POLITECNICO DI MILANO

Architettura Urbanistica Ingegneria
delle Costruzioni
Architecture and Preservation

THE INCOMPLETE FACADE OF ITALIAN CHURCHES

THE CASE-STUDY OF MILAN CATHEDRAL

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ANNO ACCADEMICO 2016 - 2017

Abstract

Italy has many unfinished historic buildings, especially churches facades. This study will analyze the issue through a few examples and will present a more in-depth study on Milan's Cathedral, for which some drawings were executed, thanks to the most recent high-tech survey.

Keywords

Facade; survey; architecture; Milan Cathedral

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Introduction

Italy has many unfinished historic buildings, especially churches facades. There are many reasons to contribute to these unfinished works. Over the long period of constructions, wars, plagues, lack of funding and workers, deaths of patrons or chief architects, and serious structural problems caused by the lack of knowledge in structural mechanics, all these factors could lead to a temporary or permanent suspension of a project. When successors tried to continue the unfinished work left by the earlier generation, the importance of the churches made it even more difficult to decide and execute

As a Chinese who has never visited uncompleted historic architecture in my own country before, I am attracted by the unfinished Italian churches. Besides, the facade, one of the most significant parts of the church, is an obvious evidence to demonstrate its uncompleted status: the rough brick exterior is always in sharp contrast to the elaborately decorated interior. Therefore, I decided to choose unfinished facades of Italian churches as the topic of my thesis. This study will analyze the issue through a few examples and will present a more in-depth study on Milan's Cathedral, for which some drawings were executed, thanks to the most recent high-tech survey.

Two Florentine churches, *Basilica di San Lorenzo* and *Cattedrale di Santa Maria del Fiore* (*Duomo di Firenze*), and another church in Milan, *Duomo di Milano*, are chosen to be the case studies of this thesis. The *Basilica di San Lorenzo* by *Filippo Brunelleschi*, which façade is not yet finished until today, despite famous architects such as *Michelangelo Buonarroti* had various proposals for it. The façade of *Santa Maria del Fiore*, the most important church in Florence, had remained unfinished for almost six centuries. The final efforts to complete the façade restarted in 1861, as an international competition for the façade was held when Tuscany became a region of the Kingdom of Italy. From the late 14th century to its rushed completion under Napoleon's order, *Duomo di Milano* remained an uncompleted façade for more than four centuries. In 1886, the *Veneranda Fabbrica del Duomo di Milano* (VFD) launched an international competition for a complete renovation of the Gothic façade. Unfortunately, the winner project chosen in 1888 was not implemented due to the sudden death of the architect. The brief history of the construction of these churches and the reasons why they are incomplete will be introduced. Various proposals for the façade in different eras would be showed and compared with.

The modern theory of architectural conservation suggests that the incomplete historic buildings should be left in an authentic status and limited interventions should be carried out for maintenance. Digital technologies are widely used in the conservation and exhibiting of historic architecture. EniTecnologie and 3D Survey Group (3DSG) of *Politecnico di Milano* helped VFD to survey the cathedral. The drawings of 2D elaborations, the creation of 3D models and the establishment of interactive databases help VFD to organize the daily conservative restoration and maintenance of *Duomo di Milano*.

In addition to the three case studies mentioned above, a description of my participation in 3DSG's survey project of *Duomo di Milano* is detailed. Two restitutions concerned with the thesis topic, i.e. the elevations of the internal façade and the chapel of *Madonna dell'Albero,* are made. Also, the thesis compares Italy and China from the perspective of my personal survey and drawing experiences in the two countries.

Over the past years I have always been interested in architecture survey, and before coming to Italy to pursue a Master's degree I used to survey vernacular architecture in both rural and urban areas in many provinces of China. With a particular interest in how people do the survey and drawing in a country where architectural traditions are different from those in China, I took the summer program "Laboratory of Places 2015, Ghesc and surroundings - History, survey, evolution" organized by 3DSG. Many high-tech survey approaches using different digital devices and software were introduced in this program. I was excited to learn that 3DSG was taking part in the survey project of *Duomo di Milano*. It is a great honor for me to participate in the drawing part of the project, and I am delighted to include related works of the project in this thesis.

Chapter 1: Incomplete facades of Italian churches

"Today it is not easy to imagine what a church meant to the people of that period.[1] *Only in some old villages in the countryside can we still get a glimpse of its importance. The church was often the only stone building anywhere in the neighbourhood; it was the only considerable structure for miles around, and its steeple was a landmark to all who approached from afar. On Sundays and during services all the inhabitants of the town might meet there, and the contrast between the lofty building and the primitive and humble dwellings in which these people spent their lives must have been overwhelming. Small wonder that the whole community was interested in the building of these churches and took pride in their decoration. Even from the economic point of view the building of a minster, which took years, must have transformed a whole town. The quarrying and transport of stone, the erection of suitable scaffolding, the employment of itinerant craftsmen, who brought tales from distant lands, all this was a real event in those far-off days."*[2]

Religious architecture always played a central role in Europe. In the Middle Ages, churches were the center of one's religious life and daily life. The biggest, highest and finest building in town was church. Besides daily religious activities, citizens celebrated festivals in church, held conferences in church, and sought asylum in church. Though most of the Christians lived in poverty, they would like to devote their property to churches and to spend their money on construction of churches. The best crafts and most beautiful treasures were used to decorate their magnificent churches.

"The great cathedrals ... of the late twelfth and early thirteenth century were mostly conceived on such a bold and magnificent scale that few, if any, were ever completed exactly as planned."[3] Besides, a large number of churches of other ages with ambitious great plans were left unfinished today.

Different Types of Incomplete buildings

a) The construction has not finished. *Castello di Rivoli* (Fig1.1) in Turin is an example. It is a former Residence of the Royal House of Savoy in Rivoli. It has been damaged by the French troop in 1693. Though new plans and façade was commissioned later, it still remained unfinished. The renovation on the Castel began in 1979, with Andrea Bruno in charge of the project and its execution. In

[1] "That period" refers to the twelfth century in the context.
[2] Gombrich, E. H. The Story of Art, Sixteenth Edition, London: Phaidon Press, 2017, p171
[3] Gombrich, E. H. 2017, p188

1984 the castle was reopened as seat of the Contemporary Art Museum of Turin. The official inauguration of the *Manica Lunga* (the long gallery) took place in February 2001.[4] The unfinished gallery was well designed to close with whole new materials of steel and glass at the end.

1.1 Castello di Rivoli, Contemporary Art Museum, Turin, Italy[5]

b) Part of the building was badly damaged mainly in wars or earthquakes, and has been repaired in a distinct way. It is easy to distinguish between the original and restoration part. *Chiesa degli Eremitani* (Fig1.2) in Padova, which chapel had been largely damaged by the bombs of Allies in World War II is in this type of situation.

1.2 The restored chapel and fresco, Chiesa degli Eremitani, Padova, Italy[6]

c) The building was converted from ancient ruins and it looks incomplete from the outside. For instance, *Basilica di Santa Maria degli Angeli e dei Martiri* (Fig1.3) in Rome, which was designed by Michelangelo and transformed from the ruins of the Baths of Diocletian belongs to this type.

[4] Castello di Rivoli, Museo d'Arte Contemporanea, The Castel - The Collection, Milano: Skira, 2008, p20-43
[5] Photo by the author
[6] Photo by the author

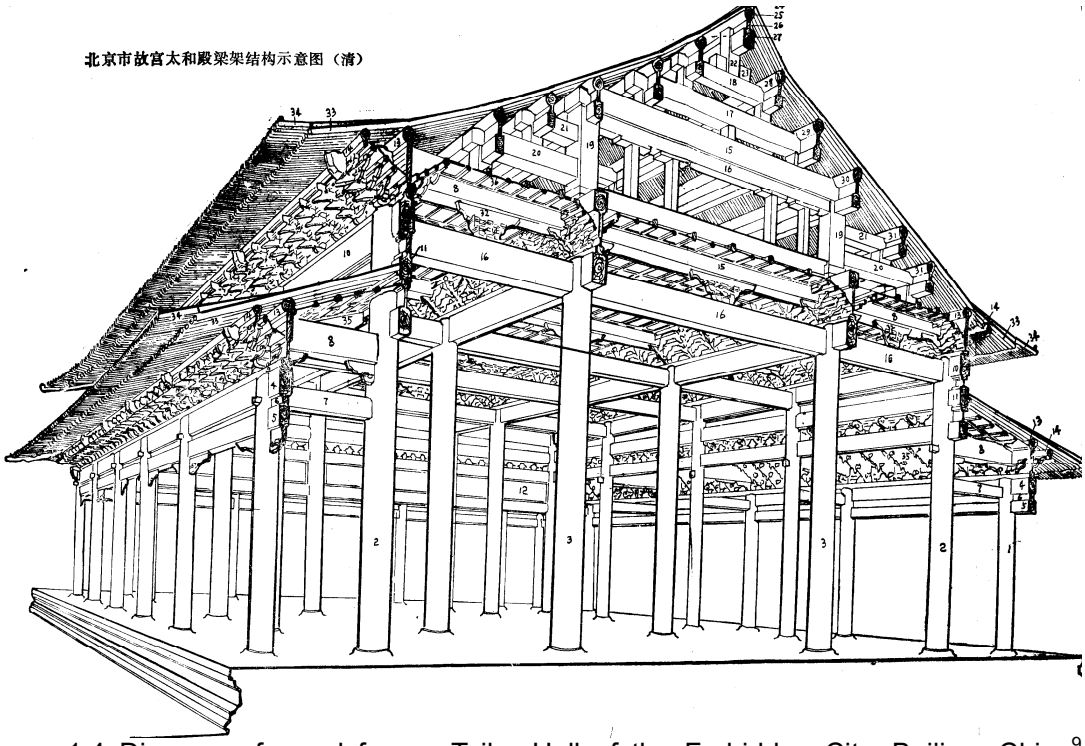
1.3 Basilica di Santa Maria degli Angeli e dei Martiri, Rome, Italy[7]

"The Thermae of Diocletian were the largest baths of ancient Rome, measuring 380by 370m and accommodating over 3000 visitors. In 1561 Pope Pius IV (1559-65) decided to build it into a church, Santa Maria degli Angeli, in order to augment divine worship as well as for the sake of conserving such an important historic building. The 86-year-old Michelangelo Buonarroti was invited to submit a design for the church executed between 1561 and 1566. The project was conceived as a minimum intervention; new was added or changes made where absolutely necessary. The exterior of the church was left in its ruined state. The whole construction was conceived as 'incomplete'. This reflected Michelangelo's state of mind at the end of his life, being concerned with the problems of death and the salvation of the soul."[8]
Other than an incomplete architecture, it is more proper to see it as a transformation of historic buildings. This kind of projects will not be included to the case study in this thesis.

Possible reasons of incomplete

There were a great number of large-scale buildings in Ancient China (and also in Ancient Rome). The structure, the building materials and the organization of multi-function complex of traditional Chinese architecture all makes it easier to complete the construction in a short time. Chinese historic architecture was mainly built in wood frame structures with stones and bricks used as the bases and non-load-bearing walls (Fig1.4), which is cheap, flexible and proper for a massive and rapid construction.

[7] Photo by the author
[8] Jokilehto, J. A History of Architectural Conservation, New york: Routledge, 2011, p34-36

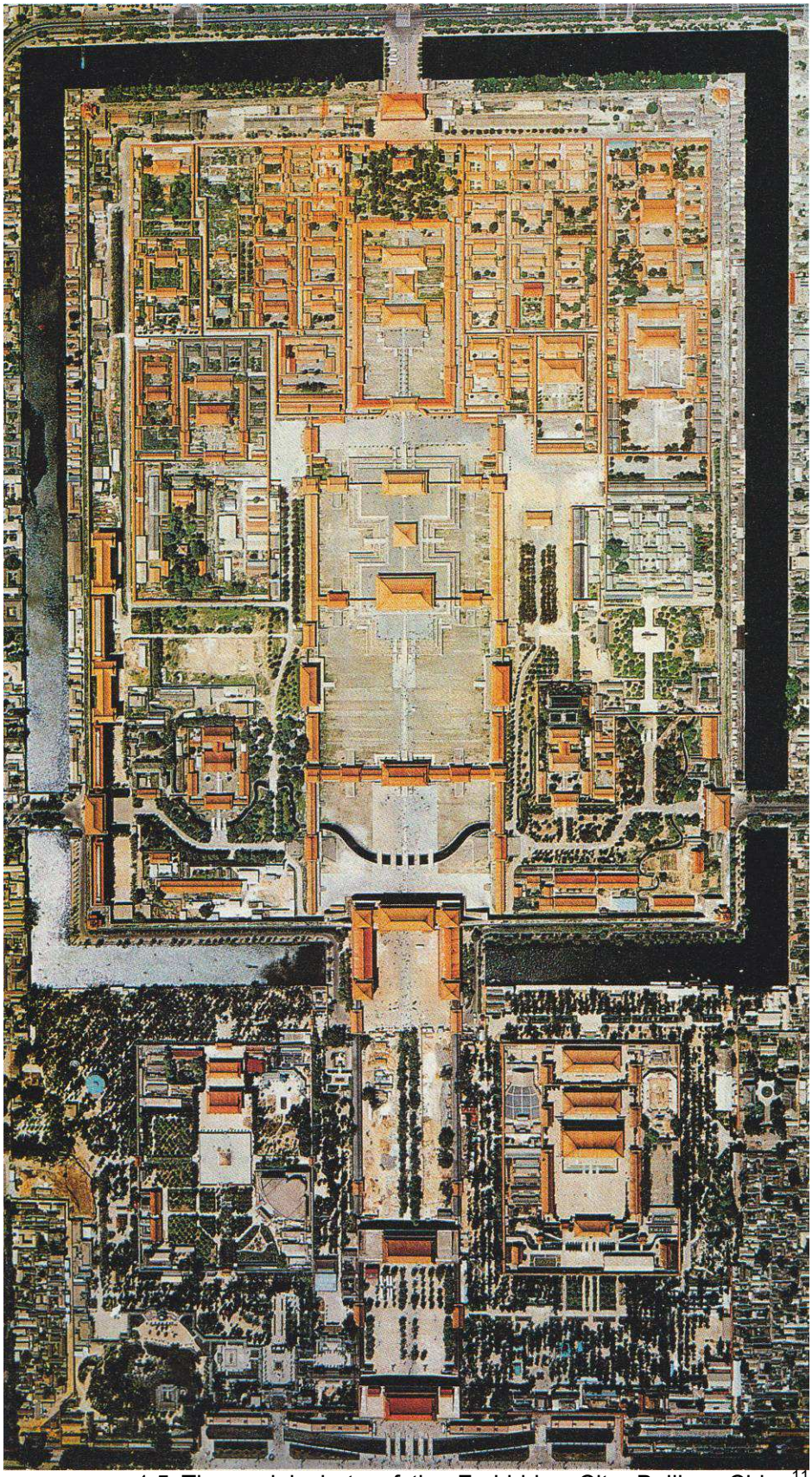


1.4 Diagram of wood frame, Taihe Hall of the Forbidden City, Beijing, China[9]

All great historic building complexes in China comprised a series of individual buildings in different sizes but use only one proven structural system. If workers and building materials were enough, several buildings would be built at the same time. This led a very short construction period in China compared to Italy in the past. For instance, the Forbidden City (Fig1.5), located in the centre of Beijing, was the imperial palace of China from the Ming Dynasty to the end of the Qing Dynasty (1420-1912). Constructed from 1406 to 1420, the main body of the Ming Dynasty Palace complex is 961 meters long by 753 meters wide, which covers 72 ha (over 180 acres).[10]

While in Italy, especially in the Medieval and Renaissance Periods, the situation was quite different. Many reasons caused a large number of ambitious projects not finished in the past.

[9] Beijing Cultural Relics Institute, Dictionary of Ancient Chinese Architecture, Beijing: China Book Press, 1992
[10] Sun Dazhang, History of Ancient Chinese Architecture, Volume 5, Architecture of Qing Dynasty, Beijing: China Architecture & Building Press, 2002, p37

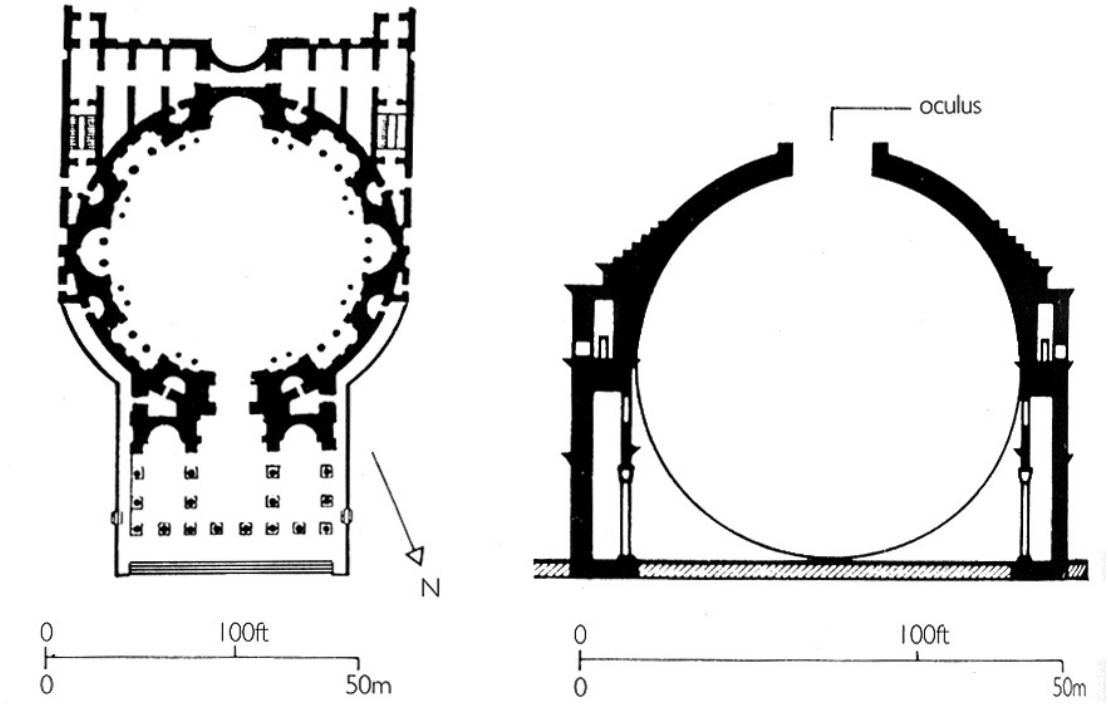


1.5 The aerial photo of the Forbidden City, Beijing, China[11]

a) The long period of construction

[11] Watkin, D. A History of Western Architecture: Settings and Rituals, Sixth Edition, London: Laurence King Publishing, 2015

Construction was very slow in Medieval and Renaissance Period. It was quite common to construct a church longer than one hundred years and still left it unfinished. The longer the construction took, the higher possibility that incident or accident would happen to suspend the project.



1.6 Plan and Section of the Pantheon, Rome, Italy[12]

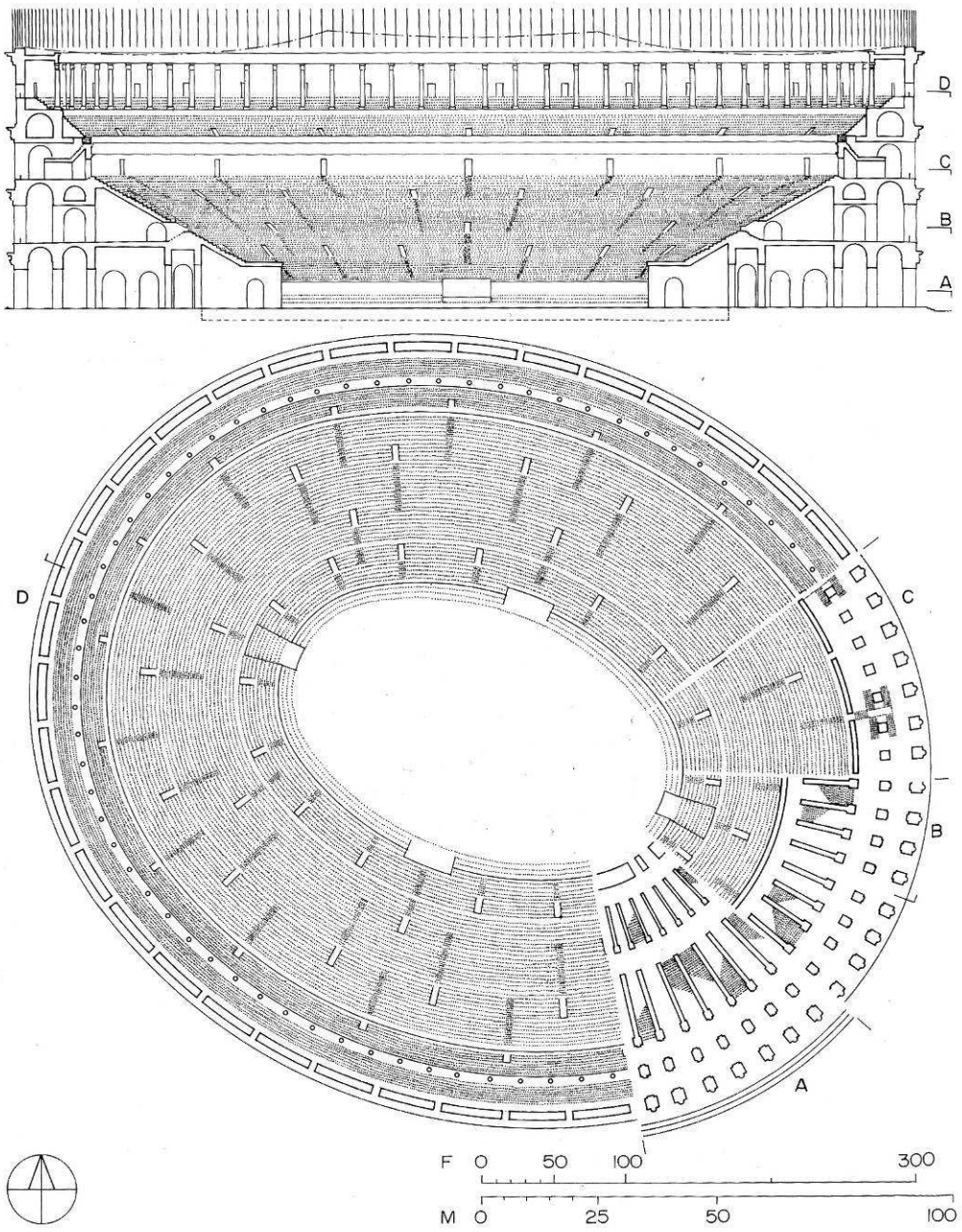
The structure and building material used in Italy were among the reasons that caused the construction slow. Stones and bricks were used as the main structural material in Italian churches. Arches, vaults and buttresses were not that quick and easy to be built. When using different materials, we do have faster examples in Italy. By using *opus caementicium* (Roman concrete) as the main building material, the construction was extremely fast in Ancient Rome. Roman concrete is strong, flexible and cheap, which is an ideal material for huge projects. The Pantheon (Fig1.6&1.7), built under the emperor Hadrian in ca. A.D. 120-127[13], was finished only within one decade. *"The span of its dome (142feet; 43.2m) was unprecedented, that of St Peter's in Rome, over 1400 years later, being 139 feet (42.5m)."*[14]

[12] Watkin, D. 2015, p76
[13] Kostof, S. A History of Architecture – Settings and Rituals, Oxford University Press, 1995, p220
[14] Watkin, D. 2015, p75

1.7 Giovanni Paolo Panini, *Interior of the Pantheon*, ca.1750
National Gallery of Art, Washington

"The most famous of Roman amphitheaters, and one of the world's best-known buildings, is the Colosseum (Fig1.8), dedicated in A.D. 80. It was an entirely freestanding structure, 188 meters long by 156 meters wide. Eighty arches all around its girth swallowed the more than 50,000 spectors that came to the games."[15] The construction under the Flavian dynasty was started in A.D. 72[16], which means it only took 9 years to complete the whole project.

[15] Kostof, S. 1995, p207
[16] Kostof, S. 1995, p208

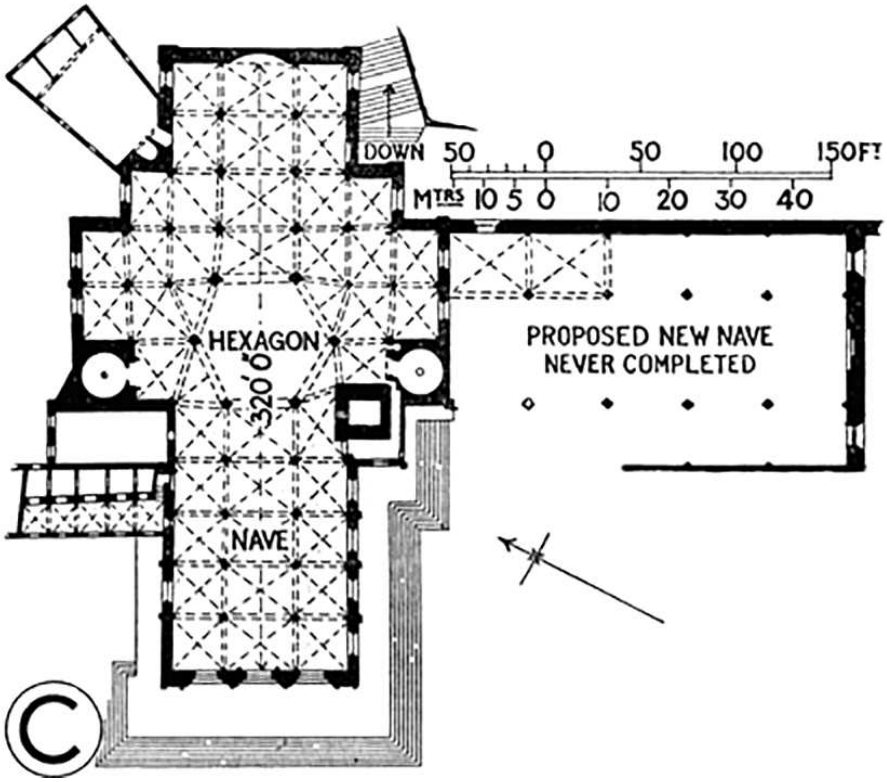


1.8 Sections and sectional view of Colosseum, Rome, Italy[17]

b) Structural problems

Italian churches always have one unique huge volume of space to accommodate the congregations. This kind of magnificent project was the best way to show off the believers' faith and wealth. The bigger and higher space demands, the more stress and shear there would be in the structure. Before the birth of structural mechanics, architects could only worked rely on their experience. Unfortunately, the skill of constructing large-scale buildings had been lost after the collapse of Western Roman Empire. Without accurate calculations of forces and moments, some huge projects were finally abandoned because of safety reasons.

[17] Kostof, S. 1995, p208



1.9 Plan of Duomo di Siena[18]

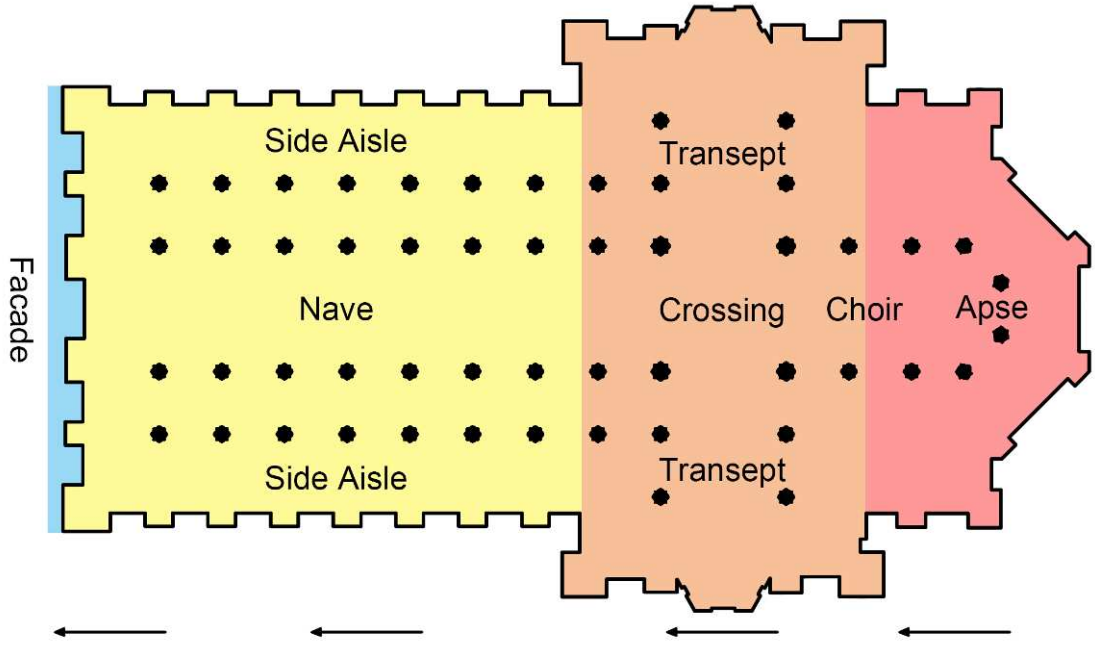
Duomo di Siena was originally designed and completed between ca. 1220 and 1325 on the site of an earlier structure.[19] *"The plan of the church was in the shape of a Latin cross with a slightly projecting transept, a dome, and a choir two bays deep. The nave and two side aisles were separated by rows of semicircular arches, resting on compound piers. The length of the nave was then five bays, as it is at present."*[20] (Fig1.9) After the first completion, Sienese became more and more convinced that their cathedral was not big enough. *"On August 23, 1339, the Gran Consiglio della Campana of the Commune decided on a further enlargement of the cathedral, consisting of a longitudinal structure with a nave and two aisles placed perpendicular to the southeastern side of the existing church. This new structure was intended to serve as the transept a new cathedral, whose apse was to have been located beyond the dome to the west. The foundation stone was laid on February 2, 1335."* The massive additional project was first halted by the Black Death of 1348, meanwhile *"basic errors in construction were already evident: the foundations were too shallow and the building material of poor quality."* The defects were irreparable. It was too dangerous to continue the construction. *"The project was abandoned in 1355 and two year later the governing body of Siena ordered the demolition of the unsound sections."*[21] The outer walls, remains of this extension, could now be seen on the south of the cathedral. (Fig1.10)

[18] Fletcher, B. A History of Architecture on the Comparative Method, Sixth edition, rewritten and enlarged. New York: Charles Scribner's Sons, 1921, p105
[19] Carlie, E. Siena Cathedral and the Cathedral Museum, Frienze: Scala, 2016, p5-13
[20] Carlie, E. 2016, p11
[21] Carlie, E. 2016, p14-16

1.10 The abandoned additional project of Duomo di Siena, Siena, Italy[22]

c) The order of construction

Nowadays, the construction order of building is from the bottom to the top. The working process is in a horizontal section: first the foundation, and then the columns, roofs, walls, at last windows and doors are assembled. The buildings are started to use after their completion.

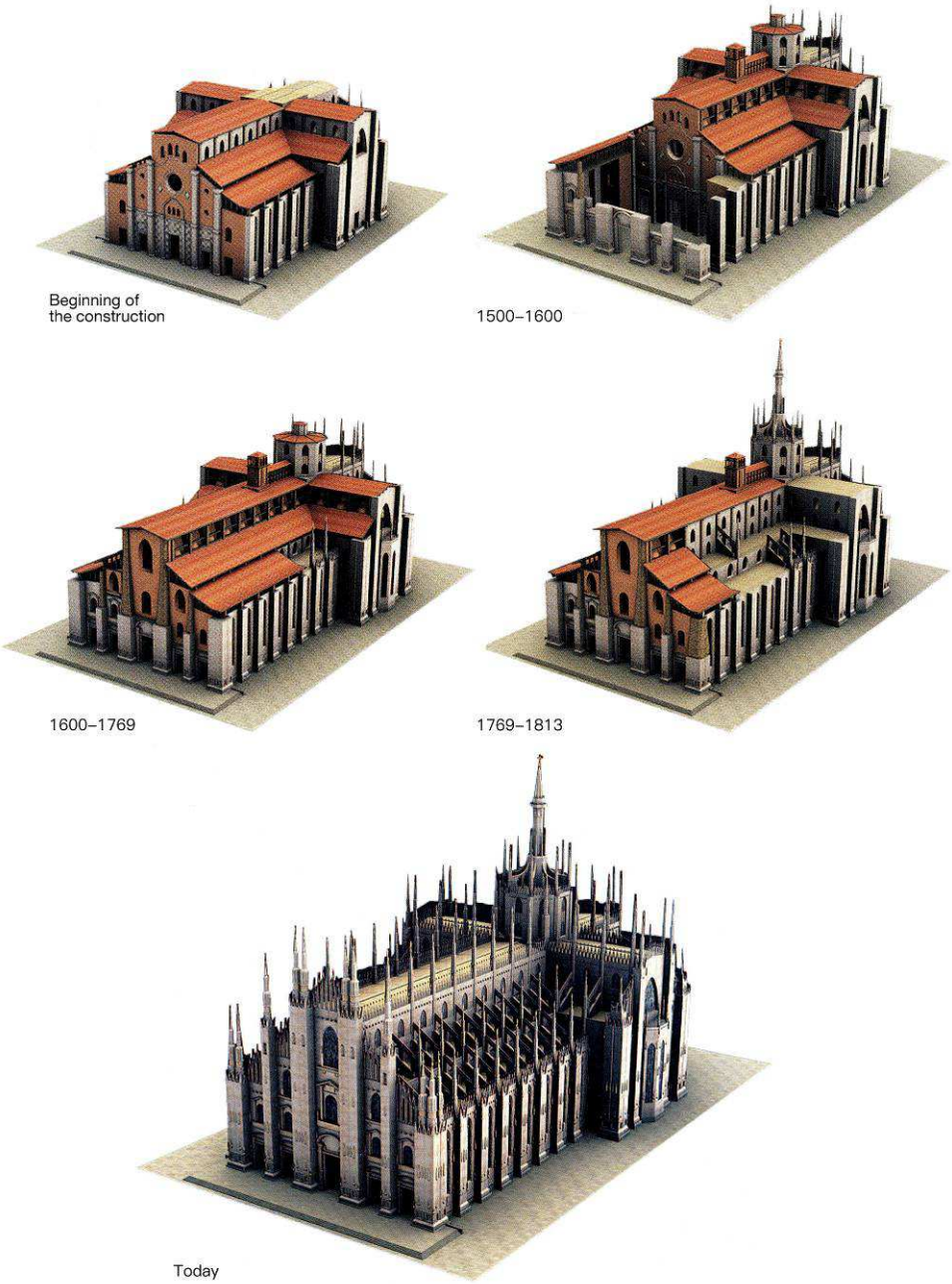


1.11 The order of construction in a church[23]

While in Medieval times, as a result of the long construction period, important architecture, especially churches in Italy, was constructed in a different order. Because

[22] Photo by the author
[23] Scheme by the author

it was predicable that the church wouldn't be finished within few generations, churches would be used under construction. Apse was the first part to complete. Choir, crossing and transept, and then nave with side aisle were built. Façade was the last part to end the whole project. The working process was in a vertical section, from the back to the front. (Fig1.11&1.12) For this reason, most of the unfinished churches left their façades uncompleted.



1.12 Principle phases of construction of Milan Cathedral[24]

A façade is generally one exterior side of a building, usually, but not always, the front. It is a foreign loan word from the French façade, which in turn comes from the Italian *facciata*, which means "frontage" or "face". The façade of a building is often the most important aspect from a design standpoint, as it sets the tone for the rest of the

[24] Moschini, C. Il Cantiere del Duomo di Milano, Milan: Silvana Editoriale, 2012, p108-109. Mauro Ferrari, Principle phases of construction of Milan Cathedral, from multimedia Leonardo e il cantiere del Duomo di Milano. Milan, National Museum of Science and Technology Leonardo da Vinci

building. This is the reason why I choose incomplete facades as the topic of this thesis.

d) Lack of funding and workers

China and Ancient Rome (both the Public and the Empire) were both a large-scale unified nation. When carrying out huge national projects, the whole nation became the strong backing. While in Medieval and Renaissance period, Italy was full of small city-states, which were fragile and unstable. During the long period of construction, it needs a continuous support of adequate money and workers. If some unexpected incident which led population and economic decline happened, such as wars or plagues, the project was easy to shut down. In our case, the Black Death，resulting in the deaths of an estimated 75 to 200 million people in Eurasia and peaking in Europe in the years 1346–1353, was a big reason. As it is mentioned before, the additional construction of *Duomo di Siena* was first slowed and then halted due to the terrible plague in 1348.

1.13 Pieter Bruegel the Elder, *The Triumph of Death*, ca. 1562. The Prado Museum, Madrid

e) The death of patrons

Many projects were executed under strong aspirations of the patrons (most of them are popes, bishops or leaders of great noble families). If the patron died, there was high probability of chance that the successor would abandon the project or change the original design to his or her own taste.

f) The death of chief architects

Some projects were stopped after the architect suddenly died with no successors left behind. In the case of *Duomo di Milano*, Milanese wasn't satisfied with the façade had been rushed to complete under Napoleon's order in early 18th century. In 1886, an international competition aimed at a complete renovation of the façade was held. The young Italian architect Giuseppe Brentano (1862-1889) became the winner in 1888.[25] Unfortunately, after his suddenly death in 1889, the new project was abandoned.

[25] Boito, C. Il Duomo di Milano e i Disegni per la sua Facciata, 1889

g) The importance of the architecture itself

As previously mentioned, when restarting a project left by elder generations, the successor might not be satisfied with the original out-of-date design. Like the case happened in *Duomo di Firenze* and *Milano*, international competitions were held, which invited famous architects from all over the world to submit proposals for a new facade. It was common that after two or three rounds of contest, there was still no winner. A referendum was held in Florence in 1872 to choose the final solution of Duomo's façade. (Fig1.14) It took long time for every decision to be made seriously.

CONCITTADINI!

OSSERVAZIONI
PER LA FACCIATA DEL DUOMO
DI FIRENZE

Firenze la bella, la gentile, non può, nè deve sottostare a delle pressioni, a delle arti sorde, che attraversino i giusti desideri del suo popolo.

In una delle mattine del perduto senno, ad insputa, ed a sorpresa di tutta Firenze, si vedeva scoprire la Facciata del Duomo, ed una quantità di Avvisi affissi per ogni dove, firmati dal Sindaco Peruzzi, strombazzavano il cominciamento della grand'opera, cioè la tanto sospirata Facciata.

Protestiamo sagramentalmente che non intendiamo, neppure per la benchè minima parte di entrare in discussione, e farsi giudici del Progetto cui era stata designata la esecuzione inquantochè la stampa e le opinioni dei Cittadini, ne parlarono d'assai. Ciò che noi diciamo, si è del come, e del perchè si sia eseguito quello scoprimento senza prima essere sicuri di non avere grandi ostacoli da superare; provandolo il fatto; ed essendo bello il tacere.

Perchè! un Ministro, un Sindaco, una Commissione vogliono aggravarsi di un gigantesco peso quale è la responsabilità della scelta del Progetto da eseguirsi; lascino al popolo questo diritto!

Molte sono le circostanze e le vane illusioni, da dire bello quello, anzi che l'altro, e poi dovere rimpiangere l'errore, ma senza riparo, e qui sta il tutto.

Dal popolano, al più alto locato tutti concorriamo, a misura dei propri mezzi a dare la nostra offerta, onde vedere eseguire un'opera tanto desiderata; ma almeno si lasci libertà nella scelta.

Ci piace citare un esempio, che è quello dell'Architetto Lusso, il quale fece grandi sacrifizi, ed espose in Via dell'Orivolo il di Lui Progetto, e per accertarsi, del pregio che avrebbe incontrato, aprì una sottoscrizione di adesione, ove furono raccolte Venisettemila firme, che Millequattrocento, delle quali, di valentissimi artisti, di quella eccelsa.

Si espongano i Progetti o Disegni della Facciata del Duomo, dei diversi Concorrenti, si faccia UN PLEBISCITO e si regolino le cose da prevenire, ogni fraudolento intrigo e maneggio, e così si compia una volta questo generale desiderio, ed ognuno resti scevro da quella severa responsabilità, appoggiando il voler di tutti.

Questo diritto non si riservi esclusivamente al popolo fiorentino, ma bensì a tutti gli Italiani che piacesse condursi qui a dare il loro voto. Questi, e nessun'altro è il sistema da tenersi, per vedere completato un Monumento assolutamente Mondiale quale è il nostro Duomo.

Come un morbo pestilenziale, riguardiamo le adulazioni, e da queste ci teniamo ben lungi, ma ove il merito esiste noi lo tributiamo di cuore, ovunque ei sia, ed è che intendiamo di parlare dell'egregio Commendatore Ubaldino Peruzzi nostro Sindaco che seppe con la sua capacità, e fermezza acquistarsi la stima, e l'affetto della nostra Firenze; come potrà essere possibile che Ei possa negare la sua promessa di compiere l'Esecuzione della Facciata del Duomo: e voglia tarpare la più bella pagina che la istoria darebbe, col mandare il di Lui nome unito a pari passo con la consumazione dei secoli.

Si faccia adunque iniziatore DEL PLEBISCITO non si lasci sfuggire, quest'unico, ed inappellabile giudizio di un popolo, ed una lapide commemorativa da restar là fino all'eternità, ricorderebbe il di lui nome per avere compiuta non solo la grandiosissima opera, ma per avere sempre data libertà al popolo sulla scelta dei Disegno.

Bisogna pure convincersi che non trattasi di creare un enorme debito, per essere un lavoro di esproprizione per aprire piazze, e strade; niente affatto questo è uno degli imponenti lavori cui piovercbbero a larga mano le offerte e gli aiuti da ogni parte di Italia; computando pure l'ingente somma che già è stata raccolta.

Quindi i vantaggi sarebbero immensi calcolando, quanti, e quanti Artisti, Lavoranti che ritrarrebbero profitto, inquantochè il denaro che circola, è un lucro generale.

Si faccia adunque un *Plebiscito*, e quel Progetto che il popolo sceglierà, si ponga inappellabilmente ad esecuzione. — E così potrà dire Firenze, che sotto gli auspici del Magnanimo **RE VITTORIO EMANUELE II** che vi pose la prima pietra, sarà completato un edifizio il quale aspira da cinque secoli il suo termine.

Firenze, Marzo 1873.

G. e B.

Tip. Uccelli e Zoltinelli.

1.14 Poster of calling the Florentines to a plebiscite to decide the final solution of the façade of Santa Maria del Fiore，March 1872[26]

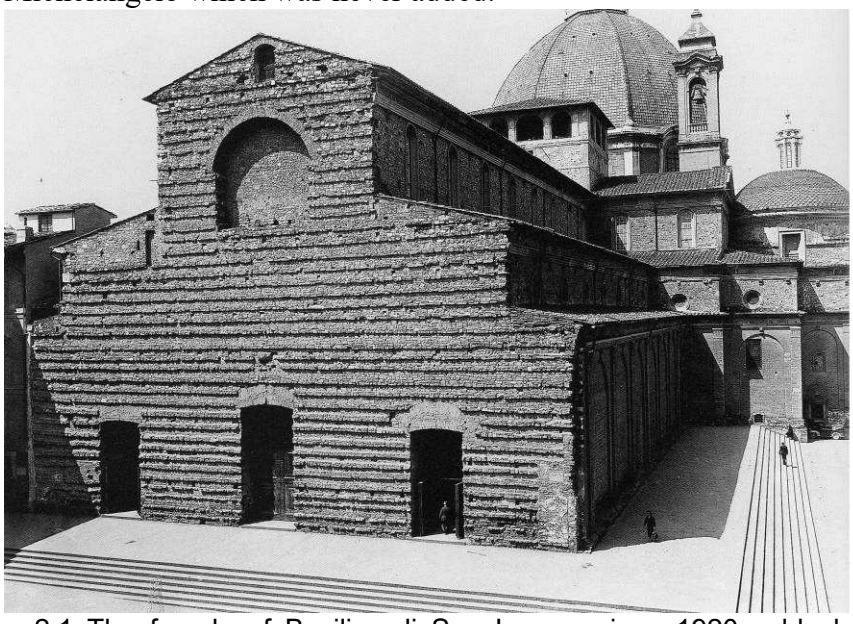
[26] Cresti, C., Cozzi, M., Carapelli, G. Il Duomo di Firenze 1822-1887 L'Avventura della Facciata, Firenze: Edizioni il Bossolo, 1987, p169

Chapter 2: Three case studies

2.1 Basilica di San Lorenzo

San Lorenzo is one of the largest churches of Florence. Situated at the centre of the city's main market district, it is the burial place of all the principal members of the Medici family from *Cosimo il Vecchio* to *Cosimo III*. It is one of several churches that claim to be the oldest in Florence; when it was consecrated in 393 it stood outside the city walls. For three hundred years it was the city's cathedral before the official seat of the bishop was transferred to *Santa Reparata*.[27]

The church is part of a larger monastic complex that contains other important architectural and artistic works: the Old Sacristy by Brunelleschi, with interior decoration and sculpture by Donatello; the Laurentian Library by Michelangelo; the New Sacristy based on Michelangelo's designs; and the Medici Chapels by Matteo Nigetti. The church's rough-hewn exterior was to have been covered by a façade by Michelangelo which was never added.



2.1 The facade of Basilica di San Lorenzo in a 1920s old photo, Florence, Italy[28]

2.1.1 A Brief History of Construction

It was the year 393 when the Bishop of Milan, Ambrose, consecrated the church dedicated to the martyred Saint Lawrence. In those years Florence was called

[27] Paolucci, A. The Muserum of the Medici Chapels and San Lorenzo, Livorno: sillabe, 2015, p20

[28] Ferretti, V., Savorra, M. La Facciata della Basilica di San Lorenzo a Firenze I Progetti da Michelangelo al Concorso del 1900, Milano: Silvana Editoriale, 2015, p52. Scheme by the author

Florentia, and its inhabitants spoke Latin and only partly professed the Catholic faith. During the time of Saint Ambrose, the original church of San Lorenzo, which no longer exists, was a small building located on the outskirts of the Roman city.[29] The church was enlarged for the first in 1059, on the initiative of Bishop Gherardo di Burgundy when he became pope Niccolò II. It was then a typical Romanesque church, which had a long deep nave with a high bell tower stood behind (Fig2.2).

2.2 San Lorenzo in the Code by Marco di Bartolomeo Rustici, ca. 1450
Seminario Maggiore di San Frediano in Cstello, Florence

In 1419, Giovanni di Bicci de' Medici (1360-1429) offered to finance a new church to replace the 11th-century Romanesque rebuilding. Filippo Brunelleschi (1337-1446), the leading Renaissance architect of the first half of the 15th century, was commissioned to design it. Lack of funding slowed down the construction and forced changes to the original design. By the early 1440s, only the sacristy (now called the Old Sacristy) had been worked on as that and the church was being paid for by the Medici. In 1442, the Medici stepped in to take over financial responsibility of the church as well. Brunelleschi died in 1446 and the job was handed over either to Antonio Manetti or to Michelozzo; scholars are not certain. Though the building was "completed" in 1459 in time for a visit to Florence by Pius II, the chapels along the right-hand aisles were still being built in the 1480s and 1490s.
The rise of San Lorenzo coincides, therefore, with that of the Medici, who had their house in the same quarter of the city. The Medici family, Cosimo (1389-1464) and Lorenzo the Magnificent (1449-1492), had lived just a short walk from San Lorenzo in the Medici-Riccardi building at Via Cavour. It was before the family became the reigning dynasty over Florence and the Grand Duchy and transferred their official residence to Palazzo Vecchio and then to Palazzo Pitti. These changes of residence did not diminish the Medici's sense of fondness and patronage for their church. San Lorenzo had been the favoured parish and church of the Medici, their palatine basilica and their mausoleum for over three hundred years.

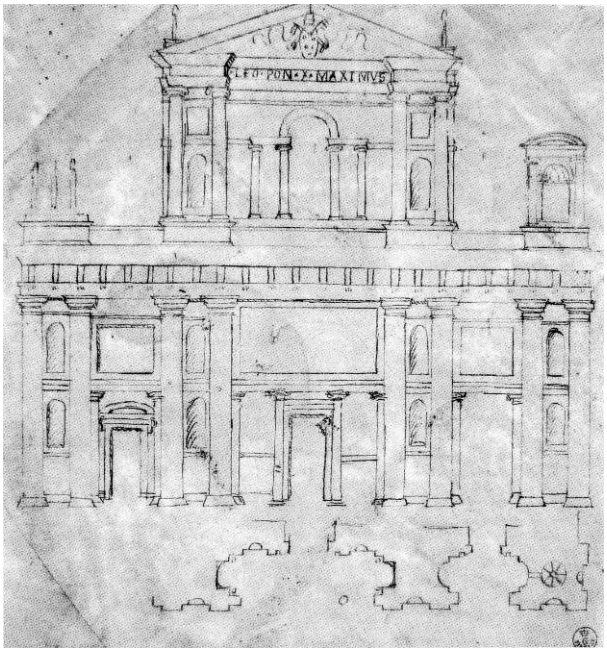
[29] Paolucci, A. 2015, p20-21

Vasari states that Medici Pope Leo X, in visiting Florence in December 1515, *as the first pope elected from Florence, wished to have the façade of San Lorenzo in Florence, the church built by the House of the Medici, should be completed for him. Leo asked Michelangelo to advise him as well as draw up plans and to take charge of the project.*[30] Leo X wanted the façade to be in white Carrara marble and decorated with statues. Between 1515 and 1517, Giuliano da Sangallo (Fig2.3), Jacopo Sansovino, Baccio d'Agnolo, Michelangelo, and also Raphael (Fig2.4) all submitted designs for the façade. The design of Michelangelo was commissioned, but never constructed, although his designs for the inner façade, library and the new sacristy (now known as the Medici Chapel) were.

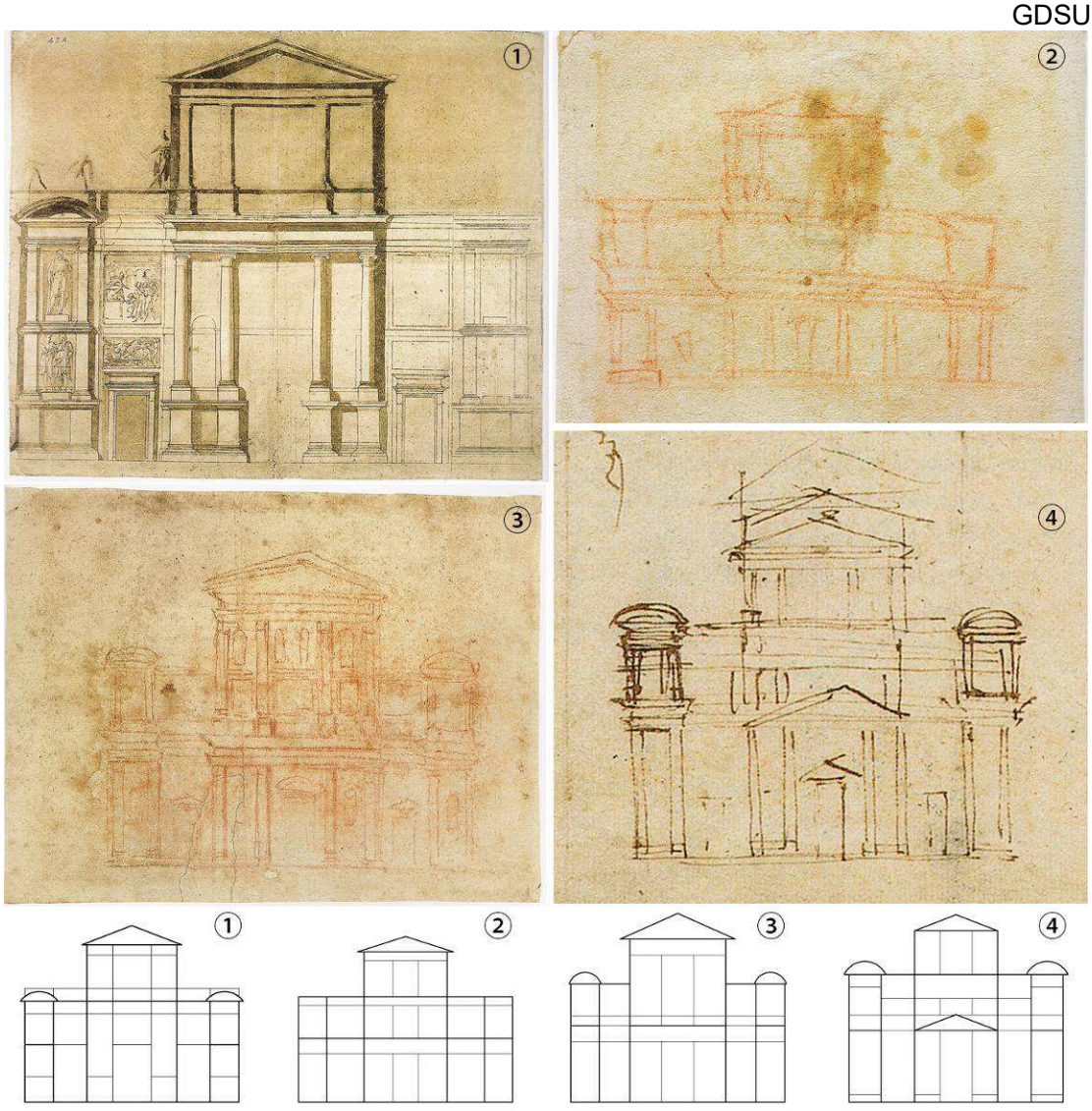
The challenge of this design is to solve the contradiction between the old Romanesque structure and the new Renaissance façade: the proportion of high nave and low side aisles system cannot fit the language of orders well. Giuliano da Sangallo presented two types of solutions as shown below: a two-layer facade hides the height difference between the nave and side aisle; a three-layer façade becomes narrower from the bottom to the top, and the middle part is a shorter interlayer.[31]

2.3 Giuliano da Sangallo, Project for the facade of San Lorenzo, 1515-1516
Gabinetto Disegni e Stampedegli Uffizi, Florence (GDSU)

[30] Vasari, G. The Lives of the Artists (Oxford World's Classics), Oxford: Oxford University Press, 2008, p451
[31] Ferretti, V., Savorra, M. 2015. p17-26



2.4 Aristotele da Sangallo (from Raphel), Study for the facade of San Lorenzo, 1518-1519, GDSU

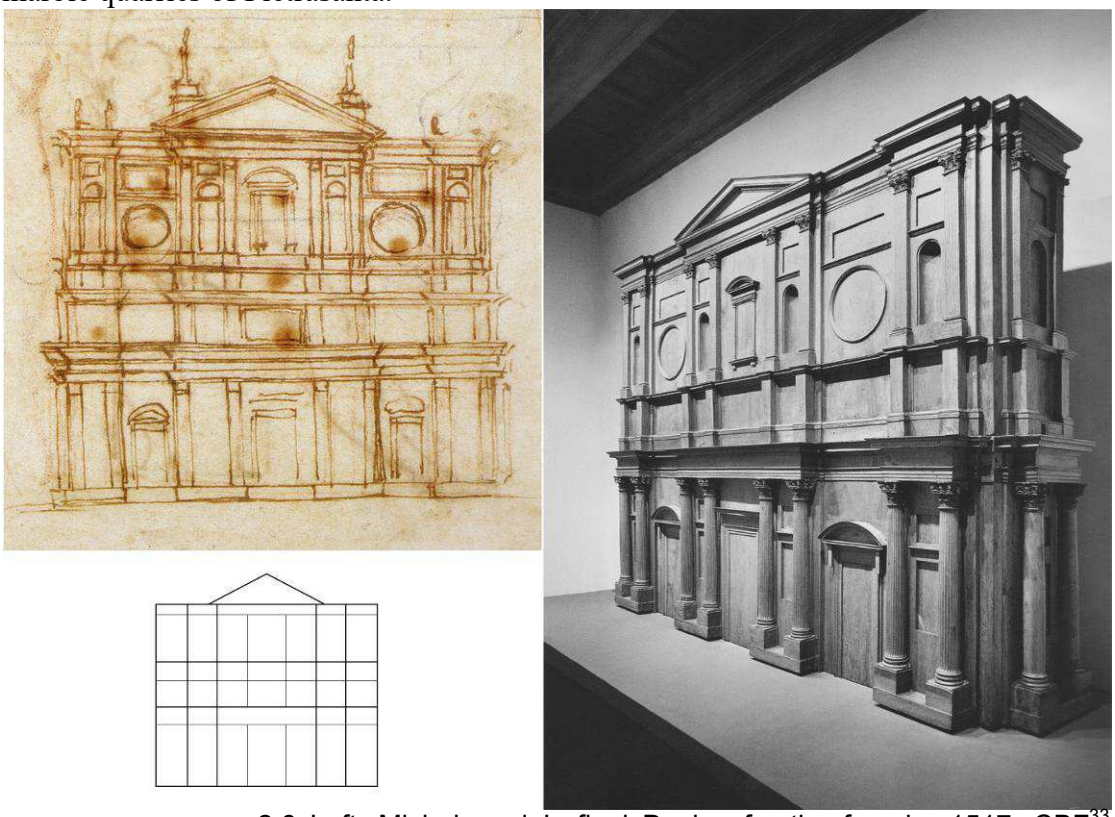


2.5 Michelangelo, Studies for the facade of San Lorenzo, 1517

Casa Buonarroti, Florence (CBF)[32]

Michelangelo's project (Fig2.5) tried to solve the problem by a façade separated from the Romanesque structure behind. Instead of following the nave and side aisle's height, he designed a two-layer side aisles and a narrower three-layer nave with triangle crown. The center and side parts were protrude from the background wall. Other than the normal two-dimensional façade, this three-dimensional solution was like a sculpture. The façade was also used as frames of display the statues.

Michelangelo made a wood model of his final design (Fig2.6), which shows how he adjusted the classical proportions of the facade, drawn to scale, after the ideal proportions of the human body, to the greater height of the nave. It can be seen in CBF now. However, on March 10, 1520, the pope cancelled the contract with Michelangelo. At that time, the first column had already arrived in Florence from marble quarries of Pietrasanta.



2.6 Left: Michelangelo's final Design for the façade, 1517, CBF[33]
Right: Wood model for the façade of Michelangelo's project, ca. 1518, CBF

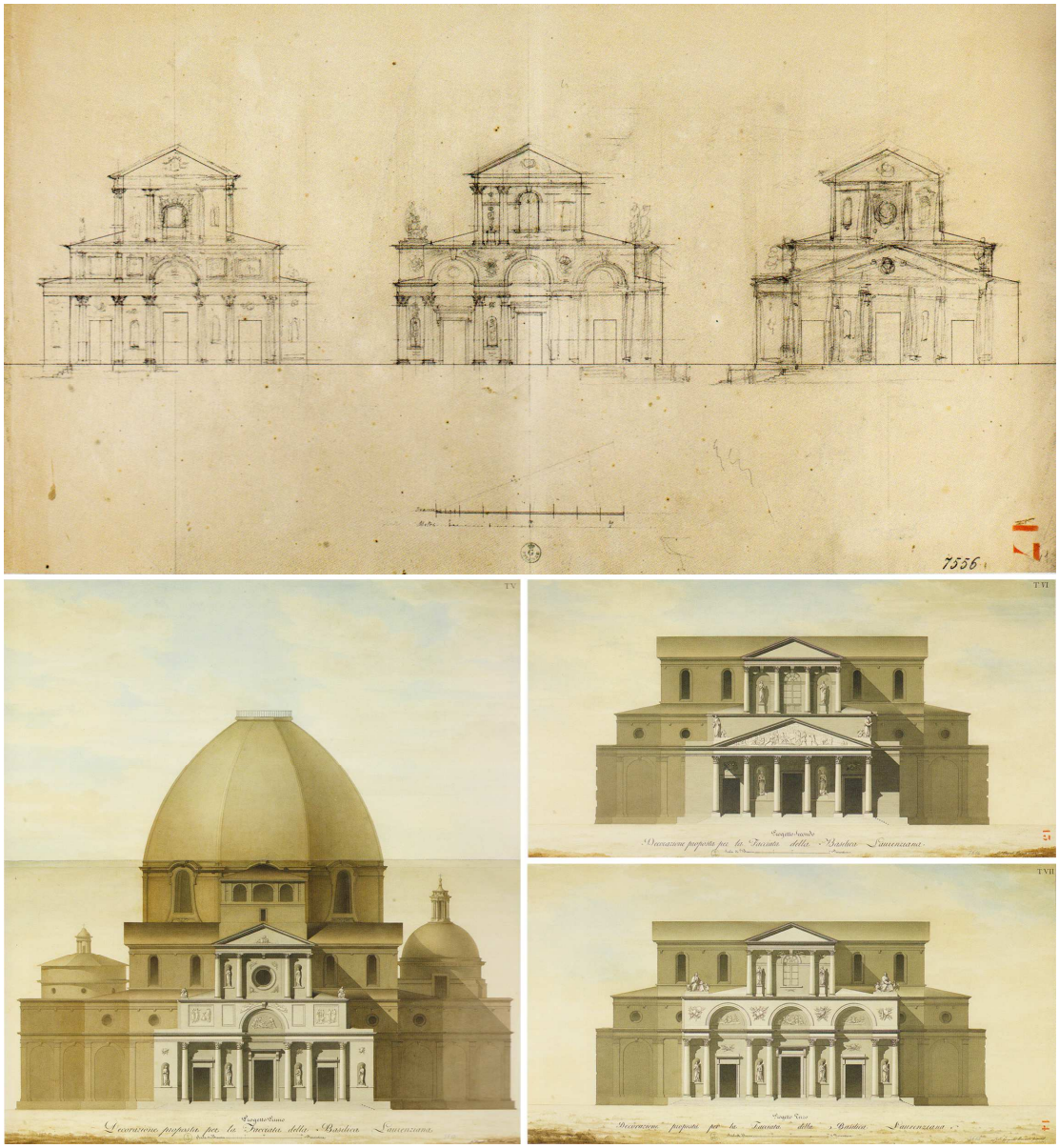
In October 1738, Anna Maria Luisa de' Medici (1667-1743), the last lineal descent of the Medici family, started the restoration of the church, with architect Ferdinando Ruggieri, including the interior decoration, adding of a bell tower and completing the Chapel of the Princes (Cappella dei Principi). She also wanted to finish the façade. Several proposals were made but never implemented (Fig2.7).

[32] Scheme by the author
[33] Scheme by the author

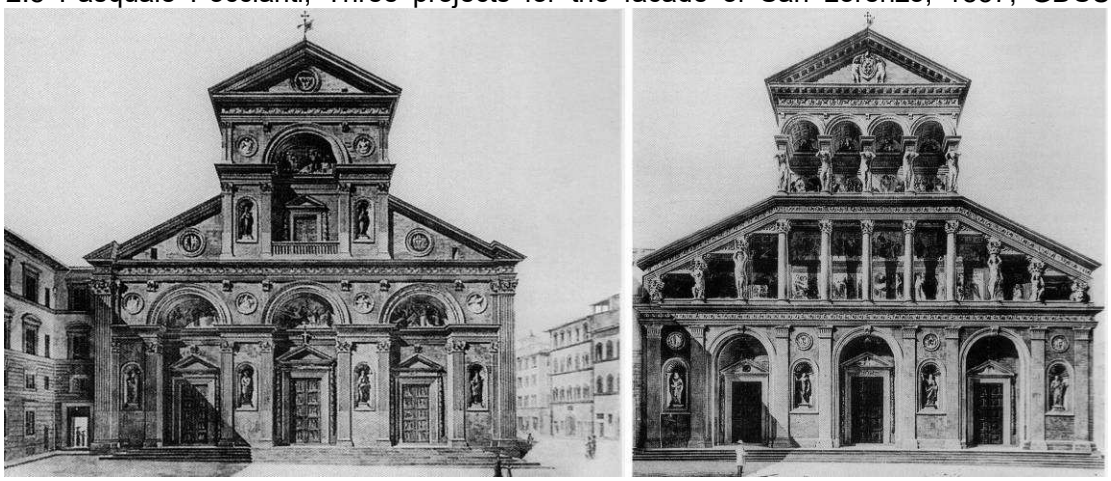
2.7 Projects for the façade of San Lorenzo
①Matteo Giovanni Alberti (?), Wood model, ca. 1710
Canonica di San Lorenzo, Firenze (CSLF)
②Carl Marcus Tuscher, ca. 1731, National Gallery of Denmark, Copenaghen (NGD)
③Carl Marcus Tuscher, 1739, Danish National Art Library, Copenaghen (DNAL)
④Paolo Posi, 1741, Biblioteca Nazionale Centrale di Firenze (BNCF)
⑤Unknown designer of the 18th century, Andrea Scacciati inc. 1757[34]

In 19th century, proposals for the façade were presented by neo-classical architect Pasquale Poccianti and Emilio Marcucci, but all remained on paper. Poccianti's design reminds us the façade of Ancient Greek temples (Fig2.8). Marcucci's was a smaller version of typical Toscana churches like *Duomo di Pisa* and *Lucca* (Fig2.9&2.10). Strictly following the height of the original structure, these projects' still had problems with proportion.

[34] Ferretti, V., Savorra, M. 2015, p89



2.8 Pasquale Poccianti, Three projects for the facade of San Lorenzo, 1837, GDSU



2.9 Emilio Marcucci, Projects for the façade of San Lorenzo
Left: 1876, GDSU Right: 1877, GDSU

2.10 Left: Façade of Duomo di Pisa, Right: Duomo di Lucca[35]

2.1.2 The Competition in 1900s

Thanks to the legacy of a private citizen, Francesco Mattei, the theme was resumed with great will in April 1900, when a contest was held with 53 architects participated (Fig2.11). Considering the complexity of the theme and noting that the 74 submitted projects needed modifications and improvements, it was decided to hold another round in 1905.[36]

We could divide the proposals from the first and second round of competition into four types (Fig2.12). Type 1 uses horizontal lines over the side aisles. Type 2 basically follows the shape of the original brick façade, while Type 2.1 uses gable end over the side aisles and Type 2.2 uses hip end. Type 3 uses curve to connect different height of nave and side aisles. Type 4 adds colonnade (or solid wall) in front of the façade to create a façade with shades. Though these designs were all in Baroque Style, comparing to designs before late 19th century, they might have been influenced by the modernism at that time, which used less decoration.

[35] Left: By Luca Aless - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=48559111
Right: Di Photo: Myrabella / Wikimedia Commons, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=19652837

[36] Ferretti, V., Savorra, M. 2015, p100

COMITATO PROMOTORE DI UN CONCORSO ARTISTICO

PER LA FACCIATA DELLA

R. Basilica di S. Lorenzo

IN

FIRENZE

Esistono tuttora e si conservano nelle pubbliche gallerie molti progetti e bozzetti per la facciata della R. Basilica di San Lorenzo in Firenze, eseguiti successivamente dai primi del Cinquecento fino ad oggi. Ma coi criterii che ora prevalgono in fatto di lavori da eseguirsi sopra antichi monumenti, non sarebbe possibile di mettere in opera alcuno di quei progetti per due ragioni:

1ª Perchè nessuno di essi tiene conto delle linee organiche interne ed esterne del mirabile edificio ideato dal Brunelleschi, ed eseguito dai suoi discepoli.

2ª Perchè quei progetti (varii dei quali bellissimi in sè, astraendo dalla loro destinazione) non sono così sviluppati, che per eseguirne qualcuno non occorra rivolgersi alla interpretazione di qualche architetto moderno.

Perciò la naturale e doverosa riserva nell'occuparsi ancora di un soggetto, cui hanno consacrato i loro studii Michelangiolo e Giuliano da San Gallo, viene ad essere corretta dal pensiero, che presumendo di sviluppare e di completare i loro disegni, si mancherebbe ad essi di rispetto molto maggiormente che non ricominciando a studiare di nuovo il problema.

È quindi naturale e consentaneo al nostro tempo, che volendosi costruire la facciata della R. Basilica di San Lorenzo, venga bandito un concorso, perchè da questo emergano tutte le ricerche indirizzate a mantenere nel modo migliore il carattere originale di questo mirabile monumento.

Perciò alcuni cittadini, desiderosi di vedere ornata decorosamente la fronte ora nuda del ricco ed elegantissimo tempio, si sono riuniti in Comitato promotore di un concorso artistico per raccogliere disegni e modelli destinati a quella facciata.

Il Comitato, considerando che i migliori artisti italiani debbono sentirsi animati dalla forte volontà di misurarsi in una gara così nobile ed alta, bandisce perciò il seguente programma di concorso, e spera che questa modesta iniziativa possa condurre all'auspicato compimento della insigne Basilica dovuta alla pietà ed al genio degli avi.

Firenze, 5 Aprile 1900.

IL COMITATO

Alinari Cav. **Vittorio** — **Andreotti** Prof. **Federigo** — **Barbolani Da Montauto** Conte **Ardengo** — **Bellandi** Prof. **Ernesto** — **Betti** Cav. **Giulio** — **Biagi** Comm. **Guido** — **Cecchi** Prof. **Adriano** — **Corsini** Principe **Tommaso,** Senatore — **Lottaringhi-Della Stufa** Marchese **Antonino** — **Fabbi** Cav. Prof. **Fabio** — **Faldi** Comm. Prof. **Arturo** — **Faldi** Ingegnere **Pasquale** — **Formilli** Prof. **Attilio** — **Ginori-Conti** Principe **Piero** — **Ginori-Lisci** Marchese **Lorenzo** — **Giovannini** Mons. Dott. **Attilio** — **Guidotti** Cav. Prof. **Dario** — **Lusini** Cav. Prof. **Enrico** — **Martelli** Nob. Cav. **Niccolò** — **Moreni** Cav. Uff. Avv. **Giuseppe** — **Pandolfini** Conte **Alessio** — **Rigacci** M. R. **Piero** — **Romanelli** Comm. Prof. **Raffaello** — **Romei** Mons. **Romeo** — **Sgatti** Cancelliere **Enrico** — **Spighi** Cav. Prof. **Cesare** — **Vai** Nobile Comm. **Luigi** — **Vannucci Emilio.**

PROGRAMMA DEL CONCORSO

Art. 1° — È aperto un concorso per il progetto della facciata della R. Basilica di San Lorenzo in Firenze.

I concorrenti dovranno essere cittadini italiani.

Art. 2° — È richiesto quale condizione assoluta, che la facciata si accordi intimamente, anche per i materiali da impiegarsi, colla ossatura organica costruttiva, colle forme architettoniche dell'edifizio e con lo stile e carattere decorativo delle sue parti, senza rendere necessaria alcuna modificazione nei fianchi, o nell'interno di esso.

Art. 3° — I concorrenti dovranno tener presente:

a) che l'altimetria della piazza dovrà esser modificata in guisa da permettere di ristabilire lungo la facciata la scalinata che esiste sul fianco di tramontana;

b) che si dovrà conservare l'apertura della porta che dà accesso ai chiostri nella posizione attuale, mentre invece potrà non tenersi conto delle sopraddificazioni.

Art. 4° — I progetti consisteranno nei seguenti disegni:

a) Una tavola comprendente la elevazione geometrica della facciata, il profilo laterale di essa unitamente ad una delle campate del fianco, e la sezione della medesima facciata sull'asse della porta maggiore, unita ad un valico interno della navata centrale, il tutto nella proporzione da 1 a 50.

Questa tavola potrà essere eseguita a penna, a tratti, o all'acquarello;

b) Sezioni trasversali della facciata al piano di terra e ai piani dei ricorsi orizzontali dei fianchi nella scala da 1 a 50;

c) Particolari geometrici delle parti principali architettoniche ed ornamentali della facciata colle relative piante e sezione nella scala da 1 a 5, eseguiti a semplice contorno;

d) Saranno esclusi dal concorso tutti i disegni che venissero presentati in forma, o proporzioni diverse da quelle enunciate nei precedenti paragrafi *a, b* e *c*.

Art. 5° — I concorrenti potranno a loro piacere, o firmare il proprio progetto, oppure contrassegnarlo con un motto ripetuto sopra una busta sigillata contenente il nome e l'indirizzo dell'autore. I concorrenti che firmino il progetto, indicheranno il loro domicilio; quelli che lo contrassegnino con un motto designeranno sulla busta un loro rappresentante residente in Firenze.

Art. 6° — I progetti dovranno essere presentati completi e saranno indirizzati al *Comitato Promotore di un Concorso Artistico per la Facciata della R. Basilica di S. Lorenzo in Firenze al N. 50 in Via Ricasoli, Palazzo dell'Istituto di Belle Arti.* Il ricevimento non avverrà prima del 20 Marzo, nè dopo le ore 17 del 5 Aprile 1901. Un incaricato del Comitato rilascerà al concorrente, o al suo rappresentante analoga ricevuta.

Art. 7° — I progetti saranno esposti in pubblica mostra prima e dopo il giudizio della Commissione giudicante.

Art. 8° — La Commissione giudicante sarà composta di quattro architetti, di uno scultore, di un pittore e di un critico d'arte.

Art. 9° — La Commissione giudicante accorderà un premio unico e non divisibile di Lire Tremila al migliore tra i progetti presentati dopo aver verificato l'adempimento delle condizioni imposte con l'articolo 2°.

Essa potrà anche accordare alcune medaglie d'oro e di argento a quei lavori che seguiranno per ordine di merito l'opera premiata.

Art. 10° — I concorrenti che non si uniformassero a qualcuna delle condizioni stabilite nel presente programma potranno venire esclusi dal concorso per voto non motivato del Comitato, perdendo così il diritto a qualunque ricompensa, o indennità.

Art. 11° — Il progetto premiato resta proprietà del Comitato, il quale d'altra parte non assume verun obbligo per la esecuzione.

Il presente programma verrà inserito nella *Gazzetta Ufficiale* del Regno.

Presso le sedi delle Accademie, Istituti di Belle Arti, Collegi di Architetti e d'Ingegneri e Circoli Artistici del Regno, oltre al programma, sarà ostensibile una copia delle misurazioni e dei rilievi della Basilica contenuti in quattro tavole litografiche ed in una tavola zincotipica.

Chi desiderasse presso di sè queste tavole potrà ottenerne l'invio mediante rimborso delle spese di stampa e di spedizione, indirizzando cartolina-vaglia di L. 4.00 al Tesoriere del Comitato, Firenze, Chiostri di San Lorenzo, lettera *Z*.

Le dette tavole saranno anche poste in vendita al prezzo di L. 2.50 presso i Signori Alinari fotografi, in Via Tornabuoni.

Firenze, 5 Aprile 1900.

1900

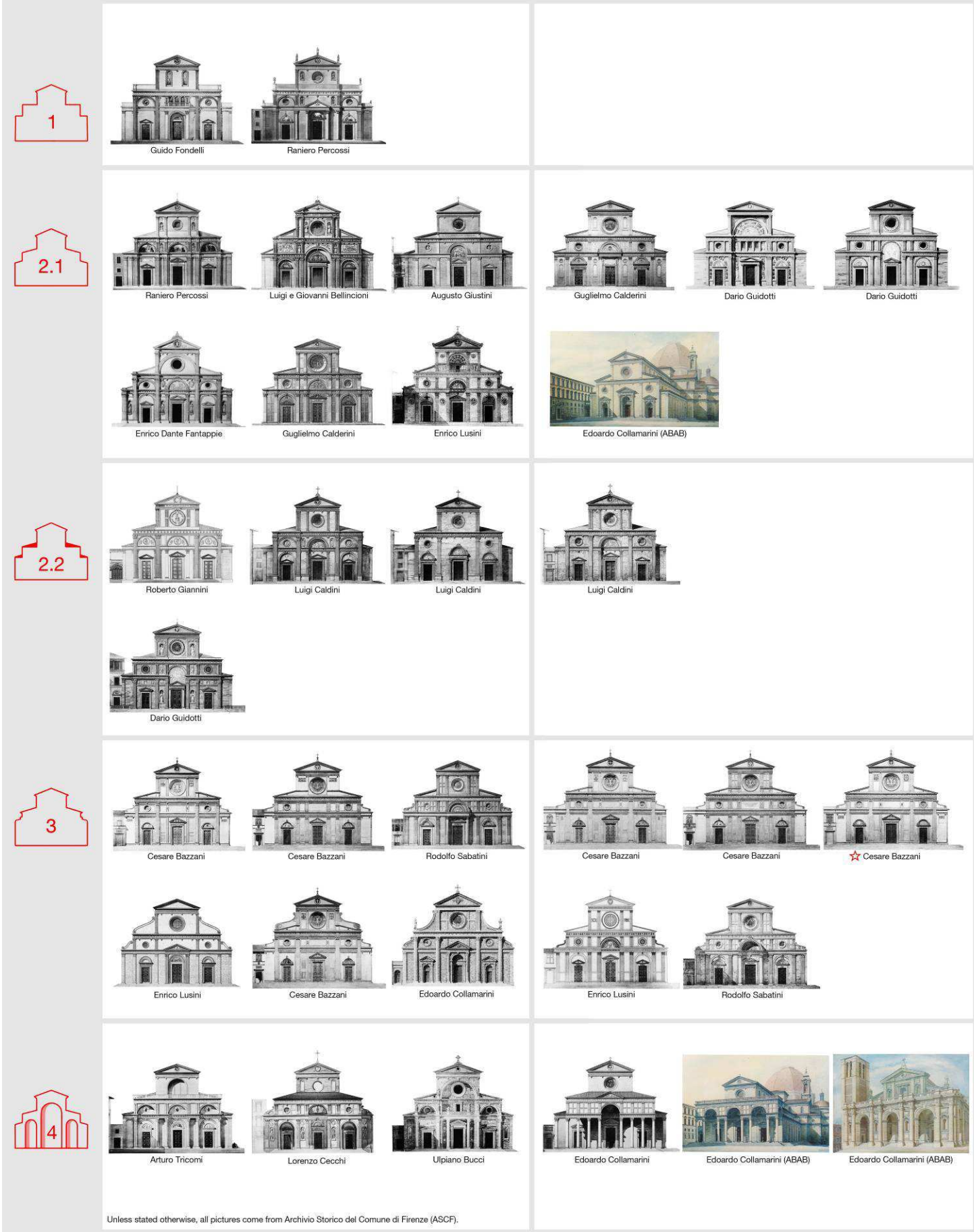
Il Segretario
GIUSEPPE MORENI.

IL PRESIDENTE
TOMMASO CORSINI.

Il Tesoriere
ARDENGO BARBOLANI DA MONTAUTO.

FIRENZE - STABILIMENTO CIVELLI

2.11 Poster of Competition for the façade of San Lorenzo, April 5 1900
Archivio Storico del Comune di Firenze (ASCF)



2.12 Two rounds of competition for the façade[37]

[37] Scheme by the author

In 1905, the Jury, chaired by Heynrich von Geymüller, finally chose Cesare Bazzani as the winner. Two proposals with one model were made (Fig2.13). But the followed controversy let the municipal government soon decided to abandon the project and divide Mattei's legacy among eight Florentine churches. After Michelangelo, it seemed like a mission impossible to complete the façade.[38]

2.13 Cesare Bazzini, winner of the contest in 1905, Model (CSLF) and two proposals, Archivio di Stato di Terni (AST)

2.1.3 Reconstruction with New Multimedia Technology

An event realized on February 18, 2007, for celebrating the centenary of *Opera Mediccea Laurenziana*, which projected virtual images obtained from Michelangelo's wood model in Casa Buonarroti on the façade and churchyard of San Lorenzo of Florence (Fig2.14). Light show was used to simulate Michelangelo's design on the site it should be.

A CG reconstruction of Michelangelo's design was also made by studioDIM associates in 2009 (Fig2.15). Three kinds of software were used to create the images: AutoCAD and 3ds Max for building the 3D model; 3ds Max for simulation the surface finishes and lighting; Photoshop for setting the virtual object in the photo.

These examples show us two different ways of using multimedia technology to "complete" an incomplete façade. Projection is 1:1 scale, on site, impressive and temporary, while Computer Graphic could be viewed on screens in anytime, anywhere. Holographic projections could also be used in the future.

[38] Ferretti, V., Savorra, M. 2015, p101-102

2.14 Projection of Michelangelo Buonarroti's design on the façade of San Lorenzo for celebrating the centenary of Opera Mediccea Laurenziana, September 14, 2007[39]

2.15 Reconstruction of San Lorenzo's façade of Michelangelo's design, Rendering: studioDIM associates, 2009[40]

[39] Ferretti, V., Savorra, M. 2015, p62
[40] Ferretti, V., Savorra, M. 2015, p63

2.2 Cattedrale di Santa Maria del Fiore

Cattedrale di Santa Maria del Fiore (Fig2.16) is the main church of Florence, Italy. *Il Duomo di Firenze*, as it is ordinarily called, was begun in 1296 in the Gothic style with the design of Arnolfo di Cambio and completed structurally in 1436 with the dome engineered by Filippo Brunelleschi. The exterior of the basilica is faced with polychrome marble panels in various shades of green and pink bordered by white and has an elaborate 19th-century Gothic Revival façade by Emilio De Fabris. The basilica is one of Italy's largest churches, and until development of new structural materials in the modern era, the dome was the largest in the world. It remains the largest brick dome ever constructed. It was not until 1887 that the façade we see today had been completed.

2.16 Cattedrale di Santa Maria del Fiore, Florence, Italy[41]

2.2.1 A Breif History of Construction

In the last decades of the 13th century, the Florentine government decided to build a new cathedral on the site of an earlier one, dedicated to *Santa Reparata* (Fig2.17). The new cathedral was motivated by various circumstances. One of them is the 1289 victory of Guelphs Florence over the Tuscan Ghibellines in the Battle of Campaldino, was to symbolize the new territorial hegemony of the Florentine Republic.[42] The ancient structure, founded in the early 5th century and having undergone many repairs, was "crumbling with age". Next to "fair San Giovanni", moreover, *Santa Reparata* appeared "quite crude", according to the 14th-century chronicler Giovanni Villani: in that period of dramatic population growth, it had become "small in comparison to so great a city". Thus was born the idea of building an enormous church, far bigger than the cathedrals of rival Tuscan cities Pisa (Fig2.18) and Siena (Fig2.19). Florence

[41] Left: By Petar Milošević - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=38860057
Right: By Jebulon - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=15677480

[42] Verdon, T. The Cathedral, the Baptistery, the Bell Tower, Florence: Mandragora, 2016, p104

wanted its Duomo to be grander in size and in exterior adornment, “all in marble and with carved figures” (reliefs and statues).

2.17 The superimposition of Santa Maria del Fiore over the church of Santa Reparata[43]

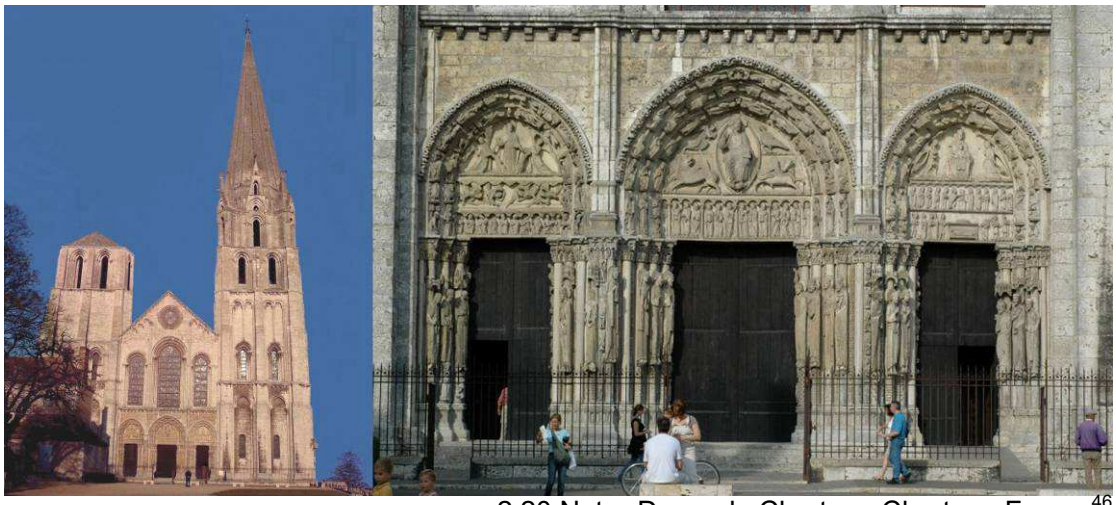
2.18 Façade of Duomo di Pisa, Pisa, Italy[44]

[43] From the digital exhibition of Opera Duomo Museum, Florence

[44] By Luca Aless - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=48559111

2.19 Façade of Duomo di Siena, Siena, Italy[45]

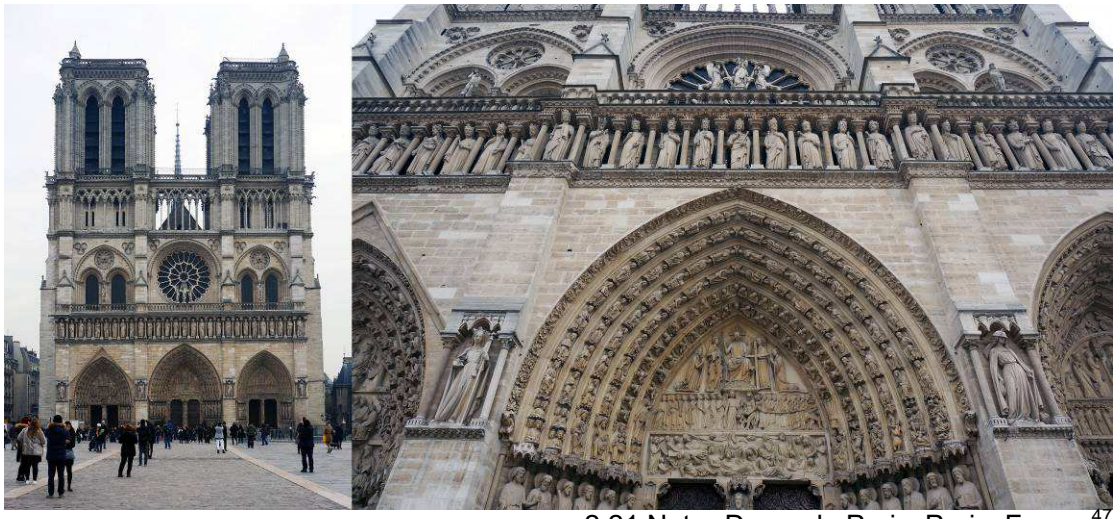
As monumental statuary was the most expensive art form then, by employing this form of art, Florence wanted to compete with the great North European churches, which abounded in outdoor sculpture, such as *Notre-Dame de Chartres* (Fig2.20), *Notre-Dame de Paris* (Fig2.21), *Notre-Dame de Reims* (Fig2.22), and also *Duomo di Siena*, the only church in Tuscany decorated in this way. The choice of the architect Arnolfo di Cambio, also famous as a sculptor, reflected the importance given to the façade. He was also architect of church of *Basilica di Santa Croce* and *Palazzo Vecchio*. His design was approved by the city council in 1294.



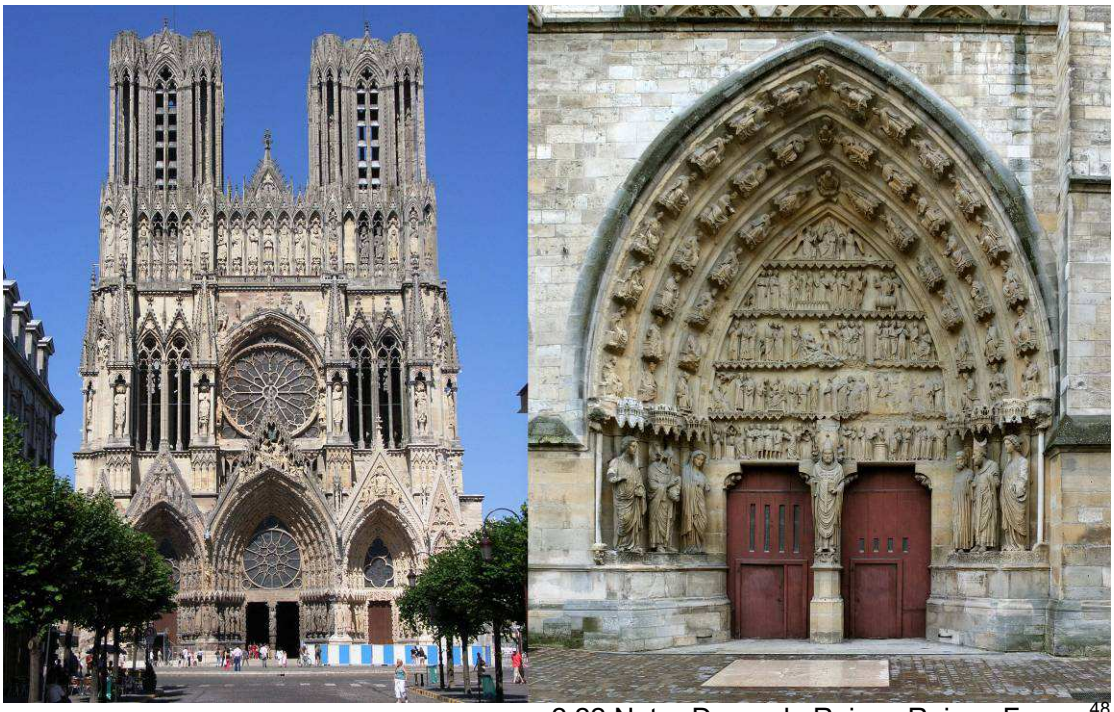
2.20 Notre-Dame de Chartres, Chartres, France[46]

[45] Photo by the author

[46] Left: ©NDC, http://www.cathedrale-chartres.org/fr/l-architecture,108.html
Right: ©NDC, http://www.cathedrale-chartres.org/fr/le-portail-royal-,article-227.html



2.21 Notre-Dame de Paris, Paris, France[47]



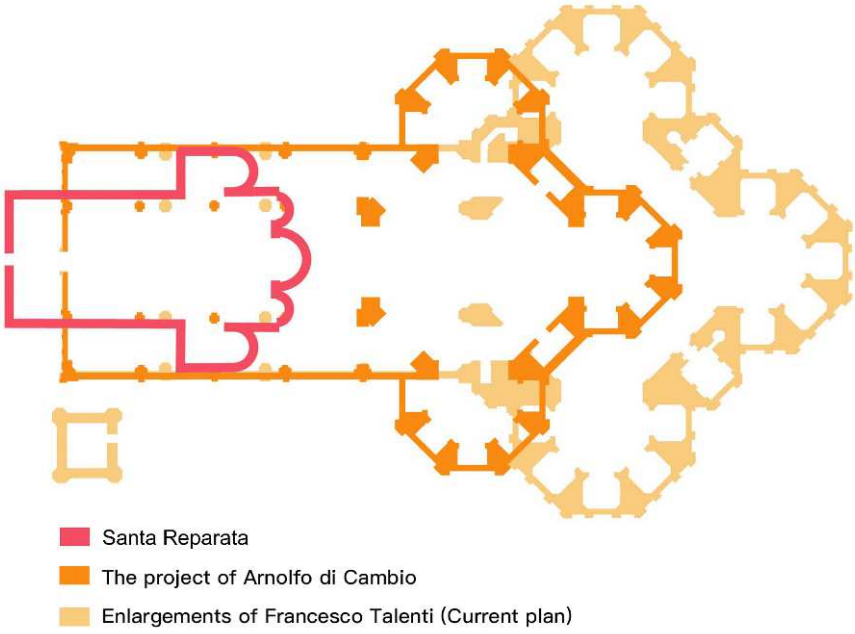
2.22 Notre-Dame de Reims, Reims, France[48]

Arnolfo designed the wide nave ending under the octagonal dome, which covering the area of *Santa Reparata*. The first stone was laid in 1296. The building of this vast project was to last 140 years; Arnolfo's plan for the eastern end, although maintained in concept, was greatly expanded in size. With Arnolfo's death in 1310, the work was apparently interrupted until the relics of Saint Zenobius were discovered in 1330 in *Santa Reparata*, the project gained a new impetus. In 1331, the Arte della Lana, the guild of wool merchants, took over patronage for the construction of the cathedral and in 1334 appointed Giotto di Bondone (1266-1337) to oversee the work. Giotto was not asked to continue work on the Cathedral but to design and construct the Bell Tower next to it. Following Giotto's death in 1337, the tower was continued by his

[47] Photo by the author

[48] Left: By bodoklecksel - own foto, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1178975
Right: By Palauenc05 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=48246404

assistant Andrea Pisano (1290-1348) and then by Francesco Talenti, who completed it in 1359. In the 1360s work began again fulltime on the Cathedral under a series of architects, whose nave and aisles were completed by 1379. Francesco Talenti introduced a series of modifications to the original design, all tied to the decision to make the rising Cathedral not only 'big' but positively titanic (Fig2.23).



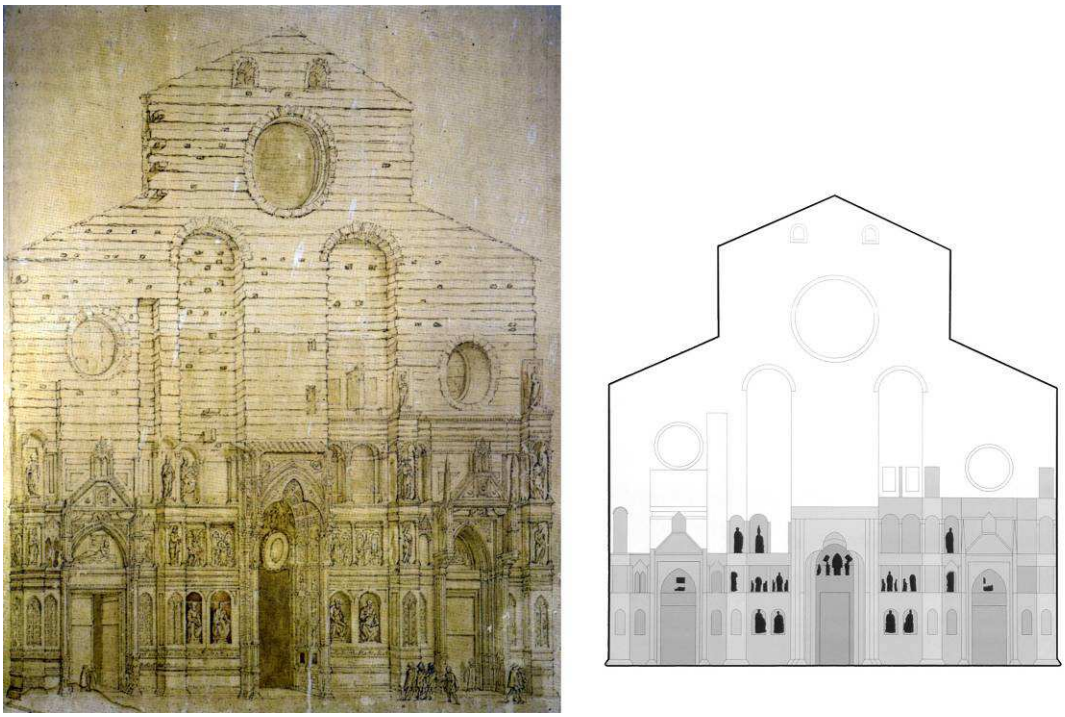
2.23 Plan of the church with various extension phases[49]

The shape of the future dome was decided and a fresco painted by Andrea di Bonaiuto in the 1360s shows it as though it already existed (Fig2.24). The construction of such a big masonry dome posed many technical problems. Finally Filippo Brunelleschi (1337-1446) found the solution. His dome rose between 1418 and 1436, followed by the lantern, designed by him but completed after his death.

2.24 Andrea di Bonaiuto, The Mission of the Dominican Order (detail), 1365-1367
Fresco in the chapter hall of the convent, Santa Maria Novella, Florence

[49] CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=785650

Throughout the 14th and early 15th century new statues were added, including masterpieces by Nanni di Banco (1384-1421) and Donatello (1386-1466), but two-thirds of the façade remained unfinished. In 1587, Grand Duke Francesco I de' Medici authorized the removal of statues and gothic decorations, expecting to build a Renaissance-style façade in a short time. Before the unfinished Gothic façade was dismantled. A drawing of it was made, attributed to Bernardo Poccetti (Fig2.25).



2.25 Left: Bernardo Poccetti, Unfinished Gothic facade of Santa Maria del Fiore ca. 1587, Archive of the Opera di Santa Maria del Fiore, Florence (AOSMF)
Right: Scheme from the Exhbition of Grande Museo del Duomo di Firenze (GMDF)

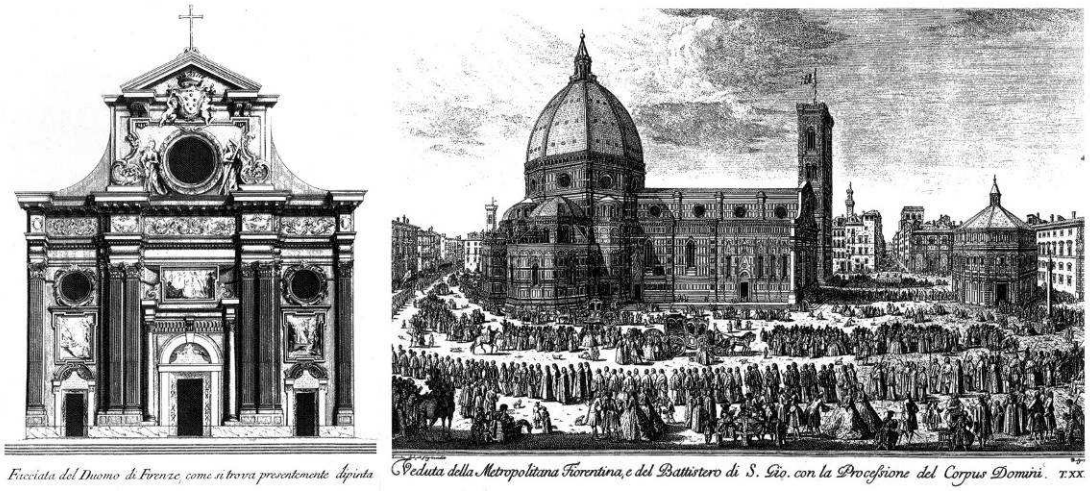
Starting in 1587, various projects were drawn up for a modern façade and large wooden models were made, seven of which are preserved in the *Grande Museo del Duomo* (Fig2.26). These designs have three-storey, rich decoration and details in a taste of temporary Florentine Mannerist style. None of the projects was implemented.

Until 1688, a façade designed by Ercole Graziani was painted on the Cathedral front (Fig2.27), as decorations for a Medici wedding. Damaged by exposure to the elements, the last traces of painting are visible in mid 19th-century photograph (Fig2.28).

All the eight proposals could be divided into three types. The basic shape follows the structure of the wide nave and two side aisles. The upper part of the façade is narrower than the lower part. Type I had horizontal crown of side aisles. Type II and III use curve lines to connect the upper and lower part. Type II divided the façade with four groups of pilasters, following the logic of aisle-nave-aisle. Type III using six groups of pilasters divides the wide nave into three smaller parts. Compare to Type I and II, Type III has one horizontal line in the middle of the lower part.

2.26 Models of projects for the new facade, GMDF
①Don Giovanni de' Medici, 1590-1600
②Giambologna, late 16th century
③Giovanni Antonio Dosio, 1590-1600
④Bernardo Buontalenti, 1587-1589 (?)
⑤Bernardo Buontalenti, late 16th century
⑥Accademia delle Arti del Disegno, 1635
⑦Gherardo Silvani, 1635-1636[50]

[50] Photo and scheme by the author

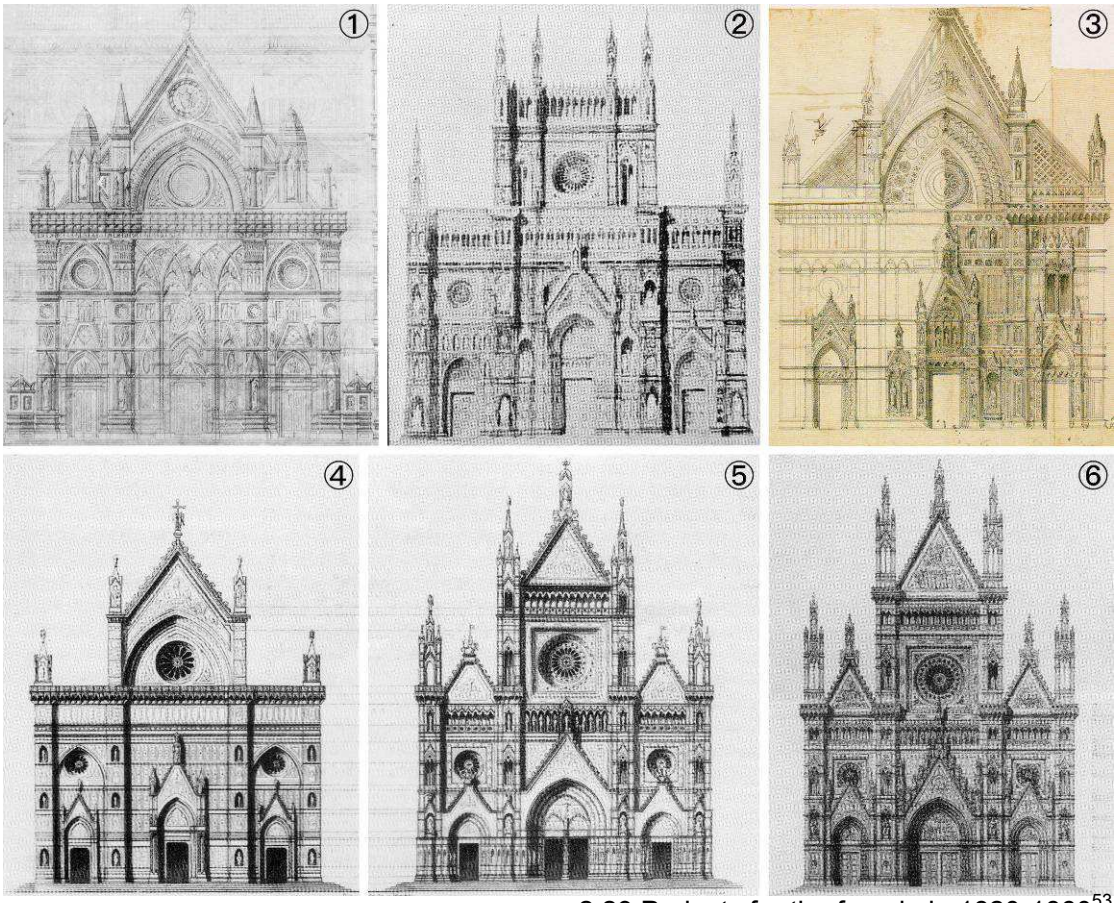


2.27 Left: Bernardo Sansone Sgrilli, Facade of Santa Maria del Fiore, with plaster-work and painted in 1688 after drawings by Ercole Graziani, in a 1733 engraving
Right: Giuseppe Zocchi, View of Santa Maria del Fiore and Battistero di San Giovanni, with the Procession of Corpus Christi, 1754[51]

2.28 Photo of the unfinished facade with traces of pictorial decorations, 1860[52]

The façade we see today was in fact the outcome of more than 60 years of planning and three international competitions. Proposals for an architectural façade to replace the ruined painted one began to circulate in the early 1820s and were all in a gothic style that alluded to the Florence of Dante. In 1822 Giovanni degli Alessandri, president of the Academy, together with *Opera del Duomo*, brought the question of façade back. A neo-Gothic style design from Giovan Battista Silvestri was presented. Several studies for the façade were made later (Fig2.29).

[51] Verdon, T. 2016, p19, p12
[52] Cresti, C., Cozzi, M., Carapelli, G. 1987, p30



2.29 Projects for the façade in 1820-1860[53]
①Giovan Battista Silvestri, 1822
②G. Muller, 1843
③M. Falcini, ca. 1850
④Matas and G. Muller, 1847
⑤Matas and G. Muller, 1847
⑥Luca Beltrami, 1858

In 1861, 1864 and 1865, three International competitions for completing the façade were held. Emilio De Fabris (1808–1883) won the competition in 1871 and the construction began in 1876. Unfortunately, De Fabris died in 1883 without seeing the completion of the façade to which he had dedicated almost his entire professional life. After his death the task of completing the façade was entrusted to his assistant Luigi del Moro. On May 12 1887, the façade was officially inaugurated. This neo-gothic façade in white, green and red marble forms a harmonious entity with the cathedral, Giotto's bell tower and the Baptistery. Both praise and criticism of excessively decorated were given to the work.[54]

The design process marked by intense artistic and ideological debate, coincided with the national unification movement known as the *Risorgimento*, and Duomo façade was in fact the new Kingdom of Italy's initial creative project. Its first stone was laid by Victor Emmanuel II in 1860 and the last of its bronze doors was unveiled in the presence of Victor Emmanuel III in 1903.

[53] Cresti, C., Cozzi, M., Carapelli, G. 1987, p48
[54] Verdon, T. 2016, p117-119

2.2.2 The International Competition for the Façade in 1860s

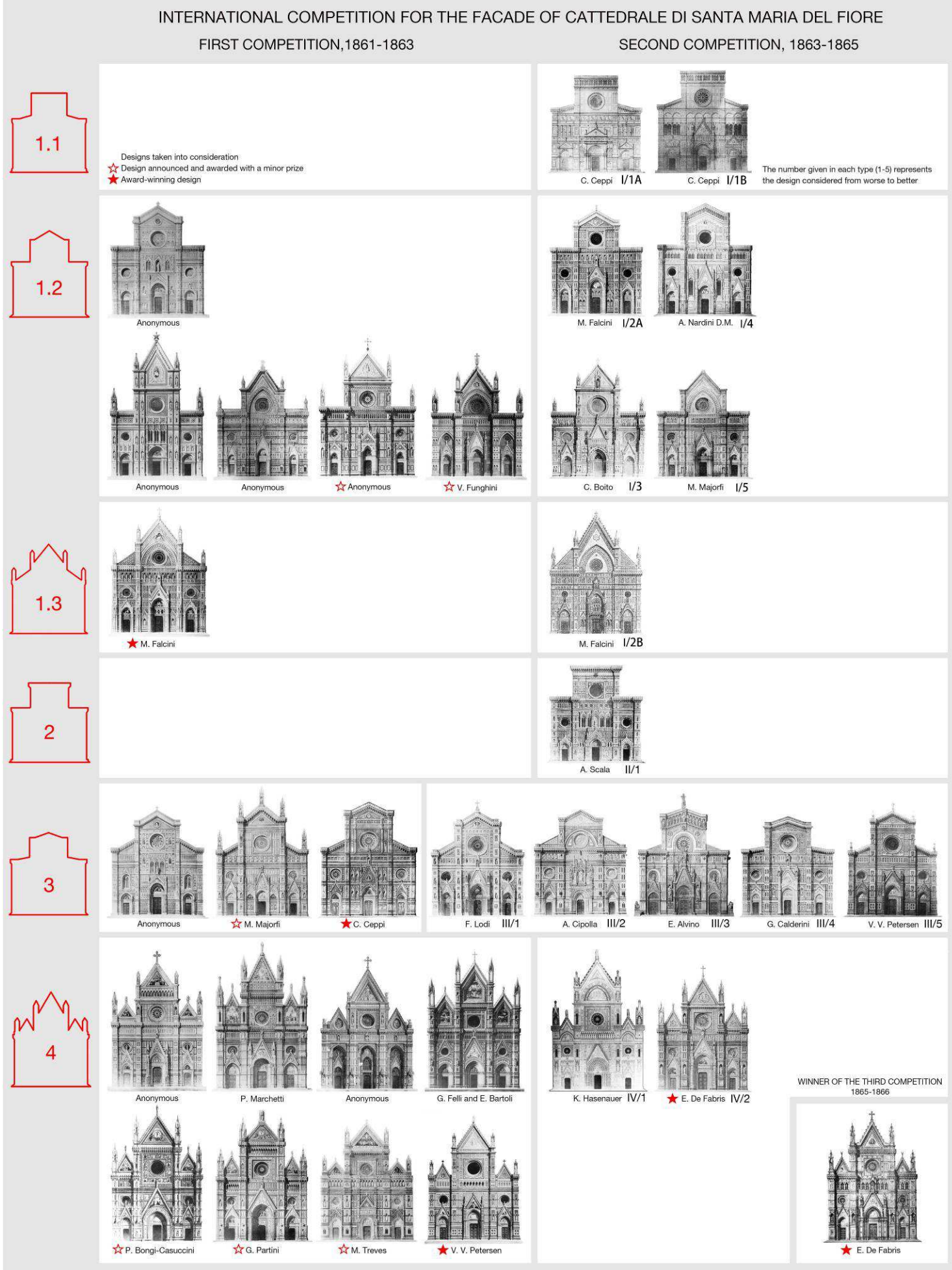
The first contest's delivery time was from November 10, 1861 to September 30, 1862. The final result was published on February 6, 1863. There were total 44 proposals (designed by 42 groups of architects) competed in the contest. Though some of the contestants were famous architects, many preferred to remain anonymous. The committee, chaired by Gaetano Baccani, was composed of Alessandro Antonelli, Fortunato Lodi, Errico Alvino, Camillo Boito, Pietro Camporese and Andrea Scala, each representing the main Italian academies and cities. Among the 44 proposals, 7 designs were said to be taken in consideration, 6 designs were announced and awarded with a minor prize, 3 designs were award winning.[55]

The second contest's delivery time was from May 11, 1863 to June 30, 1864. The most diverse proposals came to Florence in this round: from the neo-Gothic taste of the Alps, to a more respectful of Italian style, to others of a completely eclectic typical taste of the time. Many judges (Fortunato Lodi, Errico Alvino, Camillo Boito and Andrea Scala) of the first competition, two architects awarded in the first competition (Falcini and Petersen), as well as Emilio de Fabris and Antonio Cipolla took part in this round. There were total 43 proposals delivered and the Selection Board took 15 of them (from 13 architects) into consideration.[56]

According to the result announced in the second competition, we could divide the proposals into four types based on the shape of the crown. Type 1 is called "mix of lines"; Type 2 projects use horizontal crown over the nave and side aisles; in Type 3 designs, nave and side aisles finishes with parallel slanting lines; Type 4 proposals are with tricuspid crowns.

2.30 Left: Facade of Duomo di Siena, Right: Facade of Duomo di Orvieto[57]

[55] Cresti, C., Cozzi, M., Carapelli, G. 1987, p56
[56] Cresti, C., Cozzi, M., Carapelli, G. 1987, p110
[57] Photo by the author

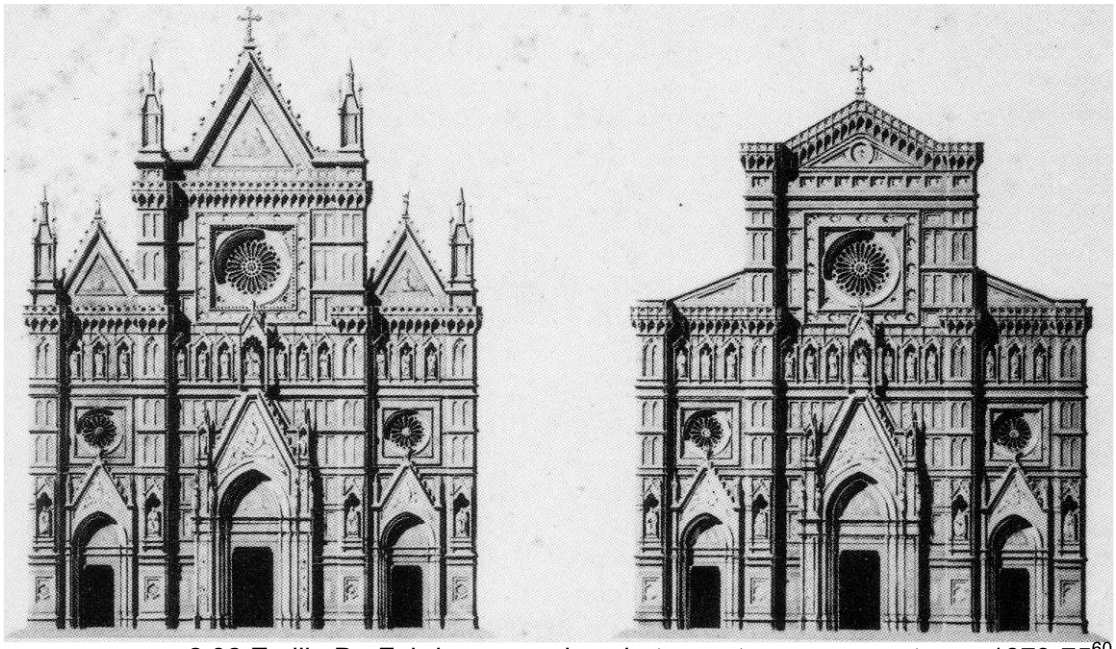


2.31 International Competition for the facade[58]

[58] Cresti, C., Cozzi, M., Carapelli, G. 1987. Scheme by the author

The winner of the second competition was Emilio De Fabris, with a tricusped project inspired by the 14th-century Gothic Style churches such as *Duomo di Siena* and *Duomo di Orvieto* (Fig2.30), but the result was criticized and raised considerable controversy within the commission. A clear objection was raised by Camillo Boito, who opposed to the three cusped crowns used in De Fabris's project with the supporters. Errico Alvino even questioned about the commission's work. Facing all these allegations, the commission asked the French architect Viollet-le-Duc for suggestions, who highlighted the limits of the tricusped system.

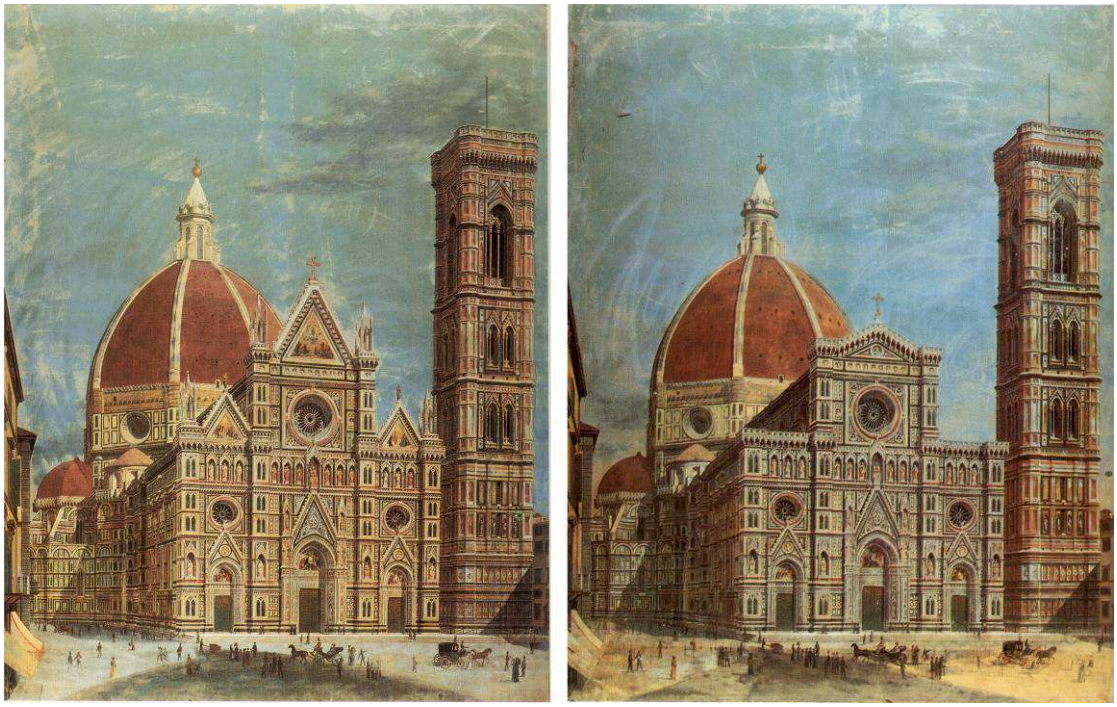
In 1865 the commission started the third contest, which invited 10 participants of the second competition and 29 free competitors, with total 45 proposals (some in fact proposed two different solutions). The competition started from November 27, 1865, and the delivery deadline was December 31, 1866. The result was published on July 27, 1867. Emilio De Fabris won again. It is said that most of the members of the commission supported the tricusped solution. But it was a narrow victory obtained with the minimum of votes. After several steps of improving, De Fabris's project was approved in 1870 and on July 4 of the same year he was appointed "Architect of the façade of *Santa Maria del Fiore*".[59]



2.32 Emilio De Fabris, comparison between two crown systems, 1873-75[60]

Even though, the controversy between design with or without the cusped crown had not finished. These two solutions can be called the "tricuspid" and the "basilican". Several architects continued to submit alternative proposals. In 1873, De Fabris designed solution with a basilican crown. Despite the uncertainty of the crown type, construction work began in 1876 according to the winner's design and was completed by Luigi Del Moro after De Fabris's death. Two solutions of aisles' crown, "tricuspid" and "basilican", were built simultaneously, and decided by a referendum of Florentines themselves.

[59] Cresti, C., Cozzi, M., Carapelli, G. 1987, p142
[60] Cresti, C., Cozzi, M., Carapelli, G. 1987, p175

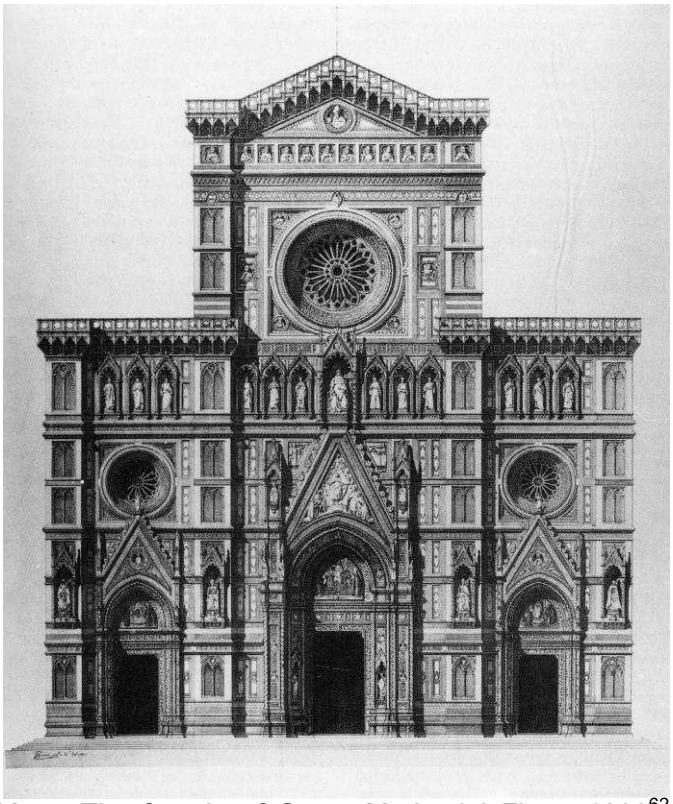


2.33 Niccolo Barducci, the “tricuspid” and the “basilican” solutions, 1883 (GMDF)

The whole debate about the façade in fact revolved around which of these interpretations of gothic style was aesthetically and politically preferable. Many considered the tricusped version to be ‘northern’ and thus ‘Austrian’, in an Italy that had just freed itself from the yoke of Vienna. By contrast the basilican version, more rectilinear, less pointy, it seemed authentically ‘Italic’. And now we all know the final choice.

2.34 Two solutions of “tricuspid” and “basilican”, built temporarily alongside waiting for the Florentines to choose, 1883[61]

[61] Gurrieri, F. La Cattedrale di Santa Maria del Fiore a Firenze. Volume Primo. Florence: Giunti Editore, 1994, p244



2.35 Luigi del Moro, The façade of Santa Maria del Fiore, 1888[62]

[62] Cresti, C., Cozzi, M., Carapelli, G. 1987, p183

2.3 Duomo di Milano

Duomo di Milano (Fig2.36) is the cathedral church of Milan, Italy. Dedicated to *Santa Maria Nascente*, it is the seat of the Archbishop of Milan. From the laying of the first stone in 1386 to the last gate was inaugurated on January 6, 1965, it took nearly six centuries to complete this Gothic cathedral. It is the largest church in Italy (the larger Basilica di San Pietro is in Vatican City). As a result of long period of working, the cathedral is an eclectic mix of Gothic, Neoclassical and Baroque styles. Though *Duomo di Milano* has a complete façade today, it did have an unimplemented project for façade renovation in the late 19th century, which could be seen in the *Museo del Duomo di Milano* today.

2.36 Façade of Duomo di Milano, Milan, Italy[63]

2.3.1 A Brief History of Construction

In 1386, Archbishop Antonio da Saluzzo made plans for a new larger and more modern cathedral, to be built on the site of two basilicas used in that period: *Santa Tecla* and *Santa Maria Maggiore*. At that time, Milan was ruled by the archbishop's cousin, Gian Galeazzo Visconti (1347-1402), whose military campaigns temporarily annexed to Lombardy a large portion of Venetian territory, most of Emilia, and a part of Tuscany. Just one year before, in 1385 Gian Galeazzo gained control of Milan by overthrowing his uncle Bernabò through treacherous means. Later in 1395, he created the Duchy of Milan and became the first Duke.

Gian Galeazzo is well-known for his ambitious of changing Milan as the center and a melting pot of different cultures in all over the Europe. The revival of monumental architecture may be attributed both to the ambitious personality of the duke and to the increase in wealth and security which resulted from political consolidation. The new architectural campaigns called for building on a scale calculated to rival the largest

[63] Left: Di Max_Ryazanov, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=29744047
Scheme by the author

Gothic cathedrals of Western Europe, a goal that was not destined to be achieved easily by a society which had so recently emerged from two centuries of cultural obscurity.

2.37 Fadace of Chiesa di Santa Maria del Carmine, Carmine, Italy[64]

At that time, a conservative Gothic church style had developed in Lombardy. *The style is essentially a compromise between the Romanseque cathedrals of the region and the French Cistercian forms introduced into central Italy in the 12th century. The flying buttress is rarely employed, fenestration remains limited, monumental sculpture is forsworn, and the exteriors are uniformly of unfaced brick. Chiesa di Santa Maria del Carmine* (Fig2.37) is a well-preserved and typical Lombard Gothic church. *The chapel rows give the plan a rectangular form and produce a façade of unusual breadth. Pinnacles and terracotta ornaments enliven the façade, which contrasts to the ascetic severity of the interior.*[65]

The reconstruction of *Duomo di Monza* is another major architectural project undertook in the Milan area at that time. The west façade of the cathedral (Fig2.38) in white and green marble was started to be built in the late 14th century. It is divided into five parts by six pilasters with pinnacles on top. This arrangement of facade is similar to *Duomo di Milano* and also Chiesa di Santa Maria del Carmine in Pavia.

[64] Left: https://i.pinimg.com/originals/a6/5b/56/a65b56b5d4743f52ef5842bb17aedc6a.jpg
Scheme by the author
[65] Ackerman, J. S. "Ars Sine Scientia Nihil Est" Gothic Theory of Architecture at the Cathedral of Milan

2.38 Facade of Duomo di Monza, Monza, Italy[66]

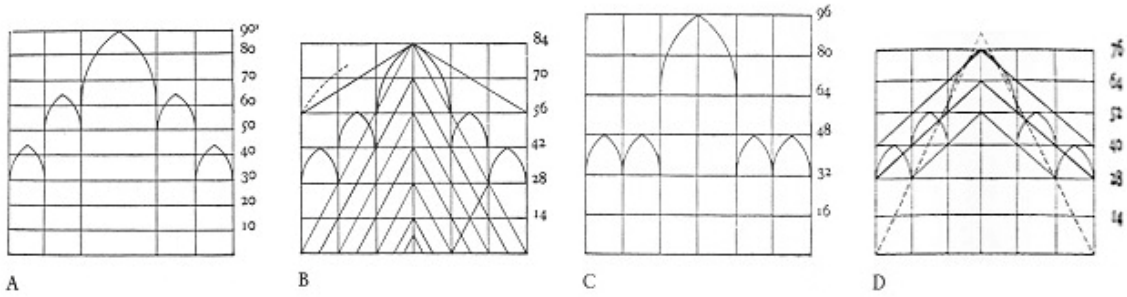
Local Lombard Gothic architects had no experience to handle such a big project as the new cathedral planned in Milan, but they had confidence and would like to build without assistance from the north at first. The building council appointed in 1386 confidently produced its own designs, and broke ground shortly after the pope granted a charter for the construction. In 1387, Visconti set up the *Veneranda Fabbrica del Duomo* charging it with supervising the work of design, building and conservation of the Cathedral. He insisted that the Gothic international style be used for Duomo, and decided to use *Candoglia* marble to cover the whole monument.

Between 1386 and 1391, because of the change of building materials and the fact that no one was fully trusted and took responsibility for the cathedral from the very beginning, doubts and uncertainties on the further development of the building came more frequently. In 1389, three years after the foundation, some faults in the foundations and the ability to decide a pier design constituted an obstacle to progress. The council invited a Frenchman, Nicolas de Bonaventure, who became a privileged engineer of the cathedral for help. From then on, the northern Gothic character of the cathedral began to take form in the original Lombard Gothic style, though the submission to alien forms was made unwillingly. In the following years, French and German masters who were hired to aid the architects of Milan Cathedral were bitterly received and poorly treated. One by one, they were dismissed soon after their arrivals. From the visiting experts' point of view, the Milanese must be stubborn and ignorance about the "science".

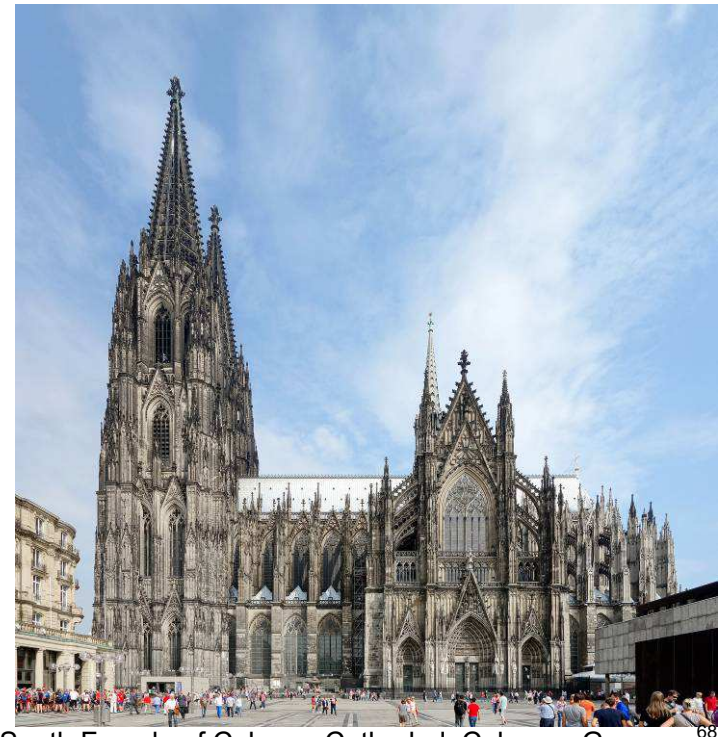
For some reason, the Milanese became increasingly anxious to give the cathedral a low, broad section (Fig2.39). The Lombard Gothic tradition immediately comes to mind as a possible motivation. The council wishes to keep the nave low enough for the two side aisles to support it without the aid of additional buttressing, and perhaps even without flying buttresses, as at the Carmine in Pavia, other than northern Gothic

[66] Left: http://www.italian-art-notes.com/2014/05/art-in-cathedral-of-monza.html
Scheme by the author

churches using flying buttress, like *Kölner Dom* (Cologne Cathedral, Fig2.40).



2.39 Projects analysis in 1390-1392
(A) project of 1390 employing units of 10 braccia, after sketch and notes by Antonio di Vicenzo (B) project of 1391 employing units of 14 braccia, after sketch Gabriele Stonrnaloco (C) project of 1392 employing grid of squares, Probably proposed by Heinirich Gmund (D) project accepted in 1392 employing Stornaloco's project[67]



2.40 South Facade of Cologne Cathedral, Cologne, Germany[68]

There was another case of a clash between two different architectural cultures and experiences, along with the arrival of Jean Mignot in 1400. It was unavoidable that this time two serious differences of opinion should arise between the French group led by Jean Mignot and the Italian engineers. In one conference's final argument, it claims that the security of the project is assured, first because the weight of the towers is to be evenly distributed on their square base, and second because "*what is vertical cannot fall*"[69]. This conclusion is absolutely irrational and ridiculous.

Although Jean's idea was never accepted, it did however result in temporarily reconciling the two opposing sides in an opportunistic compromise and naturally

[67] Ackerman, J. S. 1949
[68] By Velvet - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=35472522
[69] Ackerman, J. S. 1949

caused a considerable delay in the work. So in the few years after that, the construction process was slowed down.

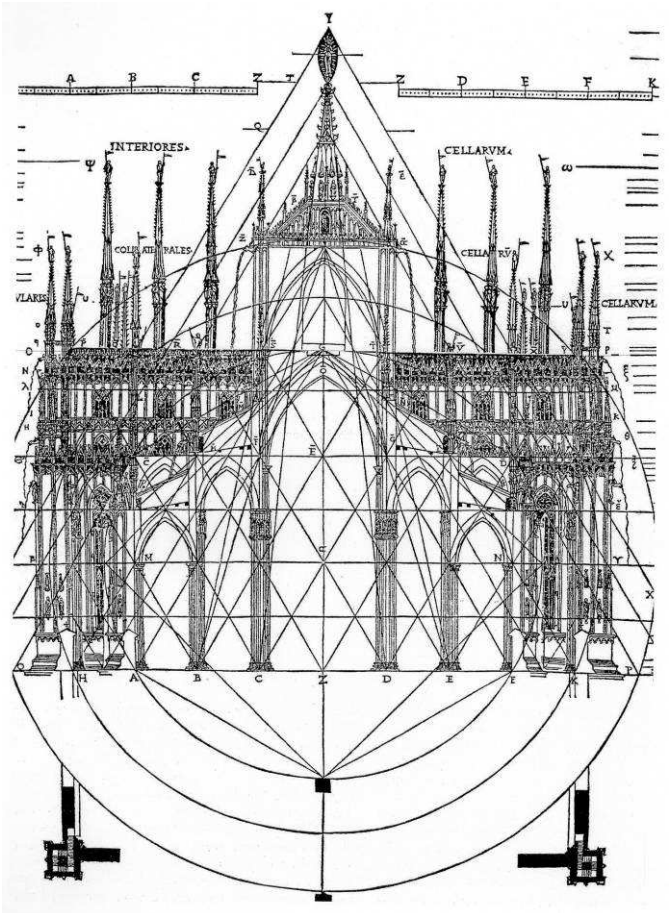
This struggle between the Milanese and foreign architects is easy to understand. When no one has the knowledge of structural mechanics, all the architects and engineers could just work with their own experience and the projects built before. Northern architects would like to and could only work in the way of their own proved structure, while the Milanese preferred theirs own. Though northern architects might know more about the structural science, they did not have a reliable theory, but only some empirical descriptions as *the height should be equal to the width*. The two sides could not persuade each other and compromises were hardly made. *A logical structural system proven by long practice is thus spurned in favor of one which, while it has vague parallels in small, provincial, brick churches, is purely experimental on this scale. Should such an experiment succeed, it would be proof either of the inventive and technical skill of men seeking to find new forms, or the sheer good luck of innocents who will try anything rather than adopt an established foreign style.*[70] The council prefers the latter alternative.

During the Sforza era (1450-1520), the difficult problem of erecting the vault of the *tiburio* (lanterm tower) had to be solved. After having consulted the advice of a number of great architects of the time, among whom Francesco di Giorgio Martini, Donato Bramante (Fig2.41) and Leonardo da Vinci (Fig2.42), the dome was eventually requested to Giovanni Antonio Amadeo.

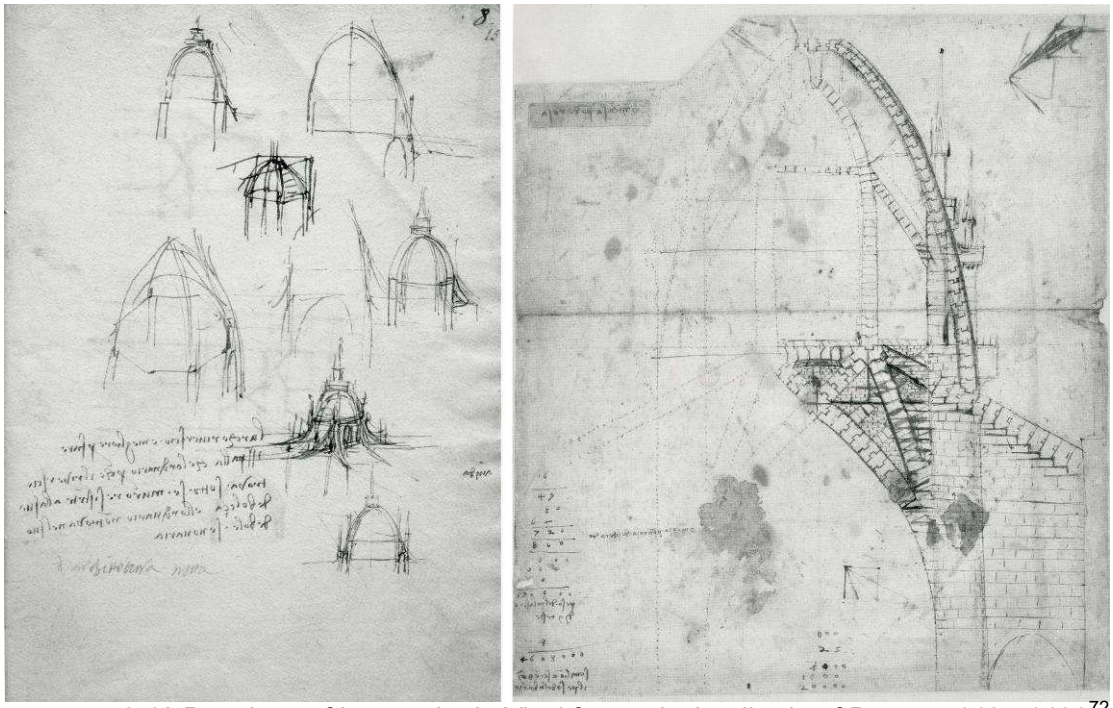
In 1452, under Francesco Sforza, the nave and the aisles were completed up to the sixth bay. In 1500 to 1510, under Ludovico Sforza, the octagonal cupola was completed, and decorated in the interior with four series of 15 statues each, portraying saints, prophets, sibyls and other Figures from the Bible. The exterior long remained without any decoration, except for the elegant little spire, sculpted by Guglietto dell'Amadeo, constructed in 1507-1510. This is a Renaissance masterpiece which nevertheless harmonized well with the general Gothic appearance of the church. The most beautiful stained glass windows were also installed.

The Duomo is the result of the mutual work of numerous masters, architects, engineers and sculptors. This site became a melting pot where culture, experience and different languages blended together giving life to a unanimous expression. Duomo became a crossroads of people and cultures: a lively place for exchange of the most widely differing ideas, experiences and manual skills expressed by workers originating from the regions stretching.

[70] Ackerman, J. S. 1949

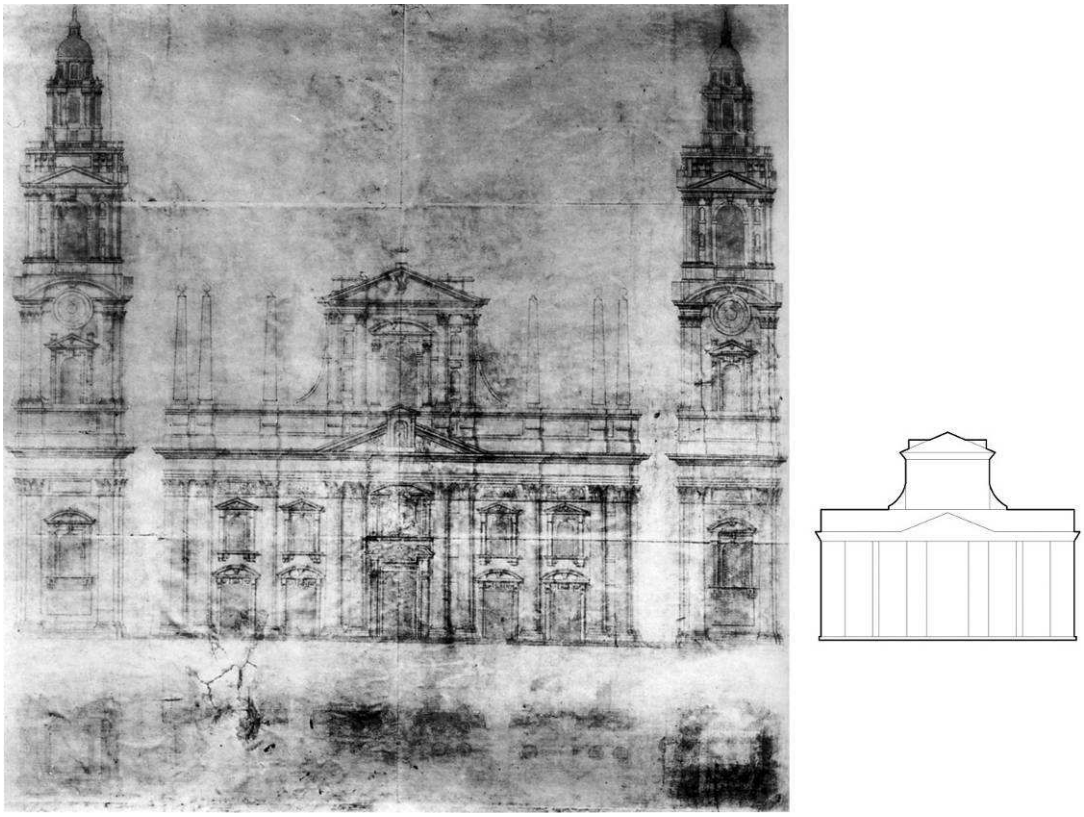


2.41 Cesare Cesariano, Section of Duomo with square tiburio, c. XVr, from *Vitruvius de architectura*, Como 1521. The engraving of Cesariano depicts the tiburio of the duomo according to Bramante's idea[71]

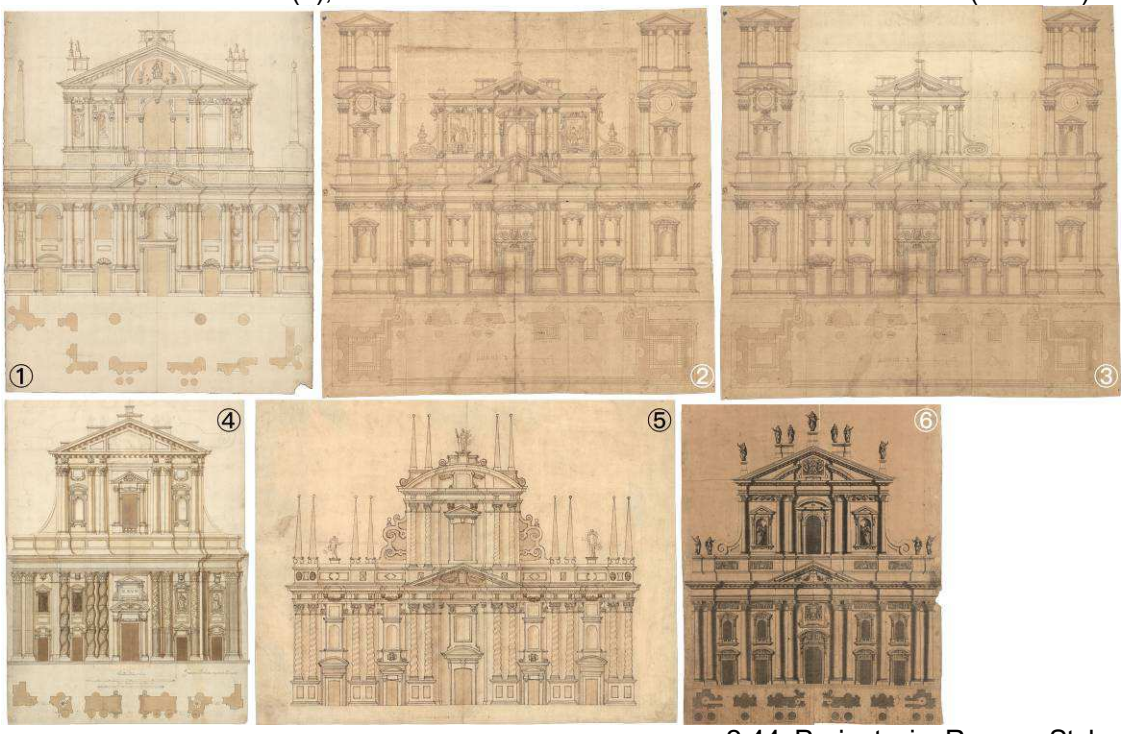


2.42 Drawings of Leonardo da Vinci for study the tiburio of Duomo, 1487-1490[72]

[71] Moschini, C. 2012, p148.
[72] Moschini, C. 2012, p140, p144.



2.43 Francesco Maria Richino (?), Copy of Pellegrino Tibaldi's project for the façade, 1610(?), Archivio Veneranda Fabbrica del Duomo di Milano (AVFDMi)[73]



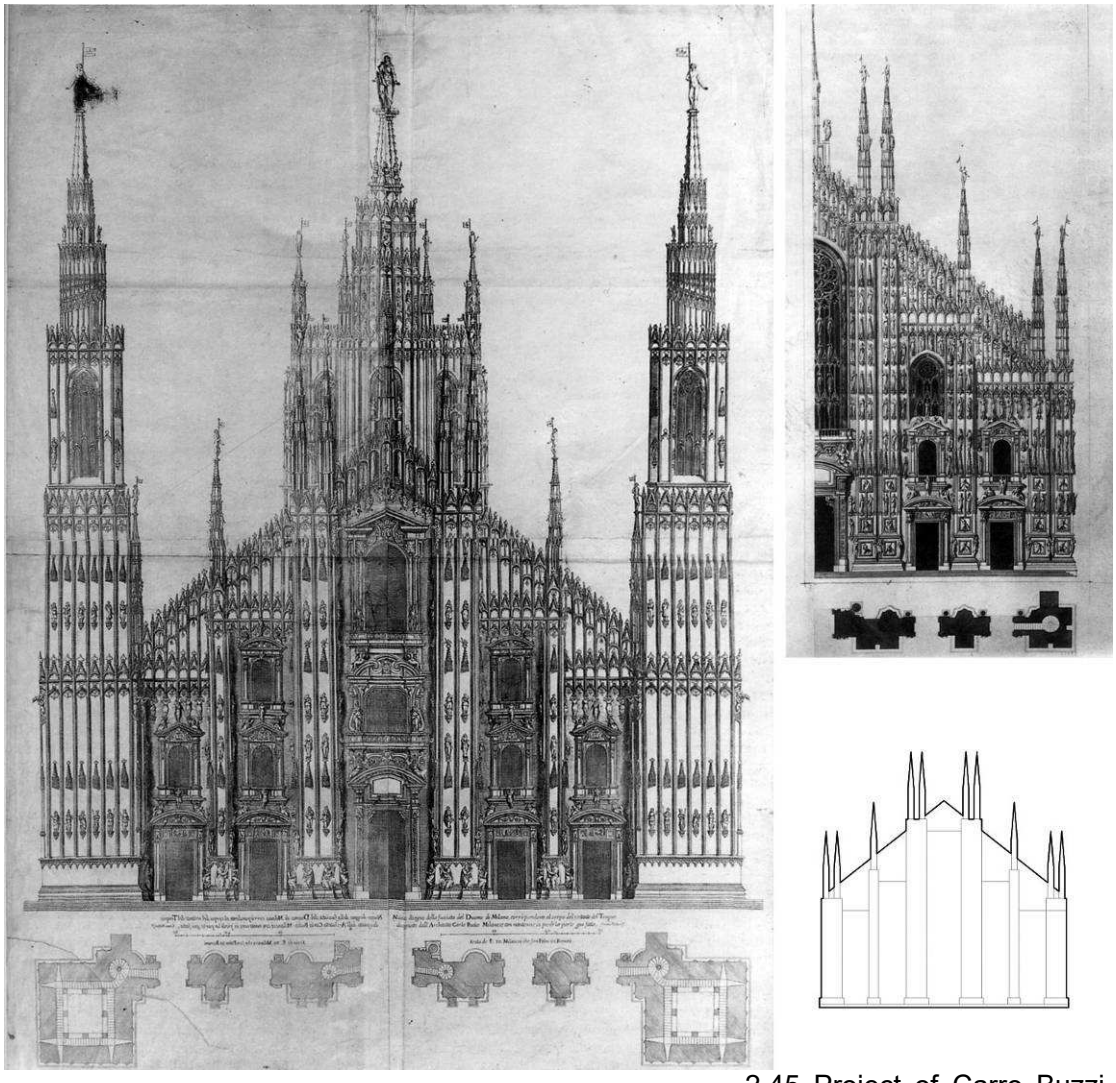
2.44 Projects in Roman Style
①Martino Bassi (?); Pietro Antonio Barca (?), 1490-1495 (?), Archivio Storico Civico e Biblioteca Trivulziana di Milano (ASCMi)
②Francesco Maria Richino, 1603, ASCMi
③Francesco Maria Richino, 1603, ASCMi

[73] Scheme by the author

④Francesco Maria Richino, 1603-1606, ASCMi
⑤Francesco Maria Richino, 1606, ASCMi
⑥Francesco Maria Richino, 1635-1637 (?), ASCMi

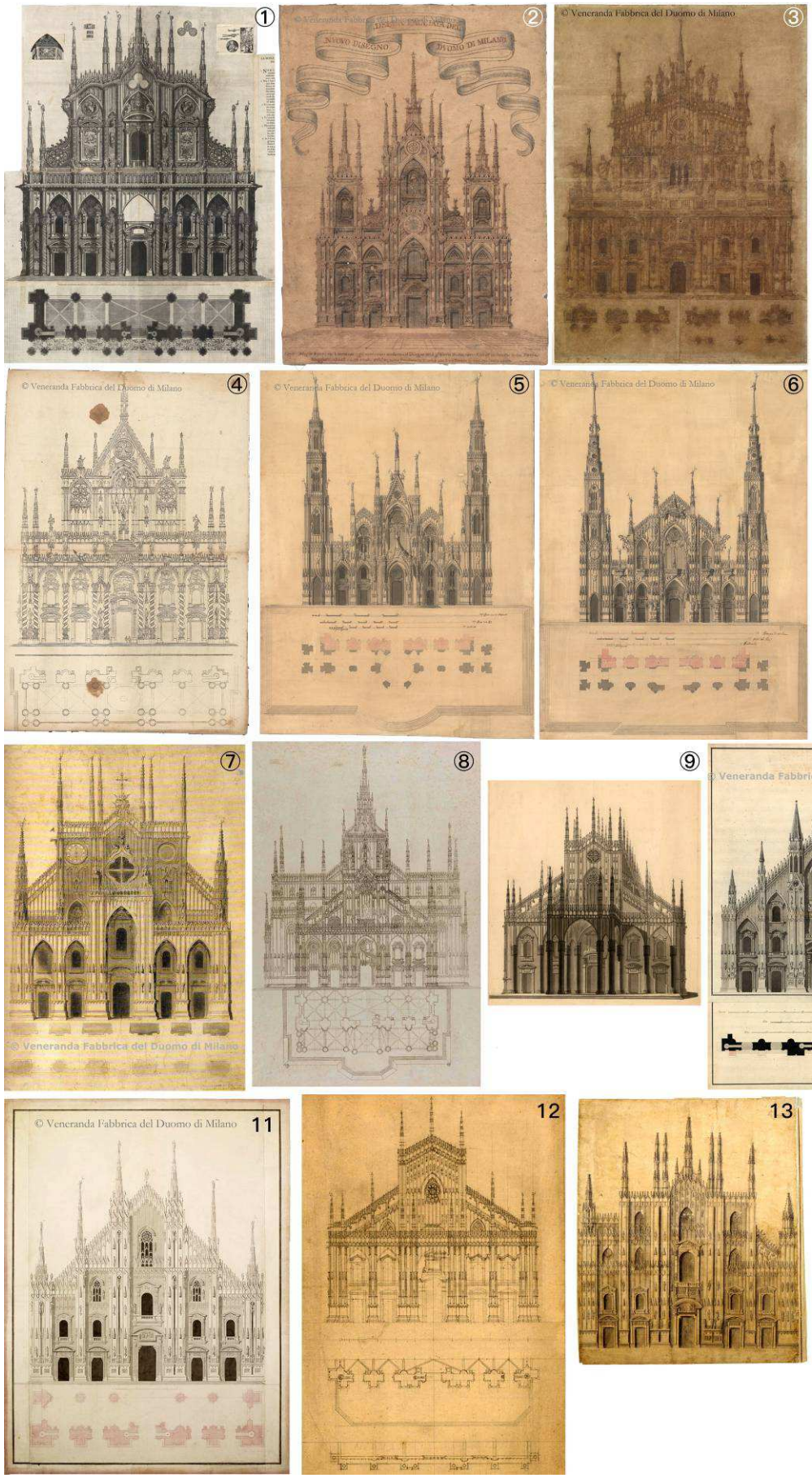
Carlo Borromeo, the Archbishop who arrived in Milan in 1656, nominated Pellegrino Tibaldi (Pellegrini), to redesign the interior of the church. Influenced by the Catholic Reformation, Pellegrini started to study a new facade in "Roman" style with impressive portals and windows and even more impressive columns that were to protrude from the wall at the pilasters but failed. The upper part of the facade, narrower than the lower part, concluded with a large eardrum and was flanked by two obelisks for each side (Fig2.43). This "Roman" Style uses different orders on the façade was the trending in Renaissance.

For a long time the façade remained that of the basilica of Santa Maria Maggiore. The previous facade was gradually demolished when the construction work progressed. It was not until 1638 that demolition of the old 15th-century façade began and the masonry structure of the new façade was built.



2.45 Project of Carro Buzzi,
Left: 1647, ASCMi Right: Anonymous copy of Buzzi's Project, 1653, AVFDMi[74]

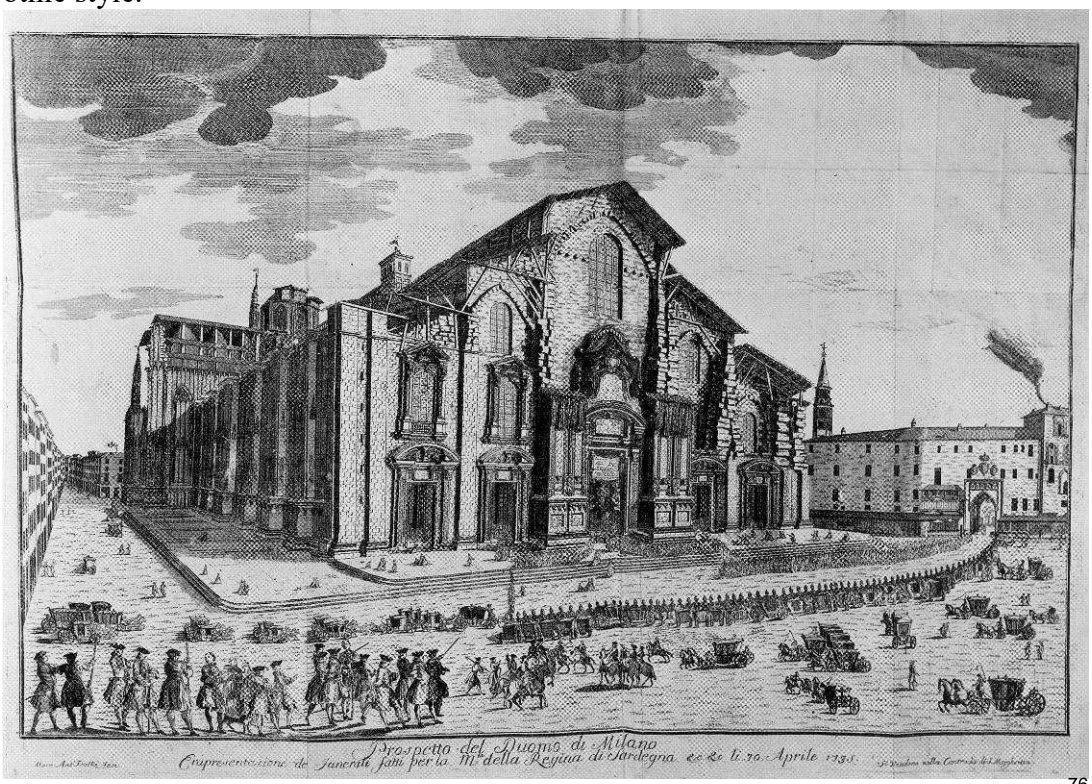
[74] Scheme by the author



2.46 Projects after Buzzi's

①Francesco Castelli, 1651, ASCMi
②Giovanni Gattini (?); Giuseppe Pozzi (?), 1653-/1668 (?), AVFDMi
③Anonymous, 1700-1750 (?), AVFDMi
④Luigi Vanvitelli, 1745, AVFDMi
⑤Bernardo Antonio Vittone, 1746, AVFDMi
⑥Bernardo Antonio Vittone, 1746, AVFDMi
⑦Giovanni Battista Riccardi, 1746, AVFDMi
⑧Carlo Giuseppe Merlo, 1751, la Civica Raccolta di Stampe di Milano (CRSMi)
⑨Giulio Galliori, 1786-1787, AVFDMi
⑩Leopoldo Pollack, 1786, AVFDMi
11 Carlo Felice Soave, 1791, AVFDMi
12 Giulio Galliori (?), 1795 (?), AVFDMi
13 Cesare Pagano, 1790-1800, CRSMi

In the second half of 17th century, the new chief architect Carlo Buzzi (Fig2.45) introduced a striking revolution: the façade was to revert to original Gothic style, including the already finished details within big Gothic pilasters and two giant belfries. On both sides, two large bell towers further accentuate the verticality of the building. It's an experiment recovery of tradition for its fidelity to the original idea of the cathedral and it is hard to define Gothic style. As it immediately arised, simultaneously with this proposal, it received a favorable reception from the *Fabbrica*. In 1682 the façade of *Santa Maria Maggiore* was demolished and the cathedral's roof covering completed. Other designs were provided in the following years, but all remained unapplied (Fig2.46). We could see that some of them were in a dramatic Mannerism style, but proposals in the second half of the 18th century followed Buzzi's Gothic style.[75]



2.47 Marc'Antonio Dal Re, Duomo di Milano, engraving, ca. 1745[76]

[75] Benati, G., Roda, A. M. Il Duomo di Milano, Dizionario Storico Artistico e Religioso, Milano: NED, 2001, p248-254
[76] Moschini, C. 2012, p113

In 1805, Napoleon Bonaparte, who wanted to be crowned the King of Italy at Duomo, ordered the façade to be finished by Carlo Pellicani. Within only seven years, the Cathedral had its façade completed mainly followed Carlo Buzzi's project. Some neo-Gothic details were added to the upper windows.[77]

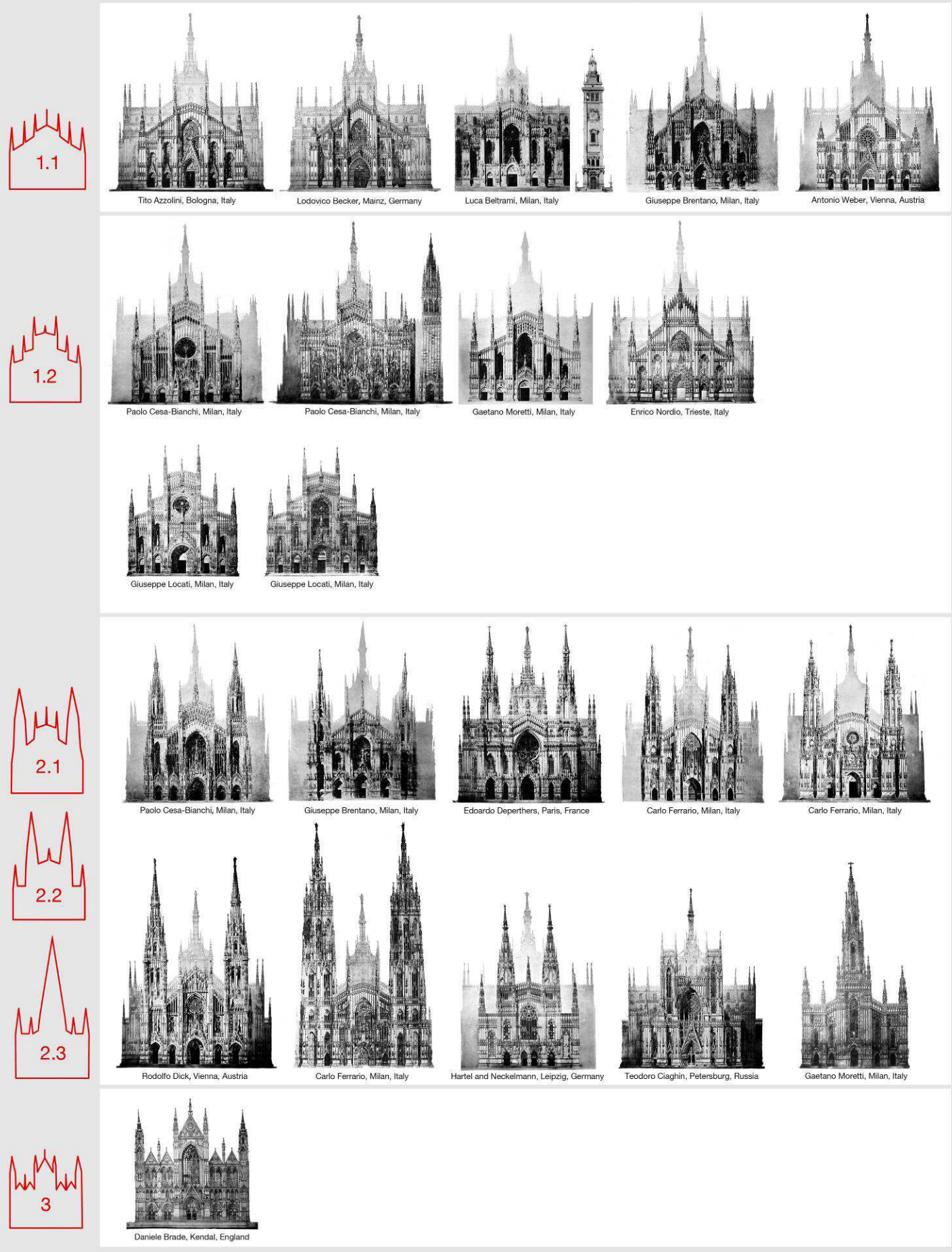
2.3.2 The International Competition in 1880s

Milanese wasn't satisfied with the façade had been rushed to complete under Napoleon's order. In 1886, *la Grande Fabbrica* started an international competition for a complete renovation of the facade in Gothic style. On June 4, 1887, 15 groups of architects were chosen by the jury for the second round of the competition. Some of them, such as Paolo Cesa-Bianchi (1877), Gaetano Moretti (1904) and Luca Beltrami (1907) became the main architect or engineer of Duomo in the following years.

Among the 15 groups of architects participated in the first round (Fig2.48), 14 groups except Teodoro Ciaghin from Russia submitted their proposals in the second round (Fig2.49). Some proposals in the first round were improved while some were abandoned. We could divide all the proposals from the two rounds into four main types. Type1 followed the shape of traditional Lombardy Gothic Style. Some gradually rise from side to the center (Type1.1), while some have a much higher nave than the side aisles (Type1.2). Type2 added big towers based on Type1. Type3 is a tricusped crown system with a high and big nave. Only one proposal of this type was submitted in each round. We could see that proposals with huge towers were abandoned in the second round. Most of the designs in round two preferred the tradition Lombardy Gothic style.

In October of 1888, the jury chose Giuseppe Brentano (1862-1889) as the winner of the second round. The jury gave him the words, "*non solo...il migliore di tutti gli altri, ma degno di venire eseguito*", which means "not only...the best of all the others, but worth of being executed."[78]

[77] Repishti, F. La Facciata del Duomo di Milano: nei Disegni d'Archivio Della Fabbrica (1583-1737), 2002
[78] Benati, G., Roda, A. M. 2001, p111-113, p255-258



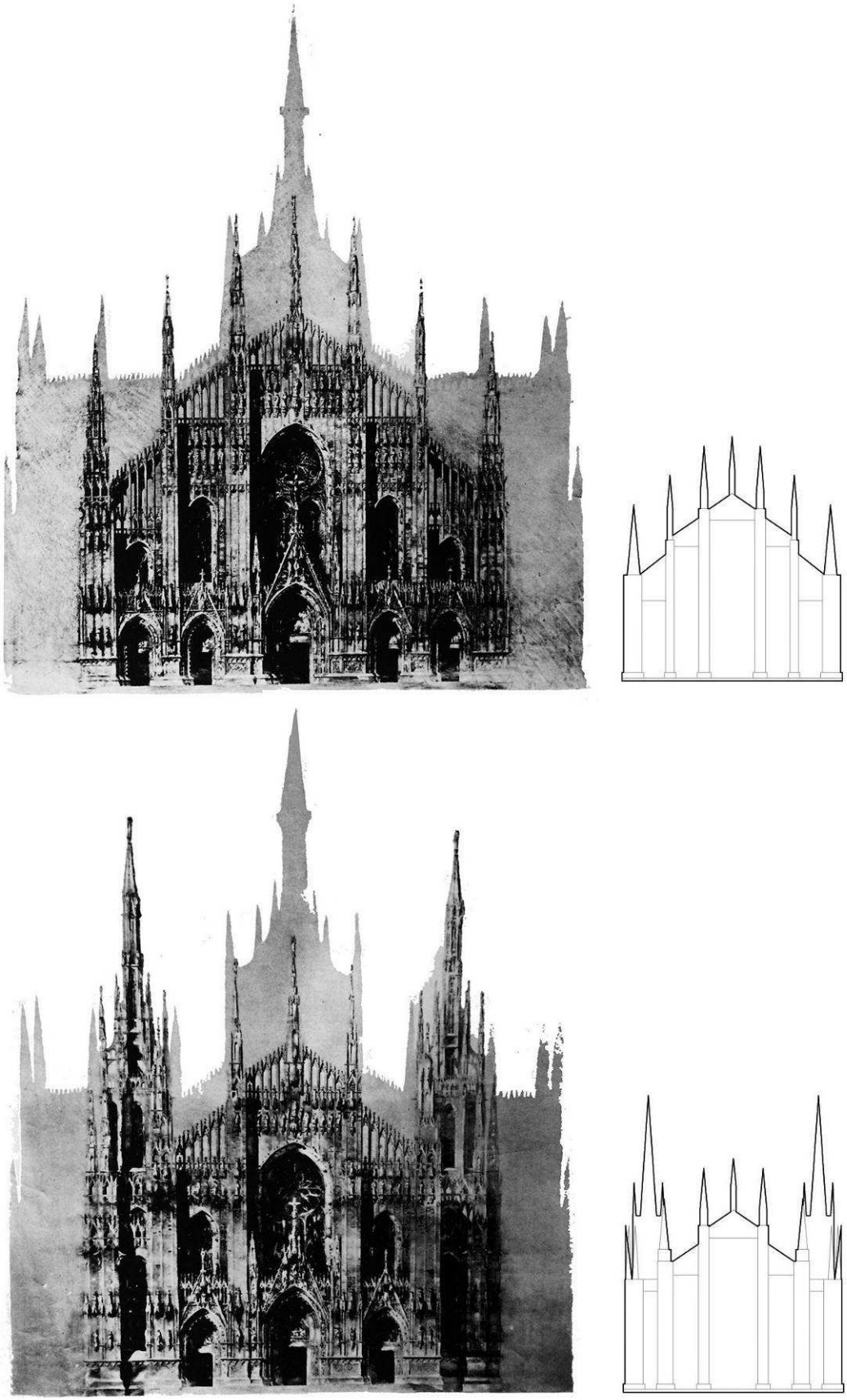
2.48 Proposals in the first round[79]

[79] Boito, C. Il Duomo di Milano e i Disegni per la sua Facciata, 1889. Scheme by the author

SECOND ROUND OF COMPETITION, 1888

2.49 Proposals in the second round[80]

[80] Boito, C. 1889. Scheme by the author

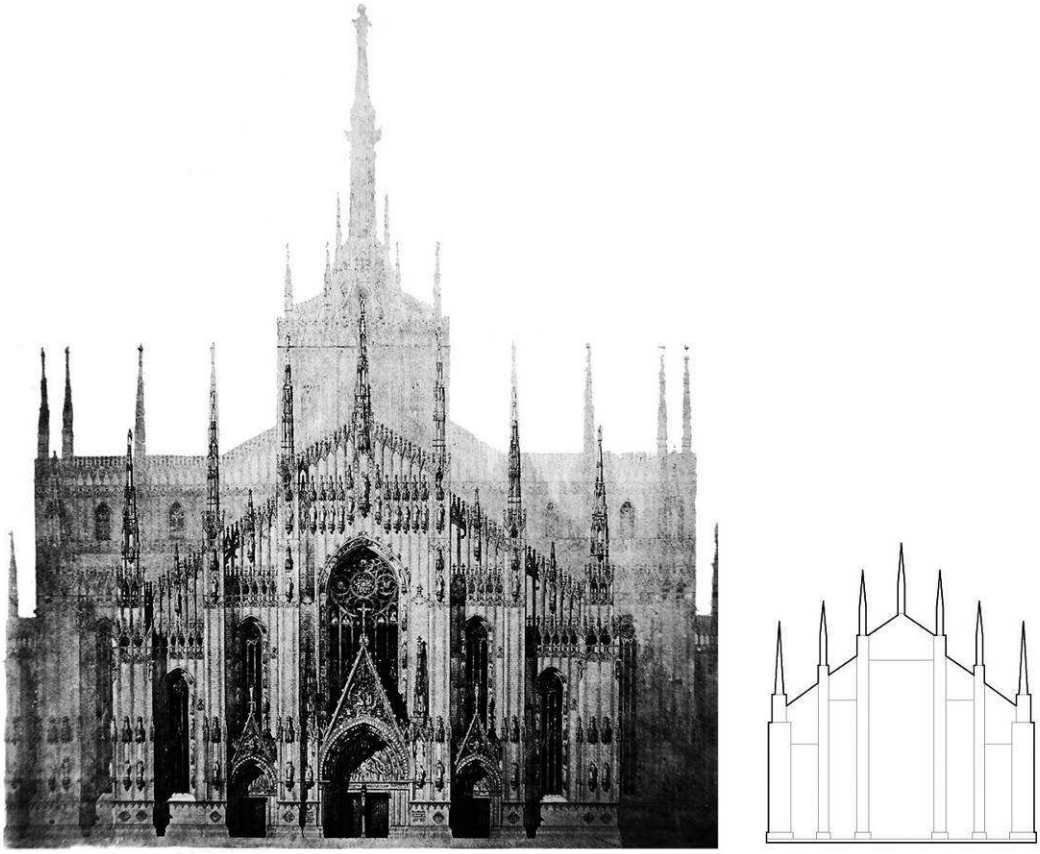


2.50 Proposals of Guiseppe Brentano in the 1st round of the competition, 1887[81]

[81] Boito, C. 1889, tavola n.50-51. Scheme by the author

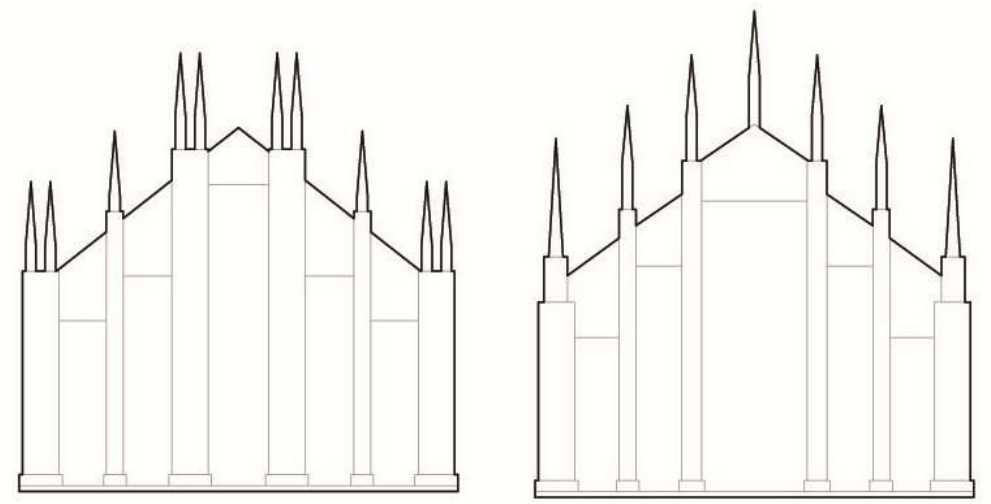
Giuseppe Brentano's father was an architect. In 1883, he enrolled in "*l'istituto tecnico superiore di Milano*" (*Politecnico di Milano* today), where he studied under Camillo Boito and his assistant, Luca Beltrami (who also participated in the competition of façade in 1886). He moved to Venice in 1884 and completed the diploma in architecture in Milan in 1887. Among these years, he won several prizes of competition and designed the Anglican Church in Como, choosing a gothic style. He had two proposals in the first round of the Duomo competition. One proposal has two towers and the other not. To improve his design for the second round, he travelled extensively through Europe, visiting similar gothic buildings. In his travels, he encountered Friedrich von Schmidt in Vienna and the son of Viollet-le-Duc in Paris, reviewing designs and building plans. A wooden model of the project, built in collaboration with Giovanni Brambilla, can be seen in the Cathedral today. While he had already begun to order materials for construction, his suddenly death led to abandon the project. Only the bronze portals on the facade by Ludovico Pogliaghi were built.[82]

Comparing to the original design, Brentano's proposal change the weak point: the proportion of the central part. He modified the central part border and higher than before, meanwhile changed the gates and windows from Baroque to Gothic Style to match the upper part.



2.51 Proposal of Guiseppe Brentano in the 2nd round, the winner, 1888[83]

[82] Benati, G., Roda, A. M. 2001, p111-113
[83] Boito, C. 1889, tavola n.83. Scheme by the author



2.52 Left: Facade of Duomo di Milano today, Right: Final design of Giuseppe Brentano[84]

In the following years, most of the missing arches and spires were constructed. The statues on the southern wall were also finished, while in 1829-1858, new stained glass windows replaced the old ones, though with less aesthetically significant results. The last details of the cathedral were finished only in the 20th century: the last gate was inaugurated on January 6, 1965. This date is considered the very end of a process which had proceeded for generations.

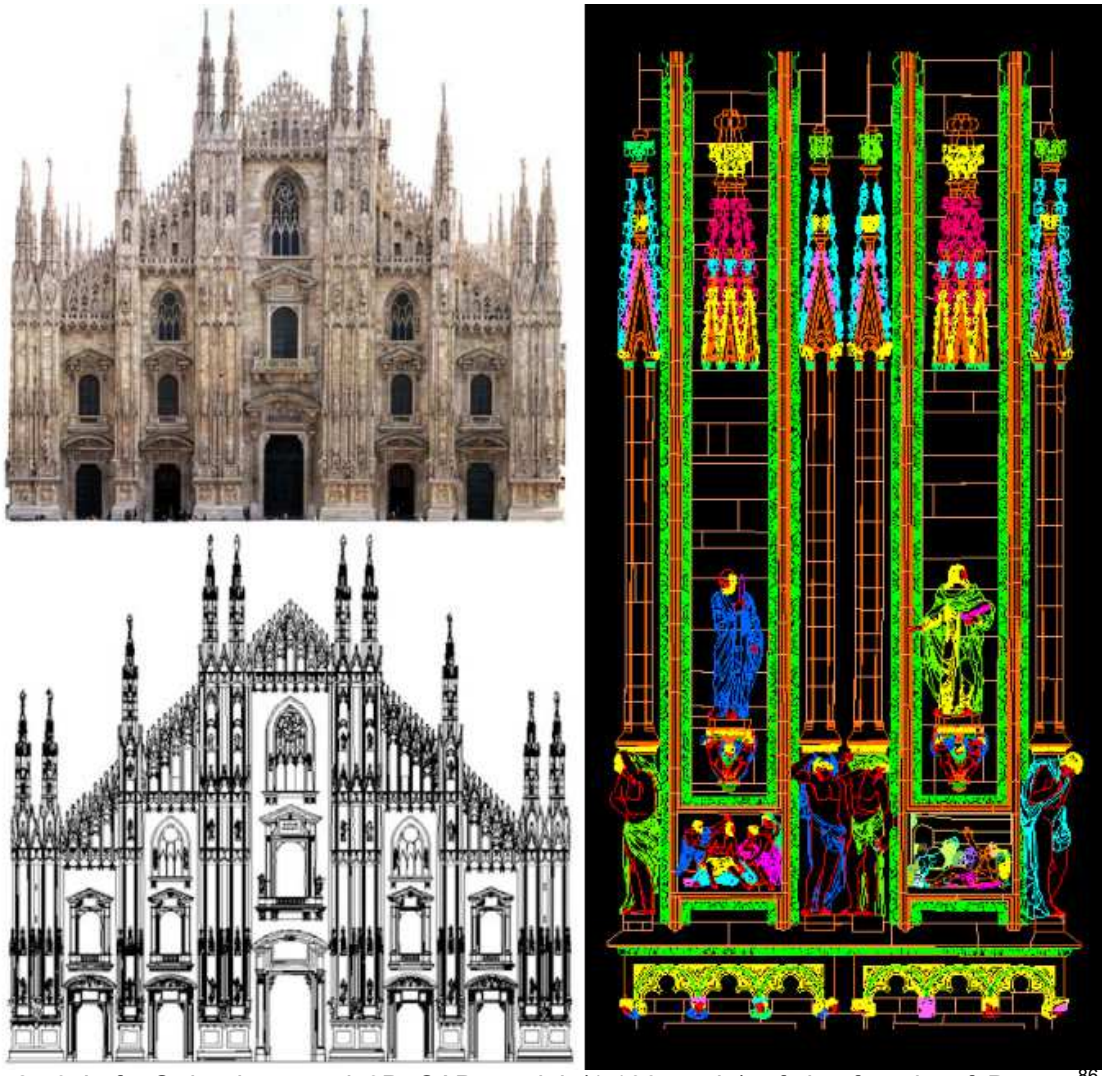
2.3.3 Recent Works on Duomo

a) Work by EniTecnologie

Now the main tasks of *Veneranda Fabbrica del Duomo di Milano* are conservative restoration and maintenance. In 2002, Giuseppe Giunta and his group from the Eni Corporate Technology Company surveyed the facade. "A preliminary laser scanning survey was done to provide a fast metric support to plan and quantify the restoration activities. An orthophoto merges the information of photos into the metric data (distances, areas, volumes). A Nikon Riegl LMS-Z210 laser scanner was used. Two acquiring stations were placed in front of Duomo, at a distance of 90 m from the façade. The point cloud has a nominal accuracy of ± 30 mm."[85]

[84] Scheme by the author

[85] Giunta, G., Di Paola, E., Mörlin Visconti Castiglione, B., Menci, L. Integrated 3D-Database for Diagnostics and Documentation of Milan's Cathedral Façade, CIPA 2005 XX International Symposium, 26 September – 01 October, 2005, Torino, Italy



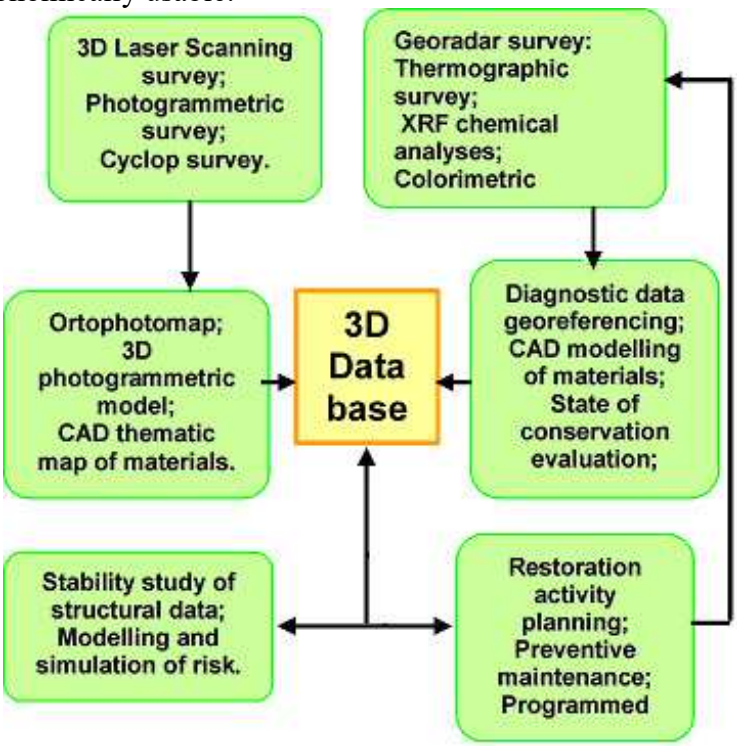
2.53 Left: Orthophoto and 3D CAD model (1:100 scale) of the façade of Duomo[86]
Right: Detail of the 3D CAD model (1:20 scale) of a counterfort[87]

A vectorial drawing of the façade on the scale of 1:100 was created to supply the restoration activities from the beginning. For some parts, a 3D CAD model on the scale of 1:20 which has a very high level of architectural detail and drawing quality were made. Besides the 3D model of the façade, models of the internal walls have also been created. It is possible to navigate through several photograms, to accurately measure the dimension of architectural details, to draw structures with a millimeter precision, through the stereoscopic vision model. On those vectorial models, it is possible to insert photos, documents, characterisation data and even to draw thematic maps.

All the data have been updated in the geo-referenced and integrated 3D database of the Cathedral, which now constitutes the necessary support for defining the specific operations. “The guiding principle of the 3D database was the intergration of the multidisciplinary data produced: the pre-restoration diagnostic results, the historic and artistic bibliography, the restoration documentation and the monitoring data, was created based on AutoCAD, a common software platform that could make the

[86] Giunta, G., Di Paola, E., Mörlin Visconti Castiglione, B., Menci, L. 2005
[87] Giunta, G., Di Paola, E., Mörlin Visconti Castiglione, B., Menci, L. 2005

database both readily and economically usable."[88]



2.54 Project scheme of the maintenance and restoration plan of Milan Cathedral[89]

"All these data (texts, images, and vectorial entities) are georeferenced in the 3D model. In particular, the material thematic maps included the following layers: missing parts, stuccoes, cramps, fractures, replaced blocks, metallic elements, decay, black crusts and pigeon dust. The structural diagnostic data produced the following layers: detached blocks, thin blocks, critical areas, stuccoes, detached stuccoes, fractures, detachments, cavities, masonry, and marble structure. In the future, it will be continuously updated with the post-restoration monitoring data and all the further maintenance activities."[90] The database could be updated both by EniTecnologie and the *Veneranda Fabbrica*.

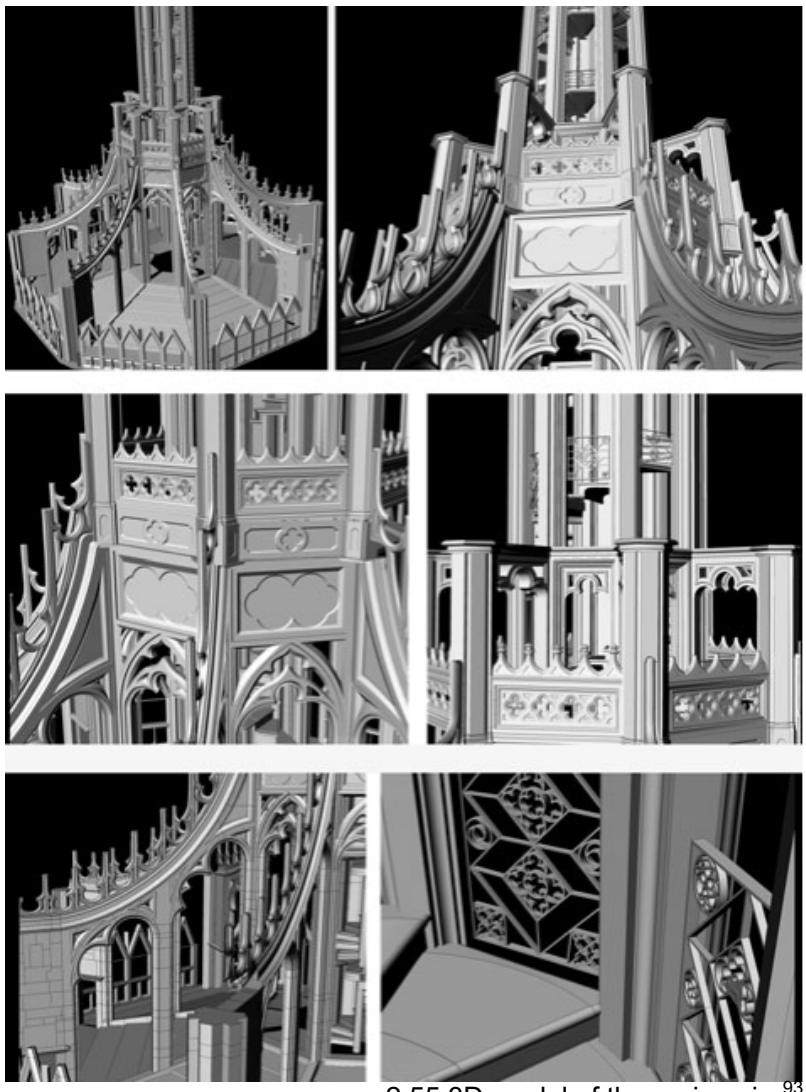
b) Work by The 3D SURVEY GROUP of Politcenico di Milano

The 3D SURVEY GROUP (3DSG) of *Politecnico di Milano* also takes part in the projects of survey on Duomo since 2008. The work commissioned by *Veneranda Fabbrica del Duomo di Milano* started with the purpose of updating the old drawings and producing new plans, sections and elevations of the Main Spire of Duomo. Since 2009, the research job involved different areas of the Milan Cathedral following or better anticipating different restoration yards,[91] such as two altars of the Duomo's transept (*Madonna dell'Albero* and *San Giovanni Bono*'s altar), indoor and external elevations and roofs.

For such a complex architecture as *Duomo di Milano*, it was impossible to preventively decide which methods and tools were more suitable and efficient for the

[88] Giunta, G., Di Paola, E., Mörlin Visconti Castiglione, B., Menci, L. 2005
[89] Giunta, G., Di Paola, E., Mörlin Visconti Castiglione, B., Menci, L. 2005
[90] Giunta, G., Di Paola, E., Mörlin Visconti Castiglione, B., Menci, L. 2005
[91] Fassi, F., Mandelli, A., Teruggi, S., Rechichi, F., Fiorillo, F., Achille, C. (2016) VR for Cultural Heritage. In: De Paolis L., Mongelli A. (eds) Augmented Reality, Virtual Reality, and Computer Graphics. AVR 2016. Lecture Notes in Computer Science, vol 9769. Springer, Cham

survey. Therefore, the survey phase involved different approaches and instrumentations and evolved over the time. A topographic survey using Leica TCRP 1203 Total Station was first to be done to georeference all data together. In 2009, the use of a laser scanner seemed to be the obvious choice to complete an exhaustive survey of Duomo. In 2010-2015, the photogrammetric method substituted the laser approach[92] in some areas. But when survey the indoor space of Duomo, laser scanning was chosen again.



2.55 3D model of the main spire[93]

The survey and modeling of the main spire of *Duomo di Milano* was a five-year research project since 2008. Several measurement surveys were conducted using innovative techniques such as laser scanning and close range photogrammetry, following step by step the evolution of 3D survey and modeling methodologies with particular attention to the "image based approaches". A Canon 5D Mark II camera with a fixed 35 mm lens was used for the photogrammetric survey.[94]

[92] Fassi F., Mandelli A., Teruggi S., Rechichi F., Fiorillo F., Achille C., 2016

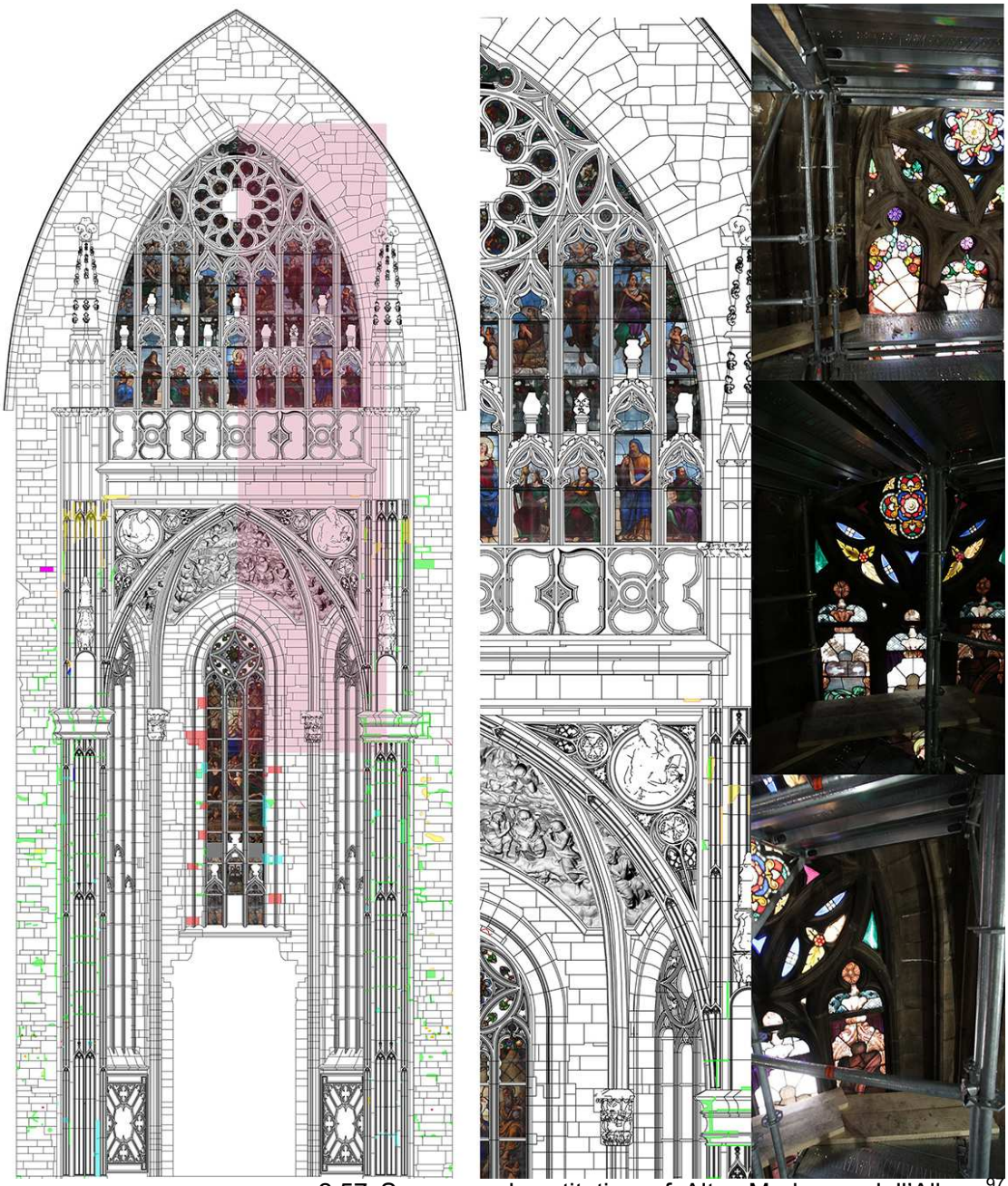
[93] Fassi, F., Achille, C., Fregonese, L. (2011), Surveying and modelling the Main Spire of Milan Cathedral using multiple data sources

[94] Fassi, F., Achille, C., Fregonese, L. 2011

2.56 Example of daily use of the system for maintenance activities of Duomo, works in situ and in office

The carefully survey of the main spire makes it possible to produce a complete model and to create a prototype of BIM useful to manage the huge 3D data together with images and information to be used during the restoration works. A complex database system was created specially for *Veneranda Fabbrica* and adapted to their operating mode. The system works as a Cloud System both inside the modeling software (Rhinoceros) and on the web platform. The database contains and links all the information in the BIM system available for each object: physical and structural data, 3D model for the Web, 3D model for the modeling software, photos, videos, archives material, site information, history and any other information which may be requested. Users could benefit from improved versatility of the system, as well as see in real time

the updates made by any user by means of any instrument.[95] By the method of using existing, widely available computer tools that are cheap or even free, this low-cost BIM prototype perfectly combines a faithful representation of the reality, with the data needed for the ordinary management of the restoration in situ. This is a pilot project to develop a way of moving toward creating a Cultural Heritage BIM system standard.[96]

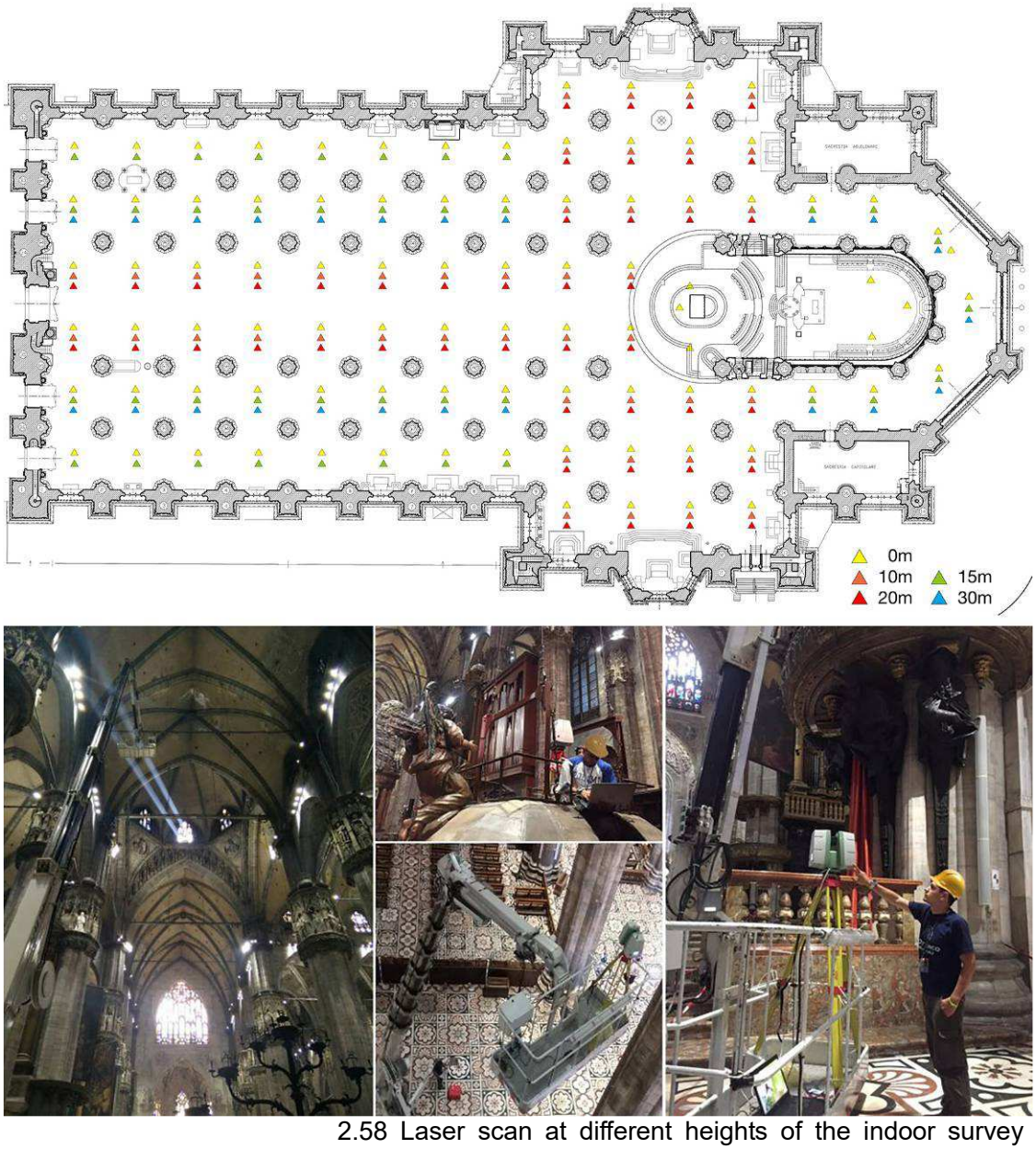


2.57 Survey and restitution of Altar Madonna dell'Albero[97]

The survey of the two Altars of the Duomo's transept focuses on the modeling and the metric survey of the stones that build the structure. Because the altars are about 40

[95] http://www.sitech-3dsurvey.polimi.it/?page_id=166
[96] Fassi, F., Parri S., 2012, Complex Architecture in 3D: From Survey to Web. International Journal of Heritage in Digital Era, vol. 1, p. 379-398, ISSN: 2047-4970 Potree, 2014, Online at: http://potree.org/wp/ (accessed: 25 January 2015)
[97] http://www.sitech-3dsurvey.polimi.it/?page_id=163

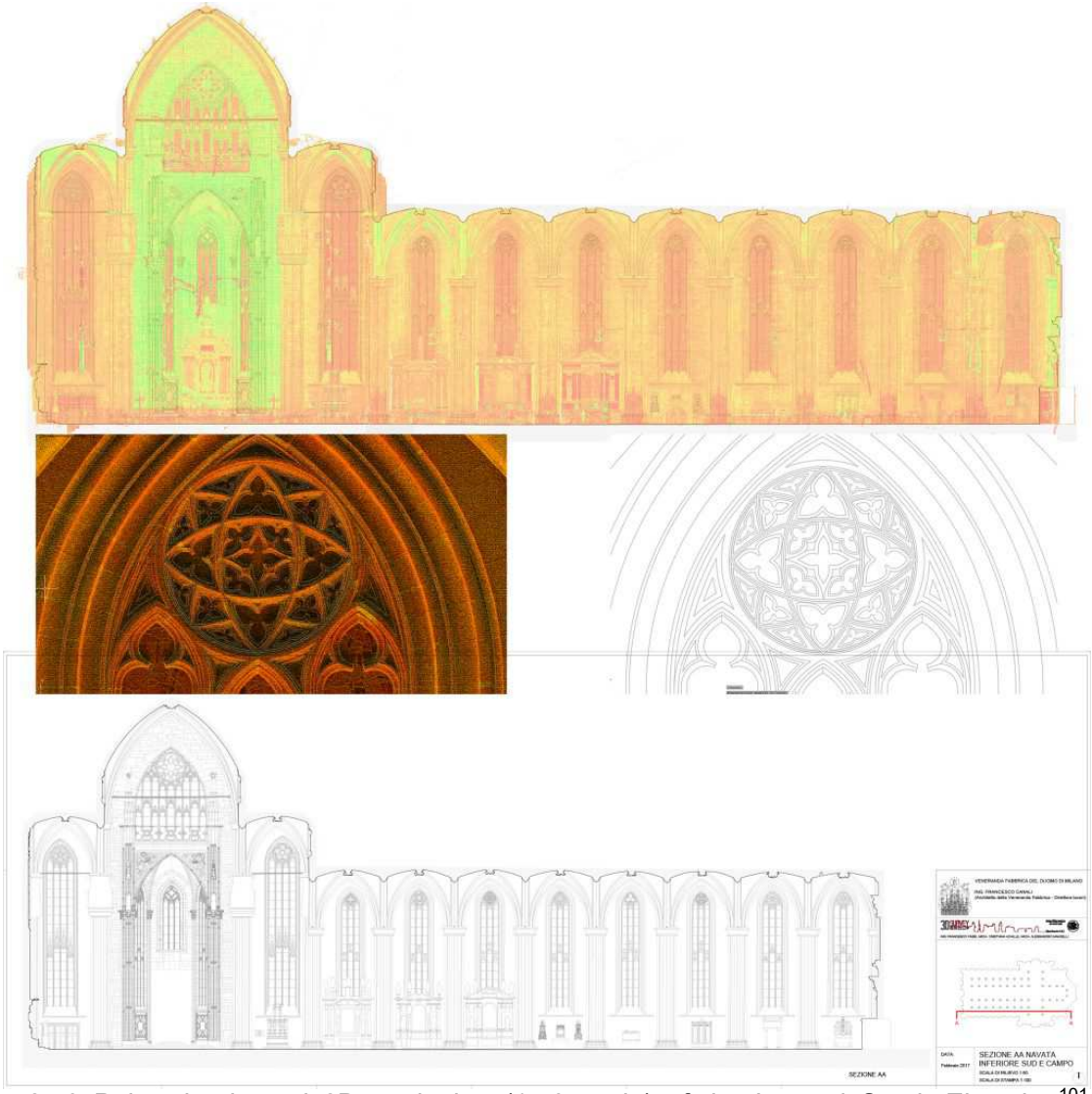
meters high, scaffoldings were built to measure the higher part. The survey integrated both Laser scanning (for the parts free of scaffolding's measurement) and Close Range Photogrammetry (for the parts blocked by scafoldings) in order to entirely cover the structure. Photogrammetry technique permitted to overcome problems linked to the penetration of the laser beam in the structure that prevents accurate and reliable measurement of structures. Moreover photogrammetry is more flexible, as it makes it better to negotiate with the presence of narrow spaces, and can be easily used on moving scaffoldings.[98] The survey was designed for and average nominal restitution of 1:20 scale. A three-dimensional model of all parts was created with Rhinoceros 3D.[99]



2.58 Laser scan at different heights of the indoor survey Up: Each triangle refers to one scan. It usually took 3 scans at each point with the height of 0m, 10m, 20m or 0m, 15m, 30m. Down: Using a crane to reach different scan heights[100]

[98] Fassi F., Mandelli A., Teruggi S., Rechichi F., Fiorillo F., Achille C., 2016
[99] http://www.sitech-3dsurvey.polimi.it/?page_id=163
[100] http://www.sitech-3dsurvey.polimi.it/?page_id=1819

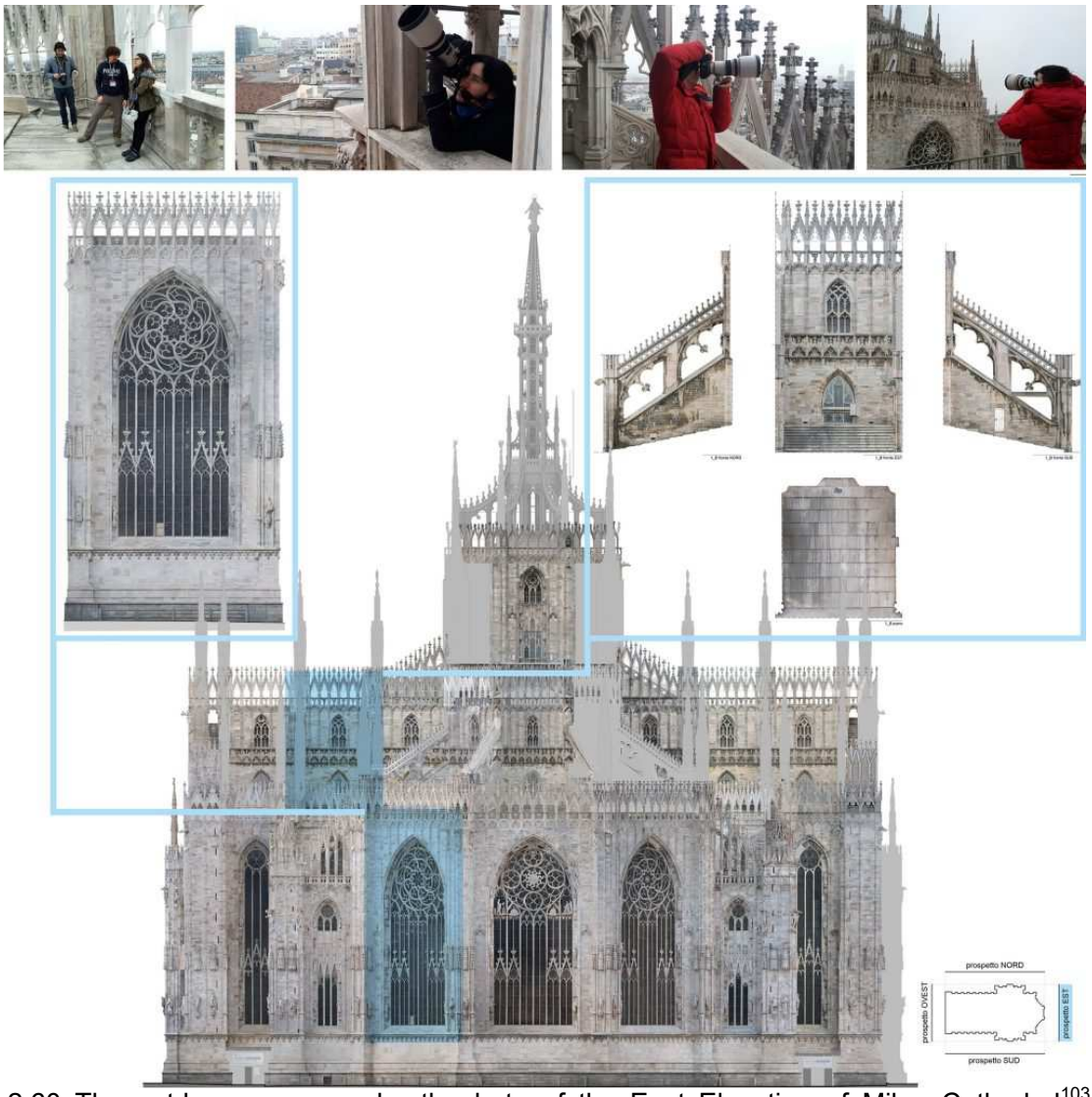
3DSG began to survey the underground space of Duomo from October 2015, using the laser scanner Leica ScanStation C10. Though the advantages of photogrammetry are listed above, it is not suitable for an extremely high and lack-of-lighting indoor space as Duomo. Since September 2016, the work has gone up to the ground level, the main indoor space, The scanning is in progress and it is designed at different heights (Fig.2.58), basing on the vaults' heights, to obtain a complete point cloud of the Church. For example, when scanned the side aisles and chevette about 30m high, three scans at ground level (0m), 10m and 20m were taken. For the 45m high nave and transept, three scans at 0m, 15m and 30m were taken. Each scan has a 5 mm at 10m resolution. With this resolution, it takes about 38 minutes to finish one scan (30 minutes for the laser scan and 8 minutes for the ScanStation to take pictures). 6-8 scans could be taken in one day. Because the dome is about 60m high and could only be scanned at ground level, a resolution with 1mm at 10m resolution was used. This higher resolution took about 4-5 hours for one scan. The restitution of 2D and 3D elaborations at 1:50 scale is still in progress.



2.59 Point clouds and 2D restitution (1:50 scale) of the Internal South Elevation[101]

[101] http://www.sitech-3dsurvey.polimi.it/?page_id=1819

The survey of the external elevations and roofs in 2017 aimed to acquire a precise 3D dense point cloud and model to be used both for the projection of the orthophotos and for the 2D and 3D final restitution. Photogrammetry technique was mainly used in the survey to obtain a high definition texture needed for the orthomosaic and also for mapping precisely some additional information like decay detection and restoration surgery information. Several camera systems and lenses were employed to obtain a complete survey of each architectonical element, maintaining the resolution approximately the same, therefore the GSD (Ground Sampling Distance) was kept suitable for the 1:50 representation scale. The different 3D reconstruction projects were then put together in a common local co-ordinates system using topography and GCPs (Ground Control Points).[102] The orthophotos made for external elevations are clear to recognize different marble blocks, which is helpful for recoding the decays of each block.



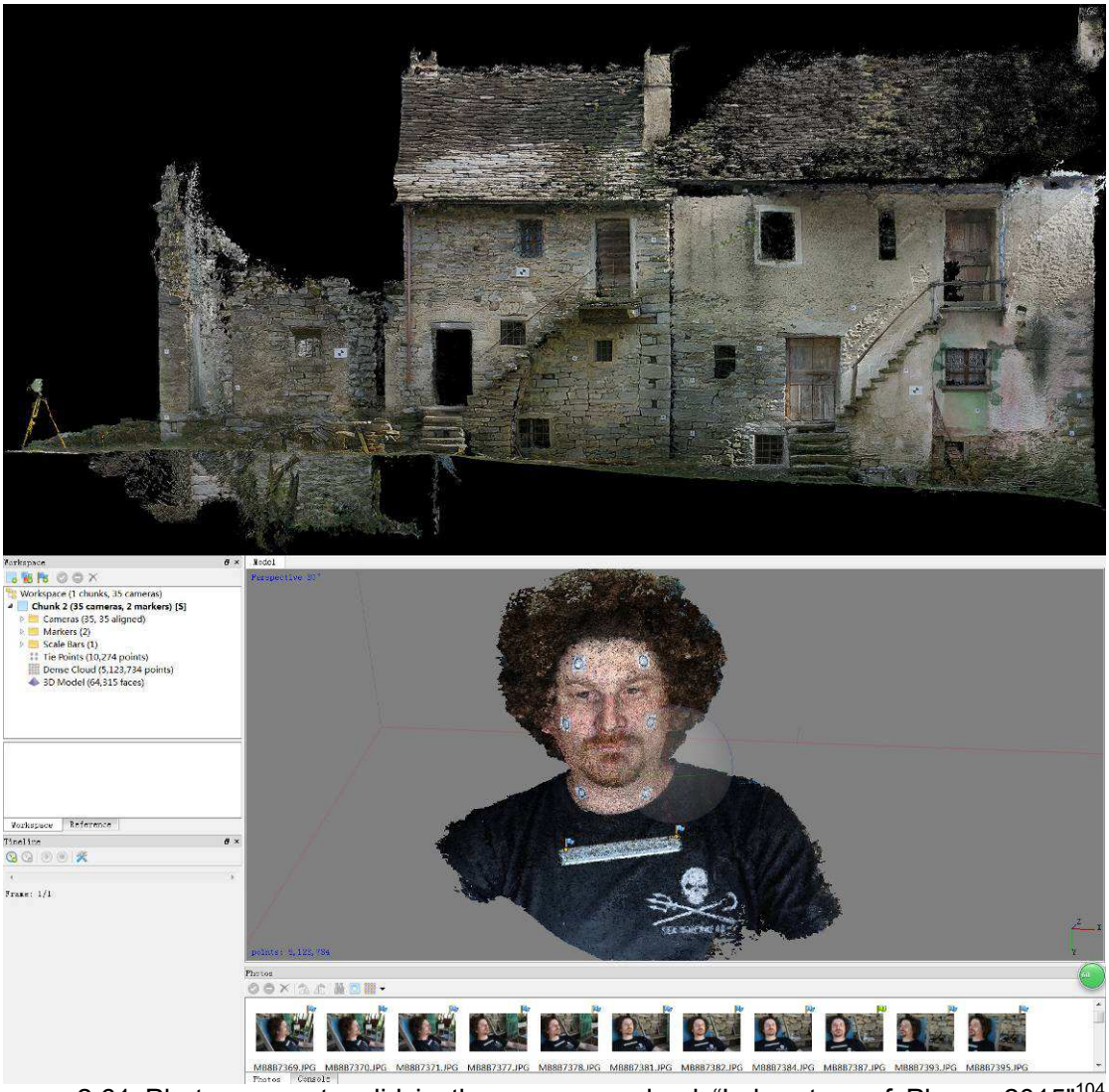
2.60 The outdoor survey and orthophoto of the East Elevation of Milan Cathedral[103]

c) Work by the author

Over the past years I have always been interested in architecture surveys, and before

[102] http://www.sitech-3dsurvey.polimi.it/?page_id=2109
[103] http://www.sitech-3dsurvey.polimi.it/?page_id=2109

coming to Italy to pursue a Master's degree I used to survey vernacular architectures in both rural and urban areas in many provinces of China. I have a particular interest in how to survey and drawing in a country that has different architectural tradition from China. As an extension of the Architectural Preservation Studio we did in course, I attended the summer school program "Laboratory of Places 2015, Ghesc and surroundings - History, survey, evolution" organized by 3DSG. In the summer school, we experienced many approaches of high-tech survey using different digital devices and software: total station for topography, scan station and Leica Cyclone for laser scan, digital camera, drone, Agisoft PhotoScan for photogrammetry, and also Geomagic Wrap for producing the 3D model from scans.



2.61 Photogrammetry did in the summer school "Laboratory of Places 2015"[104]

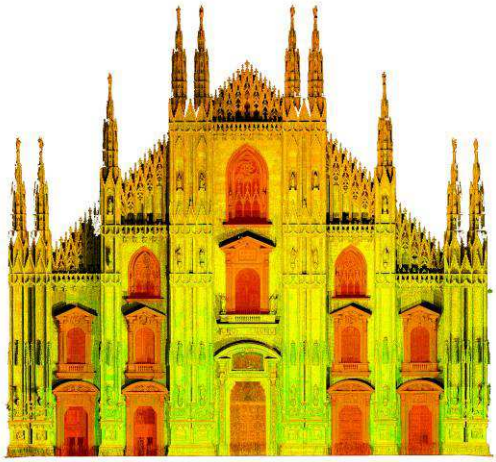
I am glad to hear that 3DSG is taking part in the survey project of *Duomo di Milano*, which is one of my study cases of the thesis. Although I couldn't join the survey in situ at Duomo, it is a great honor for me to participate in the drawing part of the project, and I am delighted to include related works of the project in this thesis. I made two 2D restitutions of indoor elevations: the internal façade (*la controfacciata* in Italian) and the Chapel of *Madonna dell'Albero*.

[104] Work by the author

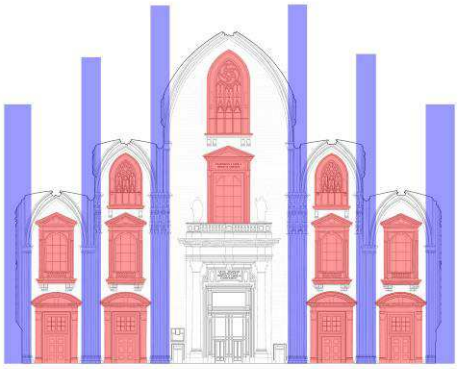
Since the survey of the façade by EniTecnologie was not far from now, 3DSG surveyed all the external elevations with photogrammetry except the main façade in 2017. After that, a laser scan of the façade was made with a high resolution of 1mm at 10m. The restitution of the façade has not been put on the schedule yet. We could get a clear image of the façade with the point cloud obtained by the laser scan (Fig.2.62). Among all the indoor elevations, the internal façade is the most related one to the main façade.

2.62 Point cloud of the façade scanned by 3DSG

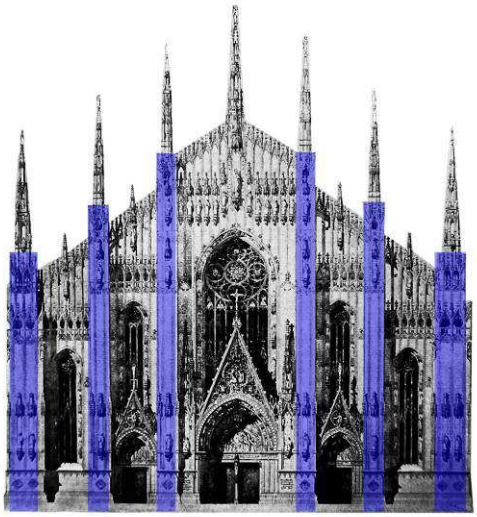
Controfacciata is the back side of the façade. Its composition follows the rule of the facade. As we could see in Fig2.63, except the central portal, all the doors and windows on the internal façade are similar as the corresponding ones on the other side. Because the two pillars in the center of the façade are twice wider than the counter side, the central portal and the balcony above it are quite narrow. Giuseppe Brentano's proposal of the façade, which won the final prize of the competition, follows the same proportion of the internal façade. All the pillars on the facade have similar size as the corresponding ones behind them, which mean this unimplemented façade follows the composition of the real structure inside. Most of the proposals of Type I and II in the contest followed the same proportion, which is more reasonable than the present façade.



Point Cloud of the Facade



Drawing of the Internal Facade



Giuseppe Brentano's Proposal for the facade, Contest Winner

2.63 Compare the façade today, the internal façade and Brentano's project[105]

In the early years of 17th century, when finally started to erect the new façade, the problem of the internal façade emerged. All the more important because of some decays, while awaiting the construction of the last bays, it was discovered that the part placed as a provisional buffer at the end of the 15th century was detached from the church's main body, those came out of the portals of the old façade of Santa Maria Maggiore almost liked a scenic backdrop. As the masonry was raised, not only to think of a solution to the exterior, with the definition of the doors, windows, and the

[105] Scheme by the author

famous columns that would have to sculpt the facade, but also the decoration of the internal façade. As the external, the internal façade also has five doors with windows in the upper part, but the internal decorations are moderate with the classical architectural solutions. The small internal doors were built between 1627 and 1642 according to the design of Pellegrino Tibaldi, while the central portal designed by Fabio Mangone in the early 17th century, was "almost finished" in 1640s.

Conceived to become the central element of the composition, the central portal was flanked by two large Corinthian columns made of granite from Baveno, with a height of 18 braccia and 1 oncia (about 10.76 meters). Above it there is a balcony with a big window ended by a triangular gable opened in the center. The two elements, portal and window, would thus be joined into a single architectural unit that would link the two different levels of the composition.

Although, after a slow start, the central portal's realization was contracted in 1635 to Giovan Giacomo Bono and Andrea Castelli, who in 1637 were paid for the columns of Miarolo (The granite from Milan), in 1640 the work was not yet completed. That year remains, in fact, from a report by Carlo Buzzi, the architect of the Fabbrica, describing the state of the work and the difficulties that arise for their conclusion. Though well-known - it has been working for fifteen years - they were still raising the two columns "which have to bring the top ornament of the architrave, frieze and frame with the railing above." They had made the capital of the columns that were to be made of "Piombino stone ... which is very fragile and vitriol", so that Buzzi proposes to use bronze, as it was the main door. Only seven years later, under his direction, the work of the main door would be completed, at a cost that was then determined in 170,000 lire imperial.

Completion of the internal facade did not occur in the 19th century until the great neoclassical central window was finished, in 1827 it was decided to put the window and close it up with a colossal head of the lion and with a dedicatory script that would be placed in the frame of the central balcony. On this occasion it is approved "the proposed way of in vivo coating of the internal facade wall". In the same year, the statues, also colossal, of the Saint Ambrogio and Saint Carlo were commissioned, respectively to the sculptors Pompeo Marchesi and Gaetano Monti of Ravenna. In 1832, two simple marble pedestals were placed in the internal facade, at the sides of the major portal, and a few months later it was decided to "decorate the roman window in the temple."[106]

There are two inscriptions in the internal façade. In the frame above the central portal and under the balcony, it graved

ARAM MAXIMAM
MARTINVS PP V
TEMPLVM D CAROLVS
CONSECRARVNT

In the frame under the triangular gable of the upper level window, it engraved

FRANCISCVS • I • CAES • A •
ORNAVIT • ADAVXIT •

[106] G. Benati, A. M. Roda, 2001, p190-191.

Chapel *Madonna dell'Albero*, the northern transept of Duomo, used to be one commonly used entrance of the church. Though various proposals were designed both for the façade and the inner space of the end of the transept, this *"verso Compedo"* gate had never been completed. It was ordered to be demolished in 1571 due to excessive use by non-believers.

In the original design of Duomo, in addition to the five doors on the façade, there were two entrances at the end of each transept. They were not built immediately since the beginning of the construction. Though long debate and numerous drawings had been produced, until early 16th century, there was no precise architectural solution for these doors. In 1392, different engineers were called by the Fabbrica to analyze a solution for the "versus Compedum" door, defined it as "pulchra et bona ac honorabilis" (beautiful, good and honorable).

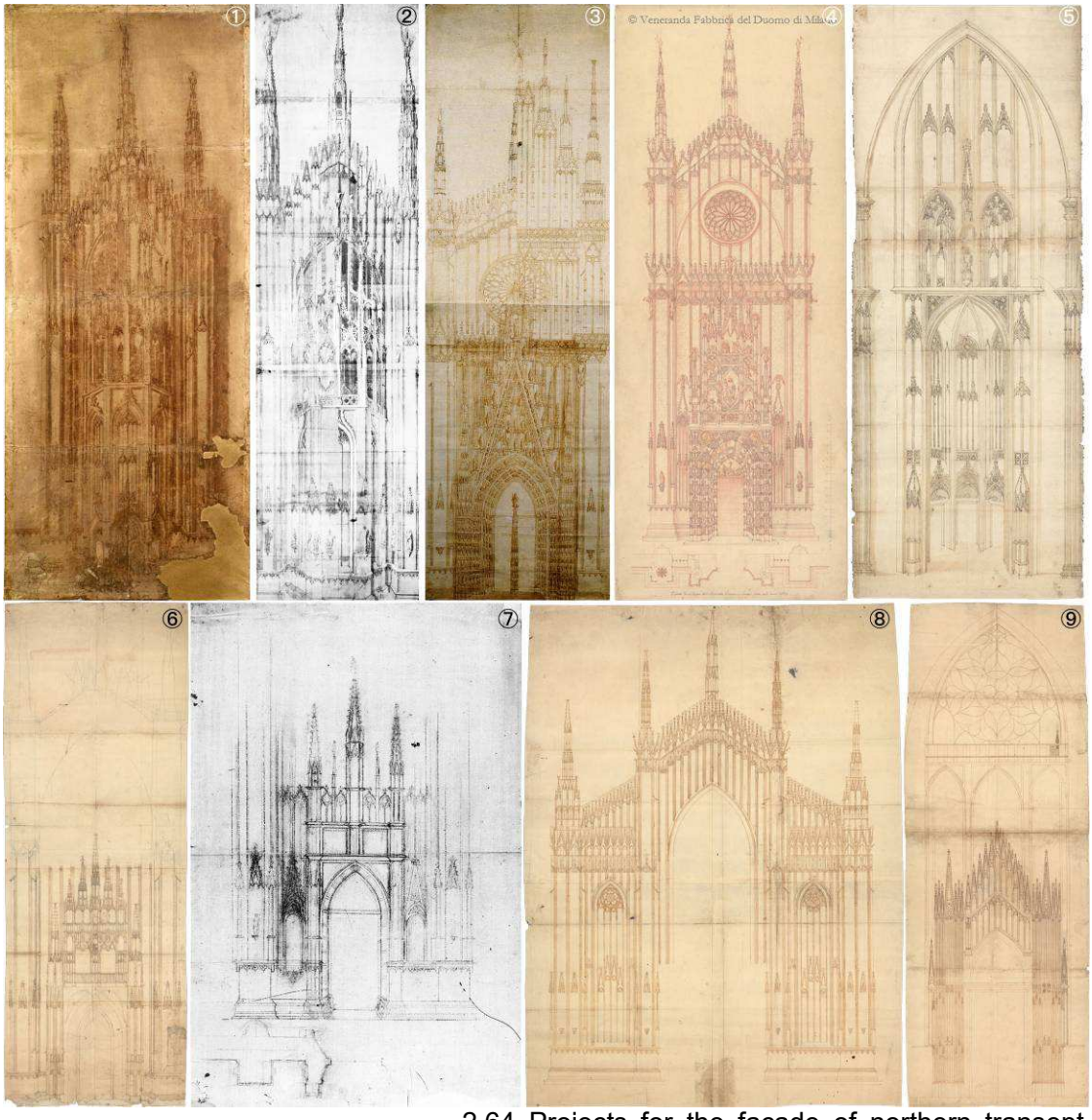
On February 23, 1503, when the council of the Fabbrica met to discuss the construction of the portals, a box with ancient drawings and models was opened in the hope of finding a definitive solution. Amadeo, al Dolcebuono, Bramantino, Cristoforo Solari and Andrea Fusina were presented. One project considered "valde mirum" (very strange) was chosen, which proposed a pyramidal element in the center, so as to form a vestibule entrance. This project might connect with a design still kept in the Fabbrica today, which with a strong gothic imprint and with a pinnacle in the center. Two groups of architects, Amadeo and il Dolcebuono, Cristoforo Solari and Bartolomeo da Briosco, were commissioned to develop a model inspired by the design. Meanwhile, to look for a design indication consistent with the original idea, it is dig before the door to see if the foundations had been already made. But after a year, nothing was decided. New ideas in the Gothic language, especially in the use of decorative elements, were given from some German architects consulted by the Fabbrica.

The problem hadn't been dealt with until 1535, when the Fabbrica wanted to start the construction of the northern gate, often called "adversus scalinos" or "verso Compedo". All the designs and models left by Gerolamo were exhibited in the hall of the Fabbrica and were reviewed. New designs were presented by various artists, including Cesariano, Antonio da Lonate, Agostino de Busti and Cristoforo Lombardo, the engineer of the Fabbrica at that time. On July 10, the design task was entrusted to Cristoforo Lombardo for the architectural part and to Agostino de Busti for the statues. Two years later, on March 24, 1537, it was still debated whether the door "of the steps" should be one, two or three openings. In 1540, a new model was presented by Cristofolo Lombardo and Baldassarre Vianello from Padova, who shared the office of the Fabbrica with Lombardo for a year. The dimensions of the door were defined then. A year later, Giulio Romano in Mantua was asked for opinions. The discussion was continued for several years. In 1547, Lombardino, who was still urged to complete the model for the northern side, was joined by Seregni.

In the meantime, since March 1538, the foundation of the northern gate "verso Compedo" had been laid and the sculptors had arranged bas-reliefs and ornaments. The work proceeded slowly that till 1562 Seregni was still asked to set up a pillar. With the arrival of Carlo Borromeo in Milan as the archbishop, on December 3, 1565, the construction of the northern portal is resumed according to a model created by the sculptor Francesco Brambilla. Also the Pellegrini, who became the architect of the

Fabbrica in 1567, prepared a model for this door.

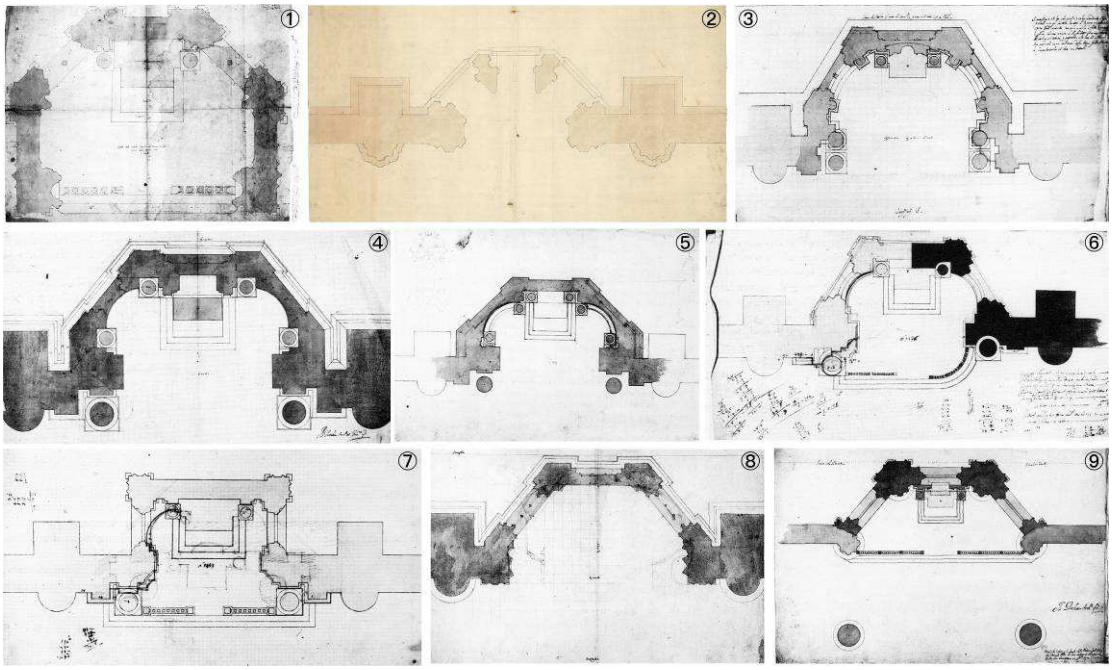
In these years it is noted that the two entrances were used not only by the believers, but also by those (mainly merchants) who had to go from the Verziere to Corsia dei Servi, sometimes even with carts and animals, since the space behind the apse was restricted by Cassina and from the buildings of the Fabbrica. In this way a sort of path was created inside the church between the two parts of the square which was bothersome and decidedly disrespectful for the functions of the cathedral. Therefore, on February 15, 1571, probably on the instructions of the archbishop, the deputies of the Fabbrica ordered the closure of the two doors and that "portarum vacuum lapidibus esse replendum" (door's stones to fill the vacuum). But, if the construction of these entrances was slow, their closure was certainly not fast.[107] *The two transepts we see today, the chapel with the altar of the Madonna dell'Albero in the northern side and the one with the altar of S. Giovanni Bono in the south, were finally finished at the beginning of the seventeenth century.*[108]



2.64 Projects for the façade of northern transept

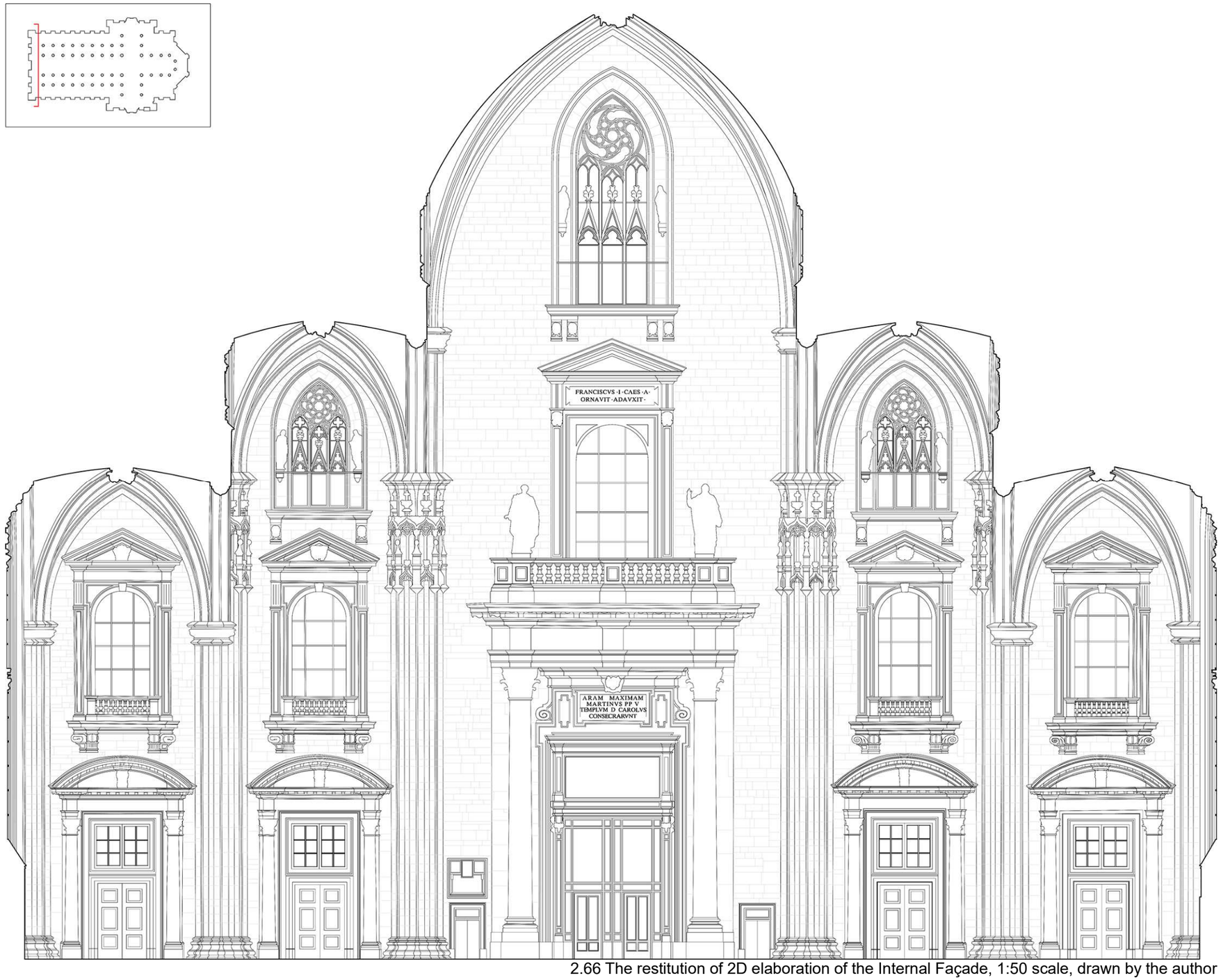
[107] Benati, G., Roda, A. M. 2001, p453-456
[108] Benati, G., Roda, A. M. 2001, p9-10

①Cristoforo Lombardo (?), 1519-1537, AVFDMi
②Anonymous, 1612-1614 (?), Biblioteca Ambrosiana (BAMi)
③Anonymous, 1503-1537, BAMi
④Luca Beltrami (?), Copy of an anonymous project (1534-), 1900-1925, AVFDMi
⑤Giovanni Paolo Bisnati, Internal façade of the transept, 1614-1625, ASCMi
⑥Vincenzo Seregni (?), 1535-1540, ASCMi
⑦Cristoforo Lombardo (?), ?, ASCMi
⑧Vincenzo Seregni, 1534-1567, ASCMi
⑨Vincenzo Seregni (?), 1534/35-1567, ASCMi



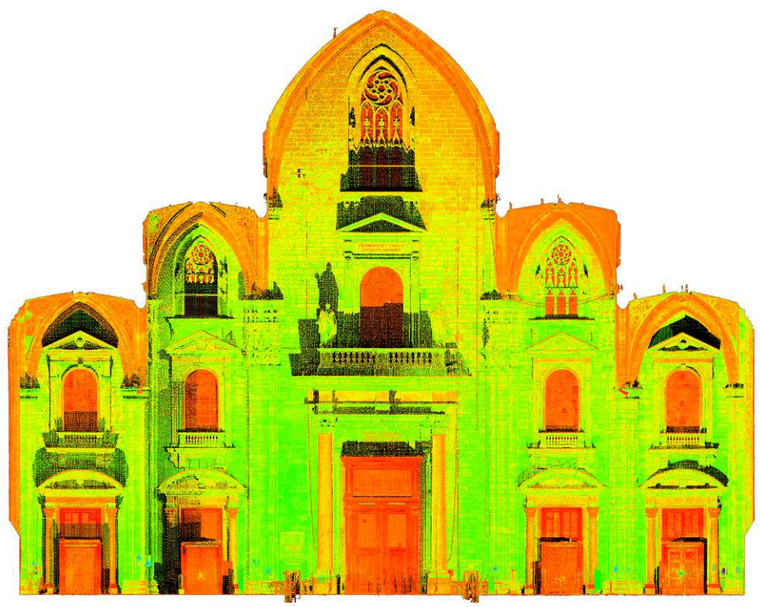
2.65 Projects for the plan of northern transept
①Pellegrino Tibaldi (?), 1576-1600, ASCMi
②Anonymous, 1600-1625 (?), ASCMi
③④⑤⑥⑦⑧⑨Francesco Maria Ricchino, 1612-1614, ASCMi

The point clouds used to draw the two restitutions are obtained from the 3D laser scan using Leica ScanStation C10 with 5mm at 10m resolution. According to the scan plan (Fig.2.58), 16 scans formed the data of internal façade and 24 scans formed the chapel's data. There are about 50 million points in one scan. Leica Cyclone was used to process the data and created the point cloud. Leica CloudWorx Plug-in and JesStream are used to access and render the point clouds in AutoCAD. The point cloud file (JSA) of the internal façade is about 46.5GB and the file of Madonna dell'Albero is about 40.4GB. Processing huge data like this acquires professional workstation and also licenses for the software, so the drawing could only be done in 3DSG's laboratory. It took me about 5 weeks for each drawing of the restitution.

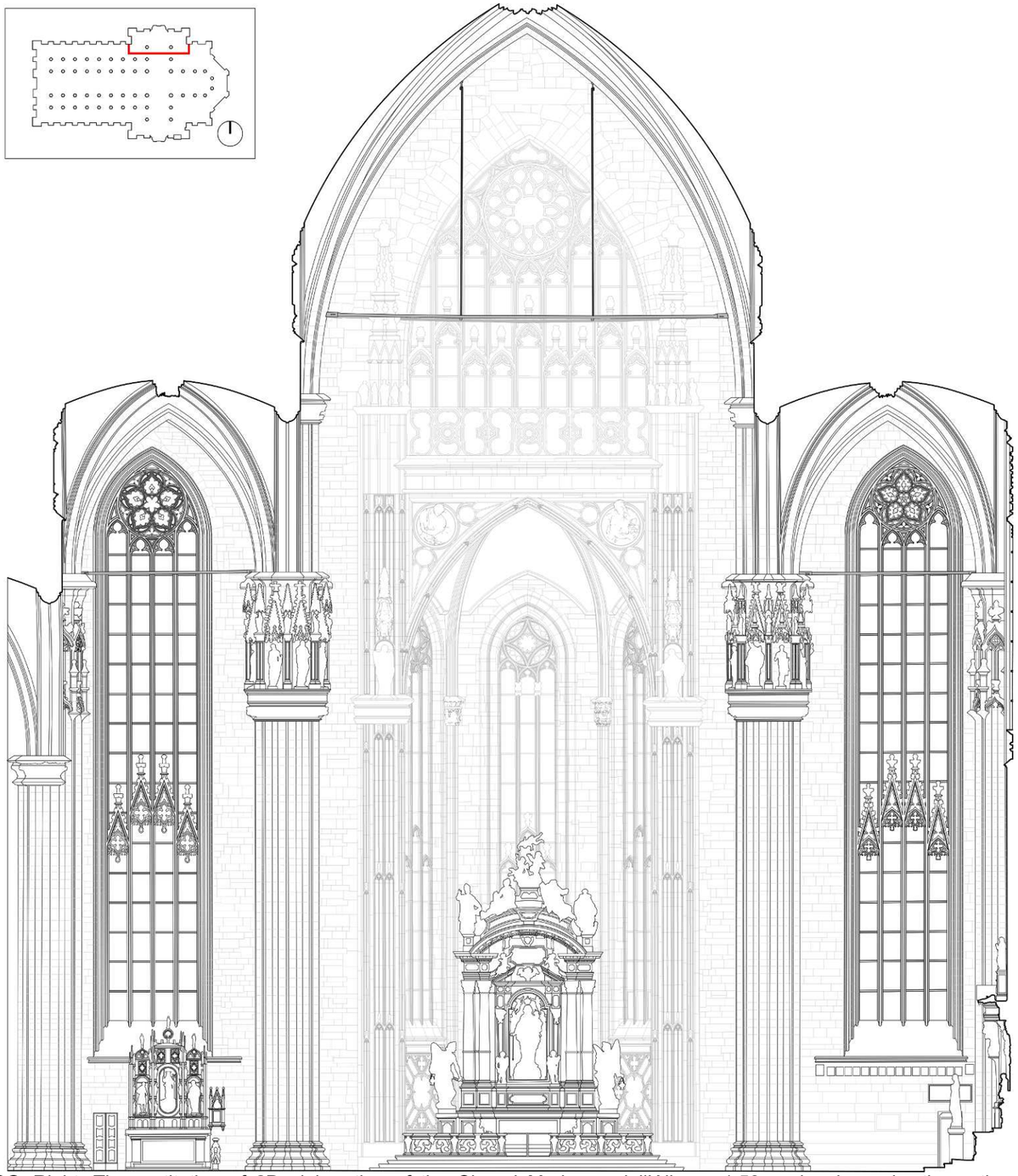


2.66 The restitution of 2D elaboration of the Internal Façade, 1:50 scale, drawn by the author

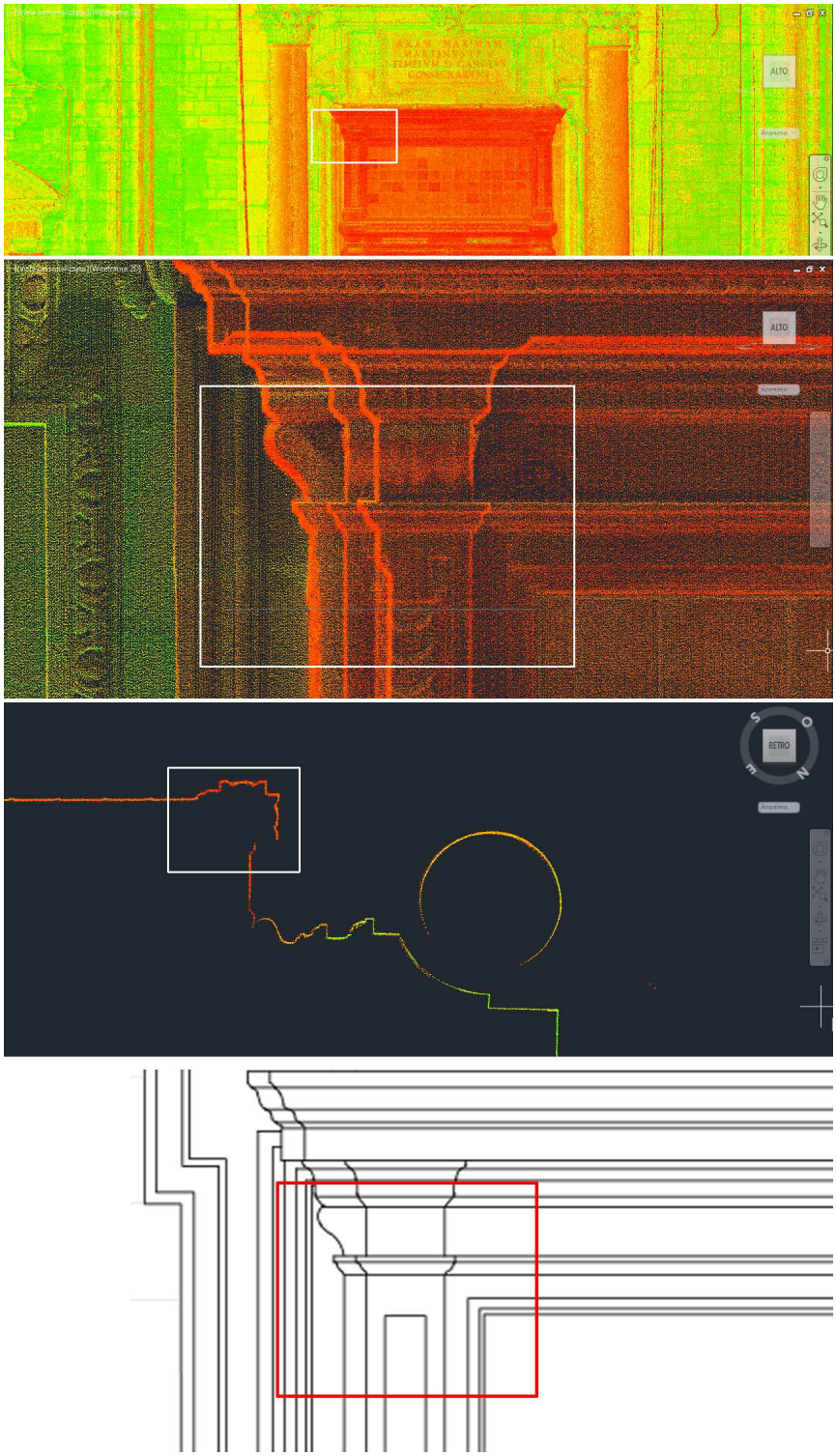
Point Cloud of the Chapel Madonna dell'Albero



Point Cloud of the Internal Facade



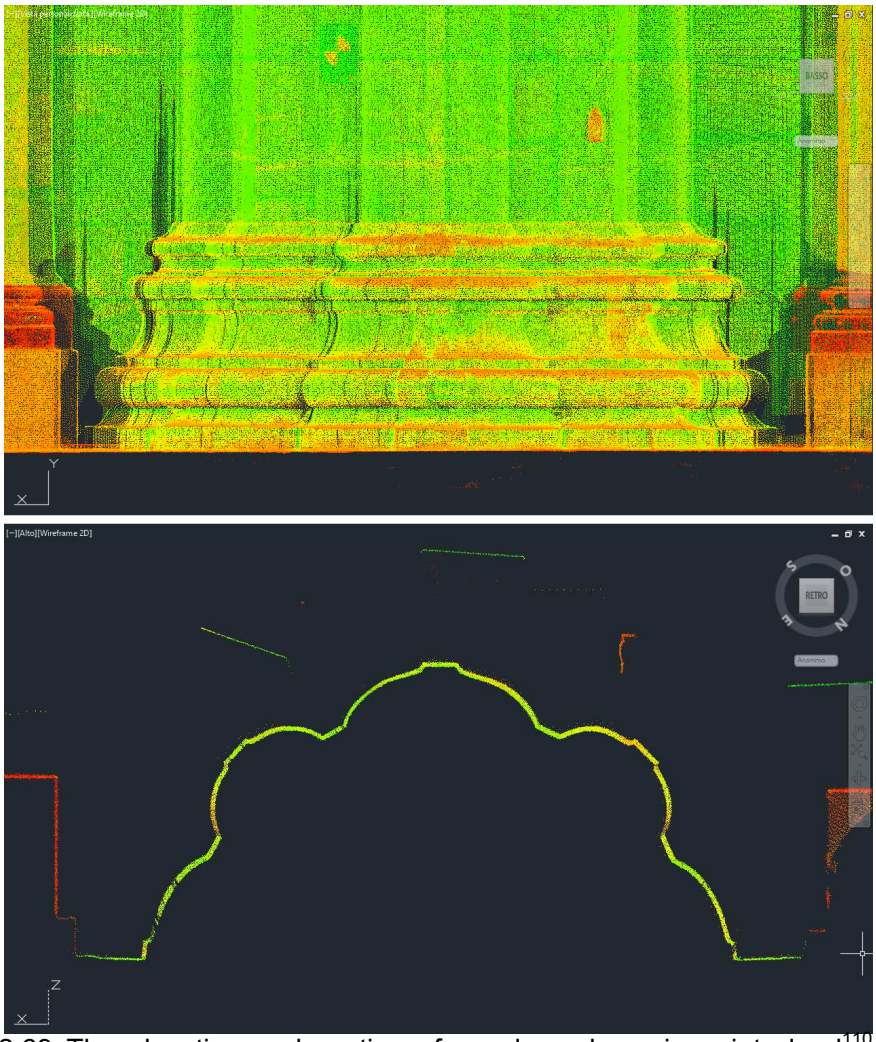
2.67 Left: Point cloud scanned by 3DSG, Right: The restitution of 2D elaboration of the Chapel Madonna dell'Albero, 1:50 scale, drawn by the author



2.68 The elevation and part of the section of the central portal Shapes hidden behind could be seen in point cloud[109]

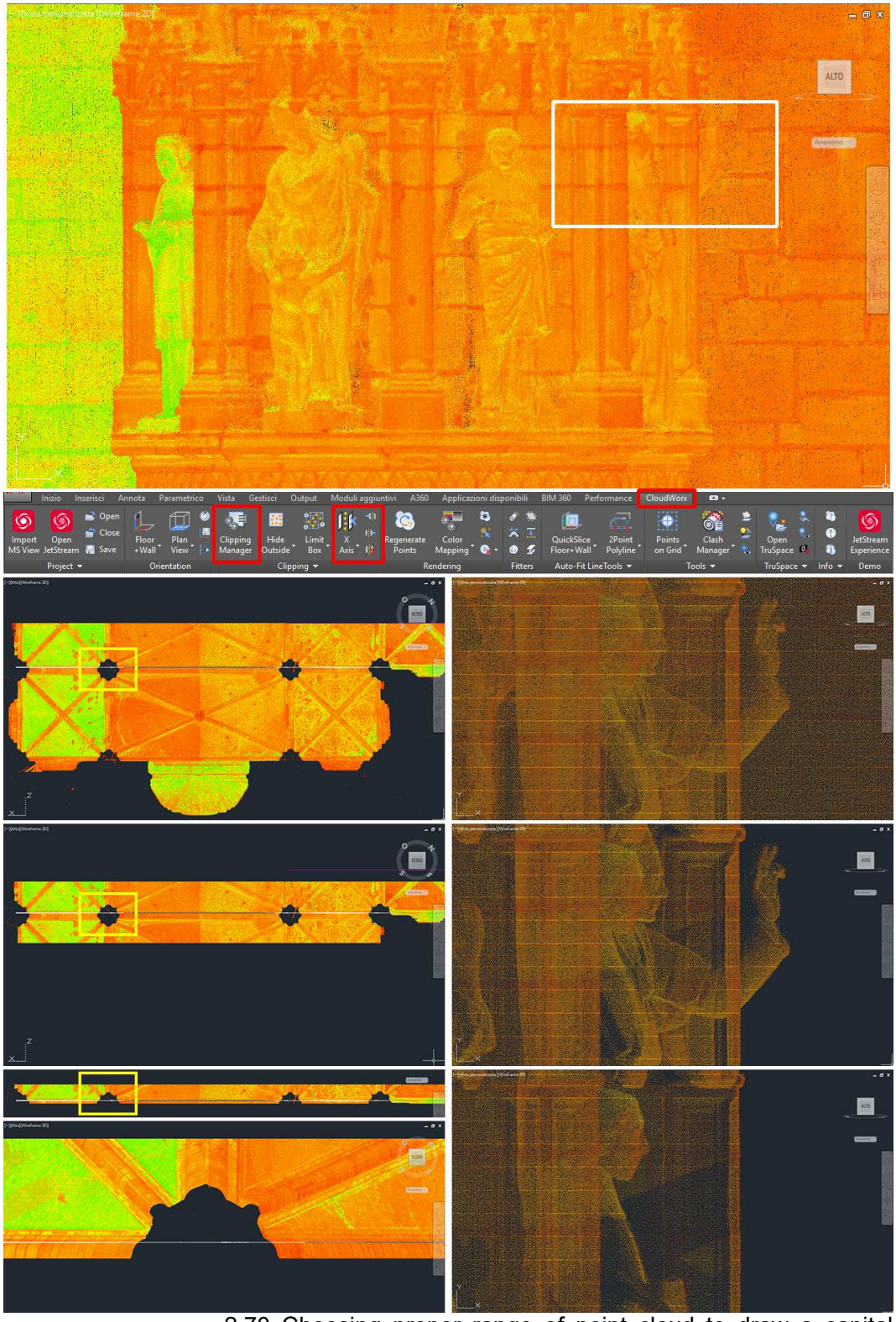
[109] Screenshots from the point cloud scanned by 3DSG, schemed by the author

The difficulties of drawing the 2D restitutions mainly come from the difference between the point cloud and the real world. The points 3D Laser scanner has measured are intended to represent the external surface of an object. Not like objects have solid bodies in the real world, there are spaces among each point and we could look through them to see the shape behind (Fig.2.68). The more points measured in one area, the more solid the object looked on the screen. Further more, laser scan's points don't show the real color of the survey object. The Point Cloud Color Stylization 3DSG chose is Intensity (as shown in Fig.2.67), which stylizes each point based on the laser pulse return intensity value. Intensity is a measure of point reflectivity, which can vary depending upon color, surface texture, surface angle, and the environment. Sometimes it is not easy to recognize the real shape of the objects based on the point cloud mainly used glitter red, yellow and green color on screen (these are definitely not friendly with eyes). Shadows are always a distracter, especially when dealing with some curved lines or surfaces, such as the molding of ribs on the vault or the shaft and base of a column. In this case, a horizontal cut should be made to see the real shape from the top view as shown in Fig2.68 and Fig2.69. When drawing objects with complex shapes, such as the capital of a column, it is hard to distinguish which statue is in front. In this case, choosing a proper range of the point cloud to display would help (Fig.2.70).



2.69 The elevation and section of a column base in point cloud[110]

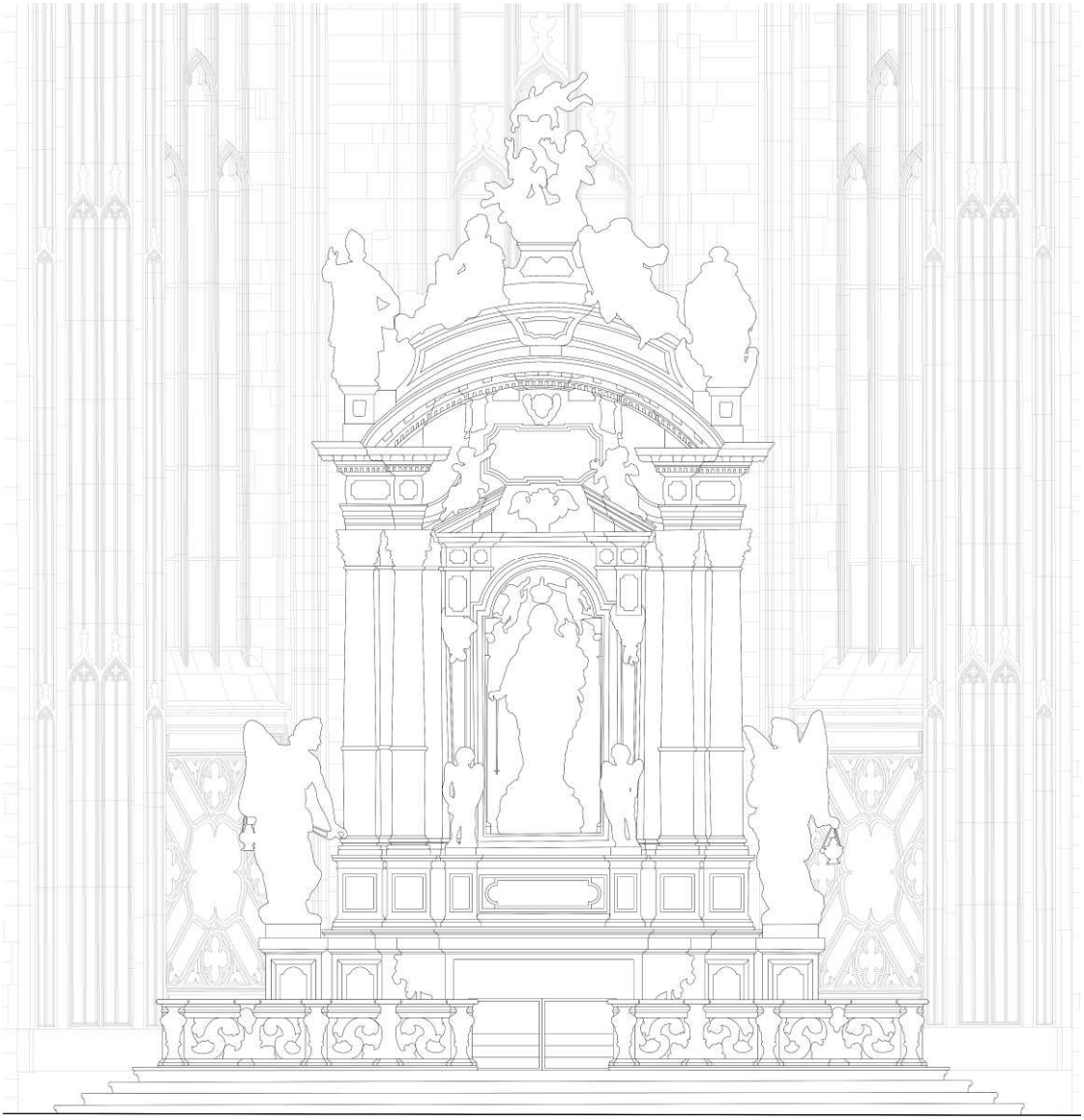
[110] Screenshots from the point clouds scan by the 3DSG



2.70 Choosing proper range of point cloud to draw a capital

Drawing the restitution requires great patience and the sense of aesthetics, especially when dealing with the statues (Fig.2.71). In order to get an accurate, clear and small DWG file, it's better to use polylines but not spline curves to feet the complicated shapes. Polylines are much easier to control and to modify. When drawing the chapel, the central part was based on a DWG file which was automatically produced from the 3D model in Rhinoceros 3D. Though some statues and flower decorations of the

windows are missing, that file is still 104 MB big, while the DWG file I drew for the internal façade is only 860KB. Small file size is much better and quicker for the software to run on PC. This difference is because the number of lines in each file. For example, there is only one object when we draw a circle, but in an automatically transformed DWG file, it may have thousands of small lines to form a circle. When dealing with complicated shapes, the AI we use now could not recognize and draw the clear outline we need to represent the real shape. At least now, human is much better than AI when drawing sophisticated shapes, this related to the algorithms the software uses now. But I think this will be improved in the future.



2.71 The Altar of Madonna dell'Albero, drawn by the author

Summary

There are many churches with incomplete façade in Italy. Each of them has a story more or less the same: an ambitious project at the very beginning, proposals submitted by numbers of architects, construction slowed down due to plague or lack of money, attempts to change the original outdated design when restarted the abandoned program, being abandoned again or finally being completed by a strong desire (with political reasons).

This is a story about time and generations. During the long period of construction, we could see how an ideal church should be like through numbers of unrealized proposals in different eras. Besides continuing the work of ancestors, every leader of their own generation wanted to leave a trace in the great monument symbol of the city. As the face of a church, the unfinished façade had chances to be designed again and again in a newer taste of architecture. We could also read the struggles in people's mind through those unfinished projects – pride, aesthetic, tradition, trending, economy and political matters.

Since the late half of last century, it has decided to freeze the status quo of historic buildings to the later generations. Although limited activities as conservative restoration and maintenance could be carried out to the incomplete buildings of our time, we have some brand-new solutions to do more. The development of computer science and technology helps various aspects of the conservation of architecture: from the survey of building and decay, the drawing of 2D elaborations, the creating of 3D models and the interactive database helps organizing the daily conservative restoration and maintenance work. With the technology of virtual reality, we could also "complete" the building in digital world or even in the real world without any change to the status quo. These are the attempts of our generation to leave traces in the history of those monuments.

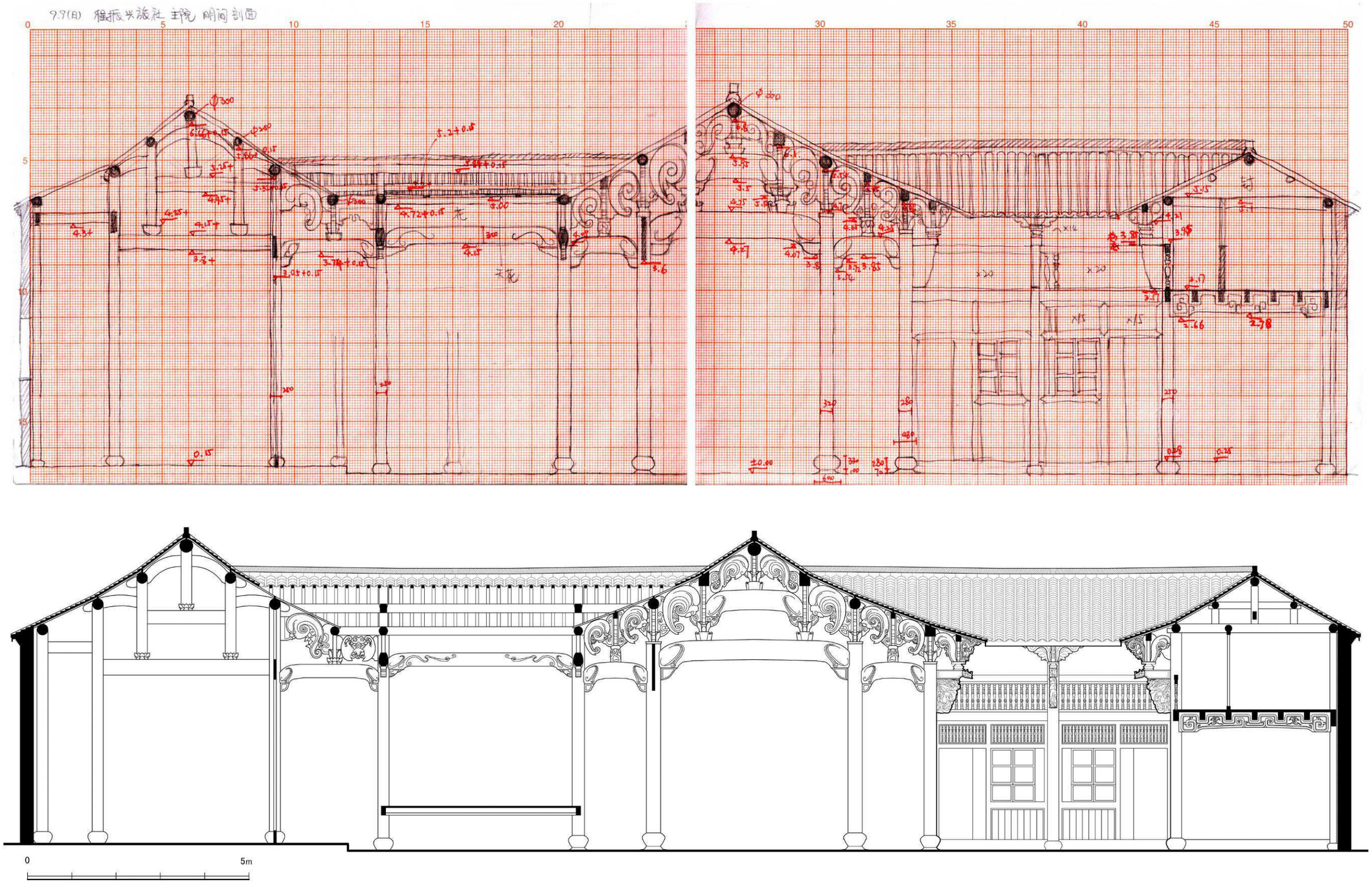
Two Types of Survey and drawing

The survey and drawing I did previous in China was quite different from the way 3DSG do it in Italy. I would like to call the survey I did before as low-tech survey and 3DSG's as high-tech survey. These two types of survey meet different acquirement of each work.

2.72 Low-tech survey tools

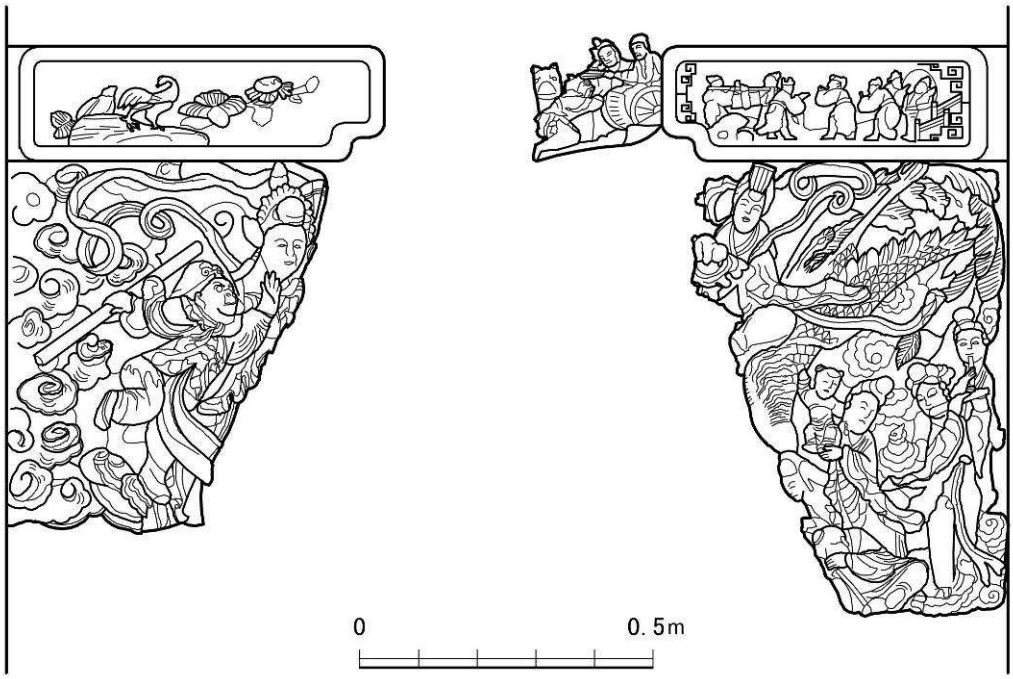
I worked in a group named “Vernacular Architecture Research Group” in Tsinghua University, School of Architecture. Our researches were mainly about villages with well preserved tradition and architecture. We studied historical documents, interviewed the locals, and surveyed the vernacular architecture, like houses, academies, stages and temples. The drawings produced would then print in books and papers as illustrations.

Most of the architecture we surveyed was traditional wood structure buildings built in late Qing Dynasty (about one or two hundred years old). Some of them were in very good condition, while some were not. Most of them were still used by the locals, but some were abandoned. The tools we used for survey are very simple: several pages of copy paper or graph paper, one pencil, two or three color pens, one metal tape measure, one long tape measure (later one laser rangefinder), one compass, and one long bamboo stick borrowed from the neighbors. In fact, the bamboo stick is originally used to hang out laundry on the clothesline.



2.73 Longitude Section, Cheng Zhenxing Inn, Yanxia Village, China, drawn by the author
Up: On-site survey sketch Down: Drawing with AutoCAD

First step is freehand drawing on papers, to draw all the plans, sections, elevations and details of windows or beams we need for the final result. This drawing doesn't need accuracy of scale and dimension. The purpose is to obtain a clear sketch to write down the dimensions later. Dimensions are divided in two types – "big dimensions" and "small dimensions". Big dimension is the length, width and height of structure elements (base, walls, roofs, columns, beams, etc.) or the distance between axis, which will be measured by long tape measure or laser rangefinder. Small dimensions will be measured by metal tape measure, such as the diameter of columns, the length and width of window frames or height and width of steps. Big dimensions would help to reduce the errors of the cumulative of small dimensions. If some heights could not be directly measured by laser rangefinder, a bamboo stick will be needed together with the tape measure. All the measurements are taken on-site and written down with color pens on the sketch. The survey sketch (Fig.2.74) we took with hands on-site was already a result of thinking. We ignored useless information and recorded the most useful ones. Plenty of photos would be taken, which helps us to remember the status in situ when drawing with AutoCAD in the office. Details like the carving on doors, windows or beams would be drawn based on an orthographic projection manually stretched in Photoshop. No measurements would be taken from the photos.

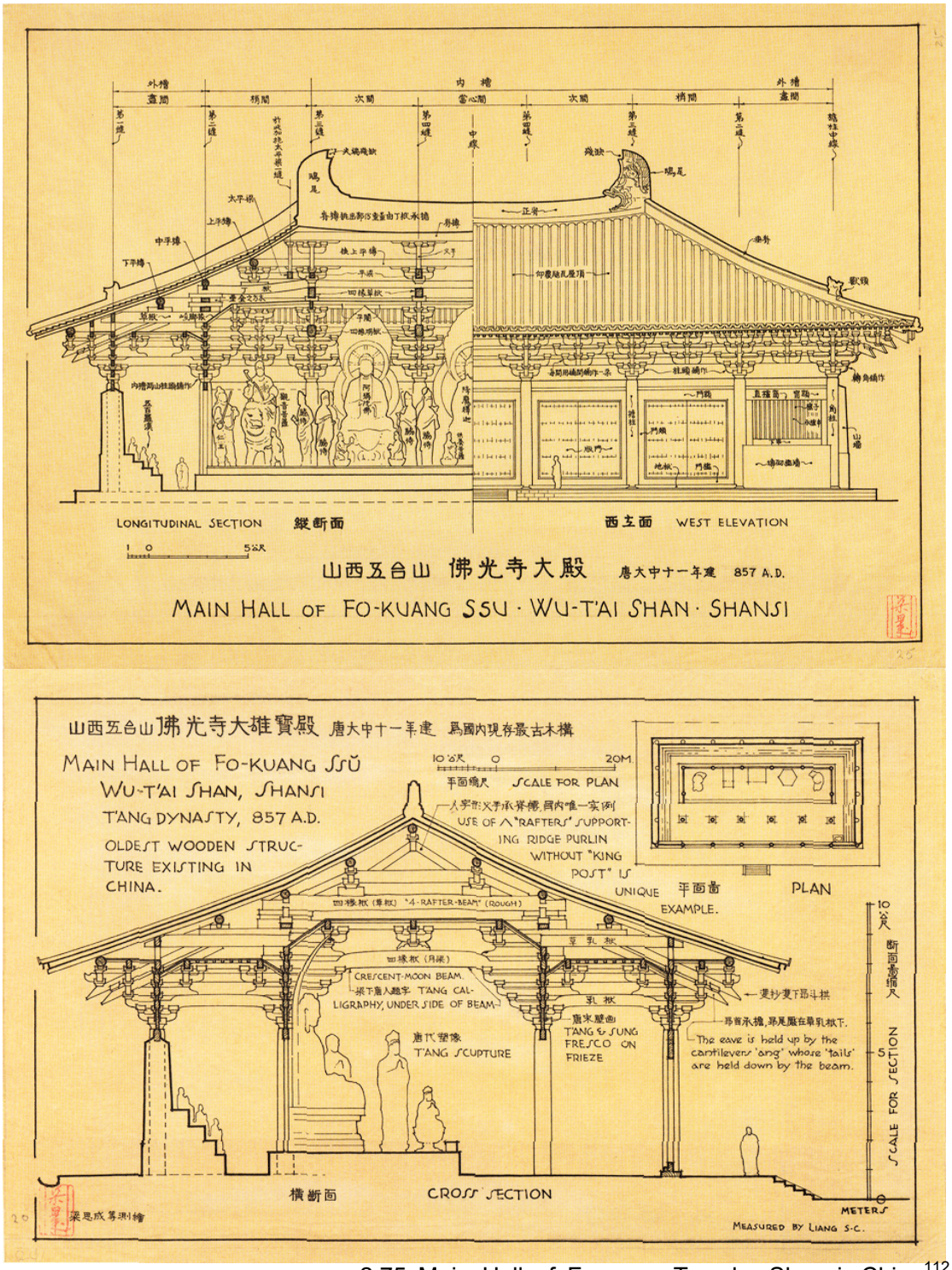


2.74 Detail of corbel, Cheng Zhenxing Inn, Yanxia Village, China[111]

When drawing master plan of a village, we never use topography. The way of working is to ask a topographical map (mainly on 1/1000 or even smaller scale) from the local Planning Bureau, and then put the ground floor of each house we draw to fit the small rectangle outline on the map. The topographical map always has a lot of errors. Our task is to adjust it as accurate as possible.

In university, another study group bought one 3D Laser Scanner for their research and survey on traditional official buildings, such as royal palace, gardens and temples, which are much more formal than the vernacular architecture in rural area. But the group I worked before still use the traditional way to survey in recent days.

[111] Drawing by Sun Na



2.75 Main Hall of Foguang Temple, Shanxi, China[112]

Economy might be one of the reasons for my previous group not choosing high-tech survey, but 3D Laser Scanning might not meet their requirements either. Not like the rib vault system in Duomo in Italy, which has a continuous surface to scan, Chinese traditional wood frame system is a spatial structure. It is very hard to scan the spaces between the columns, beams and rafters, especially in narrow spaces. After several times of scanning, some parts of the structure will still be in shade.

[112] Liang Sicheng, The Hand Drawing of "A Pictorial History of Chinese Architecture", Beijing: Duku, 2015

Another problem is deformation. For official buildings using high quality materials, this might not be a big problem. But in rural area, if the house used poor quality material or in very bad condition, the wood parts would deform a lot. In this situation, accuracy becomes interference to the survey. Because our aim for survey was not to 100 percent record the status on-site, but to recover the original ideal status of the building and to draw beautiful illustrations for the books. We don't need the high accuracy of 3D Laser Scanning and photogrammetry, which were too much for us. High precision also requires more money and longer time. In this case, low-tech survey was the most proper choice for us.

The working method and process here in 3DSG is quite different. High-tech survey uses topography, 3D Laser Scanning and photogrammetry on site. The scan process needs to be well prepared, setting the device's best position, in order to obtain data efficiently. All the data scanned would be processed and then converted to a point cloud using computers back at the office. Distances could be measured directly in the point cloud. In other words, the aim of on-site survey is to freeze the objects in real world and then transfer them into digital world. Creating 3D models or 2D graphics of the objects is a kind of translation, which makes the result could be easily understand.

From low-tech to high-tech survey, the method improved speed, efficiency, and accuracy and allowed transition from paper-based drawings to digital drawings. Low-tech survey is manual, inaccurate, but very cheap and easy to start. The result relies on the ability and experience of the person who do the survey and drawing. The using of mechanical and digital devices helps in reducing deviation by hand and speeding up the work. Though low-tech survey was a good choice for vernacular architecture we studied before in China, but it is impossible to use it in a huge building like *Duomo di Milano*. As written before, the drawing of high-tech survey still needs long hours of hard work of human beings now, but the software might learn how to draw like a real person someday in the future.

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