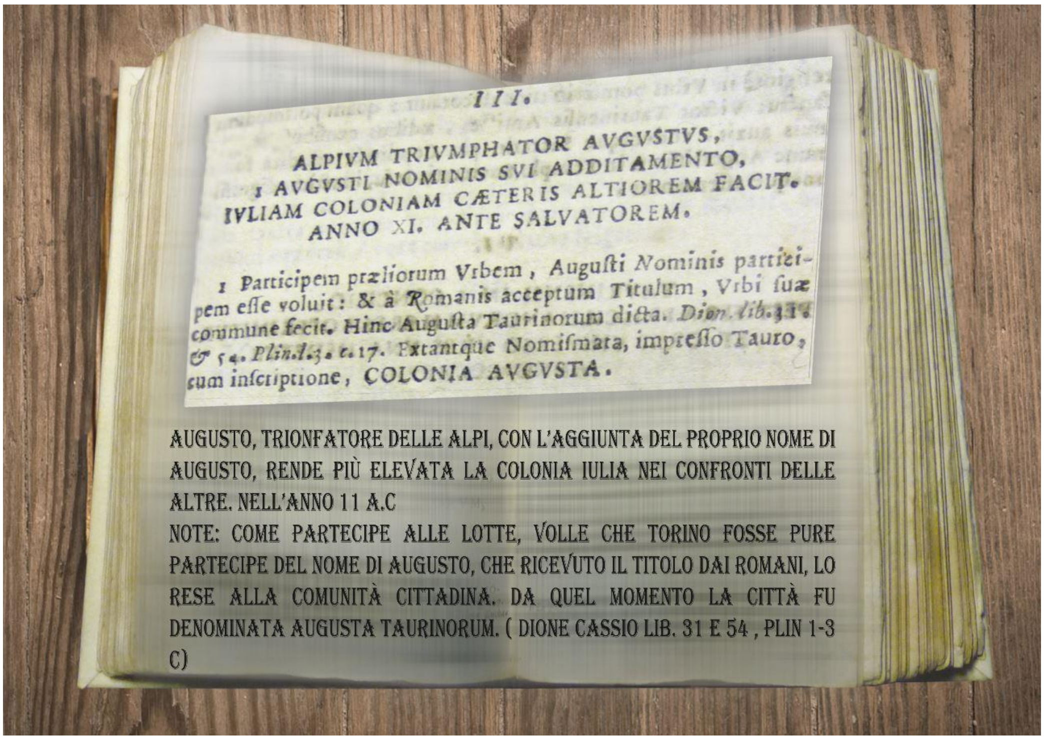


Figure 9649: Description of the 2° painting placed in the upper area of the hall highlighted by Cyan light

2) The fidelity of the city of Taurines, obtains by divo Julius privileges inherent to Julia colony so that the Gaul, receives the name of Cisalpine in 42 BC.

Notes: The painting shows Julius Caesar while giving to the Taurines his eminent colony: then he makes them Roman citizens, Caelius secund.munster, Plin. The Taurines in that century minted coins with Julius Caesar's effigy and the back of these coins shows the torus with the lettering of Iulia's Colony. The torus was also the emblem on banners. The citizens of Turin, according to Roman custom, wore the toga, and cut their hair, and along with the dress, they changed their name. (They were still called Taurines but, instead of Transalpine they become cisalpine).



111.

ALPIVM TRIVMPHATOR AVGVSTVS,
1 AVGVSTI NOMINIS SVI ADDITAMENTO,
IVLIAM COLONIAM CÆTERIS ALTIOREM FACIT.
ANNO XI. ANTE SALVATOREM.

1 Participem præliorum Vrbem, Augusti Nominis participem esse voluit: & à Romanis acceptum Titulum, Vrbi suæ commune fecit. Hinc Augusta Taurinorum dicta. Dion. lib. 31. & 54. Plin. l. 3. c. 17. Extantque Nomismata, impresso Tauro, cum inscriptione, COLONIA AVGVSTA.

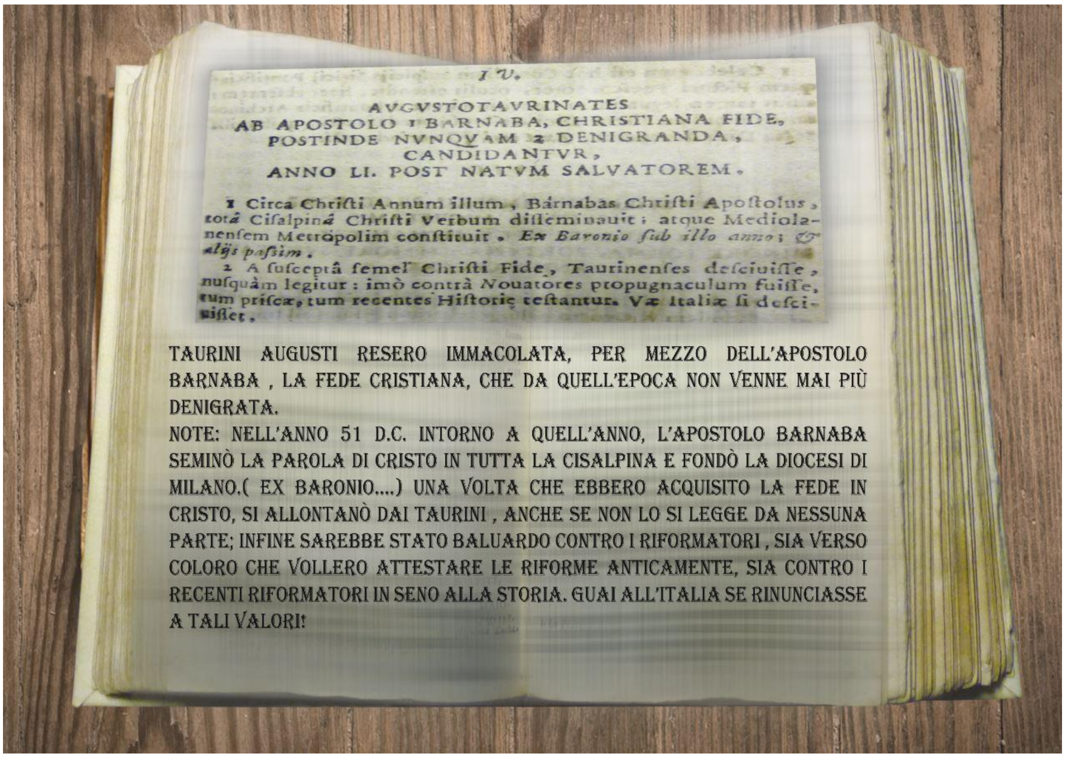
AUGUSTO, TRIONFATORE DELLE ALPI, CON L'AGGIUNTA DEL PROPRIO NOME DI AUGUSTO, RENDE PIÙ ELEVATA LA COLONIA IULIA NEI CONFRONTI DELLE ALTRE. NELL'ANNO 11 A.C

NOTE: COME PARTECIPE ALLE LOTTE, VOLLE CHE TORINO FOSSE PURE PARTECIPE DEL NOME DI AUGUSTO, CHE RICEVUTO IL TITOLO DAI ROMANI, LO RESE ALLA COMUNITÀ CITTADINA. DA QUEL MOMENTO LA CITTÀ FU DENOMINATA AUGUSTA TAURINORUM. (DIONE CASSIO LIB. 31 E 54 , PLIN 1-3 C)

Figure 9750: Description of the 3° painting placed in the upper area of the hall highlighted by Cyan light

3) Augustus, triumphant of the Alps by dding the Augustus name to his owns, makes the Iulia's Colony more elevated, compared to the others. In 11 B.C.

Notes: As a participant in the struggles, he wanted Turin to be a part of the Augustus's name as well, so that after receiving the title by the Romans, he extended it to the community of citizens. Since that time the city was called Augusta Taurinorum. (Dio Cassius, l. 31 and 54, Plin 1-3 c)



IV.

AVGVSTOTAVRINATES
AB APOSTOLO 1 BARNABA, CHRISTIANA FIDE,
POSTINDE NVNQVAM 2 DENIGRANDA,
CANDIDANTVR,
ANNO LI. POST NATVM SALVATOREM.

1 Circa Christi Annum illum, Bárnabas Christi Apostolus, totá Cisalpiná Christi Verbum disseminauit; atque Mediolanensem Metrópolim constituit. *Ex Baronio sub illo anno; & alijs passim.*

2 A susceptâ semel Christi Fide, Taurinenses desciuisse, nusquàm legitur: imò contrà *Nouatores* propugnaculum fuisse, tum priscæ, tum recentes Historię testantur. Væ Italiæ si desciuisset.

TAURINI AUGUSTI RESERO IMMACOLATA, PER MEZZO DELL'APOSTOLO BARNABA , LA FEDE CRISTIANA, CHE DA QUELL'EPOCA NON VENNE MAI PIÙ DENIGRATA.

NOTE: NELL'ANNO 51 D.C. INTORNO A QUELL'ANNO, L'APOSTOLO BARNABA SEMINÒ LA PAROLA DI CRISTO IN TUTTA LA CISALPINA E FONDÒ LA DIOCESI DI MILANO.(EX BARONIO....) UNA VOLTA CHE EBBERO ACQUISITO LA FEDE IN CRISTO, SI ALLONTANÒ DAI TAURINI , ANCHE SE NON LO SI LEGGE DA NESSUNA PARTE; INFINE SAREBBE STATO BALUARDO CONTRO I RIFORMATORI , SIA VERSO COLORO CHE VOLLERO ATTESTARE LE RIFORME ANTICAMENTE, SIA CONTRO I RECENTI RIFORMATORI IN SENO ALLA STORIA. GUAI ALL'ITALIA SE RINUNCIASSE A TALI VALORI!

Figure 9851: Description of the 4° painting placed in the upper area of the hall highlighted by Cyan light

4) Taurines August, through the Apostle Barnabas, made the Christian faith immaculate, which since that time was no more denigrated.

Notes: In 51 D.C. Around that year, the Apostle Barnabas spread the word of Christ in all the Cisalpine and founded the Diocese of Milan. (Ex Baronio ....) Once they acquired Faith in Christ, he walked away from Taurines, even if it is not written anywhere; finally, he would be a bulwark against the reformers, both to those who would attest the reforms in ancient times, and against the recent reformers within history. Shame on Italy if it gave up these values!

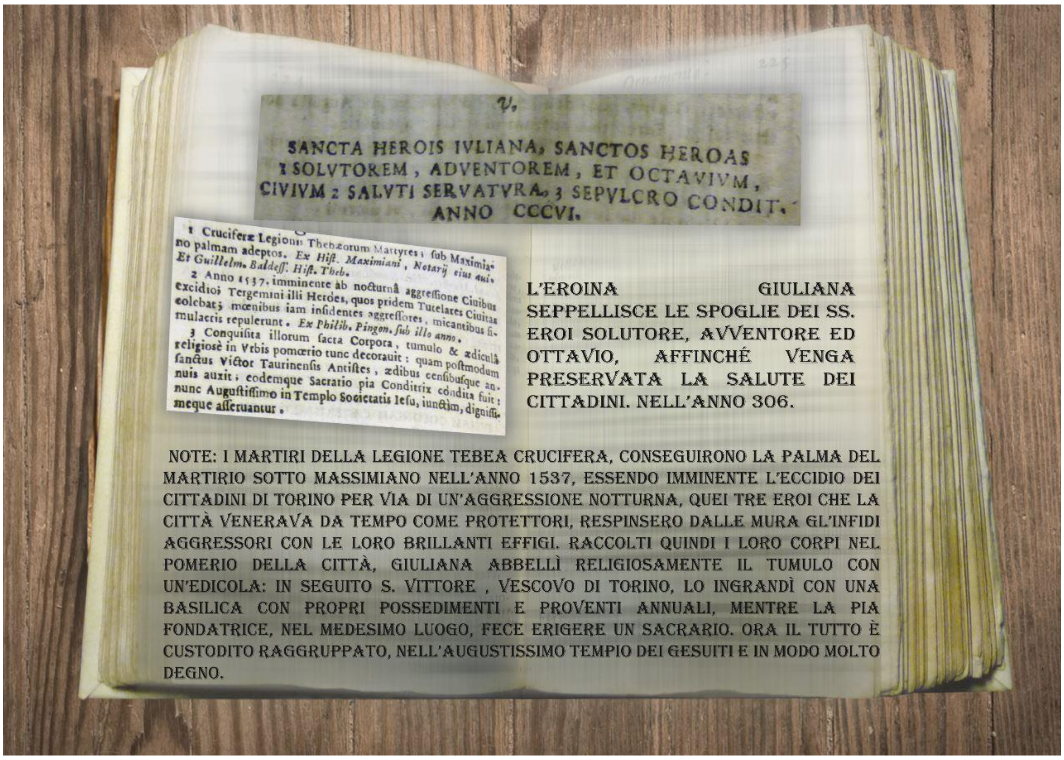


Figure 992: Description of the 5° painting placed in the upper area of the hall highlighted by Cyan light

5) The heroine Juliana buries the remains of the SS. Solutore, Avventore and Ottavio heroes, in order to preserve the health of citizens. Year 306.

Notes: The martyrdom of the Crucifer Theban Legion, got the martyrdom palm under Maximian (Ex.Hist. Maximiani ecc...)

In 1537, as a massacre loomed over the citizens of Turin because of nocturnal aggression, the three Heroes that the city has venerated as protectors for a long time, chased away from the walls the treacherous aggressors with their brilliant effigies. (Ex Phil. Pingone ...). After picking their bodies up and laying them in the city pomerium, Giuliana religiously embellished the tomb with an aedicule, which s. Victor, Bishop of Turin, later enlarged with a basilica with through his possessions and annual revenues, while the pious founder, in the same place, built a shrine, Now everything is guarded and grouped, in the August temple of the Jesuits in a very virtuous way.

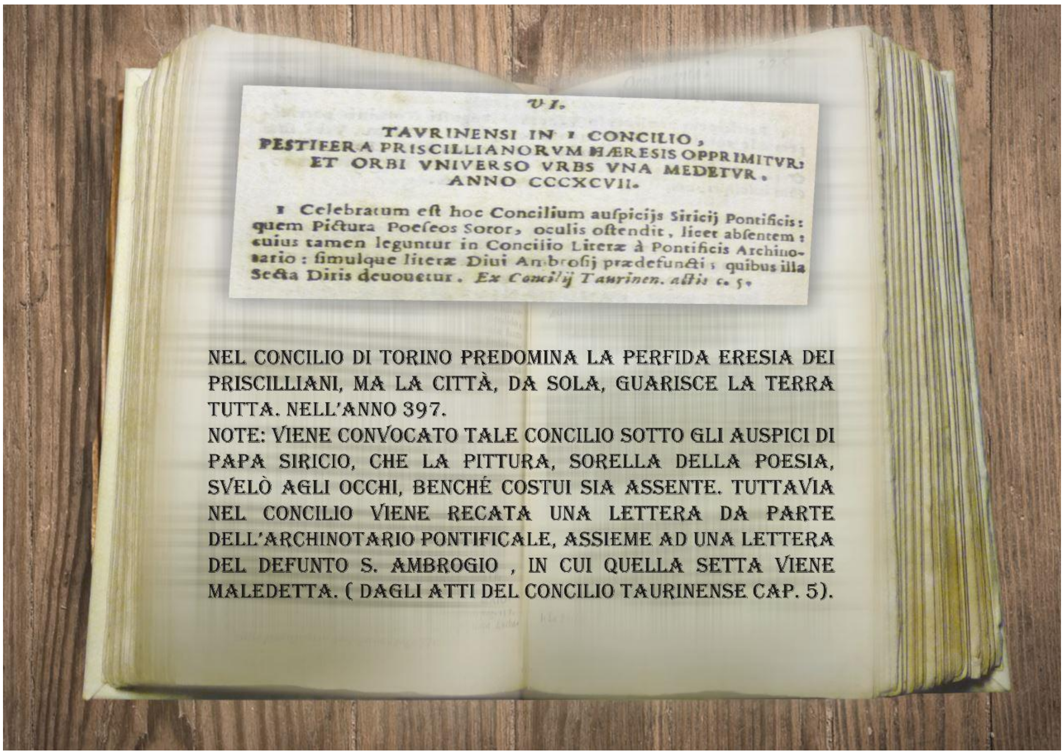


Figure 1003: Description of the 6° painting placed in the upper area of the hall highlighted by Cyan light

6) Over Turin Council predominates the perfidious heresy of Priscillianists, but the city by itself heals the whole earth in 397.

Notes: this council is called under the auspices of Pope Siricius, who was revealed by painting, sister of poetry, even though he is absent. However, within the council was brought a letter from pontifical Archinotario, along with a letter of the defunct S. Ambrogio, where the sect is cursed. (According to the documents of the Turin-council ch. 5).

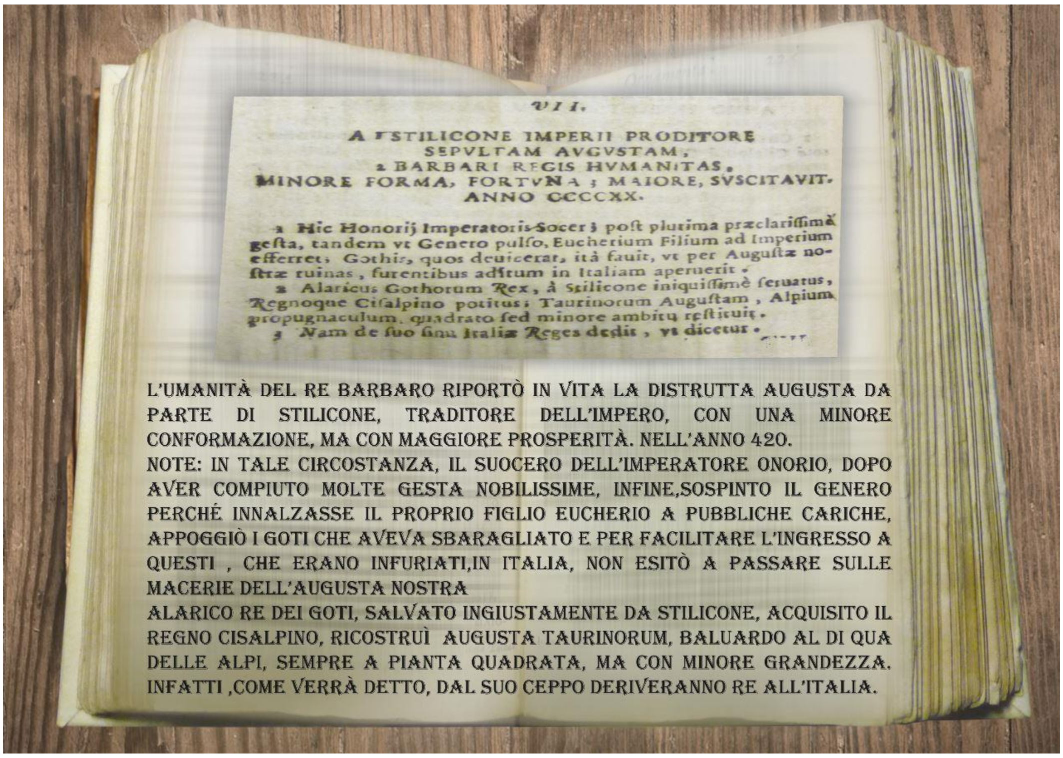
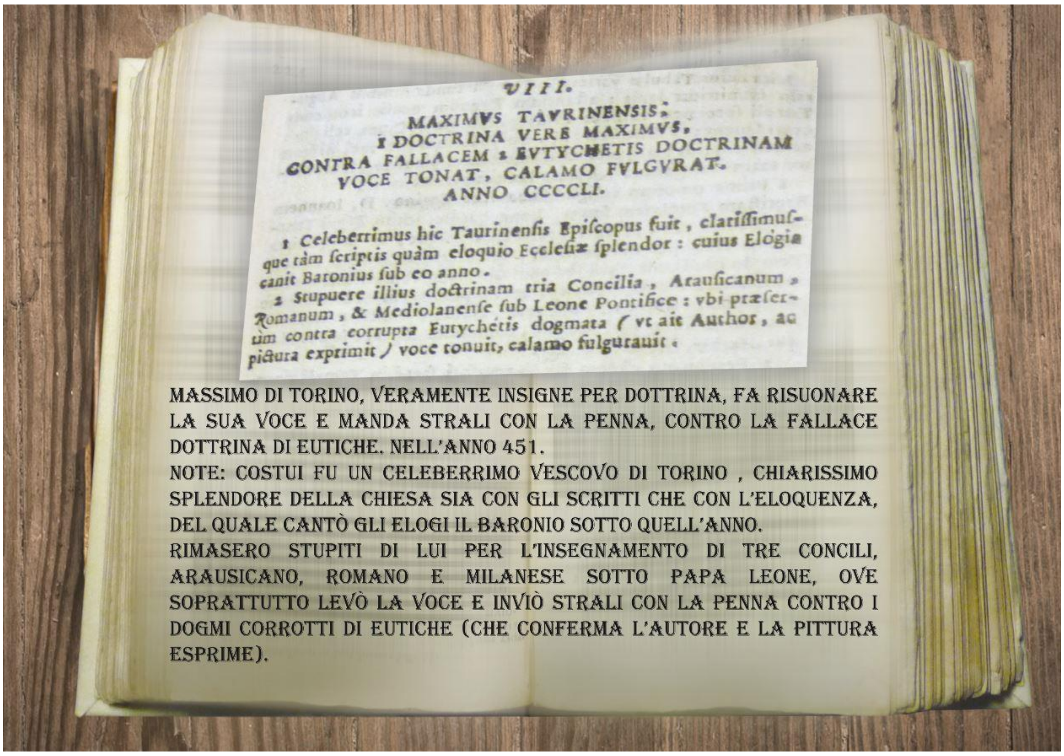


Figure 1014: Description of the 7° painting placed in the upper area of the hall highlighted by Cyan light

7) The humanity of the barbarian king brought back to life the Augusta, destroyed by Stilicho, Empire traitor, with a smaller conformation, but with greater prosperity. In the year 420.

Notes: In this circumstance, the Emperor Honorius father in law, having achieved many noble exploits, finally after persuading his son in law to give his son Eucherio public offices, supported the Goths who he had smitten, and to facilitate their entrance, who had come to Italy, he did not hesitate to walk on Augusta ruins Alaric; king of the Goths, unfairly saved by Stilicho, acquired the Cisalpine Kingdom , rebuilt august Taurinorum, bulwark on this side of the Alps, still in square plan, but in smaller size. In fact, as will be said, from his family will derive Italy's kings.


VIII.

MAXIMVS TAVRINENSIS.
1 DOCTRINA VERE MAXIMVS,
CONTRA FALLACEM 2 EVTYCHETIS DOCTRINAM
VOCE TONAT, CALAMO FVLGVRAT.
ANNO CCCCLI.

1 Celeberrimus hic Taurinensis Episcopus fuit, clarissimusque tàm scriptis quàm eloquio Ecclesiæ splendor: cuius Elogia canit Baronius sub eo anno.

2 Stupuere illius doctrinam tria Concilia, Arausicanum, Romanum, & Mediolanense sub Leone Pontifice: vbi præsertìm contra corrupta Eutychetis dogmata (vt ait Author, ac pictura exprimit) voce tonuit, calamo fulgurauit.

MASSIMO DI TORINO, VERAMENTE INSIGNE PER DOTTRINA, FA RISUONARE LA SUA VOCE E MANDA STRALI CON LA PENNA, CONTRO LA FALLACE DOTTRINA DI EUTICHE. NELL'ANNO 451.

NOTE: COSTUI FU UN CELEBERRIMO VESCOVO DI TORINO , CHIARISSIMO SPLENDORE DELLA CHIESA SIA CON GLI SCRITTI CHE CON L'ELOQUENZA, DEL QUALE CANTÒ GLI ELOGI IL BARONIO SOTTO QUELL'ANNO.

RIMASERO STUPITI DI LUI PER L'INSEGNAMENTO DI TRE CONCILI, ARAUSICANO, ROMANO E MILANESE SOTTO PAPA LEONE, OVE SOPRATTUTTO LEVÒ LA VOCE E INVIÒ STRALI CON LA PENNA CONTRO I DOGMI CORROTTI DI EUTICHE (CHE CONFERMA L'AUTORE E LA PITTURA ESPRIME).

Figure 10255: Description of the 8° painting placed in the upper area of the hall highlighted by Cyan light

8) Maximus of Turin, truly eminent for doctrine, spreads his voice and sends insults through his pen against the fallacious doctrine of Eutyches. In the year 451.

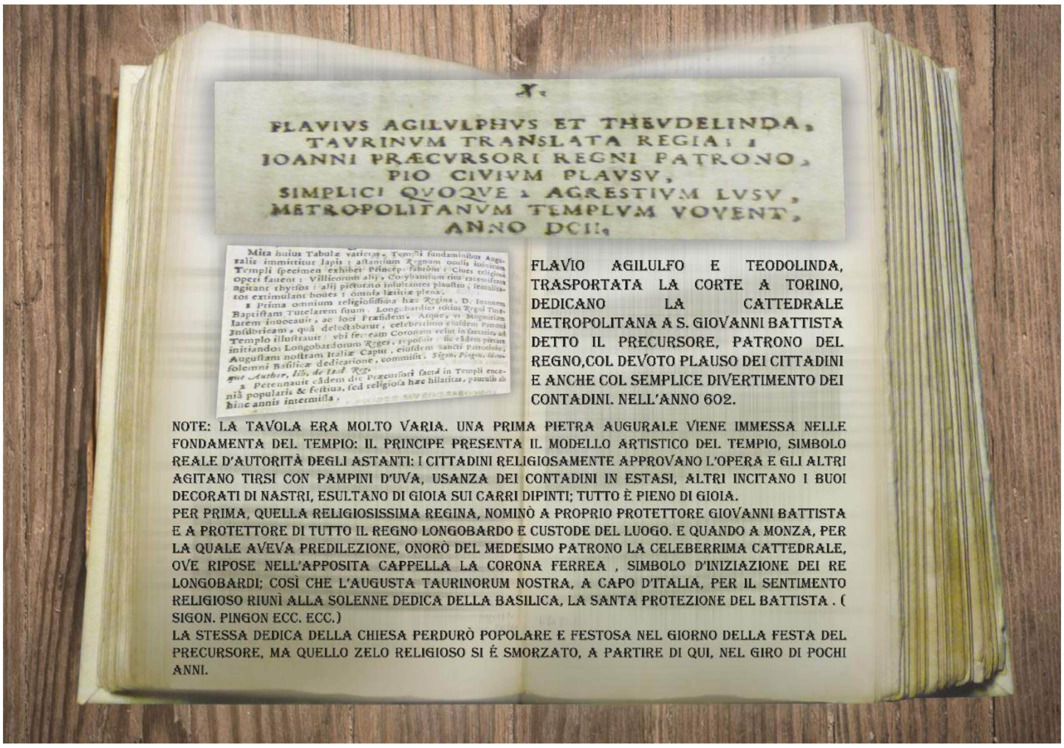
Notes: He was a famous bishop of Turin, clear splendor of the Church both with the writings and with the eloquence, which were praised by Baronio in that year.

They marveled at him for the teaching of three councils, Arausicano, Roman and Milanese under Pope Lion, especially when he raised his voice and sent insults through his pen against the corrupt dogmas of Eutyches (which the author confirms and painting expresses).

Figure 10356: Description of the 9° painting placed in the upper area of the hall highlighted by Cyan light

9) The Lombard Queen Teodolinda, having to ascend to throne, chooses Agilulfo, Duke of Turin, considered worthy of the bridal bed. In the year 591.

Notes: a very pious woman, daughter of the king of Bavaria Garibaldo, widow of the Longobard king Autari, so began her reign by the will of the nobles, as long as she choose a husband who would become king. She, not estimating anyone as worthy to reign, invites Agilulfo with an excuse, and when he kisses her royal hand, she comes close to him, and offers him her mouth; she becomes a (fundamental) dowel; she makes him husband and king. (Paul Deacon III, 35). Hence, conquered by the amenity of the place, moved the headquarters of the Kingdom in our Augusta Taurinorum for some time.



X.

FLAVIVS AGILVLPHVS ET THEVDELINDA,
TAVRINVM TRANSLATA REGIA;
IOANNI PRÆCVRSORI REGNI PATRONO,
PIO CIVIVM PLAVSV,
SIMPLICI QVOQVE AGRESTIVM LVSV,
METROPOLITANVM TEMPLVM VOVENT,
ANNO DCII.

FLAVIO AGILULFO E TEODOLINDA, TRASPORTATA LA CORTE A TORINO, DEDICANO LA CATTEDRALE METROPOLITANA A S. GIOVANNI BATTISTA DETTO IL PRECURSORE, PATRONO DEL REGNO,COL DEVOTO PLAUSO DEI CITTADINI E ANCHE COL SEMPLICE DIVERTIMENTO DEI CONTADINI. NELL'ANNO 602.

NOTE: LA TAVOLA ERA MOLTO VARIA. UNA PRIMA PIETRA AUGURALE VIENE IMMESSA NELLE FONDAMENTA DEL TEMPIO: IL PRINCIPE PRESENTA IL MODELLO ARTISTICO DEL TEMPIO, SIMBOLO REALE D'AUTORITÀ DEGLI ASTANTI: I CITTADINI RELIGIOSAMENTE APPROVANO L'OPERA E GLI ALTRI AGITANO TIRSI CON PAMPINI D'UVA, USANZA DEI CONTADINI IN ESTASI, ALTRI INCITANO I BUOI DECORATI DI NASTRI, ESULTANO DI GIOIA SUI CARRI DIPINTI; TUTTO È PIENO DI GIOIA.
PER PRIMA, QUELLA RELIGIOSISSIMA REGINA, NOMINÒ A PROPRIO PROTETTORE GIOVANNI BATTISTA E A PROTETTORE DI TUTTO IL REGNO LONGOBARDO E CUSTODE DEL LUOGO. E QUANDO A MONZA, PER LA QUALE AVEVA PREDILEZIONE, ONORÒ DEL MEDESIMO PATRONO LA CELEBERRIMA CATTEDRALE, OVE RIPOSE NELL'APPOSITA CAPPELLA LA CORONA FERREA , SIMBOLO D'INIZIAZIONE DEI RE LONGOBARDI; COSÌ CHE L'AUGUSTA TAURINORUM NOSTRA, A CAPO D'ITALIA, PER IL SENTIMENTO RELIGIOSO RIUNÌ ALLA SOLENNE DEDICA DELLA BASILICA, LA SANTA PROTEZIONE DEL BATTISTA . (SIGON. PINGON ECC. ECC.)
LA STESSA DEDICA DELLA CHIESA PERDURÒ POPOLARE E FESTOSA NEL GIORNO DELLA FESTA DEL PRECURSORE, MA QUELLO ZELO RELIGIOSO SI É SMORZATO, A PARTIRE DI QUI, NEL GIRO DI POCHI ANNI.

Figure 10457: Description of the 10° painting placed in the upper area of the hall highlighted by Cyan light

10) Flavio Agilulfo and Teodolinda, after moving the court to Turin, dedicate the Metropolitan Cathedral to St. John the Baptist said the Forerunner, the patron of the Kingdom, with the devoted praise of the citizens as well as the simple fun of the peasants. In the year 602.

Notes: The table was very varied. A first auspicious stone is placed in the foundation of the temple: the prince presents the artistic model of the temple, the real symbol of the onlookers authorities: the citizens religiously approve the work and the others wave thyrses with grape vine-leaves, a custom of farmers in ecstasy, others incite oxen decorated with ribbons, exult with joy on painted wagons; everything is full with joy.

First, the very religious queen, nominated as her protector and the protector of all the Lombard kingdom and guardian of the place John the Baptist. And in Monza, for which she had predilection, she gave the same patron to the famous cathedral, in whose chapel she placed the Iron Crown, initiation symbol of the Lombard kings; so that our Augusta Taurinorum, head of Italy, for the religious sentiment gathered *for the solemn dedication of the basilica, the holy of the Baptist protection. (Sigon. Pingon ecc. Ecc.).*

The same dedication of church endures popular and festive on the day of the precursor feast r, but the religious zeal is perished, starting from here, in a few years.

- Orange path over the perimeter with description of the lower area (A to H tables)

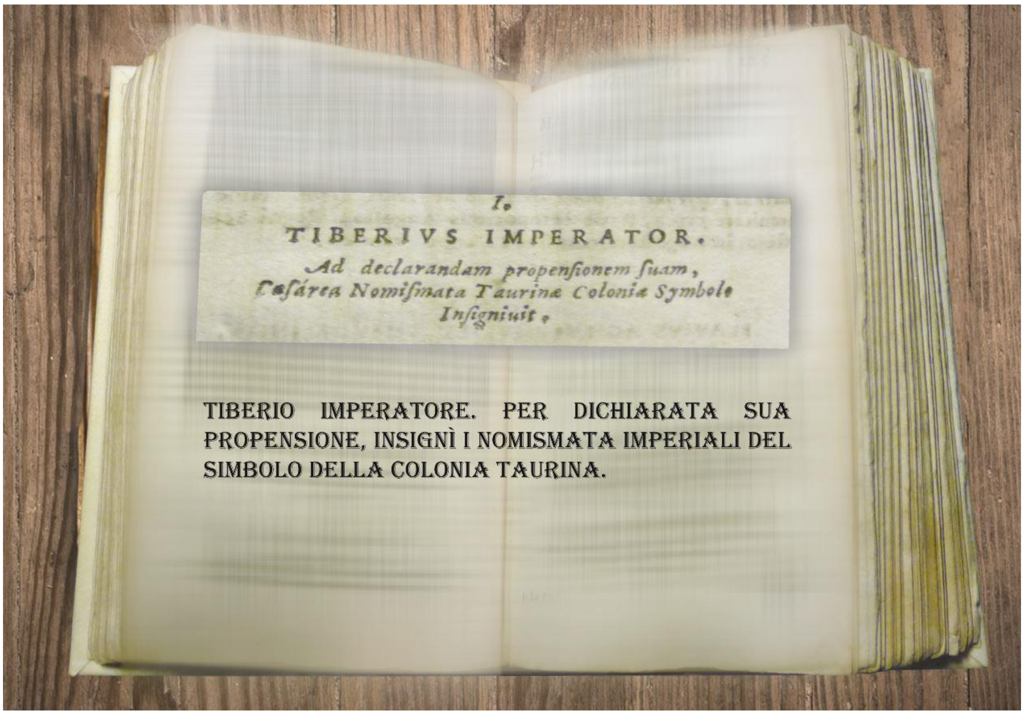


Figure 10558: Description of the 1° painting placed in the lower area of the hall highlighted by orange light

1. *Emperor Tiberius. For his declared propensity, he honored the imperial nomismata of taurine colony symbol.*

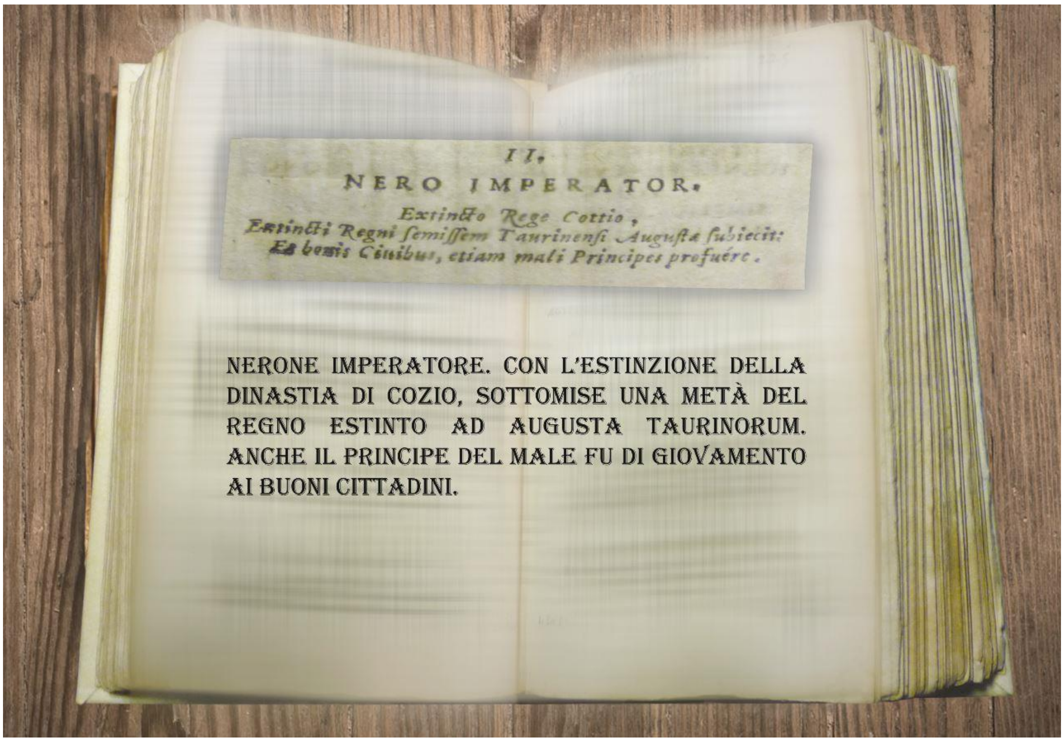


Figure 10659: Description of the 2° painting placed in the lower area of the hall highlighted by orange light

2. *Emperor Nero. With the extinction of the Cottain dynasty, he subdued half of the extincted kingdom to Augusta Taurinorum. Even the prince of evil brought benefit to the good citizens.*

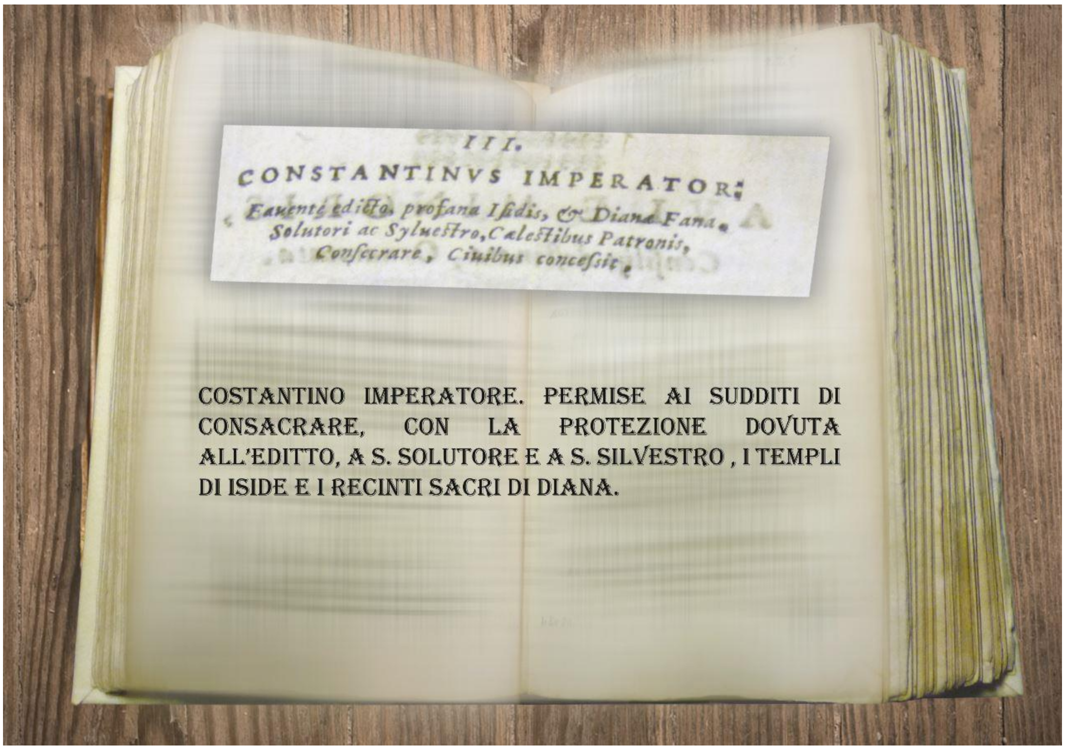


Figure 10760: Description of the 3° painting placed in the lower area of the hall highlighted by orange light

3. *Emperor Constantine. Allowed the subjects to consecrate, with the protection due to the edict, the temples of Isis and Diana's sacred precincts to S. solver and S. Silvestro.*

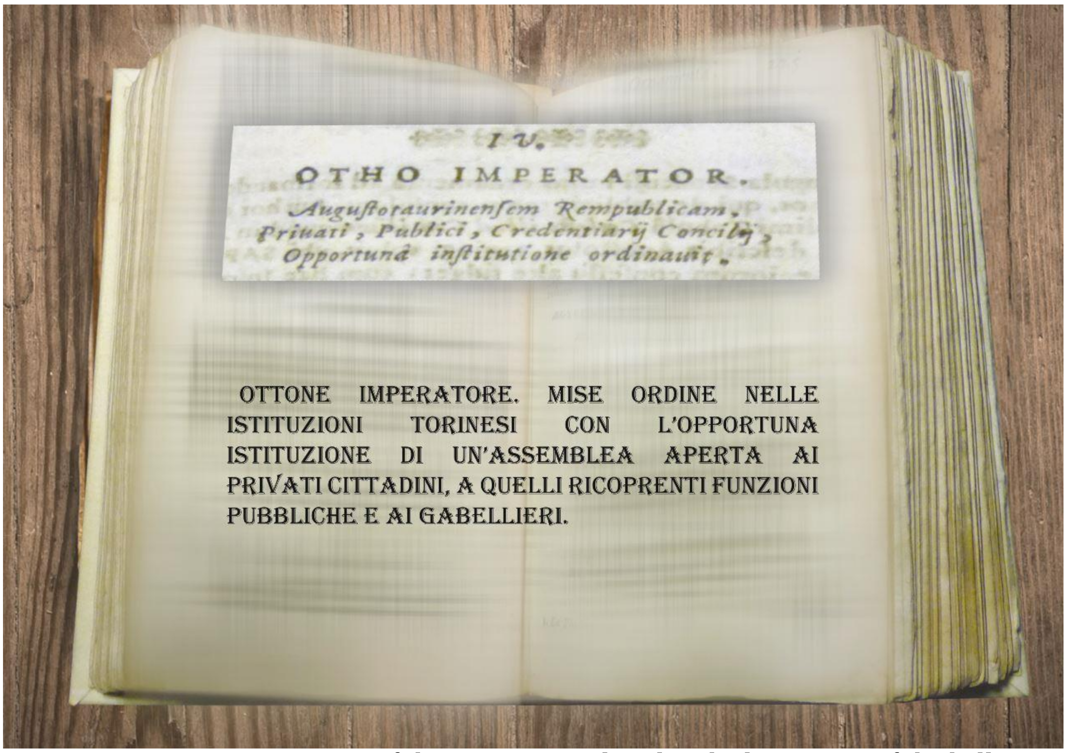


Figure 10861: Description of the 4° painting placed in the lower area of the hall highlighted by orange light

4. *Emperor Otto. He put order in Turin institutions with the appropriate establishment of an assembly open to private citizens, to who held public functions and to tax collectors.*

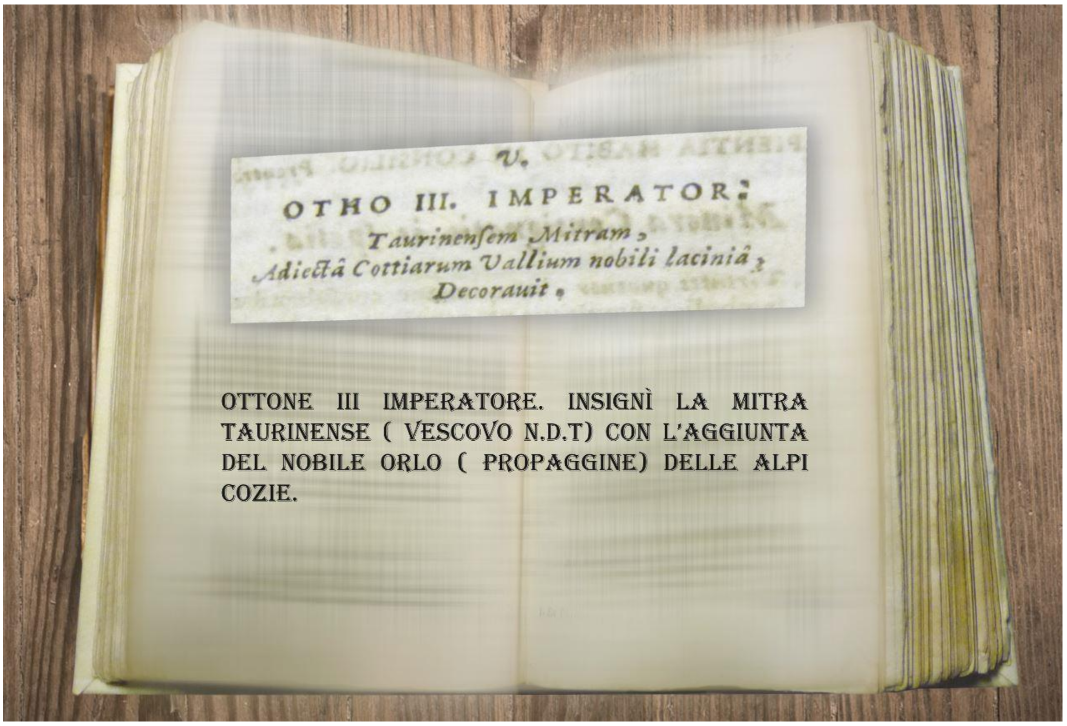


Figure 1092: Description of the 5° painting placed in the lower area of the hall highlighted by orange light

5. *Emperor III Otto. He awarded the Turin-miter (bishop n.d.t) with the addition of noble hem (offshoot) of the Cottian Alpes.*

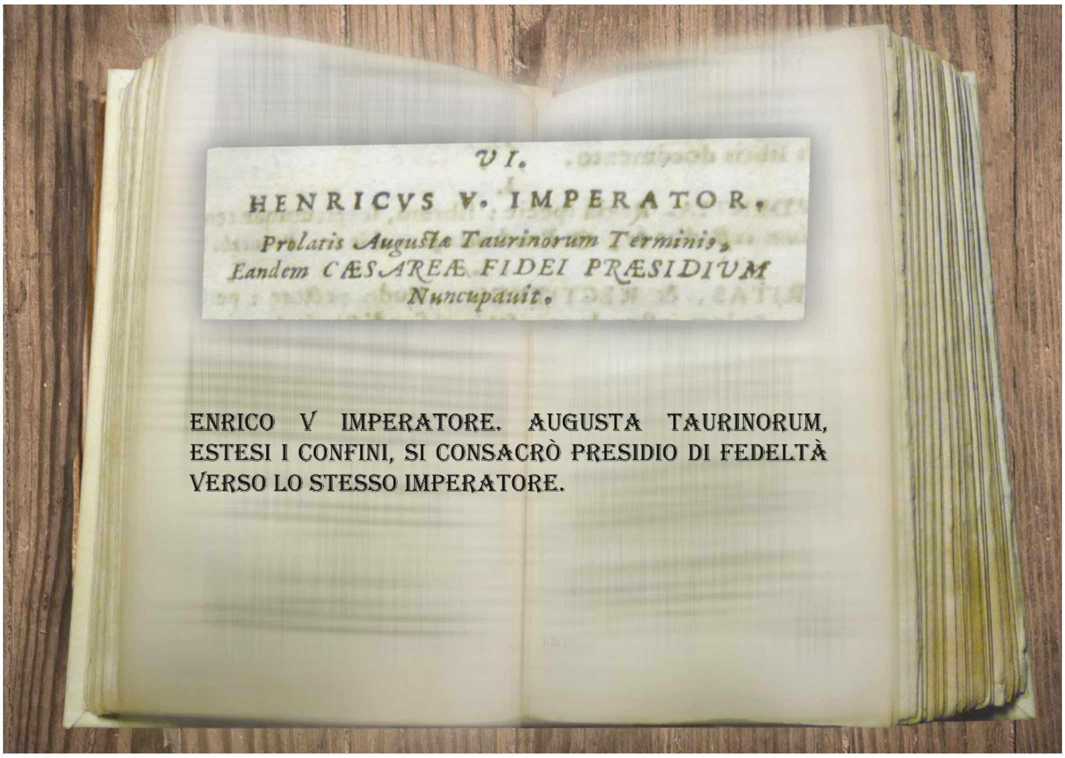


Figure 1103: Description of the 6° painting placed in the lower area of the hall highlighted by orange light

6. *Henry V Emperor. Augusta Taurinorum, after extending the boundaries, he consecrated himself as protector of loyalty towards the same emperor.*

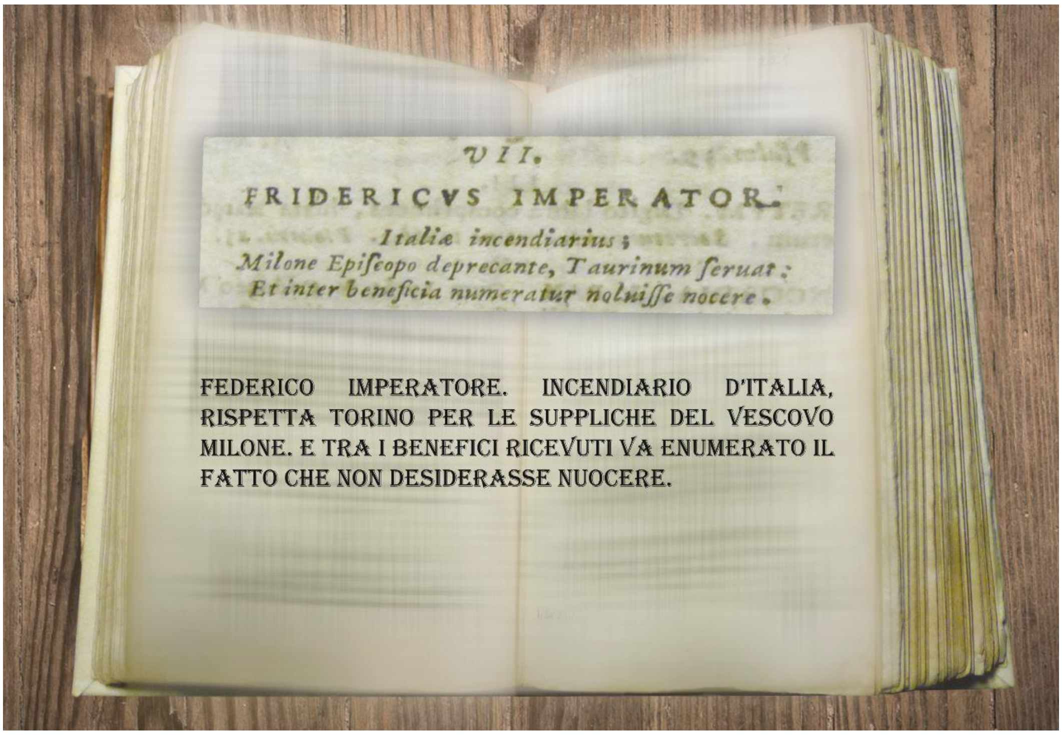


Figure 1114: Description of the 7° painting placed in the lower area of the hall highlighted by orange light

7. *Emperor Frederick. Arsonist of Italy, spare Turin because of the supplication of Bishop Milone. And among the benefits received it must be mentioned the fact that he wanted to do no harm.*

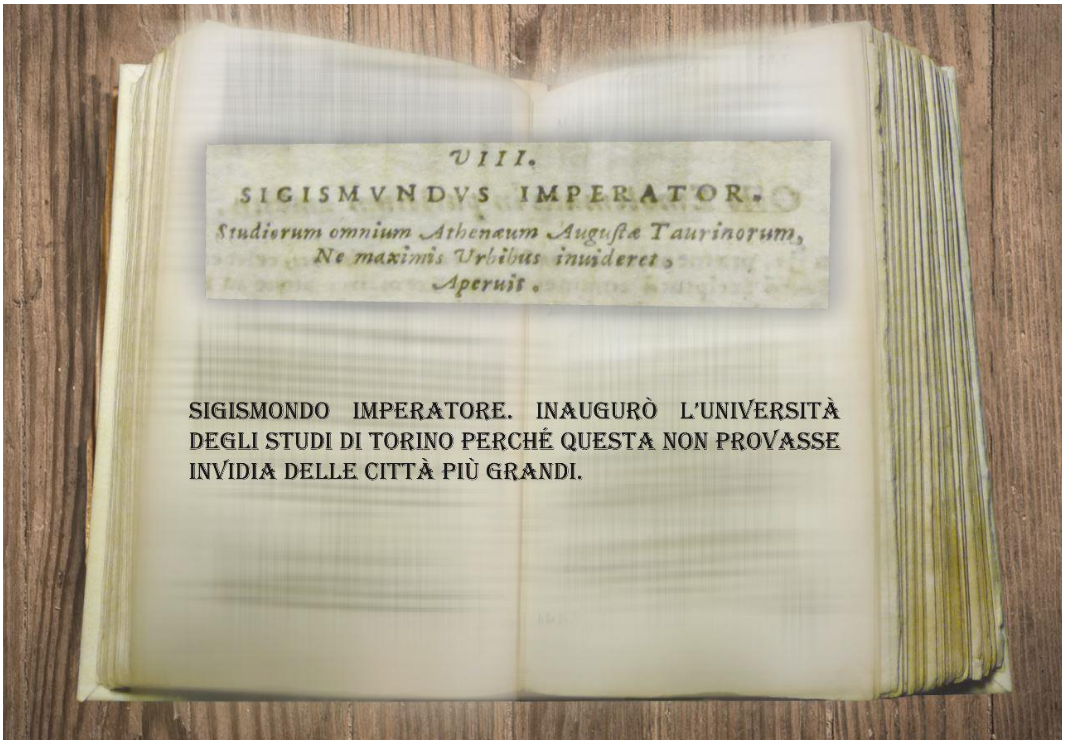


Figure 11265: Description of the 8° painting placed in the lower area of the hall highlighted by orange light

8. *Emperor Sigismund. He inaugurated the University of Turin so that it did not feel envious of bigger cities.*

- Virtual tour and Audio story in stages of Square of herbs transformations (balcony entrance), tables about the square

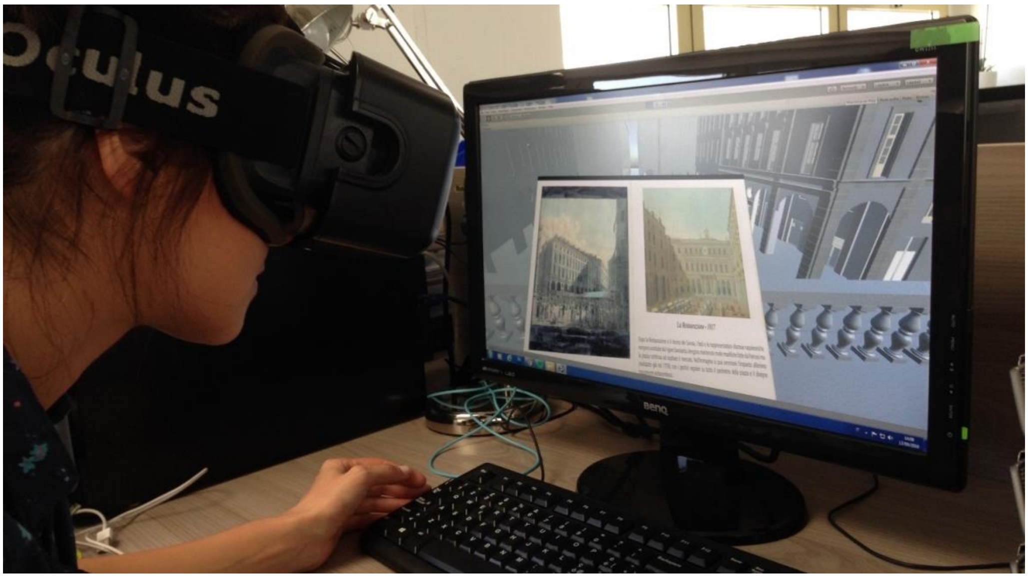


Figure 11366: Virtual Reality of square of Palazzo di Città by Oculus

Figure 11467: Virtual tour and Audio story of the medieval square - the fifteenth century

The medieval square - the fifteenth century.

Because of the absence of any direct iconographic evidence of the square medieval aspect, the only clues of customs and traditions are derived from written sources or eighteenth century paintings describing scenes of daily life, set in the fifteenth century. The square was the heart of a satellite commercial space system born on the ancient Roman forum; in particular, the area in front of the Town Hall contained the vegetable market that names after the ancient name of Square of Herbs.

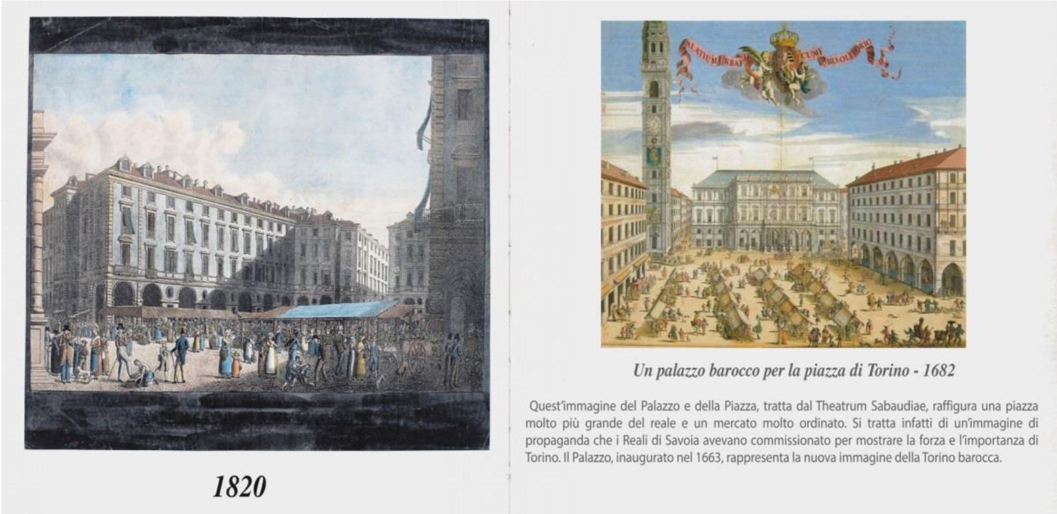


Figure 11568: Virtual tour and Audio story of a baroque palace for the Turin square - 1682.

A baroque palace for the Turin square - 1682.

This image of the Palace and the Square, extracted from the Theatrum Sabaudiae, represents a much larger square compared to the real one and a very orderly market. It is in fact a propaganda image that the Royal Savoy had commissioned to show the strength and importance of Turin. The building, inaugurated in 1663, is the new image of the baroque Turin.

Figure 11669: Virtual tour and audio story from Square of herbs to Town Hall Square. - 1756.

From Square of herbs to Town Hall Square. - 1756.

In this painting it is possible to see the square last image before Alfieri transformations. The medieval system is still recognizable in the Gothic porches on the right and the civic tower on the left. The square, in addition to being used for the vivid vegetable market, was the place where the lottery extraction for the allocation of the houses took place, as shown in the picture.

Figure 11770: Virtual tour and Audio story of The Turin Napoleon – 1798

The Turin Napoleon – 1798

The French troops of Joubert occupy Turin and take possession of the city and it's Palace. The building becomes the town hall of the Napoleonic power and the opposite square was the scene of many performances and typical representations of the revolutionary government. The image depicts Napoleon's army entrance into Square in a fictional environment. At that time in fact, the project Alfieri had already been completed, the gothic porches no longer existed and the tower was located in via Dora Grossa (now Via Garibaldi).

Figure 11871: Virtual tour and Audio story of The Restoration – 1817

The Restoration - 1817

After the Restoration and the return of the Savoy, all the glory and the Napoleonic magnificent representations are replaced by the Savoyard rigor. Many changes made by the French are preserved but the square continues to host the market. In the picture it is possible to see the Alfieri system (realized already in 1759), with regular porches around the entire perimeter of the square and the typical eighteenth-century drawing.

Figure 1192: Virtual tour and Audio story of the social transformation of the center – 1820

The social transformation of the center - 1820

The picture shows the last period of the vegetable market, moved in 1835 to make the square dignified. The upper middle class, having moved their offices and activities in the center, were able to achieve what the upper classes of Turin had required in fact for more than a century: a modernization of the environmental functions of the city's symbol. The design of Alfieri, despite criticism for porches (or portiet) that were considered impractical for the nineteenth-century vehicles, came out in order to give a new image to the palace and the ancient Square of herbs.

Figure 1203: Virtual tour and Audio story of a monument for the Square – 1853

A monument for the Square - 1853

The king Carlo Alberto, after having granted the Albertine Statute and being celebrated by the city, place in the square a monument to the Conte Verde, by Pelagio Palagi: the group of bronze statues reminds the then young Amedeo VI businesses in the East, renewing the bond between the city and the regent who had inspired the great significance celebrations. The monument was inaugurated in Piazza Palazzo di Città only in 1853, with an experiment of electric light that made glimmer in a suggestive manner both the monument and the City Hall.

Figure 1214: Virtual tour and Audio story of Turin town hall of the nascent united Italy - 27 April 1859.

Turin town hall of the nascent united Italy - 27 April 1859.

The palace, which is now the Town Hall of Turin, capital of the Kingdom of Sardinia, continues to be the meeting place for official events. Just as in original design, the king continues to appear in public occasions such as the parade of his cavalry, about to fight the War of Independence from Austria.

Figure 12275: Virtual tour and Audio story of Turin United Italy capital – 1878

Turin United Italy capital - 1878

The square and Turin are enriched with a new political role: the monument and the palace are dressed up to welcome the procession that brings as a gift to the city the sword and medals of Vittorio Emanuel II, first king of united Italy.

Figure 12376: Virtual tour and Audio story of Industrialization and motorization – 1900

Industrialization and motorization - 1900

The use of the square and the consequent drawing of the pavement are slowly changed in recent decades, evolving the dignity of this place as a result of the increasing motorization of the city practicability.

Tram lines on Via Milano and within the same square, had dictated the pavement lines so that it could resist the stresses of heavy vehicles passing there, generating an irregular and chaotic project. In addition, the need to stop and traffic made the Town Hall Square a large car park for the neighborhood offices.

Figure 12477: Virtual tour and Audio story of Redevelopment of the institutional heart of Turin – 1990

Redevelopment of the institutional heart of Turin - 1990

Today the square, due to the redevelopment of the 90's, is presented as an important museum center, as well as institutional, through the pedestrian area, new paving, and lighting and public furniture. In addition, the monument to the Conte Verde, restored to its former glory, was surrounded with a fence to better preserve it. The square, despite having lost its commercial centrality, continues to host events and occasional markets and remains an anchor of the public and institutional life in Turin.

Conclusion

The development of IT is literally running on at incredible speeds, constantly innovating our way of visualizing media content, making the technologies cheaper and cheaper, empowering our possibilities of communication and cooperation. The AEC industry, despite its renowned slowness, has entered a new era, where BIM is renovating the representation techniques more than any other technology since CAD revolution. Besides, many public administrations are supporting this renewal, perceiving the great possibilities of process control and cost-saving behind the BIM methodology.

CH professionals are not new to VR and AR, and have already demonstrated great sensibility to the opportunities of impactful dissemination behind IT. Is not difficult to experience Virtual Tour, application of AR devices and other avant-garde technologies in the main museums world-wide and even smaller reality are adopting the newest innovations in communicating with tourists.

The present work tries to take the CH beyond the dissemination level, showing how powerful these tool could be in the professional fields. The maintenance of our Heritage is presenting economic issues due to its vastness and complexity; the digitization of the historic information can undoubtedly be of great help in reduce the costs of intervention, thanks to its power to enhance accessibility and cut off the time of retrieval of the data. BIM is revolutionizing this process, eliminating incoherence between different sources (either papery or informatics) and this study validates its effectiveness even in a complex case study as a baroque building can be. The future development, thanks to 3d laser scanning and points cloud, will surely allow faithful reproduction of elaborated architectural elements, avoiding oversimplification of the modeled object inside the BIM environment.

Nevertheless, thanks to the interoperability, parametric software IFC based are already demonstrating their reliability in generating 3d models for many purposes, like in the case study here presented: energy analysis, structural calculations, FM database, maintenance planning, historical archive generation and many other kinds of information storing. Moreover, AR and VR visualizations generated from the BIM model already demonstrated the variety of fields of application and the sustainability of the economic efforts, both to produce and visualize them. Translating this concept in “tangible” results means to accept the challenge issued by our time: protecting our Cultural Heritage as a society.

To achieve this goal it is essential to involve as many users as possible in a process of collective awareness rising. Understanding the invaluable source belonging to our and future generations, is in fact the first step to take to fight its wasting. This research has been conducted in the strong believing that sharing knowledge and making it accessible to anyone is the only way to make communities protagonists of their rebirth.

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