

SWODCH 2022

Semantic Web and Ontology Design for Cultural Heritage

The Heritage Digital Twin

Work in Progress towards its semantic definition and applicability

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To document Cultural Heritage we believe that we must start from Heritage, understand it and then structure knowledge accordingly.

So, let's start!

**A long time ago in an island
far, far away...**

**A.D. 1468 - It is a period of
war. Ottoman battleships,
striking from a hidden base.**

A.D. 1468 - a series of misfortunate events

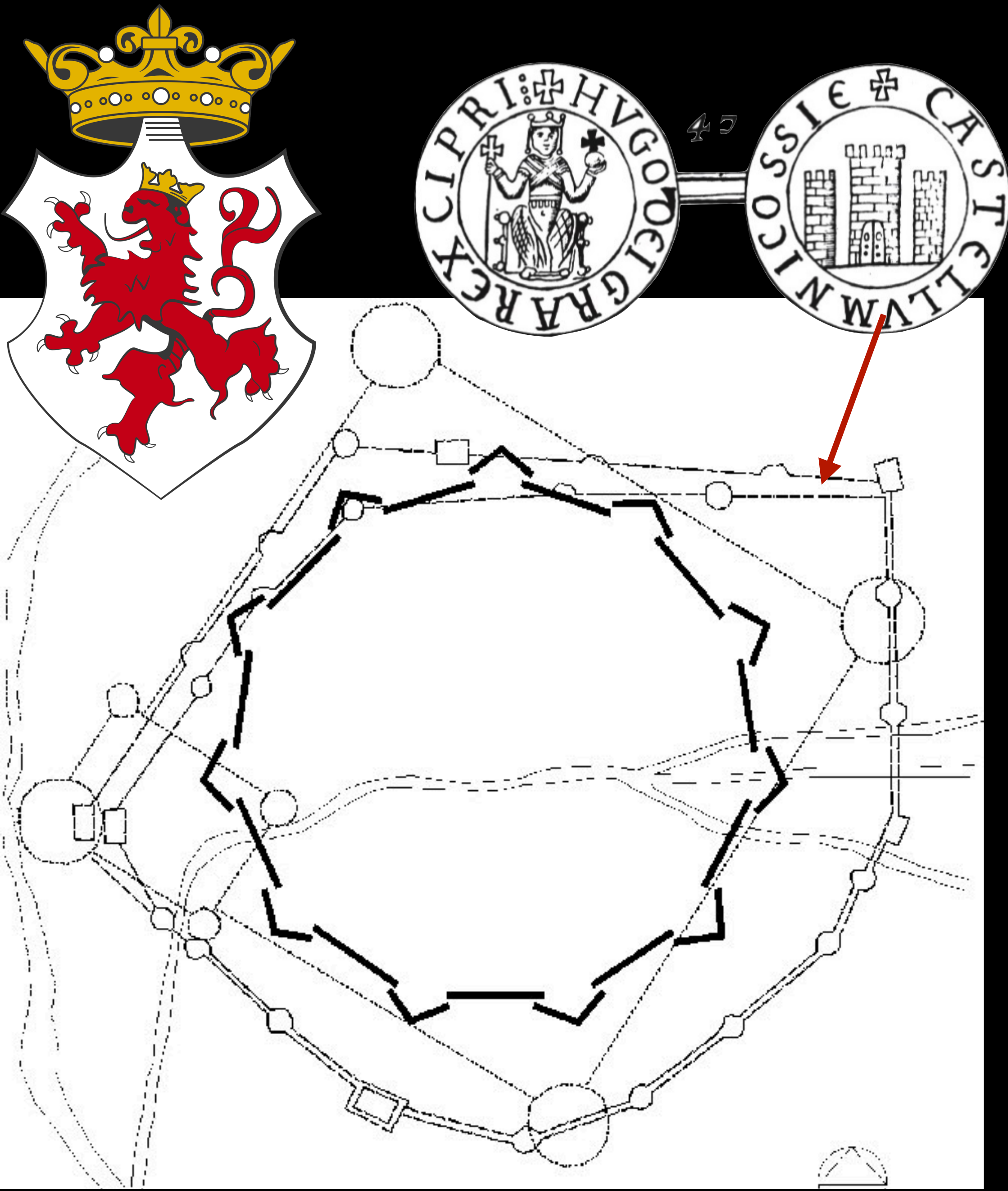
- King James II de Lusignan, king of Cyprus, marries Caterina Cornaro, a noble Venetian.
- 1473 - James II dies in unclear circumstances, followed by his infant son a year later.
- 1474 - Caterina Cornaro becomes Queen of Cyprus.
- 1489 - Caterina is forced to abdicate, the Republic of Venice sends a governor to the island.



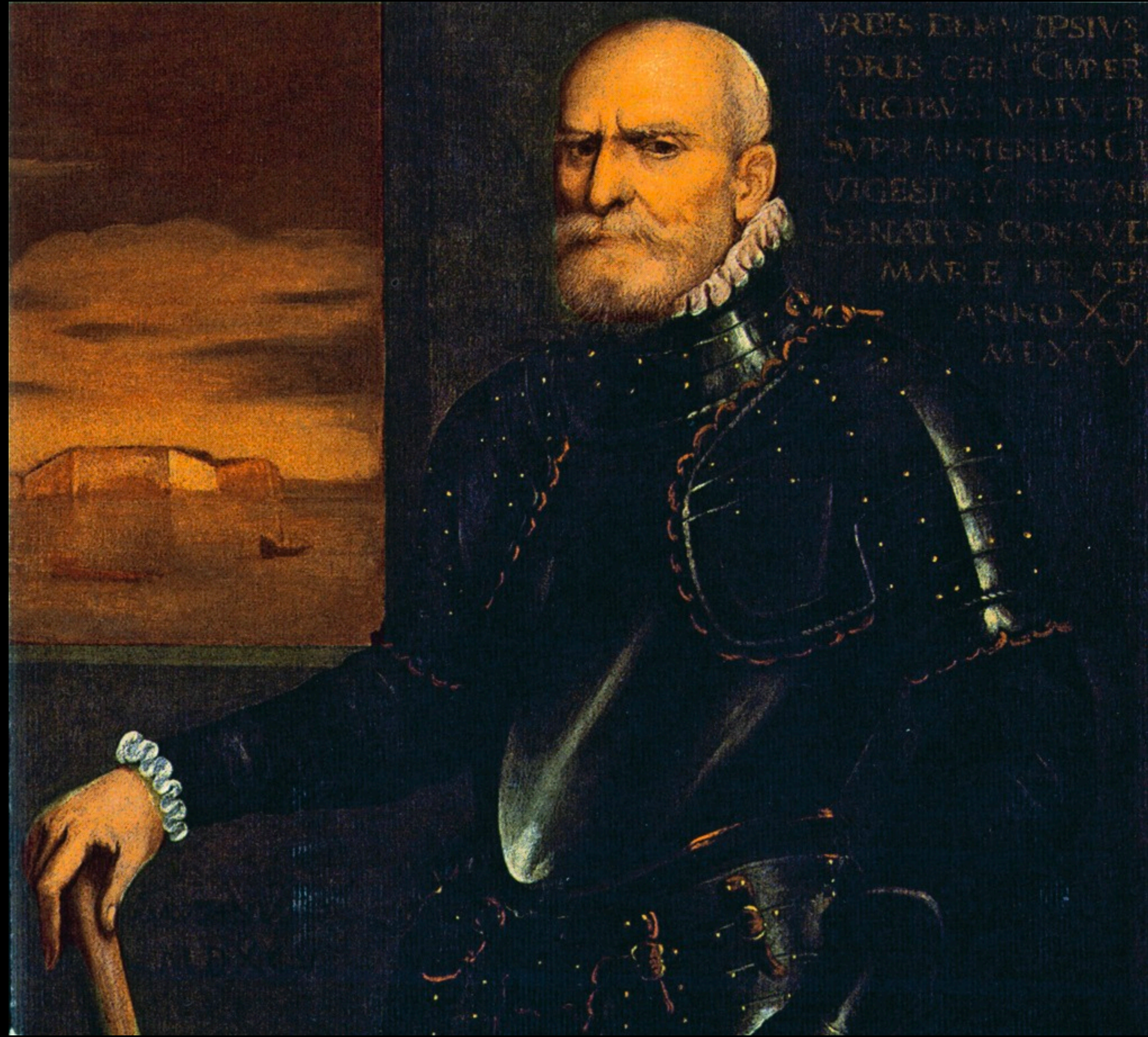
Tiziano Vecellio - Caterina Queen of Cyprus
Galleria degli Uffizi



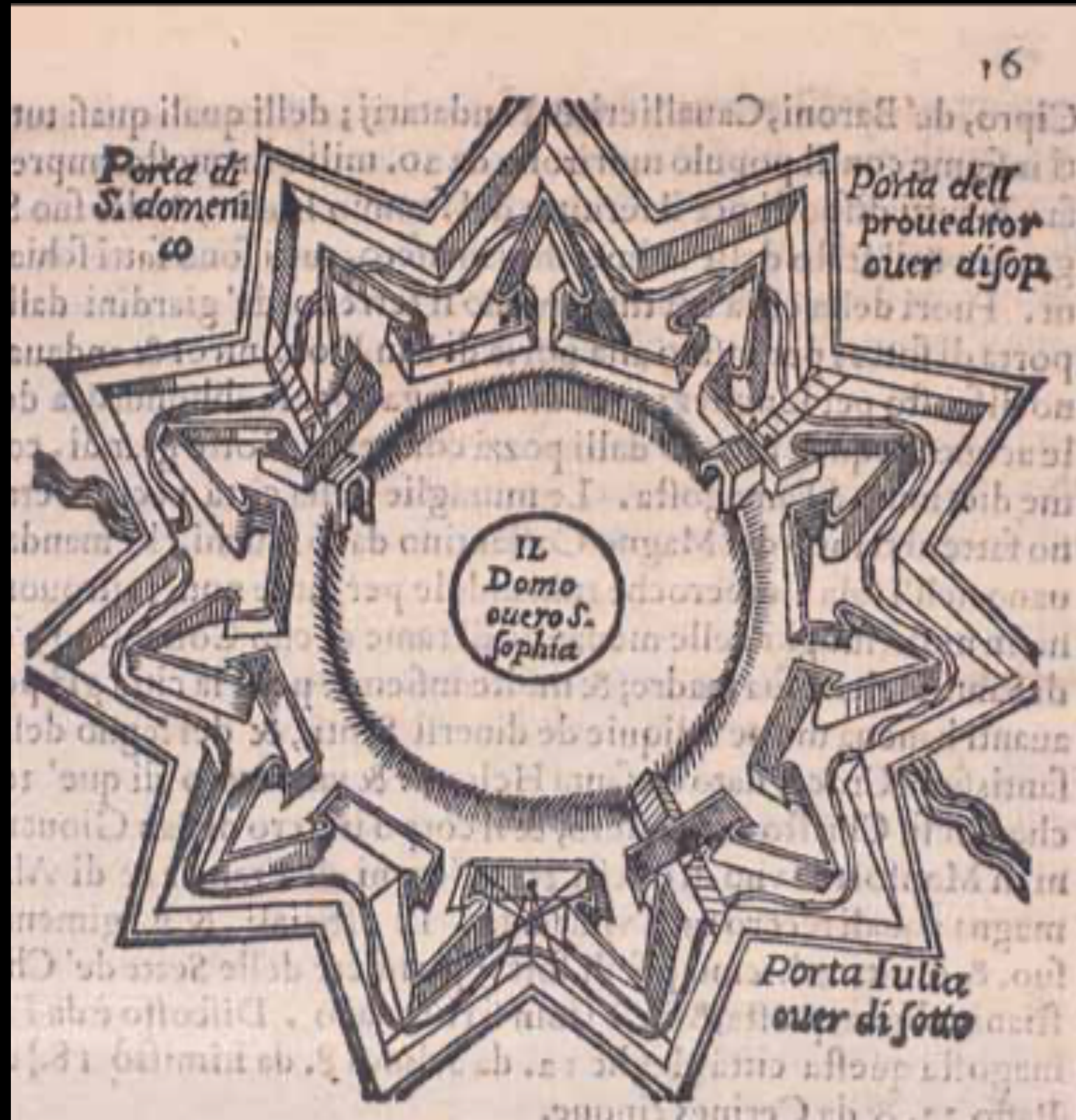
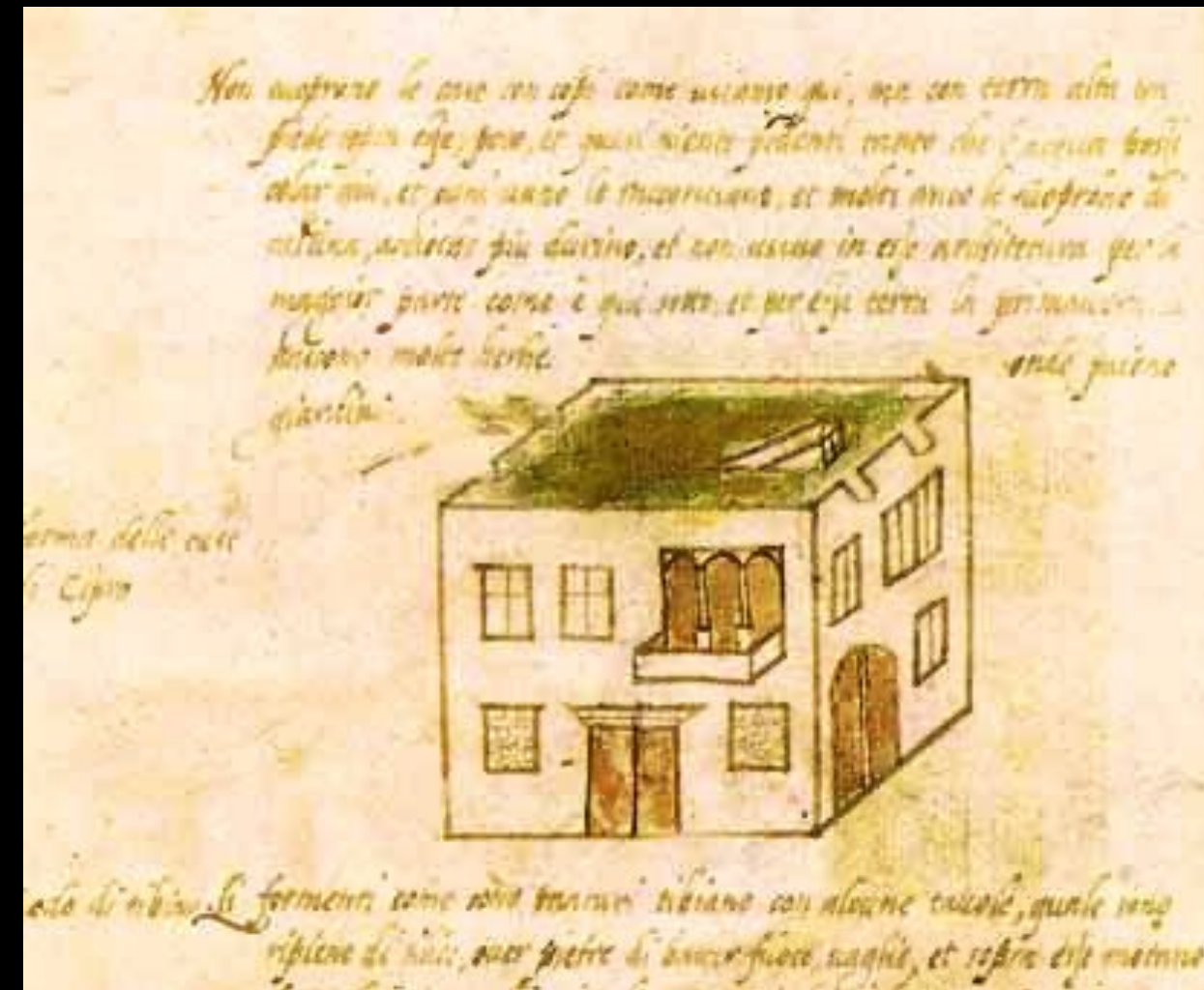
Venetian rule over Cyprus: 1489 - 1571



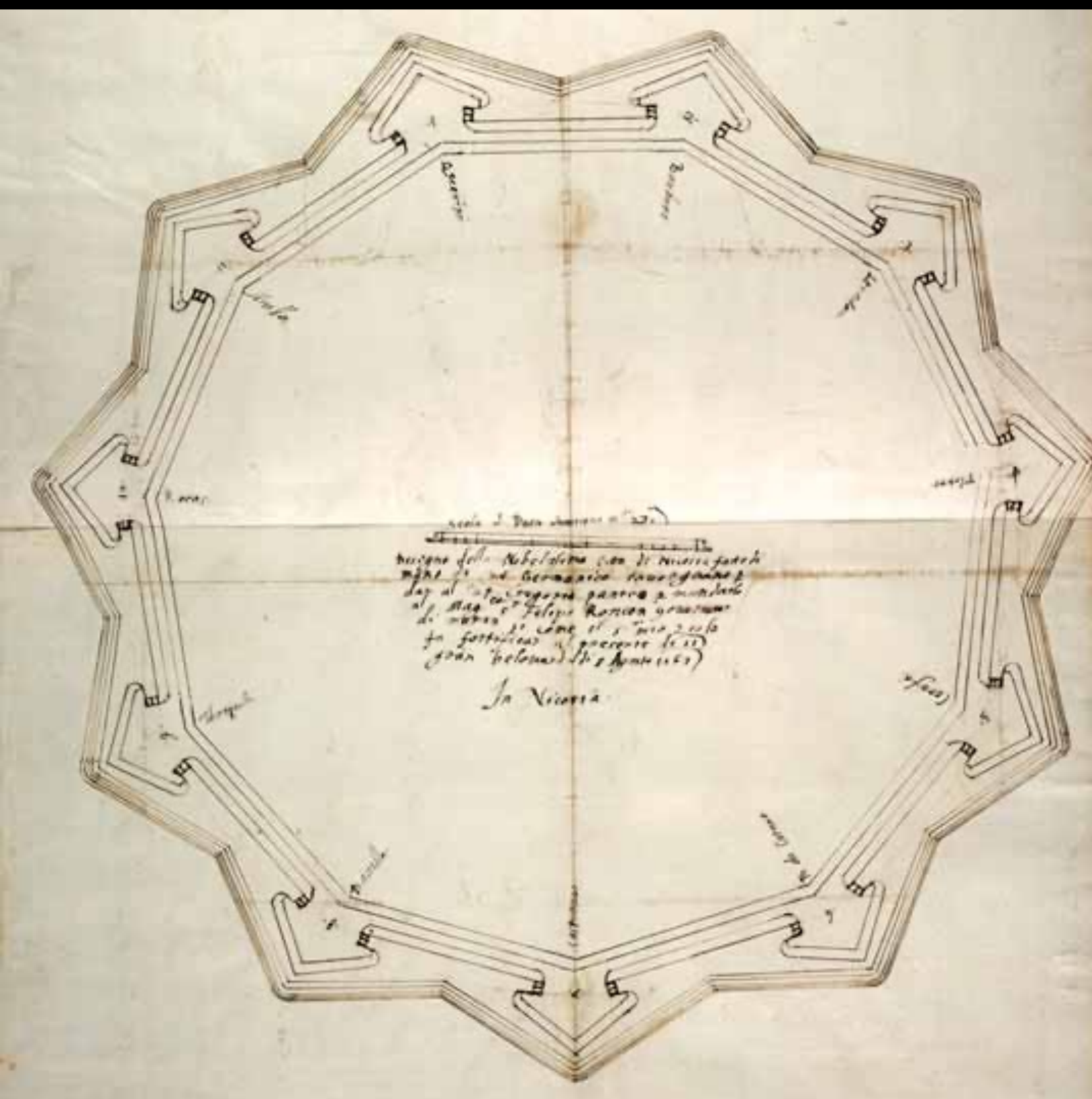
Domenico Tintoretto Portrait of Giulio Savorgnan wearing armour



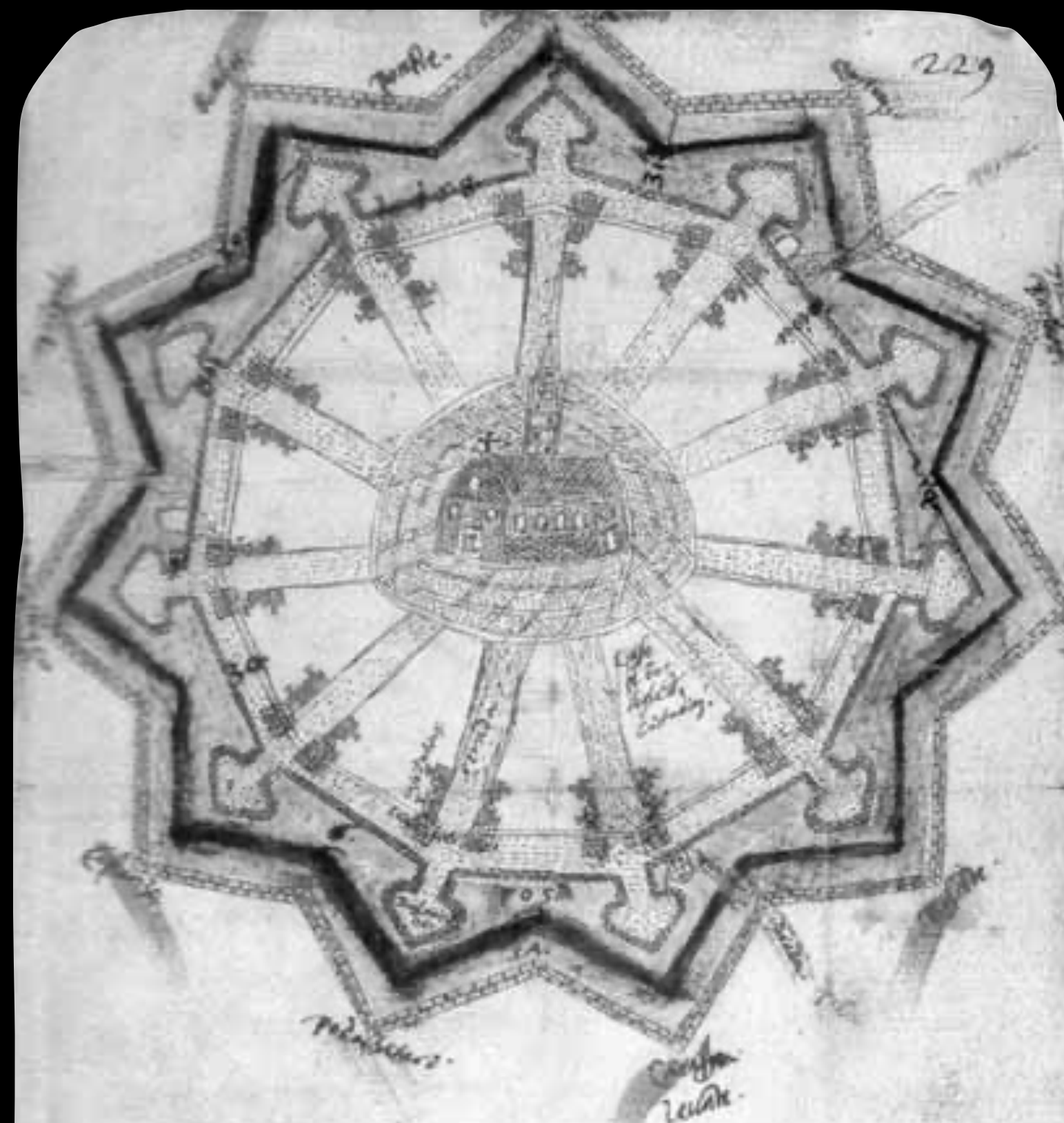
The Venetians rebuild the city



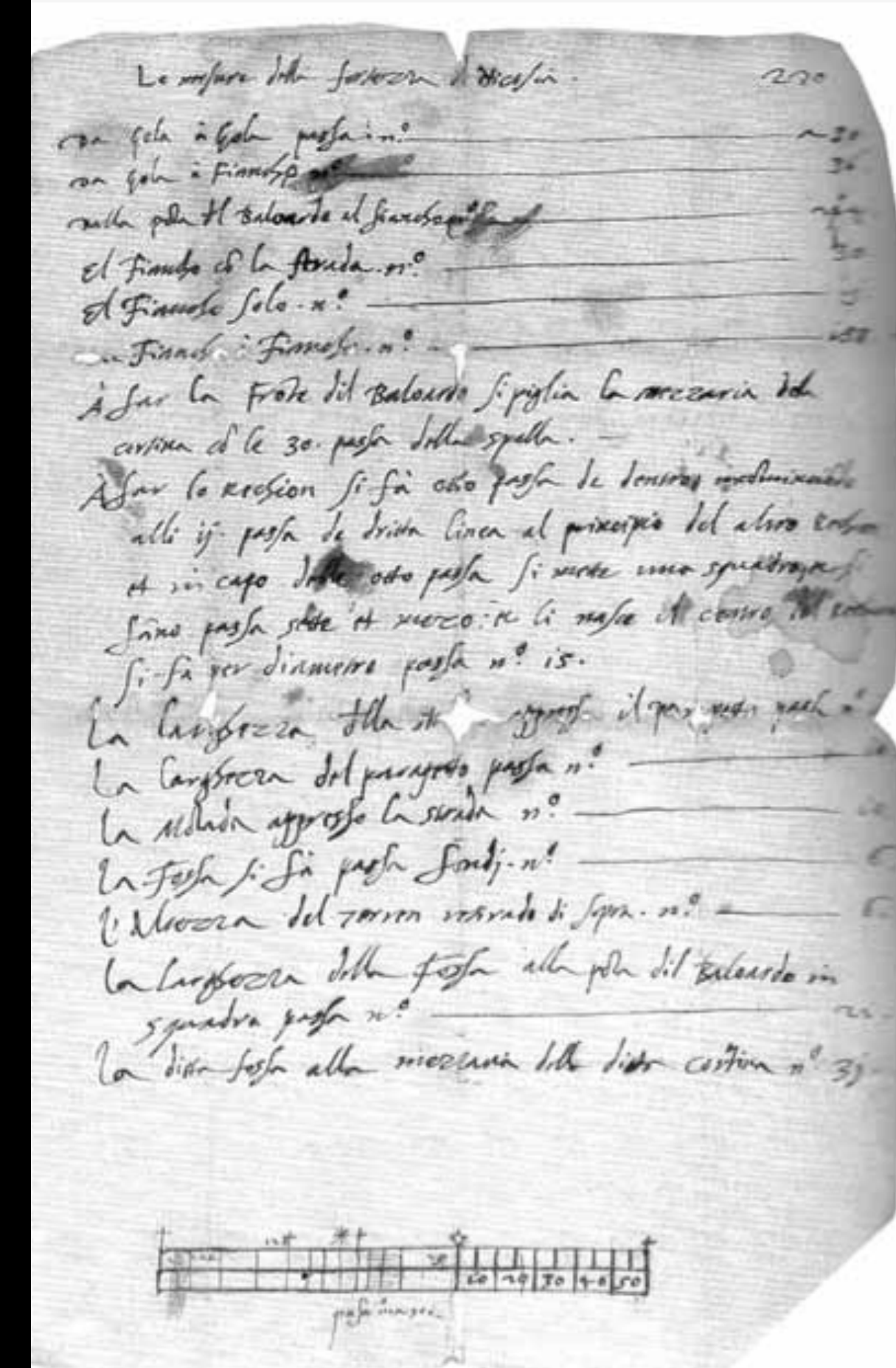
Germanico Savorgnan, Nicosia enceinte, 8 August 1567



Disegno della nobelissima città di Nicosia fatto di mano di me Germanico Savorgnano, per dar al Capitano Gregorio Pantea, per mandarlo al Magnifico Signor Felipo Roncon governor di Maran, sí come il Signor mio zio la fa fortificar al presente di 11 gran belovard, il dí 8 agosto 1567. In Nicosia.



Rochas ± Pon[en]te ± [?] ± Quirini ± porta ± Tripoli ± 30 ± 158 ± 31 ± 10.10.10 ± Barbaro ± [?] ± 30 ± case de soldati ± strada ± Case et botege di cittadini ± Costanzo ± cav[allier]o ± baluardo ± 05 ± ponte ± Podochataro ± Caraffa ± Leva[n]te ± strada ± porta ± Besa[n]te.

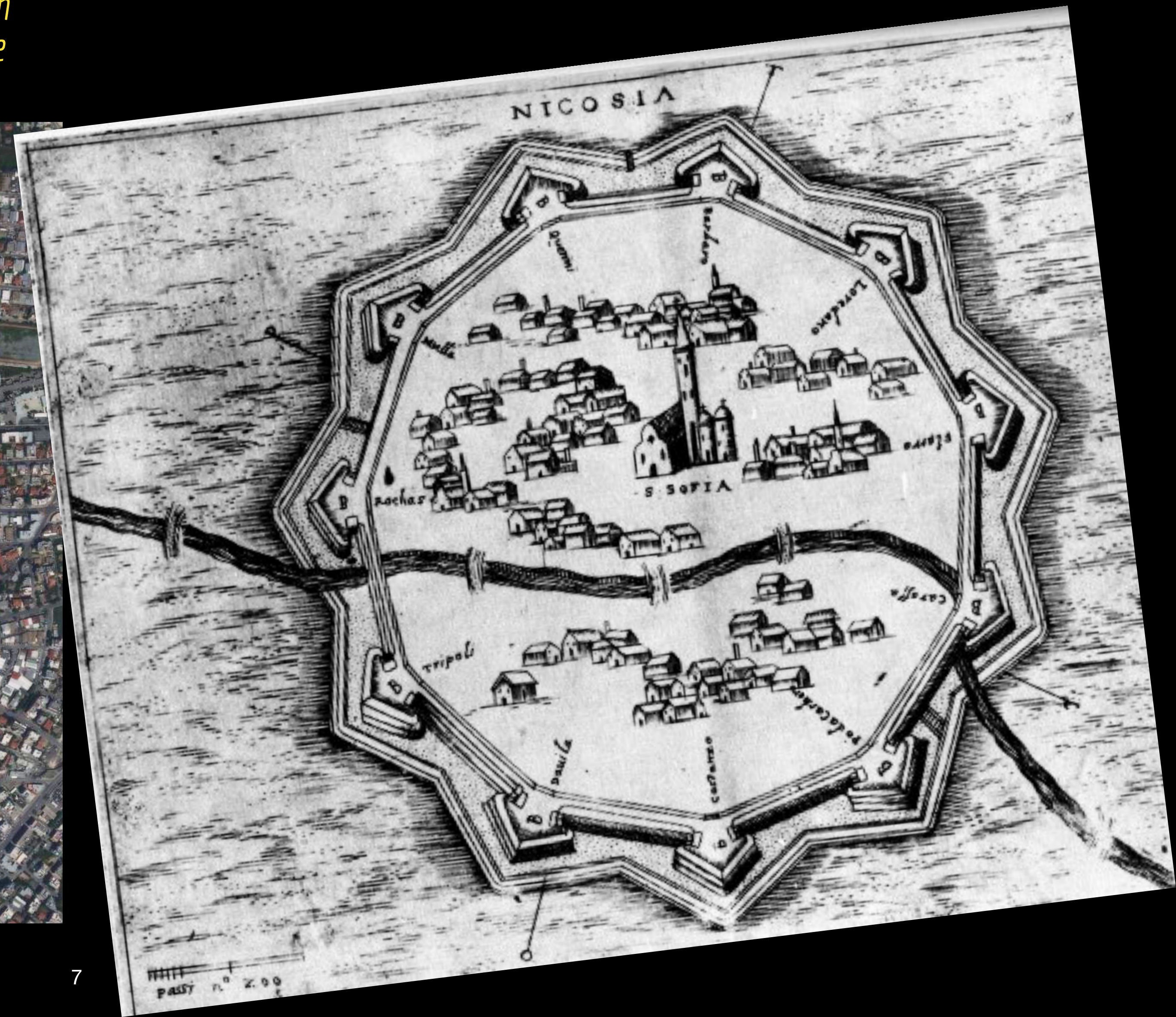


Da gola a gola passa no 280 ± Da gola a fianco no 36 ± Dalla punta del baloardo al fianco passa no 214 ± El fianco con la strada no 30 ± El fianco solo no 11 ± [D]a fianco [a] fianch[o] no 158 ± A far la fronte dil baloardo si piglia la mezzaria della cortina con le 30 passa della spalla ± A far lo rechion si fa otto passa de dentro [...] alli 11 passa de dritta linea al principio del altro rechion et in capo dalle otto passa si mette una squadra, et si fanno passa sette et mezzo, et li nasce il centro del rechion, si fa per diametro passa no 15 ± La larghezza della [...] appresso il per[a]pedo passa no 15 ± La larghezza del parapetto passa no 10 ± La molada appresso la strada no 10 ± La fossa si fa passa fondi no 6 ± L'altezza del terren retirado di sopra no 6 ± La larghezza della fossa alla punta del baloardo in squadra passa no 21 ± La ditta fossa alla mezzaria della ditta cortina no 31.

The new layout of the city - a European Renaissance plan

The fortifications are innovative for the period - later to be copied elsewhere (e.g. Palmanova)

Note the "Green Line" - demarcation between the occupied north and the southern part of the capital - vegetation grows un-attended in this abandoned stretch of the city.



The defence system



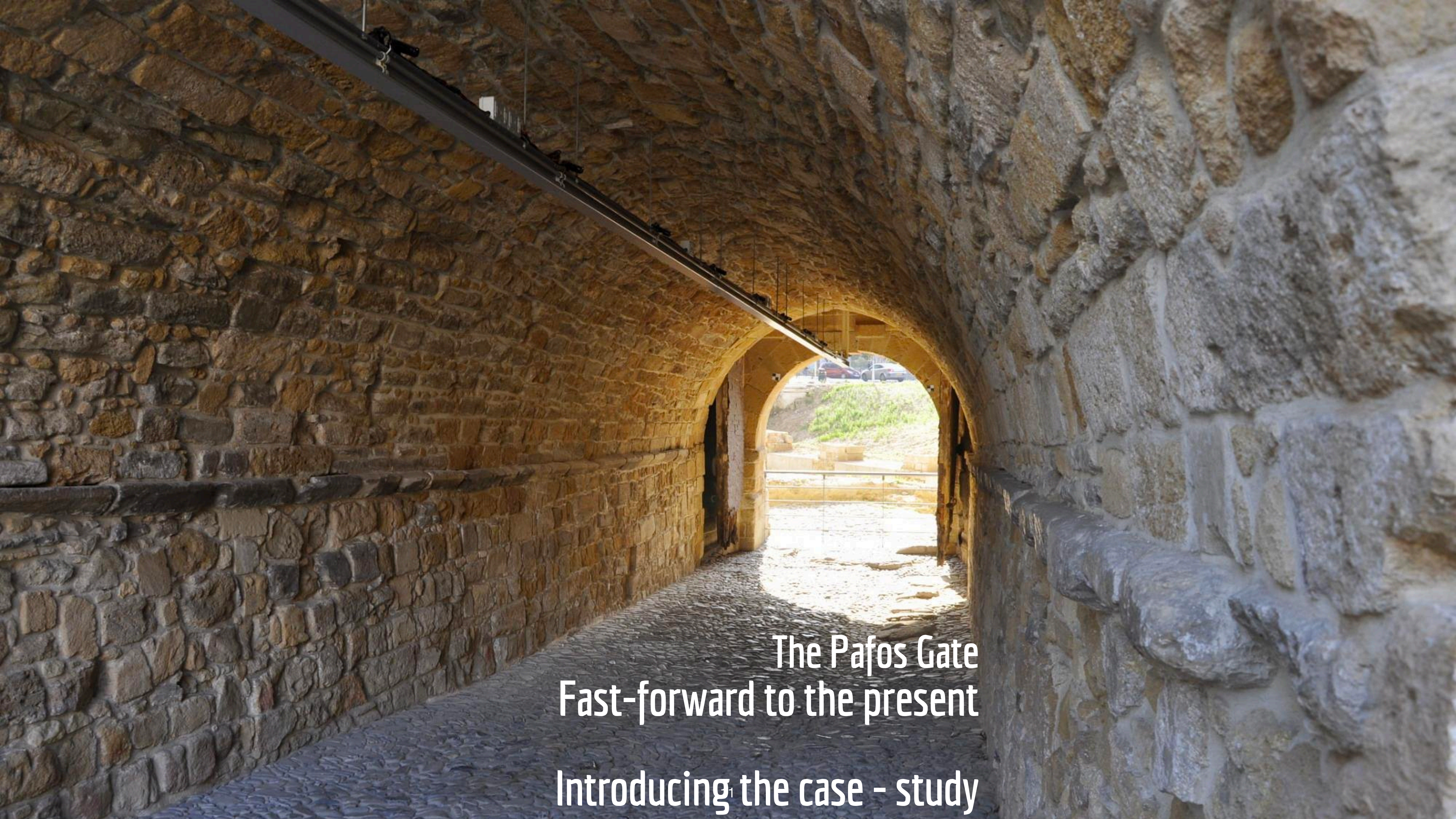


Some of the
bastions





The city fell on September 9, 1570;
20,000 Nicosians were put to death, and every
church, public building, and palace was looted.

The image shows the interior of a historic stone tunnel. The walls are constructed from large, irregular, light-colored stone blocks. The floor is paved with dark, rounded cobblestones. A series of black metal tracks or cables run along the top of the left wall. The tunnel leads to a bright, arched opening at the far end, through which a modern road with cars and greenery is visible. The lighting is warm and focused on the path ahead.

The Pafos Gate
Fast-forward to the present
Introducing the case - study

Introducing the case-study

- The Paphos Gate (Πύλη Πάφου), or the Gate of St Domenic, named after the medieval monastery of St Domenic, which housed the second Lusignan royal palace, was built by the Venetians (16th century) over an old Gate (12th century) now below ground level.
- It served all the roads connecting the western to the eastern parts of the island.
- During the British Colonial period, a section of the Venetian wall was opened to allow the ever-increasing flow of traffic and the gate was closed by the British in 1879.
- The buildings on top of the Gate functioned as “artillery barracks”, today under the aegis of the Divisional Police Headquarters and the Fire Brigade.

The gate from outside the walls



The Paphos gate

The tangible dimension

Data collection, analysis and Integration

Citizen science

Archive material (UNDP)

Invisible (buried) evidence (geo-radar)

Materials analysis (wood, stone, iron, mortars)

Multi-sensors documentation of shapes (drones, laser-scanners, RTI)

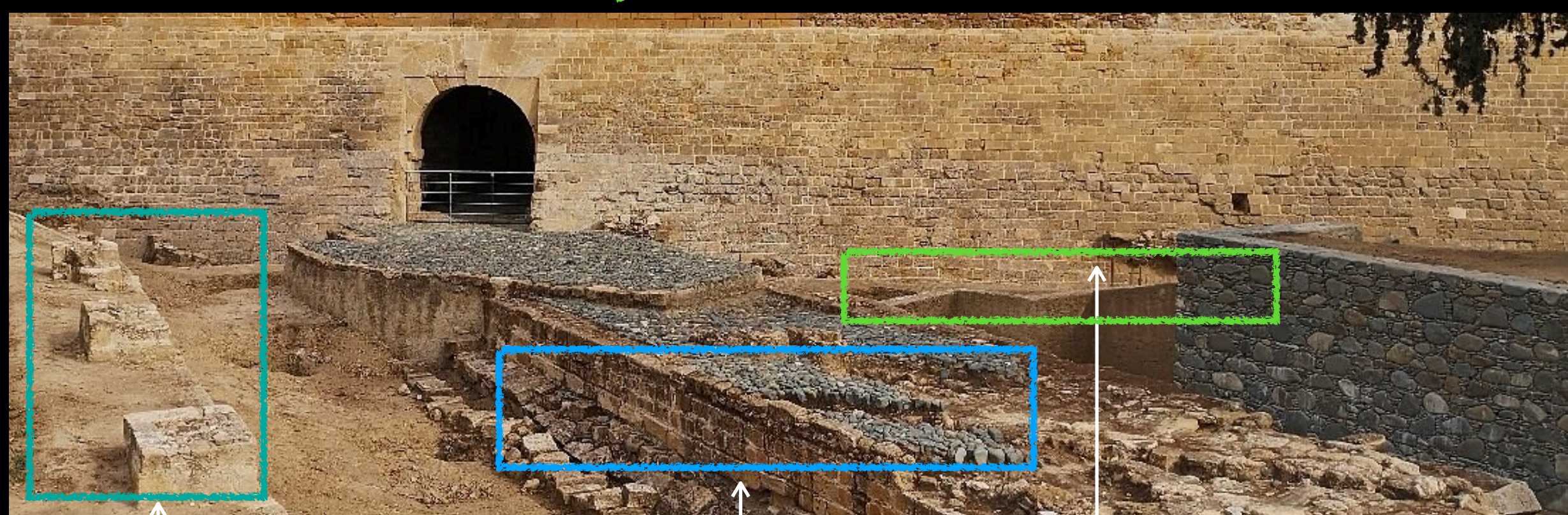
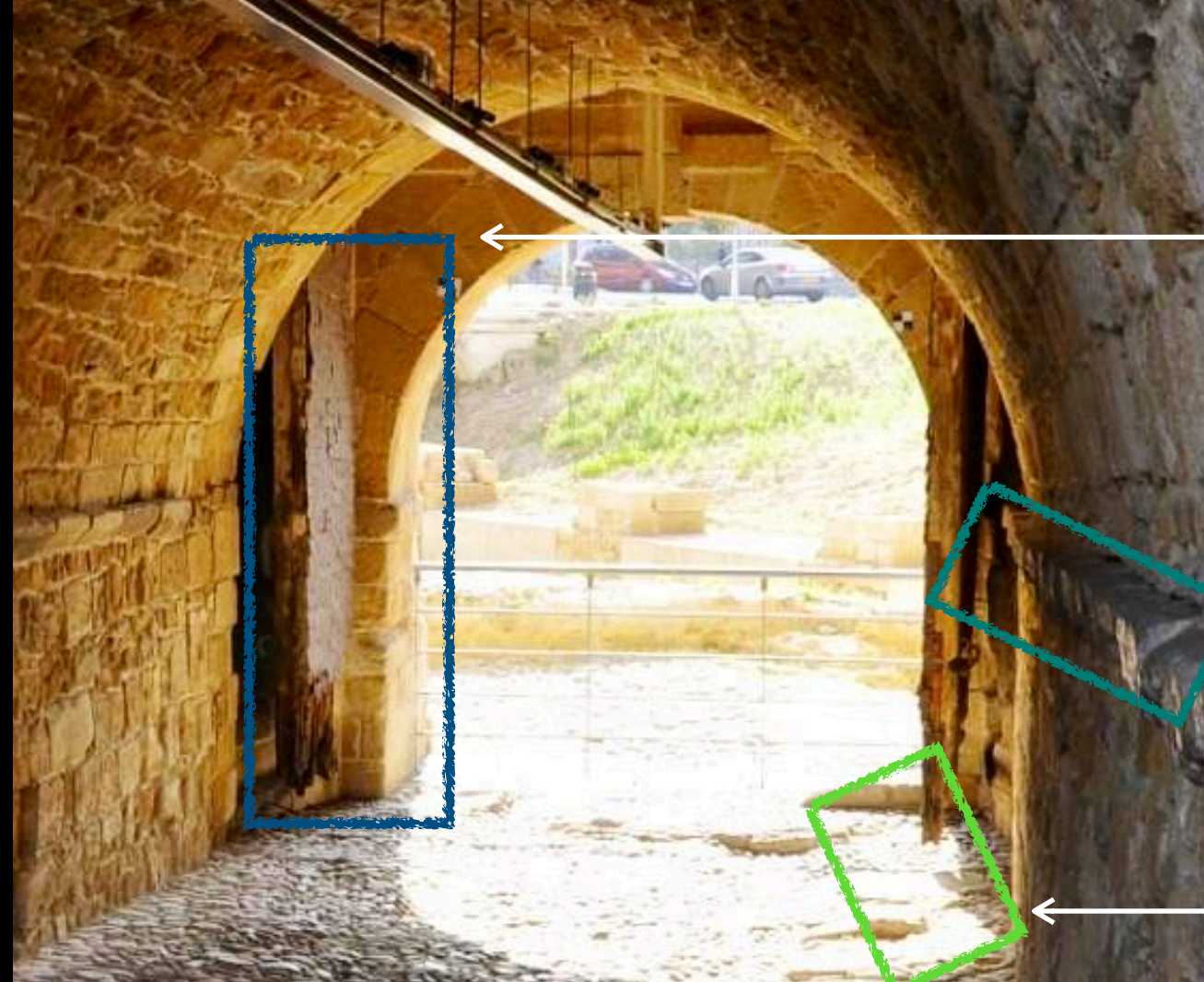


Venetian city gates (built with earlier re-used wood)



Latin Tombstones (possibly 13th c.)

Venetian sewage system



Ottoman Aqueduct

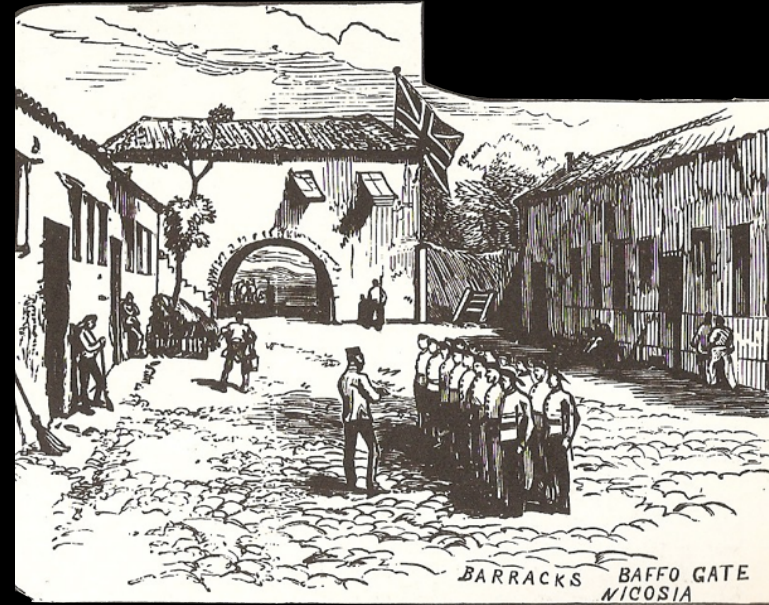
Ancient (undated) bridge

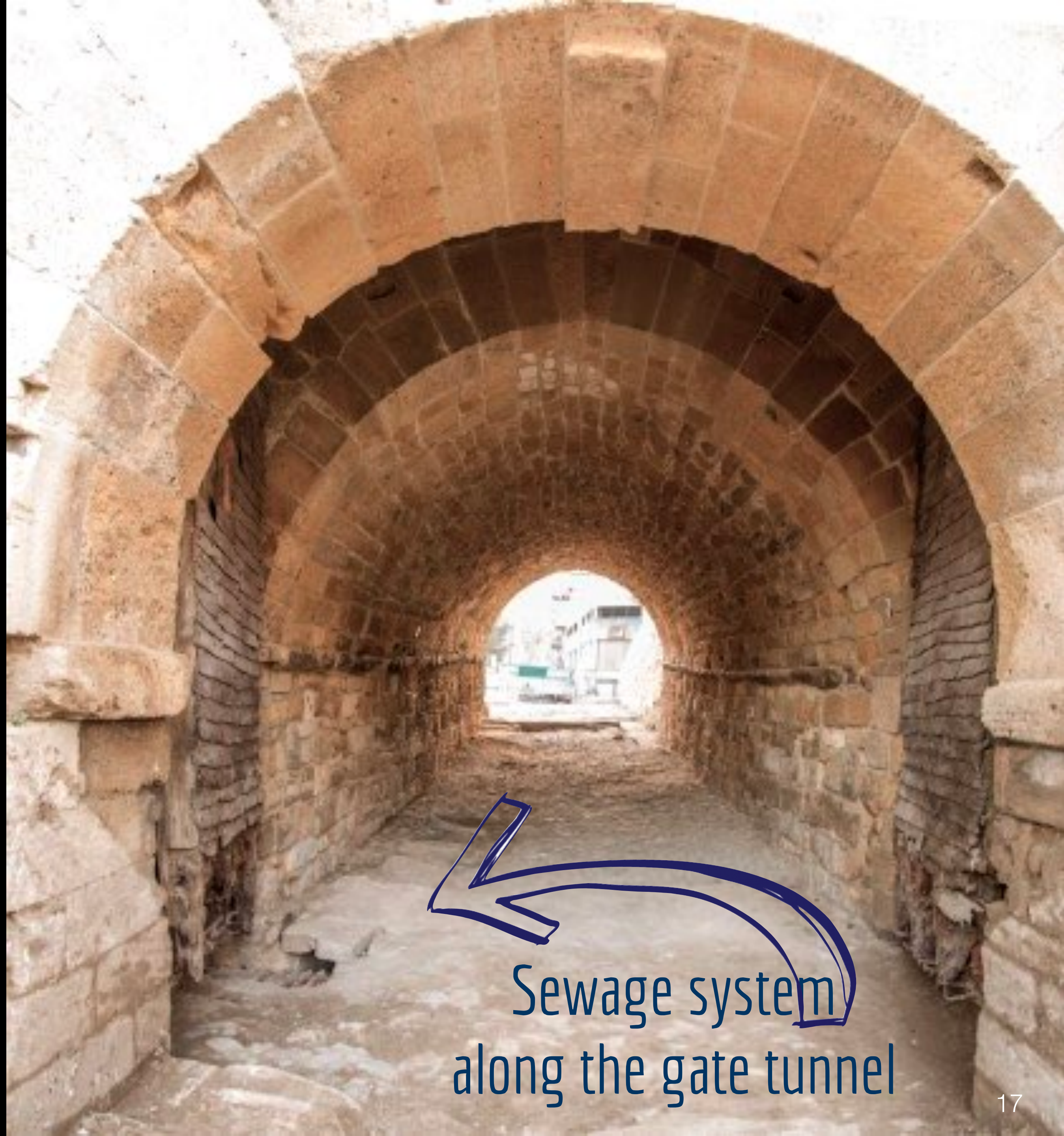
Venetian moat

Police and firemen buildings
Ex (Ottoman and later British military barracks)

The gate (ca. 1568, with an addition in 1879)

Casemates built during fights against the Turkish army (ca. 1974)

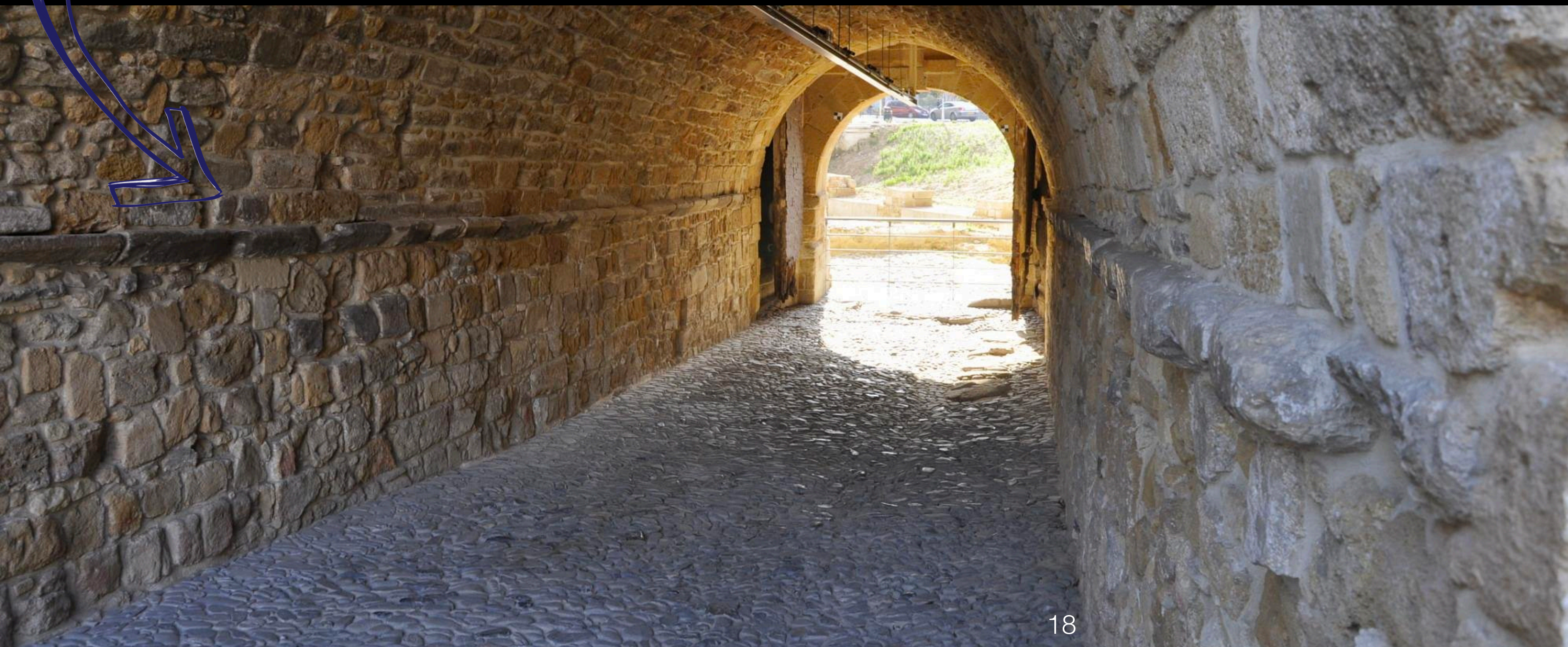




Sewage system
along the gate tunnel



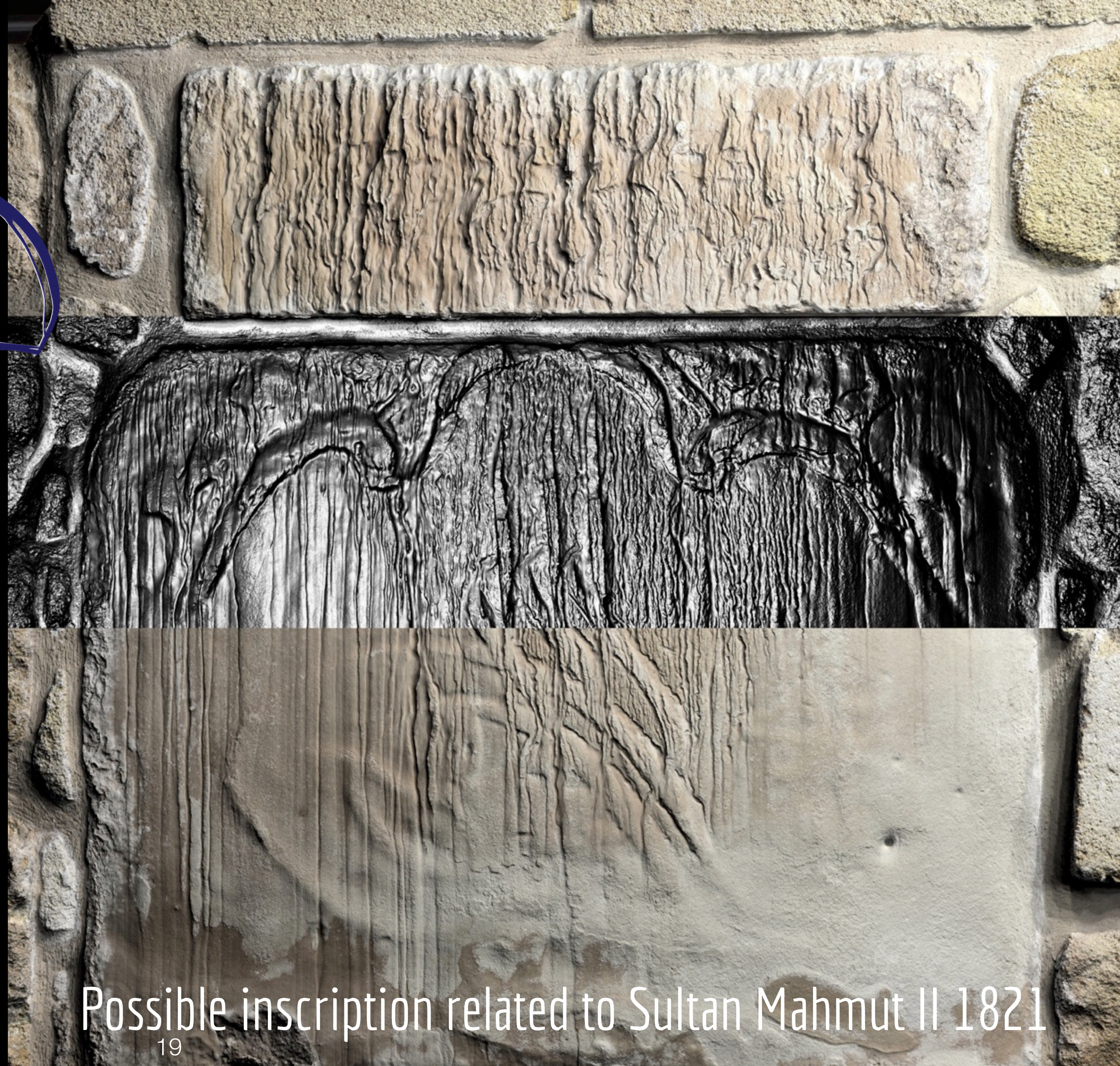
Dendrochronology reveals a pre-Venetian date of the wood



Lapidary stones with
latin inscriptions
(probably taken from
an unknown cemetery
related to the St.
Domenic monastery)



RTI image of an Ottoman inscription



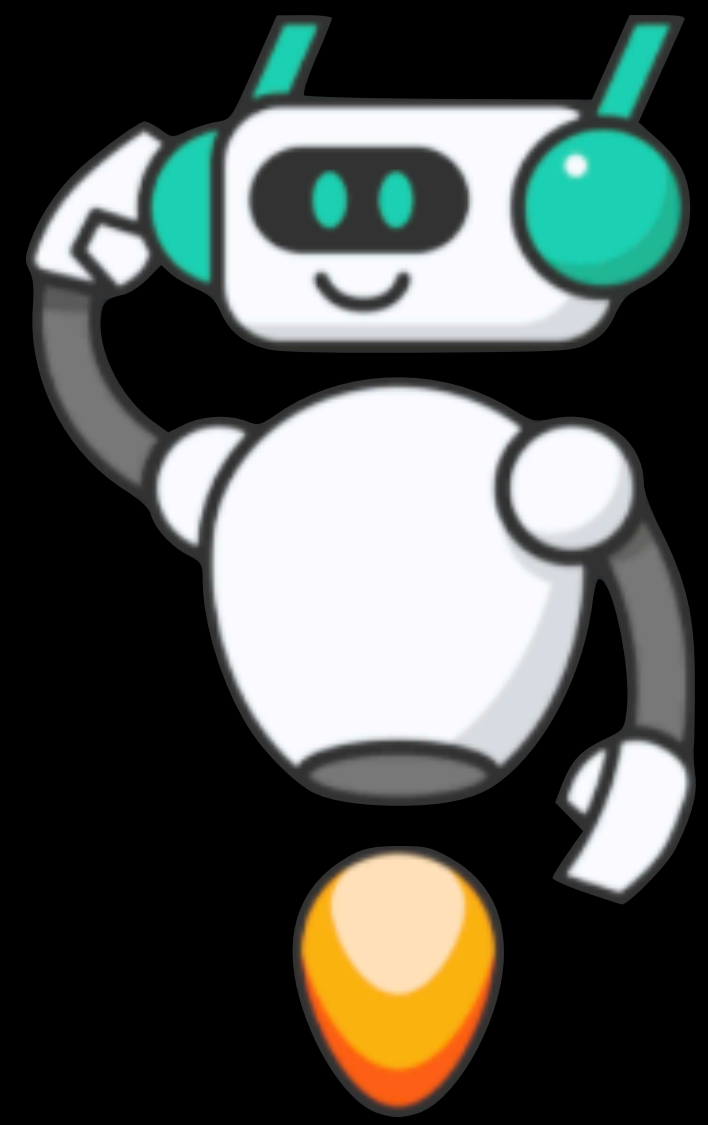
Possible inscription related to Sultan Mahmut II 1821

What about
The intangible dimension of Heritage?

From co-habitation to segregation

Green line dividing the city since 30 December 1963





How to achieve the needed
Quality Data
for the

An European Collaborative Cloud for Cultural Heritage

A decorative graphic on the left side of the slide consisting of a large blue circle at the top, followed by four smaller red circles arranged in a descending diagonal line.

Introducing the EU-funded initiative
4CH

The Competence Centre for the
Conservation of Cultural Heritage

4CH

Mission of the Competence Centre

- **Advice:**
 - Research and cutting-edge digital technologies on the preservation, conservation and sustainable promotion of monuments and sites.
 - Report on the most valuable initiatives, experiences and best practices across Europe and internationally.
- **Support:**
 - Promote a holistic and multidisciplinary approach to the conservation of CH.
 - Facilitate coordination between European Heritage Agencies and CH Institutions and European initiatives.
 - Build an effective partnership to promote the conservation and valorisation of CH.
 - Enable the take up and transfer of research project results by the CH sector.
- **Services:**
 - Define training and up-skilling programmes for cultural heritage institutions, operators and professionals.
 - Develop consultancy, guidelines and protocols on the use of digital technologies for CH management.

- Implementation of a map of risks which can damage Cultural Heritage assets for prioritising preservation and conservation activities
- Cultural Heritage monuments and sites addressed as the sum of their geometric shapes and material properties (tangible aspects), as well as their immaterial aspects (traditions, rituals, etc.), within their natural and anthropic environment.



Classification of risks - natural

(cumulative) processes

environmental

sea level raise glaciation erosion silting desertification ground-water deposition vibration

biological

animal migration pest vegetation decay degrade

disasters

invasive species

fauna flora

severe weather

fire downpour squall flood hail

geological events

tsunami earthquake landslide volcano

Classification of risks - anthropic

intended

heritage crimes

vandalism arson theft illegal excavations illicit trafficking collectors

management

modern re-use corruption political quarrying

indirect

building / infrastructure / industry

constructions industrial activity transportation pollution mining

other

war

land conversion

agriculture forestation

heritage management

negligence neglect restoration handling tourism industry visitors

(cumulative) processes

environmental

sea level raise glaciation erosion silting desertification ground-water deposition vibration

biological

animal migration pest vegetation decay degrade

PERFORATION . PERFORATION



PERFORATION . PERFORATION



Example

*monument
/ site /
landscape*

type

built
carved
natural

investigation /
legal status

studied
un-documented
preserved
recorded
excavated

location

on-ground
underwater
underground
cave

context

urban
rural
landscape

biodiversity

fauna
flora
geology

function

current
past

structure

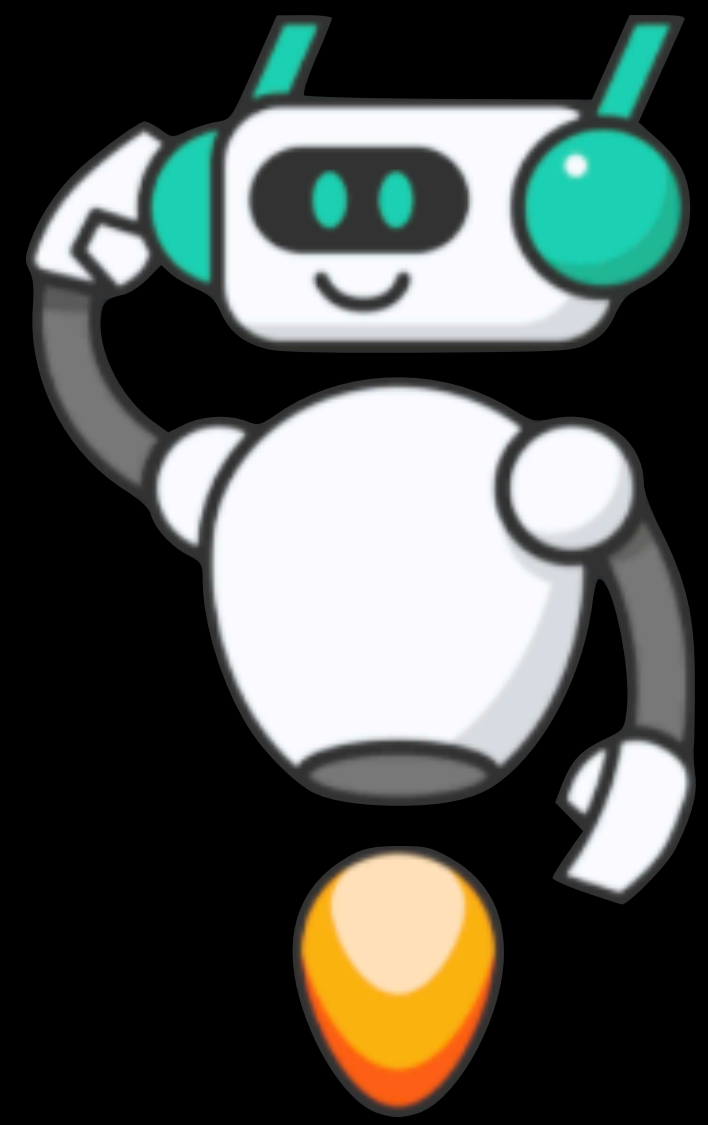
stand-alone
complex
ensemble

immaterial
aspects

artisanship
social activity
performing art

Open Challenges for 4CH

- Documentation:
 - What needs to be documented? What is out there and what is missing?
 - Which are the most suitable and sustainable methods and tools for the needed documentation?
- How to:
 - **organise all data collected?**
 - define and set a network of sensors to monitor environmental conditions at the site?
 - monitor the state of conservation of the interested sites?
 - define simulation and predictive modelling environments to evaluate what-if scenarios given current climate changes?



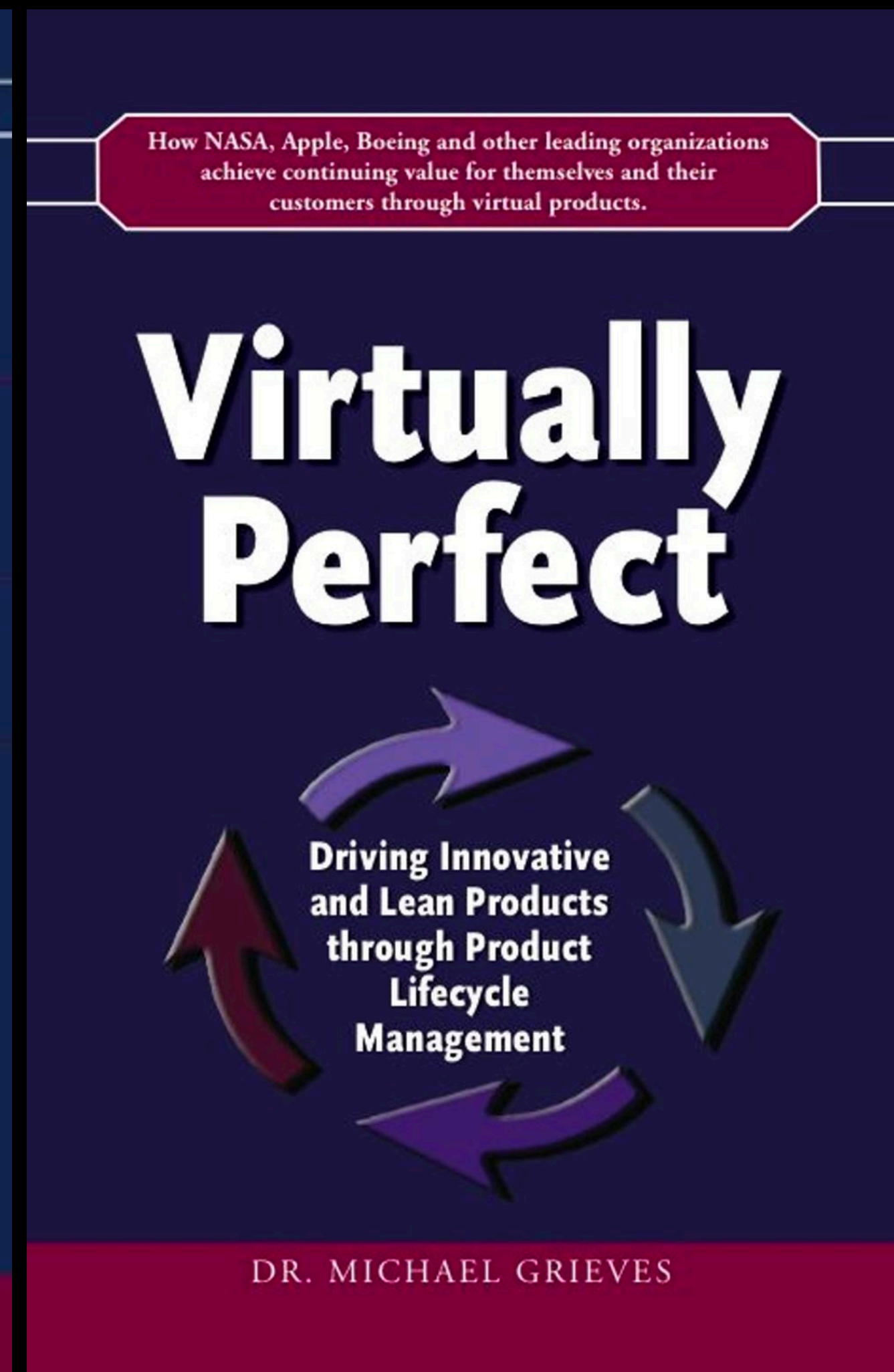
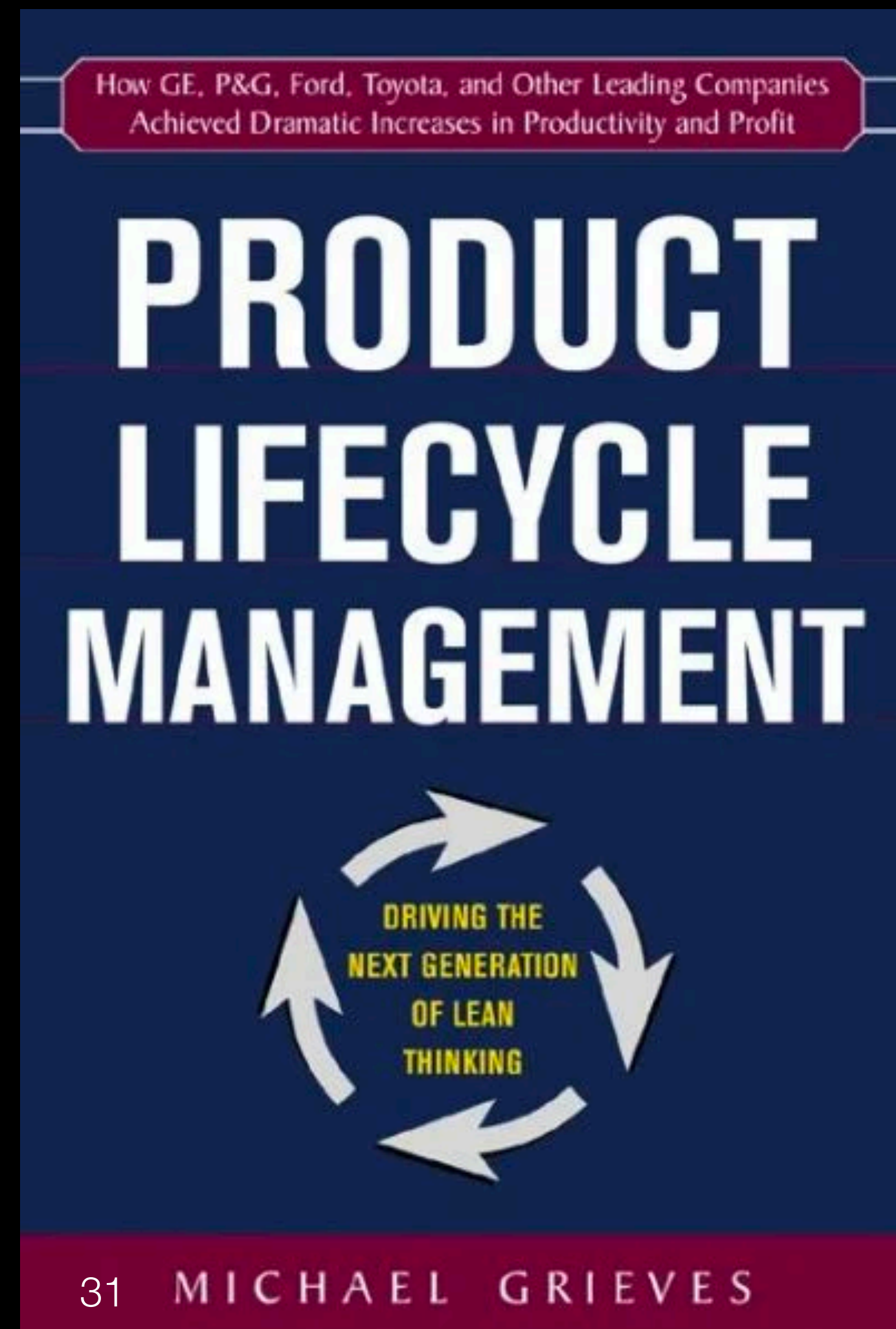
Towards a definition of A Digital Twin for Cultural Heritage

research, conservation, preservation, valorisation

Digital Twin - origin

The DT is... a digital informational construct about a physical system created as an entity on its own. This digital information would be a “twin” of the information that was embedded within the physical system itself and be linked with that physical system through the entire lifecycle of the system... (Grieves and Vickers 2017:92) ... such a fusion will ensure a higher flexibility and scalability of manufacturing systems through information technologies, while the digital transformation of enterprises requires the design and application of digital models, i.e. digital twins, which represent a set of knowledge of the real processes (Panetto et al. 2019).

The term was coined by Michael Grieves, of the University of Michigan, during a presentation to industry in 2002, for the formation of a Product Lifecycle Management center.



The National Aeronautics and Space Administration (NASA)

Multiphysics, multiscale, probabilistic, ultra-fidelity simulation that reflects, in a timely manner, the state of a corresponding twin based on the historical data, real-time sensor data, and physical model”

(Glaessgen & D.Stargel 2012)“.

The Digital Twin for Cultural Heritage

The present - an accumulation of past transformations



"Heterotopic" spaces for simulations of "what if" scenarios

Past

Present

Future

There is a need to understand past (physical and social) dynamics that shaped the present



environmental monitoring sensors and documentation of changes

Digital twins in urban heritage

A virtual representation that serves as the real-time digital counterpart of a physical object

It has to represent a unique asset in a specific instance of that asset

Conceptualisation and Instantiation

It simulates the physical state and behaviour of the asset.

Geometric, physical and chemical properties

It provides values through visualisation, analysis, prediction and modelling.

Virtual research environment

It updates continuously changes in the state, conditions of contexts of the asset, in order to assure the model mirrors reality and embodies a relational interaction data model.

Sensors monitoring network

Digital Twins conceptual structure

The semantic structure and data

CRM_{ARCHEO} CRM_{BA}

CRM_{DIG} CRM_{HS}

The Virtual Research Environment

nD Visualisation

Analysis

Modelling

Simulation

Integration of sensors data and interactivity

Input from
monitoring sensors

CH Services (conservation,
preservation, exploitation)

Relational
interactive model

Properties of The Cultural Heritage Digital Twin

- It exists in a virtual environment
- It connects, through a network of IoT, between the real world and the digital world
- It contains:
 - digital descriptions of an asset existing in the real world in some form (partial, imaginary, complete)
 - the data itself used for the above description
 - tools to update the data and consequently tools to update the digital description
 - tools to manipulate data for simulations, modelling, predictions, calculations, etc.

Properties of The Cultural Heritage Digital Twin

- Different from CAD (that exclusively focuses on the digital world) and IoT (that concentrates on the physical world), DTs are characterised by the two-way interactions between the digital and physical worlds and thereby create new possibilities.
- DTs can be addressed as integrators of both, physical and digital worlds, as well as internal and external processes of value creation.
- The main beneficiaries of DT are “services” (external value creation) and operations (internal value creation).
- The conceptual reference framework for DTs must include therefore:
 - (i) data resources - sources, categories and formats
 - (ii) external value creation - attributes of the services, level of complexity required and stakeholders profiling
 - (iii) internal value creation - lifecycle of CH asset, management and level of actualisation

The Heritage Digital Twin Ontology (HDT)

- Moving beyond HBIM (unable to address intangible and natural dimensions of heritage), we develop a semantic model of the Digital Twin where the knowledge about each asset is organised in a knowledge graph.
- The Heritage Digital Twin (HDT) of a Heritage Asset (HA) is the digital representation of the complex of knowledge about that asset, organised according to a specific, HDT ontology.
- The HDT approach organizes information for retrieval, allowing to access data by a human agent from any point of the knowledge graph that documents the heritage asset.
- Information may also be used for direct machine processing by means of simulation models integrated with the knowledge base. Thus, messages from sensors or from external big data systems may trigger automated actions (e.g. alerts in case of risks).

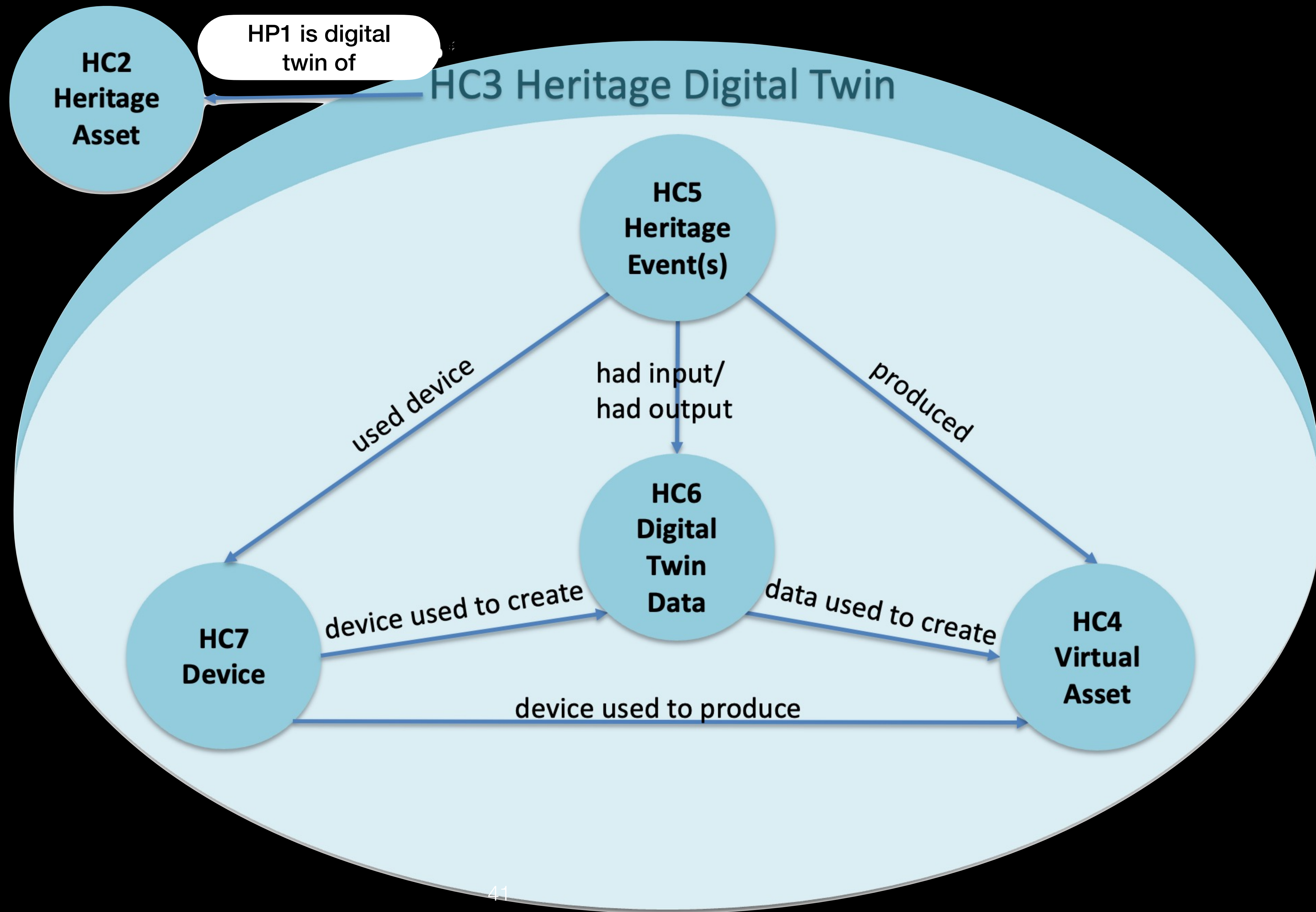
The Heritage Digital Twin Ontology

- All HDT classes are subclasses of an overarching one, *Heritage Entity*, with no instances. The pivot concepts are the class *Heritage Asset*, corresponding to actual heritage assets (physical, both movable or immovable, immaterial or born digital), and the class *Heritage Digital Twin*, to indicate the whole of the digital information pertaining to the Heritage Asset. The Heritage Digital Twin is related to the Heritage Asset via the property is digital twin of (*has digital twin*).
- Information about the parts forming an asset is relevant also to the whole; parts of a heritage asset may be considered as assets by themselves, and correspondingly the HDT of the whole will incorporate the HDTs of all the parts of the entire heritage asset (e.g. chapels in a church).

The Heritage Digital Twin Ontology

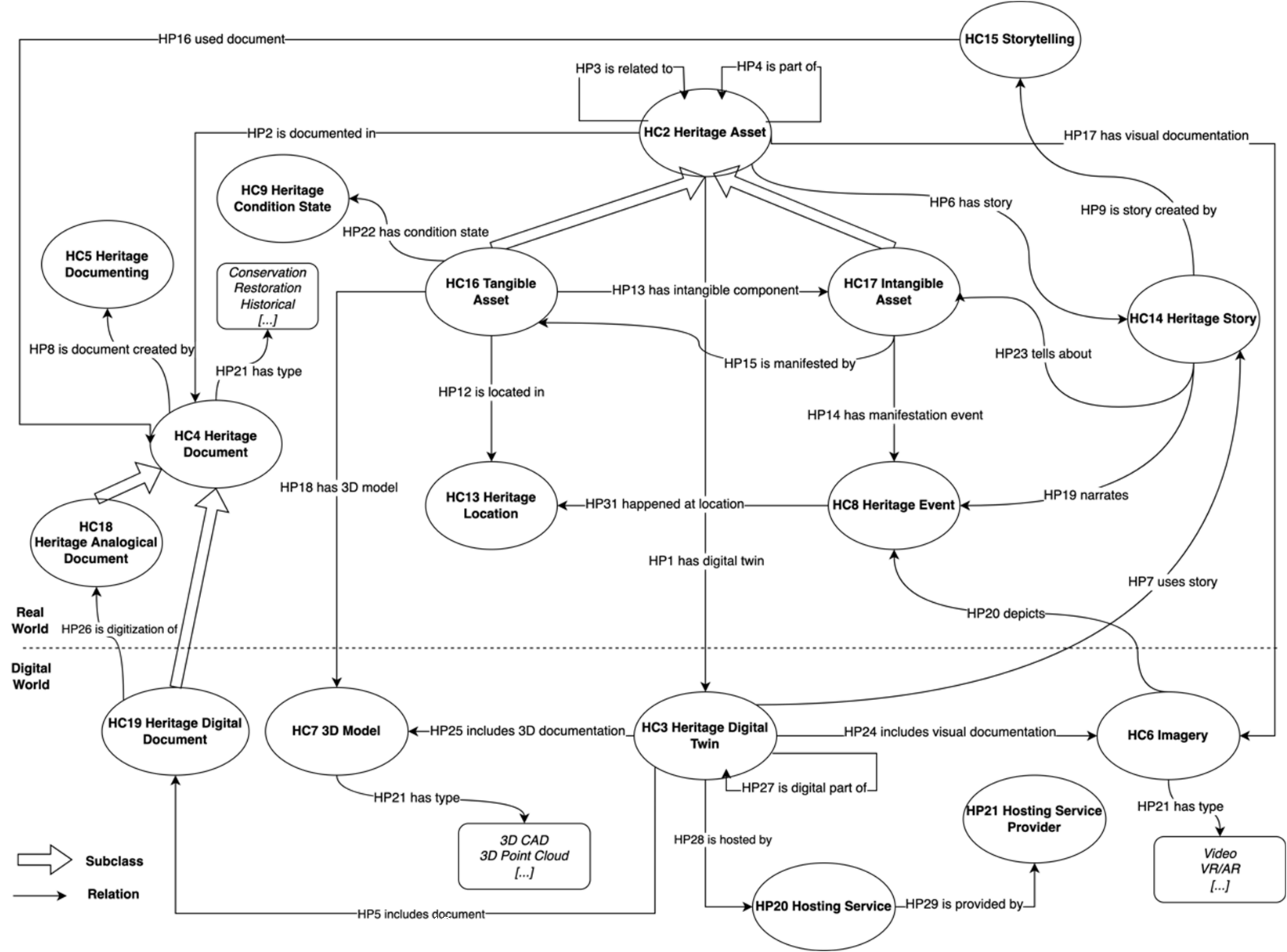
- The *Heritage Document* class includes all the documentation items pertaining to a Heritage Asset, e.g. born digital or analog objects and sensors data digitized. The property linking *Heritage Asset* to *Heritage Document* is “*is documented in*” (documents), which may apply to the whole asset or to specific parts of it.
- A *Heritage Asset* has many a *Heritage Story* associated to it. A *Story* includes any kind of witness related to the asset, e.g. a narrative, a historical source, a popular attribution, co-created content. A *Heritage Story* relates tangible heritage assets to their intangible components and to their reference communities and are of paramount importance also for the asset’s physical conservation and the safeguard of its intangible value.

The Heritage Digital Twin Ontology

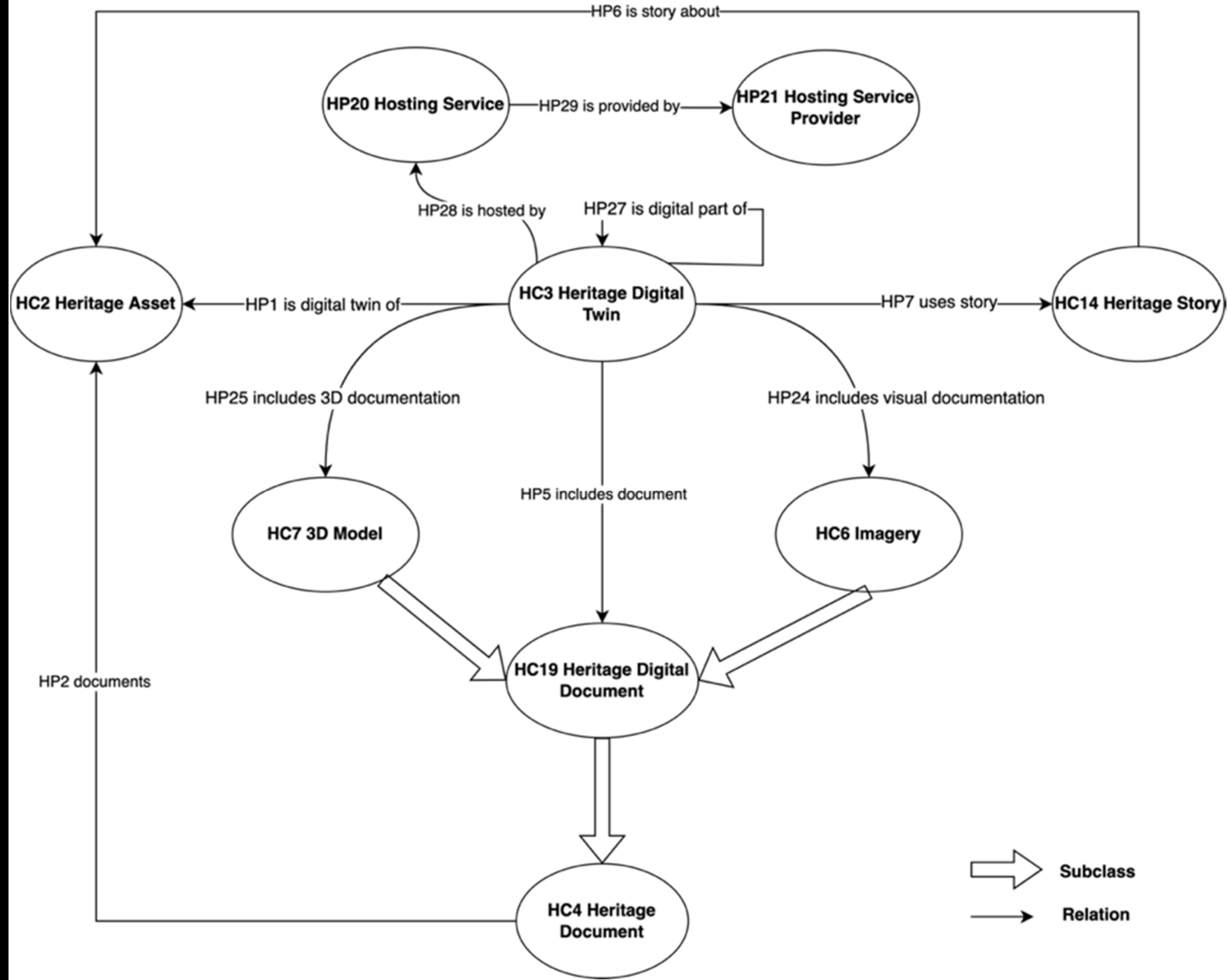


The semantic graph of the HDT ontology

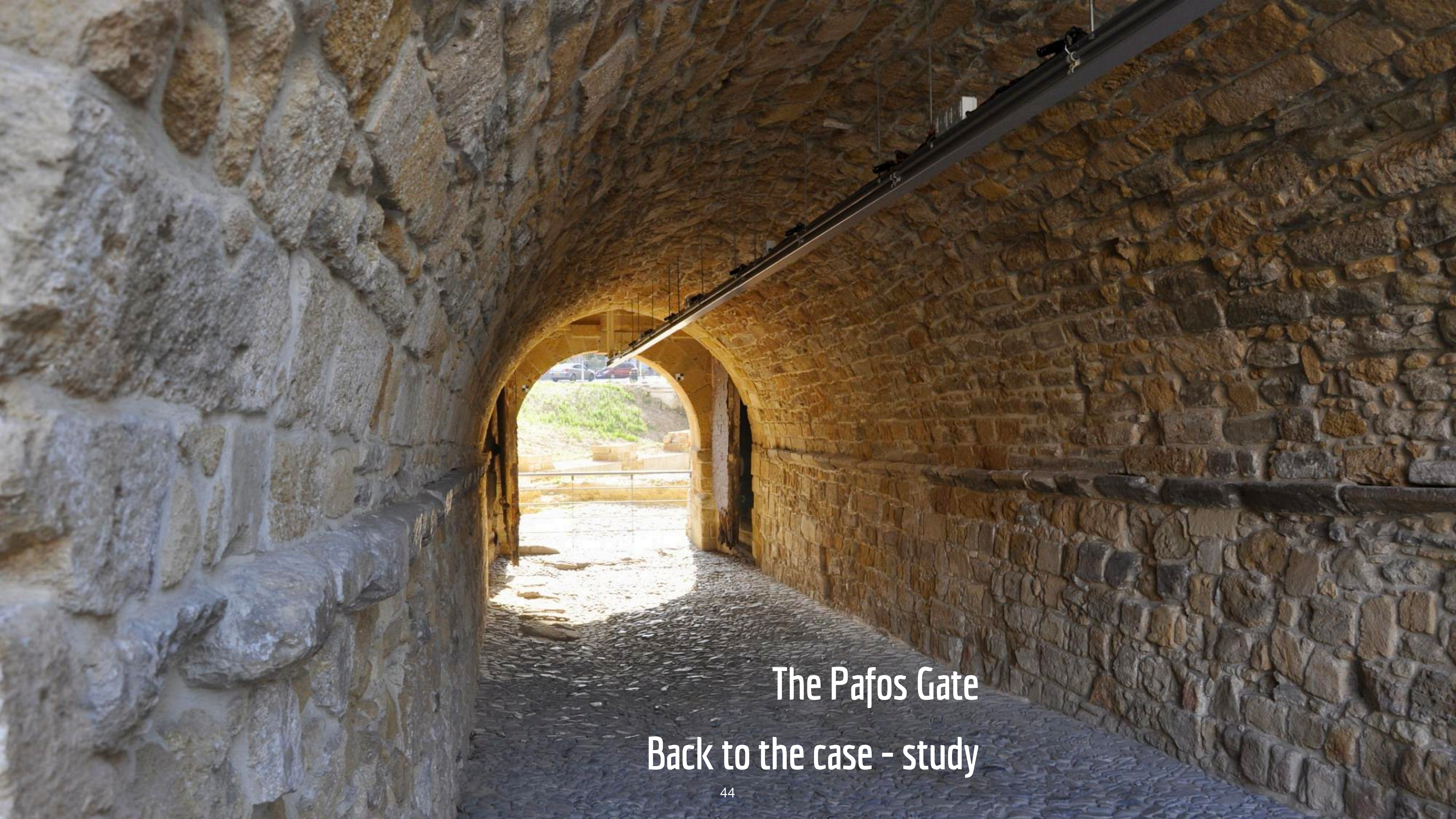
Niccolucci, F., Felicetti, A., & Hermon, S. (2022). Populating the Data Space for Cultural Heritage with Heritage Digital Twins. *Data*, 7(8), 105.



The semantic graph of HC3 Heritage Digital Twin



Niccolucci, F., Felicetti, A., & Hermon, S. (2022). Populating the Data Space for Cultural Heritage with Heritage Digital Twins. *Data*, 7(8), 105.



The Pafos Gate

Back to the case - study

an HDT for the Pafos Gate

- The historical documentation of the asset by Giulio Savorgnan and Fra' Stefano Lusignano, both as actual documents and their digital counterpart;
- The visual documentation consisting in drawings and 2D and 3D images;
- Its architectonic components and their characterisation;
- The overall monument of which it is part, i.e., the Nicosia fortifications;
- The names under which it is known and its official identifier, e.g., in the heritage inventory;
- The location where it is placed;
- Stories mentioning the asset, useful for communication and storytelling;
- Intangible components of the Gate.

Pafos Gate (*HC16 Tangible Asset*)

HP1 has digital twin Pafos Gate Digital Twin (HC3 Heritage Digital Twin)

HP2 is documented in Pafos Gate Documentation Folder (HC4 Heritage Document)

HP2 is documented in Giulio Savorgnan's Letters (HC18 Heritage Analogical Document)

HP2 is documented in Giulio Savorgnan Drawings (HC18 Heritage Analogical Document)

HP2 is documented in Fra' Stefano Lusignano's Chronography (HC18 Heritage Analogical Document)

HP3 is related to Nicosia Venetian Fortification System (HC16 Tangible Asset)

HP4 is formed by part Pafos Gate Doors (HC16 Tangible Asset)

HP4 is part of Nicosia Venetian Fortification System (HC16 Tangible Asset)

HP4 is part of Police/Firemen Headquarters (HC16 Tangible Asset)

HP6 has story Pafos Gate Story (HC14 Heritage Story)

Pafos Gate (*HC16 Tangible Asset*)

HP6 has story **Pafos Gate Story** (*HC14 Heritage Story*)

HP10 is identified by “DoAIN2022” (*HC11 Heritage Identifier*)

HP30 is titled “The Pafos Gate” (*HC12 Heritage Title*)

HP30 is titled “High Gate” (*HC12 Heritage Title*)

HP30 is titled “Porta San Domenico” (*HC12 Heritage Title*)

HP12 is located in **Nicosia, Cyprus** (*HC13 Heritage Location*)

HP13 has intangible component **Tanners and Dyers Commerce** (*HC17 Intangible Asset*)

HP14 has manifestation event **Activity of Tanners and Dyers Workshops** (*HC8 Heritage Event*)

HP31 happened at location **Nicosia, Cyprus** (*HC13 Heritage Location*)

HP17 has visual documentation **Pafos Gate Tunnel Image** (*HC6 Imagery*)

HP18 has 3D model **Pafos Gate Laser Scanning** (*HC7 3D Model*)

Pafos Gate Digital Twin (HC3 Heritage Digital Twin)

HP5 includes document Pafos Gate Documentation (HP19 Heritage Digital Document)

HP8 is document created by Pafos Gate Documenting Activity (HC5 Heritage Documenting)

HP5 includes document Scan of Giulio Savorgnan's Letters (HP19 Heritage Digital Document)

HP26 is digitization of Giulio Savorgnan's Letters (HC18 Heritage Analogical Document)

HP7 uses story Pafos Gate Story (HC14 Heritage Story)

HP24 includes visual documentation Pafos Gate Tunnel Image (HC6 Imagery)

HP25 includes 3D documentation Pafos Gate Laser Scanning (HC7 3D Model)

HP21 has type 3D Point Cloud (crm:E55 Type)

HP28 is hosted by STARC Repository (HC20 Hosting Service)

HP29 is provided by The Cyprus Institute (HC21 Hosting Service Provider)

Pafos Gate Story (*HC14 Heritage Story*)

HP9 is story created by Correspondence between Giulio Savorgnan and Venetian Officials (HC15 Storytelling)

HP16 used document Giulio Savorgnan's Letters (HC18 Heritage Analogical Document)

HP9 is story created by Fra Stefano Lusignano's Narration (HC15 Storytelling)

HP16 used document Fra Stefano Lusignano's Chronography (HC18 Heritage Analogical Document)

HP9 is story created by Giulio Savorgnan's fortifications building plan (HC15 Storytelling)

HP16 used document Giulio Savorgnan Drawings (HP18 Heritage Analogical Document)

HP9 is story created by Reconstruction of Pafos Gate Uses (HC15 Storytelling)

HP16 used document Pafos Gate Documentation (HP19 Heritage Digital Document)

HP16 used document Pafos Gate Architectonic Documentation (HP19 Heritage Digital Document)

HP8 is document created by Pafos Gate 3D Modelling Activity (HC5 Heritage Documenting)

Instances, Classes and Descriptions

Instance: Pafos Gate Digital Twin

Instance of Class: HC3 Heritage Digital Twin

Instance Description: <http://public.cyi.ac.cy/starcRepo/explore/objects> Pafos Gate collection

Instance: Pafos Gate Documentation Folder

Instance of Class: HC4 Heritage Document

Instance Description: Folder containing all material on the study of the gate in order to develop a 3D virtual environment, as part of the rehabilitation plan of the Nicosia municipality to transform the area into a visitable archaeological park.

Instance: Pafos Gate Documenting Activity

Instance of Class: HC5 Heritage Documenting

Instance Description: The activity of collecting or digitizing documents concerning the Pafos Gate

Instance: Pafos Gate 3D Modelling Activity

Instance of Class: HC5 Heritage Documenting

Instance Description: Activity of creating 3D models of the various architectonic components of the Gate



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Items per page: 20 40 80

1 2 Next

Clear all

Collections

- ☐ Famagusta_Gate
- ☐ Paphos_Theatre
- ☐ Agios_Georgios_Hill
- ☐ Byzantine_Museum
- ☐ Dromolaxia - Vizakia (Hala Sultan Tekke)
- ☐ Cyprus_Folk_Art_Museum
- ☐ Art Gallery
- ☐ The_Cyprus_Museum
- ☐ Gramatia
- ☐ Der Avedissian-Hawley
- ☐ Santa Cristina archaeological area
- ☐ The Cenacle Jerusalem
- ☒ The Paphos Gate
- ☐ Tombs of the Kings
- ☐ Church of Panagia Aggeloktistis
- ☐ Sanctuary of Apollo Hylates at Kourion
- ☐ Salamis Terracotta Fragments
- ☐ Ancient Books
- ☐ K2R
- ☐ test
- ☐ Kazaphani boat

Object type

- ☐ 3D Pdf
- ☐ Images
- ☐ X3DOM
- ☐ Videos
- ☐ Commentaries

Image size

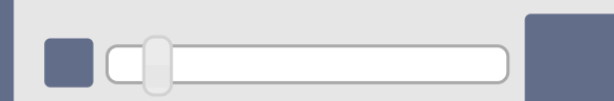


Image of the
Paphos Gate in
Nicosia, laser
scanner in process

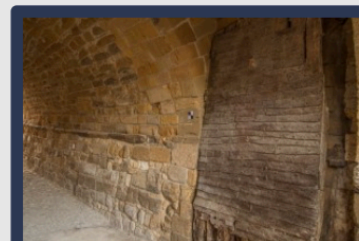


Image of the
Paphos Gate in
Nicosia, door

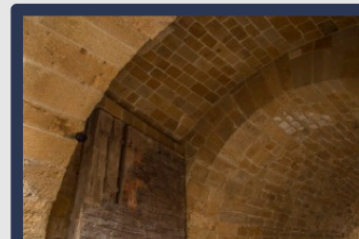


Image of the
Paphos Gate in
Nicosia, tunnel and
door

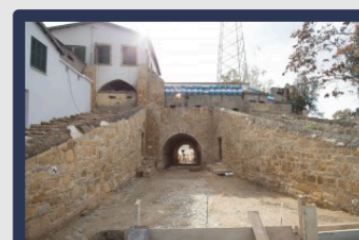
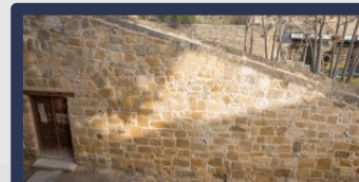


Image of the
Paphos Gate in
Nicosia, laser
scanner in process

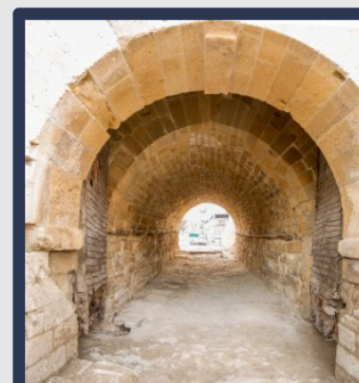


Image of the
Paphos Gate in
Nicosia, tunnel

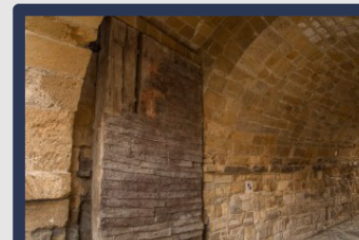


Image of the
Paphos Gate in
Nicosia, door

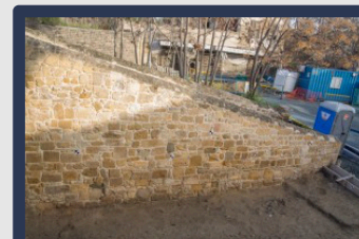


Image of the
Paphos Gate in

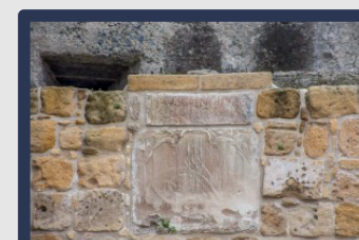


Image of the
Paphos Gate in
Nicosia, detail

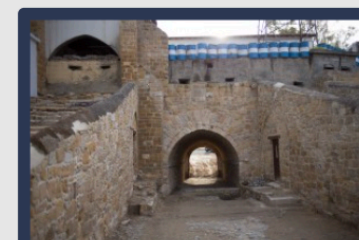


Image of the
Paphos Gate in
Nicosia

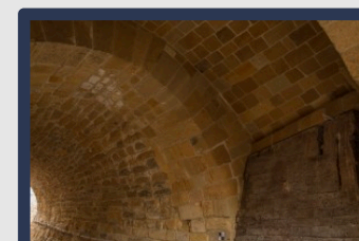


Image of the
Paphos Gate in
Nicosia, tunnel and
door

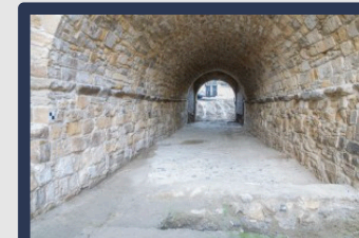


Image of the
Paphos Gate in
Nicosia, tunnel

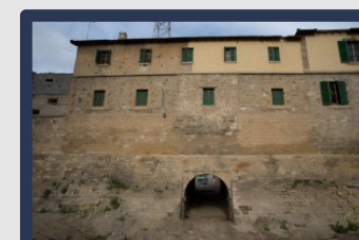
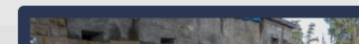


Image of the
Paphos Gate in
Nicosia, façade

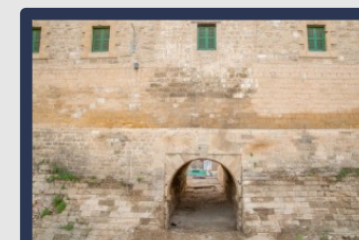


Image of the
Paphos Gate in
Nicosia, façade

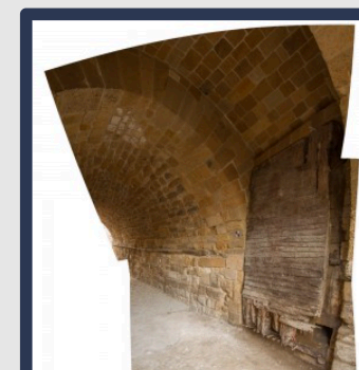


Image of the
Paphos Gate in
Nicosia, tunnel and
door

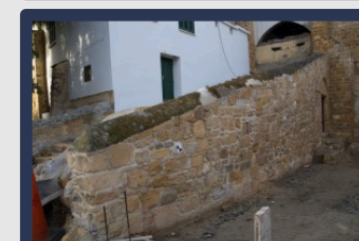


Image of the
Paphos Gate in

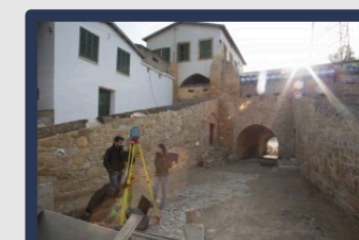


Image of the
Paphos Gate in
Nicosia, 3D data
acquisition

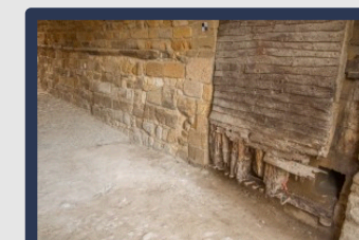


Image of the
Paphos Gate in
Nicosia, door

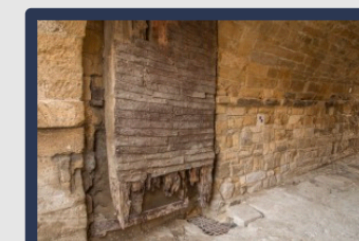


Image of the
Paphos Gate in
Nicosia, door

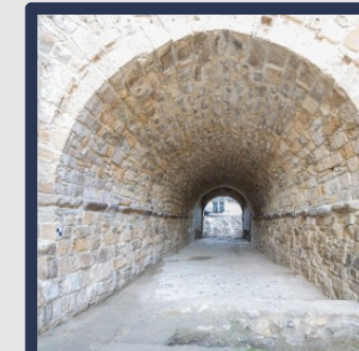
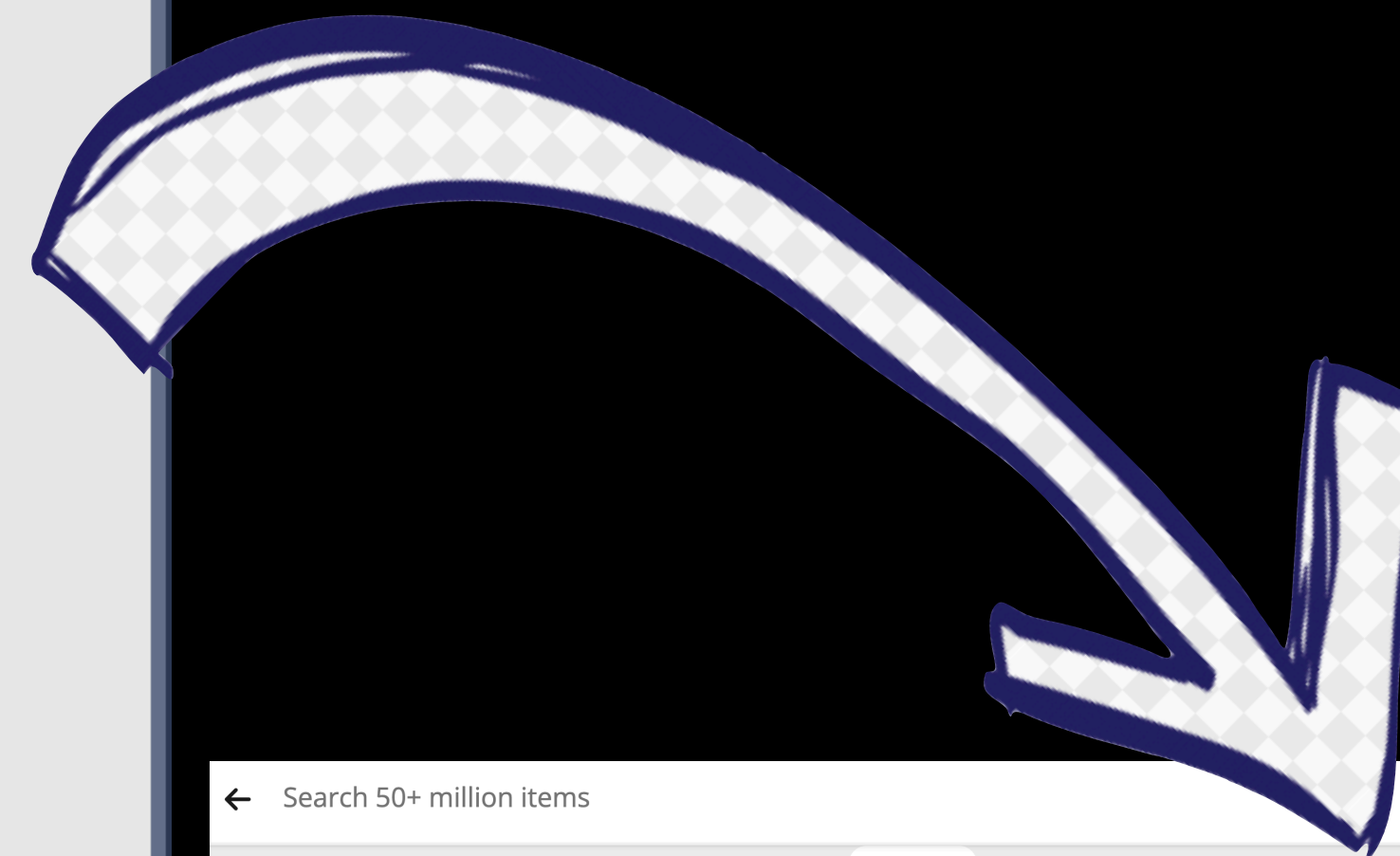


Image of the
Paphos Gate in
Nicosia, tunnel

Our data repository and link with Europeana



← Search 50+ million items

RESULTS FOR Paphos gate



Image of the Paphos Gate in
Nicosia, detail
STARC - The Cyprus Institute

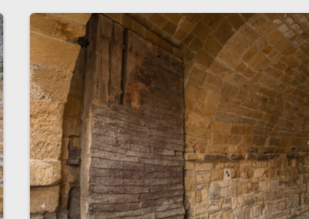


Image of the Paphos Gate in
Nicosia, door
STARC - The Cyprus Institute

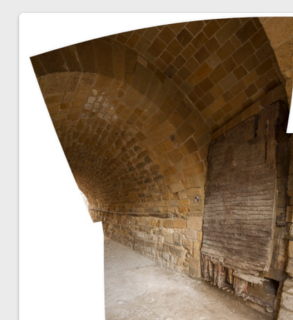


Image of the Paphos Gate in
Nicosia, tunnel and door
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia, door
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia
STARC - The Cyprus Institute

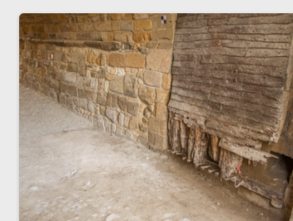


Image of the Paphos Gate in
Nicosia, door
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia, tunnel
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia, 3D data acquisition
STARC - The Cyprus Institute



Image of the Paphos Gate in
Nicosia, façade
STARC - The Cyprus Institute

Summary

- The HDT ontology primarily aims at organizing and managing digital information on heritage, in order to produce what the EU Commission calls “high quality records” in the Recommendation on a common European data space for Cultural Heritage.
- Such high quality records require rich, high-quality metadata, as those implemented by the HDT ontology proposed here.
- It relies on and is fully compliant with the CIDOC CRM international standard.
- Using the HDT ontology enables interoperability and reuse, making heritage data FAIR.
- It supports the creation of a distributed system, a federation of European Heritage storage and cloud facilities.
- It enables linking with other economic sectors such as tourism and creative industries and supports the development of advanced services, such as development of mitigation strategies in cases of alerts, climate change impact assessment,.
- It is ready to be adopted by the Knowledge Base of the forthcoming 4CH project Competence Centre for Cultural Heritage and from a broader perspective, the European Collaborative Cloud for Cultural Heritage.

That's all Folks!



4CH is a Horizon 2020 project funded by the European Commission under Grant Agreement n.101004468 – 4CH.

The views and opinions expressed in this presentation are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

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www.4ch-project.eu

