



Time  
Machine



# Time Machine Manifesto

Big Data of the Past for the Future of Europe | May 2019



# TIME MACHINE

“This manifesto is a call to launch an ambitious European large-scale research initiative to create the ‘Big Data of the Past’ that will transform our culture, traditions and achievements into a vital resource for shaping our future, while safeguarding our cohesion and identity.”

## LONG STORY SHORT

Time Machine aims to develop the Big Data of the Past, creating a huge distributed digital information system mapping the European social, cultural and geographical evolution across times. This large-scale digitisation and computing infrastructure will enable Europe to turn its long history, as well as its multilingualism and multiculturalism, into a living social and economic resource.

By pushing the frontiers of scientific research in Information and Communication Technologies (ICT) and in the Social Sciences and Humanities (SSH), Time Machine will strongly impact key sectors of European economy: ICT software, especially Augmented/Virtual Reality (AR/VR) applications; the creative industries; and tourism. Moreover, it will offer new perspectives in urban planning, land management and developing smart cities.

Time Machine will have strong positive long-term effects on European cohesion, economy and society, with concrete contributions to promoting critical thinking at all levels of decision making, to strengthening

the feeling of European identity, as well as to boosting scientific and technological competitiveness, entrepreneurship and employment in knowledge-intensive and creative sectors across the European Union.

This Manifesto calls upon Member States and European Institutions to support the launch of Time Machine within the Horizon Europe research and innovation framework programme and other European, National and Regional funding programmes, by providing the means and resources needed for the proposed long-term effort to reach its ambitious objectives.

### Goals of the Time Machine initiative

- Introduce a series of fundamental breakthroughs in Artificial Intelligence (AI) and ICT, making Europe the leader in the extraction and analysis of enormous sets of noisy, heterogeneous and complex data referring to our past and present activities and achievements.
- Enable Social Sciences and Humanities to address bigger issues, allowing new interpretative models that can smoothly transition between the micro-analysis of single artefacts and the large-scale complex networks of European history and culture.
- Be a driver of open science, as well as open (public) access to public resources.
- Provide a constant flux of knowledge that will have a profound effect on education, encouraging reflection on long trends and sharpening critical thinking.
- Act as an economic motor for new professions, services and products, impacting key sectors of European economy.

### Key areas of action – the research and innovation pillars

- Addressing the scientific and technological challenges in AI, Robotics and ICT for social interaction, for developing the Big Data of the Past, while further advancing these key enabling technologies **(Pillar 1)**.
- Designing and building the Time Machine operation, by putting in place the constituent parts of the Time Machine infrastructure and the management principles and processes for sustainable Time Machine communities across Europe and other parts of the world **(Pillar 2)**.
- Creating innovation platforms in promising application areas, by bringing together developers and users for the exploitation of scientific and technological achievements, and therefore leveraging the cultural, societal and economic impact of Time Machine **(Pillar 3)**.
- Developing favourable framework conditions for the outreach to all critical target groups, and for guiding and facilitating the uptake of research results produced in the course of the initiative **(Pillar 4)**.

### Towards a Time Machine Ecosystem

A vibrant Time Machine community has been created in the last years and is currently expanding to form a dense Time Machine ecosystem of leading scientists, innovators and other key players of civil society.

As of May 2019, this community counts 300 partners from 34 countries, comprising a large number of academic and research partners, leading industries and innovative small and medium-sized enterprises, key European museums, national libraries, state archives, as well as government bodies and policy makers.

The target is to exceed the number of 2000 supporting organisations from Europe and worldwide in the beginning of 2020.

# TABLE OF CONTENTS

|                                                                                                               |    |
|---------------------------------------------------------------------------------------------------------------|----|
| 1. WHY EUROPE NEEDS TO ACT NOW                                                                                | 06 |
| Globalisation, changing demographics and unresolved conflicts threaten the European sense of belonging        | 06 |
| Democratic dialogue is endangered by the dominion of private digital platforms                                | 06 |
| An urgent need for Europe to strengthen its engagement with its past                                          | 07 |
| An opportunity to go far beyond preservation of the European cultural heritage and envisage 'time travelling' | 07 |
| 2. THE VISION AND THE HOLISTIC APPROACH                                                                       | 10 |
| A clear vision, based on the Big Data of the Past                                                             | 10 |
| An integrated programme to ensure the required progress in different fronts                                   | 11 |
| 3. ADVANCING THE STATE OF THE ART                                                                             | 14 |

|                                                                                |    |
|--------------------------------------------------------------------------------|----|
| 4. CONCRETE AND MOMENTOUS OUTCOMES AND IMPACT                                  | 16 |
| A thorough dialogue with our past                                              | 16 |
| A transformational impact on Social Sciences and Humanities                    | 16 |
| Making education more accessible, interactive and diversified                  | 17 |
| A strong boost in European competitiveness in Big Data, AI and other ICT areas | 17 |
| Enhancing key sectors of the European economy                                  | 19 |
| A strong ally to counteract gender bias                                        | 23 |
| The strong international perspective for European excellence                   | 23 |
| 5. THE TIME MACHINE ECOSYSTEM                                                  | 24 |
| The Coordination and Support Action implementation                             | 24 |
| How interested parties can be involved                                         | 24 |
| The broader Time Machine partnership                                           | 24 |
| The Time Machine Organisation                                                  | 26 |

# 1. WHY EUROPE NEEDS TO ACT NOW

Not only is the integrity of European cultural identity imperilled by the resurgence of unresolved conflicts deep-seated in European history, but democratic dialogue is endangered by the dominion of private platforms over historical and cultural data. Time Machine addresses these crucial European phenomena.

## Globalisation, changing demographics and unresolved conflicts threaten the European sense of belonging

Over the centuries, the national, regional and local identities of Europe have evolved in relation to one another, through large swathes of transnational mobility and through dense commercial and cultural exchanges that have shaped European languages, traditions, arts and many other aspects of human activity.

These processes have largely contributed to the creation of a European culture characterised by diverse historical memories, which have laid the foundations to values and ideas harmonised by pluralistic and democratic dialogue.

To-date, however, increased globalisation, changing demographics and their threat against the idea of a shared past, as well as the resurgence of unresolved conflicts deep-seated in European memory, are key drivers of a 'localisation backlash' that places local and personal interests above any other. These growing trends present a clear threat to the cohesiveness of European cultural identity and sense of belonging.

## Democratic dialogue is endangered by the dominion of private digital platforms

Pluralistic and democratic dialogue in Europe has traditionally been facilitated by important intermediaries, such as cultural media and institutions acting as cornerstones of our shared values, principles and memories.

Today, the dialogue between different actors and the historical visions they embody is complicated by the rise of private digital platforms that have created a new space of opinion-leadership, as well as new forms of political expression and participation.

Managed by proprietary algorithms, such platforms may prioritise popularity and personal agendas over historical and cultural data, opening the way to fake news. In the resulting crisis of authority that affects journalism, academia and politics, many people do not trust anymore the information received from these institutions.

## An urgent need for Europe to strengthen its engagement with its past

These unprecedented transformations create a vital need for Europe to restore and intensify its engagement with its past as a means of facilitating an evidence-based dialogue between diverse historical memories, their values and mutual interdependencies and building a common path for existing and future generations.

Time Machine responds to this need by building the required infrastructure, and an operational environment for developing the Big Data of the Past that will streamline history and culture across Europe, opening the way for scientific and technological progress to become a powerful ally to safeguarding European identity and democratic values.

The importance of Time Machine can be most clearly seen in relation to the role of cultural heritage in processes that shape a European identity. **Heritage is our cultural DNA.** Material objects, such as artworks and monuments, as well as intangible heritage,

such as values and ideas, are the essential building blocks of local, national, and transnational identities, and are indispensable for preparing individuals and societies to face the challenges of an uncertain future.

To the same extent that today's genetics may work to the benefit of physical health, understanding the interactions between cultural heritage and identities contributes substantially to the quality, character and resilience of the individual and of society.

## An opportunity to go far beyond preservation of the European cultural heritage and envisage 'time travelling'

In April 2019, 24 countries<sup>1</sup> signed a landmark declaration of cooperation for advancing digitisation of cultural heritage (**Box 1**).

The focus of joint efforts is on Big Data, artificial intelligence, augmented reality and 3D and the development of European platforms in line with European values. These technological advances have been incorporated

### BOX 1

#### Ministerial declaration of cooperation on advancing digitisation of cultural heritage

This historic declaration<sup>2</sup> formally recognises that “natural disasters, pollution, mass tourism, deterioration over time, terrorism and vandalism, create urgent need to make the most of digital technologies to record, document and preserve Europe’s cultural heritage and foster their accessibility to European citizens.”

The Notre Dame de Paris tragedy that followed only a few days later sadly underlines that we cannot act fast enough in this area.

To face such threats, Member States have decided to join forces in developing key technologies for transforming the processing of and the access to cultural heritage.

in Time Machine, together with another critical element referring to fostering the development of common open interoperable standards for the processing and storing of cultural heritage assets.

“Our focus is on the joint efforts on Big Data, artificial intelligence, augmented reality, 3D and the development of European platforms in line with European values.”

<sup>1</sup> Austria, Belgium, Cyprus, Czech Republic, Estonia, Finland, France, Greece, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom  
<sup>2</sup> Scanned and signed declaration “Cooperation on advancing digitisation of cultural heritage”: [ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-digitising-cultural-heritage](https://ec.europa.eu/digital-single-market/en/news/eu-member-states-sign-cooperate-digitising-cultural-heritage)





But it should be stressed that for Time Machine partners, digitisation is only the first step of a long series extraction processes including document segmentation and understanding, alignment of named entities and simulation of hypothetical spatiotemporal 4D reconstructions. Time Machine offers a realistic scenario to progressively move from dense information networks to actual 4D worlds. To go back in time in cities such as Venice, Paris, Amsterdam, Antwerp or Jerusalem, one would need to jump from using a dense network of information, the result of transparent interpretation processes from reliable sources, to a continuous simulation representing the multi-scale evolution of the city and its population.

The hypothesis pursued by Time Machine is that such computational models with an extended temporal horizon are key resources for developing new approaches to policy making and services for the citizens and consumers.

Deploying itself both horizontally – across Europe – and vertically – in time, first for specific geographic locations through the **Local Time Machines (Box 2)** and then progressively in the entire territory, Time Machine offers a sustainable approach not only to safeguard European cultural heritage but also to transform it into a living resource for Europe's future.

“With Time Machine, we will offer a realistic scenario to progressively move from dense information networks to actual 4D worlds.”

## BOX 2 Local Time Machines

Even though the Time Machine infrastructure is built to enable cooperation across Europe, it simultaneously creates vertical synergies between clusters of actors operating in the same area. For example, some cities can become Local Time Machines.

This occurs when a number of Time Machine partners operating in close geographical proximity to one another decide to join forces in creating a full spatiotemporal representation of the area. These efforts, currently ongoing in 14 European cities, will also become formalised in the coming months. As a new pan-European alliance, Time Machine Organisation, comes online.

Local Time Machines evolve through successive steps in their maturity, from formal declaration of interest, to official partnership, and on to higher density of cross-linked information, population and urban reconstruction.

### Examples of Local Time Machines:

- Amsterdam: [amsterdamtimemachine.nl](http://amsterdamtimemachine.nl)
- Budapest: [hungaricana.hu/en/budapest-idogep](http://hungaricana.hu/en/budapest-idogep)
- Utrecht: [utrechttimemachine.com](http://utrechttimemachine.com)
- Venice: [vtm.epfl.ch](http://vtm.epfl.ch)

A list of all Local Time Machines in the making is available on the Time Machine website:

[timemachine.eu/time-machines](http://timemachine.eu/time-machines)



## 2. THE VISION AND THE HOLISTIC APPROACH

Time Machine will use space and time as shared references across domains, disciplines and cultures, to understand and give value to constructions, artefacts, observations and data produced over centuries.

### A clear vision, based on the Big Data of the Past

The scientific vision behind Time Machine is structured around Big Data of the Past. The concept is illustrated in **Figure 1**, where the amount of digital information available today for each historical period (horizontal axis) is plotted against time (vertical axis).

Information about the most recent years is abundant, forming the large plateau - the Big Data of the Present – at the top of the curve that shrinks rapidly as one moves down the graph and back in time (**Figure 1A**).

Time Machine aims at enlarging the stem of this funnel, by developing the technology and infrastructure for conducting massive digitisation and processing of cultural heritage sources (**Figure 1B**).

This enlarged dataset will be the basis for simulating possible pasts in order to reach an unprecedented density of information: the Big Data of the Past (light purple area

in **Figure 1C**); this enormous volume of data will also boost modelling capacity, enabling us to make evidence-based predictions for the future (light turquoise area in **Figure 1C**).

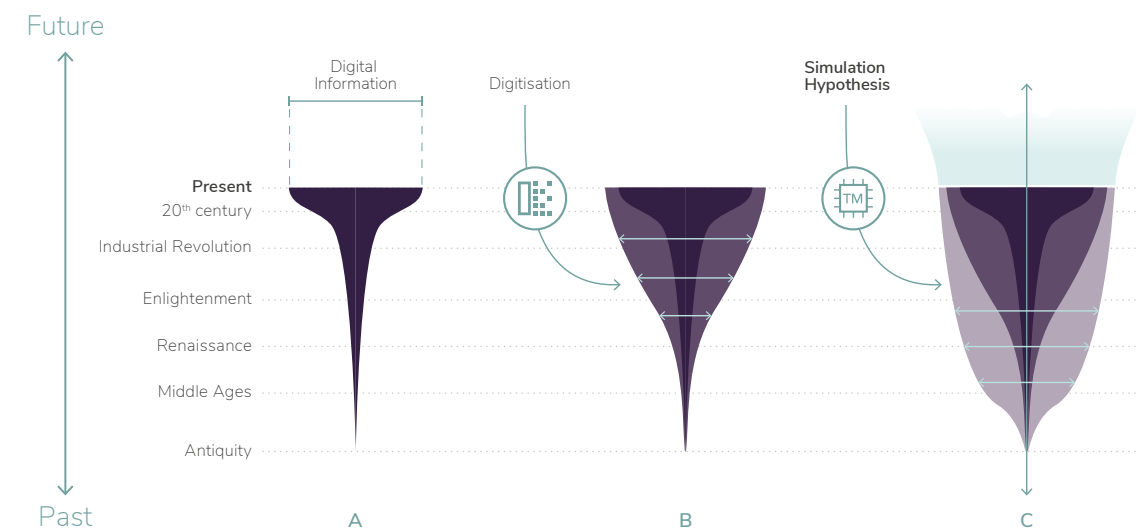


FIGURE 1: Creating the Big Data of the Past:  
(A) Current situation. (B) Extension based on digitisation and processing of new sources. (C) Extension based on simulation.

“We will develop tools, forms of analysis and modelling procedures that combine Big Data from multiple sources to explain phenomena that extend over large periods of time, and/or affect extended regions of populations.”

### An integrated programme to ensure the required progress in different fronts

To obtain the necessary data for such a reconstruction of European history and culture, Time Machine aims at developing new technologies allowing for the rapid digitisation of massive amounts of fragile documents, objects, architecture and patrimonial sites from European heritage.

Meanwhile, high-performance computing clusters<sup>3</sup> will be used to process this mass of documents using increasingly smart machine reading algorithms, segmenting, indexing and transcribing their content, and ultimately making them representable, analysable and searchable, like any other record/artefact searched for on the web.

The **game changer** nature is associated with the ‘longue durée’, a term previously used to describe the temporal horizon for SSH research, that has acquired a new meaning as a result of the Big Data presently available for digital analysis from historic, cultural, governmental, economic and ecological sources.<sup>4</sup>

This new approach will also be enhanced by radical changes in education: Time Machine will promote a stronger focus on automated adaptive and exploratory learning, more interactive processes binding generations and cultures, and a greater breadth of knowledge across disciplines.

Fundamental breakthroughs in Artificial Intelligence, Robotics and ICT are envisioned, requiring intensive collaborations amongst the leading EU actors of these fast-evolving disciplines that drive the Fourth Industrial Revolution. These breakthroughs will strongly impact key sectors of European economy – including ICT software, espe-

cially Augmented/Virtual Reality (AR/VR) applications; the creative industries; and tourism – while offering new perspectives for urban planning and the development of smart cities.

Taking into account these considerations, the Time Machine framework is built around the following specific objectives:

- addressing the grand scientific and technological challenges at hand,
- developing and operating the large-scale shared Time Machine infrastructure,
- converting the research results into innovation platforms in promising application areas and
- maximising outreach to all critical target groups and supporting the uptake of research results.

<sup>3</sup> such as the ones to be developed through the European High-Performance Computing Joint Undertaking – [eurohpc-ju.europa.eu](http://eurohpc-ju.europa.eu)

<sup>4</sup> Guldi, J. and Armitage, D. 2014. The History Manifesto. Cambridge: Cambridge University Press.



Accordingly, Time Machine is structured in four pillars, each serving one of the above objectives. The Time Machine pillars are shown in Figure 2, together with their thematic areas.

The required extensive, long-term and sustained effort in these directions exceeds by far what can be achieved in typical national or European research and innovation projects. Moreover, as digital preservation of cultural heritage is a priority in almost every Member State of the European Union, it is crucial to align national research agendas and manage multiple projects and networks in different European countries and cities.

A large-scale research initiative is needed to drive simultaneous progress on all fronts, creating synergies and multiplying the effects from different sources of funding (Horizon Europe, Digital Europe, ESIF, Private investments), structuring national research agendas around commonly agreed topics and managing multiple projects and networks in different European countries and cities.

The integrated programme that is proposed can be a strong basis for creating the required large-scale research coordination in all relevant fields, bringing together key stakeholders from academia, archives, museums, and the business sector, and creating partnerships within and between Member States and European bodies involved with culture, cultural heritage, creative industries and territorial management.

"A large-scale research initiative is needed to drive simultaneous progress on all fronts, creating synergies and multiplying the effects from different sources of funding."

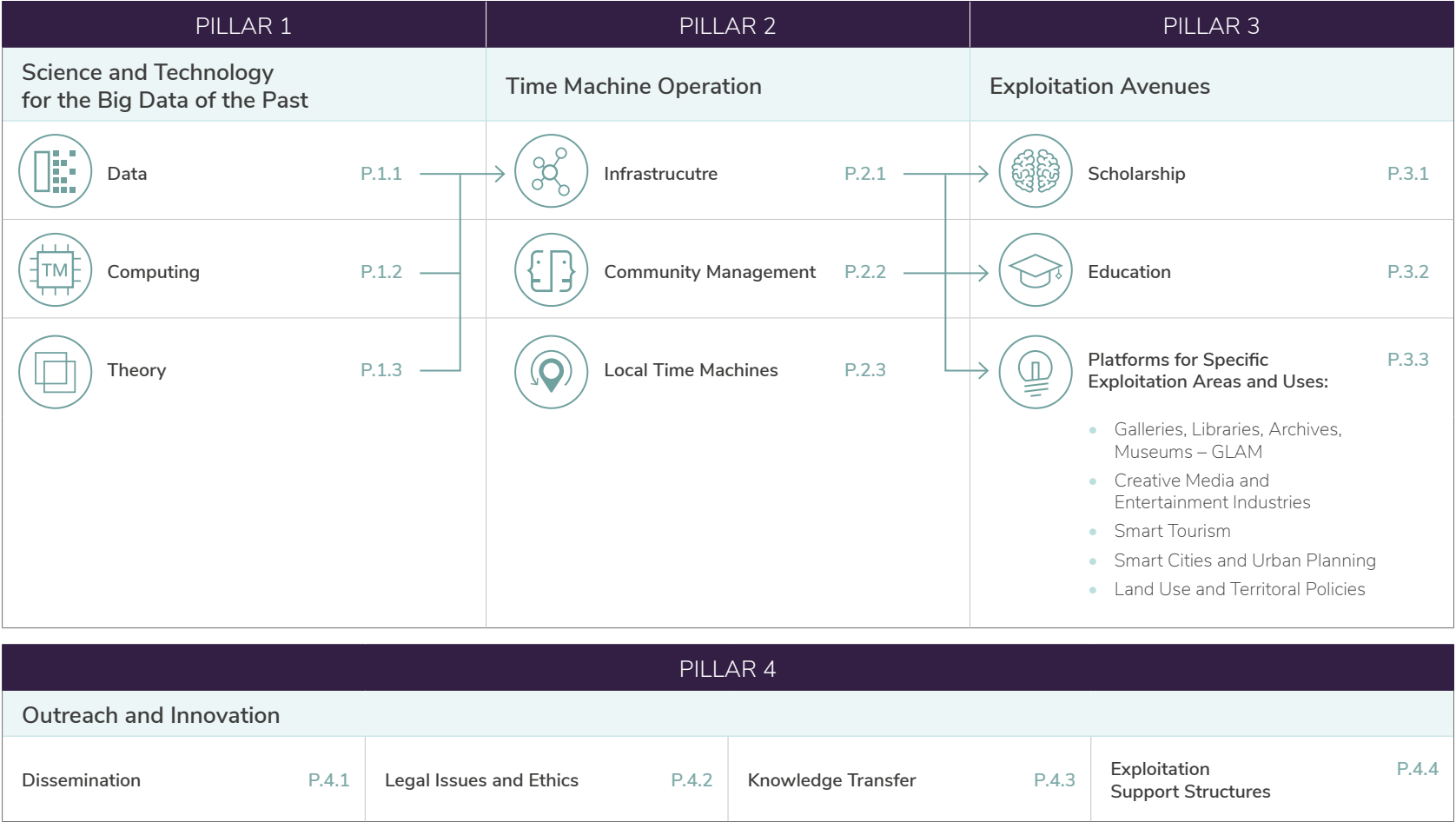


FIGURE 2: The Time Machine Pillars and Thematic Areas



# 3. ADVANCING THE STATE OF THE ART

PILLAR 1

PILLAR 2

PILLAR 3

| Thematic Area                            | State of the Art                                                                                                                                                                                                                 | With Time Machine                                                                                                                                                                                                                                                                                                |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Data                                     | Fragmented datasets only sparsely covering European Cultural Heritage.                                                                                                                                                           | Large sets of aligned and standardised Cultural Heritage data.                                                                                                                                                                                                                                                   |
| Computing                                | Disorganised sets of academic tools most of the time developed for specific projects based on state-of-the-art technology. Very few systems considering the temporal dimension.                                                  | Development of a unique computing infrastructure dedicated to the massive extraction of knowledge in Cultural Heritage sources, probably the most advanced artificial intelligence system ever built.                                                                                                            |
| Theory                                   | Digital Humanities analysis of current practices on the role of computing for the Humanities and Social Sciences.                                                                                                                | Largest effort ever undertaken to build a critical theory and sound epistemological concept on digital Cultural Heritage and multi-level historical simulation.                                                                                                                                                  |
| Infrastructure                           | A number of European coordination initiatives of Cultural Heritage with consortia, infrastructures and networks like EUROPEANA, Europa Nostra, DARIAH-ERIC, CLARIN-ERIC, CERL and ICARUS.                                        | Reinforcement and extension of these initiatives with shared computing infrastructure for processing and transforming digital Cultural Heritage at unprecedented scale. Cooperation with initiatives for optimising computing infrastructure, e.g. EuroHPC JU.                                                   |
| Community Management                     | Many communities dedicated to specific topics – limited exchange due to lack of shared data or concepts.                                                                                                                         | A large community of communities, sharing a standardised platform, with more empowering tools.                                                                                                                                                                                                                   |
| Local Time Machines                      | Uncoordinated efforts to recreate the past of several cities in Europe.                                                                                                                                                          | A franchise-based system enabling each initiative to benefit from the highest level of technology and rapidly develop sustainable models of development.                                                                                                                                                         |
| Scholarship platform                     | Global commercial search engines are the mediators of our access to knowledge and culture.                                                                                                                                       | Time Machine's open and transparent interfaces, not only analysing the pulsations of the present, but embracing wider geographical and temporal horizons, transforming the way we study, visualise and narrate the past and the future.                                                                          |
| Education platform                       | Books and video about history and culture. Some on-line lectures.                                                                                                                                                                | Massive Open Online Courses, immersive and interactive experiences, engaging material for students and continuous life-long learning. Development of a dynamic new industry for the production of educative digital material, based on aligned massive datasets.                                                 |
| Specific Exploitation and Uses platforms | Cultural Heritage seen as a cost more than a source of innovation, with remaining silos and difficulties to manage solutions truly valorising all available data and across time. Citizens regard policies as a European burden. | Fast development of market-driven platforms of Time Machine to develop relevant services for GLAM <sup>5</sup> , the creative industries, smart tourism, smart cities, and land use and territorial policies. Users regard Time Machine as a means to interact with authorities and contribute to policy making. |



<sup>5</sup> GLAM: Galleries, Libraries, Archives, Museums



## 4. CONCRETE AND MOMENTOUS OUTCOMES AND IMPACT

Time Machine will create new disruptive business models in key economic sectors and will have transformational impact on Social Sciences and Humanities. Additionally, Time Machine will make education more accessible, interactive and diversified and boost EU competitiveness in AI and ICT significantly.

### A thorough dialogue with our past

The digitisation of European cultural heritage represents a formidable challenge, both in terms of cost and in its implementation. Moreover, only a small number of artefacts in collecting institutions is actually made publicly available, while billions of digital records still need to be indexed, so that they can be searched and analysed.

Time Machine will offer new technologies, methods and protocols to address these challenges through mass digitisation campaigns across the whole of Europe, covering also landscapes, cityscapes and architecture, enabling the EU Member States to reach their ambitious objectives for Cultural Heritage preservation and access.

Due to barriers such as being able to read old writings, to understand other languages, or to visit the relevant archives or libraries

in person, citizens are, for the most part, excluded from accessing, navigating, and benefitting from this Big Data of the Past. This data is every citizen's shared heritage; it should not be 'exclusive'.

Time Machine now changes the game radically: for the first time in history, every citizen will be able to access historical data and actively engage with it by contributing their own stories and interpretations. This is also important because everything in our lives today builds upon a narrative that Time Machine will allow to be documented.

### A transformational impact on Social Sciences and Humanities

Social Sciences and Humanities (SSH) accounts for well above 40% of students in European Higher Education. SSH is also the largest European research community, with more than 30% of EU researchers in Higher Education, corresponding to about 500.000

full-time equivalent positions. The SSH research spending, however, is substantially lower than 30% of the overall research spending, and is often lower than 20% in many countries.

The main reason seems to be that research projects in SSH are traditionally more limited in scale and scope compared to the exact sciences. This limitation stems primarily from the lack of easily accessible digital datasets that cover multiple modalities (text, sound, image) indexed using uniform metadata systems. Efficiently exploiting the available datasets as linked open data in SSH still requires a considerable degree of expert domain knowledge, for example in ancient languages, which prevents scholars from answering large-scale research questions.



“We want to innovate access to cultural heritage by creating participatory platforms, allowing for a ‘polyvocal history’, that also includes citizens’ perspectives on the places and information that are relevant for them and their lives.”

A crucial leap forward is Time Machine's promise of delivering unified access to Europe's past as linked open data. This will revolutionise the individual researcher's search capabilities, ranging from yielding immensely rich results for simple term queries, to the option of exhaustively tracking individual cultural artefacts through time and space, including texts, paintings, ideas or places.

Moreover, Big Data of the Past will enhance our ability to deal with historical information, and in this way, it will drive SSH towards larger problems of world events and institutional development over longer periods of time. The abundance of new data about the past and the development of a new generation of AI will allow new interpretative models to be built on a superior scale.

Identifying larger patterns, correlations and connections will contribute to important advances in scientific approaches and methodologies that open new frontiers in our capacities for in-depth analysis and informed decision making.

Time Machine will, therefore, drastically raise the scale and scope of SSH research, enabling it to effectively contribute to devel-

oping strategic answers to major challenges, such as sustainable growth, social welfare, migration and integration of migrants, and safeguarding European democracy.

### Making education more accessible, interactive and diversified

Time Machine will develop new ways of delivering education, moving away from the traditional approaches of classroom lectures, textbooks and printed materials, and making use of localised and customised sample data at different – and extremely enhanced – levels of detail, enabling learning to be accompanied with new levels of analysis. The interactive environments that will be developed will not only offer unprecedented access to the records of our shared past, it will also promote active engagement with that heritage, which will make learning an on-going and inclusive process that will bind generations and cultures.

In this way, European history will become much more accessible to citizens of all ages and backgrounds, raising awareness of European culture, and consolidating our shared European identities. At the same time, there

will be a stronger focus on exploratory learning, encouraging reflection on long trends that have shaped our present.

New interdisciplinary methods will also be developed across the traditional scientific domains, making use of the advances in AI, the new modelling capabilities in SSH, and new simulation capabilities in most of the scientific and educational domains, and offering more depth to educational curricula, sharpening the critical thinking of learners, and contributing to informed decision-making at all levels.

### A strong boost in European competitiveness in Big Data, AI and other ICT areas

Time Machine will develop new smart algorithms that can meaningfully extract information and create knowledge from noisy, heterogeneous and complex data at a massive scale, from medieval manuscripts, collections of objects and cultural artefacts, to the recent smartphone and satellite images, and the multi-modal content from websites and platforms.



"We will develop novel scanning technologies to digitise massive amounts of fragile documents and artefacts, through new types of sensors, robots and automated processes. These will provide rapid scanning solutions in science, industrial archives, public administration, and potentially in services for consumers."

Due to this data's inherent complexity, an AI trained on Big Data of the Past will offer a strong competitive advantage for Europeans in the global AI race.

The new processing and simulation technologies of Time Machine, combined with its global curation and exploitation platforms, will enable Europe to increase its share of gains from the announced AI revolution. Time Machine will also introduce disruptive technologies in deep reading, linguistic and knowledge systems, multimodal (4D) simulation, high performance computing (HPC) and long-term data storage.

Many of the advances developed by Time Machine would require advanced software, an area in which many European companies have world-leading roles. Time Machine will further enhance their leadership, through scientific and technological achievements in rapidly growing segments of the global ICT industry. All the core components of the Time Machine infrastructure will be developed as open source software, ensuring that the large-scale research initiative creates a legacy of code that can be corrected, reused and adapted for continuous development

and deployment already during and after the end of the proposed initiative.

The simulation capabilities substantially enhanced by Time Machine will have a major impact on all areas of research in science and engineering that use HPC to process large volumes of data, including life and environmental sciences, as well as SSH. These technological breakthroughs will also have a strong impact on the European software and software-based services industry, one of the top drivers of Europe's industrial performance, and a key contributor to EU growth.

Time Machine will develop novel scanning technologies to digitise massive amounts of fragile documents and artefacts, through new types of sensors, robots and automated processes. These will provide rapid scanning solutions in science, industrial archives, public administration, and potentially in services for consumers.

Massive increases in demand for scanning services would lead to economies of scale and falling costs, and falling costs would further boost demand. As a result, vast amounts of materials and data from practically unvisited archives would be accessible

in digital form, offering a clear opportunity for European start-ups to compete in the growing Document Process Outsourcing market, currently dominated by American and Asian players (Box 3).

### BOX 3

Possible applications for massive digitisation may include:

- Administrative registries to be used for studying policies, legislation or social norms in different societies and points in time;
- Health archives and records in Europe and beyond: turning these to digital records would enable scientists to perform joint analyses of patient reports, and other vital parameters crucial for developing health policies and health management practices.

## Enhancing key sectors of the European economy

### Creative Industries

The European creative industries contribute 6.8 % of gross domestic product (GDP) and 6.5 % of employment in the EU, at the same time offering a strong potential for stimulating innovation in other sectors with a competitive edge, such as tourism, education and advertising.

Time Machine introduces disruptive technological solutions which will transform cultural heritage into rich creative assets.

Specifically, the following creative industries sectors will benefit from Time Machine:

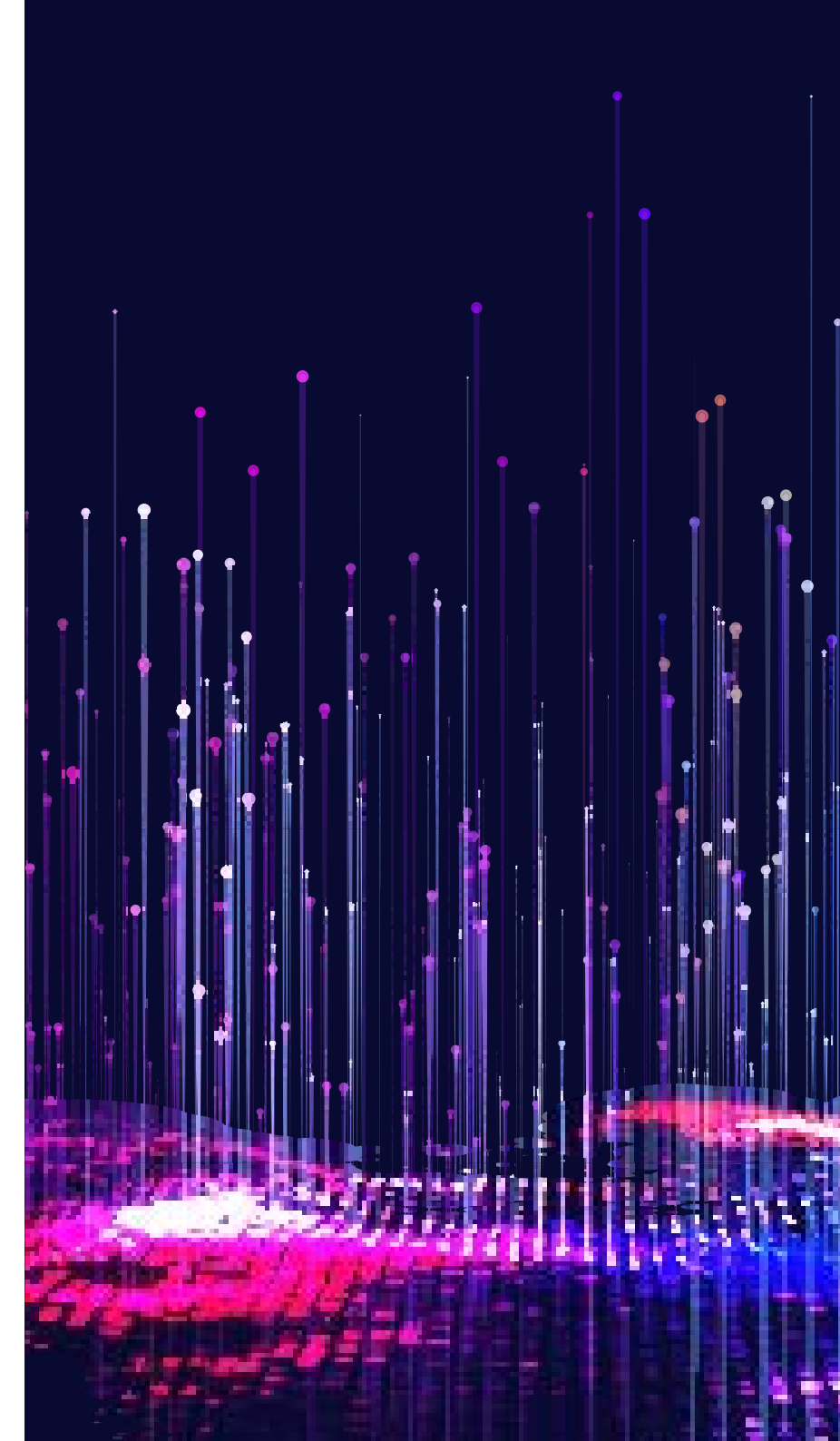
### # GAMING AND FILM INDUSTRIES

Due to the inaccessibility and costs of filming in historic locations, the use of detailed 3D reconstruction will become increasingly relevant for film and game makers. Mass-scale digitisation will remove spatial and temporal barriers to cultural heritage: using complex 3D models constructed from rich heterogeneous sources, creators will be able

to produce immersive, multi-sensorial experiences of historic sites from different periods, and customise them according to their needs. Four-dimensional cinema and virtual reality experiences on large (amusement park) and small (AR/VR headsets) scales will represent a new market for photorealistic 3D models and digitised audio-visual assets.

### # DESIGN

Time Machine will harness the potential of European heritage as a resource for creative reuse. Tools developed to analyse complex multimodal digital objects will enable designers to extract individual aesthetic features and concepts and re-appropriate them for new creations, from fashion to architecture. Advanced 3D modelling technologies combined with decentralised storage solutions will present new opportunities for real-time visualisations of objects and enable transnational, remote collaborative design processes. These enhanced engagement possibilities will translate into new avenues for creators to exploit cultural heritage sources as digital capital.





#### # MEDIA

With online video content expected to constitute 82 % of all internet traffic in 2019, media professionals will continue to develop competitive business models and services that focus on providing seamless user experiences across devices and media types and increasing the reach of their content. Time Machine will introduce disruptive high-performance computing and storage technologies for the curation, enrichment and distribution of audio-visual content. Building on these technological innovations and the availability of much richer datasets, media industries will develop smart services of a new level of quality that will close the gap between media content and audiences by offering personalised experiences.

#### # JOURNALISM

The lowered barriers for content creation and distribution via digital platforms has given rise to an unprecedented abundance of data that currently lacks effective verification and curation methods. Moving forward, the industry will rely even more on citizen journalism as well as computational journalism, both of which require knowledge-validation mechanisms to maintain the trust

of their audiences. Time Machine will fulfil this need via deep reading tools that can effectively analyse and assess the quality of digital objects. To remain competitive in the changing landscape, media agencies will utilise the distributed processing and simulation infrastructure introduced by the Time Machine to synthesise disparate datasets into facts and narratives that offer new, more transparent and engaging perspectives.

#### # GALLERIES, LIBRARIES, ARCHIVES, MUSEUMS – GLAM

The largest part of European cultural heritage can be found in the many galleries, libraries, archives and museums spread across the EU. Digitisation and open access dramatically change the way these institutions operate, putting in question current business models and funding mechanisms **(Box 4)**.

#### # SMART TOURISM

Europe is the most visited tourism region in the world, and in the EU, tourism contributes 10 % to EU GDP and creates jobs for 26 million people, through its direct, indirect and induced effects in the economy. To compete with strong competition from other world regions, Europe intensively invests

### BOX 4

**Time Machine will contribute to the emerging need to strengthen GLAM by offering these institutions and their collections new ways of exploitation, based on:**

- Promotion of innovative services through research, educational and creative activities;
- New opportunities in fundraising and brand licensing combined with cost savings associated with rights and reproduction management overhead;
- Employment of staff with more mission-critical activities, resulting in more efficient and less costly digitisation functions.

in smart tourism, i.e. in smart, innovative and inclusive approaches to touristic development, paying particular attention to cultural heritage and creativity. As a resource, Time Machine is uniquely placed to revolutionise smart tourism, through the rich, multi-faceted and comprehensive cultural





and historical data and innovative tools that will allow for the creation of endless avenues of experience and exploration, in situ or remotely. This will contribute to shaping tourists' behaviour, by attracting them to new locations or repositioning the interest for well-known and mature destinations through virtual pre-visits of cultural heritage sites, for example. It will furthermore help to regulate the tourist flow to "overwhelmed" destinations, through immersive educational and cultural experiences at home.

Time Machine will also help to diversify cultural tourism by creating tailor-made data platforms for each type of tourism: cultural, slow, rural, cruise-based, ethical, sport event-driven, wellness, medical, business, or adventure. By offering a full package (on-line preparation at home, experience-based visit, post-visit experience with materials gathered on site), the visit will become both educational and experience-driven, enhancing tourist retention of local history and identity, and thus strengthening the sense and understanding of European belonging.

#### # SMART CITIES

A Smart City is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses. Smart Cities are at present mainly based on the networking of current data from interconnected sensory devices. The exchange of information will be fundamentally intensified by Time Machine by, on the one hand, enriching it with so far unconsidered data, and, on the other hand, through data collections with historical depth.

Object recognition and tracking over time will play a vital role for future city planning. Based on the advanced modelling methods of Time Machine, urban planning will enter a new stage, as it will be possible to find examples of cities that are similar to a city's present state. In doing so, it will be possible to compare different strategic measures that were undertaken in these other cities to substantiate communal decisions.

The integration of urban information will further enhance risk mitigation in smart cities. Architectural data is essential for preservation, renovation and everyday man-

agement of buildings, and can also improve the efficiency of emergency operations or the detection of technical malfunctions. For example, the large-scale provision of architectural layouts and infrastructural aspects facilitates the mapping of infrastructural needs. The inclusion of historical data makes it possible to track urban, land and infrastructure developments such as electricity networks, gas conduits, and drainage systems. The analysis of architectural, urban planning, land use, economic and social data collected over long periods can make it possible to predict the future development of specific areas, and thereby allow for more sustainable and efficient decision-making.

#### # LAND USE AND TERRITORIAL POLICIES

Europe has the highest proportion in the world (80 %) of land used for settlement, production and infrastructure. Population growth and the increase of commercial activities for food, bioenergy and industrial crops contribute to an even higher demand for land and more intense competition between municipal and industrial uses. This excessive pressure negatively affects biodiversity, degrades habitats and raises issues

"We will create a sharp increase in the demand for digital and traditional humanists and social scientists at a time where these disciplines and corresponding university degrees do not guarantee jobs in these fields. Also, we will promote and create jobs for the new profession of Digital Humanities expert.

ranging from carbon dioxide emissions to soil sealing, landscape fragmentation and urban heat island effects.

Time Machine offers a long-term perspective for a transition to sustainable land management, based on our common history and with the perspective of the next generation. By increasing the possibilities of in-depth analysis of highly heterogeneous data (aerial and spatial images, land database, soil quality database), Time Machine will develop methods and indicators to objectively monitor the consumption of natural, agricultural or forest areas at all territorial scales. The increased potential of Time Machine in digitising and indexing old data (silver prints, maps, tables, legal texts), will also make it possible to retroactively calculate these indicators, which offers a unique opportunity to analyse the impact of policies on land use over time.

The Time Machine platform for land use will enable a shared framework to compare territorial configurations across space and time, promoting the exchange of knowledge and experience between similar territories. It will also strengthen the science-policy interface, enabling land-use stakeholders in particular

to simulate the effects of transposing European legislation into national and local levels.

#### A strong ally to counteract gender bias

The enlargement of available historical data via the systematic digitisation campaigns under the Time Machine initiative will result in much more knowledge on women in societies of the past. New knowledge will also be available about many repressed groups and minorities in the pre-modern past.

Time Machine-driven technological improvements in areas such as stylometry, or intellectual authorship recognition, will provide us with a much more accurate picture of the female contribution to human civilisation, which, because of Time Machine's scale, will fundamentally alter historical gender studies.

#### The strong international perspective for European excellence

Europe has a leading role in the digitisation of culture. Time Machine will strengthen this role at a time where this field gains momentum in Asia and the USA.

Time Machine will increase the scientific reputation of EU institutions in Digital Humanities and SSH, opening the way to launch or reinforce international collaboration.

Time Machine comes at a time where culture occupies a central role in the UN 2030 Agenda for Sustainable Development. For the first time, the international development agenda refers to culture within the framework of Sustainable Development Goals related to education, sustainable cities and peaceful and inclusive societies.

A strong opportunity exists to develop synergies with UNESCO's Culture Conventions on the safeguarding and promotion of cultural and natural heritage, and the cultural and creative industries, as well as joint programmes with other UN Agencies for the implementation of the 2030 Agenda for Sustainable Development.



# 5. THE TIME MACHINE ECOSYSTEM

## The Coordination and Support Action implementation

In recent years, the convergence between ICT, AI and SSH in the context of cultural heritage has reached a solid degree of maturity, where creating and drawing social

and economic value from the Big Data of the Past is a feasible endeavour.

For this reason, a growing community of academic researchers, businesses, and professional associations working in these fields has started shaping ideas for research topics around Time Machine in the context of the Future and Emerging Technologies part of Horizon 2020 (**Box 5**).

The whole idea led into the award of a 12-month Coordination and Support Action (CSA) aiming to develop concrete Research and Innovation agendas. This CSA runs in the period from March 2109 to February 2020.

## How interested parties can be involved

During the CSA, the consortium will design a detailed strategy and implementation roadmap for the Time Machine initiative, through internal workshops, own expert judgements, consultations with external experts as required, and document/data analysis.

Other organisations that have an interest in the Time Machine scope and objectives and who can bring added value to the road-mapping analysis and development will be kept informed of work progress and will be invited to participate in:

- Consultations organised to assess the acceptance of proposed ideas
- Workshops aiming to validate strategic directions and proposed action plans
- Other dissemination actions, organised to secure commitment to the Time Machine objectives.

## The broader Time Machine partnership

Time Machine has brought together a very broad Time Machine partnership of leading European academic and research organisations, cultural heritage institutions and private enterprises. The members of this unique alliance are fully aware of the huge potential of digitisation and the very promising new paths for science, technology and innovation that can be opened through the information system that will be developed, based on the Big Data of the Past.

As of May 2019, the Time Machine partnership comprises 300 organisations from 34 countries together with the 33 CSA partners.

These include:

- An impressive list of reputable **academic institutions and research centres**
- Leading European enterprises and innovative small and medium-sized enterprises (**SMEs**) in the fields of ICT, culture and creative industries
- **key European museums:**  
Louvre, Rijksmuseum, Belvedere
- **7 national libraries:**  
Austria, Belgium, France, Israel, Netherlands, Spain, Switzerland
- **19 state archives:**  
Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, Germany, Hungary, Lithuania, Malta, Norway, Poland, Romania, Slovenia, Spain, Slovakia, Sweden and Switzerland
- **18 governmental bodies**

Through its continuous interaction with potential stakeholders, the CSA will enable the Consortium to create a dense Time Machine ecosystem of scientists, innovators, decision makers and communities of citizens that cooperate around the Big Data of the Past. The impact of the CSA will be measured by a substantial (tenfold) increase in the current number of Time Machine supporters (from 200 to 2000).

### BOX 5 Key dates in the development of Time Machine

**2019** Europe invests in Time Machine  
The European Commission chose Time Machine as one of the six proposals retained for preparing large-scale research initiatives.

**2018** Time Machine develops algorithms that outperform humans in transcription of Venetian handwriting  
AI methods open new way to search in ancient documents.

**2016** Manifesto “L’Europe doit construire la première Time Machine”, published in ‘Le Temps’, then translated in 9 languages  
A call for action to invite Europe to invest in an infrastructure for mining ‘Big Data of the Past’.

**2014** Increasing interest  
Frédéric Kaplan’s TED Talk “How to build a Time Machine” reaches more than 1 Million views.

**2013** Venice Time Machine starts  
EPFL and University Ca’Foscari launch a project that aims at building a multidimensional model of Venice and its evolution covering a period of more than 1000 years.





Members of the Time Machine community have already established strong links through extensive joint research in EU and national projects. Furthermore, many of these partners have launched together local Time Machine initiatives in the following cities – in parentheses are the historical periods covered (**Box 6**).

## BOX 6

### Local Time Machines:

Antwerp (1500–2000)  
Amsterdam (1550–2000)  
Budapest (1680–1990)  
Dresden (1200–2000)  
Ghent-Bruges (800–2000)  
Jerusalem (2000 BCE–2000)  
Limburg (1775–2000)  
Lower Austria (800–2000)  
Naples (800–2000)  
Nuremberg (1000–2000)  
Paris (1000–2000)  
Regensburg (1200–2000)  
Utrecht (40–2000)  
Venice (1000–2000)

## The Time Machine Organisation

The continued cooperation beyond the duration of the CSA will be streamlined through the Time Machine Organisation which will be the institutional framework ensuring economic independence as well as cross-sectoral communication and partnerships.

The Time Machine Organisation is an association under Austrian law, headquartered in Vienna.

Participation is open to all members of the Time Machine ecosystem, who, thus, have the means to participate in:

- The governance of the Time Machine initiative
- The definition of research and innovation actions
- The implementation of these actions
- The development of new initiatives in relation to common interests

"With the Time Machine Organisation we provide the institutional framework ensuring economic independence as well as cross-sectoral communication and partnerships."







# Time Machine

2020 2030 2040 2050 2060 2070 2080 2090

timemachine.eu



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 820323.



@TimeMachineEU



@TimeMachineEU



timemachine.eu/trailer