



R. Žarnić & V. Rajčić: Identification of Complexity and Quality in 3D Documentation by the Significances of Cultural Heritage Assets

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Identification of Complexity and Quality in 3D Documentation by the Significances of Cultural Heritage Assets

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Cultural heritage assets comprise a wide area of tangible and intangible aspects that as whole determine and enable evaluation of asset. The inclusive assessment of asset leads to holistic understanding of variety of its significances. It enables correct preventive conservation, efficient site management and sustainable use of asset to enable extension of its life supported by self-acquiring of needed funds. However, the need for the holistic but yet in-deep understanding and data exploitation principles is a commonly understood by professionals engaged in cultural heritage preservation.

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The current development of ICT tools and introducing of 3D documentation of heritage assets brings a new momentum to discipline. In this lecture the importance of identification of significances that defines a particular heritage asset and study of their interaction is presented. It is illustrated by application on to study of heritage asset resilience to natural and man-made hazards and application on analysis of economic potential in heritage assets located in cultural environment.

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Identification of significances is based on the nine groups of significances pertaining to heritage asset that are divided in three subgroups each. It is in context of data collection organized in two major groups: the group of general characteristics of heritage asset and group of characteristics detailly presented. The detailed analysis of complex 3D documentation enables a proper decision making regarding to preventive and post-disaster interventions in heritage assets as well as planning and execution of heritage asset management.

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Outline

- ◆ Significances of cultural heritage assets
- ◆ Data collections
- ◆ Concept of cultural heritage resilience model
- ◆ Economic aspects of significances identification
- ◆ Post disaster evaluation of heritage asset that was 3D documented before the occurrence of an earthquake
- ◆ Conclusions

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Significances of cultural heritage assets

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Preservation of natural and cultural heritage, including preservation of raw material sources and reuse of materials, is based on principles applicable to:

- Natural environment, that is a global system, which includes:
 - General environment, where is located:
 - Cultural environment and landscape that contents:
 - Built environment, composed of:
 - Cities and other settlements, where are:
 - Buildings and other closed spaces with:
 - Objects: furniture, paintings and other pieces of art.

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Significances of cultural heritage asset

- Combining tangible and intangible aspects
- Importance of significances identification for resilience of heritage asset
 - Heritage and values
 - Heritage and history
 - Heritage and nature
 - Heritage and social development
 - Heritage and identity

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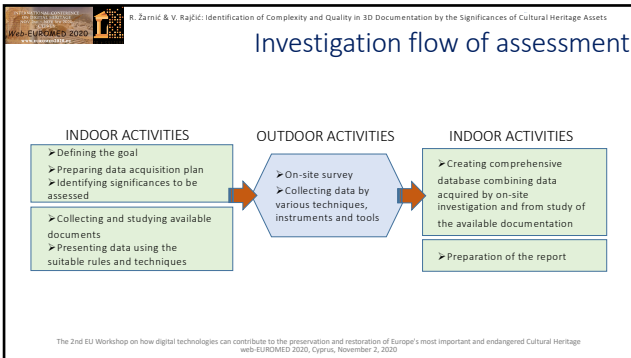
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Universal significances of cultural heritage asset

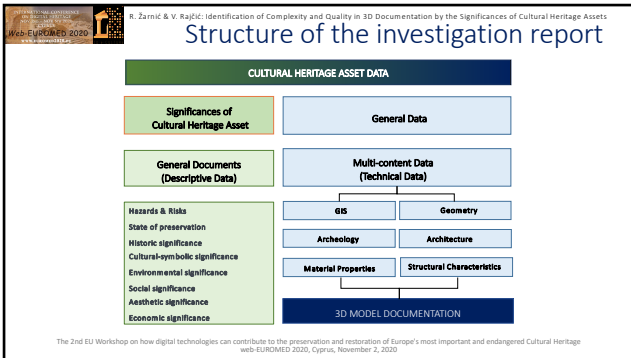
<p>GEOSPATIAL/GEOMETRIC Geographical Info system Cultural landscape Geometry</p>		<p>STATE OF PRESERVATION Materials Structure Previous Interventions</p>
<p>ENVIRONMENTAL Energy efficiency Landscape significance Spatial significance</p>		<p>HAZARDS AND RISKS Social anthropogenic Long term environmental Short-term environmental</p>
<p>HISTORIC Archaeological significance Authenticity Technological significance</p>		<p>ESTHETICS Architectural significance Integrity Rarity</p>
<p>CULTURAL-SYMBOLIC Spiritual-religious sig. Novelty Secular significance</p>	<p>SOCIAL Educational significance Management significance Scientific significance</p>	<p>ECONOMIC Non-use significance Use significance Investment significance</p>

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Hazards and Risks

Hazards are measurable potential harmful impacts to heritage assets
Risk is a possibility that harm might occur when exposed to a hazard

- ❖ **Long term environmental impact on asset**
 - Induced by the natural impacts that during the long time period degrade the materials, structural components and artefacts..
- ❖ **Short term environmental impact on asset**
 - Induced by the natural impacts that in short and sudden event damage or destroy materials, structural components and artefacts.
- ❖ **Unintended man-made impact on asset**
 - Induced by use of asset or lack of knowledge can harm the asset due to long-term exposure or due to sudden events.
- ❖ **Intended man-made impact on asset**
 - Induced by illegal action that harms the asset due to short-term exposure

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ENVIRONMENTAL RISKS

Long-term influences	Sudden events
Bio attack	Wind-storm
Climate conditions fluctuations	Fire
Aeolic impact	Flood
Water impact (ground, atmospheric)	Earthquake
Solar radiation	Landslide
Particle matter and aerosols	Avalanche
Long term influences	Tsunami
Geological conditions (global, local)	Volcano

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ENVIRONMENTAL INFLUENCE ON HERITAGE DECAY

LONG - TERM IMPACT	TIMBER	MASONRY	PLASTER	CAST IRON
Bio Attack	Red	Yellow	Red	Green
Climate Condition Fluctuation	Red	Yellow	Red	Yellow
Ground & Atmospheric Water	Red	Yellow	Red	Yellow
Long-term Loading	Red	Yellow	Red	Green
Aeolic Impact	Green	Yellow	Red	Green
Solar Radiation	Green	Yellow	Red	Green
Particle Matter & Aerosols	Green	Yellow	Red	Yellow
Geological & Geomechanic Inf.	Yellow	Yellow	Red	Yellow
IMPACT LEVEL	Green	LOW	MEDIUM	HIGH

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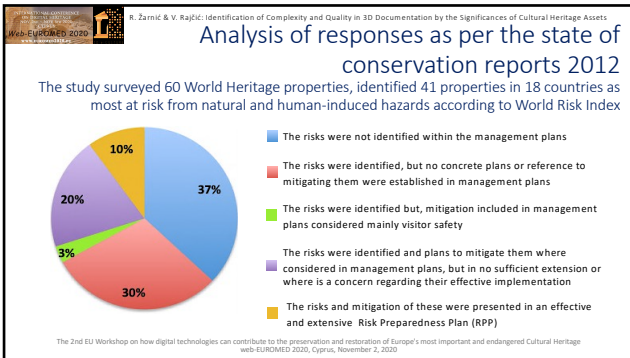
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MAN MADE RISKS

Unintentional influences	Intentional events
Economic activities	Vandalism
Accidents	Riots
Improper decisions	Wars

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State of preservation

State of preservation is condition in which cultural heritage asset has been kept by means of regular maintenance and periodic interventions.

- ❖ **Condition of the materials of asset**
 - Condition of materials is defined by the current characteristics of materials, the level of decay and damage, assessed by the identification of hazards that cause damages.
- ❖ **Condition of the structure of asset**
 - Condition of structure is defined by structural assessment taking into account the level of material decay and damages of structural elements and components.
- ❖ **Maintenance & interventions in the asset**
 - Maintenance and previous interventions are defined by the assessment of the effects of regular maintenance and previous interventions on the state of preservation.

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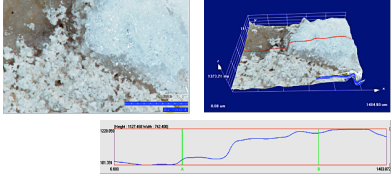
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3D digital microscope:
NDT material investigation

- ❖ Different types of deposits on the fresco surface were detected. XRD of deposits revealed presence of NaCl and gypsum
- ❖ Different salts and thickness of layers are seen in the multifocal picture




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Multi-scanner

Enhancement of documentation quality:

- Time saving up to 90%
- Higher accuracy
- Multiple Information capturing (Geometry, Colour and Infrared) in a single process



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Multi-scanning: Assinou church interior

3D Geometry Color Temperature




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Visual inspection and mapping

Advanced *methods* of data collecting, and interpretation based on IT technologies are of crucial importance for learning about heritage and its preservation



Simple visual inspection drone
DJI Mavic Pro 1.500 €





Sophisticated LIDAR inspection drone
DJI T16 15.000 €

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Thermovisual inspection

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Geospatial/geometric significance

Geospatial/geometric significance is related to the geographic position, cultural landscape characteristics and geometry of asset

- ❖ **Geographical information system (GIS)**
 - A geographic information system (GIS) integrates hardware, software and data for capturing, managing, analysing, and displaying all forms of geographically referenced information.
- ❖ **Cultural landscape**
 - A cultural landscape is the "cultural property that represents the combined works of nature and of man" or a "continuing landscape".
- ❖ **Geometry of asset**
 - Geometry of cultural heritage asset is defined by the shape of building and includes presentation of plan, cross-sections, facades, architectural details etc.

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Environmental significance

Environmental significance is related to the sustainability aspects of heritage such as environmental value, relationship of heritage to the environment and space.

- ❖ **Spatial significance of asset**
 - Spatial significance is value derived from the heritage location in the local environment, cityscapes, dominant urban silhouettes, etc. It defines contextual integration of heritage asset in the area as a basis for development opportunities
- ❖ **Landscape significance of asset**
 - Landscape significance defines the heritage value emerging from the interaction of the cultural heritage and cultural landscape.
- ❖ **Energy efficiency of asset**
 - Energy efficiency of the heritage asset is defined in terms of sustainable use of resources in the case of its renewal, increasing the occupancy comfort by energy efficient renovation and rational use of energy during the use of asset.

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Historic significance

Historic significance defines characteristics that bear witness of the past and illustrate a specific development or historical significance.

- ❖ **Archaeology of asset**
 - Archaeological significance defines the value of the heritage on the basis of archaeological finds and definition of the archaeological importance of these findings as witnesses of certain development of society.
- ❖ **Authenticity of asset**
 - Authenticity defines the degree of authenticity and originality of the elements and asset as whole. It is judged on the basis of preservation level of the original shape and design, materials, purpose and use, traditions, location.
- ❖ **Technology of asset**
 - Technological significance defines the value of heritage as a bearer of information about stage of technology development (material production, construction processes, industrial and technological development).

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Cultural-symbolic significance

Cultural-symbolic significance defines values in sense of degree of importance associated with the concept of "here" and "now"; these are the ideas, habits, actions, attitudes and cultural and civilizational values.

- ❖ **Spiritual-religious significance of asset**
 - Spiritual-religious significance defines the value derived from religious or other world heritage importance. It may be linked to the practice of religion and learning of a particular religion.
- ❖ **Secular significance of asset**
 - Secular significance is descriptive category derived from the secular experience of awe, wonder, respect of certain heritage asset or values associated with it.
- ❖ **Novelty of asset**
 - Novelty defines stylistic unity, ideal condition and removes all later additions. These include the importance of heritage resulting from the subsequent recovery, reconstruction and other interventions that lead to new stylistic or the pure image or return to the previous "ideal state".

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Social significance

Social significance is a characteristic of heritage, which create so-called »social capitals«; promote and facilitate social networking, creating social cohesion and sense of community (identity).

- ❖ **Educational significance of asset**
 - Educational significance defines the potential of heritage for formal and vocational education as well as in wider sense as learning from the past.
- ❖ **Management of asset**
 - Management significance covers the management structure and plan of the heritage asset, as well as the protection regime including legal protection, ownership and accessibility.
- ❖ **Scientific significance of asset**
 - Scientific significance defines the value and potential of heritage for development of science. Heritage conservation can contribute to the development of new materials, techniques, methods and research approaches.

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Aesthetic significance

Aesthetic significance defines the artistic features such as concept, form, colour, etc., often referred as the value of art.

- ❖ **Architecture of asset**
 - Architectural significance illustrates the authorship, typology of a certain period, technological value or achievement (workmanship, form, style, design approach, material and structural characteristics).
- ❖ **Integrity of asset**
 - Integrity defines high level of preservation of those elements that are associated with the values of heritage, on the basis of "should be protected" meaning.
- ❖ **Rarity of asset**
 - Geometry of cultural heritage asset is defined by the shape of building and includes presentation of plan, cross-sections, facades, architectural details etc.

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Economic significance

Economic significance is associated with the economic value of heritage, which can be expressed either in financial or other senses.

- ❖ **Non-use value of asset**
 - Non-use value cannot be offered and sold on the market and therefore cannot be expressed in financial terms. It relates to general awareness of existence of asset, its availability for general public access and conservation necessity for preservation to be available for ancestors.
- ❖ **Use value of asset**
 - Use value is related to the economic importance determined on the basis of the concept of utility, which can be expressed in financial terms. The market value of heritage originates from goods and services that can be offered and sold on the market (fees, wages) and reflected in the price
- ❖ **Investment in asset**
 - Investment potential is related to the assessment of the effects of investments in asset (reconstruction, restoration, ...). The basis for assessment is the conservation plan and the studies addressing desirability, feasibility and effectiveness of the investment. Studies include financial and economic analysis, among others.

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Data collections

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Data collection protocols

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Data collections

Recognizing the importance of the reliable and as complete as possible data on various aspects related to cultural heritage, its properties and values, experts and authorities in many countries have been developing and use various systems and tools for inventory and documentation of cultural heritage.

The whole tradition of care for cultural heritage is reflected in those systems, yet at the same time their approach to content stems from the local approaches and understandings. In some countries there are several systems for data collection which are not connected. Therefore, the strait comparison of data on heritage assets is difficult.

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International approach to data protocols

- ❖ Council of Europe in 1960s started to develop methodological bases for inventorying architectural, archaeological and movable heritage to overcome the problems of compatibility of systems and to make possible transnational inventory of heritage of the European countries what resulted in the guidelines; first time published in 2001.
- ❖ EU 7th Framework Coordinated Action EU CHIC - European Cultural Heritage Identity Card (2009-12) continued the Council of Europe work which resulted in CH ID Card
- ❖ Horizon 2020 project INCEPTION (2015-19) continued the work, which was started and developed within EU-CHIC project through implementation of IT tools.
- ❖ Horizon 2020 VIMM Coordination and Support Action, (2016-19) defined and supported supporting high-quality policy development, decision making, competence building and the use of technical advances. It continues work within ongoing VIMM+ initiative.

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EU CHIC General Data Collection, based on Council of Europe recommendations.

Pool of Knowledge based on:

- EU Standard EN 16096:2012 "Conservation of cultural property: Condition survey and report of built cultural heritage"
- Other professional procedures for data collecting and processing
- ICT tools for assessment of risk and other significances of Cultural Heritage Asset

Decision Support Data enabling IT supported planning and execution of interventions (H-BIM), decision impact analysis, support to site management and maintenance

eu chic Cultural Heritage Identity Card
FP7 ENV 2008 3.2.1. EU Cultural Heritage Identity Card 2009 – 2012 www.euchic.eu

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<https://www.inception-project.eu>

- ❖ Innovation in 3D modelling of cultural heritage through an inclusive approach for time-dynamic 3D reconstruction of artefacts, built and social environment
- ❖ Solving the shortcomings of state-of-the-art 3D reconstruction by significantly enhancing the functionalities, capabilities and cost-effectiveness of instruments and deployment procedures for 3D laser survey, data acquisition and processing.
- ❖ Involving all disciplines (both social and technical sciences) through collaborative research and demonstration it, technologies and sectors essential for creation and use of 3D models of cultural heritage.

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- ❖ **ViMM Manifesto**
 - The Manifesto is directed towards strategic decision makers, funding bodies, professional associations, institutions, practitioners and industries in the Cultural Heritage (CH) sector who share a common interest in the digital future.
- ❖ **Roadmap and Action Plan**
 - The Action Plan describe four priority areas where action is seen to be needed:
 - (a) research and innovation under Horizon Europe, (b) European Competence Centre network in Digital Cultural Heritage, (c) human resources, education and training and (d) policy and international cooperation.
- ❖ **Regional Studies**
 - Studies aim to analyse the relationship between the objectives of institutional policies through the development, support, and implementation of digital cultural projects, and their economic and social impact in various sectors. Situation in three countries: Spain, Greece and Cyprus has been studied.

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Concept of cultural heritage resilience model

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Resilience of cultural heritage asset

Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

IPCC-Intergovernmental Panel on Climate Change

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Assessment of resilience

- ❖ Profound knowledge of asset significances
- ❖ Reach collection of data
- ❖ Knowing the response of asset on natural and man-made disasters
- ❖ Understanding the significances of cultural heritage
- ❖ Understanding the social importance of asset
- ❖ Understanding the management of cultural heritage asset
- ❖ Having a knowledge on technical measures for increasing of resilience

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Resilient structural system

- ❖ Robust - reduced failure probabilities,
- ❖ Redundant - reduced consequences from failures, in terms of lives lost, damage, and negative economic and social consequences,
- ❖ Recoverable - reduced time to recovery (restoration of a specific system or set of systems to their "normal" level of functional performance)

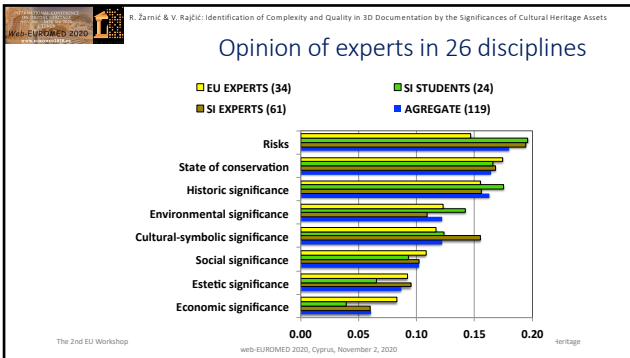
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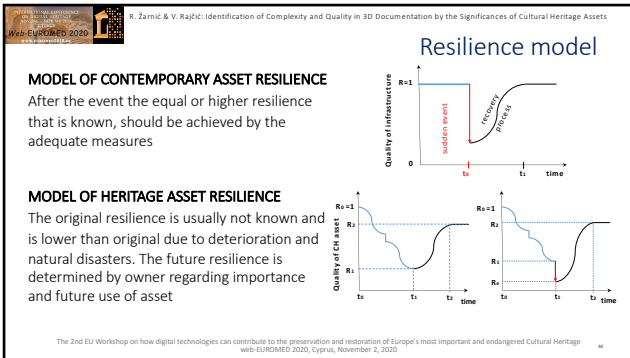
Increasing and maintaining the resilience of CH asset

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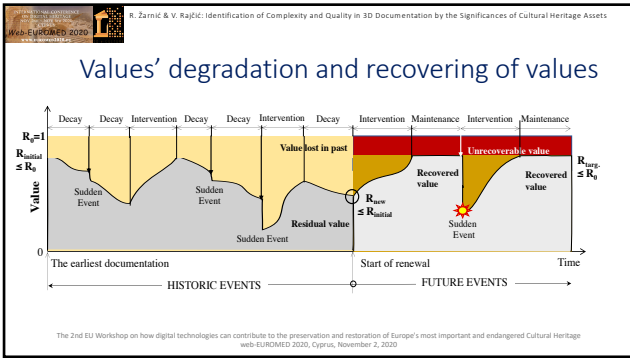
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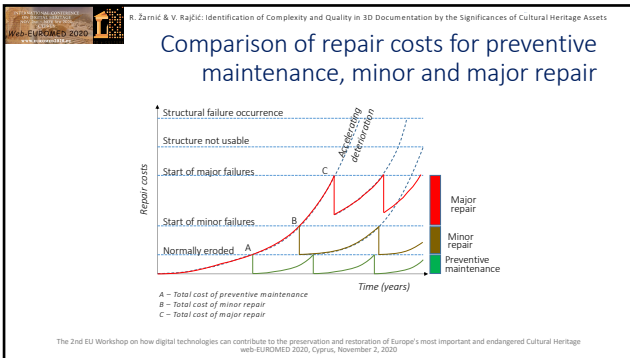
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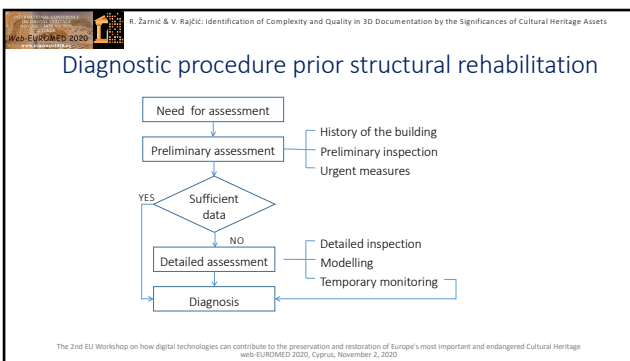
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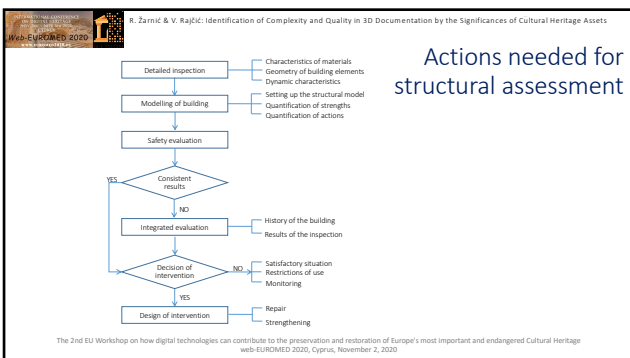
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Further development of resilience model

- ❖ The basic idea of further development of resilience idea in cultural heritage domain is to apply theory of resilience for development of efficient measures for preservation of cultural heritage assets
- ❖ For each type of environmental or man-made impact the mathematical models of resilience should be developed
- ❖ **The main problem is not in mathematical formulation of model but in reliable and realistic input data for calculation of resilience.**
- ❖ In case of heritage asset that is exposed to several different categories of impacts, the total resilience is a combination of partial resiliencies associated with every relevant impact.
- ❖ The use of the risk indicators for definition and, where it is possible, quantification of input parameters for resilience assessment is crucial for practical application of resilience model.

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Economic aspects of identification of the significances

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Prioritizing of investments

- ❖ Preservation of cultural heritage is related with high costs – permanent lack of available funds
- ❖ Needs for prioritizing of investments
- ❖ Multi-criteria assessment – possible method for decision making
- ❖ Multi-criteria method for the assessment of architectural heritage has been developed at University of Ljubljana and published in the Ph.D. thesis of Dr. Barbara Vodopivec




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Cultural heritage importance ranking

- ❖ Criteria importance ranking is based on the Analytic Hierarchy Process (AHP method).
- ❖ The interdisciplinary - brought together tangible and intangible aspects of cultural heritage.
- ❖ Rational determination of relative importance of individual criteria for the assessment of architectural heritage can help decision-makers to identify buildings with higher refurbishment priority.



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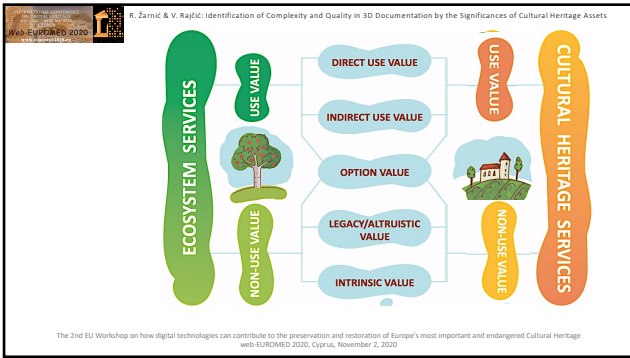
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Identification of cultural heritage services

- ❖ Sustainable use of asset to enable extension of its life supported by self-acquiring of needed funds is based on the identification of services that it can offer to community and market.
- ❖ Heritage located in environmentally sensitive areas (Natura 2000) can be sustainably exploited by linking its services with Eco-system services
- ❖ The 3D documentation based on identified significances of intangible and tangible (movable and immovable) heritage is a strong tool for achieving of economic impacts on the local society increasing their well-being in spiritual and material aspects of life

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Web-EUROMED 2020 R. Žarnić & V. Rajčić: Identification of Complexity and Quality in 3D Documentation by the Significances of Cultural Heritage Assets

Post-disaster evaluation of heritage asset that was 3D documented before the occurrence of an earthquake

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Web-EUROMED 2020 R. Žarnić & V. Rajčić: Identification of Complexity and Quality in 3D Documentation by the Significances of Cultural Heritage Assets

Technical museum "Nikola Tesla", Zagreb

Zagreb, March 22, 2020, 05:24:03, UTC
M5.3 Depth 10.0 km

Technical museum "Nikola Tesla", timber-strut structure erected in 1948, retrofitted in 2013 and post-earthquake inspected in 2020.

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Web-EUROMED 2020 R. Žarnić & V. Rajčić: Identification of Complexity and Quality in 3D Documentation by the Significances of Cultural Heritage Assets

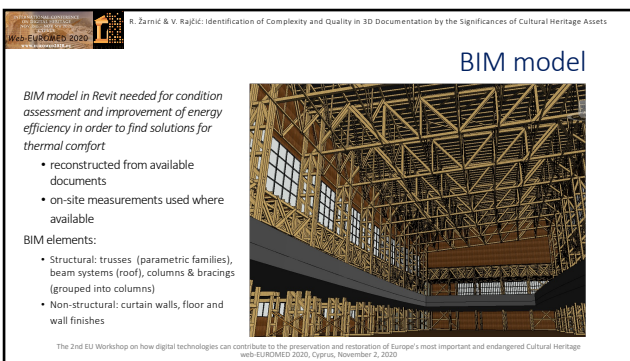
3D digital model

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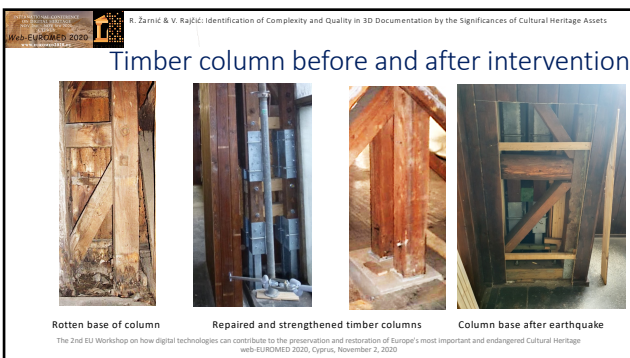
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Importance of 3D documentation

- ❖ 3D documentation of building prepared before a catastrophic event and at the beginning of long-term observation of building deterioration enables post-disaster evaluation and long term identification of decay processes
- ❖ BIM model enables pre- and post-disaster structural assessment by exporting of its properties a structural analysis software in order to evaluate the structure's response under specific loading condition. The results of structural assessment enable identification of the building's damage state
- ❖ A Life Cycle Environmental Assessment can be performed to identify the environmental impacts of the damages imposed to the building due to long term environmental and man-made impacts. For this purpose, embodied energy of the building can be calculated and then based on the damage probability, the total embodied energy losses derived.

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Conclusions

- ❖ Significances of heritage assets combine its tangible and intangible aspects.
- ❖ The recovered cultural heritage asset should encompass as many as possible original significance.
- ❖ The profound **KNOWLEDGE** about significances is the essential part of resilience needed for recovery of cultural heritage asset.
- ❖ The wide use of ICT methods and tools strongly contribute to success of resilience identification and improving, identification of economic potential of CH asset and post-disaster assessment and retrofitting.

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Thank you for attention !

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