THE EU VIGIE 2020/654 STUDY FOR HIGH QUALITY 3D DIGITIZATION

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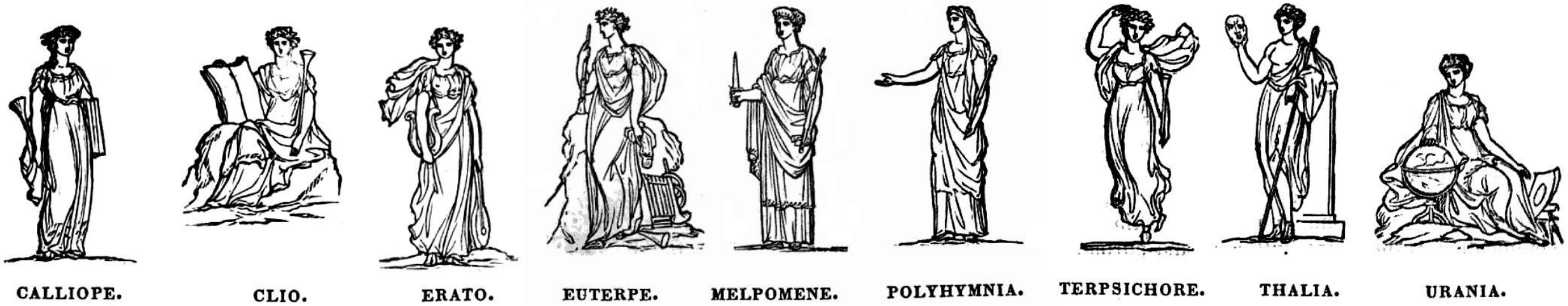
EUREKA3D

unesco Chair



EUREKA3D

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The **main object** enabling CH stakeholders/ p ligitisation services ***to define and produ*** e context of specific 3D digitisaion p

The elements different *para* level *of* *COMPLEXITY and*

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Aim

COMPLEXITY definition should :

- provide a meaningful tool for planning the 3D data acquisition, modelling and visualization
- and connect to the Data Acquisition QUALITY results

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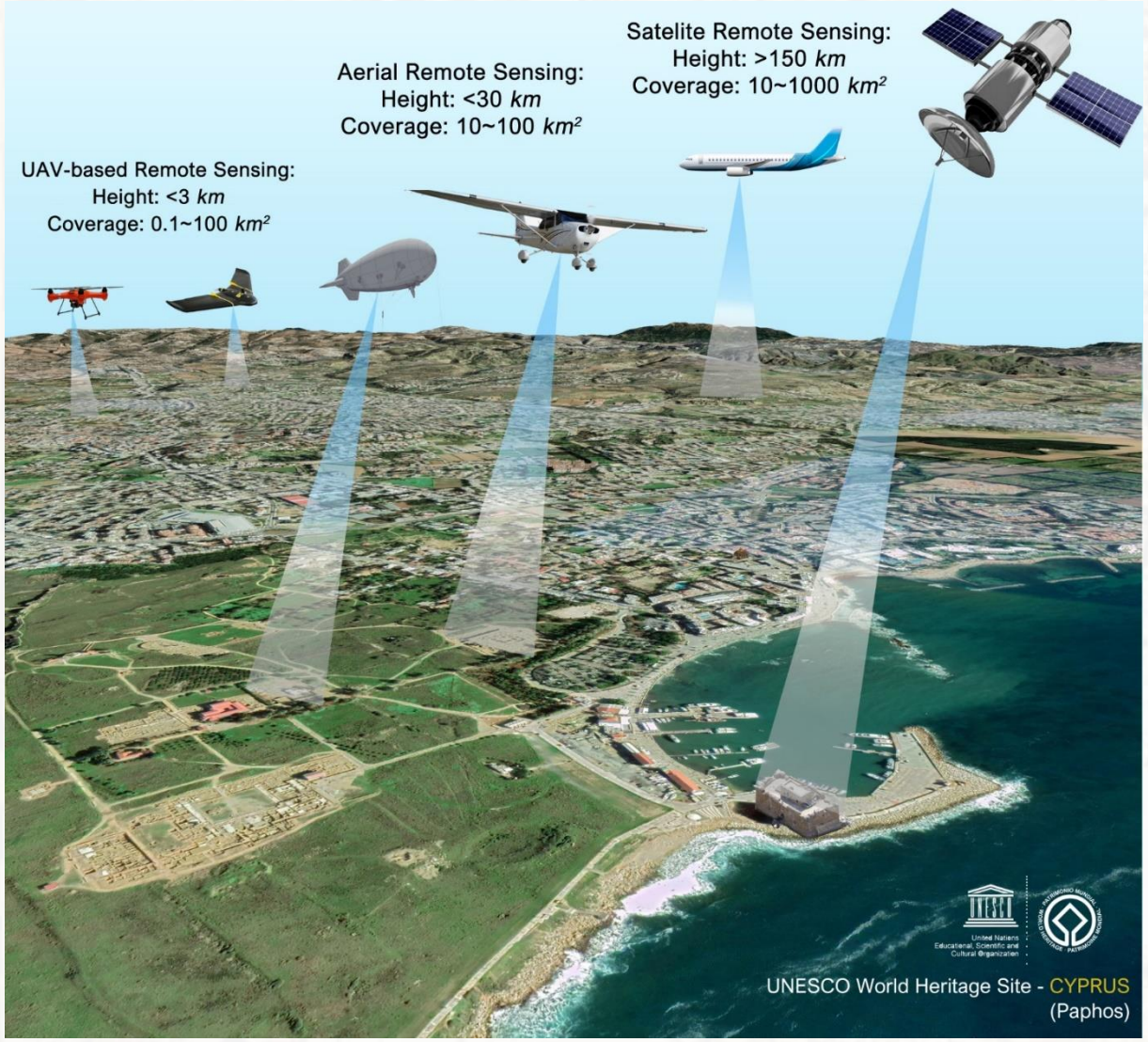
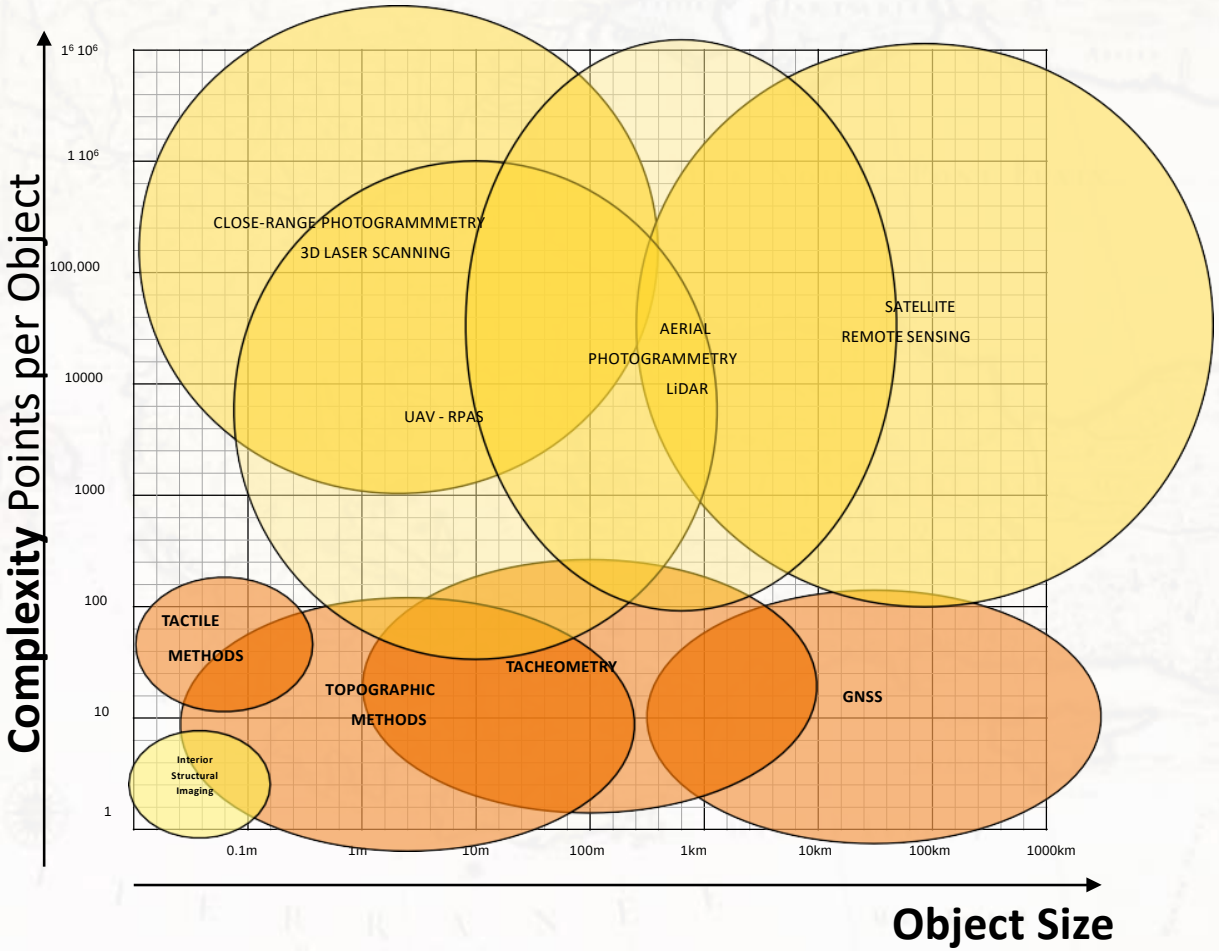
3D Digitisation





Survey techniques defined by object complexity (points captured) and size.

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The definition of Complexity in 2D and 3D digitisation - *today*

A common ground of understanding

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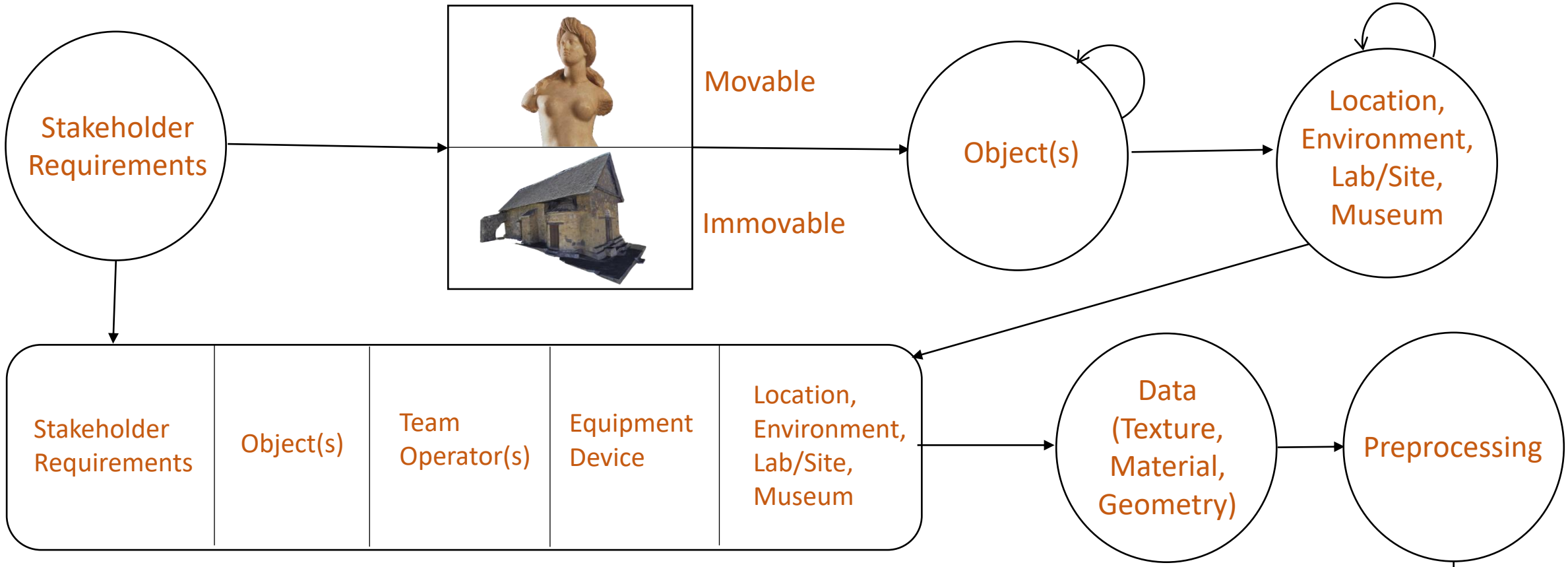

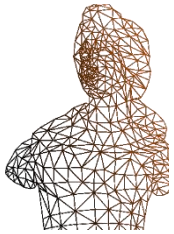

Deliverables

1. Geometry
2. Texture
3. Material
4. Structural Health Monitoring

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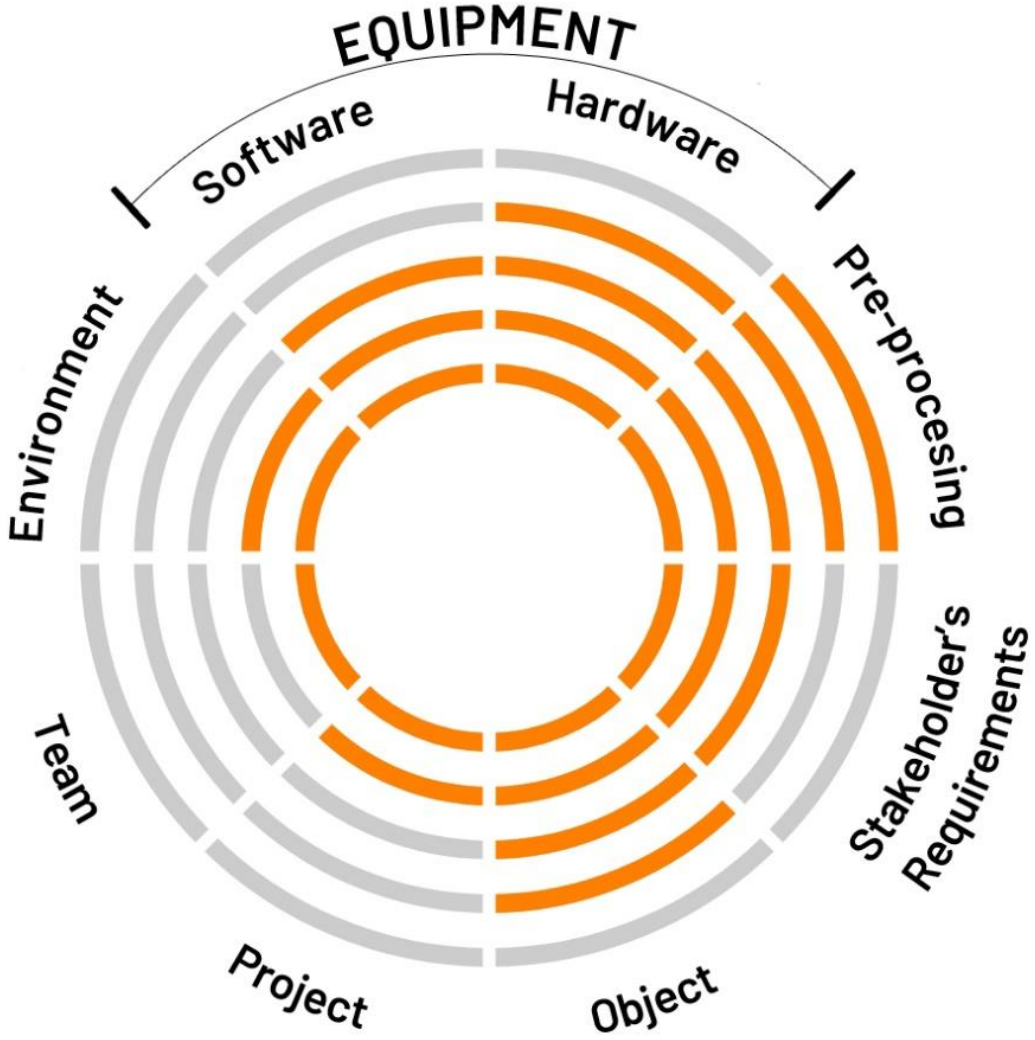
Complexity Parameters

- How Complexity is connected to purpose of 3D digitization?
- How Complexity is connected to Technology?
- What is the limiting factor in 3D digitization process today?
- Synthesis – a Decision-making workflow
- Do we need a definition of “Object Complexity”?
- How Complexity is defined – How is it measured?
- **How Complexity is connected to Quality?**



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Quality

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

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How Complexity is connected to Quality?

Degrees of object quality and component considerations

QUALITY	IMMOVABLE				MOVABLE			
Degree of Complexity	Low	Medium	High	Ultra-High	Low	Medium	High	Ultra-High
Geometric Accuracy								
Precision								
Accuracy/rms	10cm	1cm	1mm	<1mm	1cm	1mm	100μm	<100μm
Radiometric Accuracy								
Reflectance								
Transmittance								
Absorbance								
Completeness								
% of “blank” pixels	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%

Our assumption is that Resolution should not differ from Accuracy since it does not make sense to collect denser points than the accuracy level

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Documentation systems

DOCUMENTATION SYSTEMS		
Image-based	Photogrammetry	Panorama 360 photography
		Close-range photogrammetry
		Unmanned Aerial Vehicle / Drone
	Infrared cameras	
Non-Image-based	Traditional survey	Hand survey
		Theodolite measurement / Total Station
	Laser Scanner	Terrestrial laser scanner
		LiDAR
Combinative Methods	Integrated photo-laser scanner	
	Structured-light scanner	Structured-light scanner

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Mathematical definition of quality

QUALITY is a mathematical function (similar to complexity) related to:

- Budget
- Time
- Skills of personnel
- Technology (data acquisition: hardware and software)
- Software for the pre-processing and filtering, post-processing
- Object (IPR, conditions, environment, material, geometry etc.)
- Presentation [(information: **Paradata, Metadata**), data]
- USER NEEDS (reverse engineering)

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How Complexity is defined – How is it measured?

- Complexity will determine to high degree the **technology** to be used. *E.g. it is quite difficult and unproductive to use Photogrammetry to record the complexity of a cave, whereas Laser scanning is the suggested technology in this case.*
- Complexity is the missing connection between the **Quality** and the **Purpose-of-use**. *E.g. although possible it is useless to use UAV imagery to map a large surrounding landscape of an archaeological site, whereas satellite imagery is much preferable.*
- Complexity imposes **restrictions** on both the technology and intended use. *E.g. surface transparency violates basic photogrammetric rules, preventing the use of this technology; also, low reflected radiation of certain surface material poses restrictions to laser scanning.*
- Complexity connects **Quality, Accuracy and Completeness** as long as it expresses parameters like object size or resolution requirements. *E.g. complex interiors call for fusion of technologies, exploiting the merits of each one, while requirements for multiple resolutions/accuracies are often dictated by multiple uses of the same 3D acquired material.*

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object Complexity

Geometry Structure

- Purpose of digitization
- Type (terrestrial, museum, underground..)
- Location
- Budget
- Time limits

Surface Texture

- Transportation
- Infrastructure
- Format, Standards
- Security, Safety
- Team (experience, qualifications, licensing...)
- Equipment
- Environmental conditions

Material

- Dimensions
- Weight
- Permissions/touchable
- State of condition

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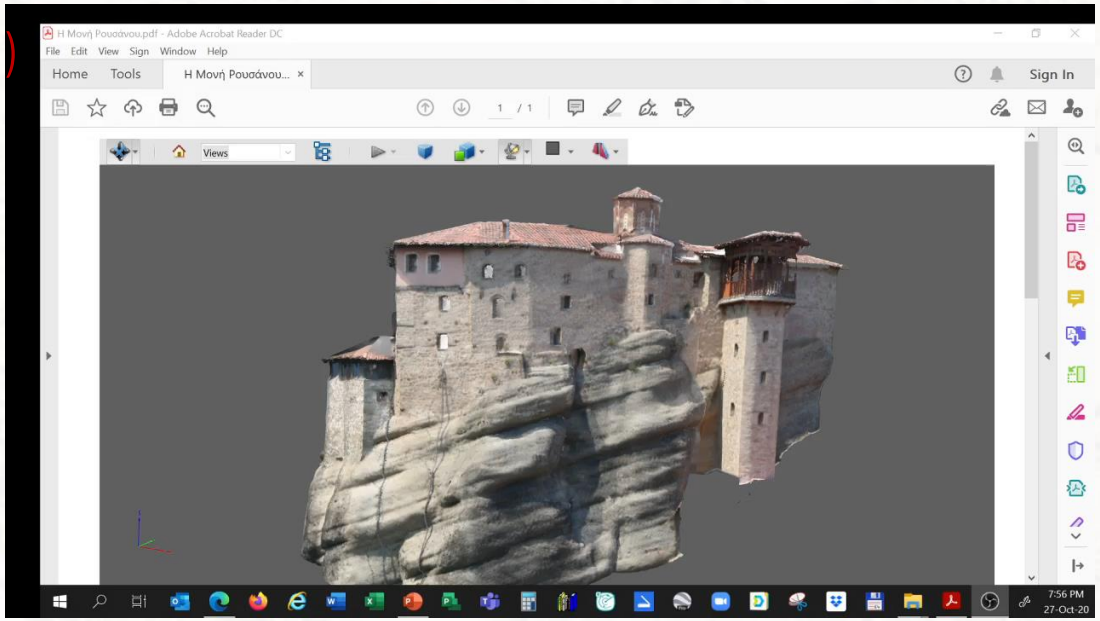
- Distance (>600m)
- Sensor fusion
- Multi-resolution



- Infrastructure
- Location
- Light
- Complicated purpose

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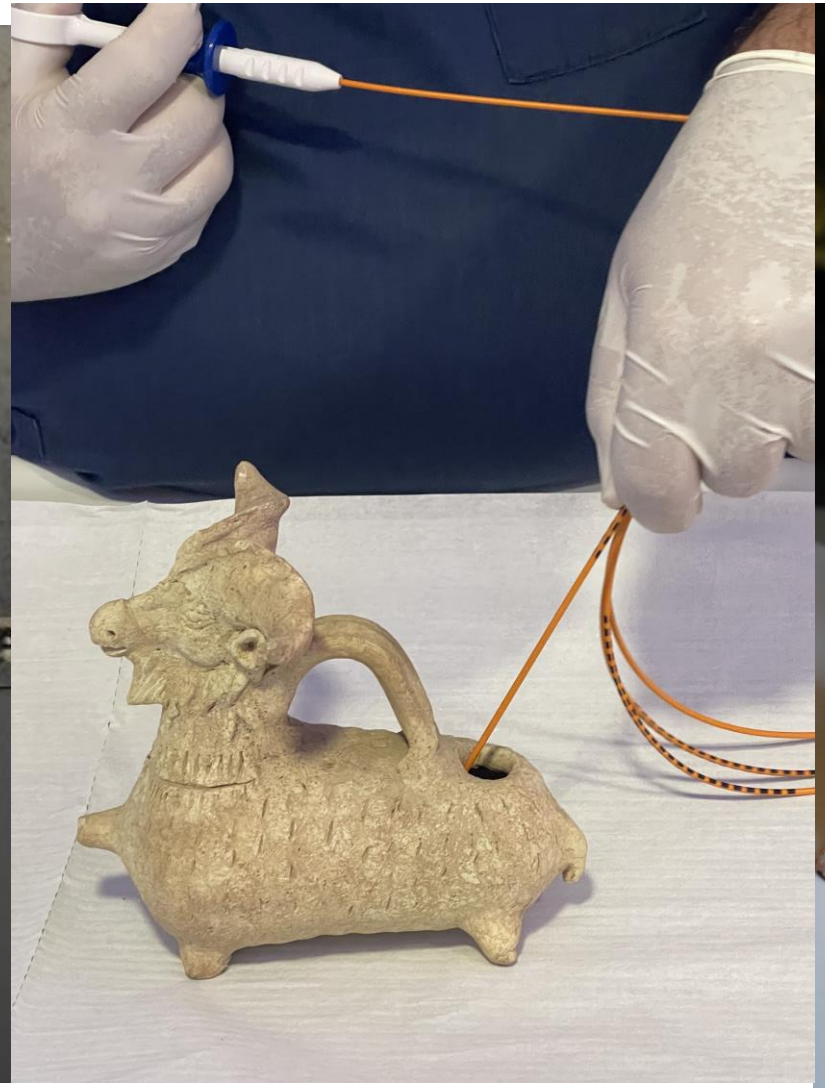
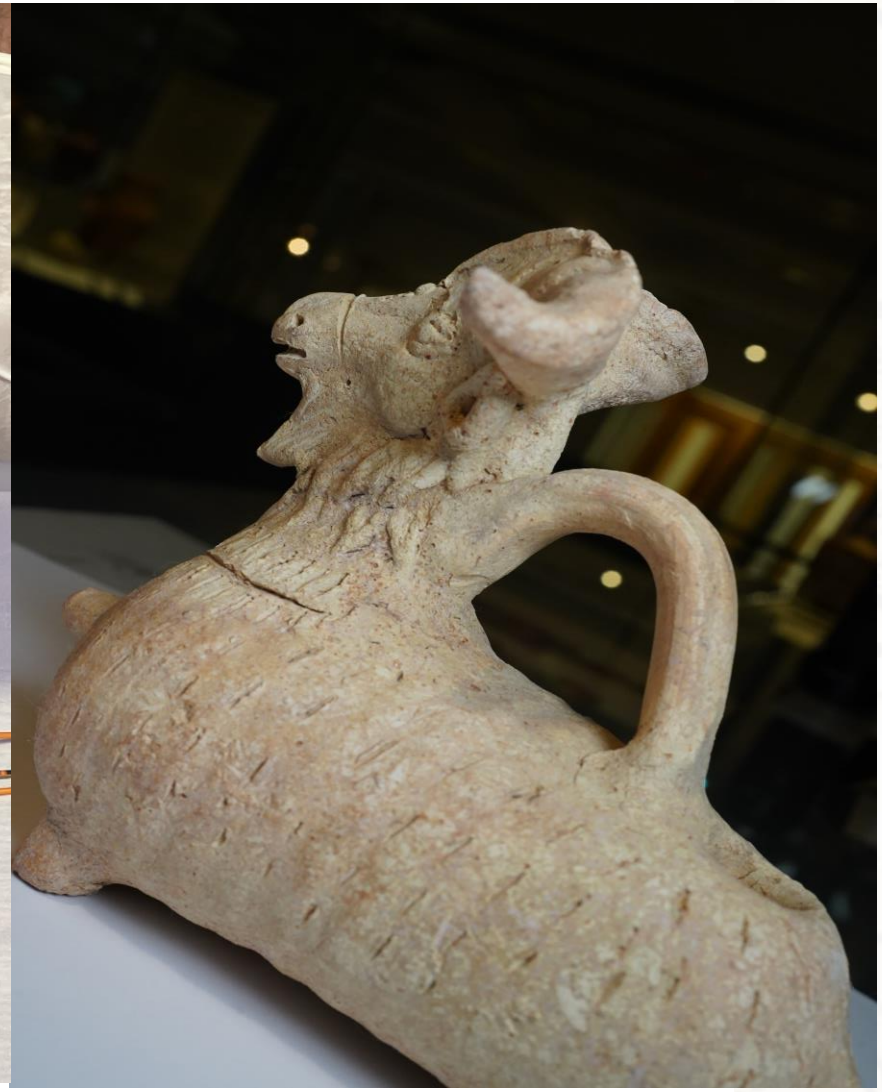
Complexity parameters: Team





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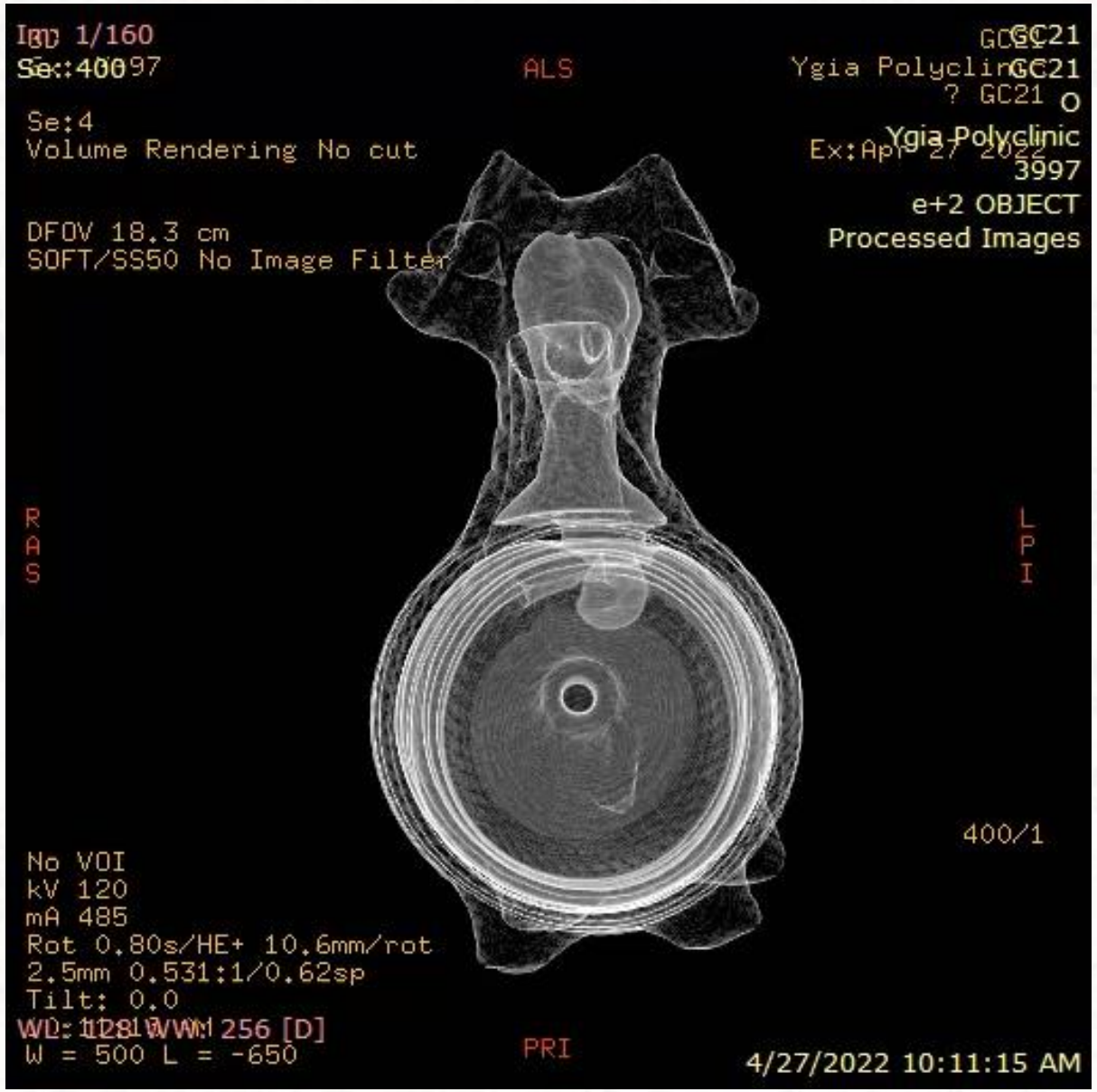

Collection of CT tomography data:

Understanding of the manufacturing technique

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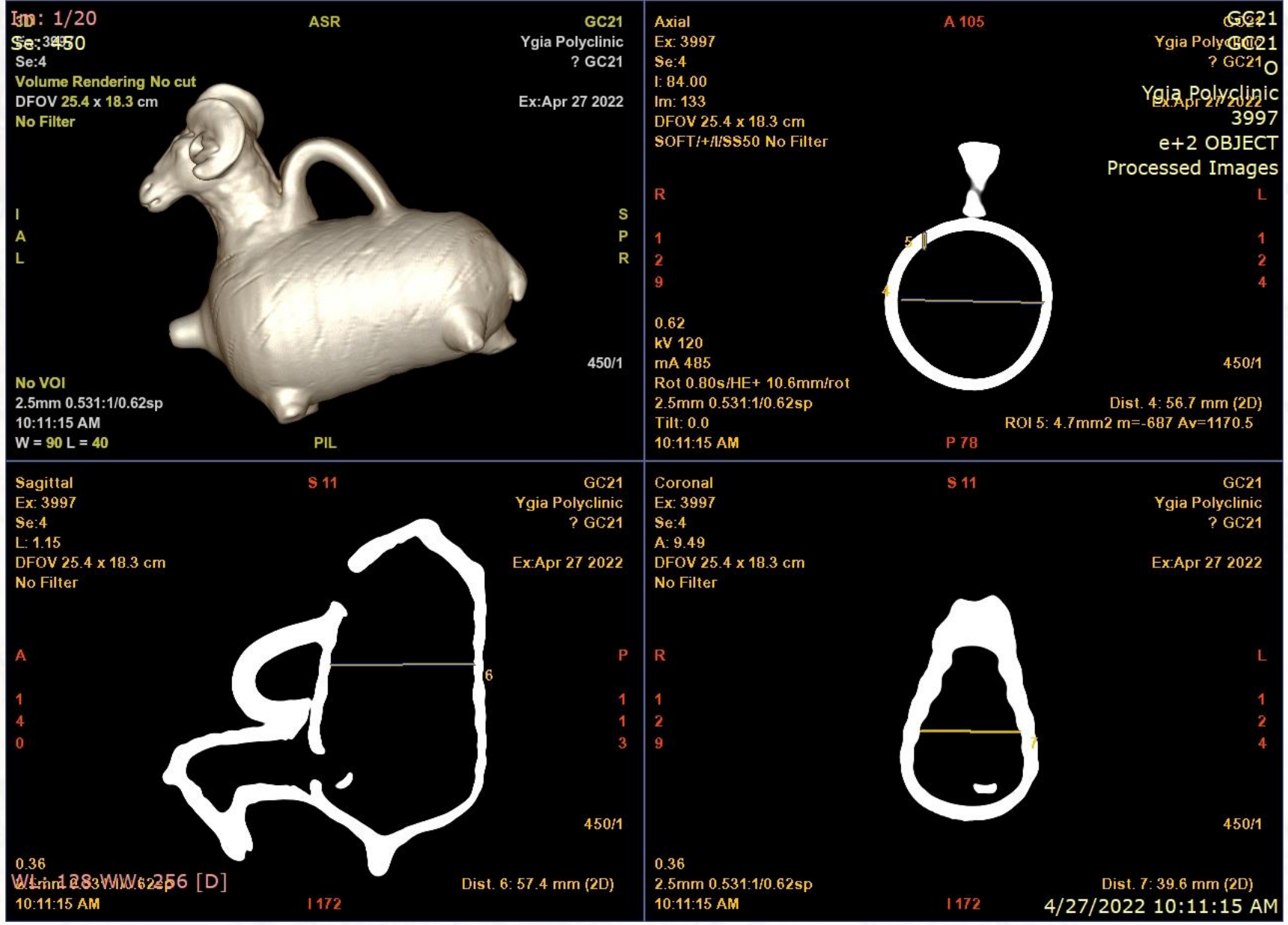

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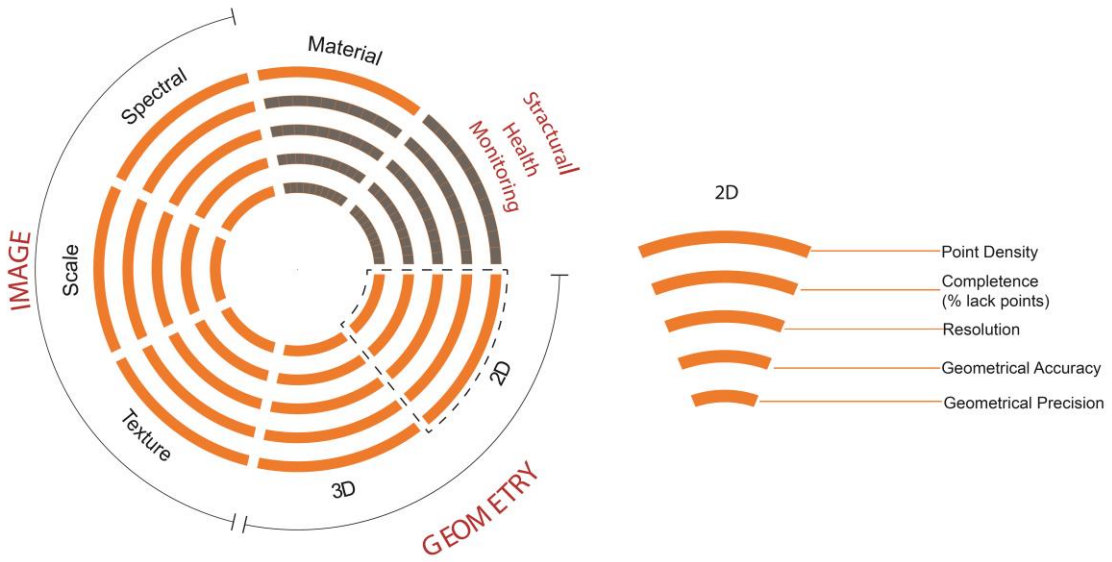
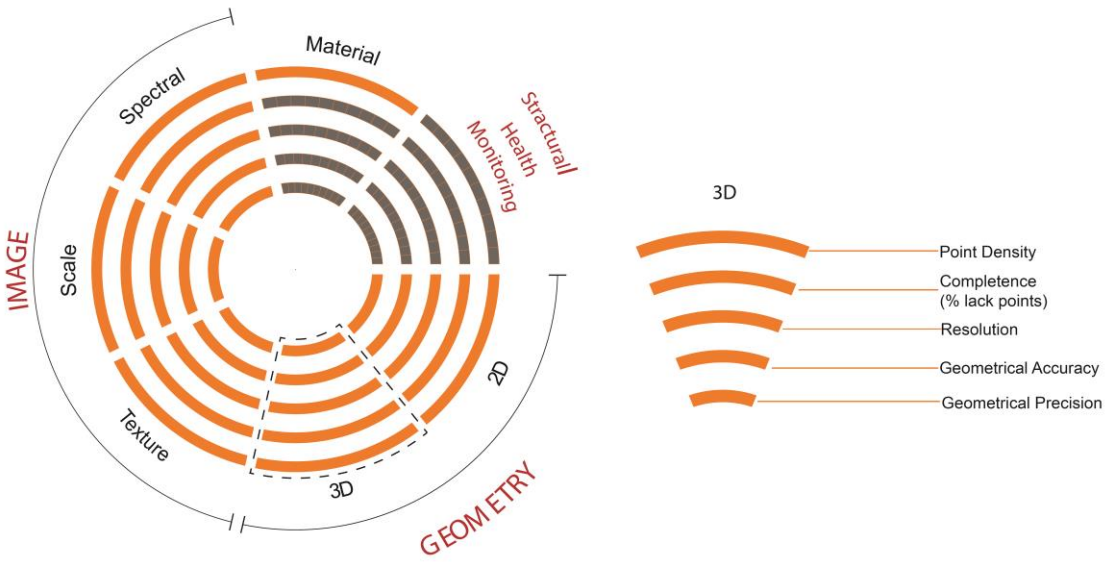
Quality parameters: 2D and 3D





The Geometry in this case is complex due to high resolution, point density, geometrical accuracy and precision.

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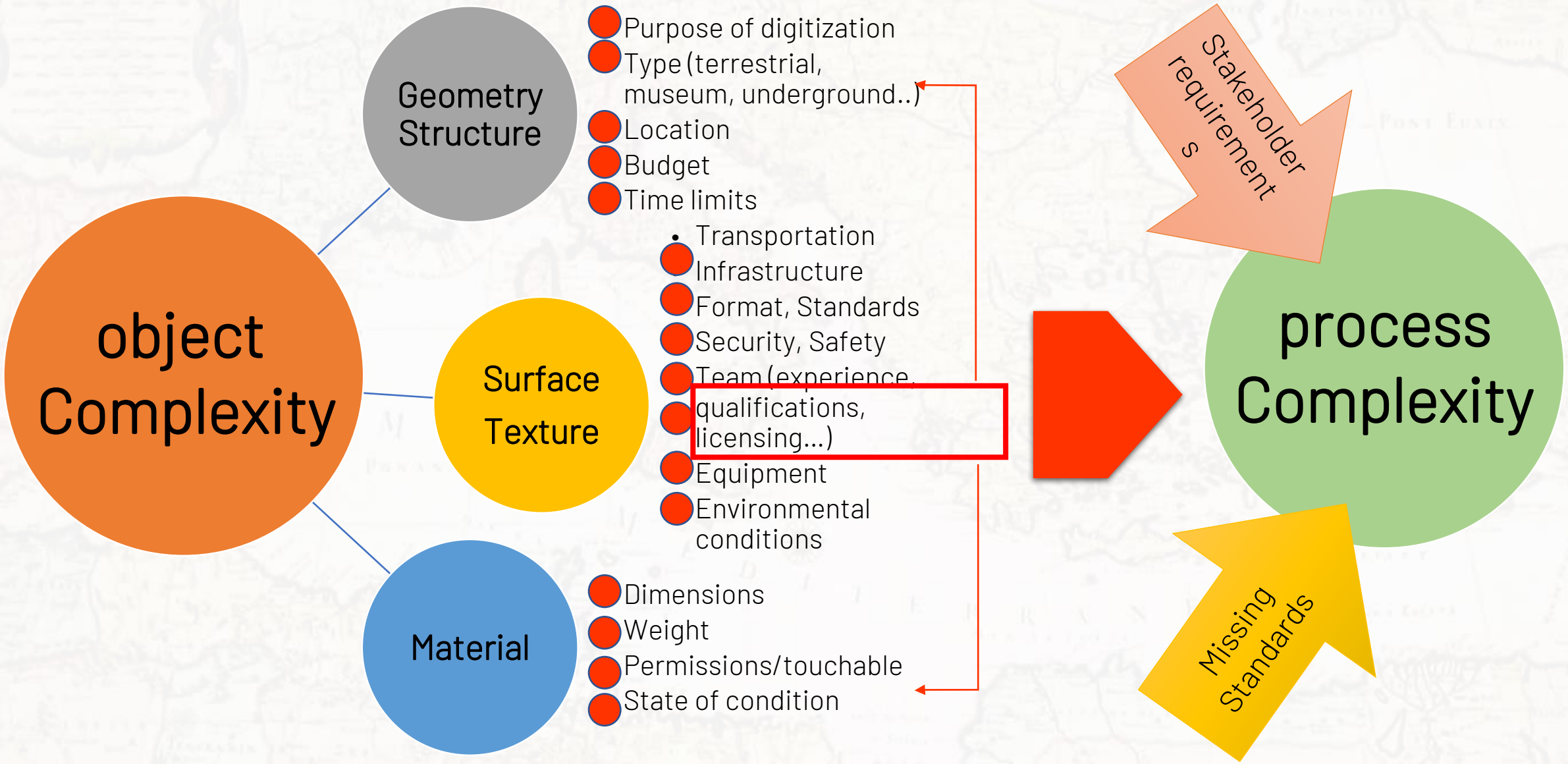

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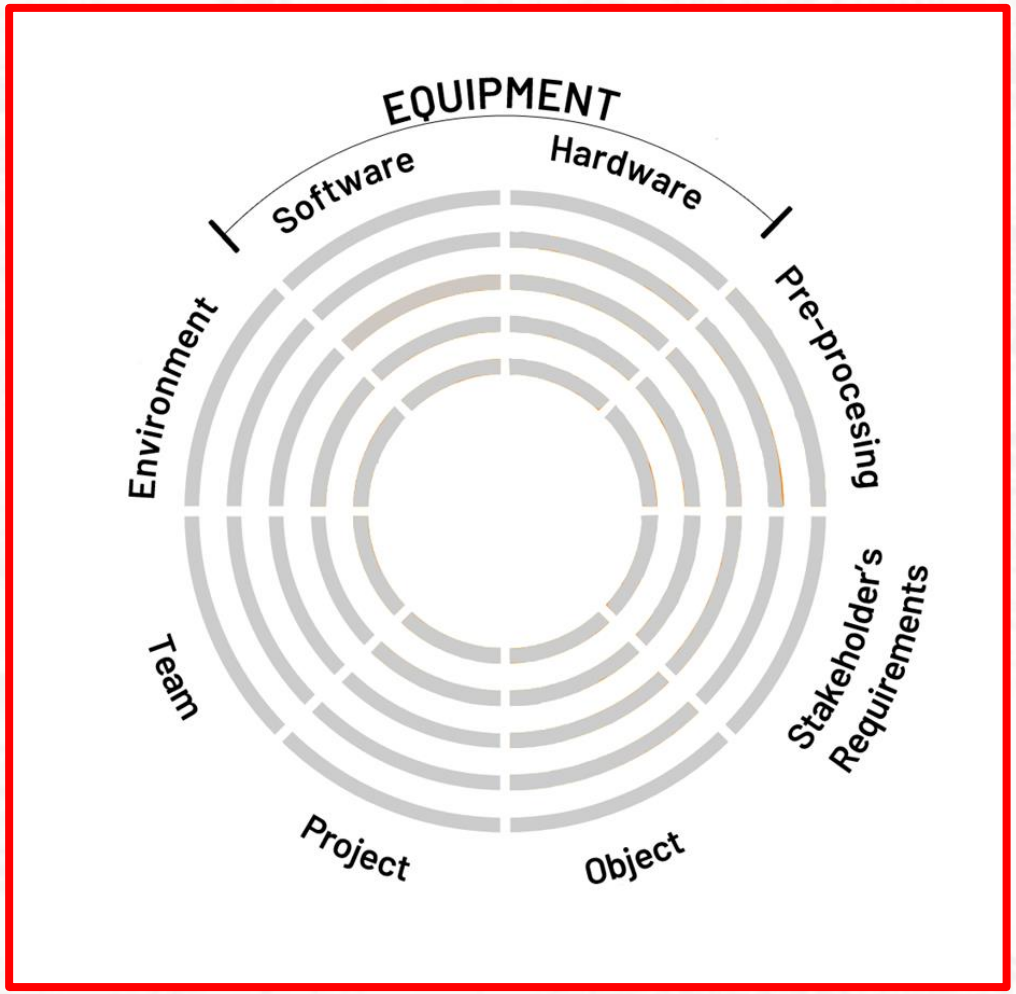
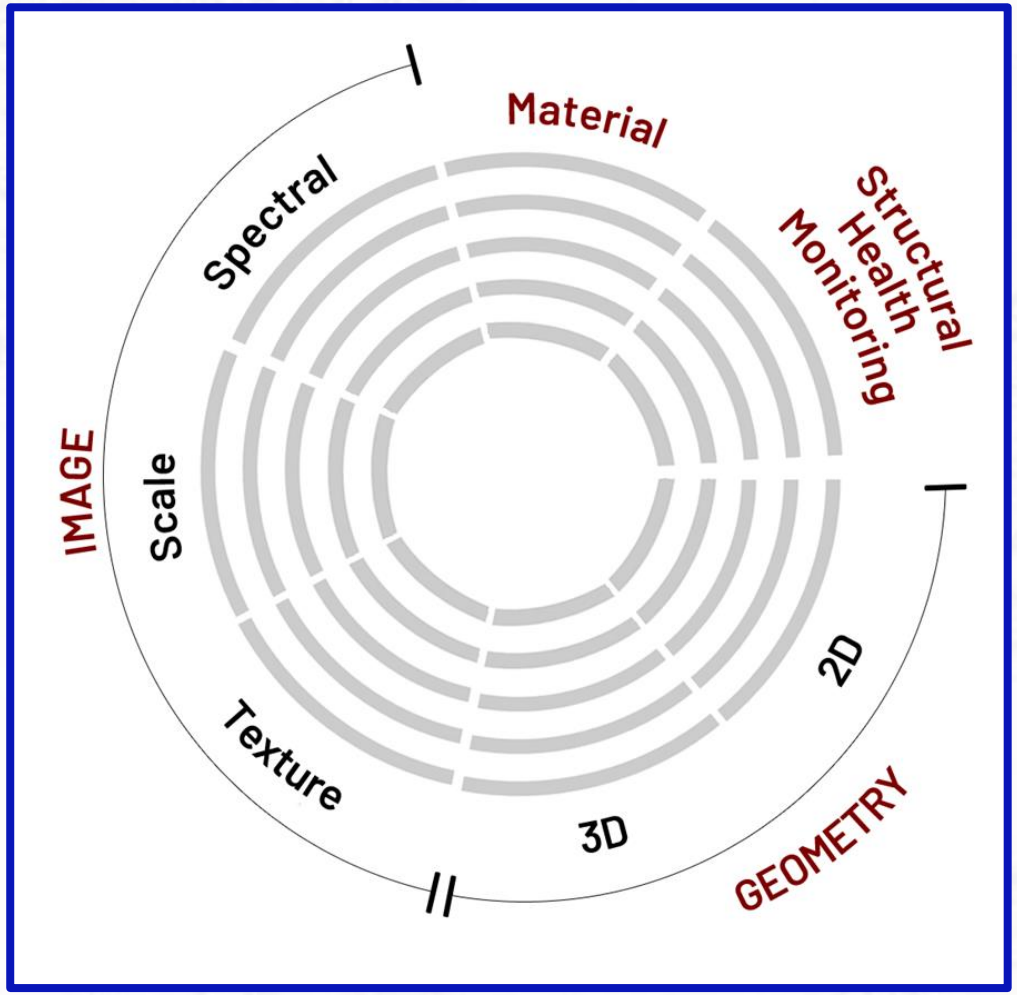
Process Complexity



Process Quality



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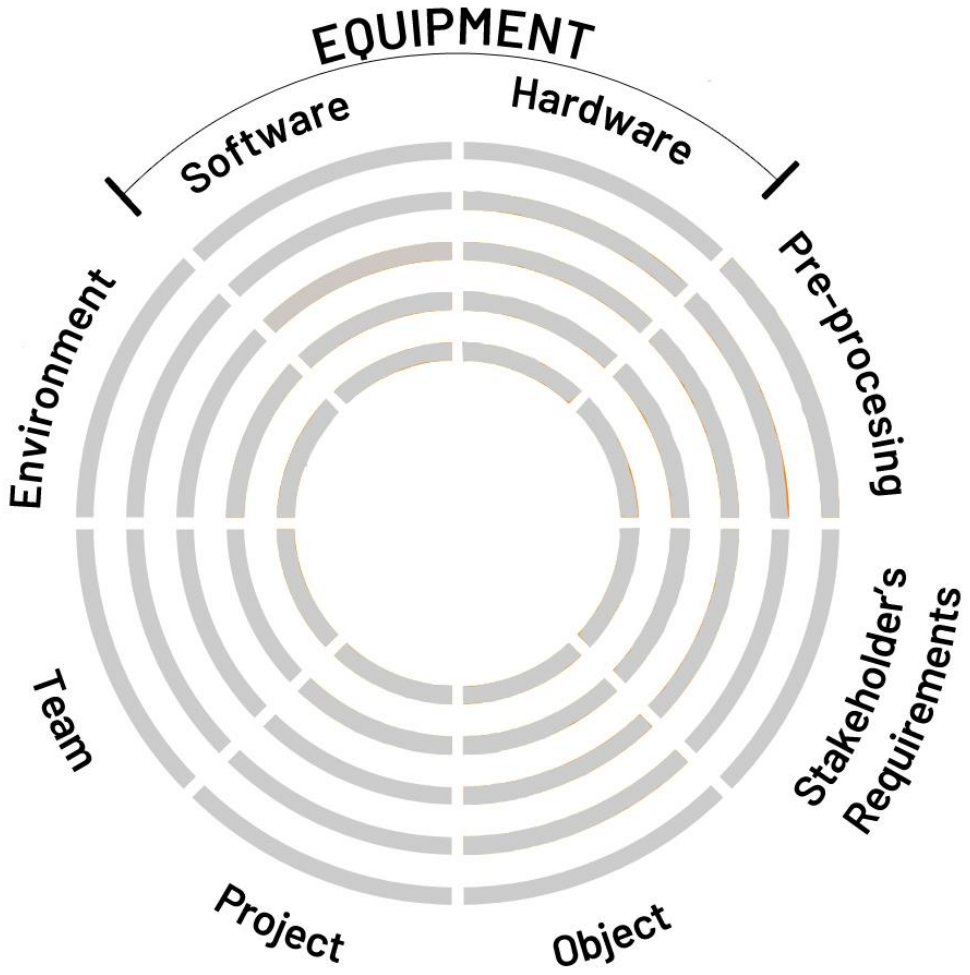
Complexity



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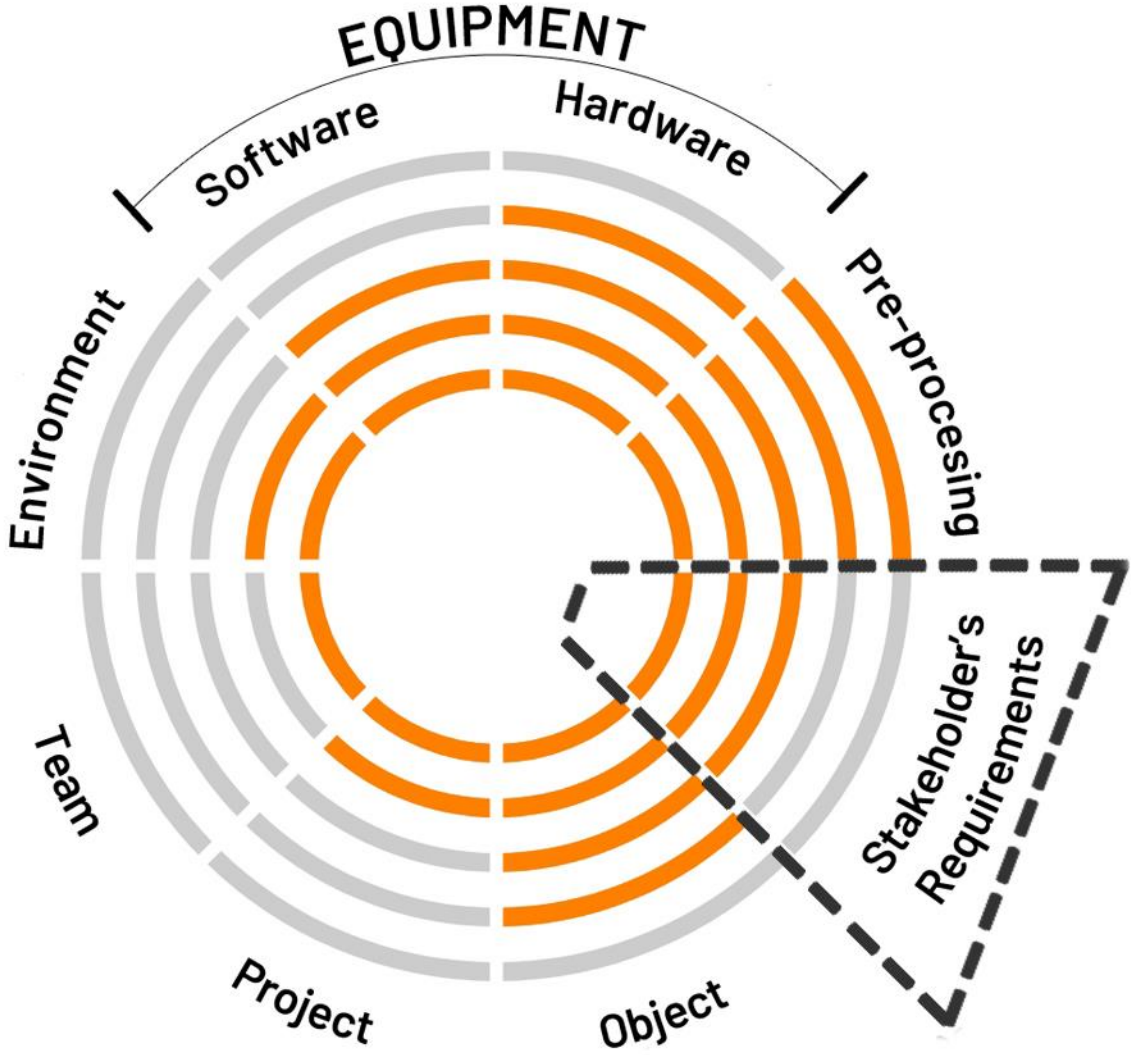

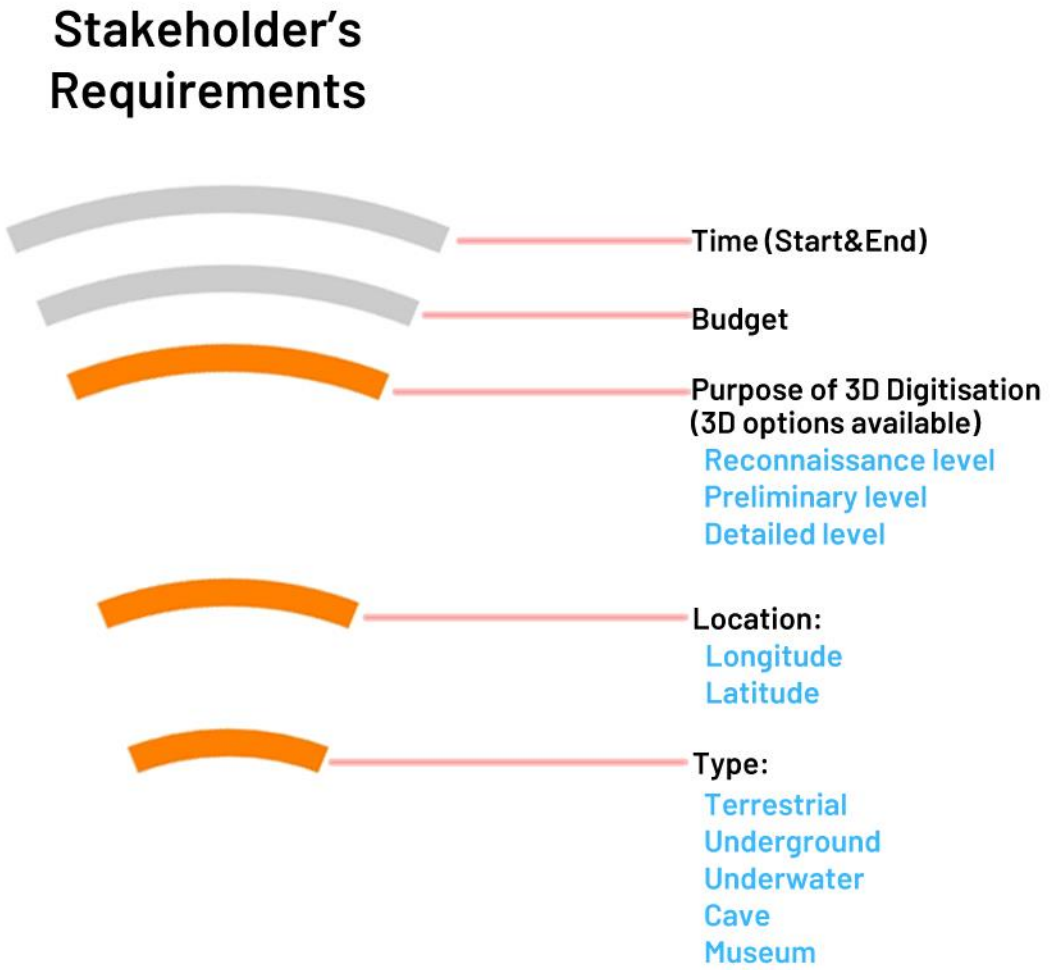

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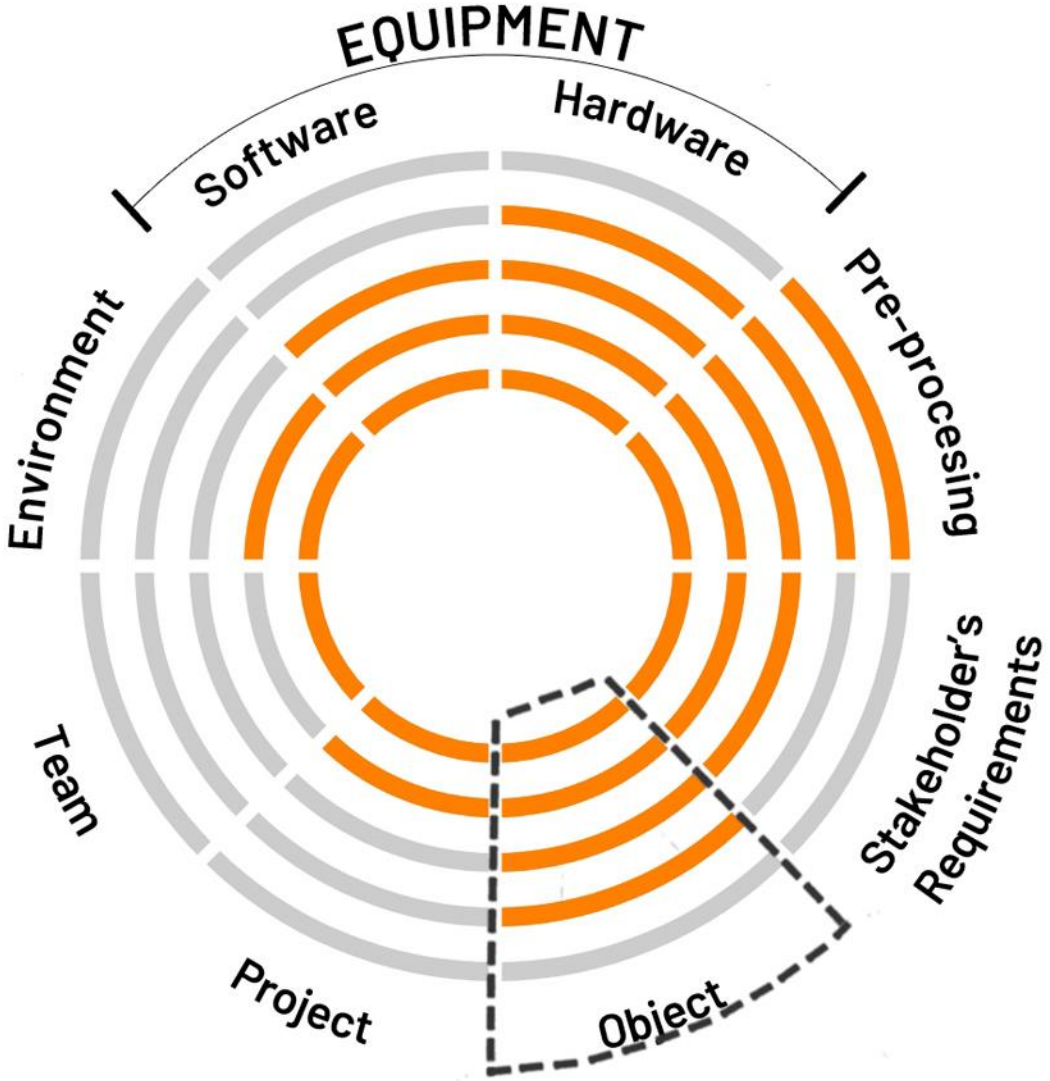

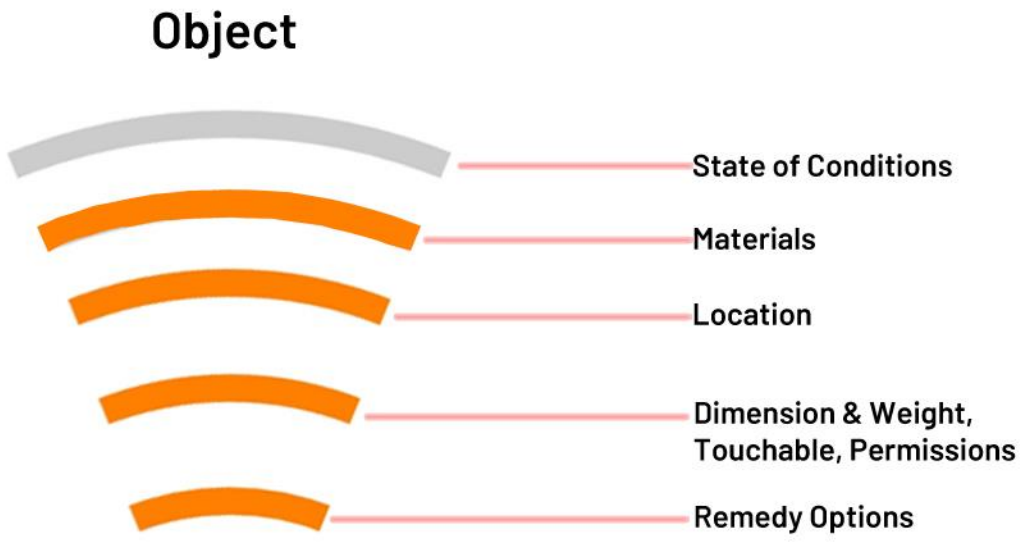

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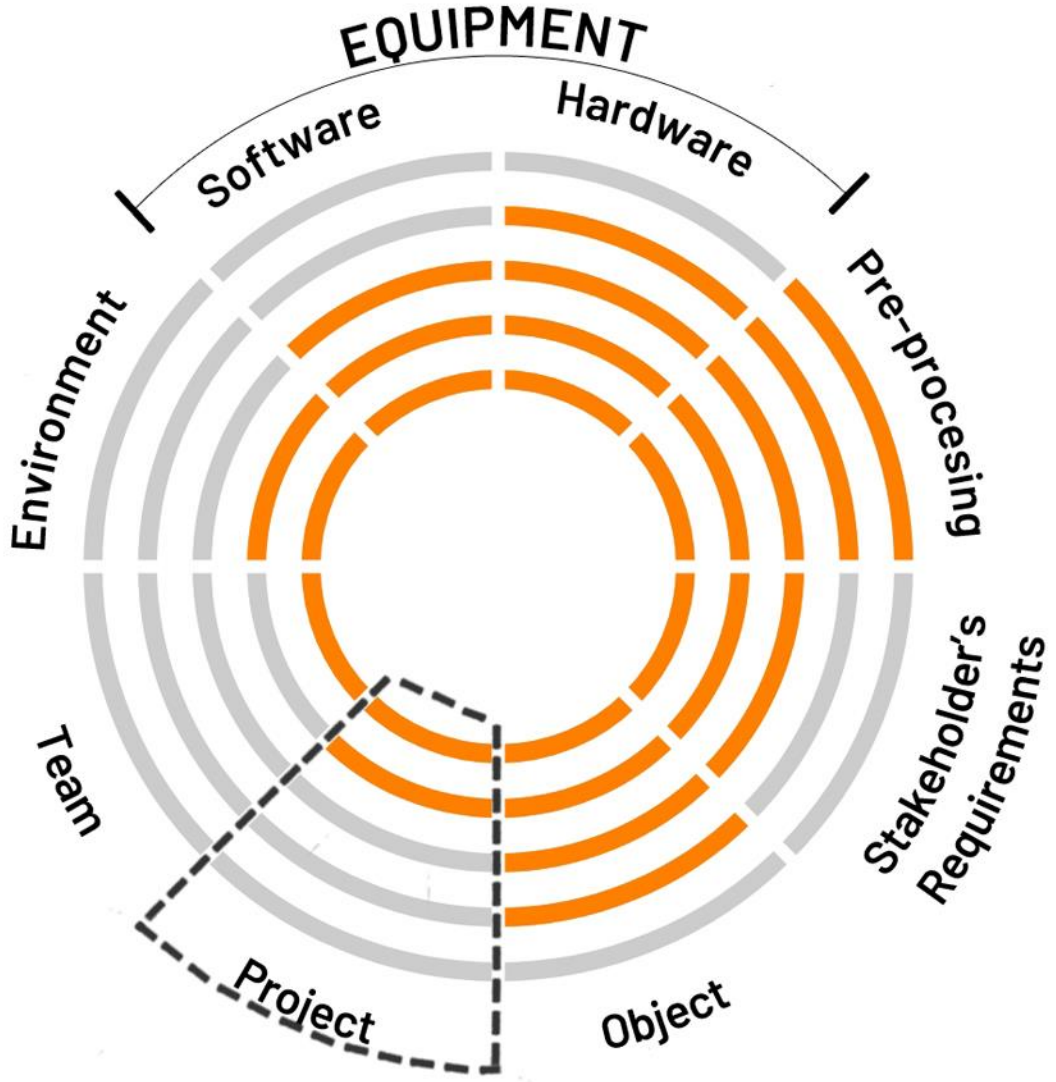

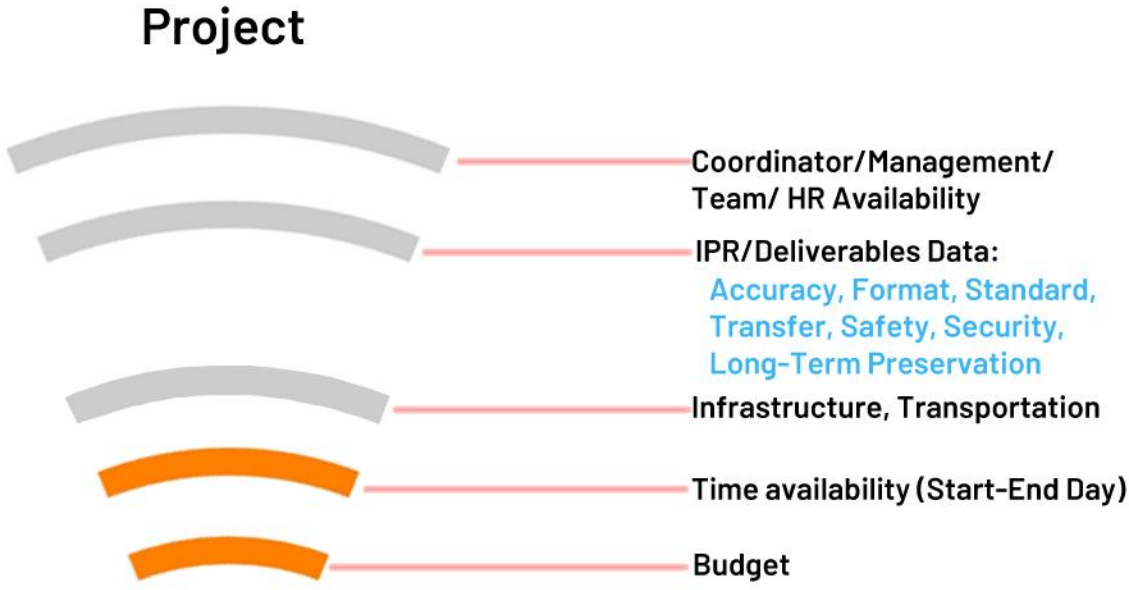

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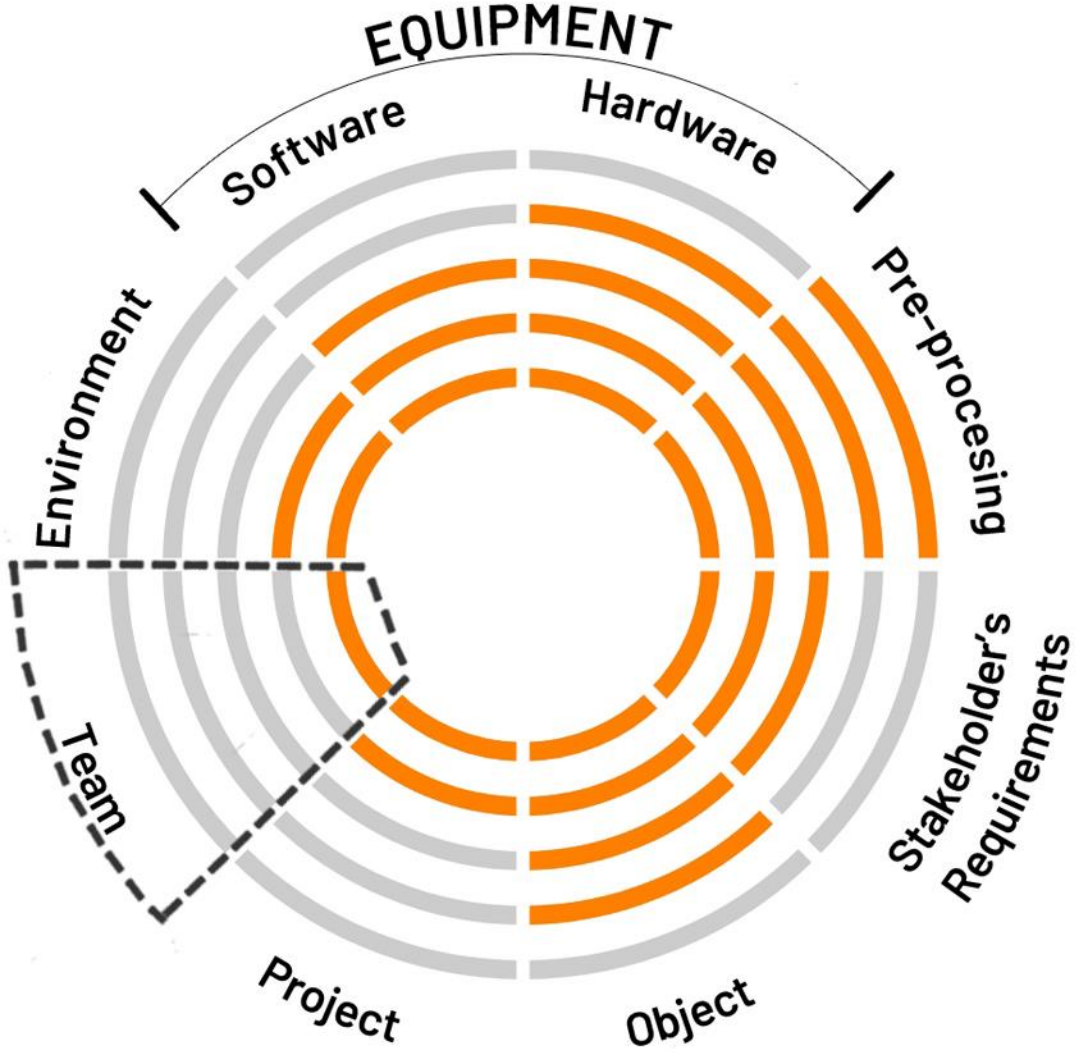

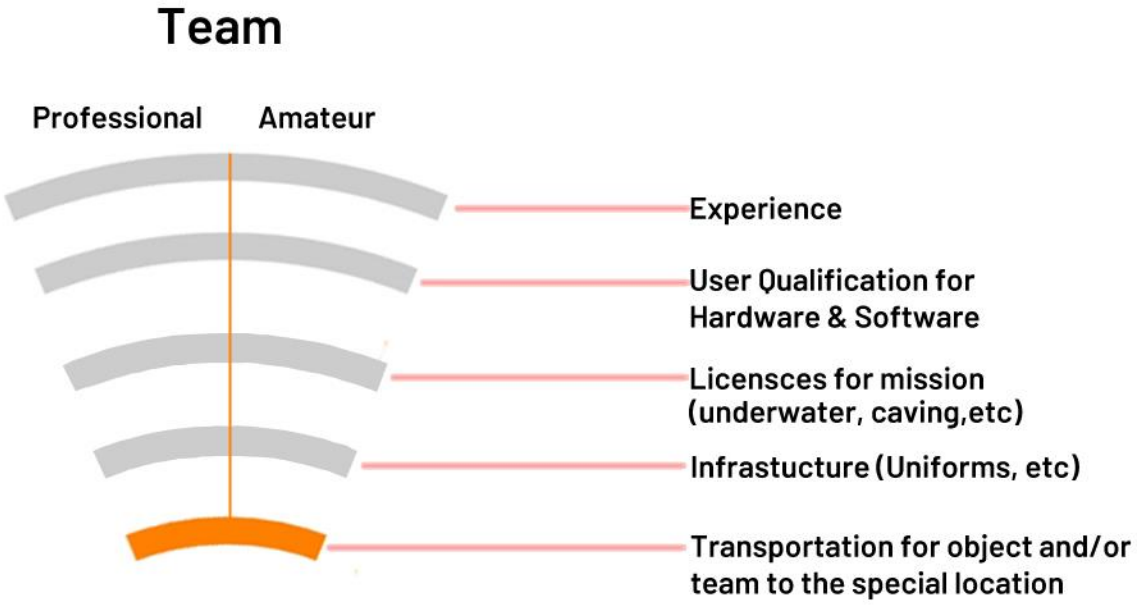

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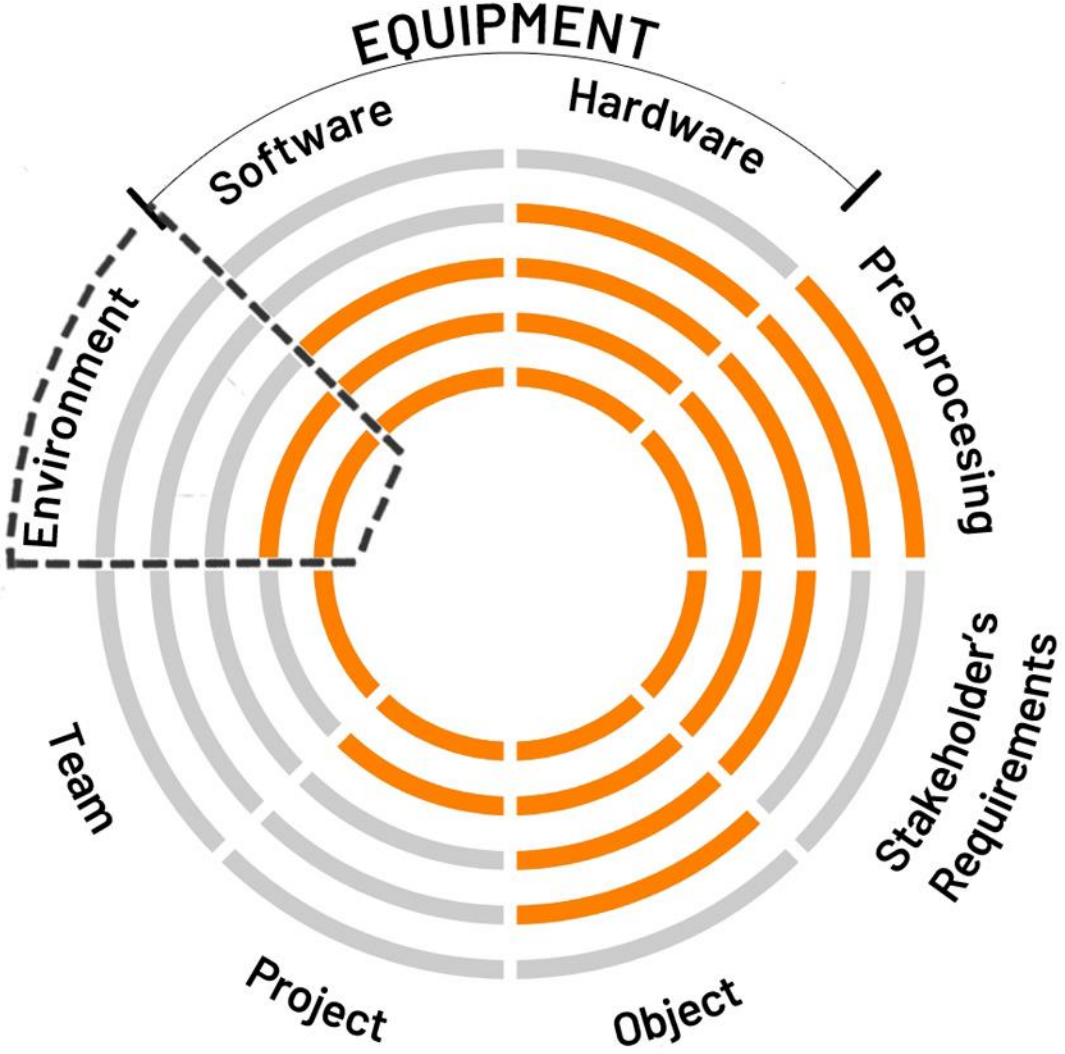

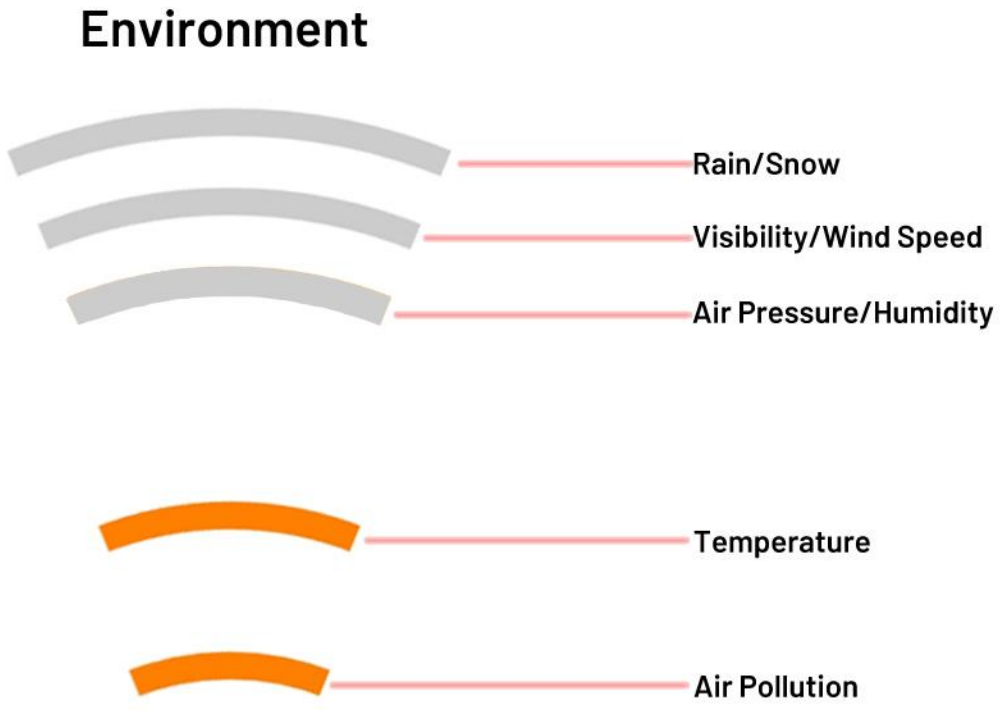

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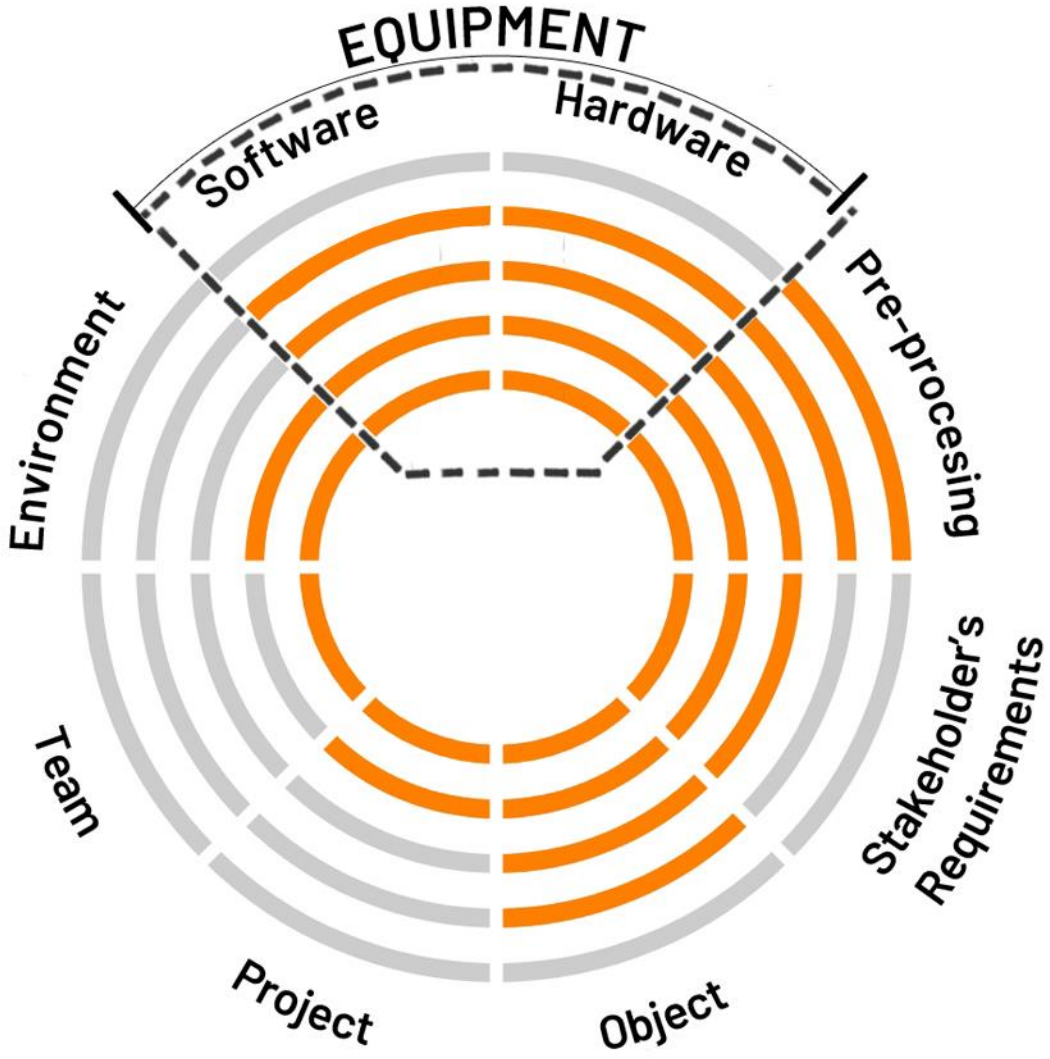
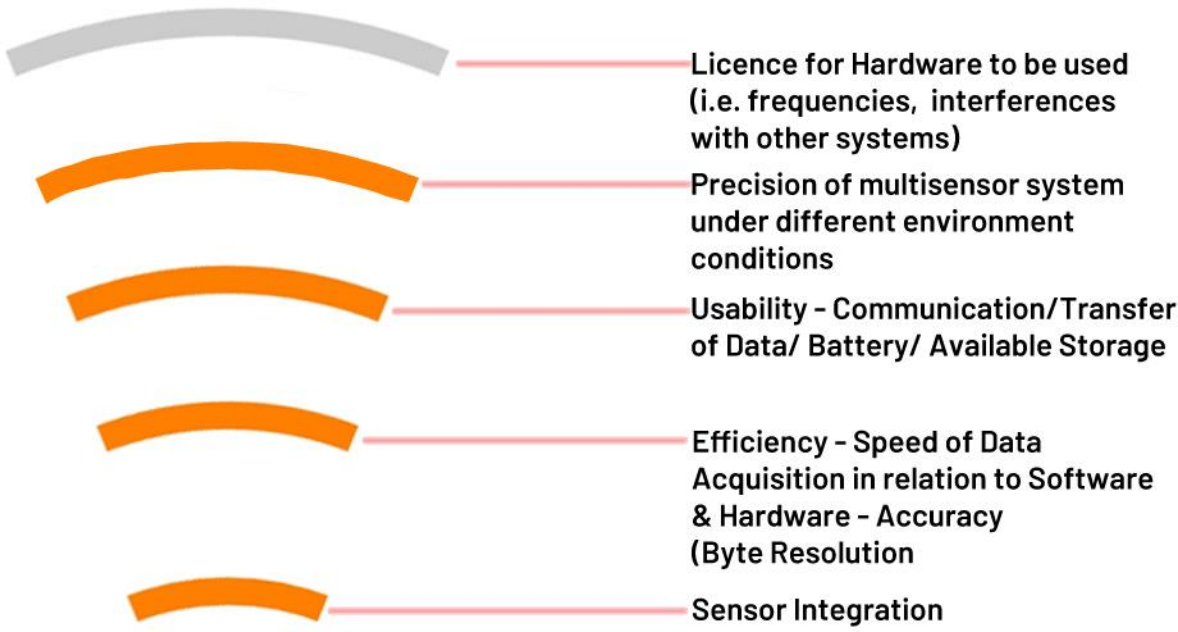


Software & Hardware



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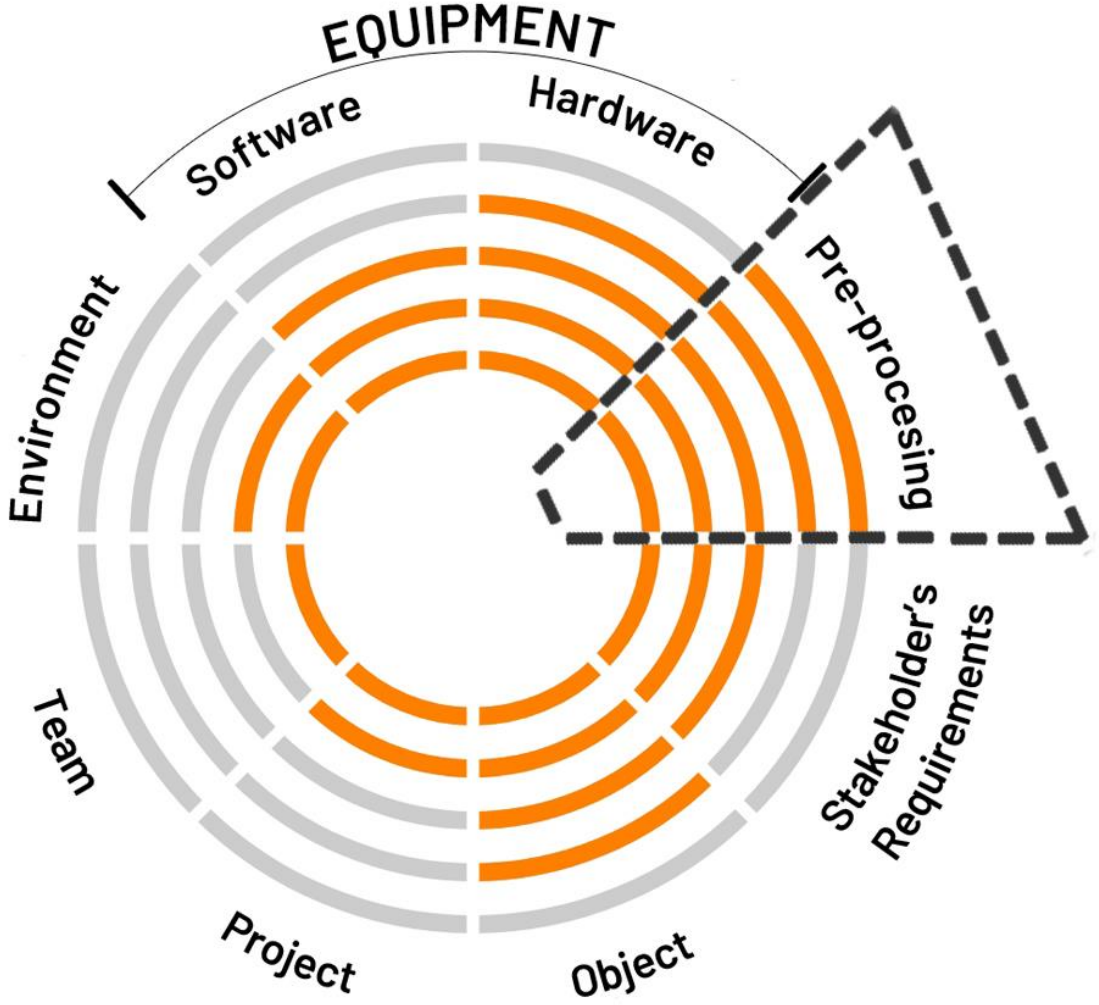

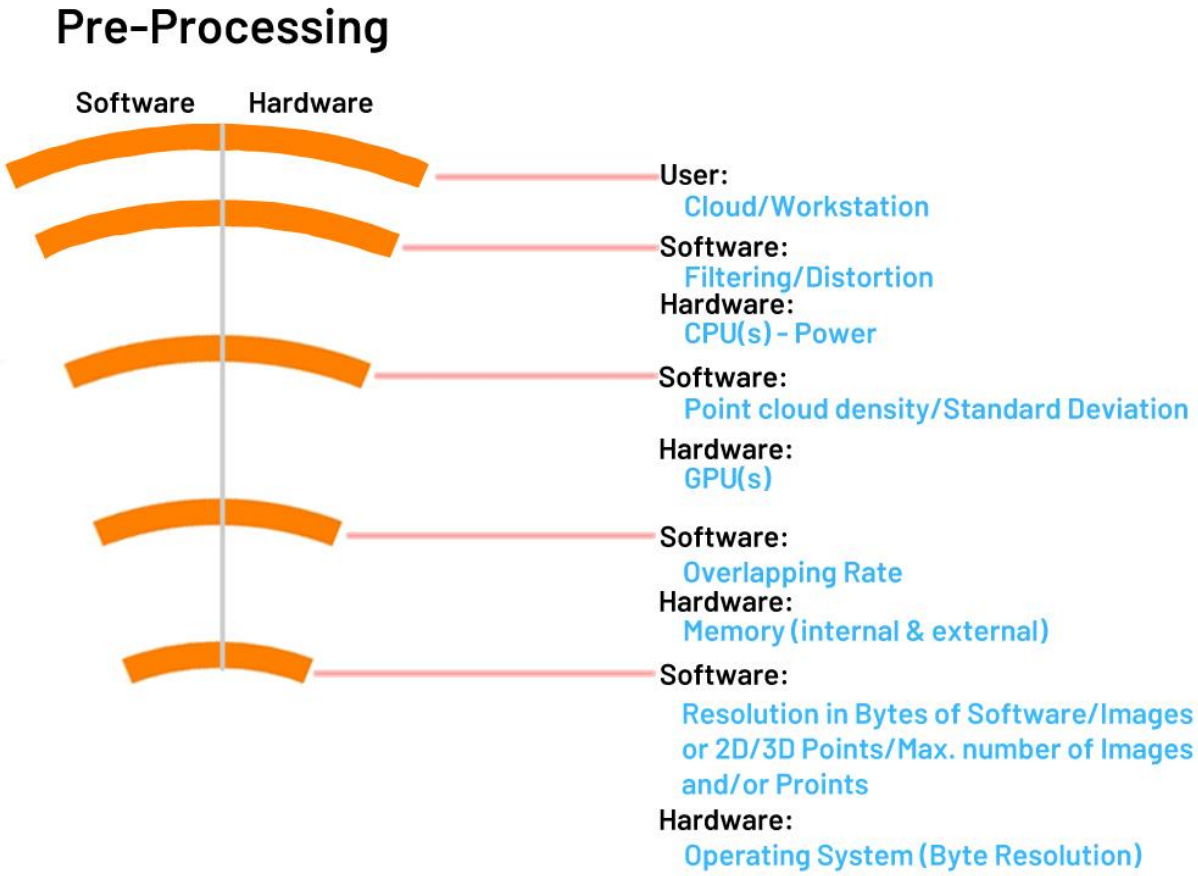

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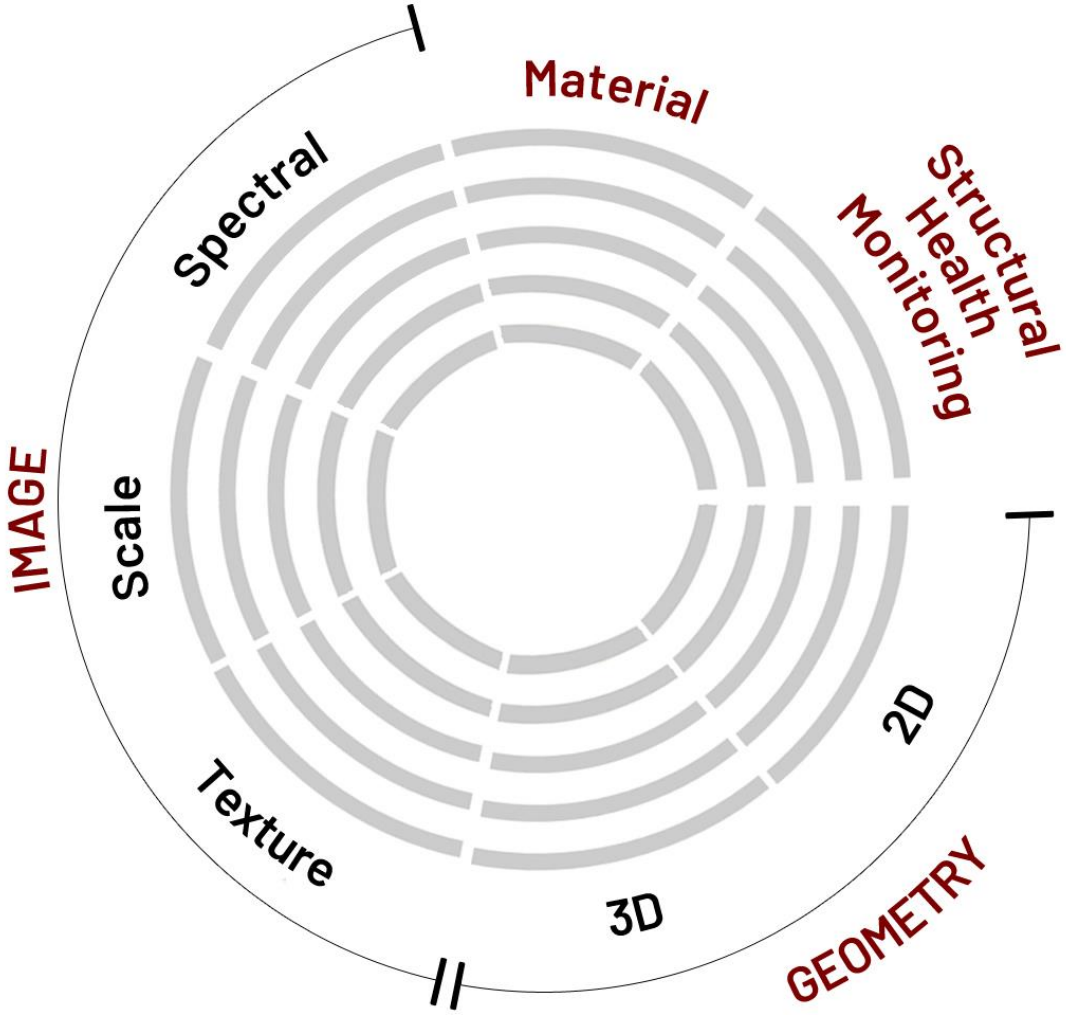
Quality



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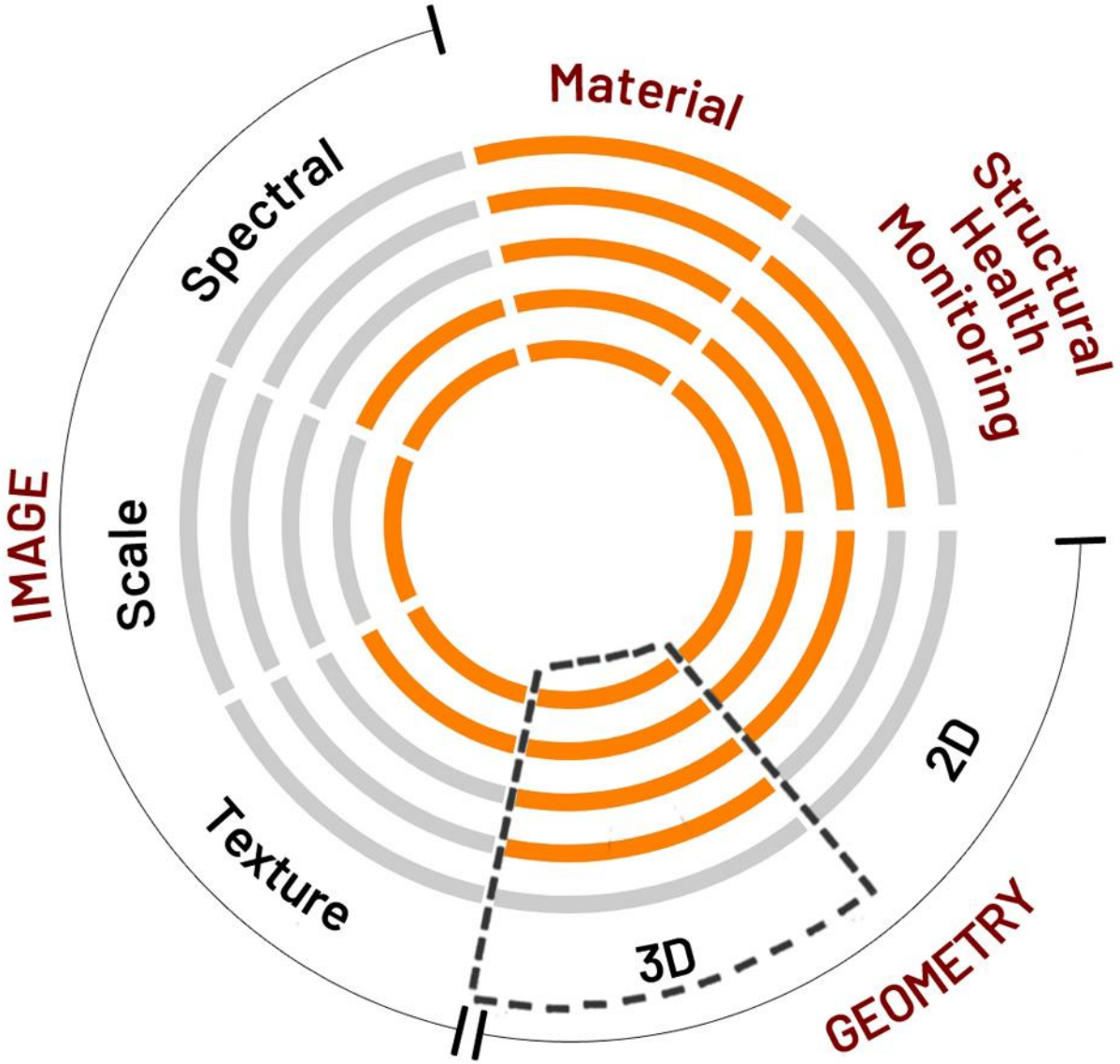

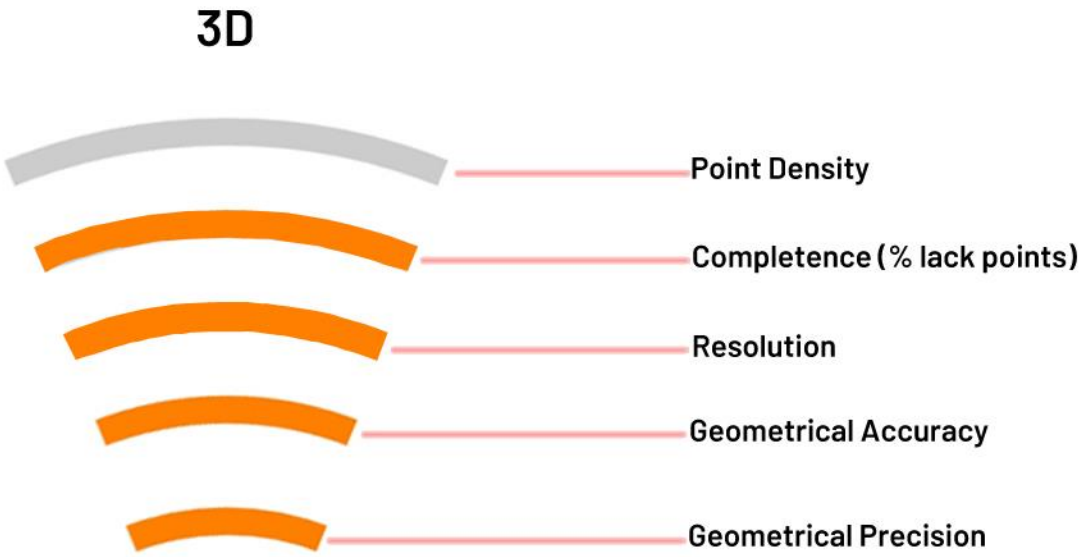

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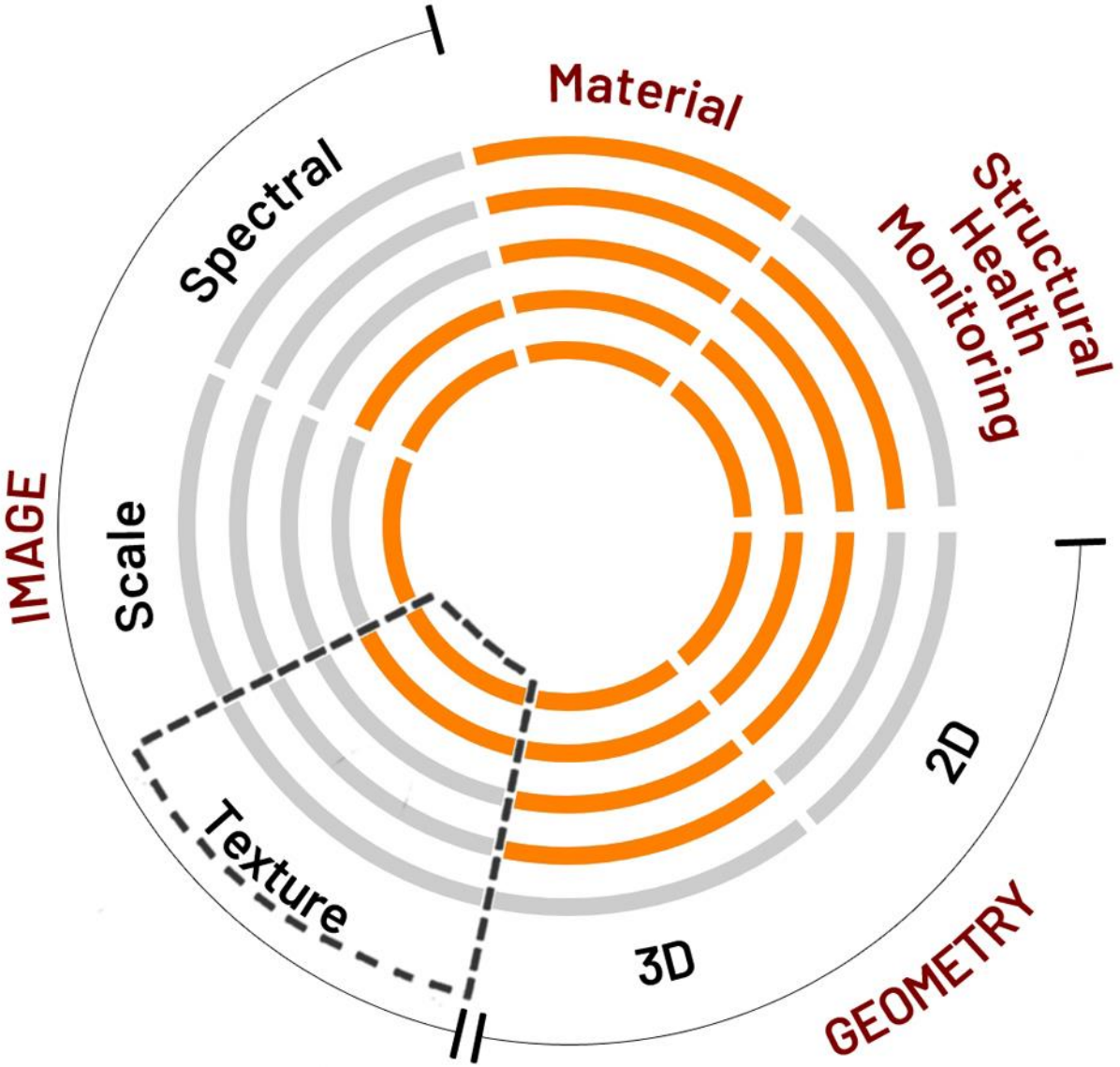

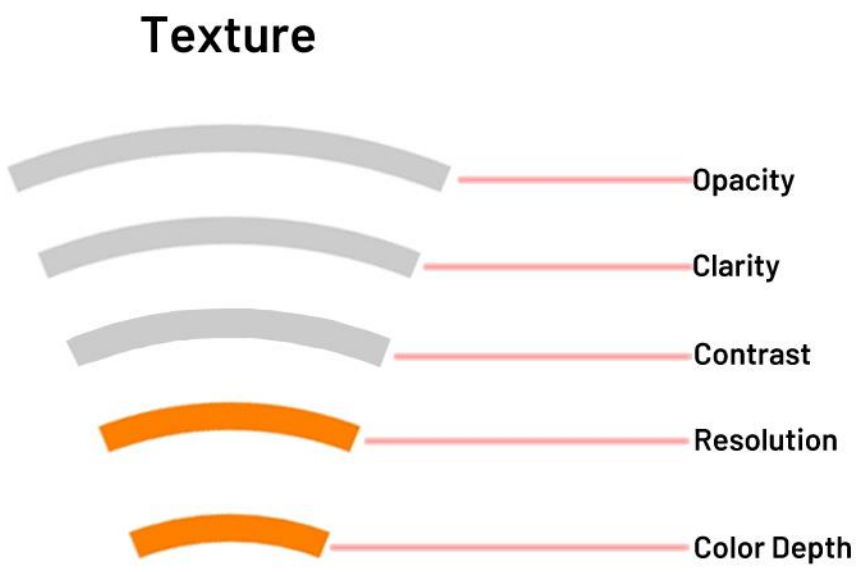

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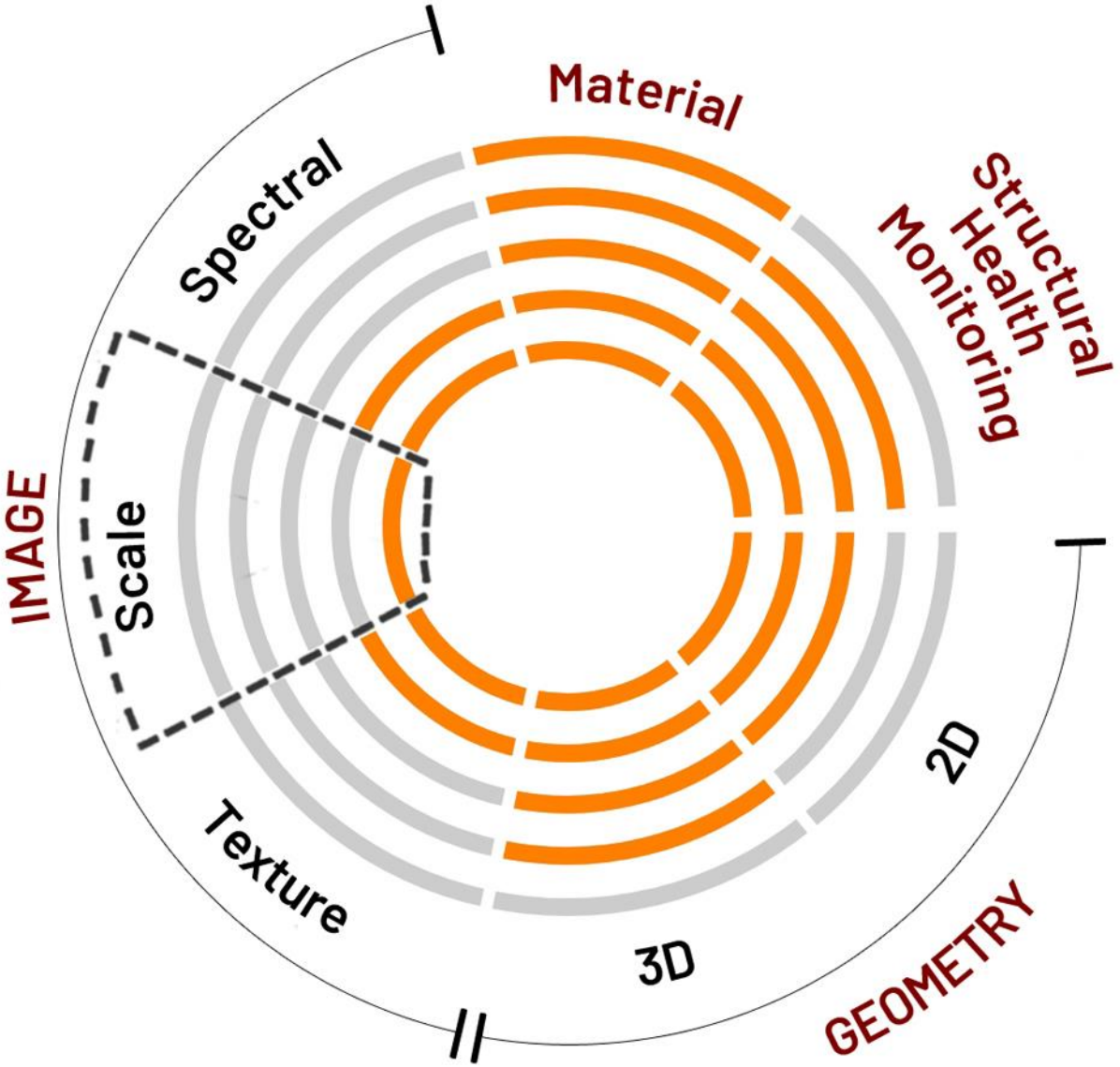

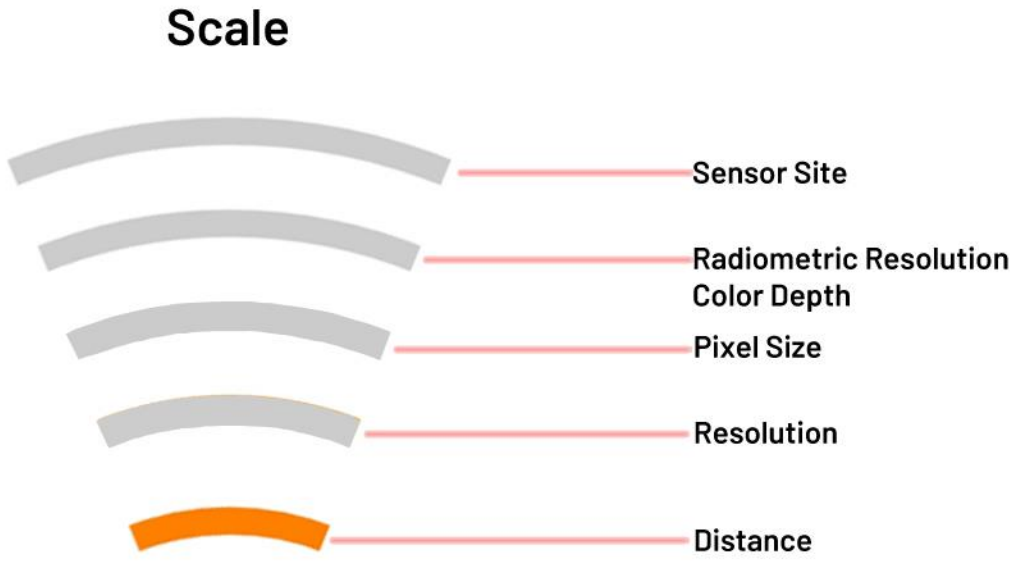

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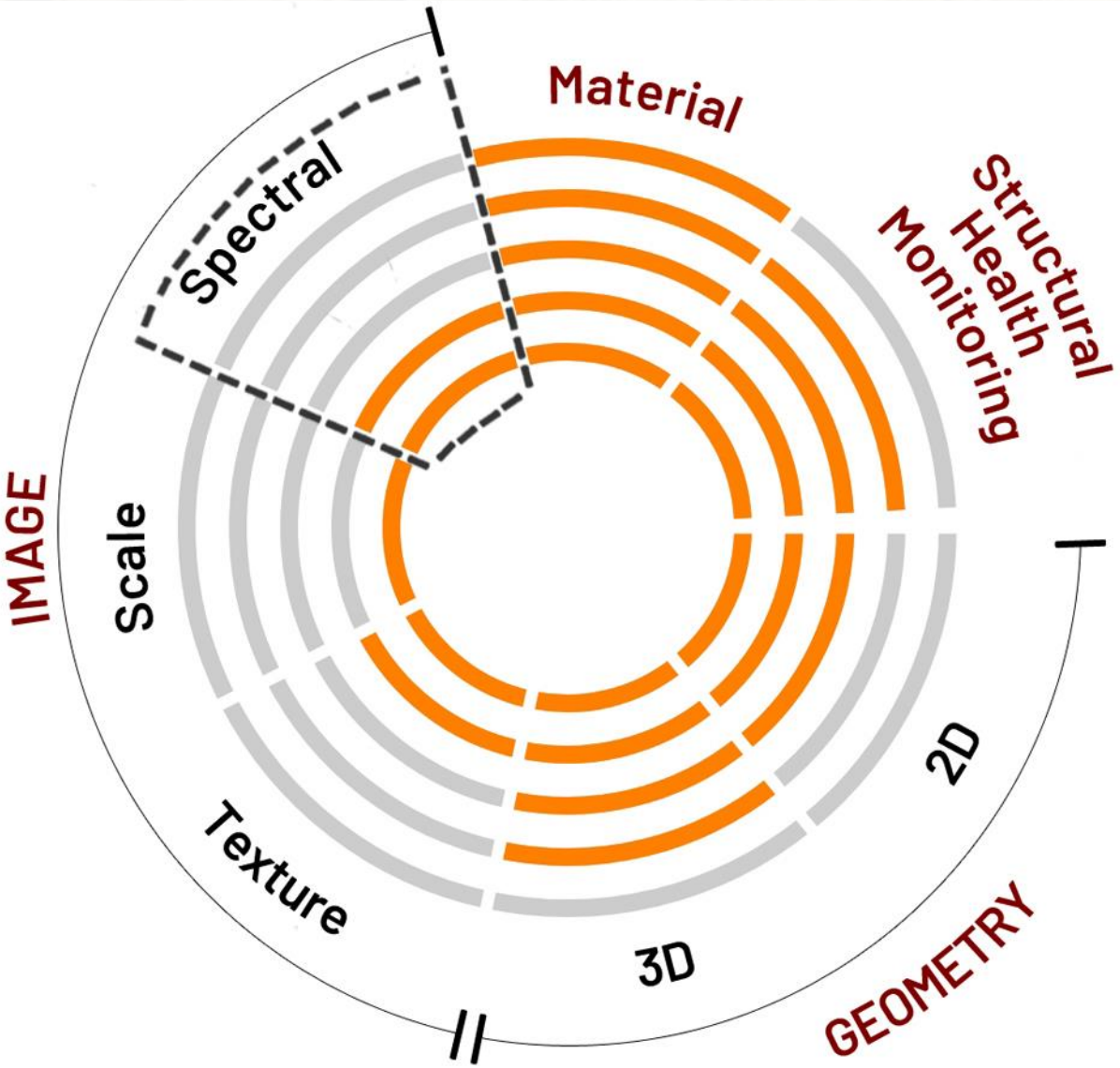

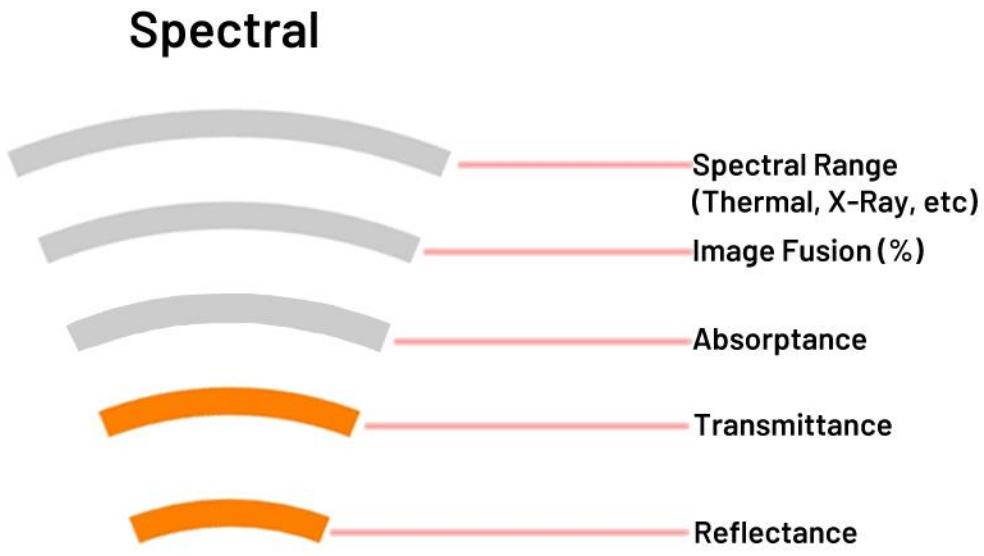

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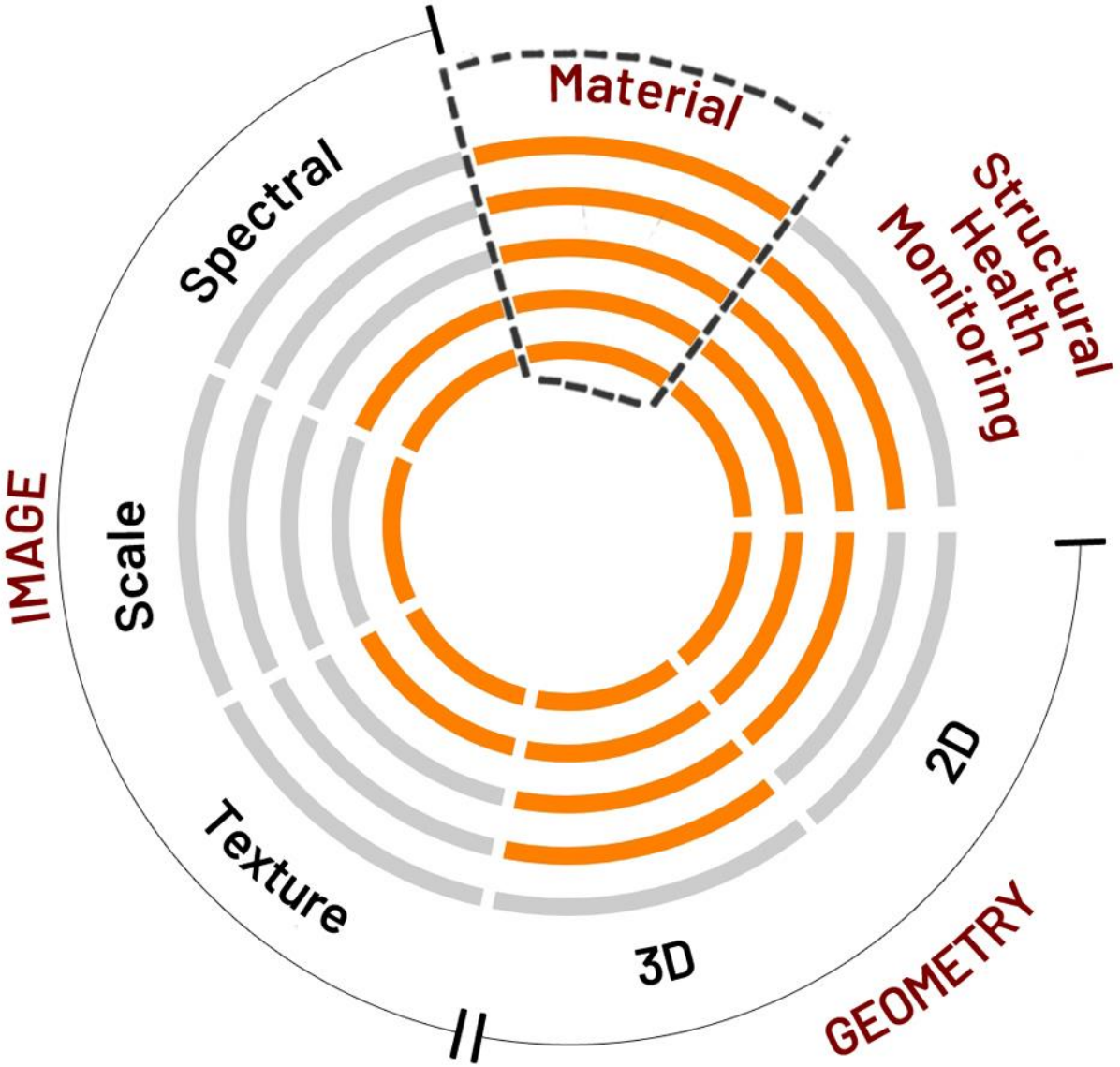

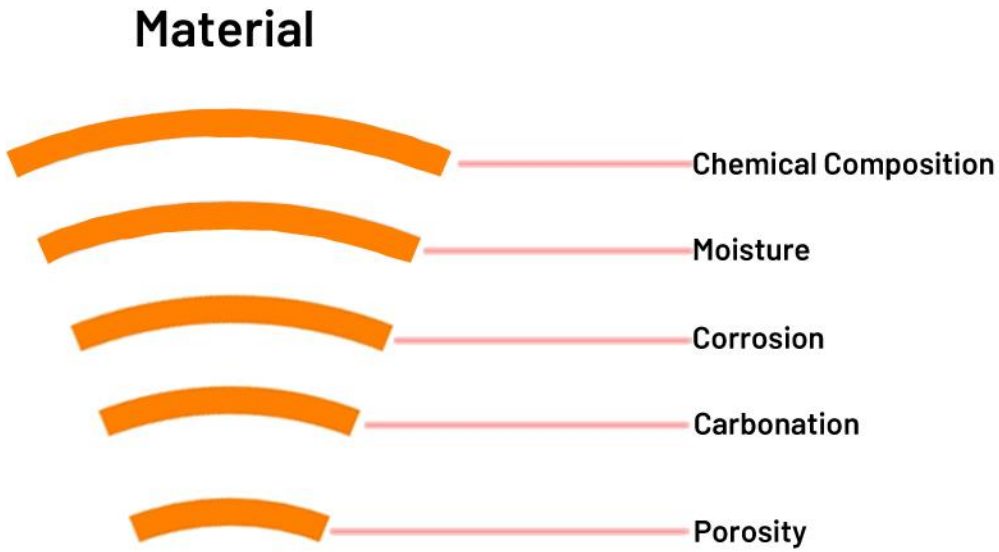

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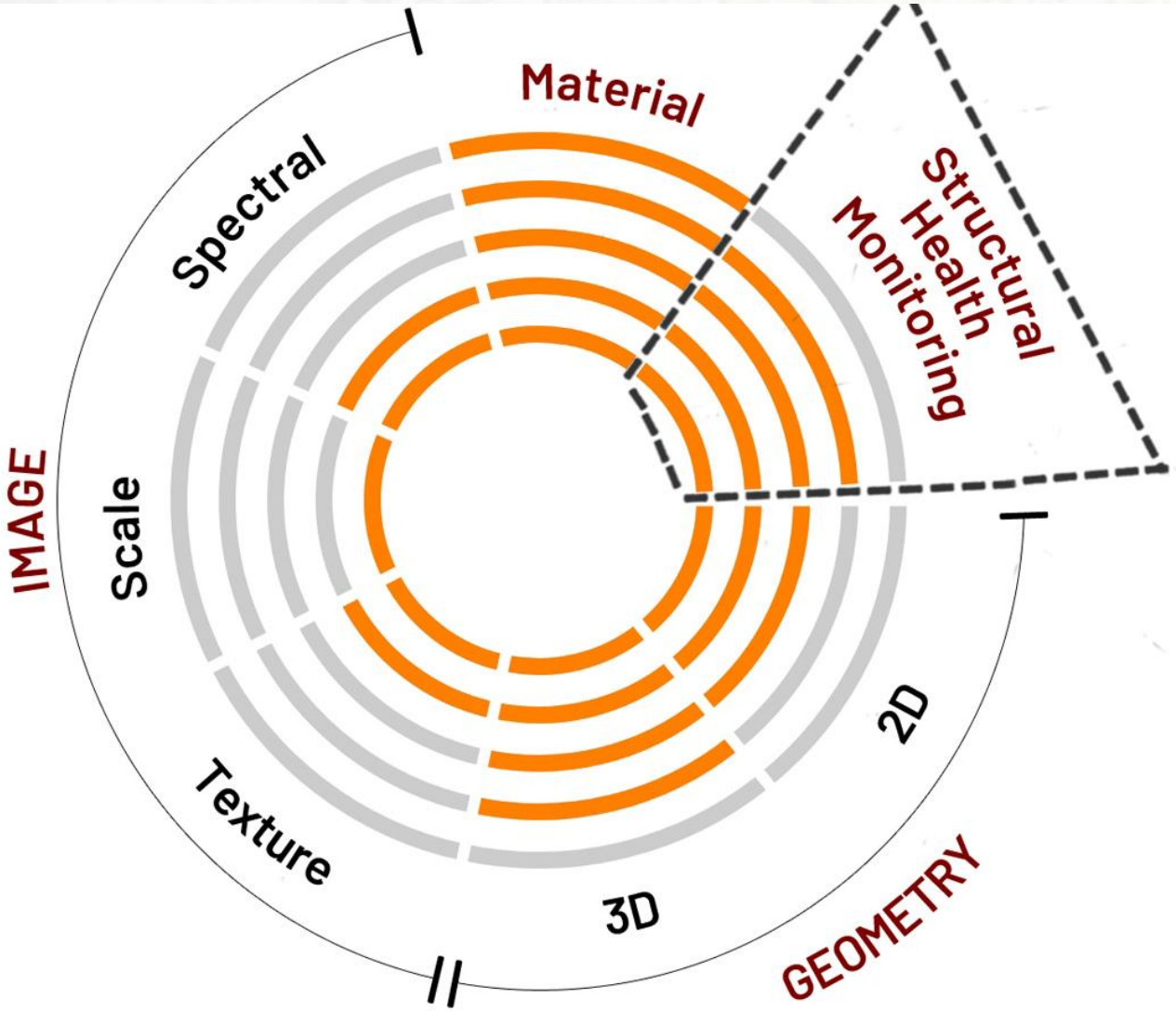

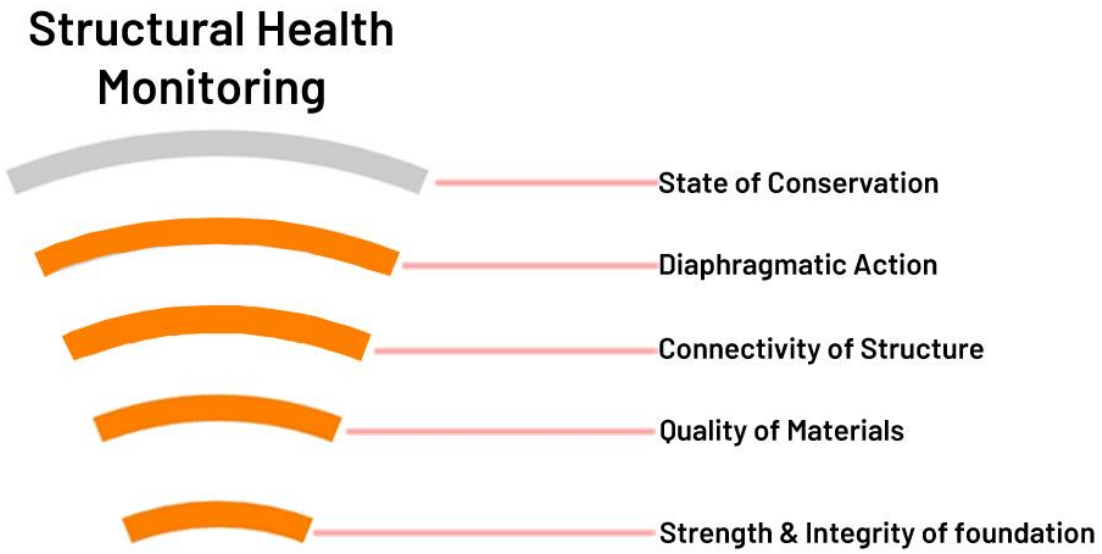

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Formats, standards, benchmarks, methodologies and guidelines

Identify and analyse existing formats, standards, benchmarks, methodologies and guidelines that are relevant for 3D digitisation of tangible cultural heritage (including metadata)

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ASINOU Church in Cyprus

europeana

Terrestrial Laser Scanning

Unmanned Air Vehicle

Photogra-mmetry

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Z+F imager 5016

Terrestrial Laser Scanning

Point Cloud

Thermal Photos

Photos

Type	Pulse
Class of Laser	1
Data Acquisition Rate	1,100,000 / sec
Beam Diameter / Divergence	< 0.3 mrad
Maximum Range	365 m
Dimensional Repeatability	Yes
Weight of Unit	6.5 kg
Dual Axis Compensator	Yes
Tilt Sensor	Yes
Operating Temperature	-10°C to +45°C
Ingress Protection	IP53
Barometer	Yes
Gyroscope	Yes
Tilt Sensor	Yes
IMU	Yes
GPS/GNSS	Yes
Compass	Yes
Laser Plummet	Yes
Onboard Lighting	Yes
Internal Camera	Yes
Thermal camera	Yes
HDR	8-14

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Matrice 300 RTK

Unmanned Air Vehicle

Photos

Video

Weight	1375g
Obstacle Sensing	Yes
GNSS	GPS+GLONASS
Internal Storage	-
Operating Environment	0°C - 40°C
Video Transmission	Dual Band 7 km
Video Format	MP4/MOV (H.264/AVC; H.265/HEVC)
Sensor Format	1" CMOS Sensor
Sensor	1" CMOS
Effective Pixels	20 million
Camera Type	4K@60fps
Flight Time	30min flight time
ISO Range	Video: 100 - 3200(auto) 100 - 6400(manual) T Photo: 100 - 3200(auto) 100 - 12800(manual)
Shutter Speed	Electronic Shutter: 8 - 1/8000 s Mechanical Shutter: 8 - 1/2000

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Sony alpha a7 iii

Photogra-mmetry

Photos

Video

Mirrorless / DSLR	Mirrorless
Sensor Type	CMOS
Sensor Manufacturer	Sony
Effective Megapixels (millions)	24,3
Total Megaixels	25,3
Pixel Size	5.98µm
Sensor Format	35-mm full frame (35.9 x 24.0 mm), Exmor RS CMOS sensor
Sensor size	35.80mm x 23.90mm
Lens Mount	Sony E-mount
ISO Sensitivity	Still images: ISO 100-51200
Image Processor	35 mm full-frame stacked
Self-Cleaning	Yes
Shutter Speed	Still images: 1/8000 to 30 s, Bulb, Movies: 1/8000 to 1/4 (1/3 steps), up to 1/60 in AUTO mode (up to 1/30 in Auto slow shutter mode)
Exposure Compensation	+/- 5.0 EV (1/3 EV, 1/2 EV steps selectable) (with exposure compensation dial: +/- 3 EV [1/3 EV steps])
Sensor shift image stabilization	Image Sensor-Shift mechanism with 5-axis compensation (compensation depends on lens specifications)
Focal Length Multiplier	No
Monitor Size	2.9" multi touch display
Monitor Resolution	1,440,000 dots
Monitor Type	Tilting TFT touch-sensitive LCD
Storage Media	Dual SD/CFexpress Type A slots
Autofocus System	Fast Hybrid AF (phase-detection AF / contrast-detection AF)
Focus Point	35 mm full frame: 759 points (phase-detection AF), APS-C mode with FF lens: 759 points (phase-detection AF), with APS-C lens: 575 points (phase-detection AF) / 425 points (contrast-detection AF)
WiFi	Wi-Fi Compatible, IEEE 802.11a/b/g/n/ac [2.4-GHz band/5-GHz band
Operating Environment	32 - 104 degrees F (0 - 40 degrees C)

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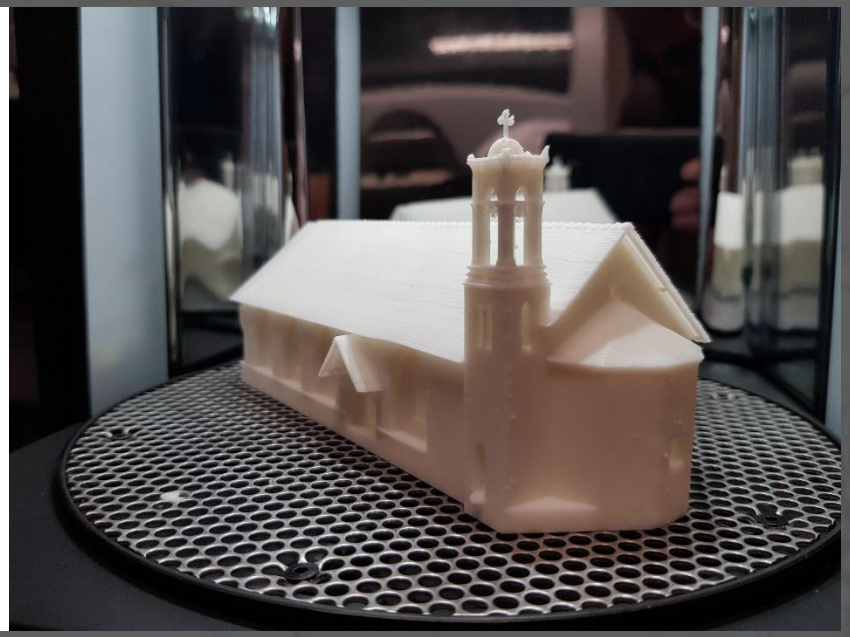
3D Printing/ USE-REUSE

Dr. Petros Siegkas

Physical → Digital → Physical



Restore
Examine
Demonstrate
Access

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3D Printing/ USE-REUSE

Considerations on quality and qualities

Modelling strategy e.g.

- Showcase interior
- Showcase exterior
- Multiple pieces ease of split-open
- Emphasis on particular elements
- Function, demonstration, aesthetics

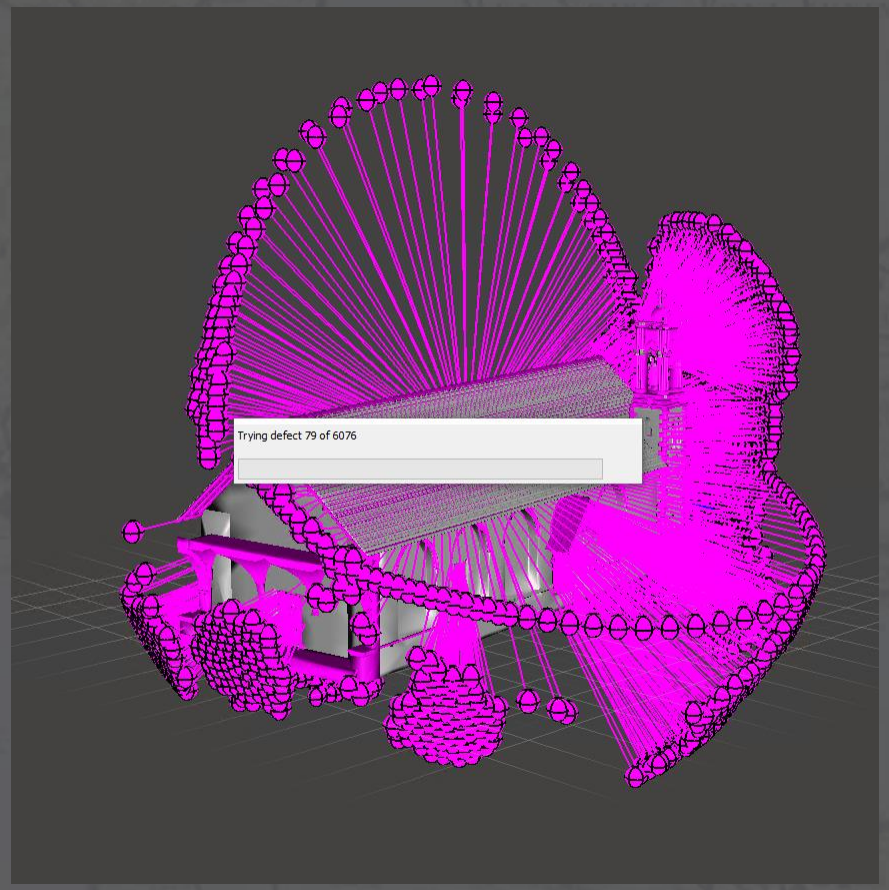
Equipment

- Stereolithography UV resin
- Fusion deposition modelling
- Combination based on texture/resolution

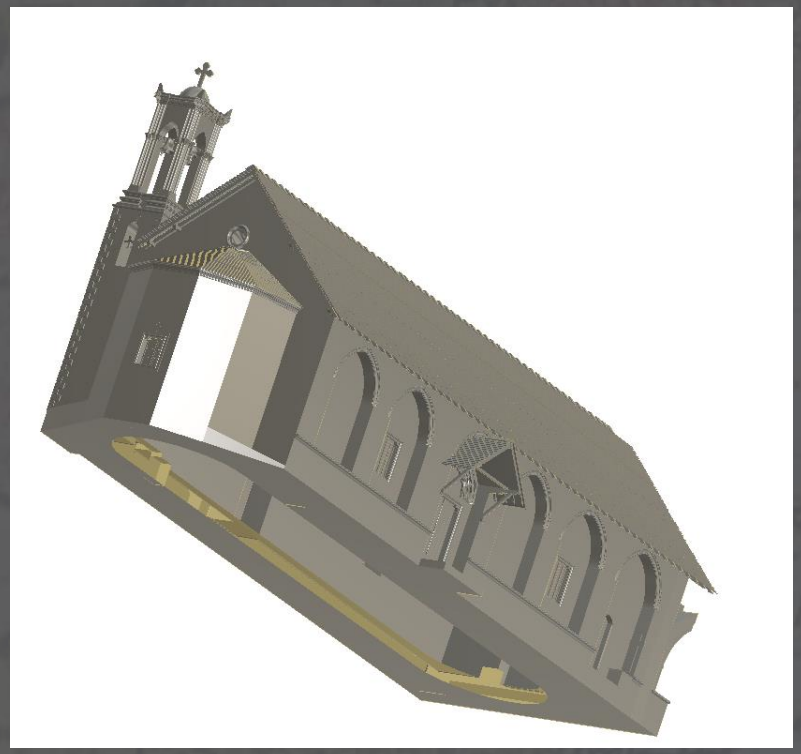
Materials

- Transparency
- Colour
- Combination for various features

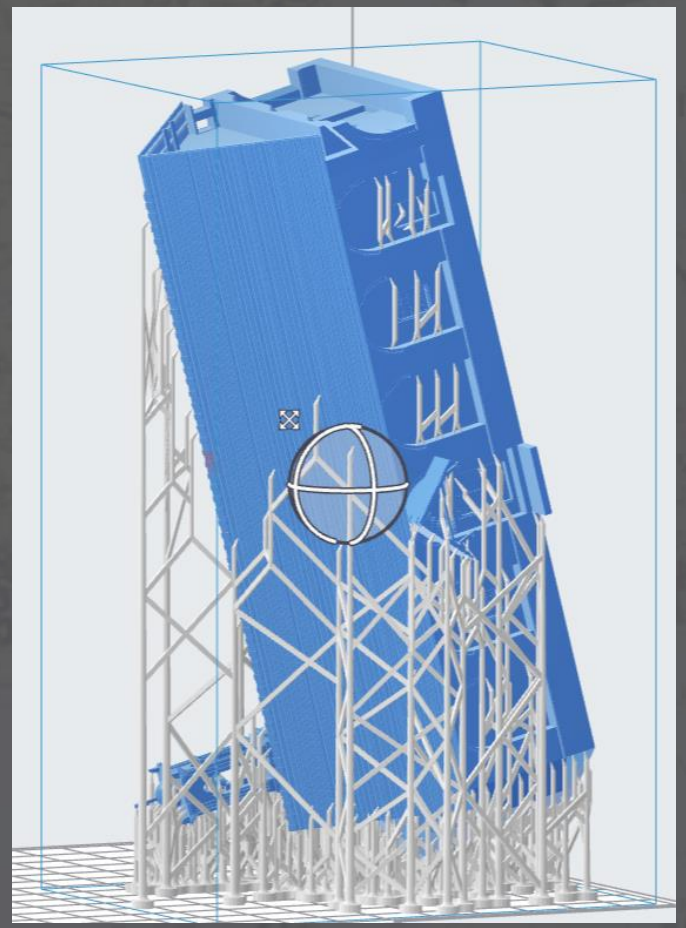
3D Printing/USE-REUSE



3D Printing/ USE-REUSE



Model fix and editing CAD programs
Show interior
Allow for resin to escape



Prepare for print
Supports and orientation (Overhanging parts, small features, avoid cups and potential collapse)

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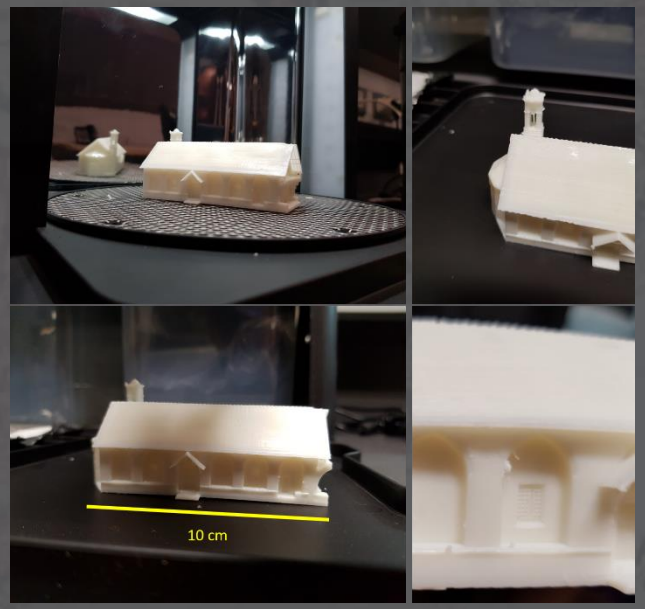
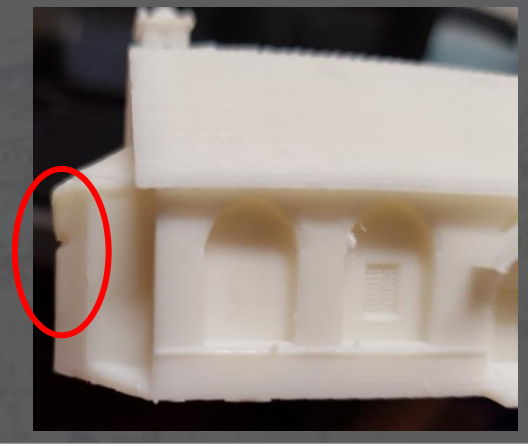
3D Printing/ USE-REUSE

1:289





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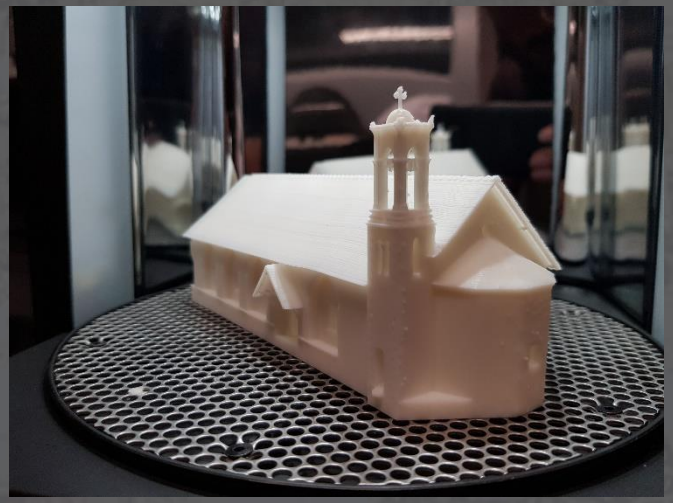

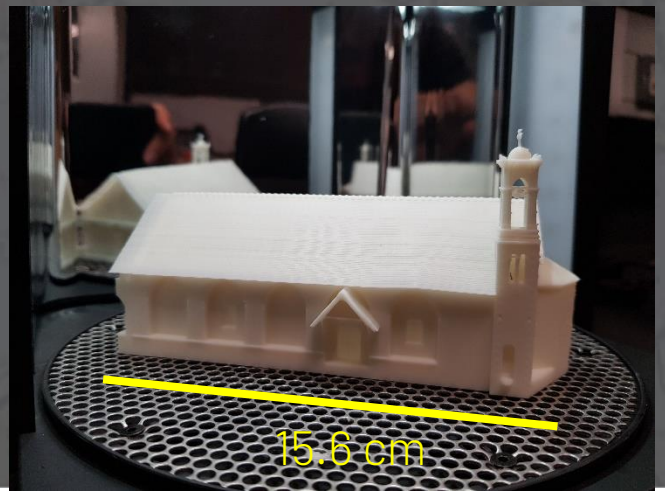

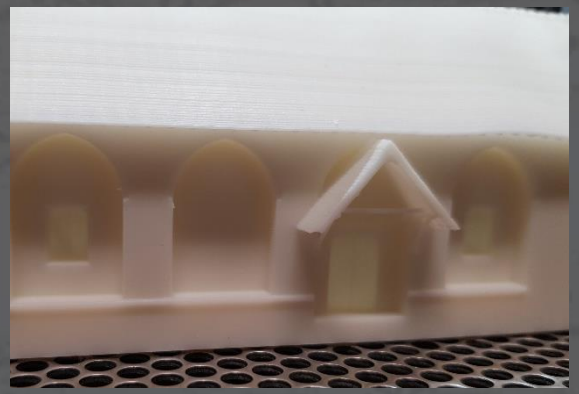

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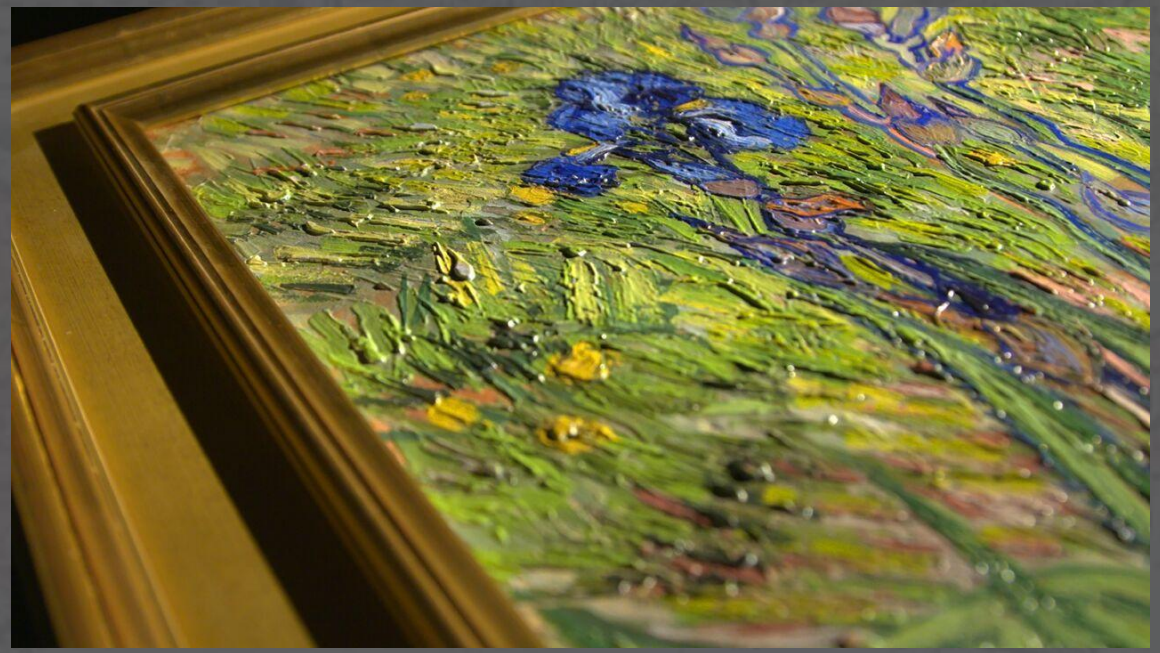

3D printed reproduction of Van Gogh's Irises

3D printed reproduction of Monet's Stormy Sea

Dr Petros Siegkas

MEDAM Lab
CUT

EUREKA3D

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THANK YOU

Marinos.ioannides@cut.ac.cy

3D printed reproduction of Van Gogh's Irises

3D printed reproduction of Monet's Stormy Sea

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