Metodologie e tecnologie digitali per il rilievo 3D nel settore dei Beni Culturali

Cristiana Achille | *Politecnico di Milano*

Venerdì 1 dicembre 2023 | Friday, December 1, 2023 Castello Sforzesco di Milano | Sala Biblioteca Bertarelli | Piazza Castello Milano

Patrimonio Culturale Italiano

D. L. 22 gennaio 2004, n. 42 Codice dei beni culturali e del paesaggio, ai sensi dell'art. 10 Legge 6 luglio 2002, n. 137 - ***Articolo 2 - Patrimonio culturale***

1. Il patrimonio culturale è costituito dai beni culturali e dai beni paesaggistici.

2. Sono beni culturali le cose immobili e mobili che, ai sensi degli articoli 10 e 11, presentano interesse artistico, storico, archeologico, etnoantropologico, archivistico e bibliografico e le altre cose individuate dalla legge o in base alla legge quali testimonianze aventi valore di civiltà.

3. Sono beni paesaggistici gli immobili e le aree indicati all'articolo 134, costituenti espressione dei valori storici, culturali, naturali, morfologici ed estetici del territorio, e gli altri beni individuati dalla legge o in base alla legge.

4. I beni del patrimonio culturale di appartenenza pubblica sono destinati alla fruizione della collettività, compatibilmente con le esigenze di uso istituzionale e sempre che non vi ostino ragioni di tutela.

SCANNER SURVEY

Design of survey

Acquire scans

Data processing

Make a 3D model

PHOTOGRAMMETRIC SURVEY

Design of survey

Acquire images

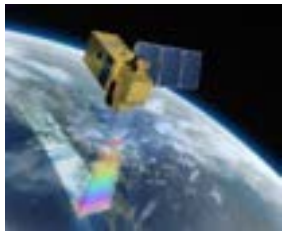
Data processing

Make a 3D model

Non-invasive techniques

Active | **Passive**

Remote sensing



Aerial/ drone

600-800 km

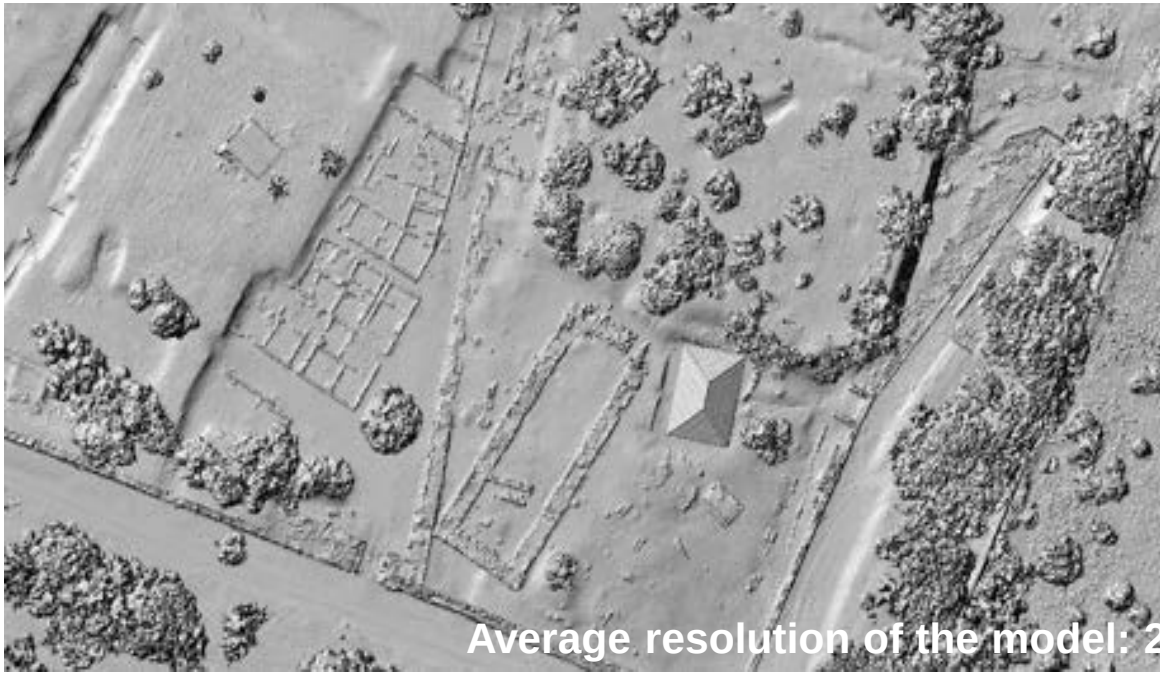
Close range

Underwater photogrammetry

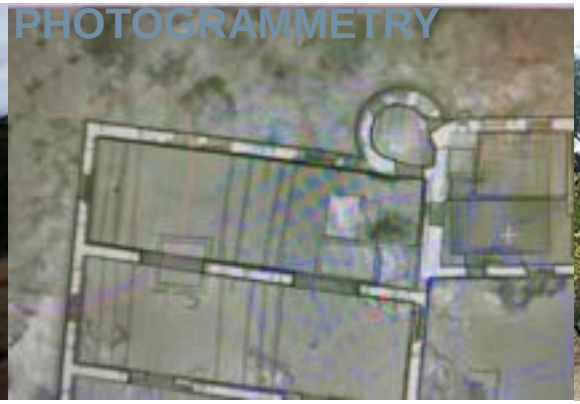
-100m

…what is the goal?

Area archeologica di Naxos
Parco archeologico Naxos–Taormina.

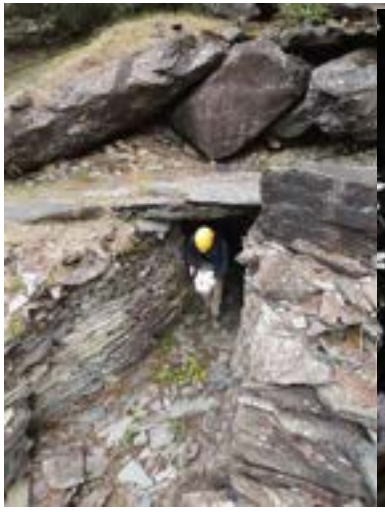


MOBILE MAPPING – CLOSE RANGE

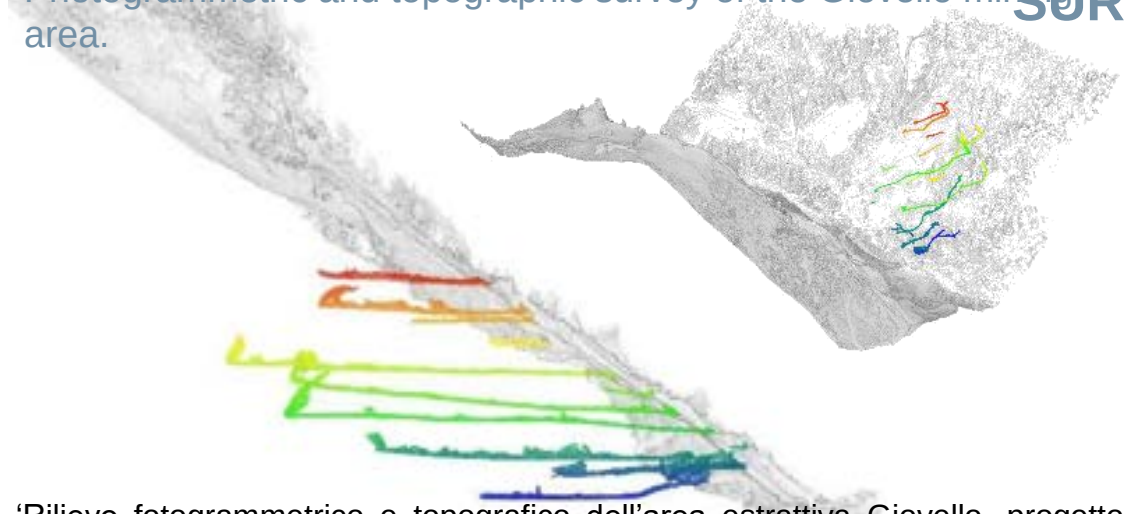


Bando PNRR - Missione 1 - Digitalizzazione,innovazione, competitività e cultura Componente 3 - Cultura 4.0 (M1C3- 3) Misura 1 - Patrimonio culturale per la prossima generazione Investimento 1.2– NextGenerationEU.

MOBILE MAPPING – CLOSE RANGE PHOTOGRAMMETRY – ANT3D system PROTOTIPE



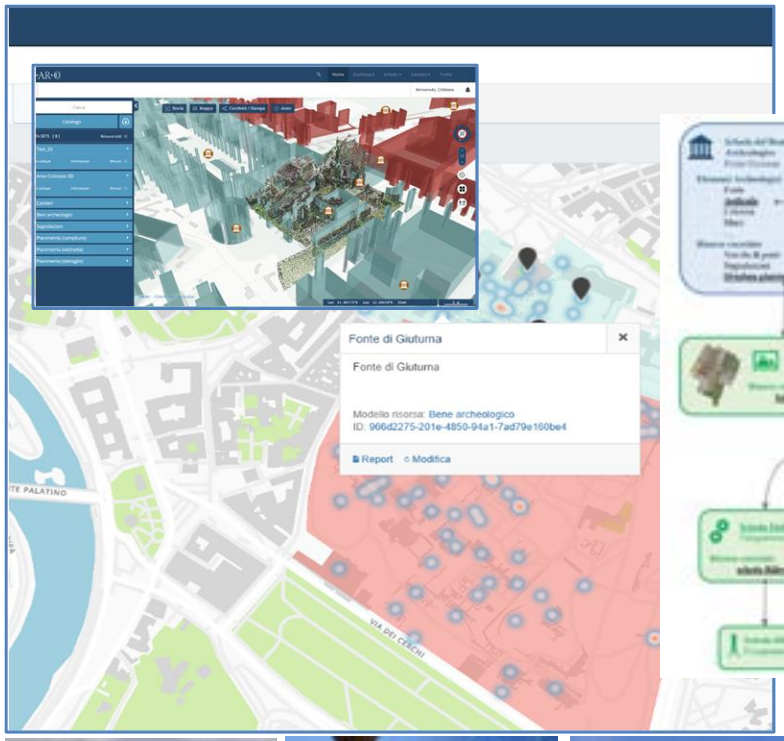
Photogrammetric and topographic survey of the Giovello mining area.



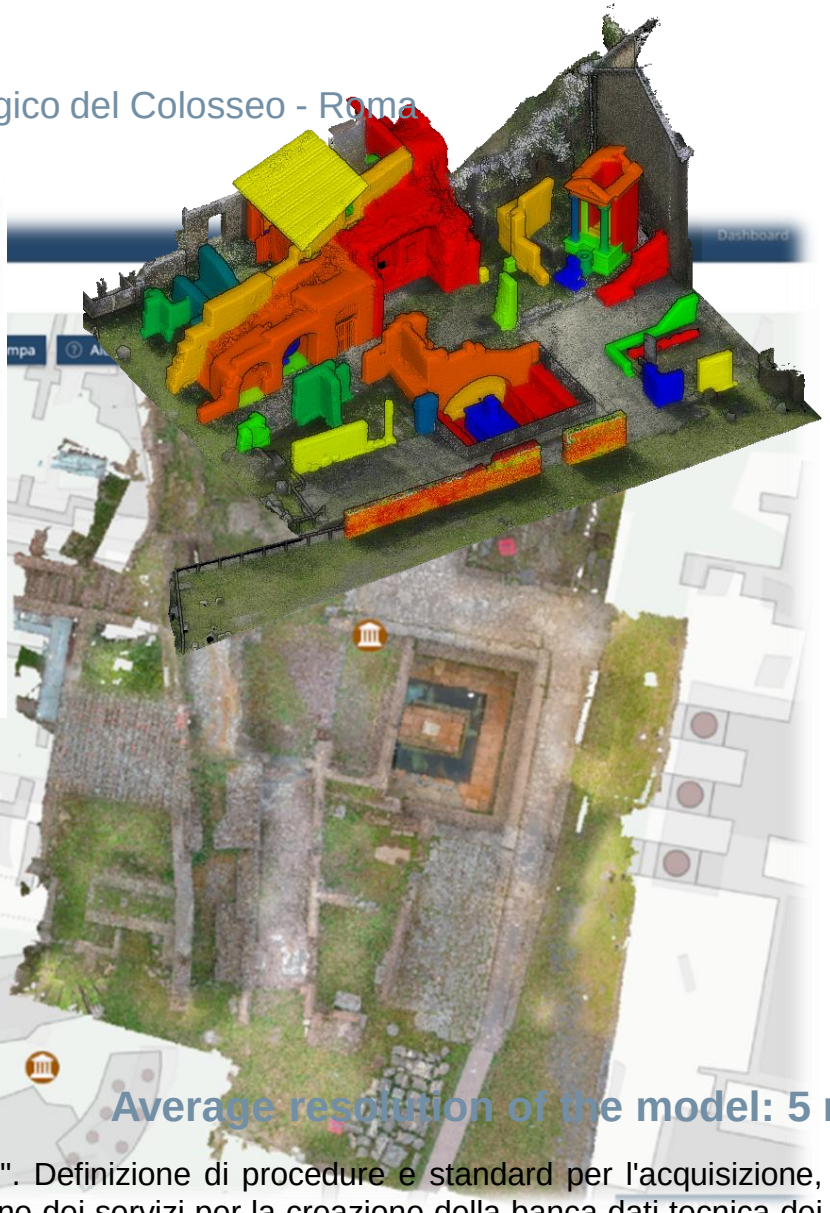
SURVEY OF UNDERGROUND SPAC

Average resolution of the model: 2cm

'Rilievo fotogrammetrico e topografico dell'area estrattiva Giovello, progetto B-ICE & Heritage (Bernina Ghiacciai e Patrimonio). Attività: rilievo per la restituzione di ortofoto e modelli 3D; rilievo dei bocchelli delle gallerie. Metodo di rilievo fotogrammetrico sperimentale (Brevetto n° 102021000000812 - ANT3D System – Fassi-Perfetti).



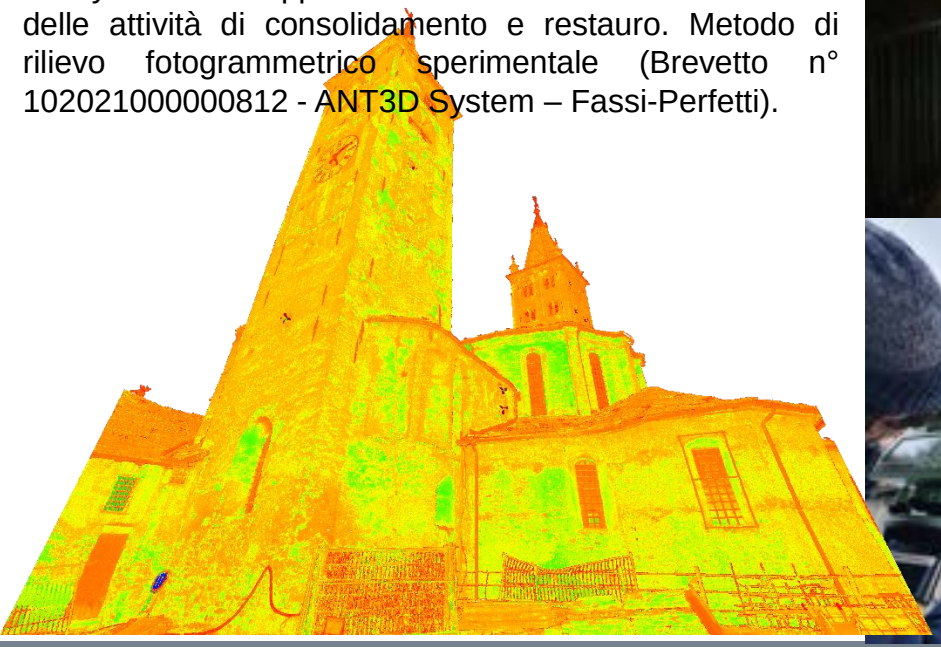
Parco archeologico del Colosseo - Roma



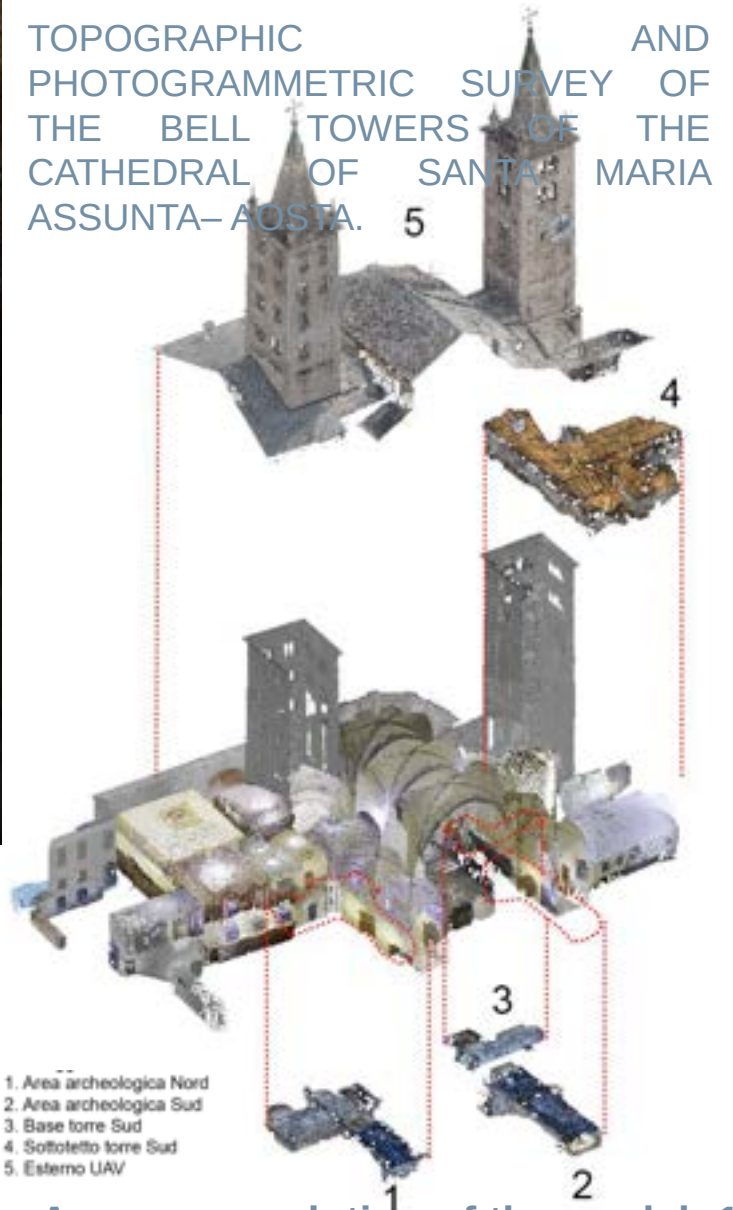
Average resolution of the model: 5 m

"Linee guida per la digitalizzazione del Parco Archeologico del Colosseo". Definizione di procedure e standard per l'acquisizione, l'archiviazione e l'utilizzo dei dati di rilievo e dei modelli HBIM. Assegnazione dei servizi per la creazione della banca dati tecnica dei monumenti del Parco Archeologico. gestione dei dati attraverso il sistema informativo web-based del Parco.

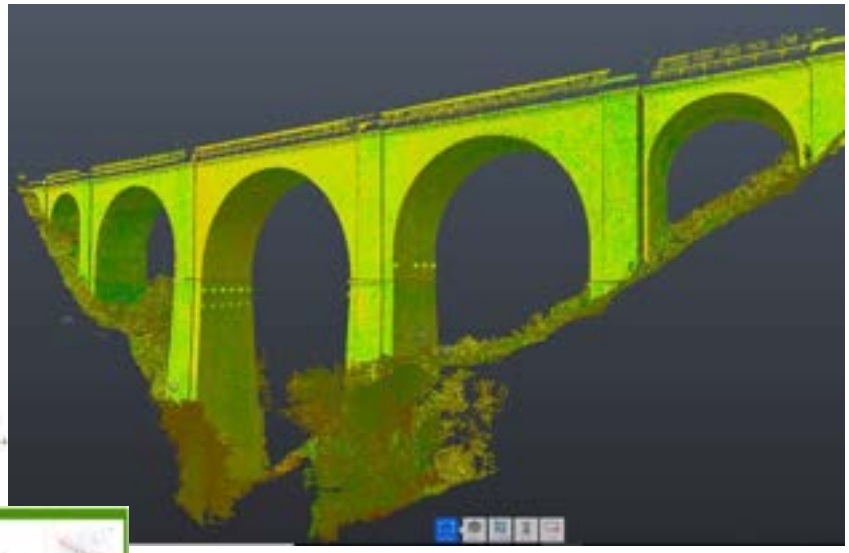
"Rilievo topografico e fotogrammetrico sperimentale per la restituzione tridimensionale dei due campanili della Cattedrale di Aosta'. Ricostruzione digitale 3D dei fronti esterni e degli ambienti di collegamento dei due campanili, realizzazione di un modello digitale di tipo reality-based a supporto del sistema informativo HBIM e delle attività di consolidamento e restauro. Metodo di rilievo fotogrammetrico sperimentale (Brevetto n° 102021000000812 - ANT3D System – Fassi-Perfetti).

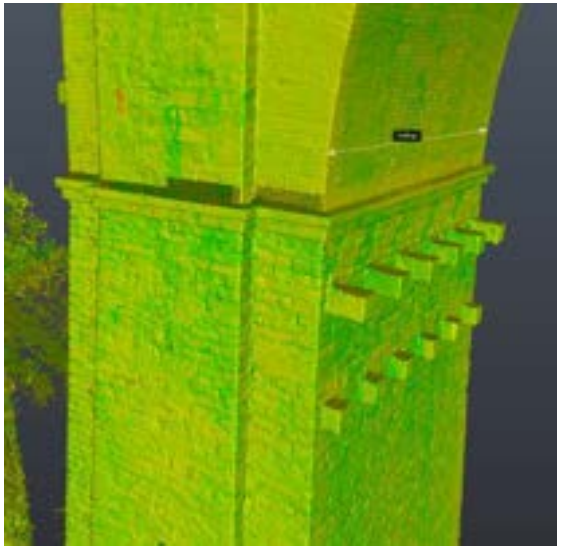


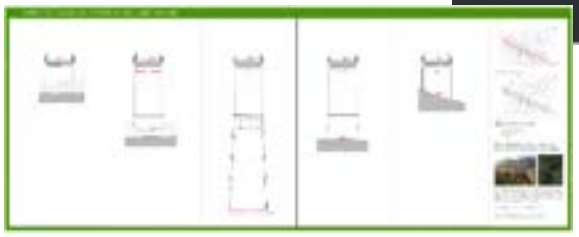
TOPOGRAPHIC AND PHOTOGRAMMETRIC SURVEY OF THE BELL TOWERS OF THE CATHEDRAL OF SANTA MARIA ASSUNTA– AOSTA.



Average resolution of the model: 1







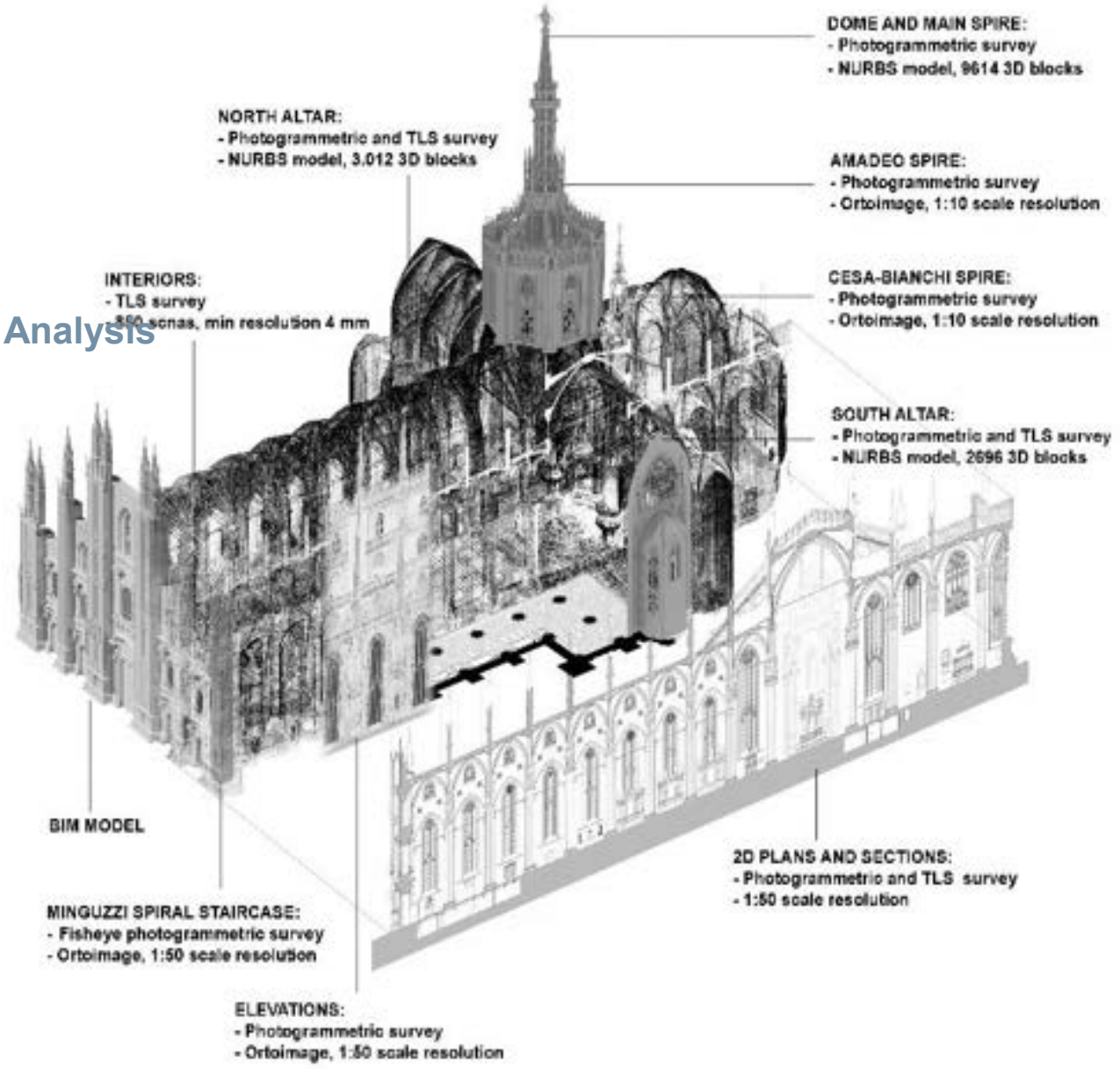
Laser scanner and topographic survey

Monitoring
Sections
Profiles
Materials

Average resolution of the model: 5m

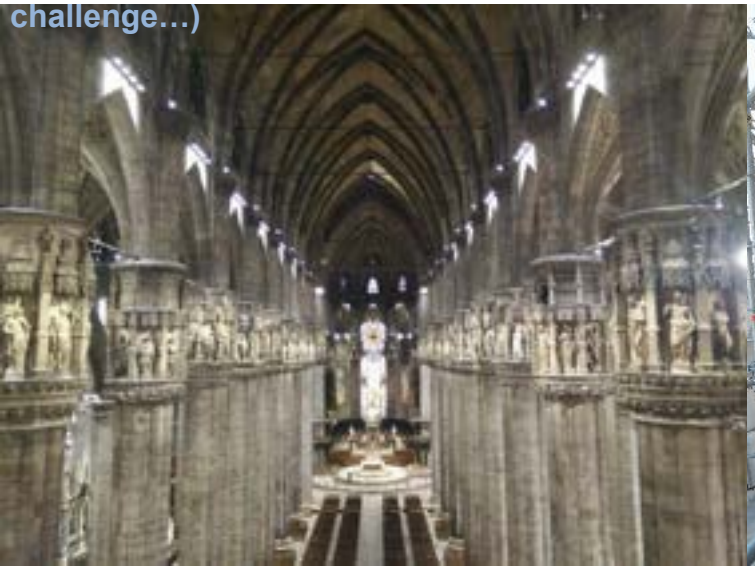
MILAN CATHEDRAL

"Survey" for the Dimensional Analysis



MILAN CATHEDRAL

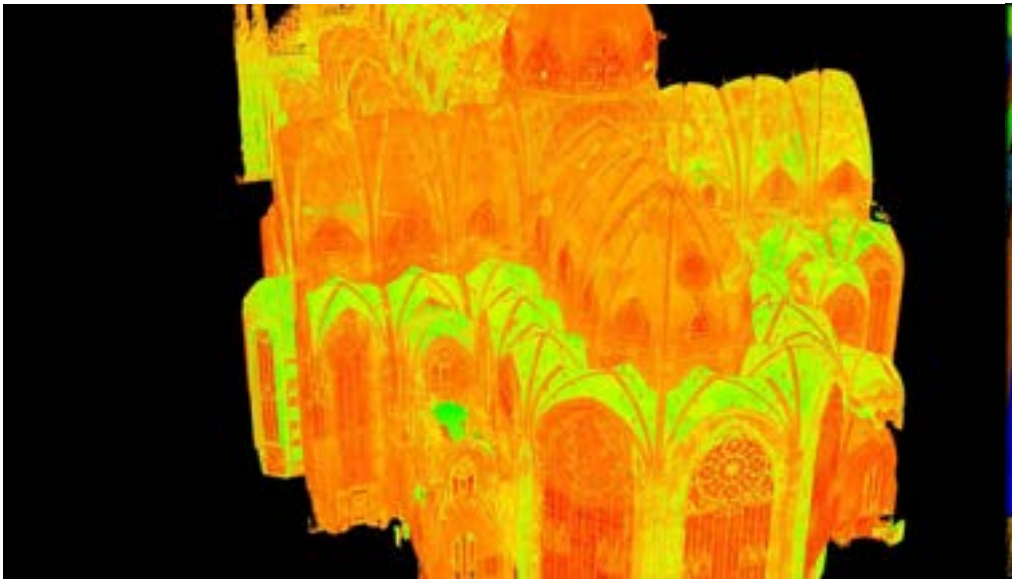
Complex Geometry (manual measurements are a challenge…)

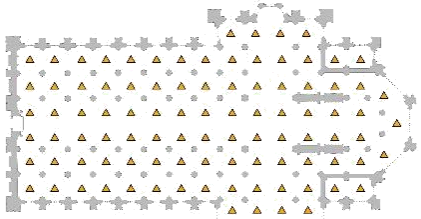


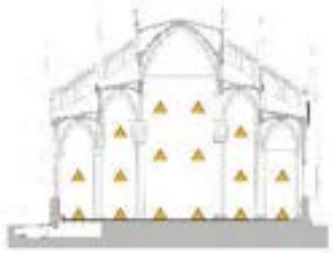
Scaffolds

Different types of objects
(Multi-scale integrated survey)

Narrow Places

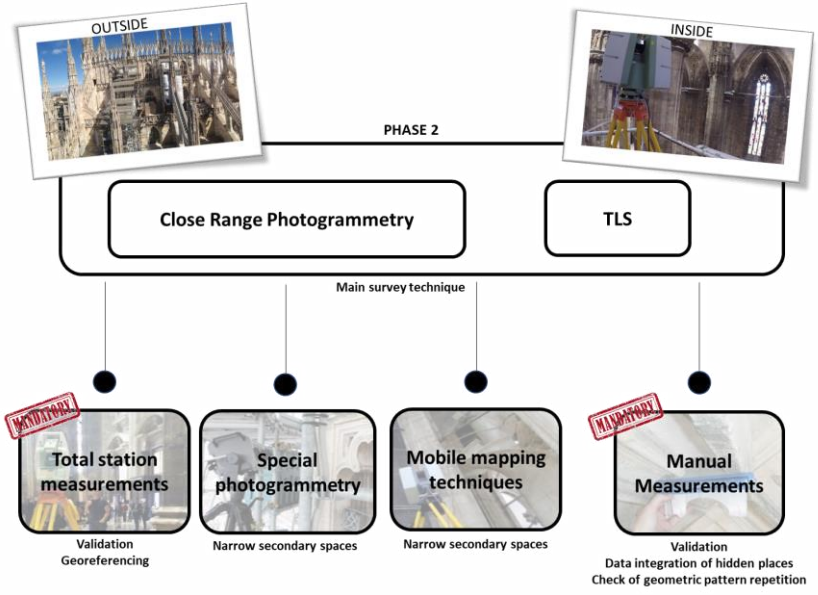






Leica C10

- Only scanner that not penetrate into marble surface
- The interiors are covered by a thin layer of dust
- The marble inside is not so deteriorated as outside (the penetration is limited)



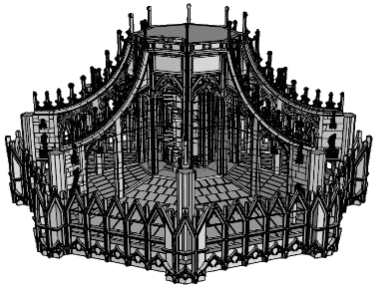
TOTAL NUMBER OF SCANS
(undergrounds, church, sacristies, vaults extrados) ~ 1.200
NUMBER OF SCANS INSIDE CHURCH ~ 260

Guaranteed SCAN RESOLUTION < 5 mm
Point cloud registration error (Target + Cloud to Cloud) < 5mm
TOTAL POINTS = ~ 50 billion of points

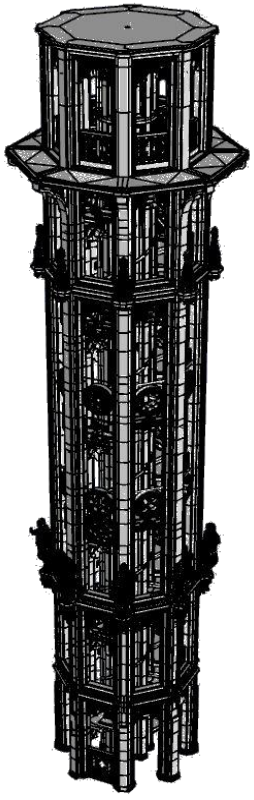
MILAN CATHEDRAL

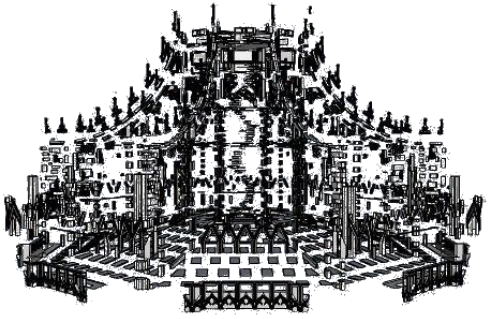
Relative to Survey		Relative to Elaborations	
5	Number of Lenses		
2	Number of Cameras	1.5	Billion Points
40	Number of Targets		
3.580	Number of Photos	65	Number of Orthophoto

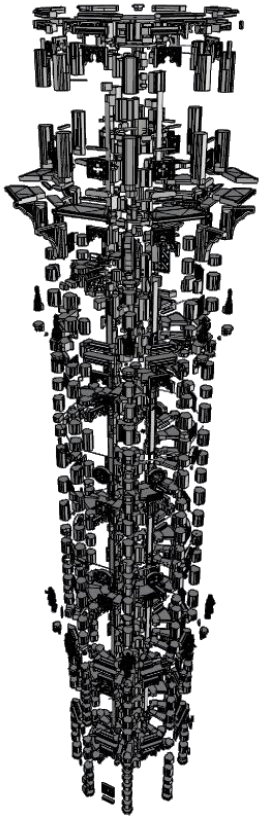
MILAN CATHEDRAL

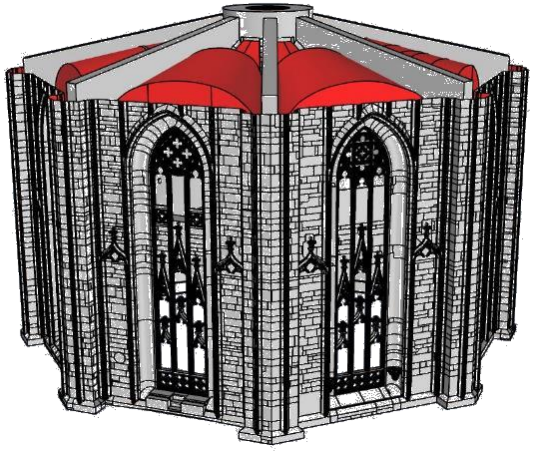


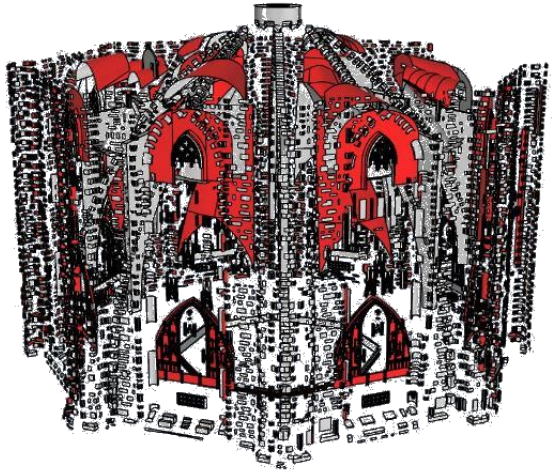
15639 marble blocks







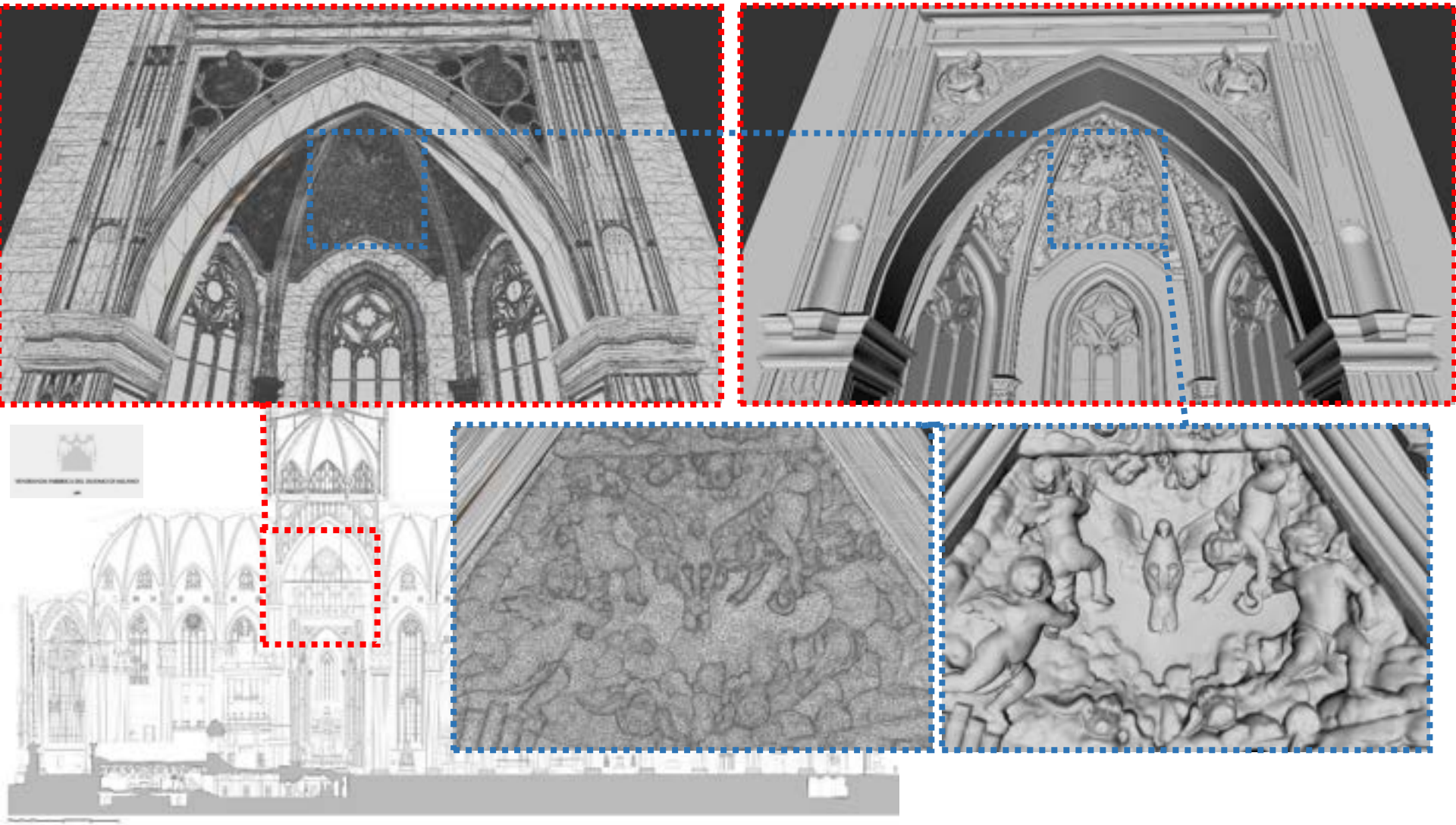




REALITY BASED MODEL – INTEGRATED SURVEY METHODS

MILAN CATHEDRAL

MILAN CATHEDRAL



The marble bock is the principal actor !

The requests by Veneranda Fabbrica:

- **2D representations** of all the structures
- at **1:20-1:50 representation scale**
  (4 mm to 10 mm Plotting Error) – (10 mm to 30 mm tolerance)
- a complete **subdivision block by block**

To design block substitution or tessellation

To design new structure and anchorages

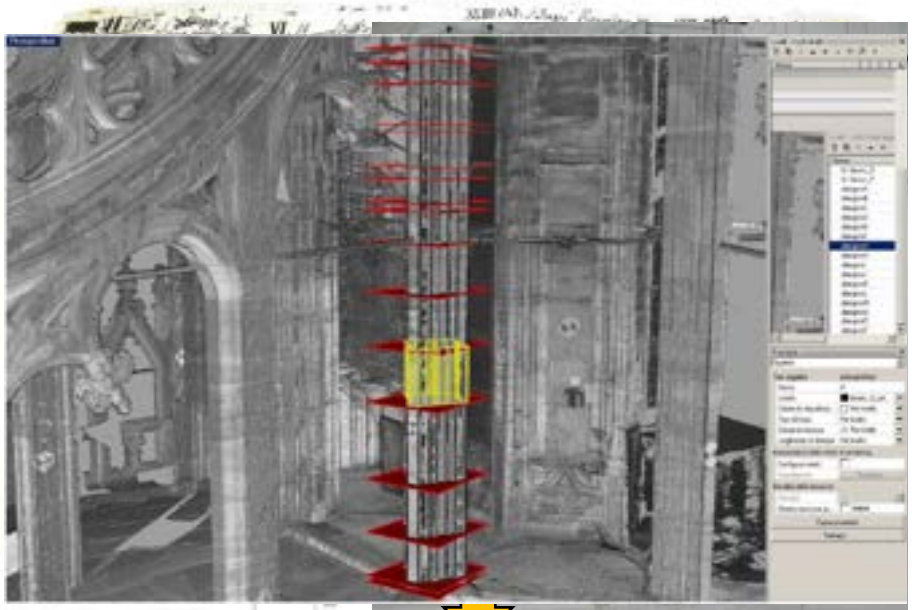
To design scaffolds

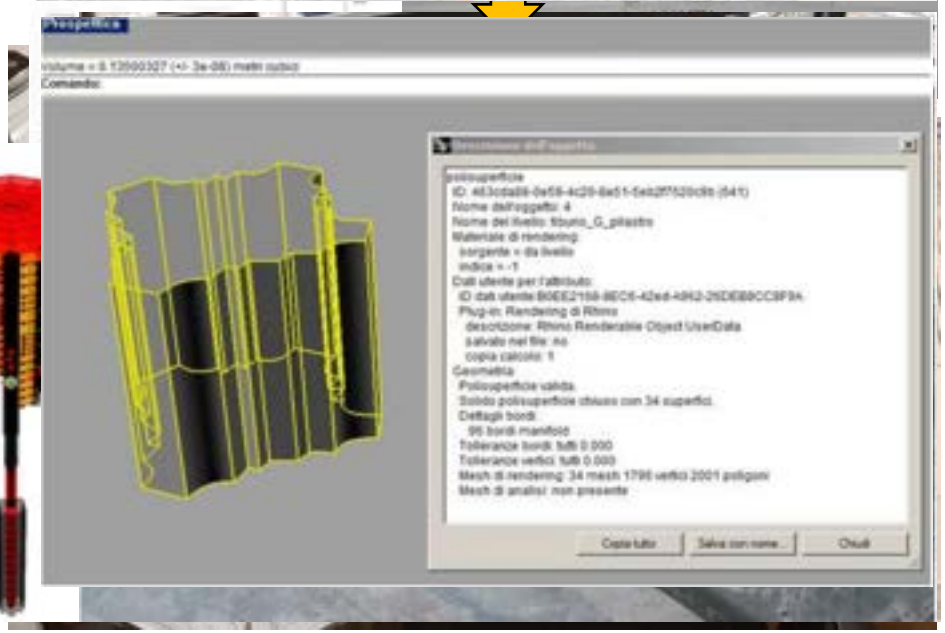
To understand structural behavior

To allow the estimation of costs (made on volume and surface measurement of every single block)

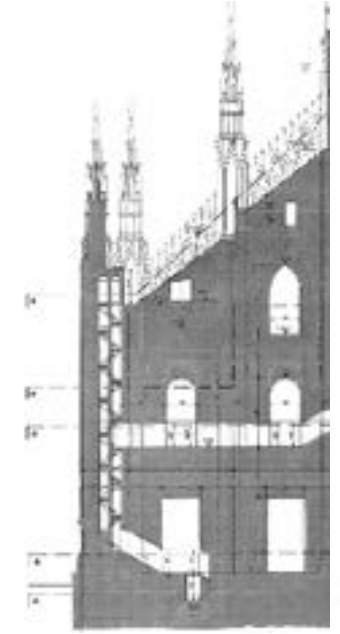
To track all the changes

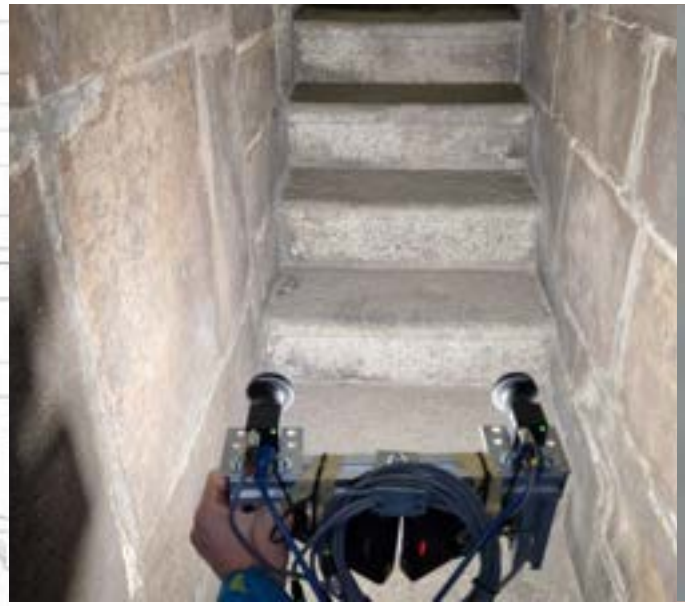
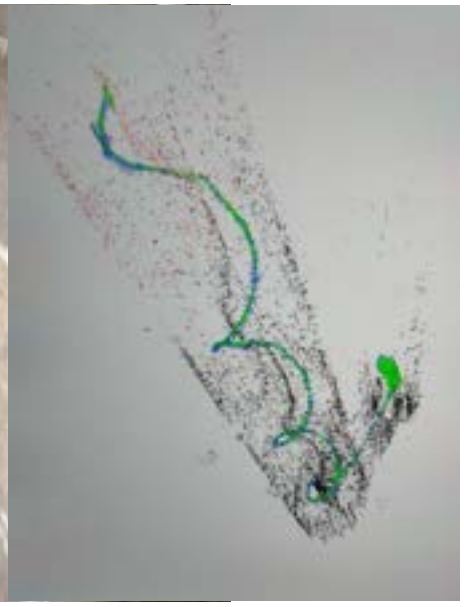
To create risk maps



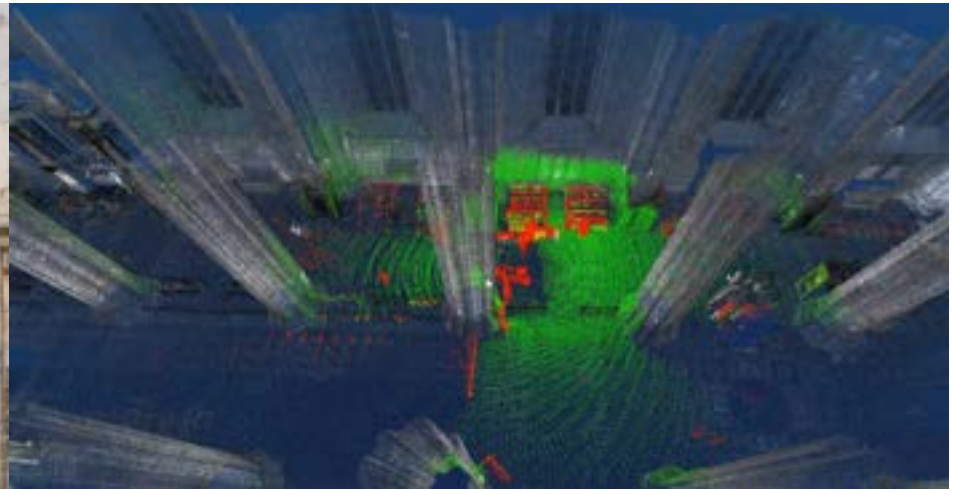
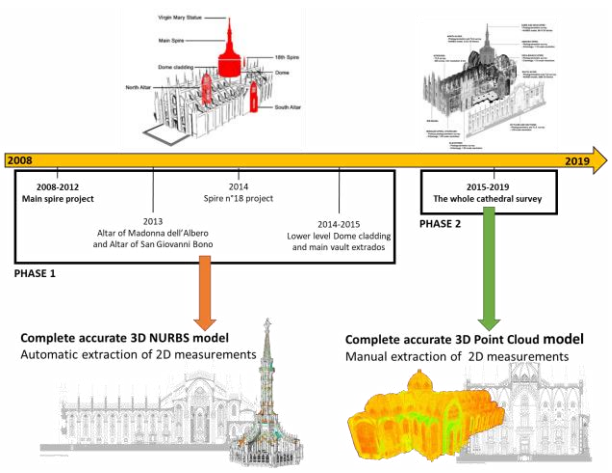


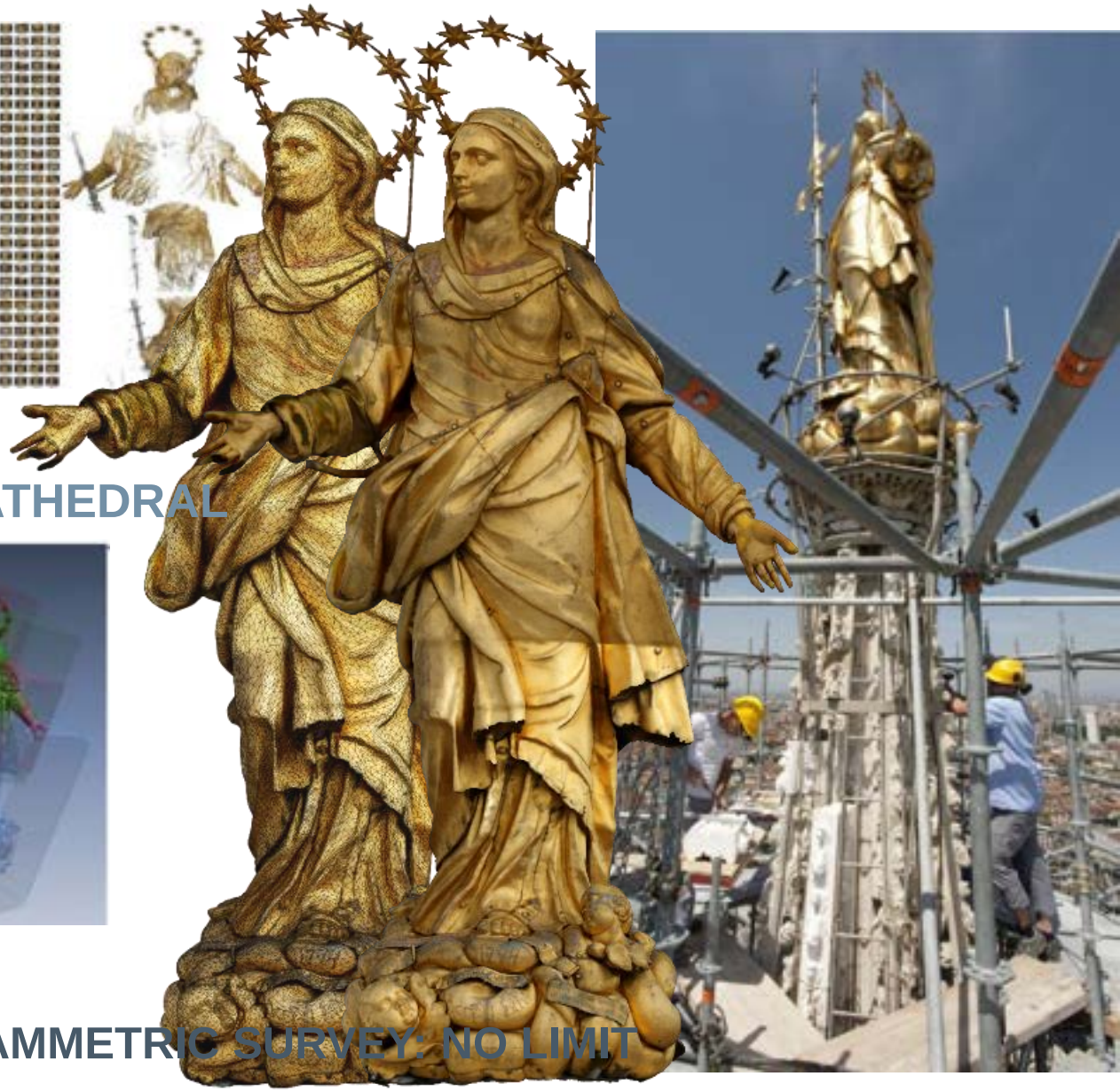
MILAN CATHEDRAL




RESEARCH AND TESTING: COMPLEX SPACES AND MOBILE MAPPING



MILAN CATHEDRAL

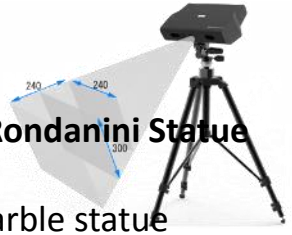
2012
PHOTOGRAMMETRIC SURVEY: NO LIMIT

Survey specifications

- 270 scans
- 80 cm distance
- Optimized geometry
- Use of circular targets

TARGET:

1:1 MODEL



Pietà Rondanini Statue

- Marble statue
- Height 195 cm ca
- High detailed

STRUCTURED-LIGHT SCANNER

- 21 millions triangles - Resolution = 0,2 mm - Colored mesh

Progetto **'SMART CULTURE'** Regione Lombardia FESR-POR Competitività 2007-13, Bando Smart Cities and Communities 2013', capofila per il Politecnico di Milano Prof. G. Valentini, Dip. Fisica. Partners tecnologici: Engineering, Cefriel, WebRatio, CiaoTech, Innovation Engineering e Optec, Open Technologies Company.

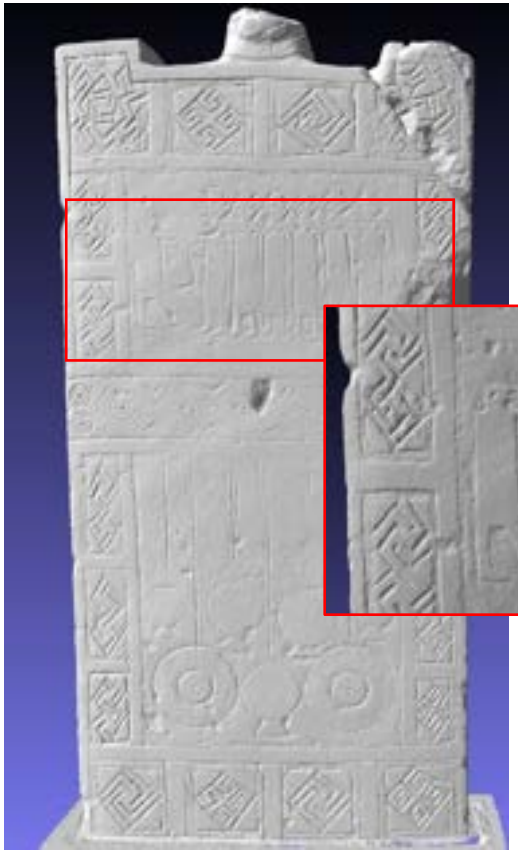
- 5 anelli di immagini
- distanza di presa 80 cm ÷ 1 m
- ricoprimento ≥ 80% sia longitudinale che trasversale
- 265 immagini, risoluzione 0.15mm
- scalatura dei modelli mediante barre calibrate

LARGE SCALE PHOTOGRAMMETRIC SURV

Average resolution of the model: 0.15 mm

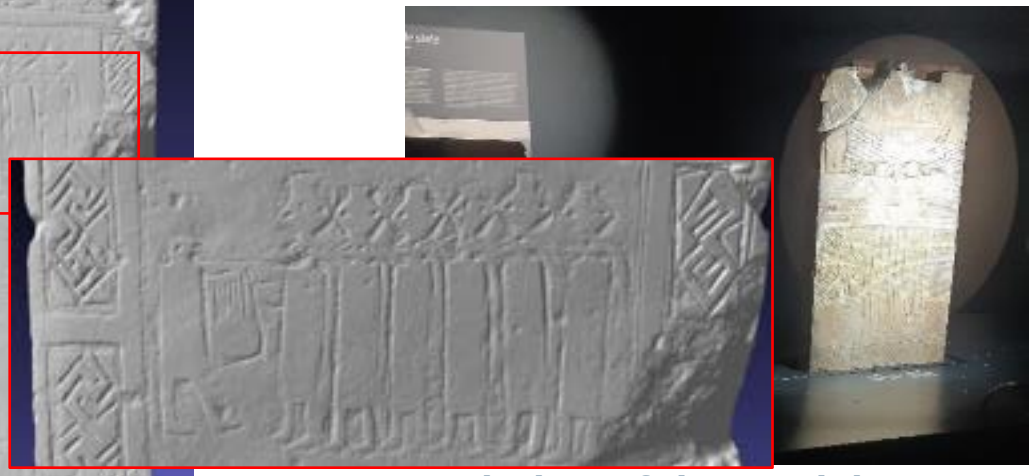
Modello + texture

STRUCTURED-LIGHT SCANNER



STELE 1207_1395

Tempo 60 min (scan in due tempi, prima recto poi verso, allineamento, mesh). Scansione completa Fronte+retro+base e laterali. **Risoluzione 0.5 mm.**



Average resolution of the model: 0.5 mm

Museo archeologico nazionale e Castello di Manfredonia - Programma Operativo Nazionale "Cultura e Sviluppo" FESR 2014-2020. Asse I. Linea di Azione: 6c.1.b. Programma Operativo Nazionale "Cultura e Sviluppo" FESR 2014-2020, CUP: F38F20000050001. Attività: redazione di specifiche tecniche per l'acquisizione digitale dei reperti archeologici del Museo. Sistemi di elaborazione, restituzione, archiviazione e consultazione dei dati, ai fini della redazione del capitolato per la realizzazione del sistema informativo del Museo.

'Luini in nuova luce', Bando "Progetti territoriali per la città di Milano e provincia«, Fondazione Cariplo. Capofila Veneranda Biblioteca Ambrosiana, partners Politecnico di Milano (dipartimenti: Chimica, Fisica ABC 3DSurvey Group), Fondazione Trivulzio, Università di Milano Bicocca, Università degli Studi di Milano, CNR IFN Milano, CNR-INO Firenze, Università Bergamo, Factum art.

Very high resolution orthophotos

Sacra Famiglia - Ortofoto del recto e verso

- Recto 0.05 mm
- Verso 0.15 mm

Very high resolution orthophotos

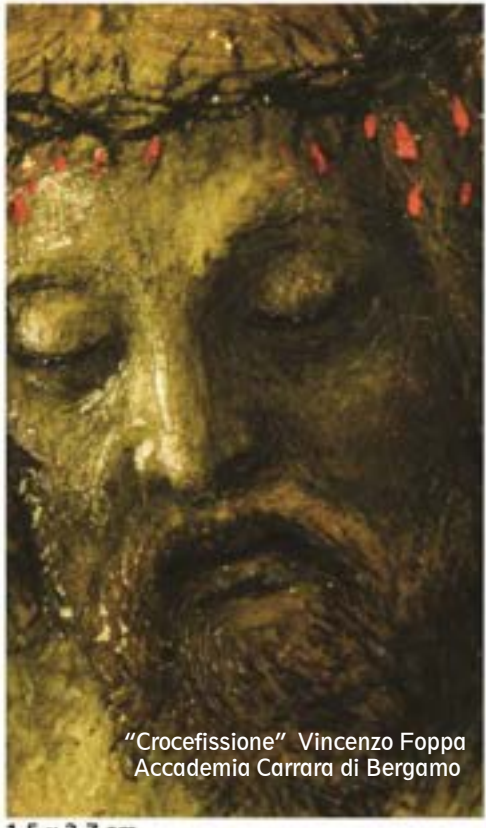
San Giovannino
Recto 0.035 mm
Verso 0.1 mm

Very high resolution orthophotos

38 x 68 cm


10 x 18 cm (scala 1:1)

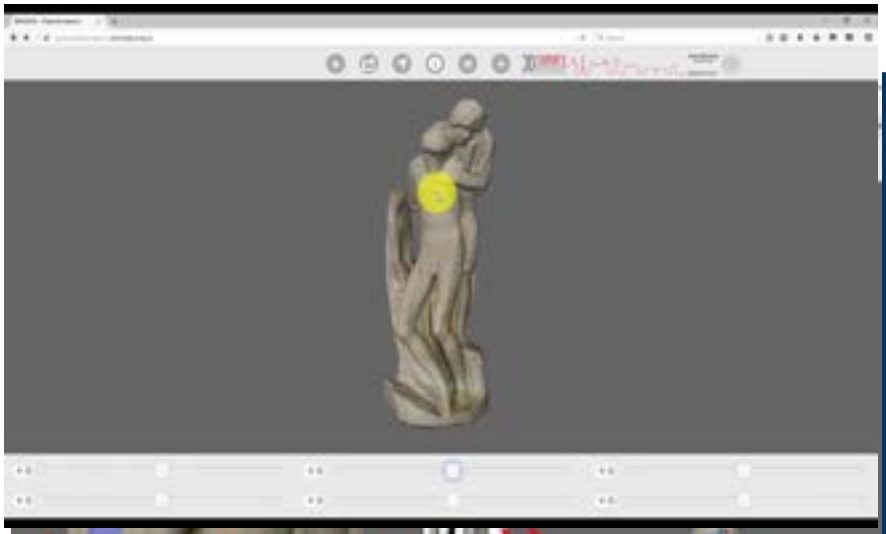

7 x 12,6 cm

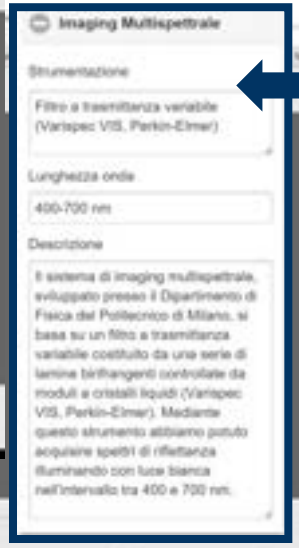


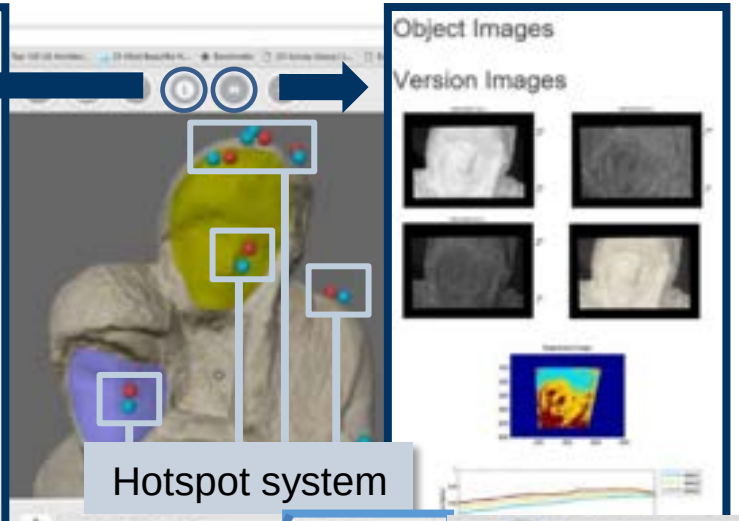
1,5 x 2,7 cm

- 182 images, 80% coverage
- resolution required less than one tenth
- final point cloud approximately 100 million points, average resolution 0.07 mm

DATA SHARING







Hotspot system