Building and sharing knowledge from quality driven content models

STUDY ON QUALITY IN 3D DIGITISATION OF TANGIBLE CULTURAL HERITAGE

POLITECNICO MILANO 1863

Raffaella Brumana

Building and sharing knowledge from quality driven content models

WHAT

Define different **degrees of complexity** of tangible cultural heritage, from the point of view of **3D digitisation processes**

COMPLEXITY

Live Digital Twins

the complexity depending from:

- **state of the art … as resulting from**
- **PAST stratified results of centuries and transformation phases with its own materials and techniques**
- impacted by CURRENT **hazards and pressures (i.e. earthquakes, flooding, flash water bombs)**
- **Within FRAGILE context of the built environment**

with the aim
to **better understand the behaviour**
to drive the preservation plans
and **prevent** damages and **planned preservation** (**Long Life Cycle**)
to deploy knowledge transfer of enriched models.

Digitization - Data acquisition and decoding - has crucial role to continuously FEED **'live' digital twins**
TO DRIVE THE FUTURE LLCM ACTION
TO TRANSFER THE GAINED KNOWLEDGE TO THE FUTURE GENERATION
avoiding to loose the time and costs

Complexity and quality control

WHAT

Define different **degrees of complexity** of tangible cultural heritage, from the point of view of **3D digitisation processes**

HOW

Identify and analyse the **parameters** that determine quality in 3D digitisation of tangible cultural heritage

complexity

which parameters?

Meters to measure the quality : surveying parameters

Digitization/Surveying data quality acquisition

- [ ] permission for Site access (e.g. official EARTHQUAKE RED AREA NO ACCESS area)
- [ ]Environmental conditions (e.g. temperature, humidity, dust) > TLS and IRT (i.e. active heating)
- [ ]Surface conditions (e.g. reflectivity, material) > TLS close distance marble surface
- [ ]For TLS, resolution of point cloud Scans Overlap
- [ ]For SFM images overlap and resolution in f of scale
- [ ]For MMS GEOSLAM robust path and geodetic referrement
- [ ]Camera calibration parameters (lens distorsion…)
- [ ]Connection to a robust geodetic network
- [ ]Level of Error, Accuracy and Precision > scales
- [ ]Quality of associated imagery Terrain Pixel and scale
- [ ]Quality Data storage and data sharing for multi-actor coworking and re-use
- [ ] Libraries and metadata in a Common Data Env

Meters to measure the quality

Digitization/Surveying data quality acquisition

Surveying methods and restitutions	Few numbers….	Survey methods accuracy (mean square error, sqm) and required scales Quantities output
Plano altimetric Geodetic Network	27 stations	σ = ± 1 mm
Geodetic control points -Total Station Leica T70 (GCP for Scan REGISTRY and GCP for SFM images)	260 points	σ = ± 1.5 mm
Laser Scanner Faro Focus 3D	182 point clouds	σ = ± 3 mm
Direct hand survey of the column stones ashlars	**n. 14 Columns. 574 stone ashlars (9÷13 column courses 1:2 columns**	TOT ~53 m^3
Photogrammetric image blocks Ortophoto / models 3D (external and internal walls surface vaults intrados, ….)	**Ground Dimension Pixel** **Terrain pixel res:** **5mm per external fronts 1:50** **2mm internal fronts 1:20,** **1mm vaults 1:10,** **0,5mm the main facade 1:5**	TOT ~7.000 m^2
Plans (horizontal sections)	**1:50 Ground level (3000 m2), underground , crypt, first floor** **1:20 walls profiles for 3Dmodel analysis** **1:5 columns**	TOT ~ 4200 m^2
Vertical Sections (transversal and longitudinal)	**1:20**	12 sections with double direction)
UAV Falcon8 Covering and facades	RGB (GDP 10 mm) and IRT	TOT ~ 3000 m^2

HOW TO MEASURE QUALITY MODEL? Models and scales quality control

WHY? We need a meter to measure the quality: needed/acquired/processed/shared

Model Scale definition (GOAs) and specification helps to **adopt the proper scales** addressing:

- the **surveying** and data acquisition
- the **modeling** phases
- **quality** check
- the models **re-use**
- **Data models recovery**
- model **circulation**

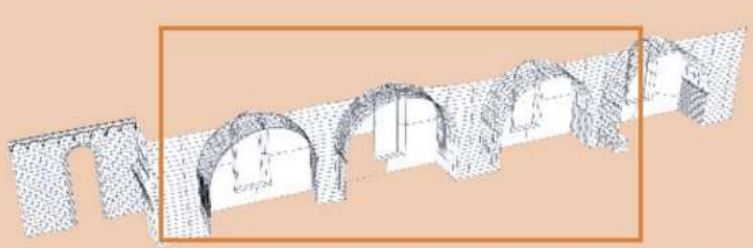
SURVEYING,DRAWING AND 3D HBIM MODEL SCALES	GRAPHIC ERROR G. E.=0,2 mm	Minimum detail in case of raster data G. E.=0,2 mm/2	TOLERANCE VALUE T = 2 ÷ 3	Model accuracy > GOA Grade of Accuracy GOA Grade of Accuracy of the HBIM MODEL generated at the different scales	GOA HBIM MODEL Minimum detail GRAPHIC ERROR G. E.=0,2 mm	GOA HBIM MODEL TOLERANCE VALUE of the HBIM MODEL
1:10	2 mm	1 mm	4 ÷ 6 mm	GOA 10	2 mm	4 ÷ 6 mm
1:20	4 mm	2 mm	8 ÷ 12 mm	GOA 20	4 mm	8 ÷ 12 mm
1:50	10 mm	5 mm	20 ÷ 30 mm	GOA 50	10 mm	20 ÷ 30 mm
1:100	20 mm	10 mm	40 ÷ 60 mm	GOA 100	20 mm	40 ÷ 60 mm
1:200	40 mm	20 mm	80 ÷ 120 mm	GOA 200	40 mm	80 ÷ 120 mm
1:500	100 mm	50 mm	200 ÷ 300 mm	GOA 500	100 mm	200 ÷ 300 mm
1:1000	200 mm	100 mm	400 ÷ 600 mm	GOA 1000	200 mm	400 ÷ 600 mm
1:2000	…	….				

Models and scales quality control

The grade of 3D HBIM model accuracy correspondent to the different scales and related tolerance value

THREE POSSIBLE MODELS OF THE SAME WALL – FROM URBAN TO HBIM SCALE

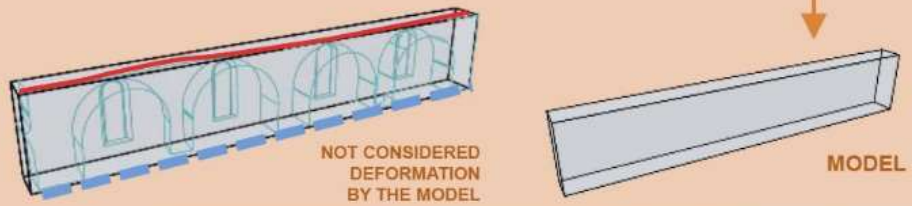
WIREFRAME MODEL FROM POINTCLOUDS AND ITS DEFORMATION



DEFORMATION= 46 cm

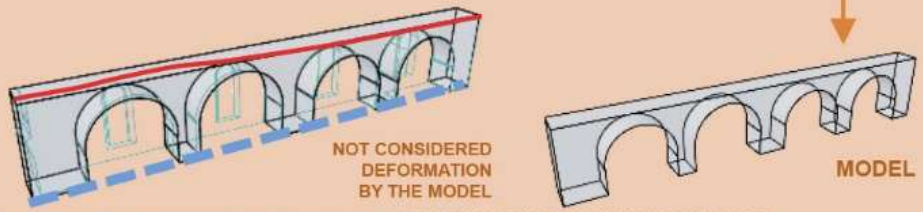
CASE 1 - URBAN SCALE

GOA 2000 T = 600/1000 mm



CASE 2 - CONCEPTUAL SCALE

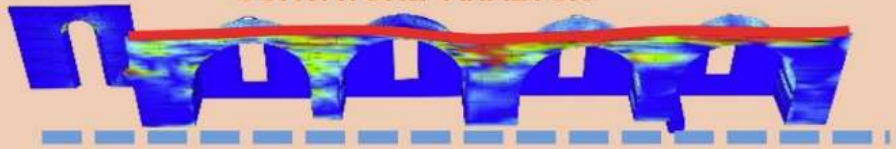
GOA 1000 T=200/300mm



CASE 3 - SCAN-TO-HBIM PROCESS

GOA 20 T=8/12mm

CURVATURE ANALYSIS



AVS

3D quality content models

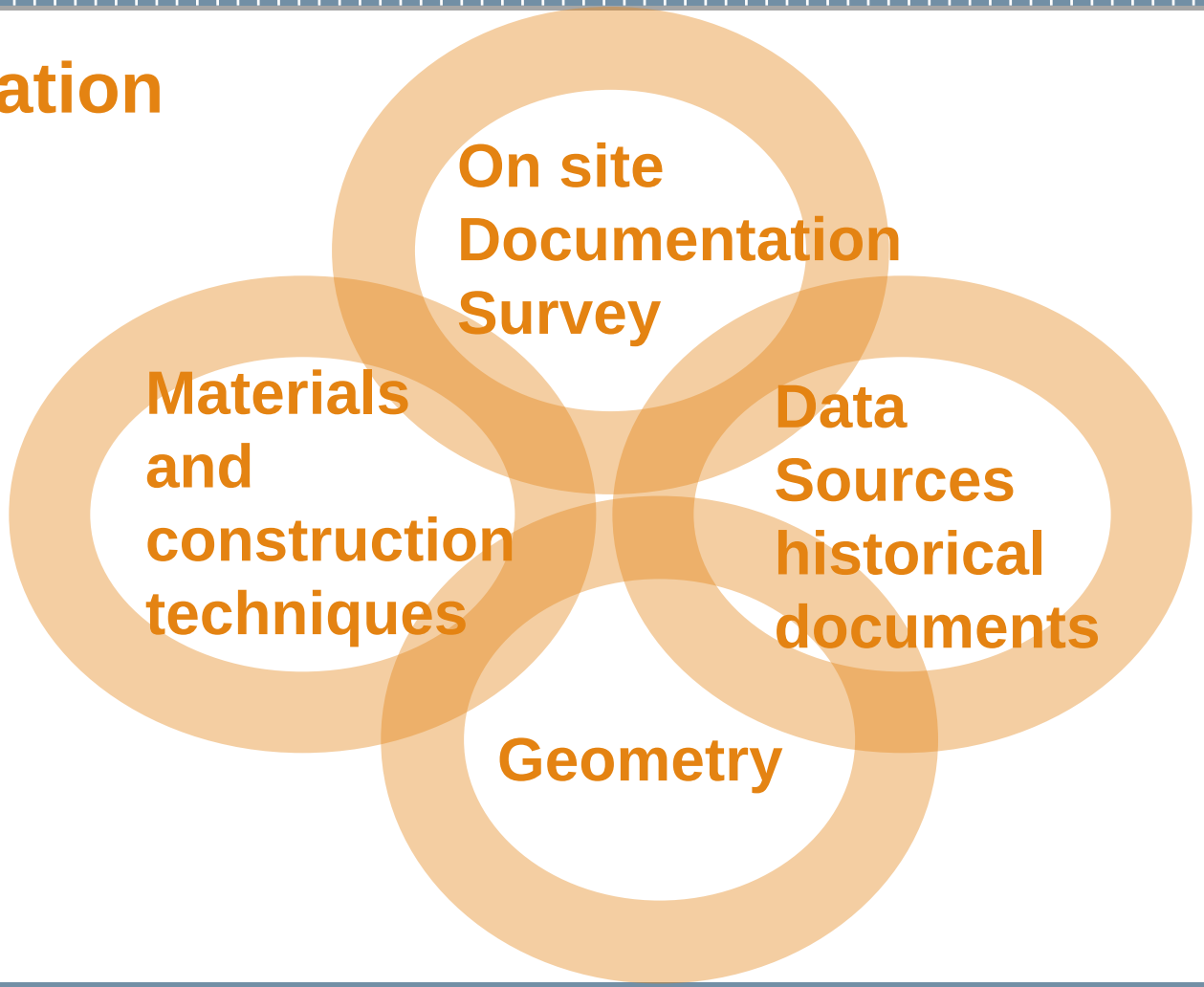
NOT JUST A MATTER of MEASURING!

Preservation

3D quality content model

INFORMATIVE MODELS

Geometry + materials and construction techniques



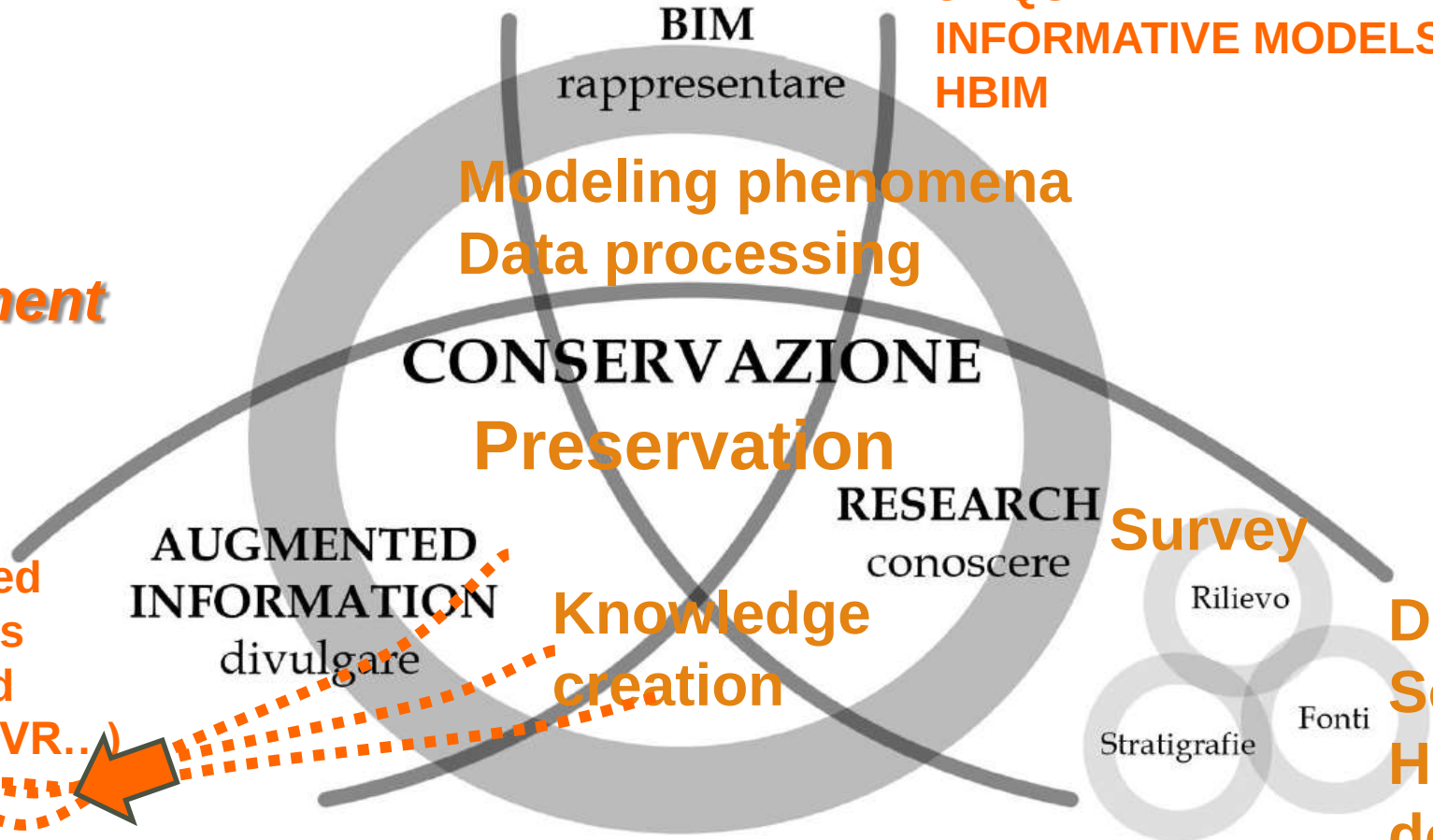
Models quality and knowledge creation

Concept

3D QUALITY INFORMATIVE MODELS HBIM

Modeling phenomena
Data processing

Boosting
Common Data Environment
GEOSPATIAL VH
remote
open HBIM access
Citizen fruition



eXtended Realities (beyond AR,MR,VR..)

Knowledge creation

Survey

Data Sources Historical documents

Stratigraphic analysis

Communication

inheriting BIM logic reversing LOG LOD toward geometric complexity HBIM

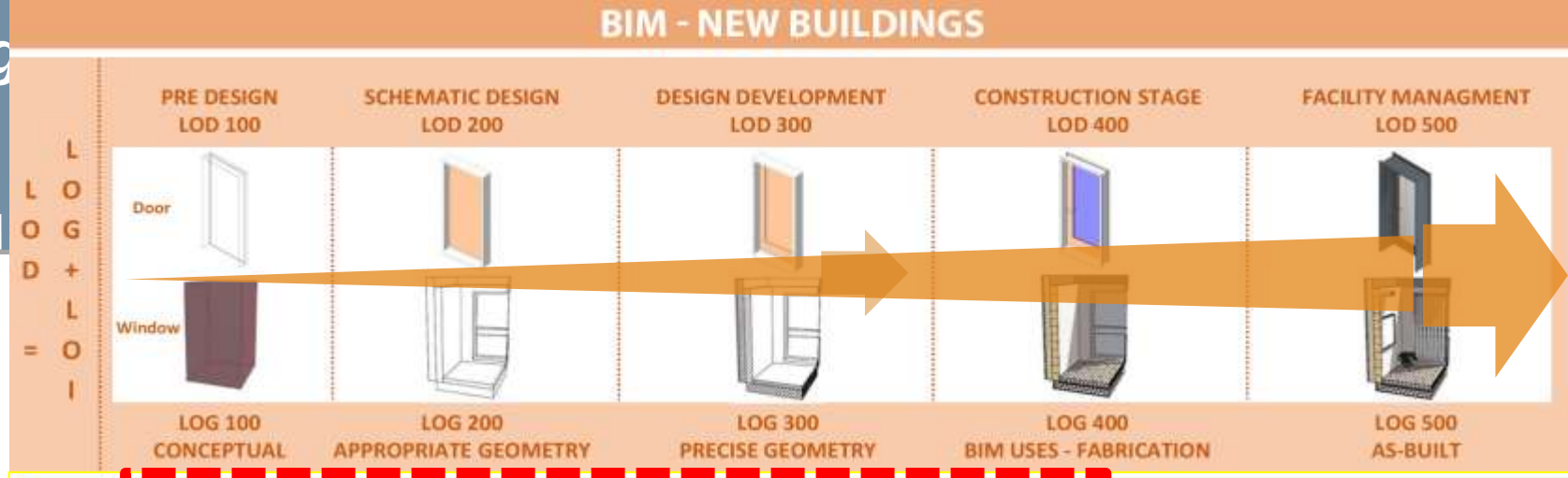
NOT JUST A MATTER METER MEASURING!

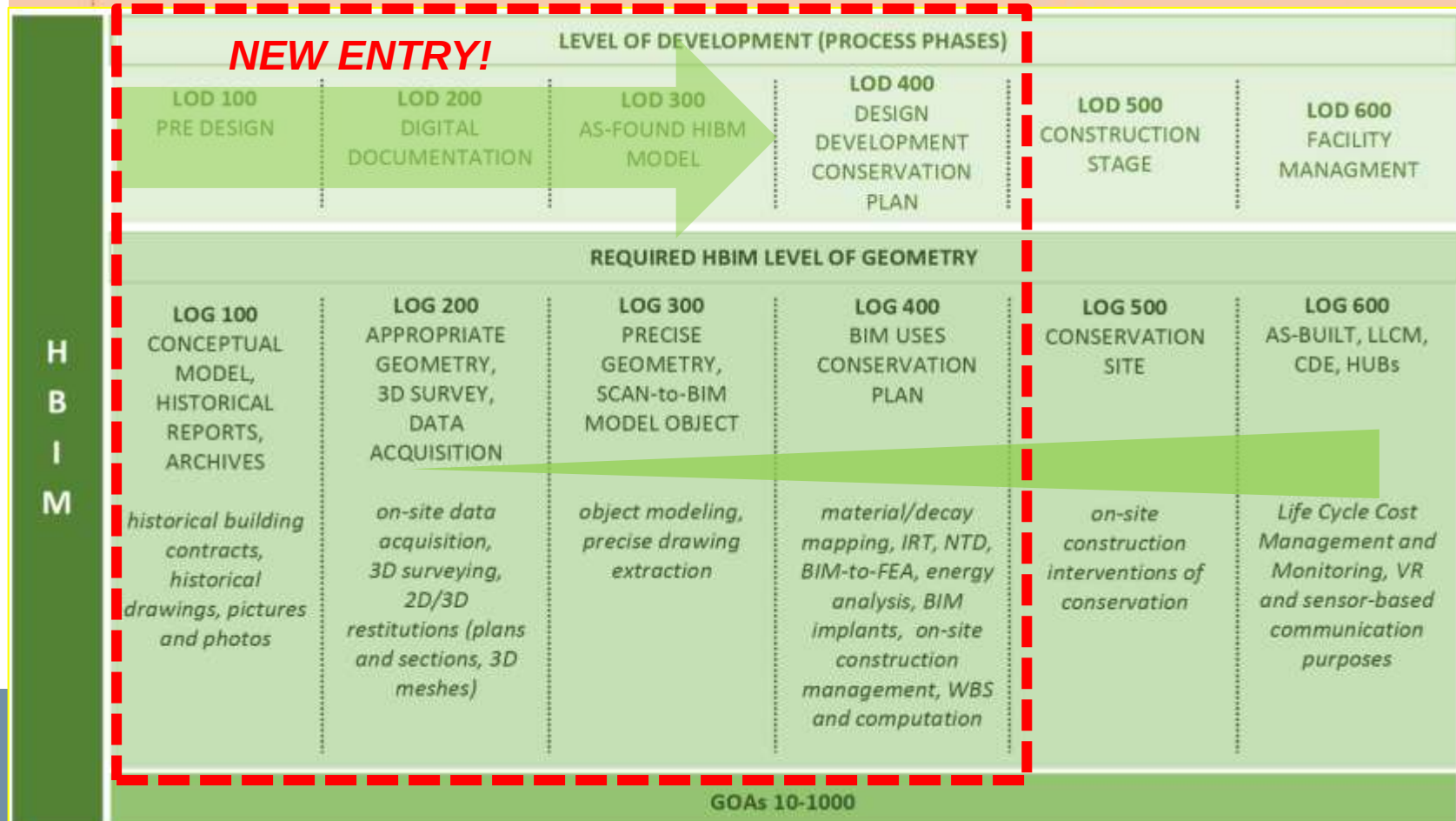
HBIM logic to 3D quality models

Content model >

Geometry model + information

Geometry + material and construction techniques





Complexity matters

The grade of 3D HBIM model accuracy correspondent to the different scales and related tolerance value

Natural hazards
Built Environment

Earthquakes

Transformation across the centuries impacted by the hazards

History of skilled workers **Intangible values** **Structural damages** **Holy Door and damaged north wall**

Complexity matters

Basilica di S.Maria di Collemaggio (L'Aquila, earthquake 2011)

European Heritage Award/Europa Nostra Award 2020
The Basilica of Santa Maria di Collemaggio
May 07, 2020 | **Conservation** | **Italy** | L'Aquila.

Superintendency Office of L'Aquila *> Responsible for the*

> Design Project >Preservation Plan > Conservation Site.

ITALIANA COSTRUZIONI SPA Construction Company

POLIMI S. Della Torre Coordinator of the Support to the Preservation project
(POLITECNICO DI MILANO, UNIV L'Aquila and ROMA LA SAPIENZA)

R.Brumana responsible of the Scan-to-HBIM consulency contract to support the preservation design project on site management, and video production.

The Basilica di Collemaggio (1274) yearly joined by 30.000 pilgrims for the Jubilee: an important church in the history of Christianity

POPE Celestino V is famous for establishing at the Basilica di Collemaggio the **Papal Bull of 29 September 1294**

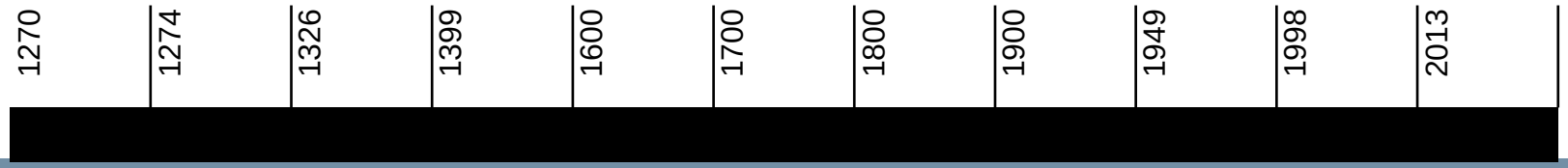
On the 28-29th August the **Holy Door** is yearly opened and it is celebrated the feast called Festa della Perdonanza **(Jubilee - forgiveness) yearly joined by more than 30.000 pilgrims.**

1274 Pope Gregory X in the Council of Lyon recognized the Order of Celestines founded by Pietro Angeleri del Morrone (**Ascetic Benedictin monk**)

1294 Pietro Angeleri del Morrone was **elected Pope Celestino V** e moved the Roman seat to the Basilica di Collemaggio **(29 agosto 1294 - 13 dicembre 1294)**

I saw and recognized the shade of him
Who by his cowardice made the great refusal.
—*Inferno* III, 59–60

But some historicians hyphotized he might have been killed by Bonifacio VIII inserted by Dante in the Inferno as well



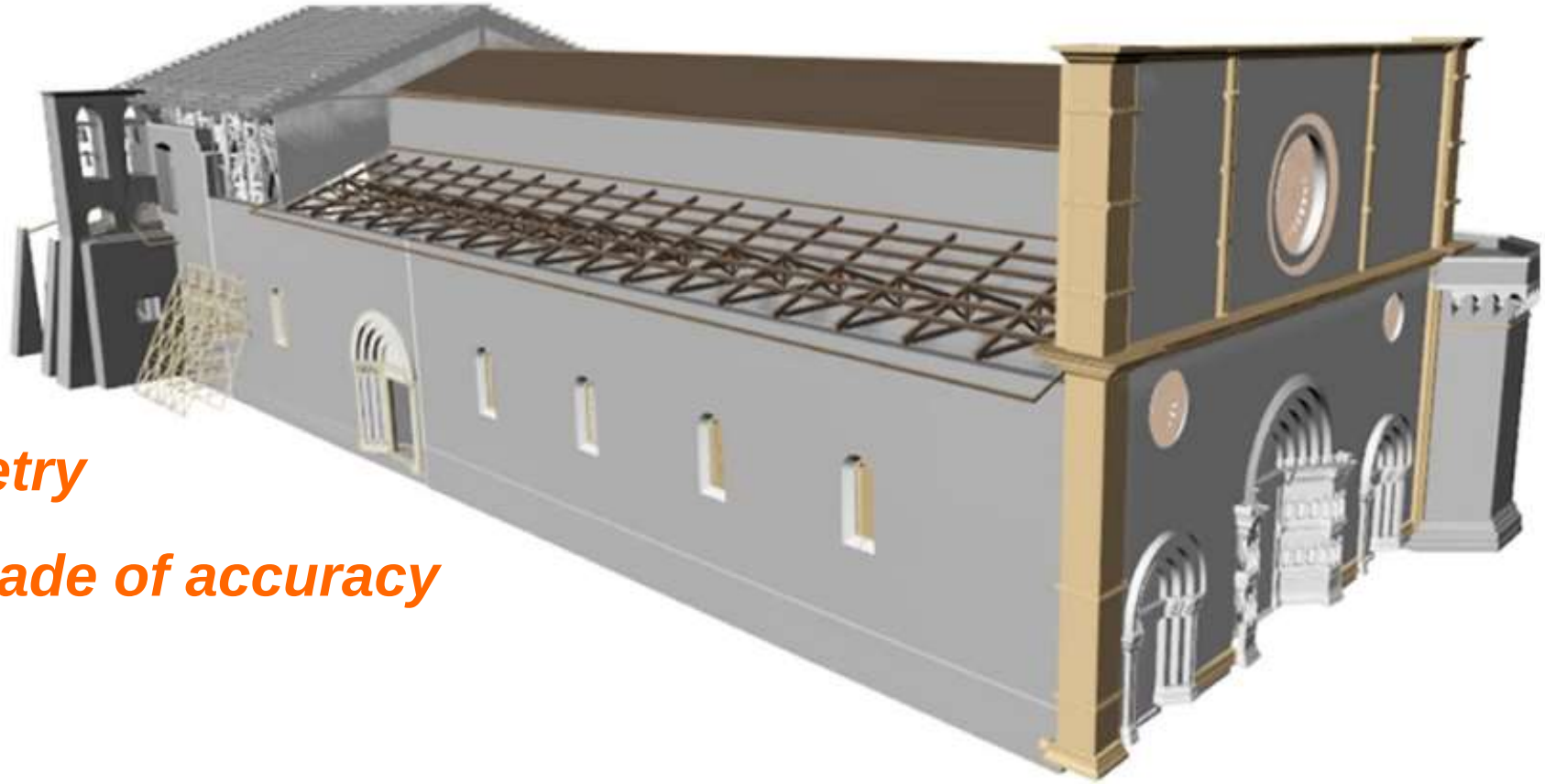
Complexity matters

on the back end …

GENERATIVE MODELLING PROCESS BIM-ENABLE

SCAN-to-BIM MODEL

LOG 300

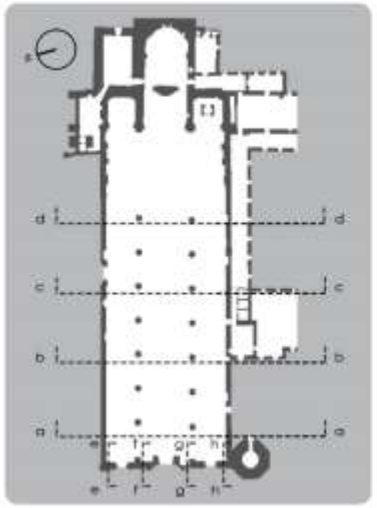


Appropriate Geometry

and the different grade of accuracy

GOAs

Models and scales quality control



Per valutare le irregolarità geometriche del corpo longitudinale, abbiamo impostato quattro sezioni trasversali poste ad una distanza più o meno costante tra di loro. Per ognuna delle sezioni sono stati individuati i fuori piombo, gli spanciamenti e gli spessori murari.
Successivamente abbiamo confrontato la quota di imposta della vecchia copertura, esistente prima degli interventi di restauro degli anni '70, con gli spaccati (a,b,c e d), individuando, in tal modo, una certa corrispondenza con le irregolarità riscontrate.

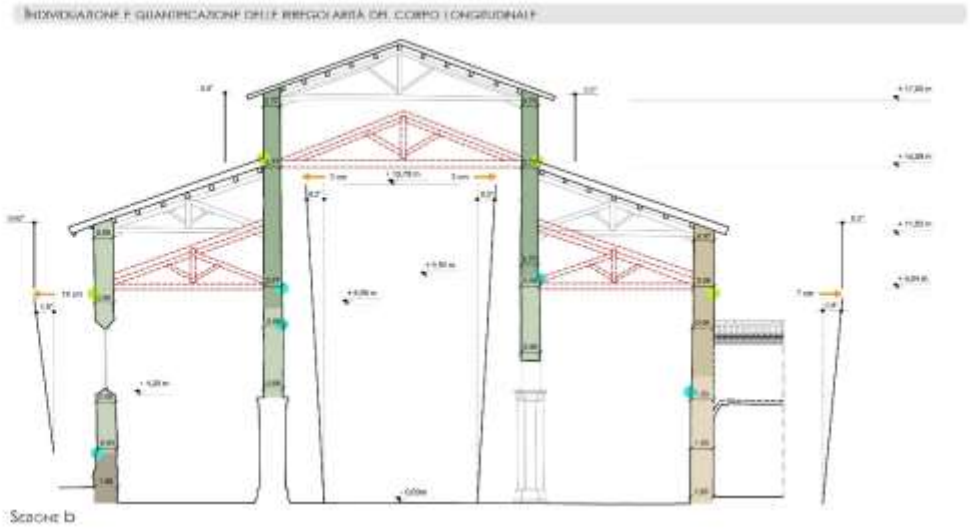
LEGENDA

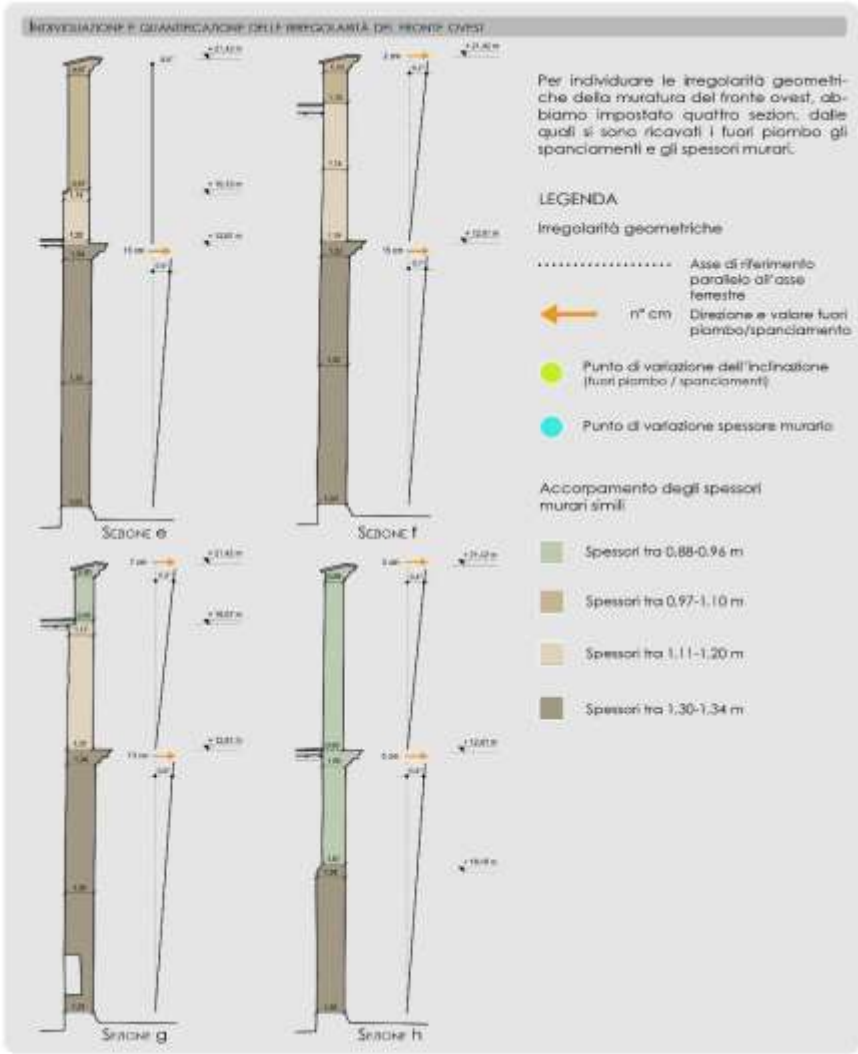
Irregolarità geometriche

- Copertura prima dei 1970
- Asse di riferimento parallelo all'asse terrestre
- n° cm — Direzione e valore fuori piombo/spanciamento
- Punto di variazione dell'inclinazione (fuori piombo / spanciamenti)
- Punto di variazione spessore murario

Accorpamento degli spessori murari simili

- Spessori tra 0.75-0.81 m
- Spessori tra 0.82-0.90 m
- Spessori tra 0.91-0.98 m
- Spessori tra 0.99-1.05 m
- Spessori tra 1.06-1.17 m





Per individuare le irregolarità geometriche della muratura del fronte ovest, abbiamo impostato quattro sezioni, dalle quali si sono ricavati i fuori piombo gli spanciamenti e gli spessori murari.

LEGENDA

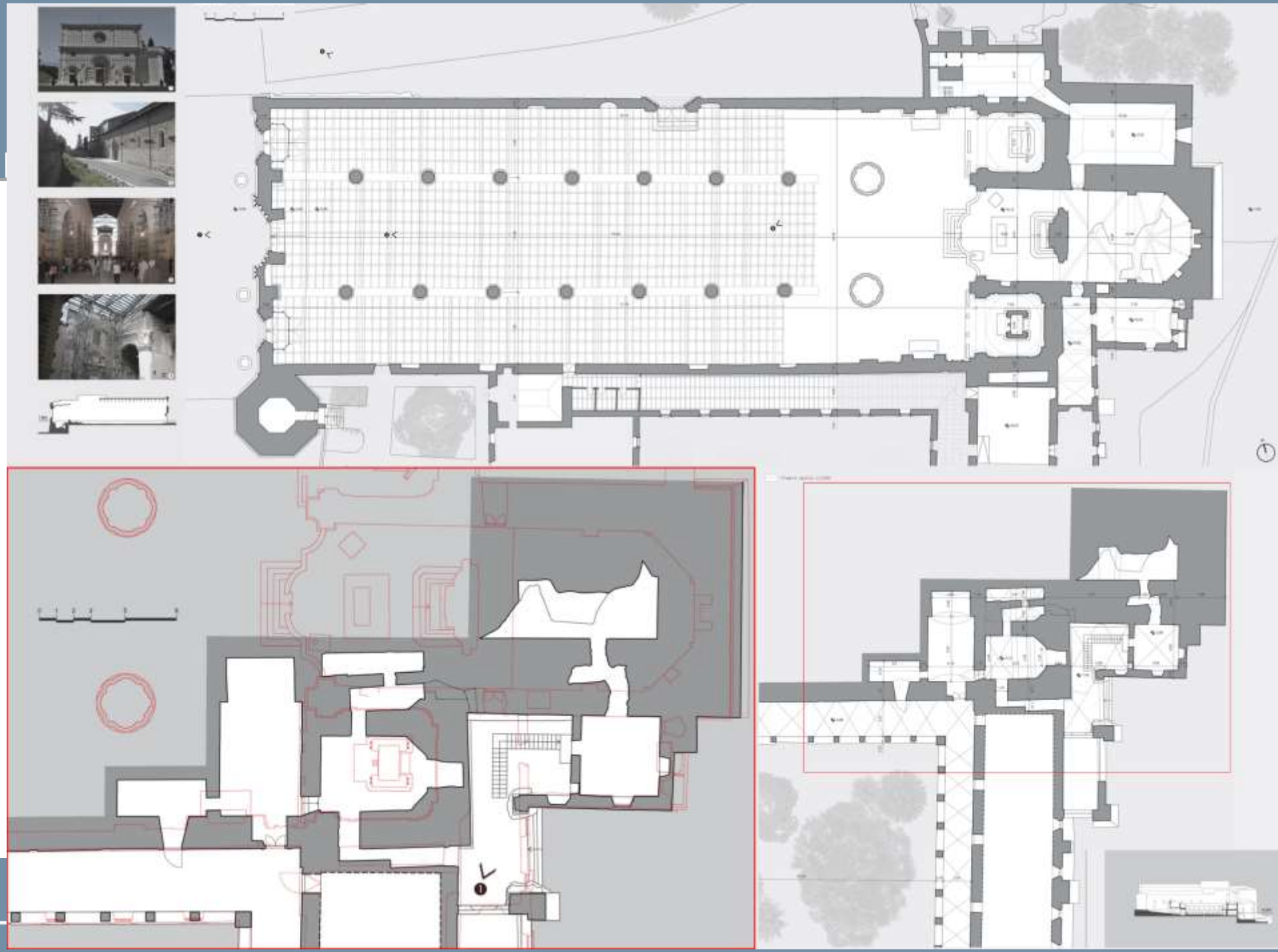
Irregolarità geometriche

- Asse di riferimento parallelo all'asse terrestre
- n° cm — Direzione e valore fuori piombo/spanciamento
- Punto di variazione dell'inclinazione (fuori piombo / spanciamenti)
- Punto di variazione spessore murario

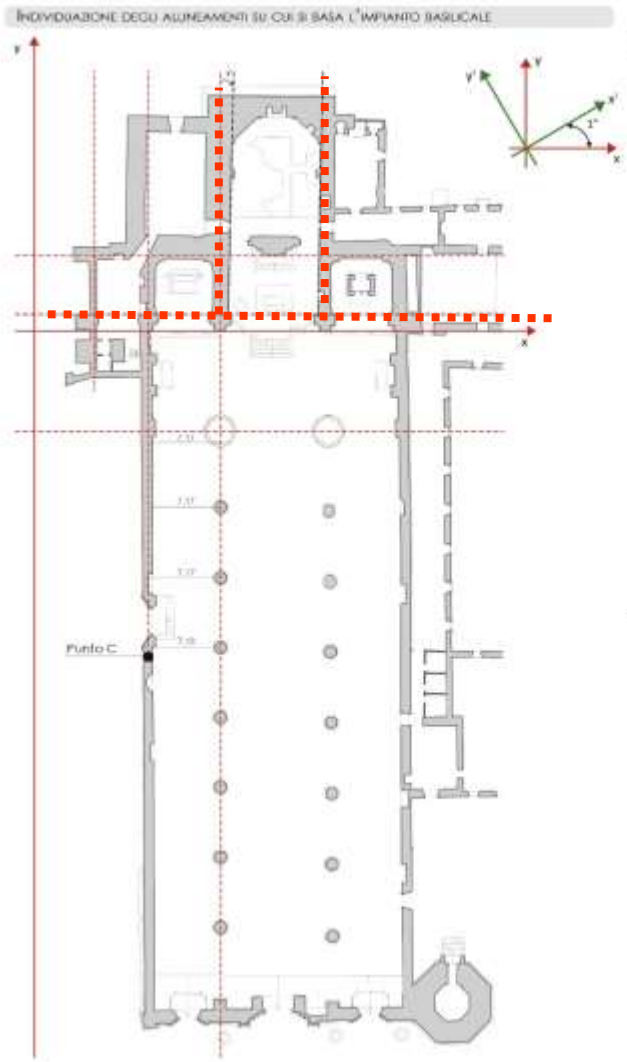
Accorpamento degli spessori murari simili

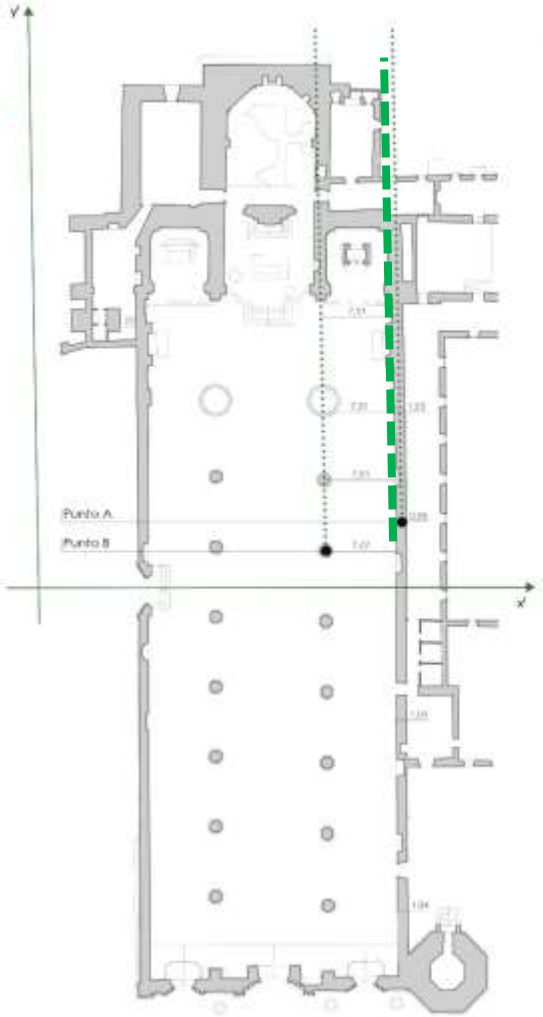
- Spessori tra 0.88-0.96 m
- Spessori tra 0.97-1.10 m
- Spessori tra 1.11-1.20 m
- Spessori tra 1.30-1.34 m

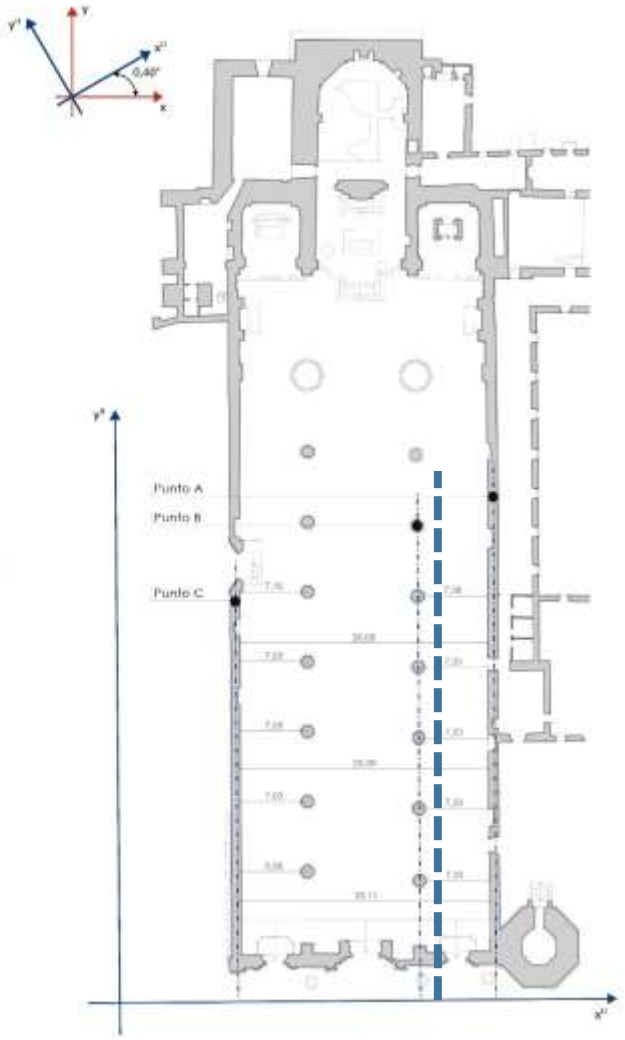
Complexity matters



Models and transformation phases surveying + documents + stratigraphic units

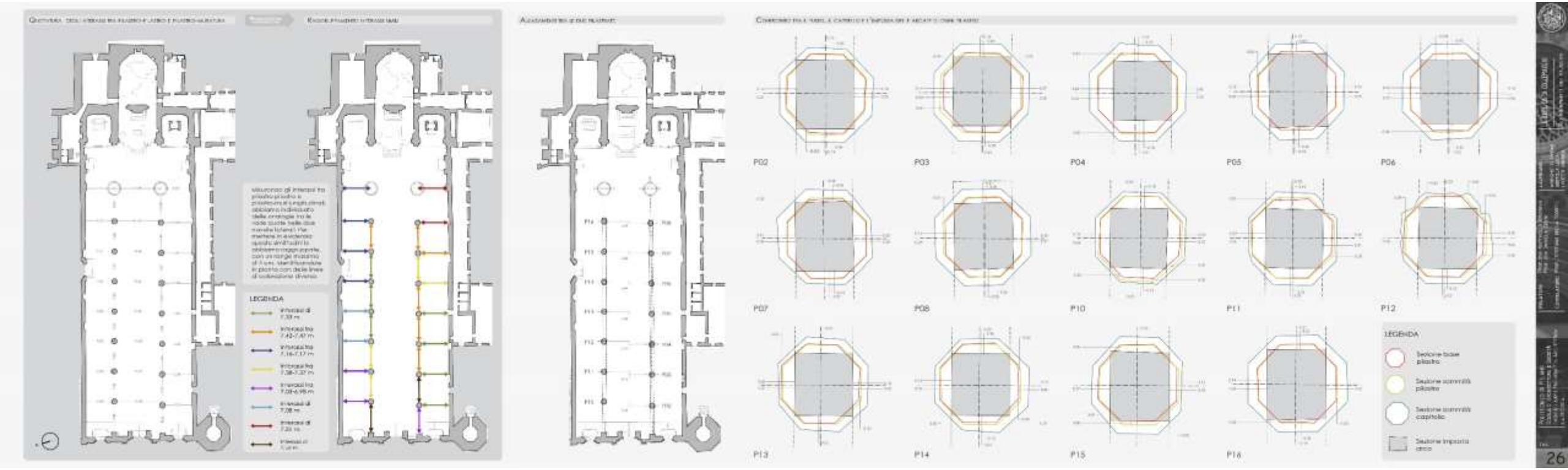






3D quality models and structural behaviour

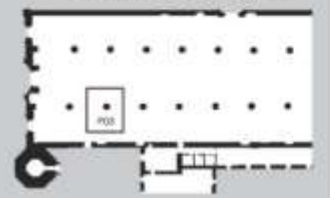
Columns out of plumbs

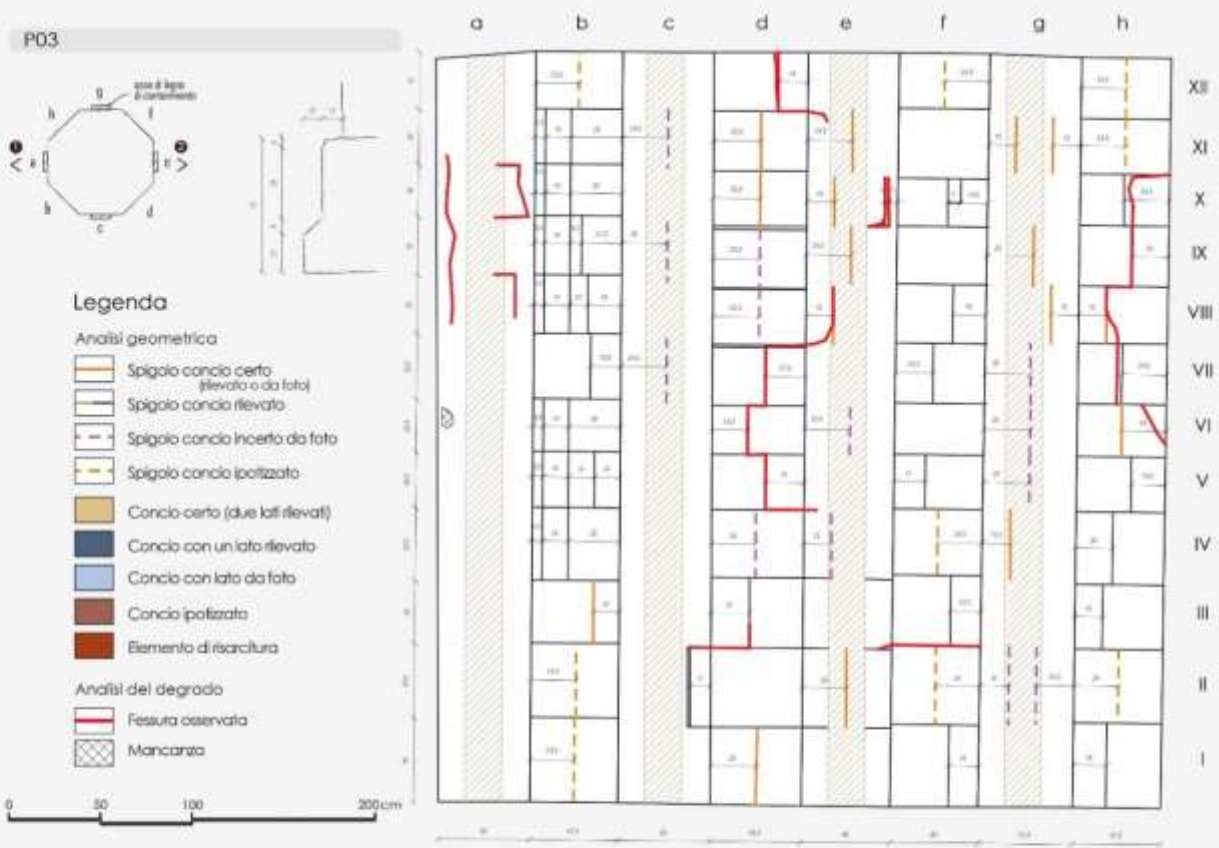


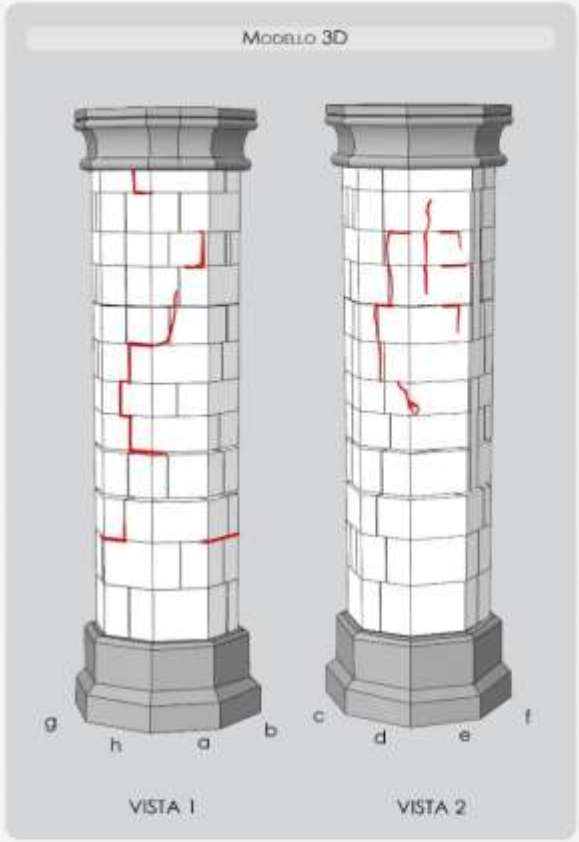
Models and scales quality control the stone ashlar direct surveying 1:1

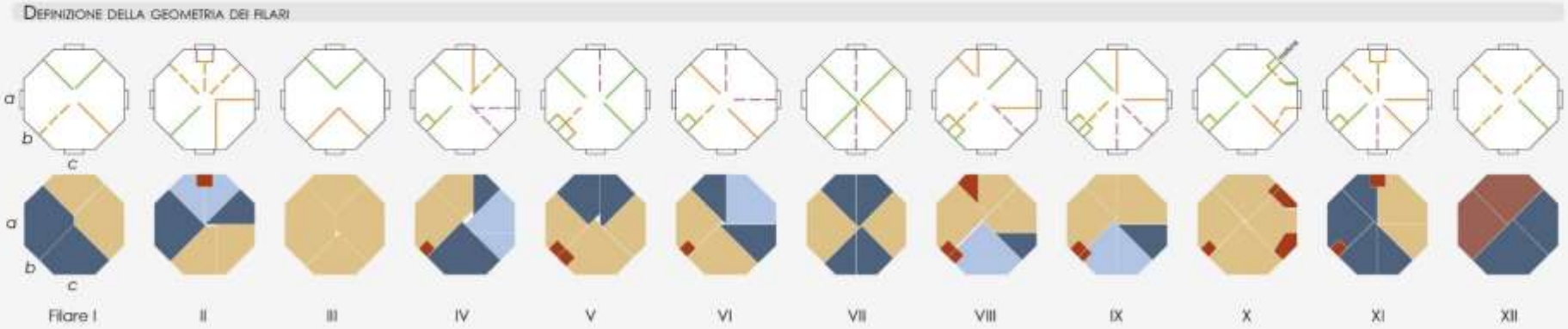
Lato D-E-F

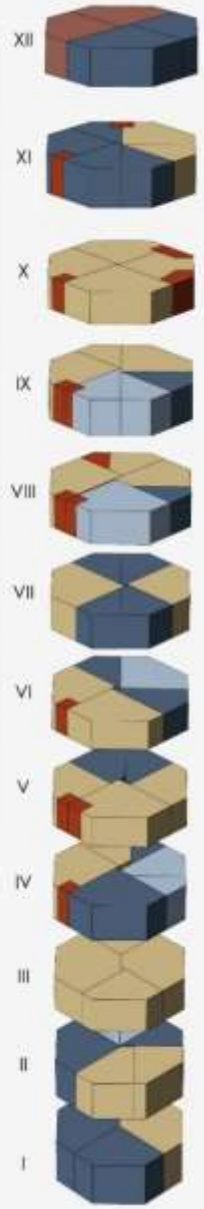
Particolare fessura
nel giunto filare II-III lato F



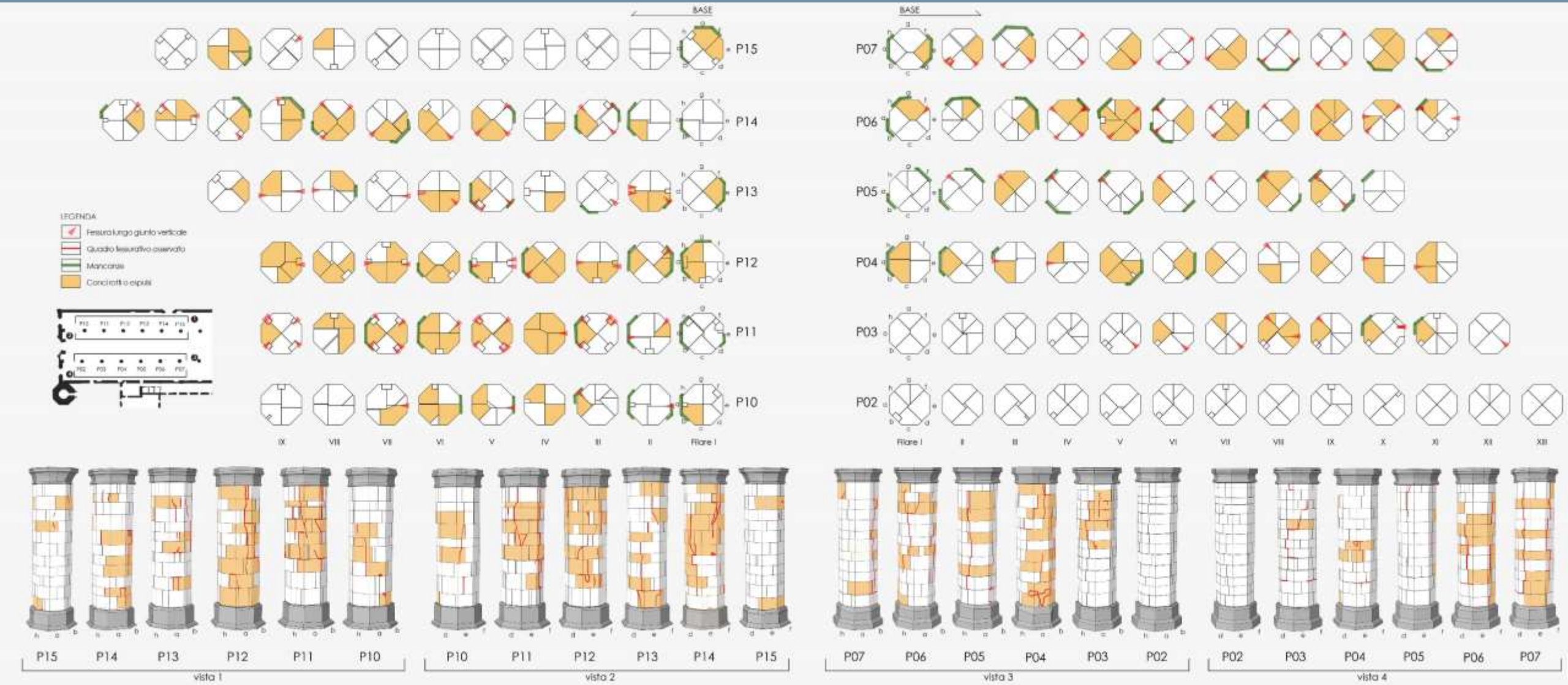






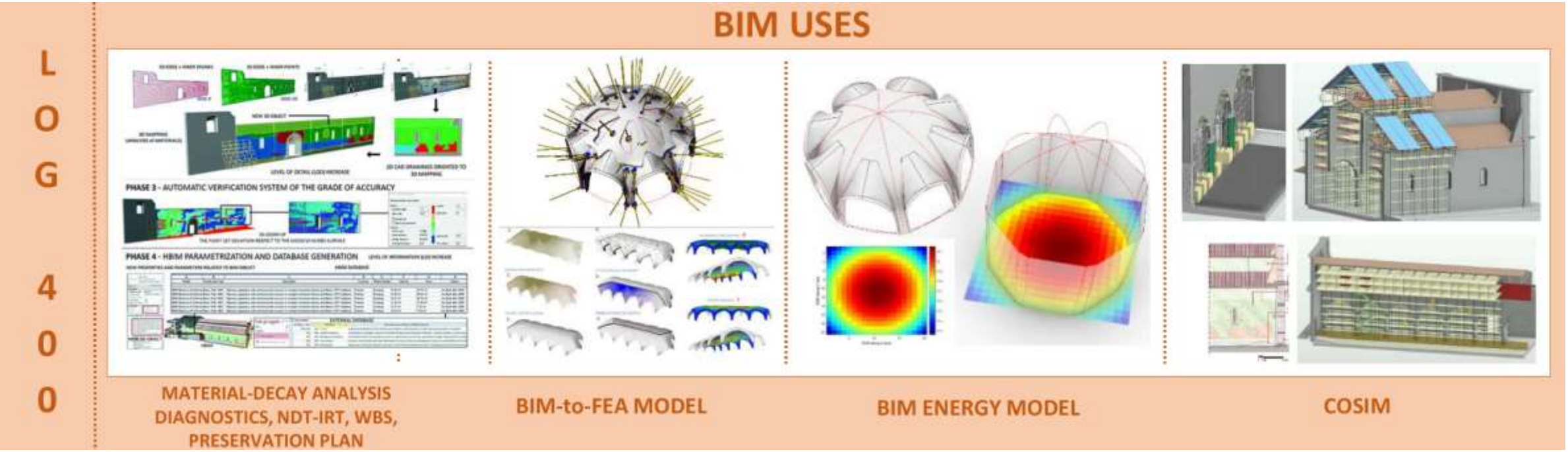


Models and scales quality control the stone ashlar direct surveying 1:1



Models and scales quality control

LOG400 (HBIM-USES - Conservation Plan)



LOG400 (HBIM uses – Conservation Plan) within the **LOD400 (Design development – Conservation Plan).**
The HBIM model LOG300 support **BIM-based analysis** to improve their results using different oriented-model types to perform the **decision making phases** of the Conservation Plan, as in the case of the **material and decay analysis with the related cost computation and Work Breakdown Structures**, **BIM-to-FEA** or BIM Energy Models, **Design development** (i.e. implants, new components, new structural elements) and Construction Site Management.

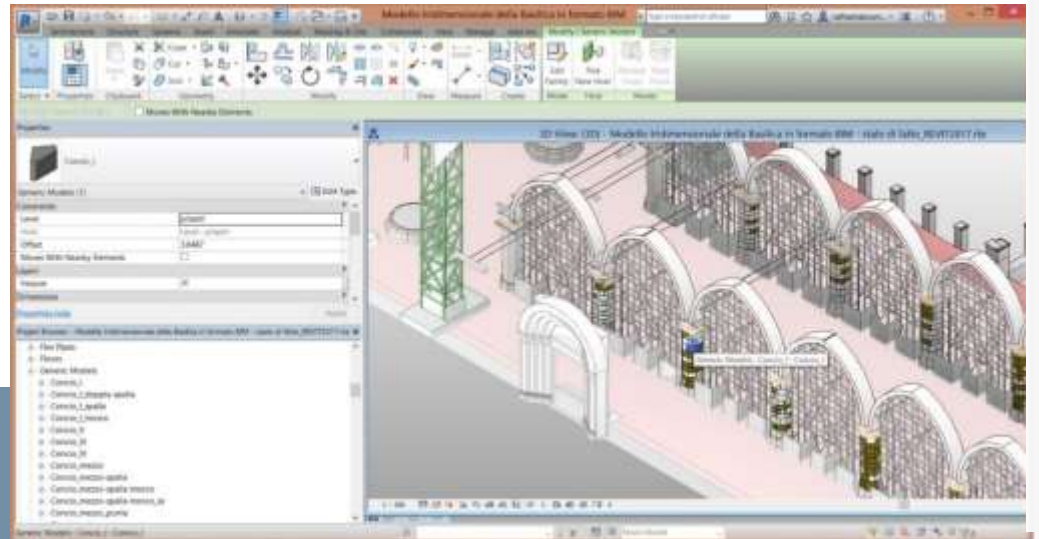
Complexity matters

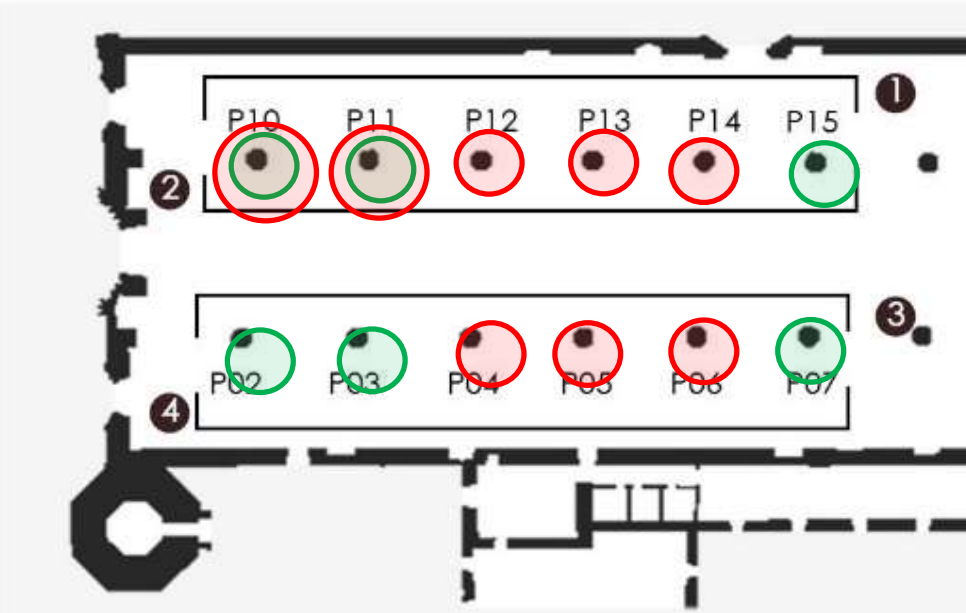
Models supporting Decision Making System

Green – «Scuci cuci» Design project on 3-4-5 10-11-12 columns
puntual on site replacement of less damaged ashlars

Intervention>>>> For pillars 3 4 5 12 more then 50% of the stone ashlars SAVED IN PLACE!!!!! According to the Design project!!!!
For pillars 10-11 round 100% Scuci cuci …

Red - Column reconstruction Design project on 13-14-15 5-6-7 columns
On site reconstruction of the most damaged columns with replacement and re-use of integer stones
Intervention as planned





POLITECNICO

Models and scales quality control

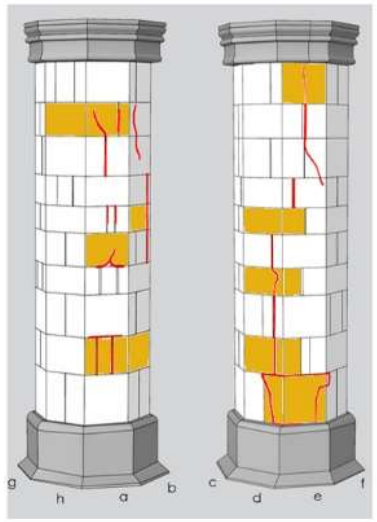
LOG600 (As-Built, LLCM, CDE, HUBs) within LOD600 (Facility Management)

LOG500: Conservation site and HBIM management of the interventions of preservations

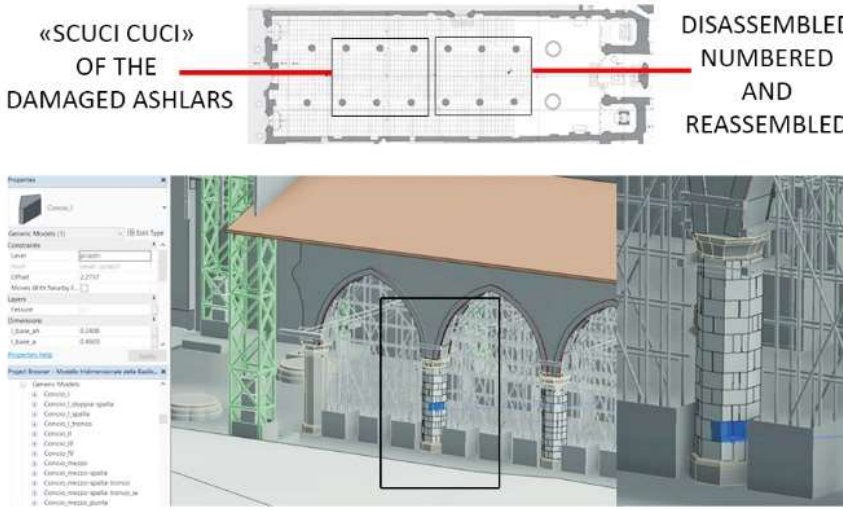
Models and scales quality control

AS-DESIGNED BIM FOR THE RESTORATION OF THE DAMAGED PILLARS

PILLAR N°13 OUTSIDE AND INSIDE VIEW



3D MODEL



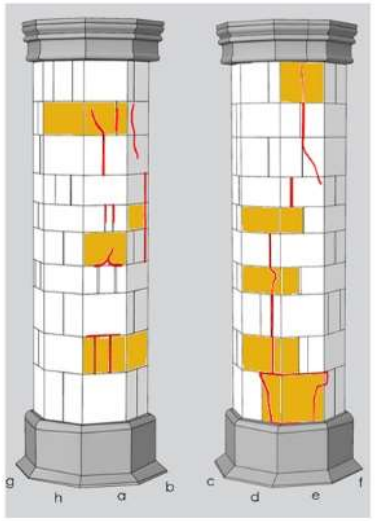
FROM AS-FOUND TO AS-DESIGNED HBIM

DISASSEMBLED PILLAR

REASSEMBLED PILLAR

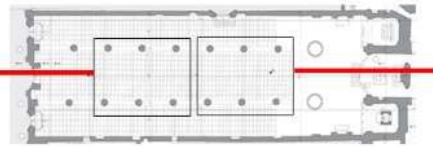
AFTER RESTORATION

HE RESTORATION OF THE DAMAGED PILLARS

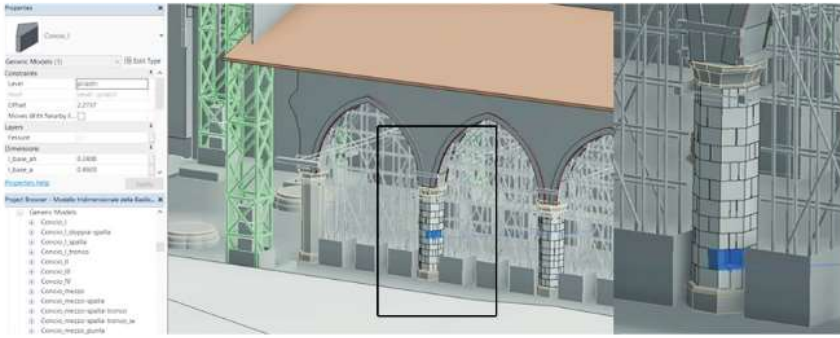


3D MODEL

«SCUCI CUCI» OF THE DAMAGED ASHLARS



DISASSEMBLED NUMBERED AND REASSEMBLED



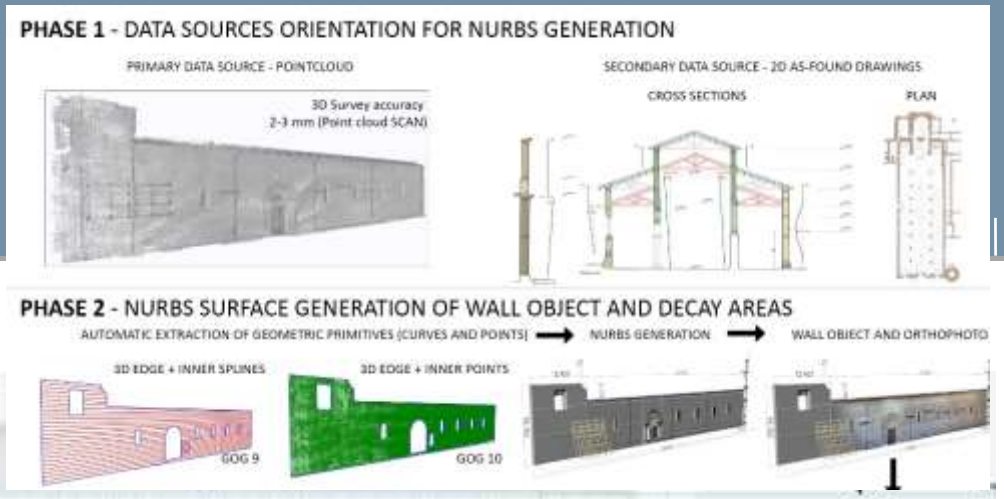
FROM AS-FOUND TO AS-DESIGNED HBIM

REASSEMBLED PILLAR

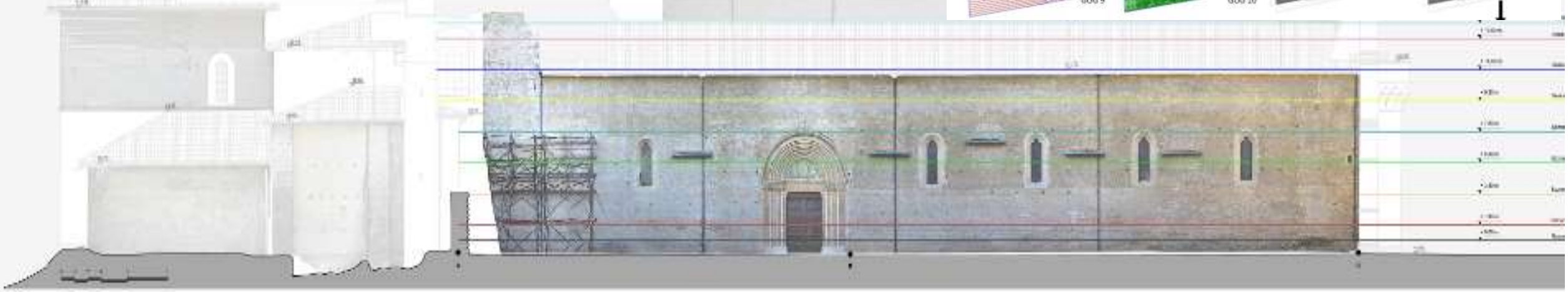
AFTER RESTORATION

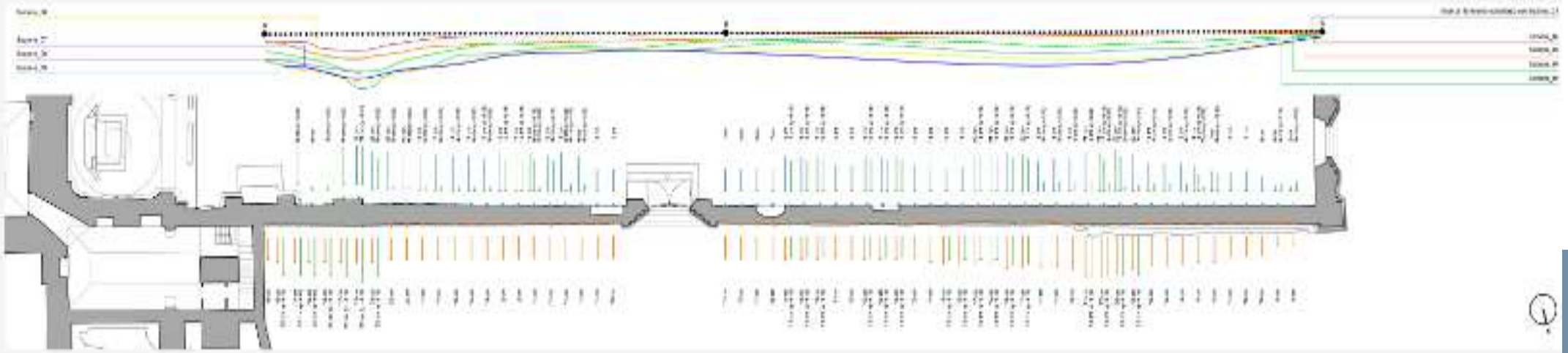
Models and scales quality control

structural analysis (BIMtoFEA)



The North Wall with the holy door



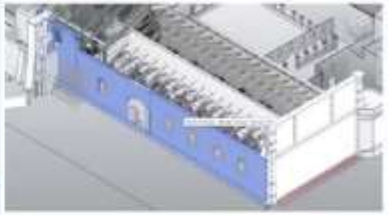


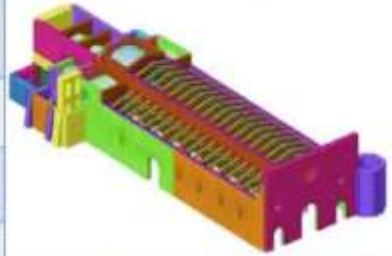
Models and scales quality control

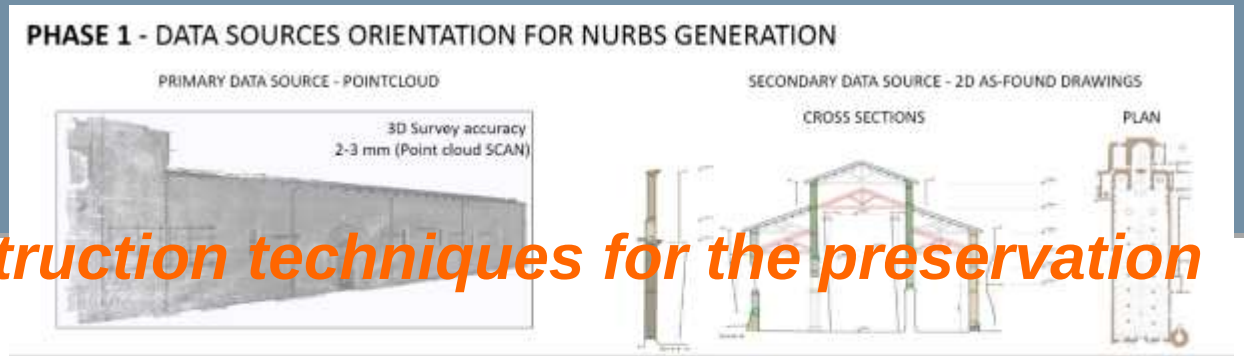
GOA 1:20 out of plumb

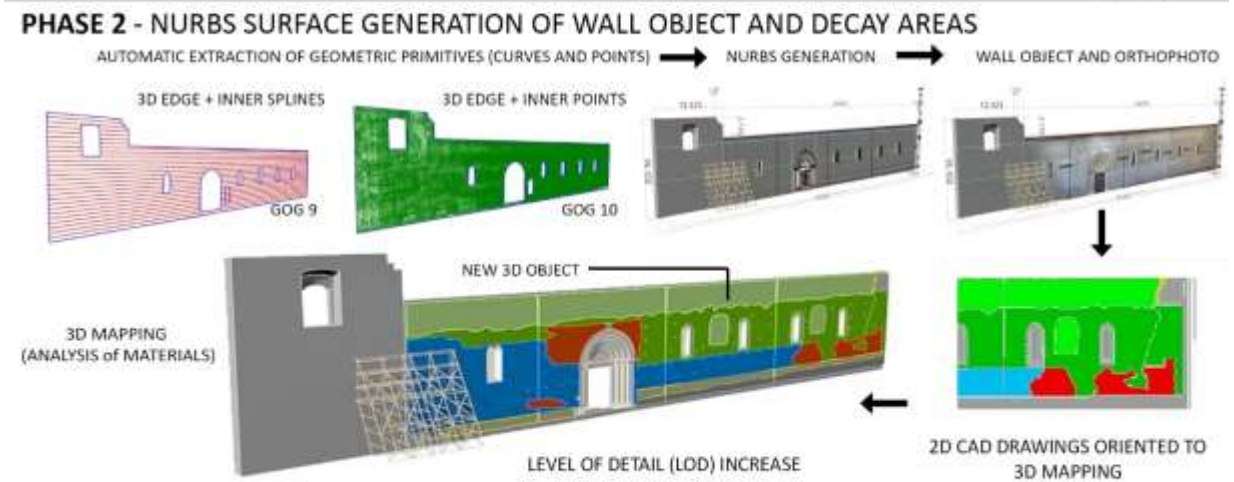
Generative modeling + materials and construction techniques for the preservation plan → geometry + materials → BIMtoFEA

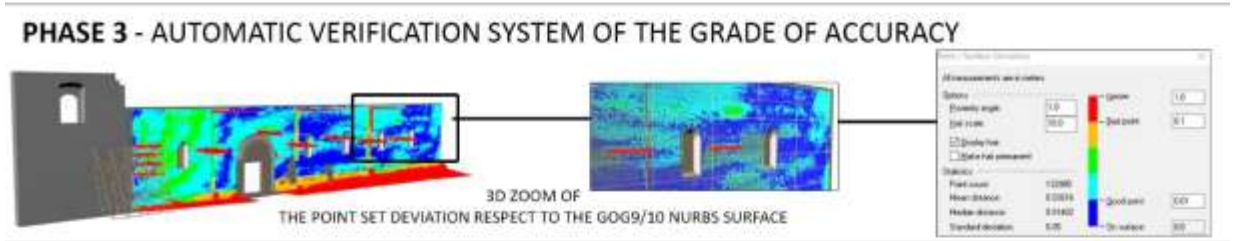
WALL	INTERNAL SPACE VOLUME	WALL VOLUME	GROSS FLOOR AREA	TIME REQUIRED BIM GENERATION BY GOG 2013 (GOG 9-GOI 1-2) & 2017 (GOG 10-GOI 1-2) (Hours - h)	TIME REQUIRED BIM GENERATION BY TRADITIONAL PROCESS (GOG 9) (Hours- h)	LEVEL OF DETAIL (LOD)	REF. HBIM OBJECTS
	m³	m³	m²				
MAIN FACADE	/	1274	/	30h, 2013 & 15h, 2017	35-40	300	
TOWER	929	190	LEV.01+02=140	6h, 2013 & 2h ,2017	10-12	300	
NORTH WALL	/	1141	/	20h, 2013 & 3h ,2017	30-35	500	
SOUTH WALL	/	941	/	8h, 2013 & 3h ,2017	12-15	500	
INTERNAL NORTH WALL ARCHES	/	537	/	20h, 2013 & 3h ,2017	12-15	500	
INTERNAL SOUTH WALL ARCHES	/	460	/	15h, 2013 & 6h ,2017	20-25	500	
BELL TOWER	437	180	LEV.01+02=25	20h, 2013 & 15h ,2017	25-30	400	
APSE WALLS	11491	1790	LEV.01=823	60h, 2013 & 25h ,2017	70-80	500	
APSE VAULTS	/	160-190	/	50h, 2013 & 20h ,2017	60-70	500	
CRYPT	977	250	LEV.00=336 LEV.01=280	60h, 2013 & 20h ,2017	50-60	400	
ROOF	36987	7244	LEV.01=2194	120h, 2013 & 50h ,2017	130-140	500	
TOT.	51 000~	14 000 ~	3798 ~	409h~, 2013 162h~ ,2017	522~		

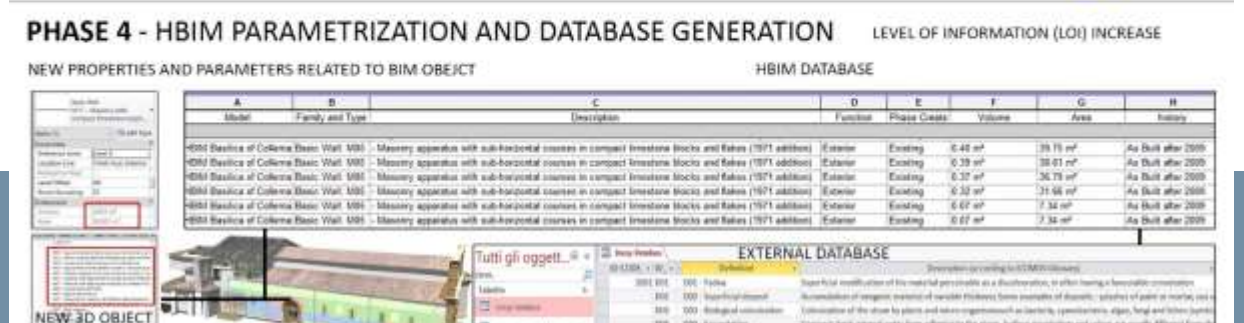








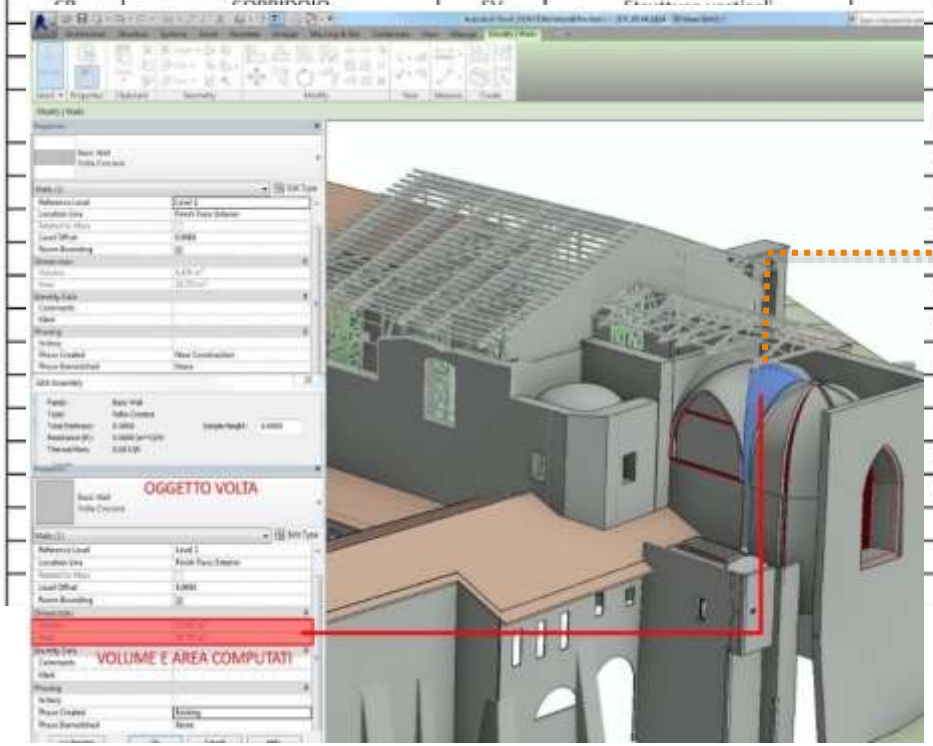


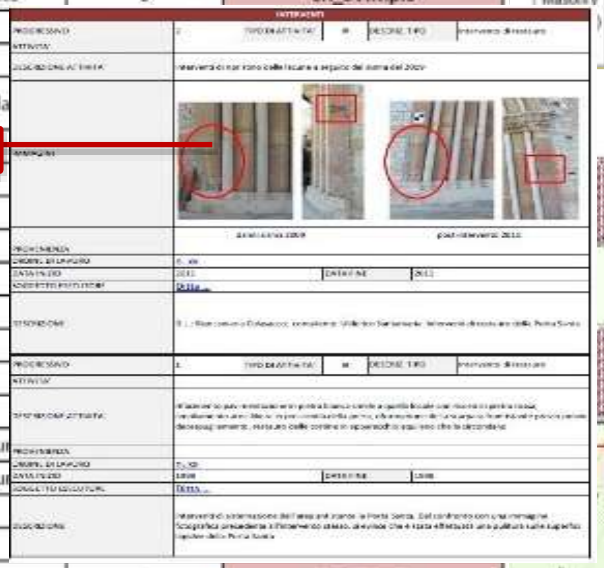


HBIM to support the Conservation Plan and Planned Maintenance across the Life Cycle Management (LCM)

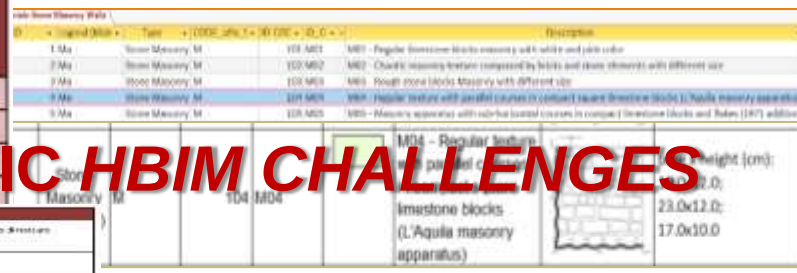
Decision Support System DSS

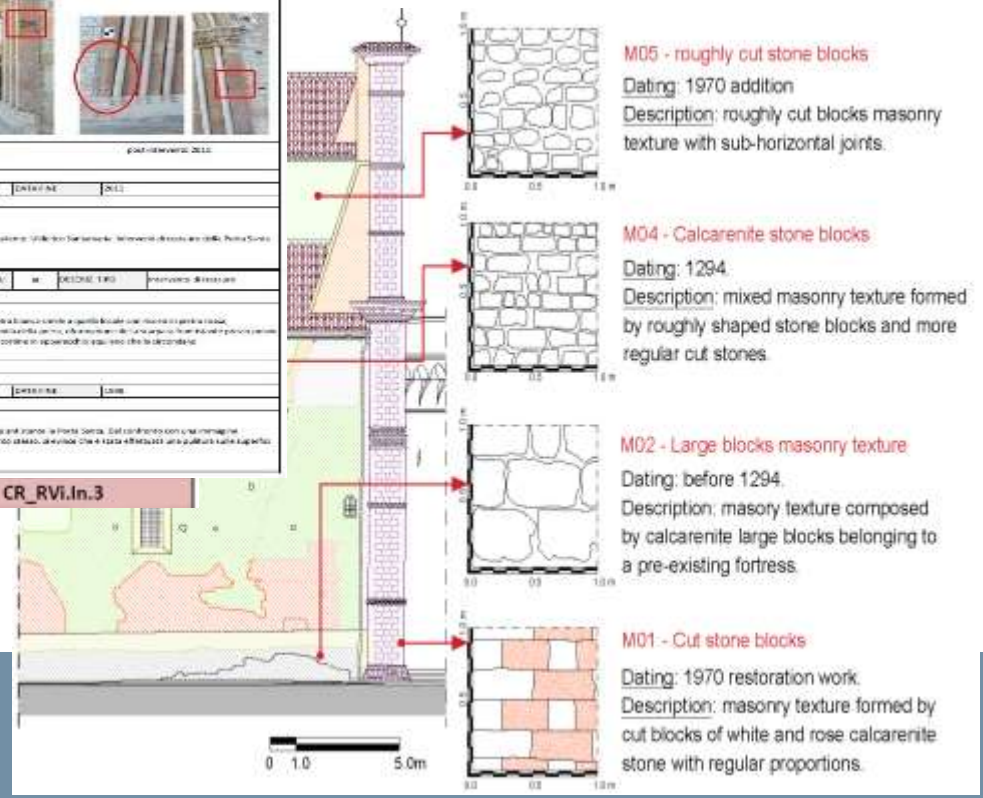
LOCALIZZAZIONE		CLASSE TECNOLOGICA		ELEMENTO COSTRUTTIVO	ELEMENTO COSTRUTTIVO	N. ELEM.	CODICE
CR	CORRIDOIO	ADe	Apparati decorativi esterni	Co	Cornice	2	CR_ADe.Co.2
CR	CORRIDOIO	SV	Strutture verticali	Mp	Muratura portante	1	CR_SV.Mp.1
CR	CORRIDOIO	SV	Strutture verticali	Mp	Muratura portante	2	CR_SV.Mp.2
				Mp	Muratura portante	3	CR_SV.Mp.3
				Fi	Finestra		
				Fi	Finestra		
				Gr	Canale di gronda		
				Po	Portale		
				Po	Portale		
				Po	Porta		
				Vo	Volta		
				Vo	Volta		
				Vo	Volta		
				Vo	Volta		
				St	Struttura		
				St	Struttura		
				Mc	Manto di copertu		
				Mc	Manto di copertu		
				In	Intonaco		
				In	Intonaco		
				In	Intonaco	3	CR_RVi.In.3





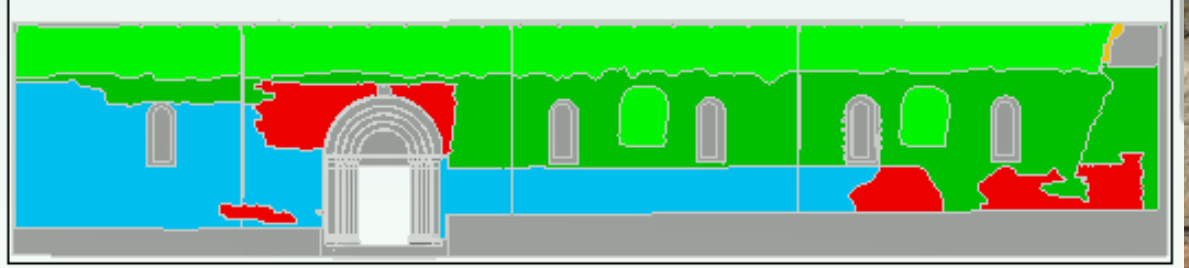
HOLISTIC *HBIM CHALLENGES*

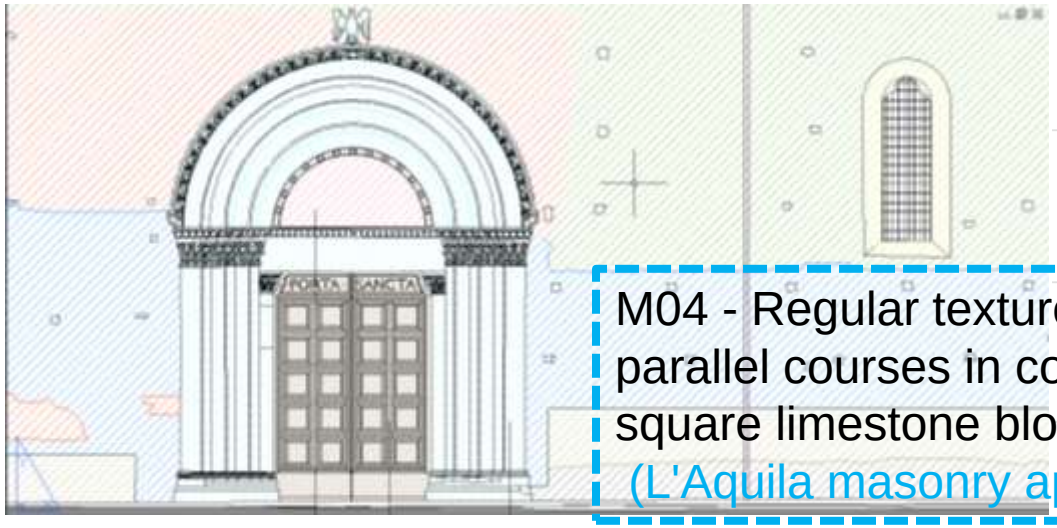




Informative Models

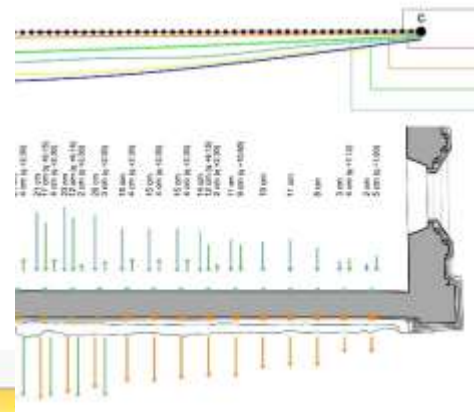
HBIM DB Materic analysis





	Symbol		Description	Layout	Texture information
ID-CODE	Stone Masonry Walls (M)				
100		M01	M01 - Regular limestone blocks masonry with white and pink color		base x height (cm): 22.0x20.0; 32.0x20.0; 48.0x20.0
101		M02	M02 - Chaotic masonry texture composed by bricks and stone elements with different size		base x height (cm): 22.0x24.0; 34.0x24.0; 32.0x15.0
102		M03	M03 - Rough stone blocks Masonry with different size		base x height (cm): 57.0x32.0; 22.0x32.0
103		M04	M04 - Regular texture with parallel courses in compact square limestone blocks (L'Aquila masonry apparatus)		base x height (cm): 19.0x12.0; 23.0x12.0; 17.0x10.0

M04 - Regular texture with parallel courses in compact square limestone blocks (L'Aquila masonry apparatus)



Tutti gli oggett...

Cerca...

Tabelle

- Decay DataBase
- Materials-Stone Masonry Walls

Decay DataBase | Materials-Stone Masonry Walls

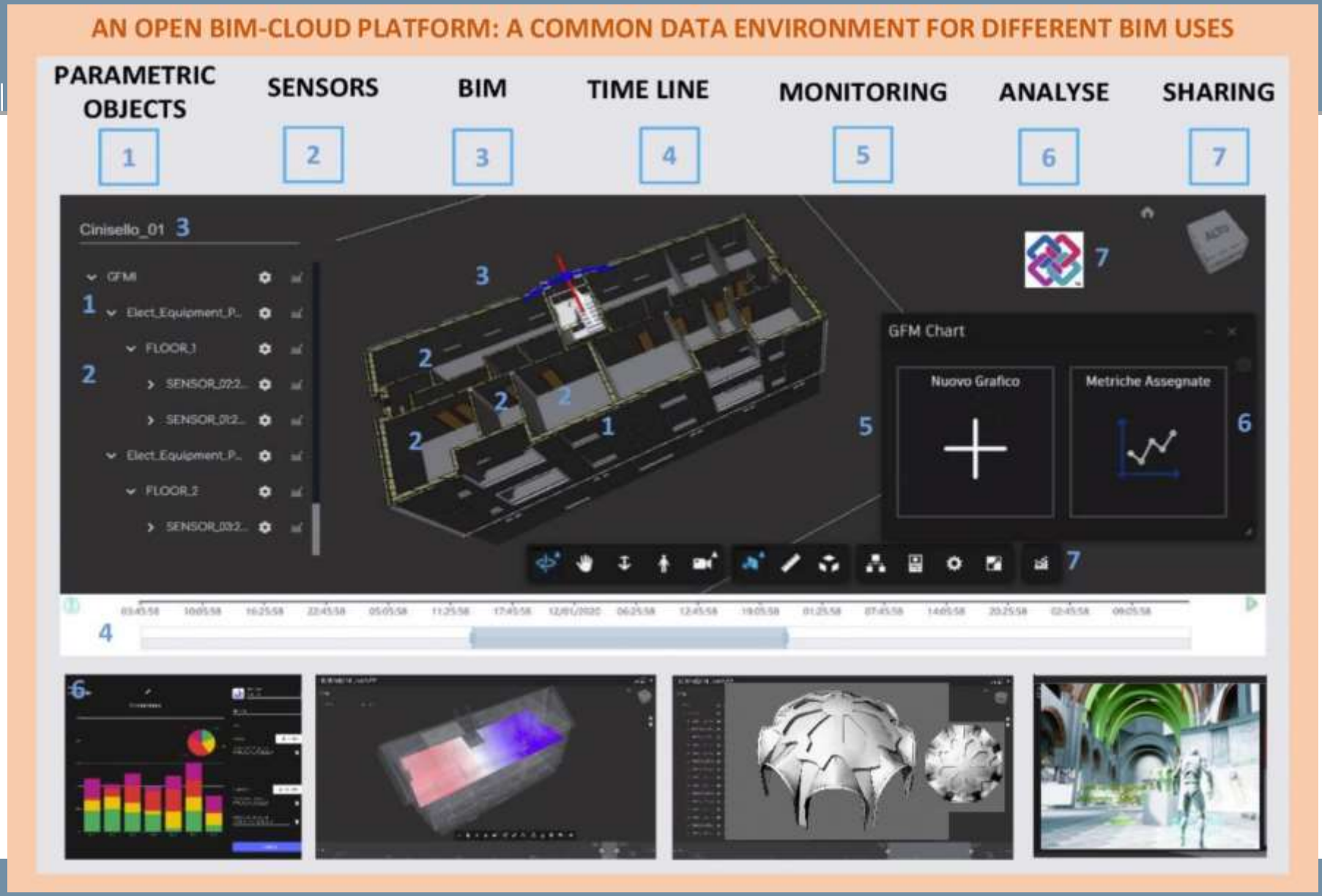
ID	Legend (Mat	Type	COD	ID-CODE	ID_	Description		
1	Ma	Stone Masonry	M	101	M01	M01 - Regular limestone blocks masonry with white and pink color		base x height (cm): 22.0x20.0; 32.0x2(
2	Ma	Stone Masonry	M	102	M02	M02 - Chaotic masonry texture composed by bricks and stone elements with different size		base x height (cm): 22.0x24.0; 34.0x2
3	Ma	Stone Masonry	M	103	M03	M03 - Rough stone blocks Masonry with different size		base x height (cm): 57.0x32.0; 22.0x3
4	Ma	Stone Masonry	M	104	M04	M04 - Regular texture with parallel courses in compact square limestone blocks (L'Aquila masonry apparatus)		base x height (cm): 19.0x12.0; 23.0x1
5	Ma	Stone Masonry	M	105	M05	M05 - Masonry apparatus with sub-horizontal courses in compact limestone blocks and flakes (1971 addition)		base x altezza (cm): 26.0x12.0; 16.0x1
6	Ma	Stone Masonry	M	106	M06	M06 - Masonry with irregular stone-blocks and sub-horizontal joints		base x altezza (cm): 19.0x12.0; 23.0x1
7	Ma	Stone Masonry	M	107	M07	M07 - Masonry with large square compact and alveolar limestone blocks		base x altezza (cm): 53.0x24.0; 31.0x2
8	Ma	Stone Masonry	M	108	M08	M08 - Shaped stone elements		base x altezza (cm): 57.0x32.0; 22.0x3
9	Ma	Stone Masonry	M	109	M09	M09 - Regular stone blocks	arch	
10	Ma	Stone Masonry	M	110	M10	M10 – Stone-blocks masonry with different size (reparation)	arch	
11	Ma	Stone Masonry	M	111	M11	M11 - Masonry with compact limestone rough blocks	arch	
12	Ma	Stone Masonry	M	112	M12	M12 - Brick masonry	arch	
13	Ma	Stone Masonry	M	113	M13	M13- Others	arch	


M04 - Regular texture with parallel courses in compact square limestone blocks (L'Aquila masonry apparatus)

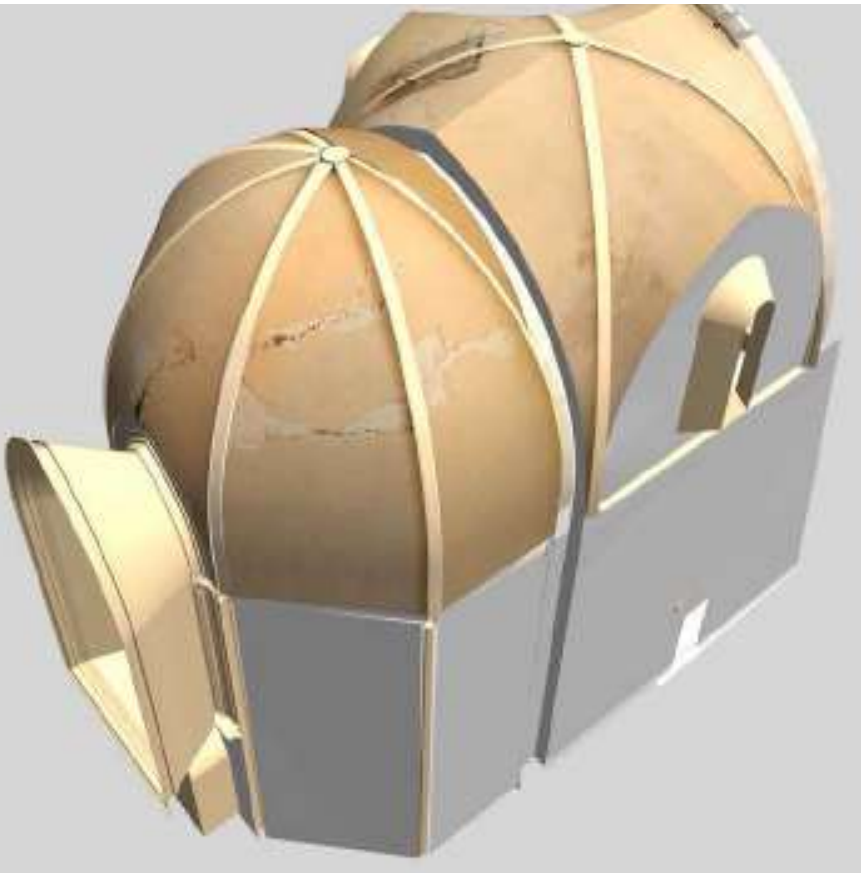
Models and scales quality control

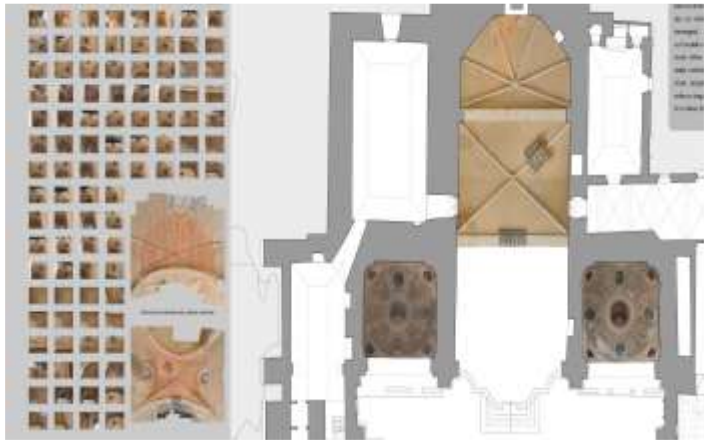
An open BIM-cloud platform: a common data environment for different BIM uses. The bottom-up methodologic workflow: from building scale to complex scenarios (model and information) with different LOG-LOI

Energy efficiency and plants



Complexity matters



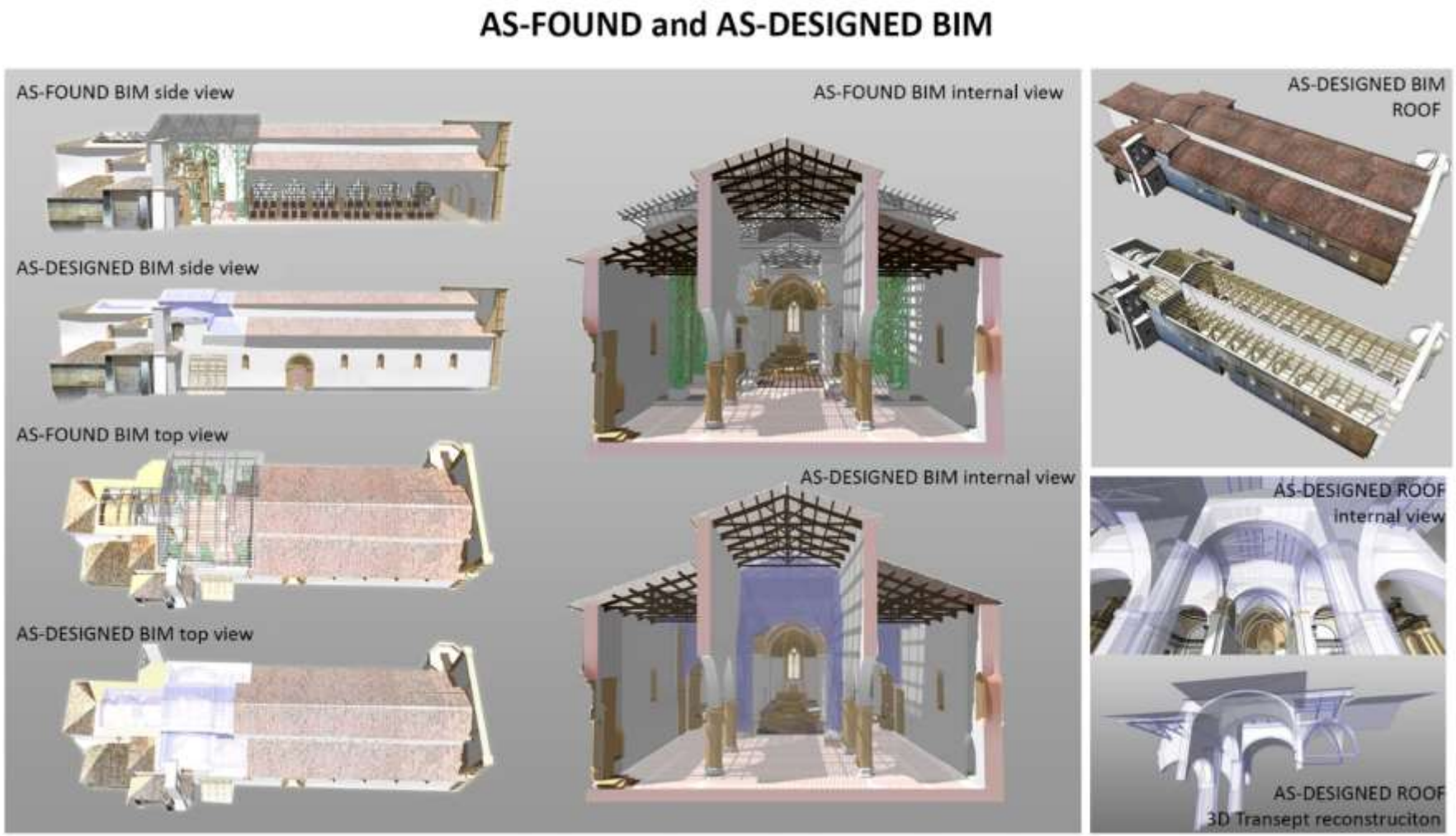


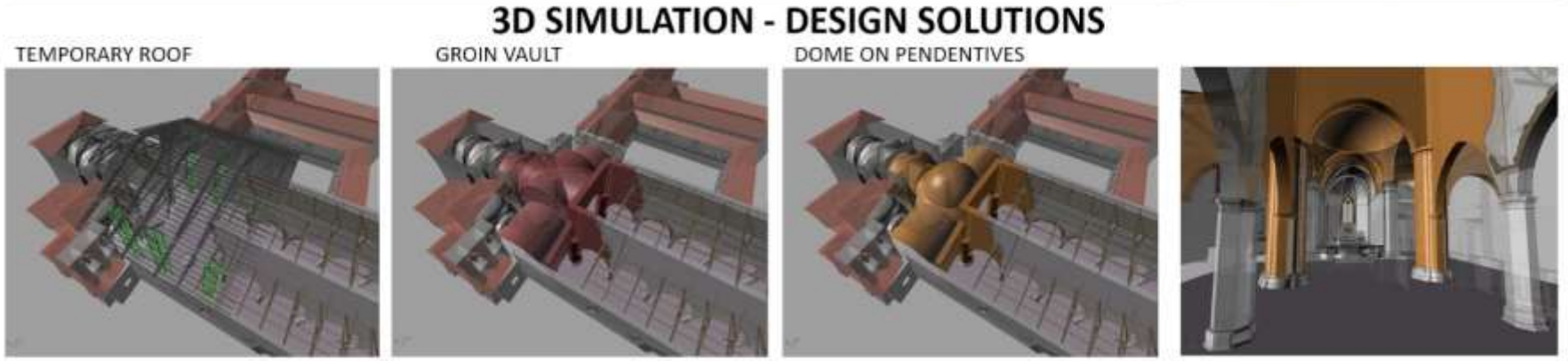
As-design Models

DSS

The different design solutions

3D simulation





Models and scales quality control

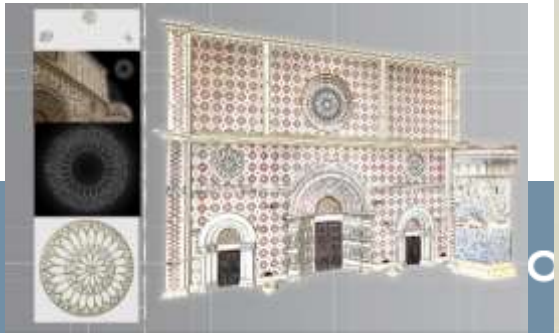
GOA 20 facade modeling GOA5 surface finishing mapping

Il fotopiano è stato realizzato in scala 1:20 con risoluzione 1 pixel=2.5 mm a partire da immagini acquisite con distanza di presa progettata per ottenere immagini a risoluzione geometrica di 2 mm pixel terreno (equivalente a 0.1 mm, ovvero metà errore di graficismo, 0.2 mm alla scala 1:20 come da convenzione cartografica in uso). Il blocco fotogrammetrico è composto da 58 immagini.

Models quality control

GOA 20

GOA 20 facade modeling GOA5 surface finishing mapping

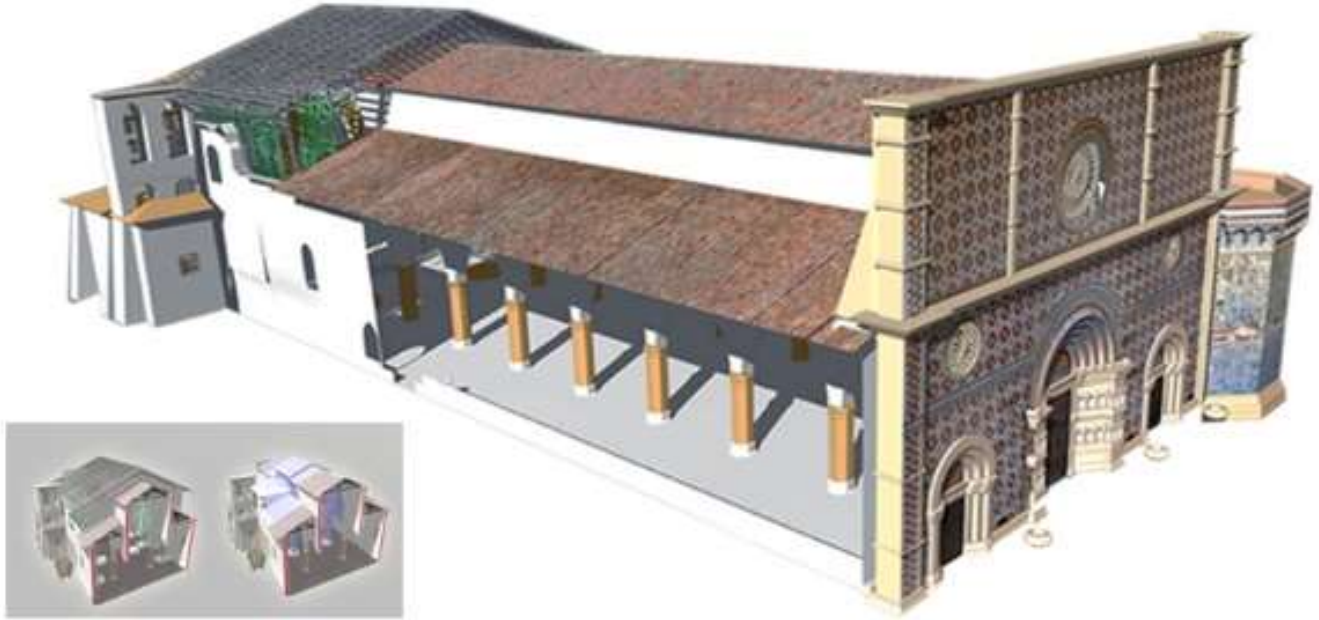


Intangible values communications by mean of content models

Previous hazards (earthquakes) and damages

Different skilled workers capacity building on stone and marble finishing across the centuries

GOA5

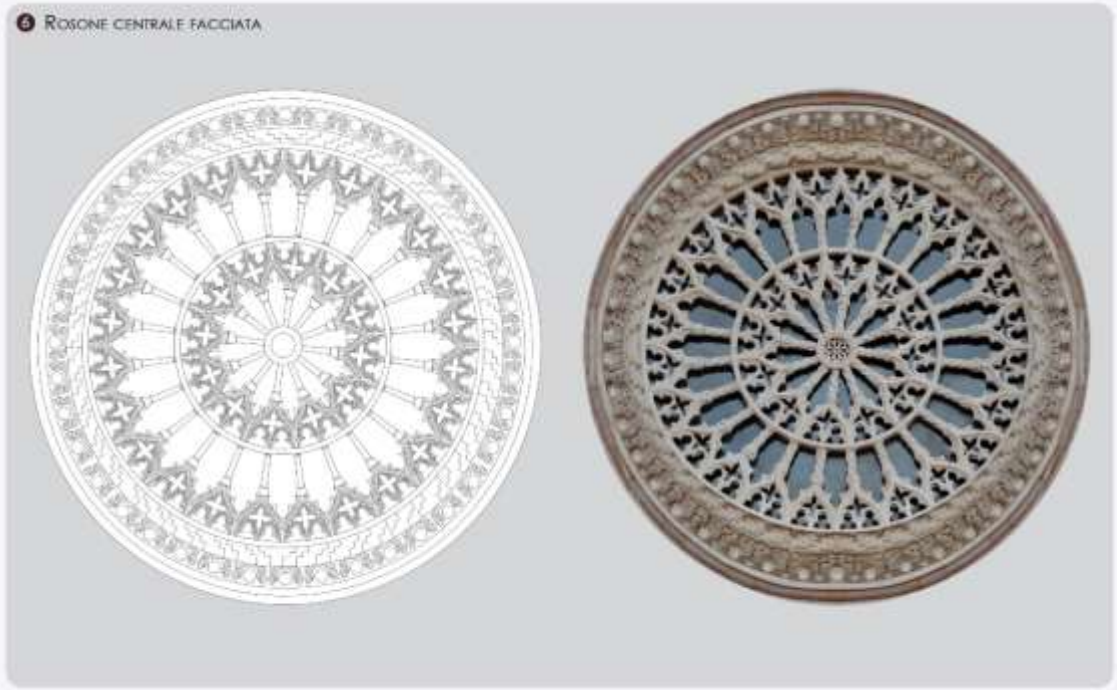


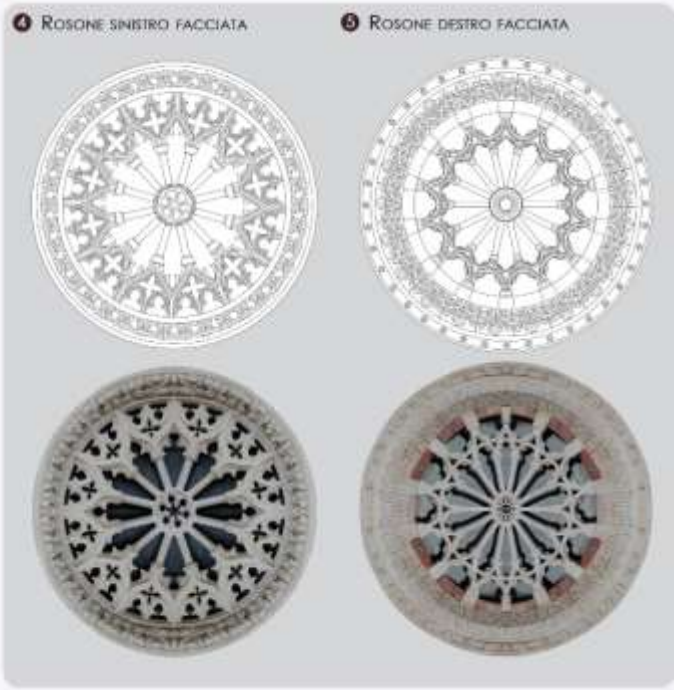
POLITECNICO MILANO 1863

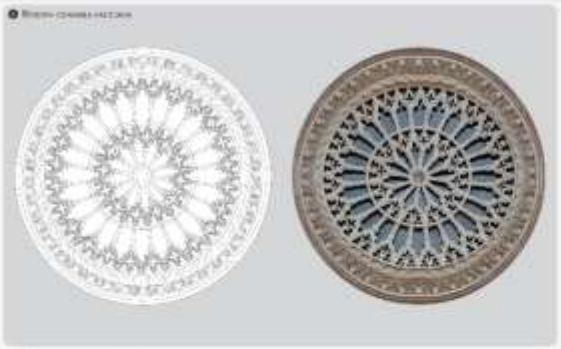
Models managing the complexity of the facade
Stone by stone surveying to detect the different surface finishing and
the simplification process in the different reconstruction

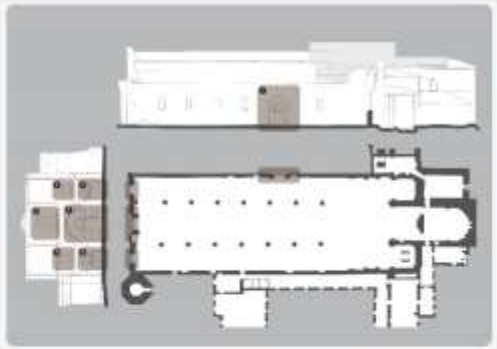
Intangible values communications by mean of content models

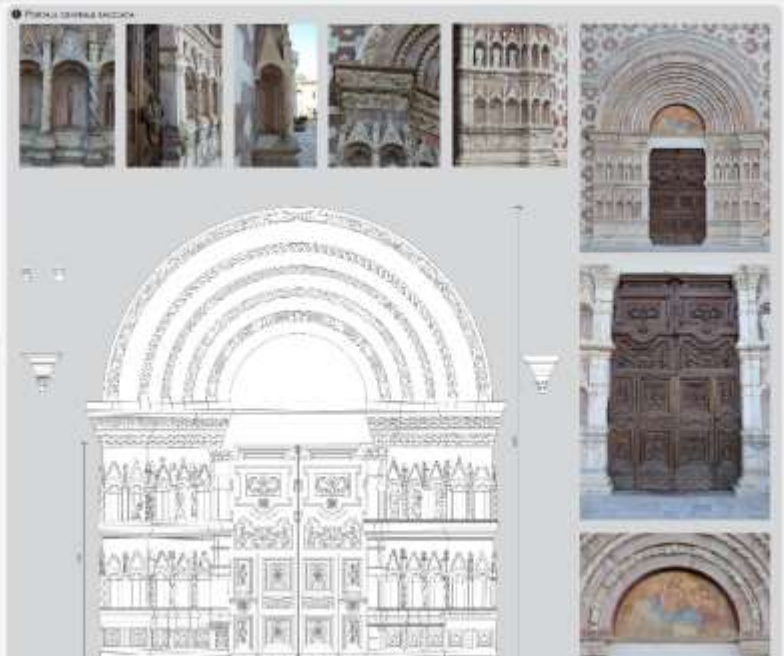
GOA 10

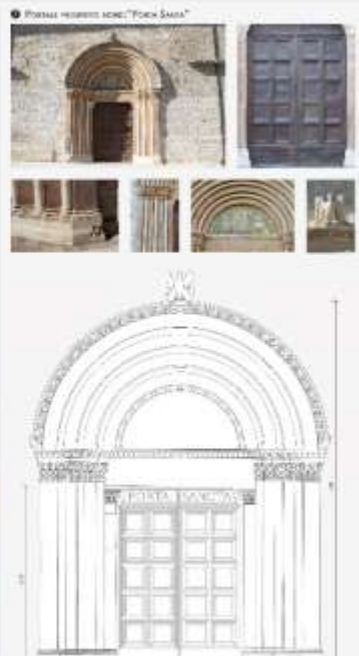












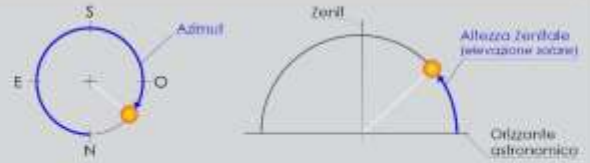
Intangible values communications by mean of content models

Andamento solare durante il giorno dell'Assunzione della Beata Vergine Maria (15 Agosto)

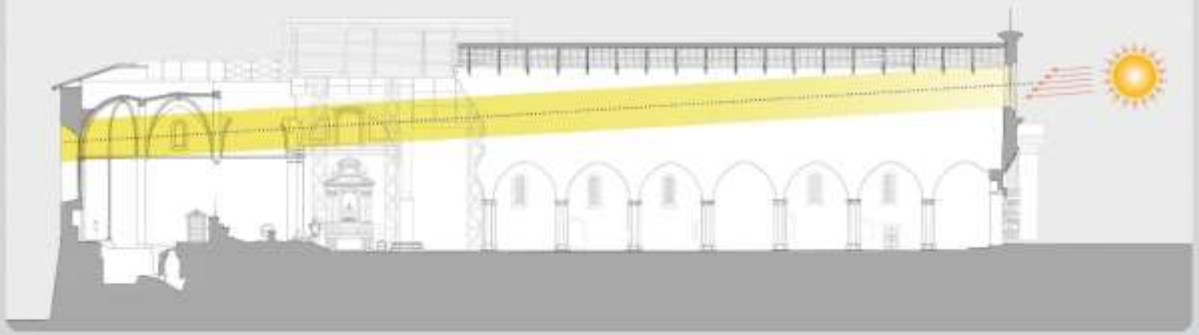
Nel 15 Agosto tra le 19.40 e le 19.50, il sole penetra dal rosone della fronte principale (ovest) e inonda un punto specifico della basilica, più precisamente, cade sulla parte alta della bifora posta nel fronte opposto.

Parametri utilizzati nelle verifiche
Coordinate geografiche basilica:
- latitudine 41° 21' 57" 60 N (pari a 42.366°)
- longitudine 13° 23' 39" 84 E (pari a 13.3944°)

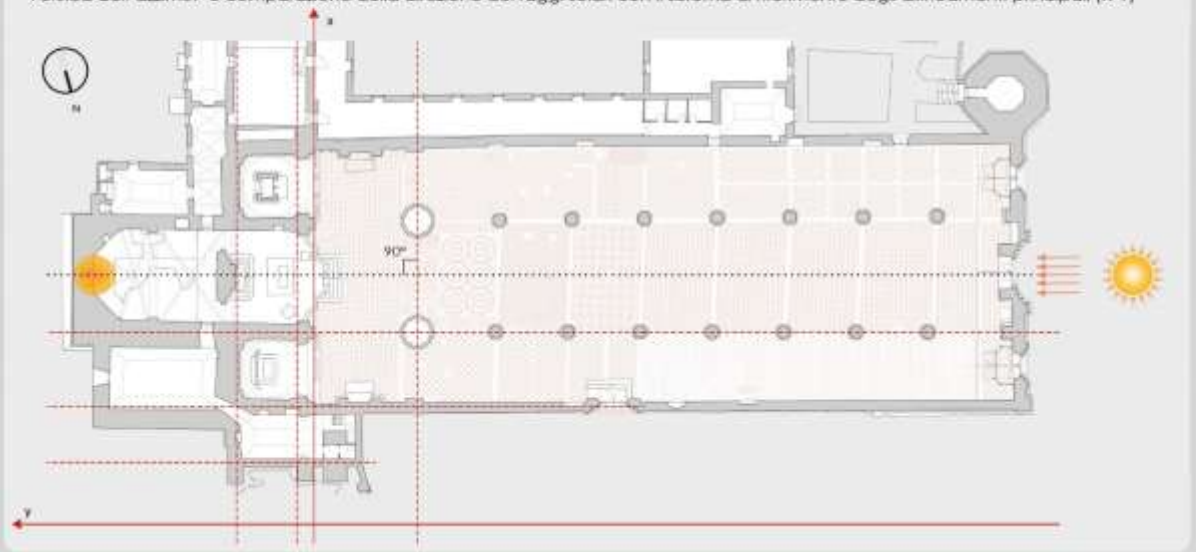
Coordinate astronomiche sole:
- Azimut 286°
- Altezza zenitale (o elevazione solare) 3.4°



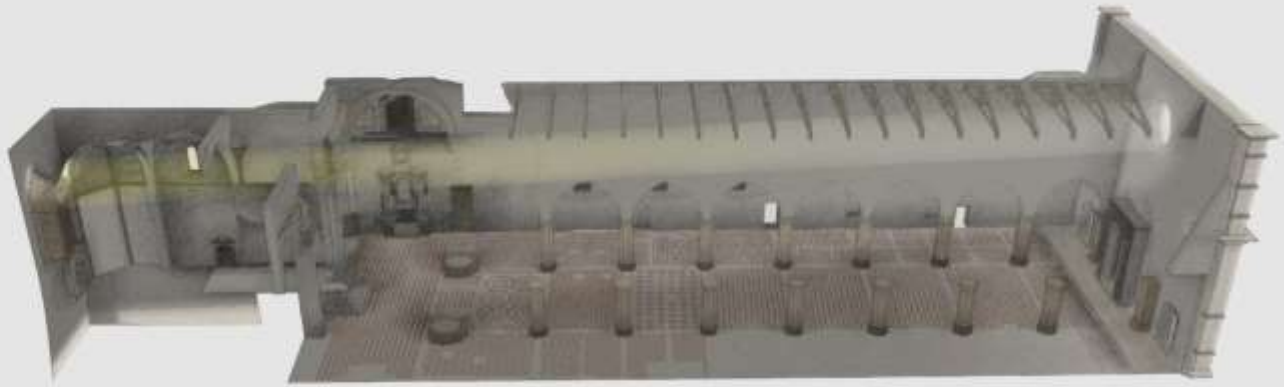
Verifica dell'altezza solare in sezione



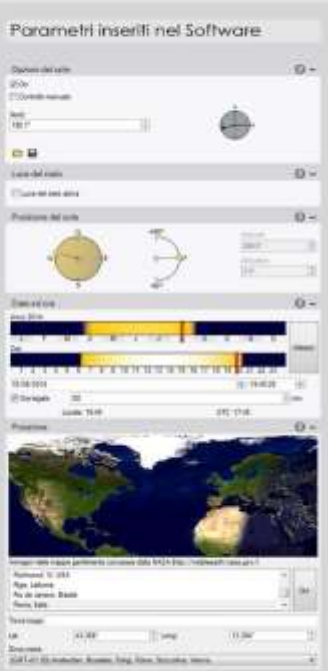
Verifica dell'azimut e comparazione della direzione dei raggi solari con il sistema di riferimento degli allineamenti principali (X-Y)



Simulazione orbita solare col modello 3D



Parametri inseriti nel Software



Complexity matters : toward specifications

Toward the definition of specifications

(GOA-LOG)

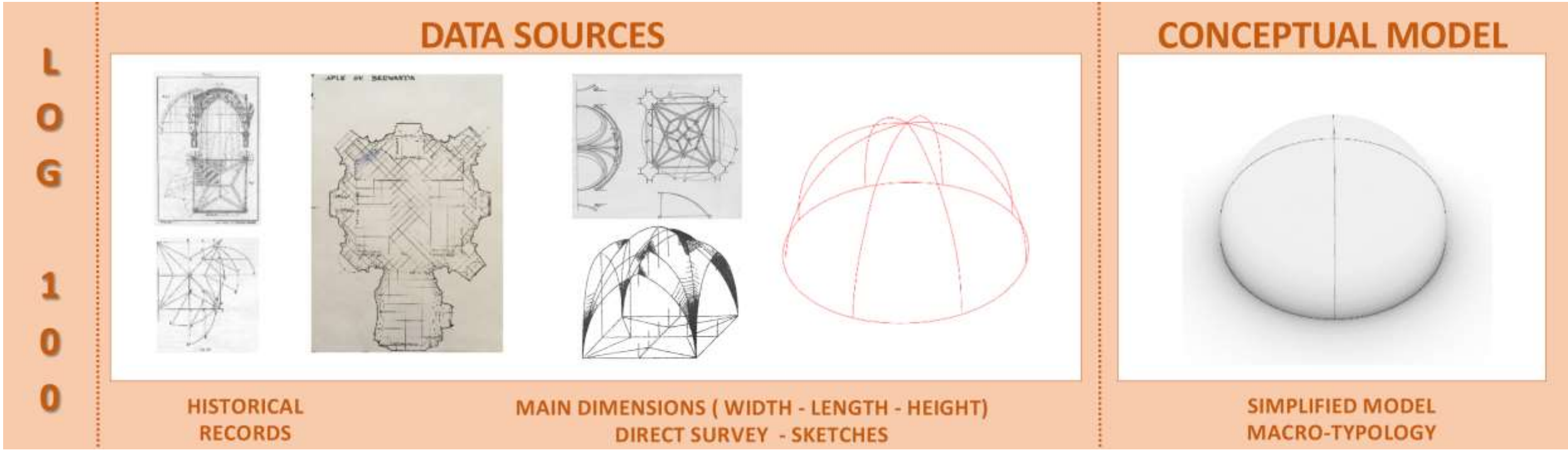
for the generation, use, re-use and communication

of HBIM Object Libraries

in a Common Data Environment

Models and scales quality control :

turning the LOD LOG from new building to Heritage matters



LOG100: historical records and conceptual simplified models decoded from the object and from the treaties

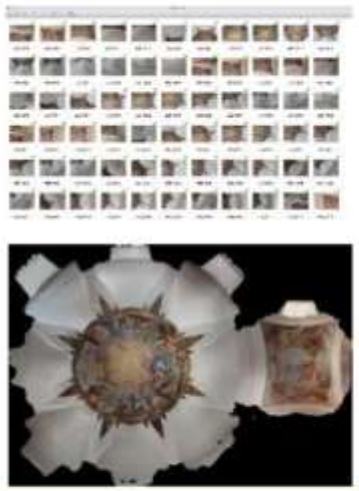
the LODs and LOGs have been turned as follows: the LOD100 (Pre Design) has been addressed to LOG100 “Conceptual model, historical reports and archives”;

Models and scales quality control

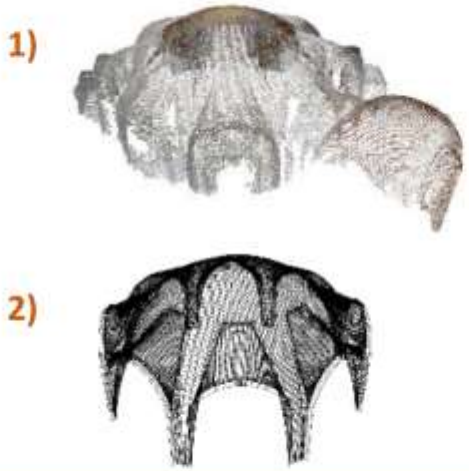
LOG200 (Appropriate geometry, on site data acquisition, 3D survey)

LOG200

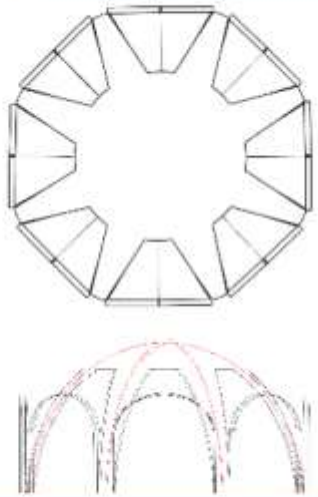
DATA SOURCES – 3D SURVEYING



PHOTOGRAMMETRY ORTHOPHOTO



POINTCLOUDS (1) & MESH (2)



LUNETTE'S GEOMETRY EXTRACTION 2D

SURFACE BASED MODEL

APPROPRIATE GEOMETRY

LOG200 (Appropriate geometry) turned to the **surveying** purpose addressed to support **appropriate geometric analysis**

LOG200 includes surveying
Lidar data (i.e. Terrestrial Laser Scanner)
GEOSLAM Based Mobile Mapping Systems:
Photogrammetric image blocks: such data are commonly used
Output: (2D-3D plans, sections, fronts), 3D meshes, DTM, TIN, Orthophoto clouds, meshes, orthophoto, 3D textured meshes, local 2D profiles, plans and sections.

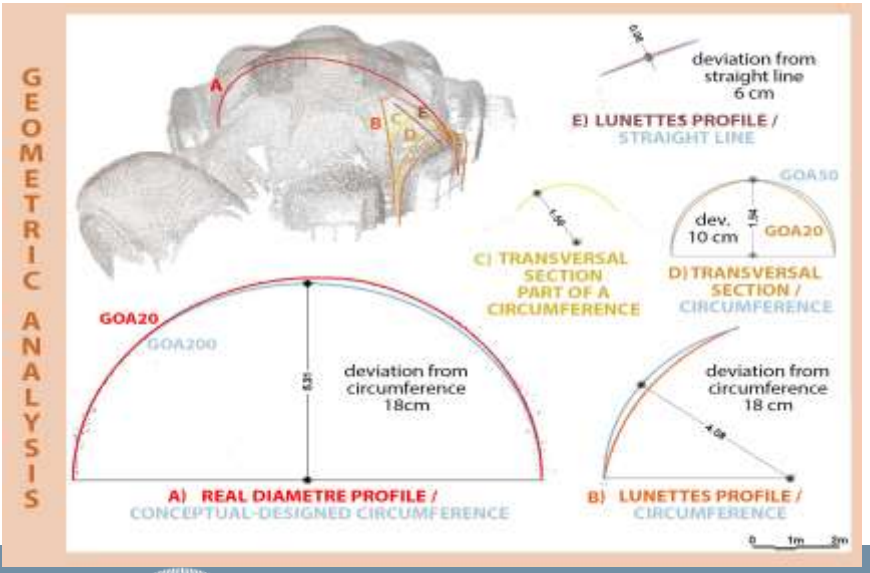
Models and scales quality control

LOG300 (Precise Geometry): SCAN-to-BIM MODEL OBJECT

LOG300 (Precise Geometry, SCAN-to-BIM model object) (As-found HBIM model). On the left: the HBIM model generation process adopting different GOAs. LOG300 for the HBIM of St. Bernard's chapel star vault models with different Grades of Accuracy correspondent to the scales (GOA20-50-10) and the **data model validation (AVS).**
On the right the LOI information process and HBIM parameters with the **GOAs** attributes

Complexity matters :
Geometry + Matericity matters

Grade of Accuracy to properly detect the geometry and construction techniques



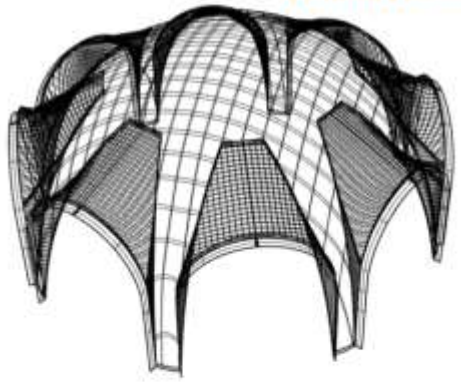
Grade of Accuracy to properly detect the geometry + materials + construction techniques

THE RESEARCH CASE STUDY (GOA 20 AND 50)

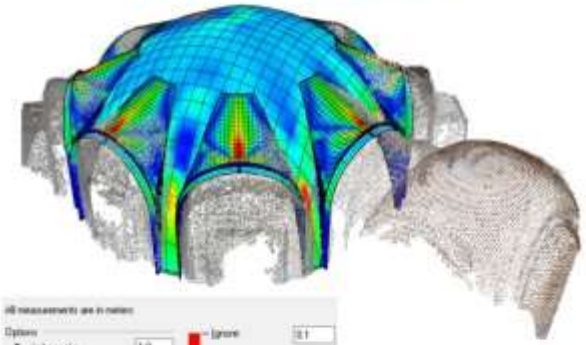
GOA 20 INTRADOS

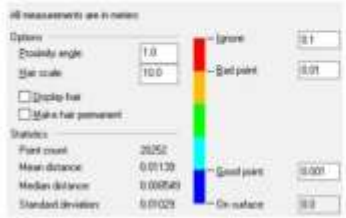
Point cloud

WIREFRAME MODEL



MODEL based on GOG 10

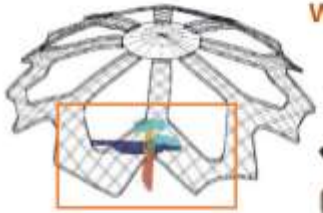




GOA 50 EXTRADOS

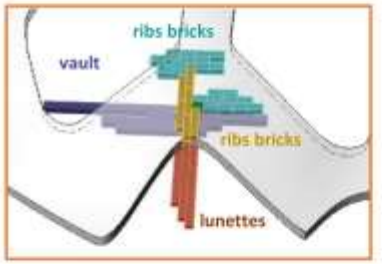
Point cloud

WIREFRAME MODEL

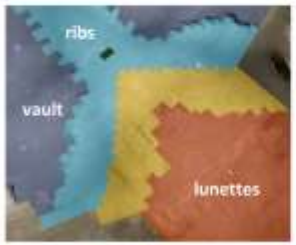


ORTHOPHOTO

GOA 10 FOCUS ON BRICK ARRANGEMENT

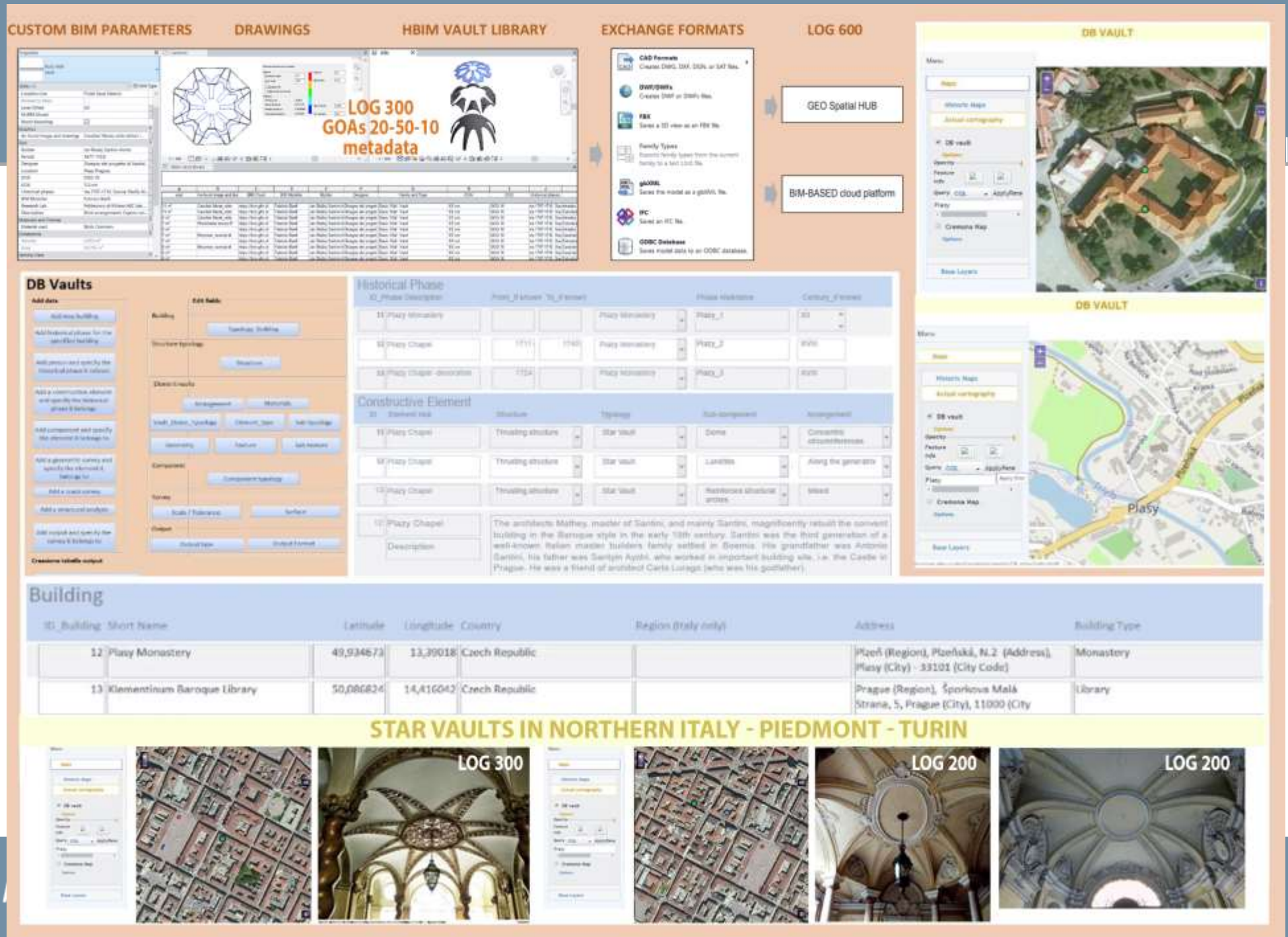


lunettes bricks
ribs bricks
parallel to lunettes
ribs bricks
parallel to vault
header
vault bricks



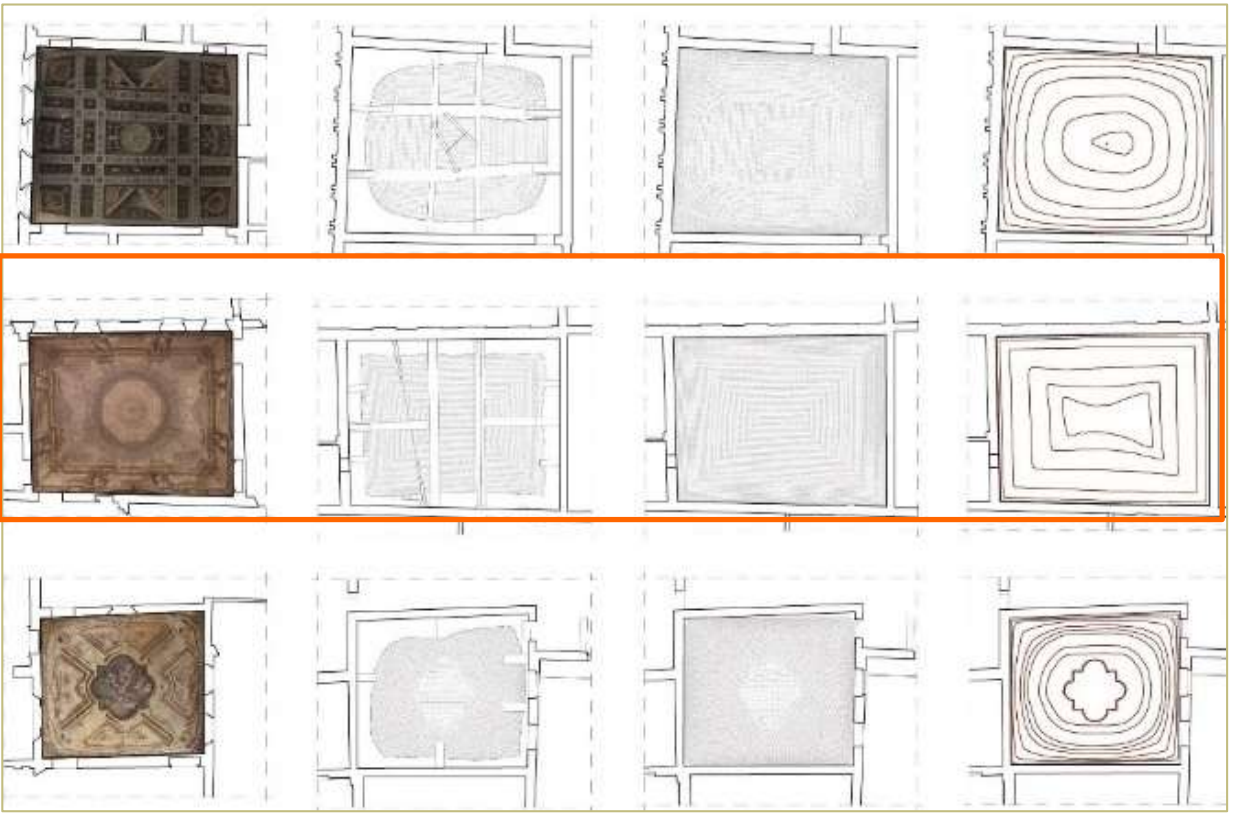
Quality control to re-use and share content models

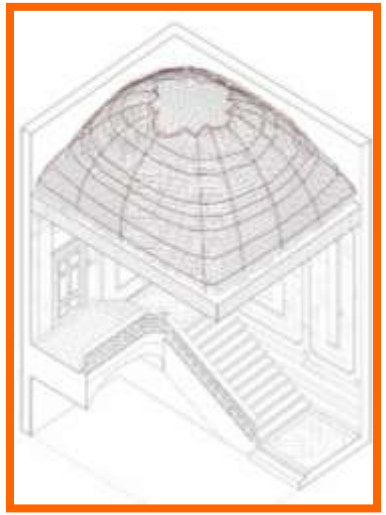
Linked HBIM vault library and its exchange formats for LOG 600 though the Geospatial Hub and the BIM based cloud platform (upper). The GeopanAPP implemented within the Geospatial Virtual Hub with the Vault GEODB and linked HBIM object libraries. Queries based on the GeoDB can be performed correlating the different objects libraries (in this case the Plazy St. Bernrd Chapel with some star vaults in Northern Italy, and the GOAs information)



POLITECNICO

Models matters: geometry + arrangement + construction technologies rediscovery





Proprietà

Muro di base
Volta_Scalone

Muri (1) — Modifica t

Livello di riferimento	00_Piano Terra
Linea di ubicazione	Superficie di finitura: esterno
Relativo a massa	☐
Offset del livello	0.0000 m
Delimita il locale	☑
Testo	
02_Structure	Trusting Structure
03_Typology	Vault
04_Construction Technology	Degenerative
08_Arrangement	Course - Harringbone
10_Materials	Bricks
13_Texture	A coltello
11_Geometry	Circumference
00_ID_Element	EL_2
05_Sub-typology	
01_Element_nick	Stairs - Hall
07_Elements	
09_Arrangment description	Arches rotated by 45° to the major axis o...
12_Building	Palazzo Magio_Grasselli
14_Sub-texture	Single texturing
15_Description EN	Thin pavillion vault degenerative to dome
15_Description IT	Volta sottile a padiglione degenerativa i...
16_Bibliography	
06_Room Code	1.26

Models and scales quality control

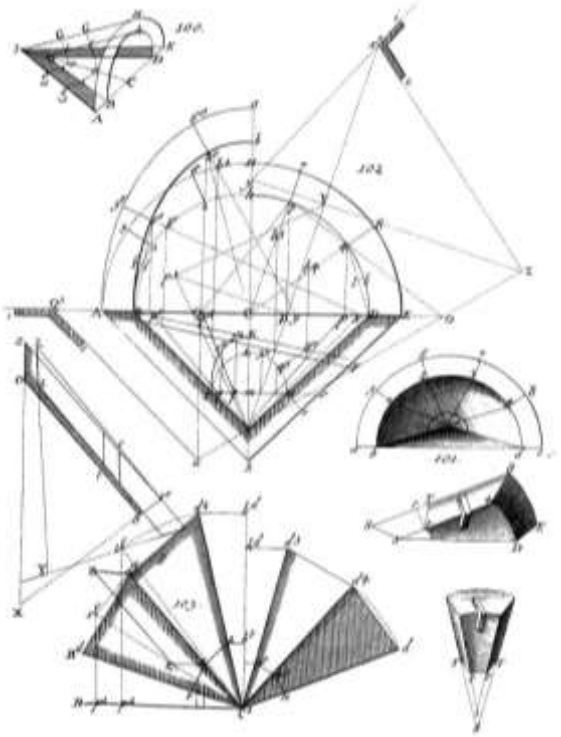
Non Destructive Techniques NDT > i.e. IRT Infrared Thermal Images to detect the texturing and arrangement under plaster

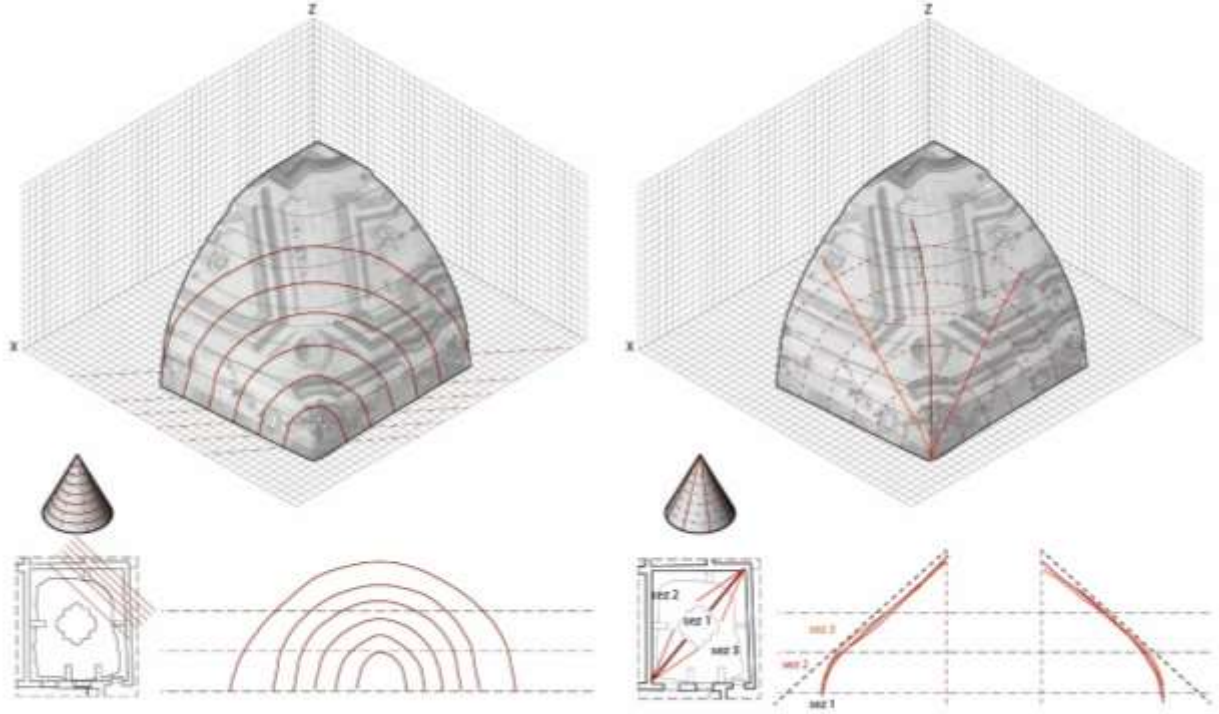
3 ‘similar’ construction solutions obtained on the common ‘**cloister**’ typology. some details of the 2 deviations: the Manfredini Hall, Closter - to –Trompe solution (centre), and the Stair Hall, Cloister-to-Dome-to Trompe corners (below); Magio Grasselli Palace.

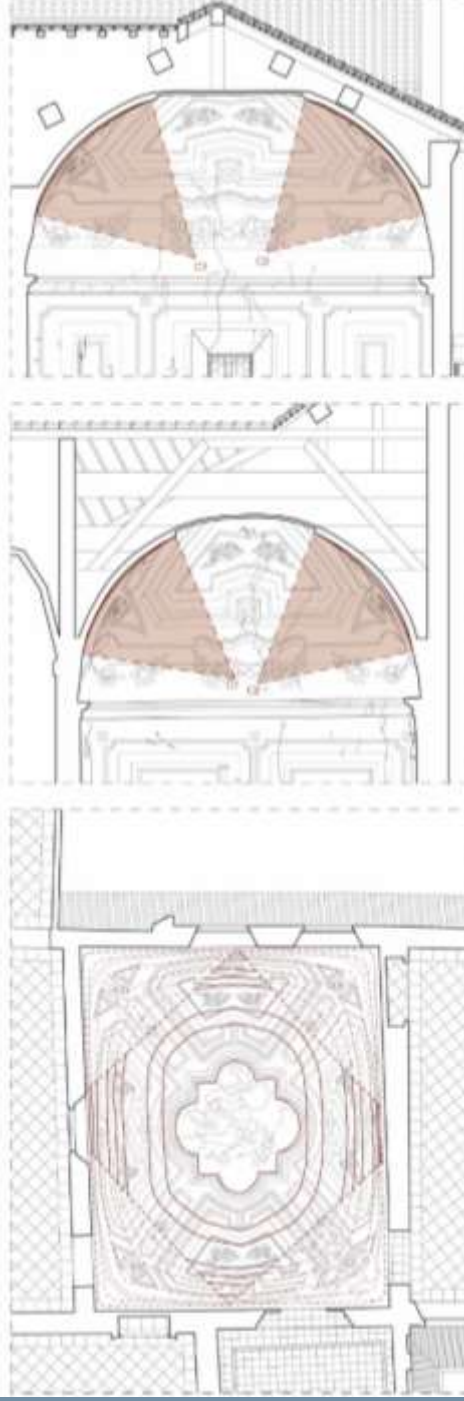
Models and scales quality control

Models and scales quality control

Geometry to detect the construction phases







Treaties roles and theoretical geometry to manage the spatial construction :

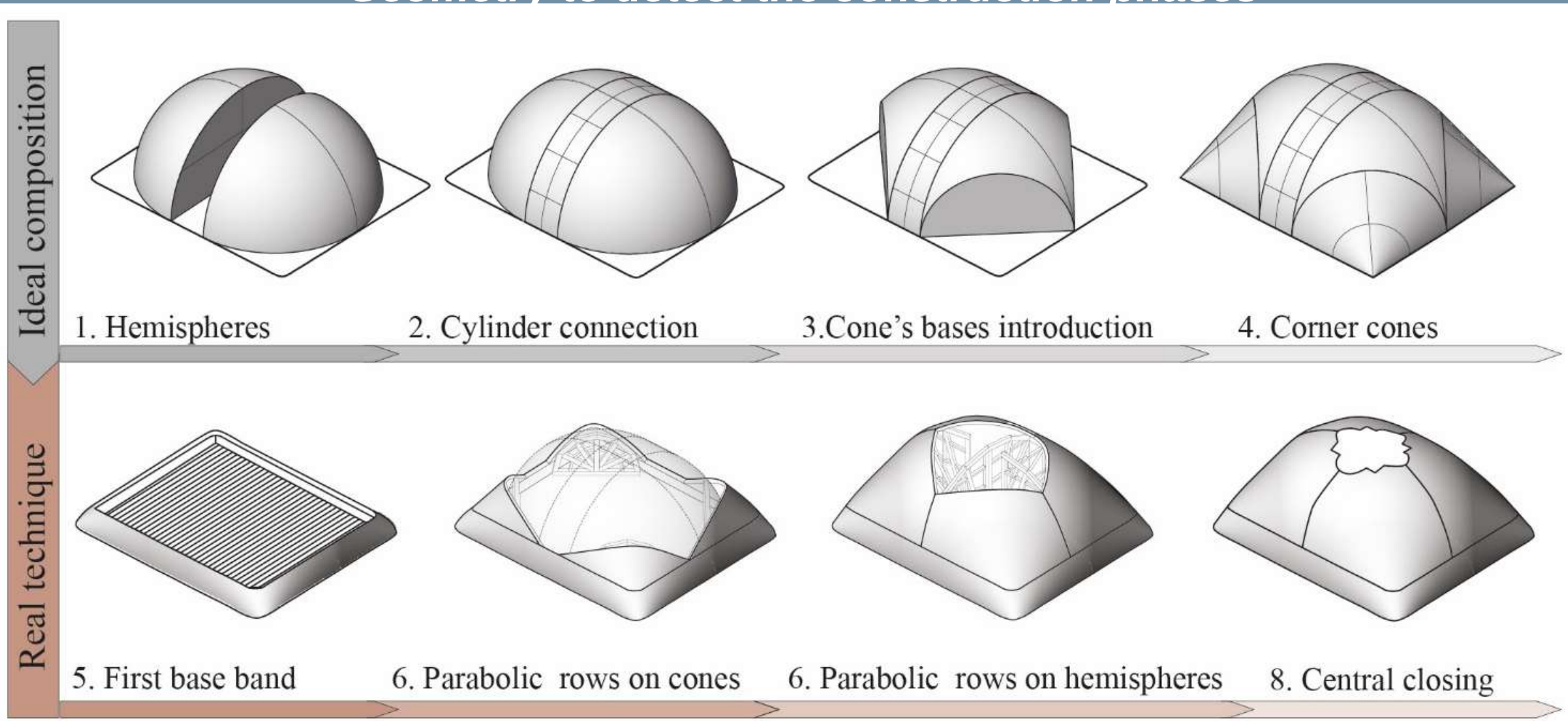
Trompe (Guarino Guarini)

The geometric model analysis GOA10

Double curvature solid to limit the centrings

Models and scales quality control

Geometry to detect the construction phases



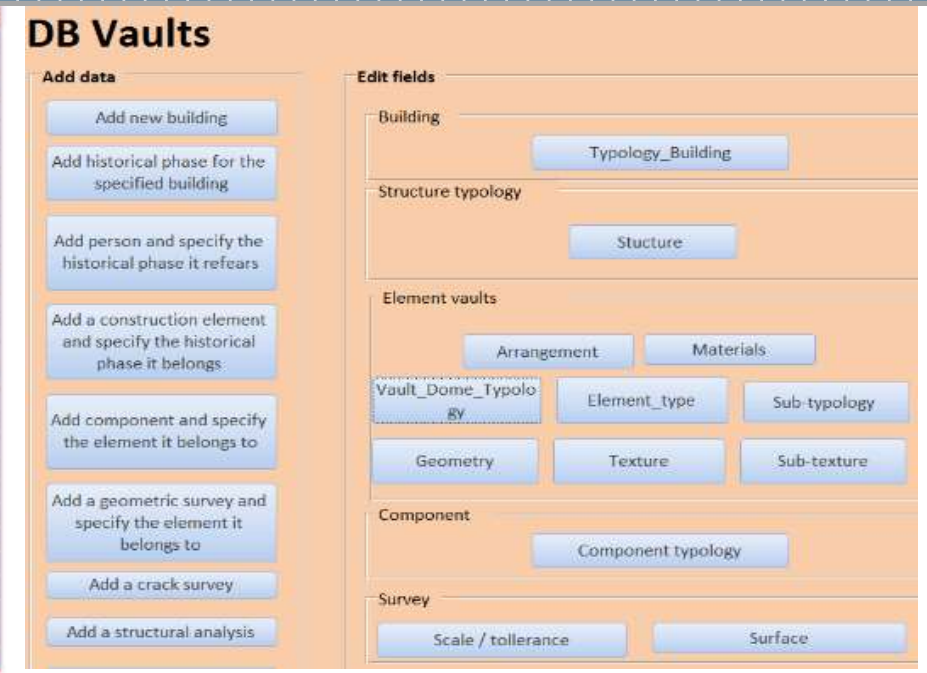
Sharing model data > enriched metadata

the added value of vocabularies in the creation of common shared knowledge

Vault and Dome Construction Typology
Arch and Vault (mixed)
Barrel Vault
Cloister to Dome (centre)
Cloister to Trompe (corners)
Cloister Vault
Cloister-Pavillion Vault
Dome
False Dome
False Vault
'Frenelli'
Groined Vault
Lintel (Filler Tiles)
Lowered brick tile vaults and iron girders
Lunette
Others
Pavillion Vault on circular plan
Pendentive Dome
Planterian Vault

The Vault Data Base with the different description tables related to the Buildings, the Typologies and the Historical Phases of the vaulted systems. The DB has been populated by the HBIM information gathered.

The vault vocabulary derived from the HBIM of palace (the Magio Grasselli Palace in Cremona):
the bottom up process will allow to compare different HBIM nodes within the Hub platform.



POLITECNICO MILANO 1863

Models and scales quality control Quality control to re-use and share content models

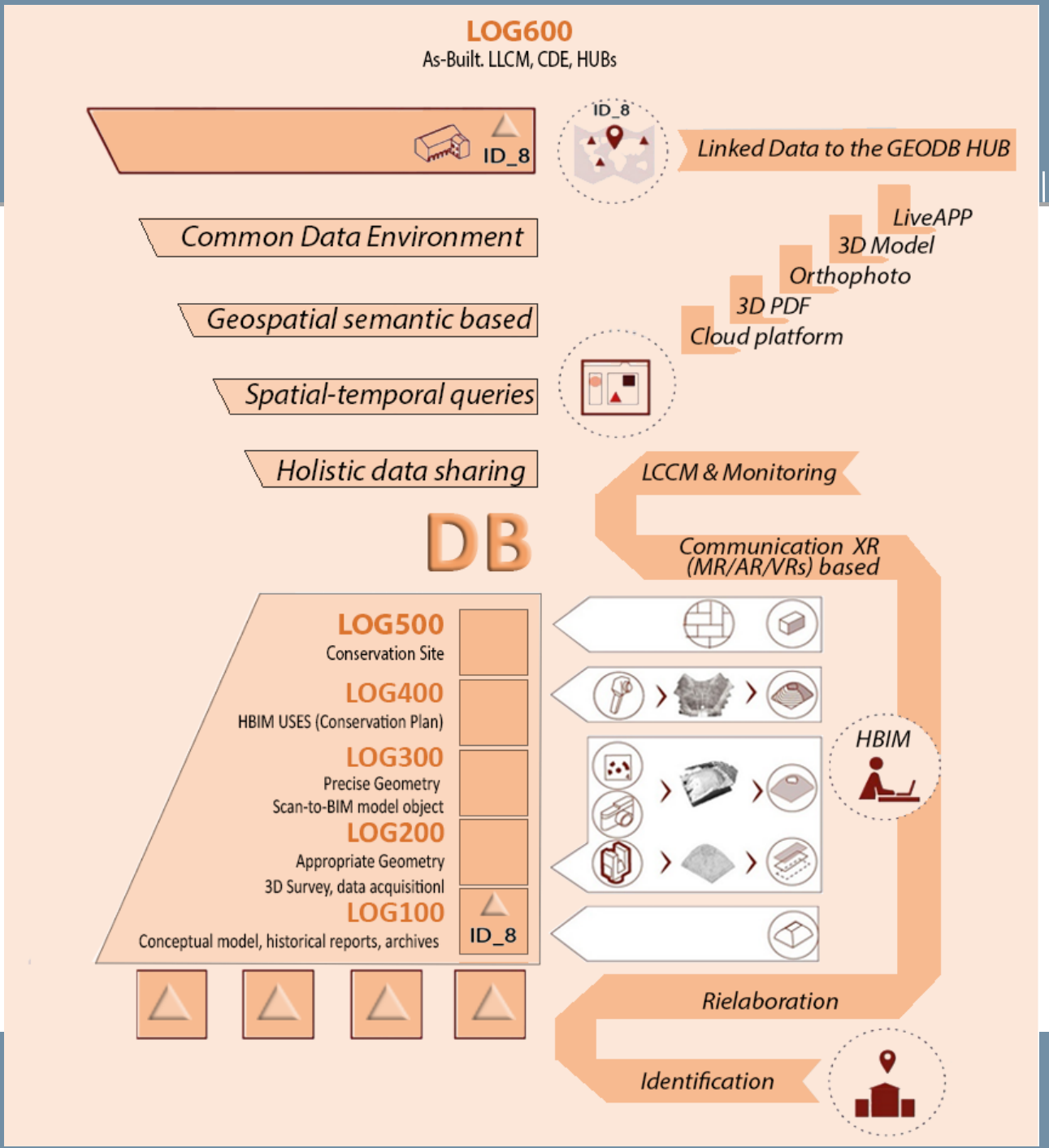
LOG 600: GeoSpatial Virtual Hub with Linked HBIM implementation to manage Object Libraries and a BIM-based collaborative cloud platform

LOG600:
the work flow of the single **object libraries sharing** data by mean of:

- **GEODB Virtual Hub**
- **Common Data Environment**

to support:

- **Life Cycle Management and Monitoring continuously fed up by sensors**
- **Communication purposes to large public**



ENRICHED CONTENT Models > transferring the complexity of the knowledge gained toward communication purposes MR

GIcarus LAB (4D BIM - HBIM - WEBGIS - SDI)

Geospatial Information Content modeling: Architectural heritage &built environment, eUrbanAtl@s, Data Surveying

Research group:

Raffaella Brumana - Scientific Responsible, Daniela Oreni - Project Manager, Architectural and Built Environment Content Modelling&Interpreting HBIM, Fabio Roncoroni - Monitoring, - Luigi Barazzetti- Photogrammetry Mattia Previtali - Laser Scanner ORR GIS, Branka Cuca -WebGIS, SDI, INSPIRE Fabrizio Banfi - 4D Modelling BIM, Riccardo Valente - Archaeological HBIM, Carlo Savi - IT System Manager

Office: **-GIcarus**, *Surveying&Modelling* – Campus Leonardo Via Ponzio, 31 20133 - Milan, Italy Ph. +39 02 2399 6513

-GIcarus, IC&T Surveying, *Surveying&Monitoring* - Polo Regionale di Lecco, Via Gaetano Previati 1/c, 23900 Lecco, Italy Ph. +39.02 2399 6534 /8778