

"Multimodal Scanning of Cultural Heritage Assets for their multi-layered digitization and preventive conservation via spatiotemporal 4D Reconstruction and 3D Printing"

# The Scan4Reco Project (Scopes & Achievements)

WORKSHOP on novel non-invasive technologies assisted by Robotic & Artificial Intelligence for Cultural Heritage preservation & documentation

**Presenter: Dr. Anastasios Drosou** (Deputy Coordinator)





Project funded by the Horizon'2020 in topic "Reflective-7" Grant Agreement #665091



**Summary** 

- Grant Agreement No.: 665091
- **Project acronym:** Scan4Reco
- Project title: Multimodal Scanning of Cultural Heritage Assets for their multi-layered digitization and preventive conservation via spatiotemporal 4D Reconstruction and 3D Printing
- Start date: 01/10/2015
- Duration: 36 Months Currently @ M30

• **Project website**:

#### www.scan4Reco.eu



This project has received funding from the European Union's Horizon 2020 Research and innovation programme under Grant Agreement n°665091



## The Scan4Reco Consortium

Participant organisation name	Short Name	Country	Org. Type	Logo
CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	CERTH	Greece	Research	fi
IDRYMA ORMYLIA	OF-ADC	Greece	Research/ End User	
FRAUENHOFER INSTITUT	FRH IGD	Germany	Research	Fraunhofer
UNIVERSITY OF VERONA	UNIVR	Italy	University	3
OPIFICIO DELE PIETRE DURE	OPD	Italy	End-User	
CENTER FOR ADVANCED STUDIES, RESEARCH AND DEVELOPMENT SARDINIA	CRS4	Italy	Research	
BWTek Europe GmbH	BWTEK	Germany	SME	Burehope Your Spectroscopy Partner
Avasha AG.	AVASHA	Switzerland	SME	avasha advanced optical and photonic engineering
RESEARCH FOR SCIENCE, ART & TECHNOLOGY (RFSAT) Ltd	RFSAT	UK	SME	RFSAT Ltd.



With respect to Cultural Heritage documentation & preservation, the following holds:

- enormous European Cultural Heritage (CH) including a vast and rich variety of cultural items
- different materials with different ageing patterns
- different restoration procedures
- multi-factorial reasons for the CH deterioration
- lack of detailed & efficiently collectable documentation
- enriched 3D representations (printed or digital) is valuable for conservators
- limited accessibility to public



- The study of the cultural assets and archeological findings/remains from past periods of the human history helps us better understand the origins and the way human and human societies have evolved over the centuries.
- Europe has a particularly **rich & diversified cultural heritage**, monuments and objects of all sizes, composed of a great variety of materials.
- High importance CH objects are preserved in museums effectively protected conditions against environmental influences to secure them against effects of relative humidity, temperature and exposure to light, etc.
- There is an **increasing tendency for the digitization** (virtual reconstruction & representation) for:
  - dissemination
  - educational reason (i.e. via digital copies),
  - research (i.e. detailed computerized analysis)
  - conservation & restoration.



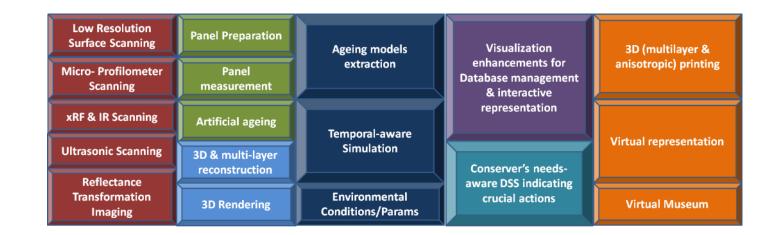
"Truth is like a sculpture - one perspective is never enough for true understanding" F. Nietzsche

→ Scan4Reco offers a multi-angle (in spatio-temporal terms) view of the objects ←

- Automatic approach: Lack of an end-to-end platform for CH documentation; HQ 3D models generation <u>underdeveloped</u>
- Multi-sensorial platform: multi-perspective view on the CH object
- Assisted Positioning: Human driven scanning may be <u>unhealthy</u>, <u>imprecise</u>, <u>fatigue</u> <u>sensitive and of limited capacity</u> for simultaneous multi-sensorial scanning
- **DSS:** Conservation decisions & actions are mainly based on heuristic knowledge & punctual information
- 4D Simulation: Risk estimation & degradation potential of a CH object are <u>not</u> systematically defined
- **3D Printing:** <u>Haptic</u> interaction of the CH object (informatively rich version)
- **3D Reconstruction & Visualization:** CH objects are difficult to be studied <u>out-of-situ</u> in depth; only accessible to limited public (i.e. visitors)



- Scan4Reco aims to facilitate the preservation, conservation, curation, restoration & documentation via automatic digitization of a wide variety of cultural heritage assets even in situ, using:
  - Multispectral scanning & digitization
  - Material exploration, identification & modelling
  - Accurate 3D reconstruction models
  - Demonstration in virtual museums
  - Tactile multilayered surrogates for both scientific and commercial usage





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Domain	Research Project									
virtual 3D-capture/scanning	<b>3D-PITOTI</b> - 3D acquisition, processing and presentation of prehistoric European rock-art									
processing & modelling	<b>3D-COFORM</b> - Tools and Expertise for 3D Collection Formation <b>V-City</b> – The Virtual City									
reconstruction via scanning with simple RGB/laser cameras/ penetrative THz technologies	<b>c-Space</b> - An affordable tool to turn the space surrounding us into a creative experience <b>INSIDDE</b> - INtegration of cost-effective Solutions for Imaging, Detection, and Digitisation of hidden Elements in paintings									
visualization tools arousing a series of senses like vision hearing, touch & as animation/VR	<b>Dreamspace</b> - A Platform and Tools for Collaborative Virtual Production <b>CREATIF</b> - Digital creative tools for digital printing of smart fabrics <b>CultAR</b> – Culturally Enhanced Augmented Realities									
dataset enrichment & metadata	<b>DIACHRON</b> – Managing the Evolution and Preservation of the Data Web <b>DECIPHER</b> - Digital Environment for Cultural Interfaces; Promoting Heritage, Education and Research									
predictive augmentation technologies for the completion of fragmented/incomplete CH standardized preservation processes	<ul> <li>PRESIOUS - Predictive digitization, restoration and degradation assessment of cultural heritage objects</li> <li>FORGETIT - Concise Preservation by combining Managed Forgetting and Contextualized Remembering</li> </ul>									
interconnections between large, cross-discipline multimedia	<b>PAPYRUS</b> - Cultural and Historical Digital Libraries Dynamically Mined from News Archives PrestoPrime – Keeping Audiovisual Contents Alive <b>KEEP</b> – Keeping Emulation Environments Portable									



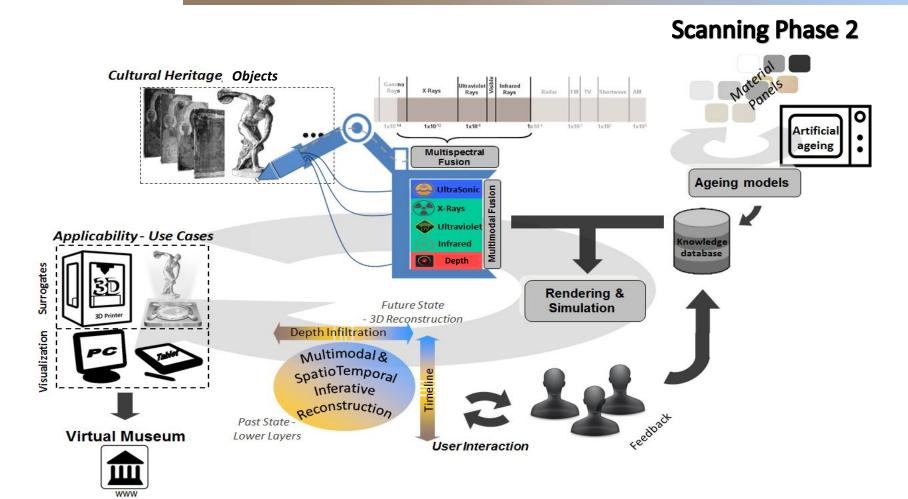
# **The Scan4Reco Objectives**

 Development of a novel, portable, integrated, modular solution for customized, costeffective, automatic digitization and analysis of Cultural Heritage Objects (CHOs), even in situ, using:

√	Multi-sensorial 3D scanning facilitated by a mechanical arm to collect multi-spectral data used for the application of hierarchical approach for 3D reconstruction of CHOs that will enable multi-layered rendering for analysis & 3D printing
√	Creation of high precision <b>digital surrogates</b> of CHOs to provide details about <b>surface</b> , <b>volumetric structure</b> , <b>material composition</b> , <b>shape/structure of underlying materials</b> and to render them via <b>visualization techniques</b> or <b>via transparent multi-material 3D printing</b>
$\checkmark$	Material Analyses to understand heterogeneity of CHO, to identify classes of materials, to monitor degradation over time, to create <b>ageing models</b> per material
$\checkmark$	<b>Spatiotemporal Simulation</b> of CHOs to render degradation effects, predict and recreate CHOs' future appearance and automatically restore them
$\checkmark$	A <b>Decision Support System</b> to suggest over appropriate <b>conservation methods</b> for the indicated by Scan4Reco spots/segments of CHOs that are in eminent conservation need
$\checkmark$	A <b>Virtual Museum</b> to enhance accessibility of the digitized cultural objects to scientific community, field experts, general public

# Scan4Reco Conceptual Architecture





 Two classes of cultural heritage objects, i.e. paintings & metallic objects will be used as validation pilots.



- 2 classes of cultural heritage objects, i.e. paintings & metallic objects will be used as validation pilots.
- Use cases:
  - Environmental conditions & metadata definition
    - Environmental conditions of artwork degradation and the corresponding type of restoration intervention will be defined and studied.

#### ✓ Cultural Object Scanning

• A selected artwork will be digitally acquired to generate (a) a global coarse-resolution 3D representation of the color and geometry of the artwork and (b) local physical and chemical measurements of small, flat areas on the artwork surface/subsurface.

#### ✓ Spatiotemporal Simulation

• Virtually simulating the evolution of artwork condition over time, in order to make reliable prediction on the object behaviour and the effect of the restoration treatments.

#### ✓ Analysis & Guidelines generation

• It will provide curators and restorers with a rendering-based help to take the right operational strategy.

#### ✓ 3D Visualization, Interaction & 3D Printing

• Using visualization tools, both virtual and physical, will allow for a real-time, easy interaction between the end-users, scholars, curators and general public, and the cultural heritage assets.



# **Overview of reference samples**

#### **Pigments/samples with varnish**





Fig. (up) Pigment panel, (down) Design of the 3d structure of the panel with combination of successive layers of pure pigments or of mixtures of them in each sub layer

#### **Metallic reference samples**

<u>COATED SILVER SAMPLES</u>

Silver SET1: 16 samples Silver SET2: 16 samples Two not treated samples (one smooth and one chased)

<u>COATED BRONZE SAMPLES</u>

Bronze SET1: 9 samples Bronze SET2: 9 samples

One not treated sample

BRONZE SAMPLES WITH PATINA

Patina SET1: 16 samples

Not treated strips in between areas

with patina





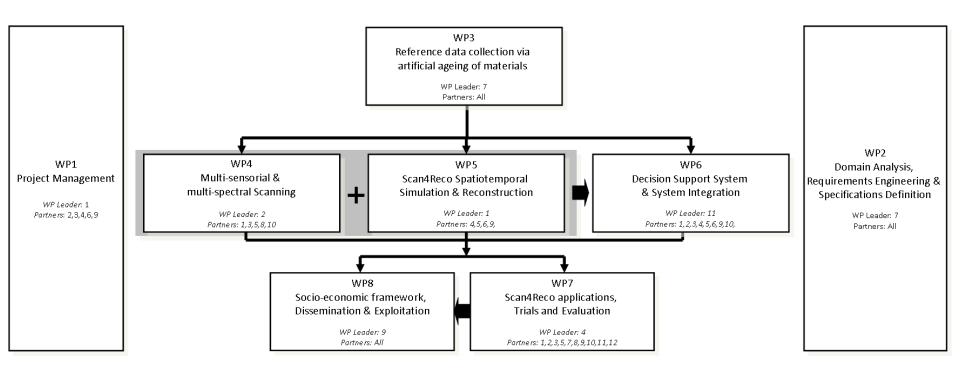




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## **WPs Inter-dependencies**

#### **Pert Diagram**





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	W	ebsite	Spec	cification		Architectur	e Ageing M	odels	VR Museum	Early Prototype	e Sca	anning Platform	Fin	al Prototype	End
		Q1	<u> </u>	Q2	1	Q3	Q4	61	Q2	2 Q3	Q4	Q1	Q2	3 Q3	Q4
	Milestones				M6					18 M19 M20 M21 M22					
WP1	Project management														
	Overall Project Coordination, Administrative and Financial Management	_	D1,				D1.4				D1	ວ			
	Quality Assurance and Risks Management	_		D1	3	_									
	Management of Data, Knowledge and Intellectual Property Right Issues				D1.	2		_			_				
WP2	Domain Analysis, Requirements Engineering & Specifications Definition						<b>D</b> 2.4								
	Sensing Probes and Modalities Specification	_					D2.4 D2.1	_							
Task 2.2	Technology Exploration and S/W fusion requirements	_				D2	2 02.1			10 5					
Task 2.3	System Requirements and Architecture Specification End-user requirements	-					2			<mark>)2</mark> .5					
					D2.	3									
WP3 Task 3.1	Reference data collection via artificial ageing of materials						<b>D</b> 2 4								
	Exploration of artworks physical chemical properties Reference samples preparation	-					D3.1 D3.2								
	Application of artificial ageing procedure and treatments	-					D3.2 D3.3								
	Reference samples measurements and Ageing Factors extraction and modeling	-					03.3	D3	4						
WP4	Multi-sensorial & multi-spectral Scanning							00	*						
	Surface optical scanning microprofilometry, semantic feature extraction & reconst	ruction										D4.0			
Task 4.1 Task 4.2	Ultrasonic scanning, semantic feature extraction & reconstruction	iluction										D4.3 D4.1 D4.2			
	0	on										L D4.1			
	RTI acquisition, semantic feature extraction & reconstruction											U4.2 D	4.4		
	Scan4Reco Spatiotemporal Simulation & Reconstruction												4,4		
	Multi-sensorial Data Fusion								D5.2		D5	3 0	5.1		
	Digital modeling of material appearance and features	-							03.2		05	r -			
Task 5.3	Spatiotemporal simulation	-											D53		
	Dynamic 3D Model Reconstruction	-											D5.4 D5.5 D5.6		
	Degradation Identification and automatic spatiotemporal Annotation	-												<b>5</b> .7	
WP6	Decision Support System & System Integration														
	Conservation oriented Decision Support System													D6.1	' <b></b> _
	Visual & real 3D Printing compatible format conversion	-													
	System Integration	-										D6.3		D62 D6.4	1
	Conservation related Visualization tools & Virtual Museum development	-								06.5		00.3		066	
	Scan4Reco applications, Trials and Evaluation														للجعاد
	Definition and planning of trials scenarios											D	7.1		Now
	Trials Setup and Execution	-												D7.2	
	Evaluation of the prototype scanning and simulation system	-												21.2	D7.3
Task 7.4	Evaluation of the DSS driven conservation strategy and users experience	-													D7.3 D7.4
WP8	Socio-economic framework, Dissemination and Exploitation														
	Definition of the Scan4Reco communication plan				D8.	2									
Task 8.2	Establishing and Managing the Scan4Reco Website	D8.1			29.										
Task 8.3	Continuous Dissemination Activities														
	Recommendations and Contribution to Standards														
	Market Analysis and Exploitation Strategy development	1								083					



- 43 Deliverables produced
  - 32 Public deliverables to be found at <u>http://www.scan4reco.eu/public-deliverables</u>
- 9 Milestones timely fulfilled
- >50 Publications in prestigious (IEEE, ACM Siggraph, etc.) journals & conferences to be found at <a href="http://www.scan4reco.eu/content/publications">http://www.scan4reco.eu/content/publications</a>
- **4 Newsletters** (+1 in press) have been released, to be found at <a href="http://www.scan4reco.eu/newsletter/scan4reco-newsletter-view">http://www.scan4reco.eu/newsletter/scan4reco-newsletter-view</a>
- **Pilot Evaluation** conducted with professional conservators

## The Scan4Reco DataBase

(accessible at <a href="http://scan4reco.iti.gr/ords/f?p=107:2001">http://scan4reco.iti.gr/ords/f?p=107:2001</a>)

# **Technological Achievements**

 The Scan4Reco VR Museum (with Oculus support) in online & desktop version

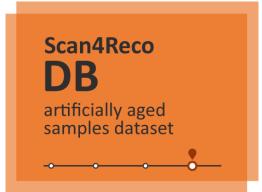
(accessible at <a href="http://www.scan4reco.eu/virtual-museum/">http://www.scan4reco.eu/virtual-museum/</a> )

The Scan4Reco portable integrated solution











## **Principles of 3D Reconstruction**



Surface, MS&RTI and 3D Microprofilometry Prototype



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# **Scientific Achievements**

## Photogrammetry





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## **Capturing the Surface (RTI & m-Prof)**



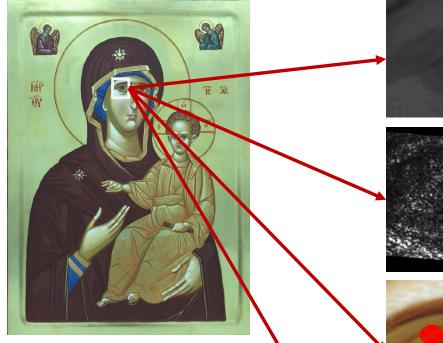
Scan4Reco Workshop, Thessaloniki, Greece, 25<sup>th</sup> of September 2018



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# **Scientific Achievements**

## **Capturing the Stratigraphy**



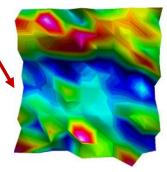
#### IR imaging 1-5µm



Ultrasound & IR imaging

Ultrasonic µTomography

Information provided Refaeiguapigiosinficrematiocolour Unifolografiadryngs, Richardeniadsraned sureen1e3+26furne Regationialstidentification Initial designs, Underdrawings Roughness, elastic properties of the materials



**UV-VIS Spectroscopy** 

IR Spectroscopy



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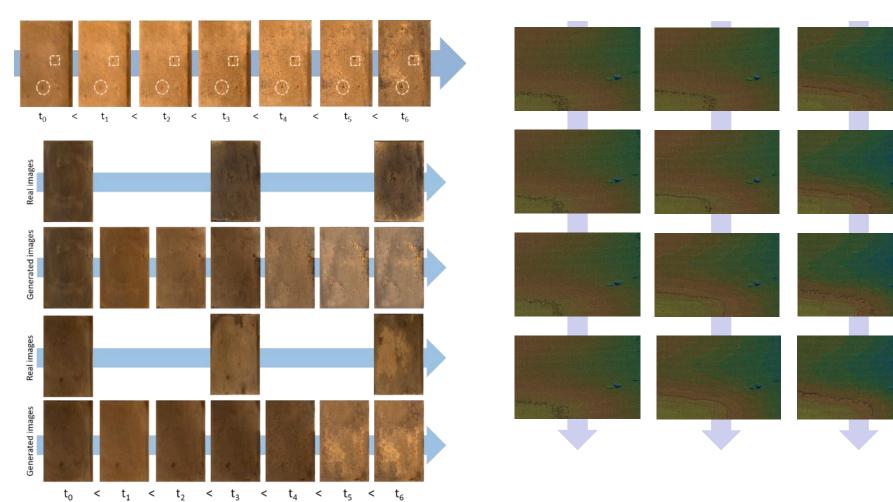
For- & Backward Ageing Simulation - Utons





For- & Backward Ageing Simulation - DNNs

• Texture Simulation



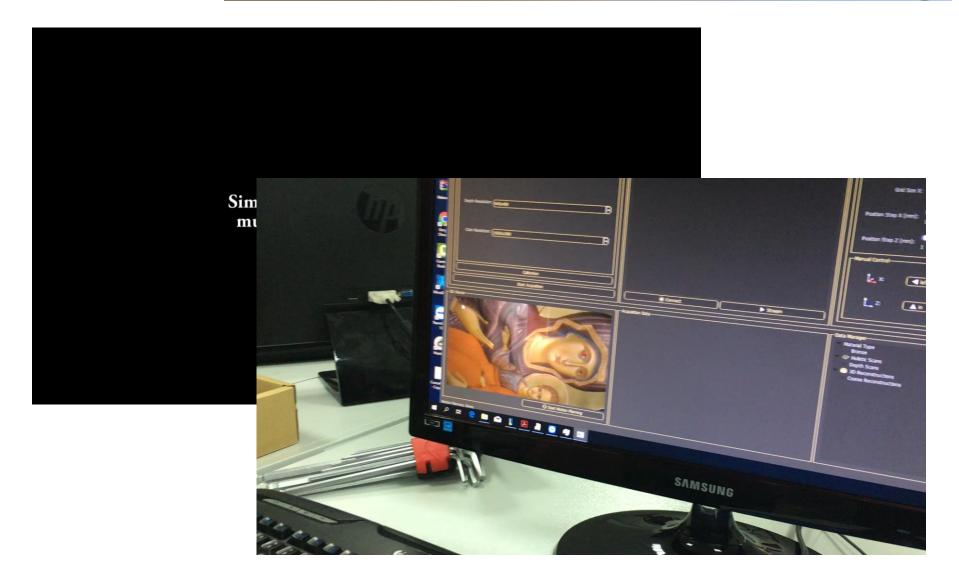
Shape Simulation



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# **Scientific Achievements**

## **Robotic Motion Planning**



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**Rendering & Exporting to 3D Printing** 





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