Time Machine: Big Data of the Past for the Future of Europe

Deliverable D4.2
Exploitation Avenues (Pillar 3) Roadmap

Preamble:

This deliverable is part of a structured set of outputs produced and built upon during the 12-month TM CSA project. As such, the content contained within was further refined, synthesised and improved throughout the project and in particular when combined with material from other deliverables during the production of the full D8.5 TM LSRI Strategy and Implementation Proposal. Please be advised that the most up-to-date version of any information found in this document will be found in D8.5, where it can also be viewed in proper context as part of the entire TM LSRI proposal.

Abstract

A draft roadmap is presented for the Time Machine Exploitation avenues, which is one of the main pillars (Pillar 3) of the Time Machine LSRI. The objective is to show how the scientific & technological advances (Pillar 1) and operational models (Pillar 2) can be utilised to provide social and economic impact across a range of areas of potential exploitation avenues.

The main areas explored cover:

- Scholarship
- Education
- Specific exploitation areas and uses in key economic sectors, including GLAM, Creative Industries, Smart Tourism, Smart cities & urban planning, and Land Use and Territorial policies.

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

Project Identification

Project Full Title	Time Machine: Big Data of the Past for the Future of Europe
Project Acronym	TM
Grant Agreement	820323
Starting Date	1 March 2019
Duration	12 months

Document Identification

Deliverable Number	D4.2
Deliverable Title	Exploitation Avenues (Pillar 3) Roadmap
Work Package	WP4
Delivery Due Date	31 October 2019 (Month 8)
Actual Submission	05 June 2020 (Version 3.2)
Leading Partner	EF, UNIVE, IGN
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History of Changes

Date	Version	Author	Comments
03.06.2020	3.2	Kevin Baumer	Added preamble to title page which points to D8.5, per final review meeting.
05.03.2020	3.1	Frédéric Kaplan, François Ballaud	Minor changes implemented (alignment with D8.5 and D3.2). Annex A removed
19.12.19	3.0	Julia Fallon, Dorit Raines, Valérie Gouet-Brunet	Reviewer comments addressed, small updates made and Annex A added
31.10.19	2.4	Julia Fallon, Dorit Raines, Valérie Gouet-Brunet	Document ready for submission.
29.10.19	2.3	Julia Fallon, Dorit Raines, Valérie Gouet-Brunet	Resolve final comments and typos, final format checks.
28.10. 19	2.2	Dorit Raines, Valérie Gouet-Brunet	Check and review updates from sub-task leaders

25.10.19	2.1	Julia Fallon	Update deliverable information. Check and review updates submitted. Resolve comments.
24.10.19	2.0	Dorit Raines, Julia Noordegraaf, Emillie de Keulenaar, Stefan Meysman, Paul Sommersguter, Johan Oomen, Rasa Bocyte, Max Kaiser, Bénédicte Bucher	Various updates and refinements to roadmaps following consultations and stakeholder feedback.
28.6.19	1.0	Julia Fallon, Valérie Gouet-Brunet, Dorit Raines,	Document ready for submission, after integration of comments by internal reviewers.
20.06.19	0.9	Harry Verwayen, Julia Fallon, Valérie Gouet-Brunet, Dorit Raines, Julia Noordegraaf, Emillie de Keulenaar, Stefan Meysman, Paul Sommersguter, Johan Oomen, Rasa Bocyte, Max Kaiser, Bénédicte Bucher	First Draft
01.04.19	0.8	Valérie Gouet-Brunet	Format & structure created

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Definitions

4D Simulator	One of 3 TM Simulation Engines. The 4D Simulator manages a continuous spatiotemporal simulation of all possible pasts and futures compatible with the data. The 4D Simulator includes a multiscale hierarchical architecture for dividing space and time into discrete volumes with a unique identifier: a simulation engine for producing new datasets based on the information stored. Each possible spatiotemporal multiscale simulation corresponds to a **multidimensional representation** in the 4D computing infrastructure. When a sufficient spatiotemporal density of data is reached, it can produce a 3D representation of the place at a chosen moment in history. In navigating the representation space, one can also navigate in alternative past and future **simulations**. **Uncertainty and incoherence are managed at each stage of the process and directly associated with the corresponding reconstructions of the past and the future.**

Big Data of the Past	A huge distributed digital information system mapping the social, cultural and geographical evolution. A key objective of Time Machine is that such system brings together dense, interoperable, standardised (linked data, preferably open) and localised (marked up with spatial-temporal information) social, cultural and geographical heritage resources.
Citizen Science	Citizen Science - a scientific research design that typically incorporates engagement of public volunteers in the data gathering, analysis, and other vital research assistance roles of the study. Citizen Science research projects are also often referred to as community science, crowd science, civic science, and the recently coined term crowdsourcing as a method to achieve Big Data scale results while coping with limited funding resources.
Citizen Scientist	A human role applied to non-traditionally trained, non-traditionally experienced, and often independent research scientists. Such self-identified researchers often substitute an active PLN (Personal Learning Network) of mentor/collaborators to address their knowledge gaps and to gain access to research technologies and data. In all major aspects of their participation in the research community, Citizen Scientist activities are comparable to, and sometimes indistinguishable from, that of academic colleagues.
Communities	Group of users, self-organised by territorial or transversal interests, offering various voluntary works and favours (annotation, digitisation, bibliographic research, development), according to the standards in place, to the partners. Those communities can elect a representative.
Digital Content Processor	Automatic process extracting information from documents (images, video, sound, etc.). Digital Content Processor of Level 1 just label mentions of entities. Digital Content Processor of Level 2 label relations between entities. Digital Content Processor of Level 3 label Rules. Each processing is fully traceable and reversible. The results of the processing constitute the core dataset of the Big Data of the Past and are integrated in the TM Data Graph.
Large-Scale Inference engine	One of 3 TM Simulation Engines. It is capable of inferring the consequences of chaining any information in the database. This permits to induce new logical consequences of existing data. The Large-Scale Inference Engine is used to shape and to assess the coherence of the 4D simulations based on human-understandable concepts and constraints. Its origin comes from more traditional logic-based AI technology, slightly overlooked since the recent success of the deep learning architecture, that can, nevertheless, play a key role in an initiative like TM.
Local Time Machine	Zone of higher "*rebuilding the past activities*" density. Constituted of a group of local partners and communities bound by a common territorial focus and a declaration of intent, which respect both graphical and values charters. Any institution who meets eligible criteria can integrate a Local Time Machine. The declaration of intent is reviewed on an annually basis (time for new partners to integrate the TM)

Project with Time Machine label (PWTML)	Project respecting the technical charter, whose tasks are documented - modelled within the Time Machine graph. All the partners of a PWTML must have signed the declaration of intent of the related Local Time Machine.
Stakeholder	In the context of Pillar III, a person, group or organisation with an interest in the avenues for exploiting the results of the Time Machine Organisation. They may also be identified as a beneficiary of the results.
Technical Charter	Should contain information about infrastructure standards required within any project with Time Machine label. The Technical Charter defines the Time Machines Rules, Recommendations, Metrics and Official software. The document is revised periodically.
Time Machine Box	Servers that allow partners to store their documents and metadata and integrate easily the Time Machine Network and be appropriately documented in the Time Machine Graph. The Time Machine Box is part of the Time Machine Official Components.
Time Machine Data Graph	Formal representation of knowledge extracted by human or automatic process, represented with semantic web technology
Time Machine Index	The TM index is a global system indexing different type of objects: e.g. documents; iconography; 3D geometries. It gathers all information regarding documents and their contents. Could be used as a basis for other search engine infrastructures (allows backups).
Time Machine Infrastructure Alliance	Coalition of TM's partners regrouping in-kind donators for infrastructure components (server's space and computing power).
Time Machine Mirror World	One of the API of the Time Machine using the processing of the 3 TM Simulation Engines to produce a continuous representation model that can be accessed as information stratum overlaying the real world.
Time Machine Network	Set of all the partners *actually* interacting in the Time Machine. Each member of the Time Machine Network must have signed the Value and Technical Charter
Time Machine Official Components	Pieces of software (e.g. Time Machine Box) that help partners conforming to the Time Machine rules as they are directly embedded in the software.
Time Machine Operation Graph	Formal representation of the past, on-going and future operations of the partners in the Time Machine Network and the data pipelines.
Time Machine Organisation	Association regrouping the Time Machine Partners. Some maybe active and other not. Not all may have signed the Values and Technical Charters.
Time Machine Recommendations	Recommendation on technology which are not obligatory at this stage for the development of the Time Machine (e.g. choice of a particular IIIF image server).

Time Machine Request for Comments	Main document for the progressive design of the Time Machine infrastructures, standards, recommendations and rules, inspired by the process used for 50 years for the development of Internet Technology, today administrated by the Internet Engineering Task Force (IETF) as part of Internet Society (ISOC).
Time Machine Rules	Standard and rules that need to be followed to be acceptable in the Time Machine Network and become a Time Machine operators. Any entity not following these rules are out.
Time Machine Standard Contracts	Set of standard contracts to facilitate the interaction between Time Machine partners.
Time Machine Standard Metrics	Measures helping partners of the Time Machine Network coordinate with one another to compare performance (for quotes of services, but not only, there are also use for research performances, etc.).
Time Machine Super Computing Architecture and Simulation Engines	TM Super Computing Architecture composed of distributed computing resources from the TM Network provided by the TM Infrastructure Alliance. On this distributed architecture, different typologies of computing process can run. For instance, Digital Content Processors are intrinsically easier to run in parallel, whereas Simulation engines, which allow users to generate possible pasts and futures from the TM Data Graph need for more specific computing architecture.
Universal Representation Engine	One of 3 TM Simulation Engines. The Universal Representation Engine manages a multidimensional representation space resulting from the integration of the pattern of extremely diverse types of digital cultural artefacts (text, images, videos, 3D), and permitting new types of data generation based on transmodal pattern understanding. In such a space, the surface structure of any complex cultural artefact, landscape or situation is seen as a point in a multidimensional vector space. On this basis, it could generate a statue or a building, produce a piece of music or a painting, based only on its description, geographical origins and age.
Values Charter	Conform to the principle of openness in EU law

List of abbreviations

AI	Artificial Intelligence
CH	Cultural Heritage
GLAM	Galleries, Libraries, Archives, Museums
LTM	Local Time Machine
PWTML	Project with Time Machine Label
RFC	Request for Comments
SSH	Social Sciences and Humanities
TM	Time Machine
TMO	Time Machine Organisation

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1 Introduction

Time Machine (TM) is a Large-Scale Research Initiative (LRSI), pushing the frontiers of scientific research in Information and Communication Technologies (ICT), Artificial Intelligence (AI) and the Social Sciences and Humanities (SSH).

TM is built around the vision to develop the Big Data of the Past, a huge distributed digital information system mapping the European social, cultural and geographical evolution. 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 for co-creating a common future. The proposed LRSI 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, enabling Europeans to better appropriate their heritage and strengthen the feeling of European belonging.

The key objective of the TM CSA project is to develop a full LSRI proposal around this TM vision. Detailed roadmaps will be prepared, organised around four pillars, namely science and technology, TM operation, exploitation avenues and framework conditions.

The roadmap for the TM exploitation avenues is developed in WP4. This document is the formal deliverable D4.2 presenting the roadmap for Pillar 3.

Following this short introduction, the deliverable is organised as follows. Section 2 presents an overview of the TM LSRI and then discusses the main aspects for the design of the exploitation avenues. The next 3 sections present the key findings in the 3 main exploitation directions identified: Scholarship, Education and the thematic areas in key economic sectors for Europe, comprising Galleries, Libraries, Archives & Museums (GLAM), Creative Industries, Smart Tourism, Smart cities & urban planning, and Land Use and Territorial policies.

2 Design of Pillar 3 – Exploitation Avenues

2.1 Overview of the Time Machine LSRI

Rationale

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 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.

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.

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, building a common path across 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 transform and enhance the role of 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, in line with Europe\s long-term development and democratic principles.

For Time Machine, digitisation is only the first step of a long series of extraction processes, including document segmentation and understanding, alignment of named entities and simulation of hypothetical spatiotemporal 4D reconstructions. The hypothesis pursed by Time Machine is that such computational models with an extended temporal horizon are key resources for developing new approaches to policy making by organized education and through people's narratives and by its often millenary-built environment and to offering services to European citizens and consumers, as well as community building and identity construction.

Still, there is one more crucial reason supporting the cause of Time Machine. After the creation of the web that digitised information and knowledge and the social media that digitised people and characteristics of human behaviour, a third technology platform is being created, digitising all other aspects of our world, giving birth to a digital information "overlay" over the physical world, a "mirror-

world"[1]. The mirror-world will aim to be an up-to-date model of the world as it is, as it was and as it will be. All objects (including representations of landscapes) of the mirror-world will be machine-readable, and, therefore, searchable, traceable and subject to be part of simulations by powerful algorithms. In the mirror world, time will be a fourth dimension, as it will be very easy to go back to the past, at any location, reverting to a previous version kept in the log. One may also travel in the other direction, as future versions of a place can be artificially created based on all information that can be anticipated about the predictable future. Such time-trips will have an increased sense of reality, as they will be based on a full-scale representation of the present world. Time Machine is today the most advanced concrete proposal to build the first version of a European mirror-world.

Like the other two platforms, the mirror-world will disrupt most forms of human activity, as we know them today, giving birth to an unimagnable number of new ideas (and many problems) and creating new forms of prosperity from new forms of economic and social activity that will shape new behaviours and ecosystems. In this scenario that is currently unfolding, Time Machine will enable Europe to be one of the leading players, shaping the mirror-world according to its democratic values and fundamental ethics (open standards, interoperability). With Time Machine, while it will have a powerful tool to strengthen its cohesion and sense of belonging, Europe has, moreover, an opportunity to impose its own terms against the multinational technology giants that will fight for dominating this new technology platform, just as those who now govern the first two platforms have done in the past.

Expected impact

- A strong boost in EU competitiveness in AI and ICT:
  - An AI trained on Big Data of the Past will offer a strong competitive advantage for Europe in the global AI race.
  - Disruptive technologies in machine vision, linguistic and knowledge systems, multimodal (4D) simulation, HPC and long-term data storage will strengthen the competitive position of EU industry in these fields.
- New disruptive business models in key economic sectors:
  - Cultural Heritage is a unique asset for European businesses. Time Machine will act as an economic motor for new services and products, impacting key sectors of European economy (ICT, creative industries and tourism).
  - Time Machine will develop a paradigm to follow for cities that wish to make a creative use of their historical past.
- A transformational impact on Social Sciences and Humanities (SSH):
  - With Time Machine, SSH will be able to apply their lines of inquiry to large amounts of data, and to analyze the data across language borders, over administrative and collection divisions, 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.
- Moreover, Time Machine will:
  - Be a driver of open (and citizen) 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.

[1] The term was first coined by Yale computer scientist David Gelernter in 1991 in its book "Mirror Worlds: Or the Day Software Puts the Universe in a Shoebox...How It Will Happen and What It Will Mean" (Oxford University Press, 1991)

- Render education for Europeans more accessible, interactive and diversified.
- Develop new or updated legislation or guidelines in the field of AI, including ethical norms and ethical standards in areas such as access to and re-use of digital data, harmonised rules on data-sharing arrangements, especially in business-to-business and business-to-government situations, as well as clarified concepts in data ownership.
- Create new jobs for digital and traditional humanists and social scientists, while offering clear opportunities for talented humanities graduates with increased digital skills, by demonstrating the benefits of the new profession “Digital Humanities expert”.

- Having confirmed itself as one of the pioneers, Europe will make meaningful contributions to the foundation and use of the mirror-world, in line with its values and ethics.

LSRI Structure

The Time Machine LSRI is articulated around four pillars, each defining a specific objective of the initiative:

- **Pillar 1** – Science and Technology for the Big data of the Past: Addressing the scientific and technological challenges in AI, Robotics and ICT for social interaction, for developing the Big Data of the Past, while boosting these key enabling technologies in Europe.
- **Pillar 2** – Time Machine Operation: Building the TM infrastructure for digitisation, processing and simulation, in order to develop a sustainable management and operational model (“TM franchise”), as well as to create the basis for and engagement with the TM communities participating in the development and use of Time Machine.
- **Pillar 3** – Exploitation Avenues: 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 4** – Outreach and innovation: 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 LRSI.

Each pillar comprises thematic areas, as shown in Figure 2-1.

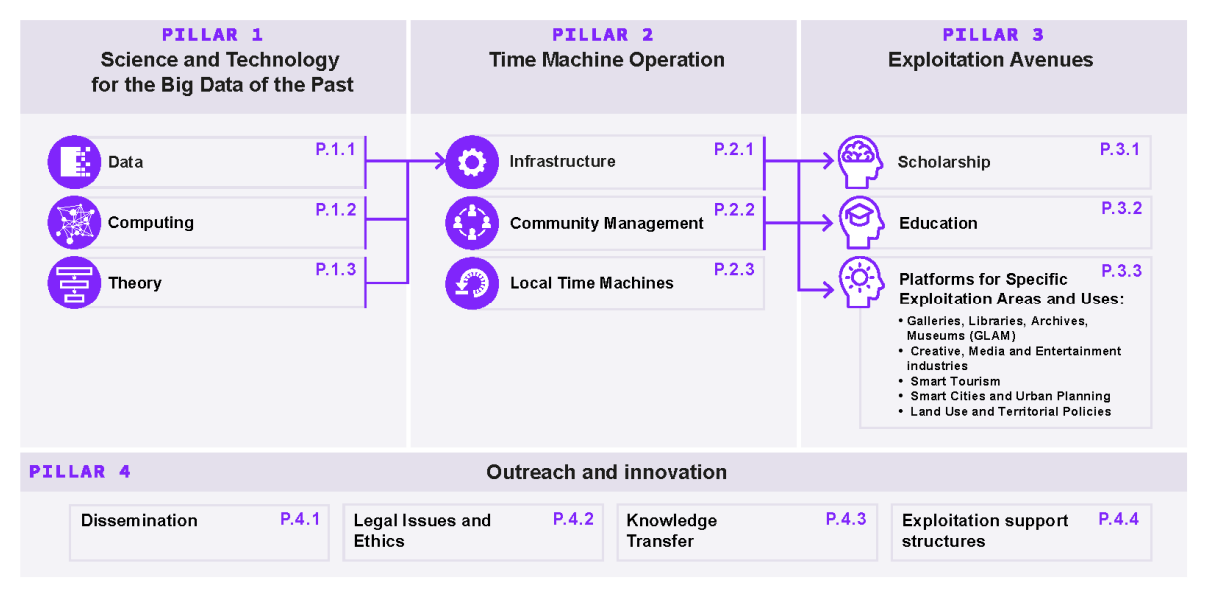


Figure 2-1: Time Machine Pillars & Thematic Areas and their interrelations

2.2 Pillar 3 approach

Objectives

The roadmap for Pillar 3 seeks to demonstrate how the scientific & technological advances (Pillar 1) and operational models (Pillar 2) enable us to work towards the vision of developing the Big Data of the Past, and in turn how that is foreseen to provide social and economic impact across a range of areas of potential exploitation avenues.

The main areas explored cover:

- Scholarship
- Education
- Specific exploitation areas and uses, including GLAM, Creative Industries, Smart Tourism, Smart cities & urban planning, and Land Use and Territorial policies.

Potential for impact of Time Machine

The vision for Time Machine centres around creating opportunity through access to the Big Data of the Past, understood as a huge distributed digital information system mapping the social, cultural and geographical evolution.

From research undertaken into the potential exploitation avenues, we can build a common picture of the challenges faced by users of social, cultural and geographical heritage data. We can, also, look at what the unique components of Time Machine allowing to address these challenges.

Identifying the challenges common to most exploitation avenues examined starts with looking at the fundamental issue faced by the contemporary mass producer of authoritative cultural & heritage data: Galleries, Libraries, Archives & Museums (GLAMs). Here high barriers to digitisation of cultural assets result in an estimated 22% of digitised assets being made available online (of which only an estimated 7% for reuse).

If we look to the primary users of social, cultural and geographical heritage data, the first issue to note is the inefficiency in access to these digital assets - often created through fragmented platforms (silos), unsustainable project tools and resources and lack of awareness of these amongst user groups; this is especially the case for cultural heritage. The second issue is synonymous with the first, that users lack the tools and services to make full use of the digital assets created. They need tools which can help them discover and build upon the big data of the past and manage the volumes of data at different scales, to create new tools, resources and assets and share those back into the same environment. This includes tools for adding data on topics and groups that are underrepresented in current cultural heritage collections, which can be retrieved with the help of Citizen Scientists.

To better understand the potential for impact of investment into Time Machine, we can replace the concept of revenue as the primary output of the exploitation avenues, with the concept of impact, where impact is defined as the changes in social, economic and environmental conditions that are enabled through exploitation of the digital assets made available through Time Machine.

In this way, we can identify five Impact-facilitating objectives for Time Machine:

O1: *Cheap Digitisation*: Enable the provision of cheap and cost-efficient solutions for the further digitisation of resources through standardised offers and services and easily replicable open hardware technologies.

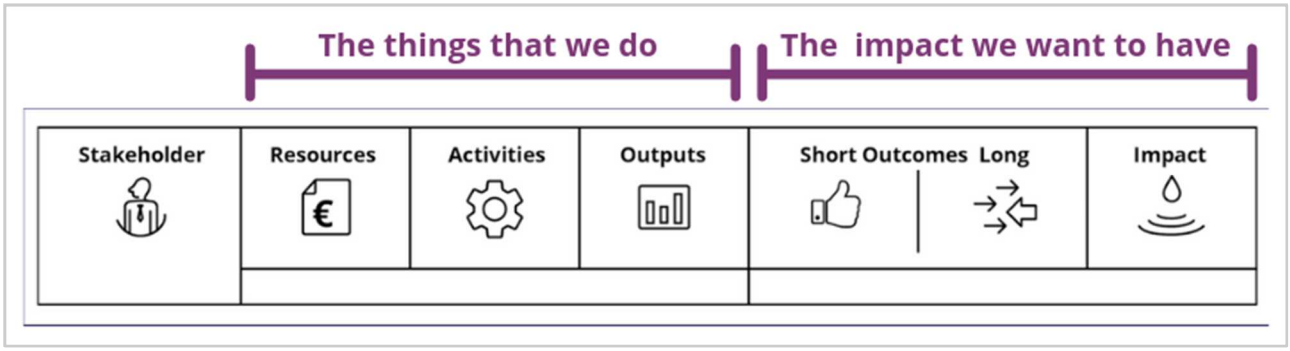
O2: *Generic Automation*: Enable the automation of the mark-up of these resources tagging concepts, named-entities, relations and rules.

O3: *Connection*: Facilitate the intelligent connection of existing fragmented data resources using, adopting and building on existing legal frameworks and developing standards for distributed storage solutions.

O4: *Simulation*: Transform sparse data into continuous 4D representations capable of representing multi-worlds.

O5: ***Experience***: Enable new paradigms for the restitution of the data to the end-user including spatio-temporal search engines, geo-historical services and Mirror Worlds.

Each of these can be broken down further using Europeana's Impact Framework's Change Pathway Canvas[2] shown below, to build a preliminary picture of where this value is delivered.



The Change Pathway.

The availability of these resources will create opportunities for social and economic impact on the customer side, while at the same time providing cost saving potential for the cultural & heritage institutions. For this reason, GLAM institutions, as well as other agencies such as mapping agencies, represent a special case for the exploitation as they are both beneficiaries as well as contributors of the Time Machine; some of them will directly contribute to the construction of tools exploiting these resources through research activities, and then will have a direct influence on them, while it will be less the case for others (GLAM).

These objectives are further discussed below with the assistance of illustrative examples.

O1. Cheap & cost-efficient digitisation solutions enabled digitisation at scale

Achieving greater and more democratic access to low cost digitisation and enrichments processes could transform the ability for cultural & heritage institutions to share their collections digitally and at scale. With the opportunity to digitise greater amounts of curated objects and collections through better and lower cost digitisation resources, more jobs and career opportunities drive an increase in employment opportunities (an economic impact indicator) in response to the need for more digital skills throughout the sector.

Stakeholder	Activities	Outcomes (to 2030)	Indicators (of Impact)
GLAM	Collection Custodianship & Enrichment (i.e. Innovative, cost-effective digitisation methods and tools)	Lower barriers to digitisation	Increased employment of resources with digital skills in GLAM

[2] A tool to help connect the activities we undertake with the changes to our stakeholders, networks or communities that we want to achieve - https://pro.europeana.eu/what-we-do/impact

	Collection Access (i.e. Rethink and innovate existing methods of information retrieval at GLAMs)		Increased share of digitised assets being made available online
	New skills required at GLAMs through training, access to information resources & standards	Greater pool of resources and expertise to support digitisation	

O2. Technologically enabled enrichment tools deliver geo-spatial data

Providing efficiencies in data discovery, mining and sourcing could lead to more high-quality research & teaching being undertaken at scale thanks to the lower costs of such. Through improved tools and access to high linked data featuring critical reference points to social science and humanities researchers such as date and geographical references, Time Machine can deliver enriched opportunities for scholars and educational resources providers to work with the digital assets.

Stakeholder	Activities	Outcomes (to 2030)	Indicators (of Impact)
Scholarship	Open source platform for historical and cultural information	Mitigation of limitations from fragmentation through better connected and accessible platforms and infrastructures	The amount of connected, accessible and multimodal data available for scholarly use
	More research undertaken/funded with a longitudinal perspective into present day social challenges	Greater social value placed of humanities research	The amount of publications that reference SSH scholarship; number of SSH scholars in advisory roles regarding societal challenges

O3. Connection of fragmented infrastructures & networks enabled through AI tools and standardisation

Stakeholder	Activities	Outcomes (to 2030)	Indicators (of Impact)
Education		Open source platform for historical and cultural information	Development of Public & Private partnerships
Creative Industries	Incubation of new ideas and partnerships between creative industries, academia and GLAMs on a local level (through LTMs), national level (through activities of TMO members) and	Production of new creative works, innovative tools, services and businesses powered by TM resources.	Growth in employment on the creative industries and contribution to GDP, particularly boosting SMEs and self-employed individuals.

Stakeholder	Activities	Outcomes (to 2030)	Indicators (of Impact)
	transnational level (through TMO).		
	Metadata about the Intellectual Property is managed in a machine-readable way to track copyrighted content on a granular level (tracking of individual elements or excerpts).	Collective licensing frameworks and other security mechanisms (e.g. smart contracts, fingerprinting) ensure authenticity and traceability of sources and support renumeration, providing sustainable revenue streams for content providers and creators of new content.	Implementation of standardised right framework i.e. Europeana Licensing Framework, RightstStatements.org
GLAM	Interlinking through AI tools of data at large scale to track copyrighted content (automatic detection of copies) on a granular level (tracking of individual elements or excerpts) and support remuneration and rescue.	Collective licensing frameworks and other security mechanisms (e.g. smart contracts) will support smaller actors in the sector and provide sustainable revenue streams	
Smart cities, urban planning, land use and territorial policies	Integrating cultural heritage and humanities in information systems design, building connections across domains, across space, across time and scales, Proposing similarity measures between territorial situations	Technological solutions for the understanding of the environment and its dynamics, for the citizen up to the policies (regulation) Recommendations engine connecting situations (and people) across Europe	Development of Public & Private partnerships Successful connections between territories

O4 & O5 Enabling smart applications that utilise cultural & heritage data could disrupt the traditional business model for tourism by focusing on a regenerative or circular model, reversing the global experience of the depletion of resources through traditional tourism models.

With towns, cities and regions, alongside monuments, national parks and areas of cultural significance seeking a sustainable and responsible tourism strategy, Time Machine is ideally placed to enable the connection of resources and encourage the circular generation of digital assets.

Stakeholder	Activities	Outcomes (to 2030)	Indicators (of Impact)
Smart Tourism	Identify the components of territorial clusters which can be interested in developing specific technological innovations	Innovative clusters working with local TMs to create a permanent ecosystem of smart tourism	- number of local TM's - number of heritage sites & partners involved in local TM's

	and tools for local TM cultural-heritage experience platforms and create the conditions for smart tourism to be considered a local/regional priority.		- number of digital projects & heritage assets disclosed - level of integration of TM tools and services in strategy & operation of cultural heritage partners, tourism partners etc. - number of (unique) visitors & users - qualitative data of users (appreciation, user feedback etc.)
Smart cities, urban planning & land use	Collaborative and debating platforms based on data to collaboratively describe places, to share and defend hypothesis related to urban planning and land dynamics	Integration of cultural items, soft values, and long-term development in urban planning and architectural design.	Humanities joining smart cities projects Regulation curation across different scales Number of urban planning/land use projects involving TM data and tools; Higher scores for quality of living/working/recreating in areas that have been developed taking users and soft values into account.

3 Scholarship

3.1 Research and Innovation plan

Objectives

The TM platform aims to contribute to the current state of several academic disciplines that rely on historical and cultural heritage data. It aims to do so in three principal ways: technology development for research-related activities; development of data processing for cultural and historical data; and development of methods and content for SSH research.

Technology development implies **incorporating multi-disciplinary research concerns and traditions in the design of TM's data infrastructure and software utilities**. It calls for (1) *platformising* historical and cultural data in Europe by, e.g., uniting relevant data centres across the continent for open and wider access to research communities; (2) making code and APIs accessible for scholars to develop their own tools and to scrutinise TM's tools from a tool criticism perspective (e.g., how transparent they are regarding data processing); (3) providing scholars with multi-purpose software to support them in various stages of their research, from reference, to data collection, analysis and visualisation.

The Time Machine consolidates a relatively fragmented ensemble of institutes involved in data processing and data collection. In doing so, it aims **to contribute to the craft of historical and cultural analysis, as well as to any other discipline that relies on "big data of the past" and**

its subsequent interlinkages with present-day data. TM gives researchers access to interlinked datasets of thousands of years of European historical and cultural developement. The fact that such datasets are interlinked allows scholars to examine numerous new data points (e.g., connections between data hitherto neglected or unseen). The connections that forge these new data points is facilitated by ontological aggregators that extract multiple layers of metadata and content to cross-reference multiple sources for trustworthy scholarship.

In equipping researchers with rich, interlinked datasets and numerous new data points, TM aims to enrich temporal analysis and offer researchers access to a polyvocal perspective on European history and culture. Researchers may add to existing measures and understandings temporal analysis relying on, e.g., correlation, evolution, regression, loss and other time-based probes, while datasets from diverse sources also imply access to a multitude of perspectives with their own accounts of past events, ideas and people. Though in many respects a foundational value of the web, "multi-vocality" has been infamously endangered in current research environments and online infospheres, due to the tendency of popular software (such as Google's) to organise initially large and incoherent swathes of information and users through the basis of personalisation techniques.

Finally, **the Time Machine consortium will itself engage in producing methodological and theoretical content for scholars that rely on "big data of the past"**. Techniques used for data processing in the Time Machine are especially relevant for the digital humanities, who have as of the past two decades considered the implications (and contributions) of "big data" for textual and historical analysis. TM aims to offer practical knowledge of techniques and analyses developed by the use and integration of "big data of the past", though, e.g., online tutorials, workshops and open-source code.

State of the art, technological monitoring

As of yet, SSH research accounts for well above 40% of students in European Higher Education. SSH is also the largest ensemble of disciplines to include the European research community, with more than 30% of EU researchers in Higher Education, corresponding to about 500.000 Full Time Equivalent (FTE) positions (ISSC World Social Science Report, 2016). Among these are approximately 180 courses teaching the digital humanities across Europe (DARIAH-CLARIN, 2019). The SSH research spending, however, is substantially lower than 30% of the overall research spending and is often lower than 20% in many countries (ISSC World Social Science Report, 2016). The main reason seems to be that research projects in SSH are traditionally more limited in scale and scope compared to the exact sciences and are usually less expensive as far as infrastructure and equipment goes.

Indeed, the current state of the art concerning digital platforms and infrastructures for historical data in Europe is one of fragmentation, at least for the fields of history, archaeology, historical literary studies, media studies, etc. Many digital collections and corresponding accessing tools are developed within specific research institutions and/or projects, often with a specialized focus (source type, region, thematic uses, archival provenance, etc.). Apart from large(r), professionally developed and maintained international, national and regional databases and tools (e.g. Europeana, Gallica, Flandrica), GLAM-developed databases (e.g. the Rijksstudio of the Dutch Rijksmuseum) or commercial products (e.g. the Brepols databases), few actually succeed in gaining broad uptake in scholarly and scientific communities. The main reasons arguably being that: (a) they are not easily accessible or remain insufficiently known among researchers; (b) they do not have user-friendly interface or provide too little descriptive metadata; (c) commercial products are often expensive; and (d) they have limited stand-alone relevance for the wider research community (beyond the research questions, project or institution for which they were developed). The Time Machine infrastructures for exploitation of the TM data for scholarship should take these challenges into account.

Additionally, many - perhaps most - smaller digital tools run the risk of being insufficiently updated once project funding runs out. Without a sustainable financial and managerial framework, most reach

a static 'archival state' over time and eventually become redundant as digital research tools, especially when the added value of a specific tool is concentrated in the provision of metadata relying on the latest research (e.g. bibliographical data, author and provenance identification, dating of sources, etc.). At best, they become occasionally-consulted repositories of digitized source material, but are never fully developed *post hoc* into a useable tool for researchers and/or stakeholders (see, e.g., Stanford's "Palladio" research platform in the case of the US, as well as "Geobacklight" from the Big Ten Alliance). Some remain hidden on institutional servers, others might be deposited as open source, often without a proper strategy or user-community.

Part of the problem is that, as of yet, professional maintenance of digital tools is cost- and labour intensive. Processes of automation might provide (partial) answers to this challenge, for example through automated harvesting of (new) bibliographical references and data. However, in order to remain relevant and well-used, digital infrastructure will always require significant investments of time and money, and at least a minimal involvement of human specialist expertise. Current infrastructures often lack the support of larger technology, payment of licenses and other issues, and fail to compete with software from private companies such as Google without benefitting from the same technical capacity and amount of data.

Next to a dynamic innovation environment, open source is also a scientific graveyard. There are troves of present-day digital data - i.e. the science heritage of the digital age - to be unearthed, safeguarded and valuated on open source platforms. If the Time Machine would be able to source these existing but undisclosed digital collections (thus also providing a service to researchers and host institutions in helping them value their collections and considering proper IPR), accelerated growth of the Big Data of the Past might be realised (next to the new first-time digitization efforts).

The funding of the European infrastructures and networks (e.g. DARIAH since 2014), often also providing sustained support and services for developers and users of digital research tools, has partially remedied some of the issues outlined above. However, in order to take a serious leap beyond the state of the art, there will have to be both a significant investment and a coordinated R&D effort in the future, focusing in particular on shared, standardised research infrastructure components and linked datasets that are curated along standards agreed on by the disciplines which use them.

Where possible, the **Time Machine data and tooling will be made available via the existing Pan-European infrastructures for sharing historical data and tools**, including Europeana and the various ERICs and projects on the ESFRI Roadmap. The advantage of this collaboration is that where **Time Machine acts as the infrastructure for digitization and information extraction, the various RIs will serve to provide sustainable access to this Big Data of the Past and to connect this with users in the various associated domains/disciplines.** For domains or topics for which presently no central, pan-European infrastructures exist (e.g., for geospatial data), the Time Machine project will initiate the establishment of new ones.

Existing infrastructures[3]	Specialty
CLARIN ERIC	Digital language resources for the digital humanities
DARIAH (Digital Research Infrastructure for the Arts and Humanities), including CENDARI	Tools and data for digital humanities research

[3] The Europeana team probably has a good overview of large-scale infrastructures. They have authored Cultural Heritage Infrastructure in Digital Humanities (Routledge, 2017).

Existing infrastructures[3]	Specialty
EHRI (European Holocaust Research Infrastructure)	Access to sources related to the Holocaust
E-RIHS (European Research Infrastructure for Heritage Science)	Access to (mostly scientific) data on the preservation of cultural heritage
Copernicus	Geographical data
National geoportals (e.g., remonterletemps.ign.fr in France)	Geographical data
European open Science Cloud	Re-use of data and tools generated in various European projects
Europeana	Specialized in providing general web users access to historical and cultural data
Google Search, Google Books, Google Library	Immensely popular source of web linked data
Wikidata	Open dataset underlying the most accessed knowledge base Wikipedia
Online data repositories of GLAMS	Access to (metadata on) digitized parts of the collections of galleries, libraries, archives, museums, usually via the institutional website (e.g., Rijksstudio of the Rijksmuseum)
On-site data repositories (e.g., GLAMS)	Most of the historical source material is available in analogue form in archives, libraries and museums
Github, GitLab, Stack Overflow, dev.to, Bitbucket…	Widely popular web-based, code-sharing infrastructures
Various DH tool repositories, including DiRT or the MIT recommendations for tools in digital humanities[4]	Guide scholars towards the tools available for various tasks of digital humanities scholarship
MOOCs (e.g., Europeana's, Digital Methods Initiative)	Training in digital methods, code and (new) media literacy

Targeted Achievements

With regards to its aim to serve the needs of scholars invested in historical and cultural data, the Time Machine is driven to two main ensembles of targeted achievements.

Technical development of the TM for Scholarship platform

[4] Some of these infrastructures are very good, but if funding drops, they are no longer maintained, or they are really specific and limited. Only works if there is a community behind that maintains these curated overviews (e.g., https://socialmediadata.org/social-media-research-toolkit/).

The first, which concerns technical development for scholarly research developed in Pillar 1, implies **the design of a research platform where scholars can access big data of the past and use TM tools to process and visualise such data.** This specific goal is conceived to remedy the current fragmentation of data and tooling listed above, and to provide scholars with a more comprehensive knowledge base for the study of longitudinal trends across various sectors and locations. Targeted achievements would then imply designing several prototypes of the TM for Scholarship platform, drawing from existing expertise (including the European CLARIN and DARIAH infrastructures) to combine researchers and developers (or researchers with developer capacities) in joint software design (and usage).

Software development for scholarly use of the "big data of the past" is seen here as an incremental process, informed at all stages by user (researcher) needs, practices and ongoing use of TM tools, which we refer to as "use cases". Though TM tools can draw from user data automatically collected from trackers, it sees technical development as an integral aspect of research software design, making it important to engage scholars in active deliberation over how TM research tools should function and which tools to build. This is particularly the case for disciplines concerned with tool criticism, software infrastructure, data analysis and empirical methods, which are include all disciplines relying on (digital) research tools.

Opportunities to deliberate upon TM tools will be provided in concise "design sessions"; passive (tracked) or active (written, surveyed, inquired) user feedback; and workshops, courses and other taught and applied research material focused on processing the "big data of the past." More "discrete" or passive feedback mechanisms will also rely on existing platforms for tool development, particularly Github and Stack Overflow, both of which allow users from all backgrounds to exchange relevant code and development support.

Though developing a platform for TM for Scholarship entails focused and planned technical development, the platform also draws from non-scholarly user feedback. This type of feedback is important because it reveals practical and intuitive uses of the TM platform neglected in focused research environments. This concerns several praxeological features, from the most trivial usage of TM tools – e.g., exporting and importing data from one environment to the other, having it be automatically recognised in its original format, etc. -- to the more general purpose of tools – e.g., poor usage of TM geo-historical maps may be indicative of the irrelevance of the tool for its users, or of poor design.

Specific tools to include in our targeted achievement roadmap include as of now: 4D mapping systems, where users may add and compare historical map layers and data linked to locations on such maps; "deep reference" plug-ins and tools to look up the historical background of any given information (be it an image, a term, a location, a person…), similar to the current (Mac-based) "Look Up" function; storage of various historical and cultural datasets *in* or *on* Europe, accessible via a single access point (similar to, e.g., Google Datasets, with optional indication of relevant information, such as data provenance, gaps, date range, interopability with other data types and datasets…); a directory of researchers using the TM for Scholarship platform for them to communicate, exchange datasets, methods and code; and other tools to be developed on the basis of the former.

Developing a common platform and interface for datasets containing historical, cultural and other interlinked heritage data is crucial, since it addresses the core issue of combining scattered, fragmented and poorly curated existing datasets (for example, architectural images and databases like SAHARA, ArtStor, geospatial databases). In being a *platform*, TM for Scholarship is to be developed from the bottom-up, through user feedback and crowdsourced development, and welcome, as such, inputs from the "crowdsourced scrutiny" of researchers and Citizen Scientists on, e.g., the quality of uploaded data, the relevance and plausibility of its inter-links, data provenance, completeness, and other issues that affect the quality of research. The data in question can include non-textual content and should allow integrated research with multimodal sources (text, images, AV, 3 and 4D object, etc.).

Supporting scholarly research practices that rely on the "big data of the past"

The second ensemble of targeted achievements for the TM for Scholarship platform is to **support advances in interlinked, interdisciplinary research with new methodological and theoretical input.**

TM for Scholarship will be designed to support and facilitate interdisciplinary research. In aggregating diverse datasets, TM creates new data points and enriches analyses that rely upon historical, cultural and geolocated data (amongst other items) across not one but various disciplines with hitherto unforeseen relations. Actors as varied as architects, urban planners, landscape specialists, educators and others will indeed benefit from the depth, diversity and interlinkages of the historical and cultural data TM for Scholarship provides. One can, for example, envisage a situation where research combines the strengths of hermeneutic research (e.g., interpreting human culture and society at the microlevel of individual sources, places, people or events) and quantitative methods (e.g., seeing patterns in large datasets and analysing those with statistical methods), smoothly alternating between them. Similarly, planners, designers and technologists would need TM data to contextualise their projects in time and space and develop long-term accordingly (making TM a basis for future-oriented design, for example). We devise this approach to interdisciplinary research methods to contribute to scholarship in three ways:

(1) *Facilitate heuristic* methods – that is, in such a way that observed patterns lead to new hypotheses on investigated phenomena, that are subsequently analysed within traditional, interpretative methods. Conjectural prediction (and design) of the future, for example, can be combined with predictive computational analysis inferred from data from the past. Outputs could include (critical) simulation of alternatives past(s) based on such trained models, while correspondingly test existing assumptions based on smaller data samples.

(2) Combine different data types and *facilitate analysis of complex systems and phenomena*. Analysis that relies on geolocation coordinates of TM data (if applicable), for example, would allow scholars to query datasets of different origins and types and relating historical data to present-day data on a particular location. This would also facilitate research geared towards present-day societal challenges, providing those challenges with a longitudinal perspective on their historical roots.

(3) Bringing different types of expertise and knowledge, including academic knowledge with non-academic knowledge. This is key to scholarship relying on TM for Scholarship, as data are not only provided by formal institutions but can draw from user-compiled and curated datasets and tools. Non-academic researchers concern members of associations or members of formal Citizen Science Cohort, or Partenos.

The heuristic and predictive dimension of methods developed thanks to TM data is particularly beneficial to any profession that invests in future-oriented analysis. Knowing the past to read the present, plan and prognosticate the future is an essential and critical skill that informs all sectors of society, such as governance and policy making, security, law, education, culture, architecture, and more. If enhanced with more data and analytical modalities, this capacity could lead to new “design” approaches, in the sense of new strategies for deliberating, planning and coping with future challenges in all of these sectors. TM for Scholarship is thus designed to facilitate eventual “collaborative responsibility”, i.e., dialogue between sectors interlinked by shared responsibilities and shared planning.

TM for Scholarship will also focus on *training* scholarly research that relies on big data of the past. One important aspect of such training is code literacy and developing (critical) approaches to data analysis, nurtured by centuries of methodological research in all disciplines involved in using big data, in particular historical data. Though such skills will be be taught formally, in, e.g., workshops, data sprints and courses in higher education, TM for Scholarship also invests on a growing, autonomous community of researchers and Citizen Scientists who draw from crowdsourced expertise and skills exchanged in online platforms (particularly code-sharing platforms). It is important that TM for Scholarship deposit knowledge and applicable techniques in an open and accessible format, in the same vein that online MOOCs and knowledge-sharing platforms already do.

Methodology

Apart from the obvious R&D challenges in creating a user-friendly Big Data of the Past (WP2), for uptake and exploitation in Scholarship, **accessibility and awareness are probably the most important challenges**. How will the TM project make sure that the infrastructure is used by researchers and thus will change the state of the art? Though TM for Scholarship (and other sectors) will at all times work alongside development in Pillar 1, there are a number of unique steps it will take to ensure that prototyped tools, interfaces and planned activities be relevant for scholarship.

1. TM for Scholarship will first **strengthen collaboration initiatives and outreach towards existing infrastructures**. These include CLARIN, DARIAH, EHRI, E-RIHS and Europeana. After establishing this outreach, TM for Scholarship will appoint Time Machine "Ambassadors" in the SSH scholarly community; 3) develop training, mentoring and peer-teaching programs; and 3) maintain regular participation (papers, workshops) in a representative number of annual SSH conferences.
2. TM for Scholarship will then design and conduct a number of **use cases** that focus on the value of a longitudinal, comparative perspective on present-day societal challenges and serve to advance and validate the Time Machine platform for scholarship. Use cases would need to be approved by the TM General Assembly. Use cases are developed and executed in a first round with selected participants from various SSH and CS disciplines.
3. Based on the use cases, TM for Scholarship will develop a **best practices and training and dissemination materials** in collaboration with the Research Infrastructure communities and via domain-specific professional organizations (including papers and workshops at their annual conferences, e.g. the European Urban History Association, Digital Humanities, etc.).
4. TM for Scholarship then issues two rounds of **open calls for proposals to test and validate the platform** and its services and tooling, and to open up the project to new stakeholders.
5. Throughout this process, TM for Scholarship measures the impact of TM components and infrastructure.

The use cases are **large-scale, long-term (*longue durée*) and comparative research projects, transcending existing subfields and focusing on the relations between economy, society and culture**. They innovate existing SSH scholarship by making it comparative in nature, extending its scope in four dimensions:

a. Time (enlarging temporal scope);
b. Space (enlarging geographical scope);
c. Disciplines (combining methods and tools from SSH, computer science and other relevant disciplines, drawing from existing efforts in the digital humanities in combining methods from such disciplines);
d. Sources (combining different data types).

This extended scope allows scholars to study present-day societal phenomena and challenges in their inherent complexity, considering their economic, social, legal, technical and cultural dimensions over time, across space. Possible topics include:

- The role of local cultural values for belonging and social cohesion;
- Democracy and democratic values;
- Welfare and wellbeing;
- Financial markets and crises;
- Security;
- Populism;
- Migration and social and cultural integration;
- Climate change and environmental issues;
- Adoption and impact of new technologies;
- Urban growth and shrinkage and its built environment, planning;
- Governance systems and their spatial impact;

- Transnational and cross-cultural exchange patterns;
- Food production and distribution;
- Infrastructure and Mobility (including ports, airports, roads, rail, etc.);
- Education and knowledge distribution;
- Religion and other cultural practices;
- Materials and technologies and their spatial spread;
- Health;
- Networks and flows of people, goods, and ideas;
- Water access, distribution, consumption through time and place and its link to issues of spatial, societal, environmental justice.

The selection of use cases will be prepared by the relevant work package leaders and proposed to the General Assembly of Time Machine Organization for approval. They will be conducted by Founding Members of the Time Machine Organization, combining SSH and CS expertise (co-development approach), with possible participation of Regular Partners for subtasks. The open calls can be on any topic but have to use one or more components of the Time Machine toolbox, in order to ensure that these are tested and improved with the results of the projects. Each round of projects is followed by thorough evaluation and implementation of the results.

Dependencies

WP2.1 How to design an interface for exploring and retrieving the big data of the past? How can we combine this interface with capable storage? -- would it be centrally organized or distributed?

WP2.3: Our role in WP4.1 could be to coordinate the further development and integration of the proofs of concept developed in WP 2.3.

WP3: Building communities of developers/users around tools (e.g. ELAN for a successful example).

WP5: Investigate relation with European Open Science Cloud (reuse of data and tools generated in various European projects).

Milestones

Cluster	Milestone number	Milestone	Means of verification	Due date
1. Collaboration and outreach	MS1.1	Plans for collaboration with existing SSH research infrastructures	Actions as listed in Memorandums of Understanding with relevant research infrastructures (CLARIN, DARIAH, EHRI, E-RIHS & Europeana) translated into concrete plans for collaboration	YR1
	MS1.2	Outreach strategy in place	The outreach strategy includes 1) appointing Time Machine Ambassadors in the SSH scholarly community; 2) developing training, mentorship and peer-teaching program; 3) regular participation (papers, workshops, demo's) in a representative number of annual SSH conferences	YR1

2. Use Cases	MS2.1	Use cases defined	Set of use cases proposed by WP leaders and submitted for approval to TM General Assembly	YR2
	MS2.2	Use cases executed	Successful development and execution of the first round of use case with selected participants from various SSH and CS disciplines	YR2-3
3. Proof of concept	MS3.1	Development of best practices and training materials	Based on use cases, a set of best practices and training materials are produced in collaboration with the Research Infrastructure communities	YR3
	MS3.2	Concertation efforts across the TMO Pillars	Outcomes from the use case are discussed with Pillars 1, 2 and 4. This results in updated activity plans across the Pillars	YR3
4. Open calls for proposals	MS4.1	First open call for scalable SSH research with TM Data Graph	Broad variety of high quality projects from SSH community selected; projects build on Pillar 1 achievement 3.1 and participate in the development of the TM Data Graph	YR4-5
	MS4.2	Concertation efforts across the TMO Pillars	Outcomes from the first call projects are discussed with Pillars 1, 2 and 4. This results in updated activity plans across the Pillars	YR6
	MS4.3	Second open call for SSH research with TM box components	Broad variety of high quality projects from SSH community selected; projects contribute to Pillar 1 achievement 3.2 and participate in the development of the TM simulation engines	YR6-7
	MS4.4	Concertation efforts across the TMO Pillars	Outcomes from the first call projects are discussed with Pillars 1, 2 and 4. This results in updated activity plans across the Pillars	YR8
5. Impact	MS5.1	Monitor of scalable SSH research	Measuring the impact of TM components and infrastructure on SSH scholarship	YR1-10

Key performance indicators

The social impact of researcher aided by TM for Scholarship could be assessed by considering:

- Usage of the TM data and tooling (indicators: user statistics on TM infrastructure; papers; publications and other scholarly output);
- Integration of TM data and tools in higher education curricula in SSH field (e.g. via the CLARIN-DARIAH Digital Humanities Course Registry[5]);
- Monitoring the research valorisation activity of SSH publications (e.g. as evidenced by attention in the media), as well as their impact in societal debates;

In turn, the economic impact of TM for Scholarship could be measured by looking at increase in number of startups that emerge from SSH and other fields (e.g., via facilities such as the University of Amsterdam's Venture Labs[6]).

3.2 Funding sources

The proposed match-making system to stimulate SSH scholars to include the TM data and infrastructure in their research projects and funding applications (with the purpose of obtaining requirements for further developing the infrastructure) can be realized by issuing calls from our own budget, and/or by convincing funders, including HE, to make use of TM data and/or tools a requirement for certain calls.

3.3 Stakeholders

This part integrates suggestions for expert interviews or questionnaires.

Industry	Areas of impact
SSH scholars and associations (these include institutes with strong digital humanities departments, such as NWA, CLADA-BG, EPFL, IRHT-CNRS, TU Dresden, TU Delft, UvA, U. Luxemburg, U. Warsaw, U. Utrecht, U. Gent, U. Antwerp, FAU, U. College London and U. Oxford; and larger associations, such as the Network of European Cinema and Media Studies, HOMER, Archives Portal Europe, DARIAH, E-RIHS, EuroSDR, CERL, IIIF, EAUH, CLARIAH, CESSDA and ARIADNE.)	Data (timespan, size and breadth of datasets), analysis (size and breadth of data would impact scholarly understanding and study of history and culture, particularly longitudinal perspectives on present-day phenomena), access (an inter-institutional data infrastructure would provide scholars with vast access to various big data of the past) and practicality (ease of access and linked data would allow scholars to repurpose various data points for extended analyses).
AI scholars (e.g. INRIA, and UvA's Institute for Language, Logic and Computation) and private sector partners (INDRA, Thales and Naver Labs)	AI scholars may benefit from big data of the past for developing alternatives for non-supervised learning approaches (see also Task 2.3, on interdisciplinary research). Private sector partners, can, like AI scholars, benefit from working with longitudinal data, complex 4D

[5] See https://registries.clarin-dariah.eu/courses/.

[6] See https://www.uva.nl/en/faculty/faculty-of-humanities/humanities-in-the-city/humanities-lab-avs/humanities-lab-avs.html.

	modelling and non-supervised learning approaches.
Non-academic researchers (e.g., citizens scientists such as historical associations)	
Other exploitation areas (including the creative industries), such as the gaming industry	Also worth mentioning are architects and other professionals that can reuse historical data (see Task 4.3). Notable gaming companies based in Europe (Ubisoft in France, Guerrilla Games in the Netherlands) currently find themselves in a market with a notable interest in serious and historically-informed games. Access to historical data and scholarly scrutiny can be of interest to these companies because they refine storytelling, enrich immersive environments, and guarantee the interest of consumers who would like to inform themselves about past histories and other cultures through immersive play.

3.4 Framework conditions

Framework conditions	Proposed actions
Copyright and IPR regulations	Support take up of RightStatements.org
Privacy regulations (e.g. regarding the collection of user data for the TM infrastructure)	Comply with latest GDPR guidelines

3.5 Risks and barriers

Potential risks and barriers	Likelihood	Impact	Proposed risk-mitigation actions
Low participation from the scholarly community due to little integration with more practical or accessible platforms (e.g., Google datasets, Google images, Google search...).	High	High	Seek exhaustive integration with other platforms used for scholarly research (for data collection, search, etc.), increase user options and ensure that data be linkable.
Scholarly community does not have the technical expertise to	Medium	High	Ensure that TM data is easily accessible outside of TM interfaces, via, e.g., more user-friendly

access the TM ecosystem.			and popular interfaces. Ensure that linked data literacy not be a requirement for TM usage, but open TM's code and API for critical assessment and individual repurposing.
Scholarly community does not find data analysis justifiable or better than traditional methods of analysis.	Low	Low	Ensure that the TM ecosystem be presented to SSH scholars not (just) as "revolutionizing" traditional SSH methods, but as building upon these constructively.

4 Education

4.1 Research and Innovation plan

Objectives

The field of education bears today hefty responsibilities, due, in part, to the complexity of today's European societies. Current challenges include forming critical citizens, equipped with media and coding literacy, oriented toward a sustainable lifestyle, and ready to approach currently polarising political, social and economic issues with critical awareness of Europe's historical past. Given its depth, diversity and interlinked nature, we can expect that cultural and historical data in TM will become subject to study (consultation and reference) and training for critical analysis in the education sector. Such training concerns educators, students, and the activities that tie them.

TM for Education is being developed at a time that the field of education in Europe also deals with challenges of its own. There is currently a focus on life-long learning, customising educational material, training media and coding literacy, and training students to tackle increasing complexity and change rate of the knowledge-intensive labour requirements of today's "knowledge economy". Facing these challenges, the TM platform for Education plans for concrete deliverables, including web-based reference tools for students, educators and general users, experience-based blended learning, Citizen Science infrastructure and approaches based on various digital technologies (VR, AR, AI).

Our **main target group are educators and students in primary, secondary and higher** education, and our goal is to enable developers of educational materials (private and public) to develop new tooling within education platforms to enhance learning (e.g., secondary self-learning (courses, tourism etc.)). Time Machine exploitation avenues for education can be geared to all forms of learning (pre-school, primary, secondary and higher education; lifelong learning; vocational training; informal learning), it focuses on developing pedagogical content for schools, universities, and lifelong learning in free and web-accessible tools and data. By tapping into Citizen Science, we imply that users (hereby educators, students and other users relying on tools and data created for the latter) also actively engage with TM products for Education by co-creating content for analysis and educational purposes.

Important objectives will be to enrich the teaching and learning of disciplines that rely upon historical and cultural data with open availability of diverse and multi-perspectival views on a given subject, as well as emphasis on epistemological and methodological issues and critical analysis. Students will be in position to study complex societal and urban challenges and thus to acquire the knowledge and skills for informed decision-making, considering and balancing relevant facts, interests, values, costs and benefits.

State of the art, technological monitoring

At present, the state of the art can be summarized in four main areas relevant to the Time Machine:

1. the general "web of knowledge", including search engines, wikis and other open sources of information;
2. platforms and tools designed to extend educational content, such as virtual learning environments and massive open online courses;
3. tools intended to manage education environments, including teaching and studying practices;
4. tools designed to extend education skills, including critical and analytical thinking, by way of, e.g., analytical tools.

The **first of these areas refers to sources of knowledge used for day-to-day knowledge consultation**. While it may be redundant, with regards to the very existence of the web, to distinguish them at all, it is worth noting their role in multiplying and diversifying our current sources of information, and therefore of education. Google, Wikipedia, YouTube and personalised information aggregators like Facebook and Twitter serve as reference tools that have been successfully

streamlined into the everyday life of students and citizens at large, and, together with online archives, remain go-to (though not specialised) repositories of historical and cultural information. Thanks to their flexibility, these platforms have equally ventured into selling education-specific services and products, particularly software bundles and extensions for tasks such as e-mailing, grading, writing, storage, analytics and other tasks already accessible through free services (such as Google Drive and Google app bundles). Despite their expedience, these platforms are not exempt from important drawbacks that the Time Machine could tap into. **With private interests, these platforms cannot guarantee a safe education environment for students. Above all, most of them lack a comprehensive integration of historical and cultural information through their products and user interfaces and are not always representative of interests in the European education sector.**

Second, there exist techniques, tools and bundles designed to extend skills traditionally trained in educational settings, be these analytical and critical thinking or knowledge gain in various disciplines. Massive open online courses such as Coursera, the Khan Academy and iTunes University are all education platforms in their own right, in that they aggregate and centralise education material — courses, skill training, educators — over multiple applications, be these web-based, mobile applications, or widgets extensions. Such platforms respond to the tendency to develop 'content that is responsive instead of adaptive', as well as to create 'microlearning experiences that can sync across multiple devices and give learners the flexibility to learn on the device of their choice.' (EDUCAUSE Horizon 2019, 21). **Rather than rebuilding entire systems of learning,** then, **users should have the choice between various options to access, extract, combine and repurpose granular data for educational purposes. We may also add virtual or online learning environments intended to extend and simulate environments that students can consult, explore, experiment with, and train their skills in**. This includes Labster, a simulated lab for scientific experimentation, or, most popular yet, games and other immersive works of fiction that have been heavily informed by historical information, such as Assassin's Creed or Red Dead Redemption. These virtual learning environments arguably act as virtual, interactive references about a given subject, be it a period, culture or biological environment.

The third area refers to platforms and applications designed for education management, be these manual repositories, (online) teaching material kits, or tools for monitoring various processes in an education environment. These systems have been **actively designed for education institutions**, and intend to recreate the essentials of education environments, as by, e.g., containing and/or linking to knowledge sources, providing students and staff means of communication and tasks, such as grading, submitting assignments, attending lectures, etc. These include platforms like the Open Suny Course Quality Review, the Quality Learning and Teaching, RiPPLE, the Jefferson Competency Assessment Tool, the University of Sydney's Student Relationship Engagement System, the AdmitHub, and Edulai (EDUCAUSE Horizon 2019, 21-27). These platforms are often integrated in **online learning environments and infrastructures**, including learning management systems such as Canvas and Moodle (EC 2019, 34).

The fourth area refers to tools designed to extend various education skills, including critical and analytical thinking. While learning environment systems and open online courses extent various aspects of education environments, they fall short of providing students with actual tools for research and analysis. **These tools are found in large digital humanities repositories or expert lists, and** are often spared in Github and Stack Overflow, where developers share knowledge, approaches and codes for users to apply at will. They **usually combine one or various computational techniques designed to scrape, combine and visualise large amounts of textual, visual or other data**. A very modest list of examples of tools applicable to textual analysis include WordiJ; to network analysis, Gephi; to cartographic analysis, Cesium; and to data visualisation, Raw Graphs – all of which can be used for comprehensive data visualisation. Though they may come across as obvious (if not redundant) to many scholars involved in data analysis, it is worth noting that **these tools have yet to be formally introduced to secondary educational**

environments, be they used for data analysis or as instruments for qualitative-quantitative empirical methods.

Type	Description	Examples	Cons
Search engines	Portals to information and the web.	Google, Bing...	
Online encyclopaedia	Popular online encyclopaedia, well-integrated in mobile and web-based software.	Wikipedia, Encyclopaedia Britannica…	While extremely informative, these encyclopaedia lack immersive or integrated environments.
Video platforms	Platforms that include videos at large, but also specific education-focused channels, such as the Khan Academy.	YouTube, Google videos…	While these platforms are extremely exhaustive in information, they can at times be particularly counter-productive for learning: they are designed for entertainment.
Analytical tools	Tools providing students with computational techniques for analysis, information retrieval and other capacities.	CLARIN, DARIAH, CLARIAH tools, Digital Methods Initiative tools, self-coded analytical tools or scripts…	Many infrastructures of analytical software are not easily accessible due to technical barriers and by virtue of poor UI design. To date, many students have yet to learn how to code.
Material supporting education staff	Various material used by teaching and admin staff in education institutions for various day-to-day tasks and practices.	Open Education Resource (a public digital library of open educational resources), digital material for teaching staff provided by Ministries of Education, teaching material sold by academic publishers, SELFIE (tools to monitor educational activities), Learning Engagement Platform and Open Digital Education,	Limited use. Does not apply to TM particularly: it is not intended to design a learning environment, but to provide material for study or learning.
Learning Management Systems	Similar as above; large platforms that simulate or transpose various tasks typical to educational environments, such as homework distribution, submission of files, communication, grade submissions, and other.	Moodle, Canvas, e-Twinning, CloudClassRoom, AppScho...	Limited use. Does not apply to TM particularly: it is not intended to design a learning environment, but to provide material for study or learning.
Broadcasters, GLAMs, game developers		Red Dead Redemption 2, Assassin's Creed and, e.g., *Origins'* discovery tour of Egypt, and popular historically-informed games. Kahoot "...uses an	The latter type – games – are particularly informative, in that, partly due to their interactive nature,

Type	Description	Examples	Cons
		interactive gaming tool accessible from mobile devices to provide instantaneous feedback and class data to keep students motivated." (EDUCAUSE Horizon 2019, 22).	they marry historical information with fiction.
Virtual learning environments	Environments that replicate, simulate or experiment with various objects of study.	Manzalab as 3D and 4D learning environments; Labster, a virtual lab environment; in the area of cultural heritage, there are the Skin and Bones exhibit at the Smithsonian National Museum of National History and the CHICAGO 00 (EDUCAUSE Horizon 2019, 25). The University of Pennsylvania's PennImmersive (https://commons.library.upenn.edu/pennimmersive) and Yale University's Blended Reality: Applied Research Project (https://blendedreality.yale.edu) are both immersive libraries. Other initiatives include the Virtual Field Trip to Iceland, which provides "students connections through geological landscape, hazard management, and geothermal power." (EDUCAUSE Horizon 2019, 26).	
VR/Smart campuses	Campuses equipped with various technologies, including VR tools.	"VR campuses" include the Miami Beach Urban Studios at Florida International University and the Wilbur Powerhouse, both "building-sized makerspace-like facilities" that provide "a range of technologies, including MR, to [campuses] and local communities." (EDUCAUSE Horizon 2019, 25). The Virtual Immersive Teaching and Learning (VITaL), from San Diego State University: "provides a variety of virtual reality, augmented reality, and mixed reality immersive tools for use across the pedagogical spectrum." (EDUCAUSE Horizon 2019, 26).	Overtime, these campuses may no longer be exclusive. Also, some of the technologies used may be superfluous or unjustified.
Massive open online courses	Platforms focused on aggregating, crowdsourcing, and distributing university courses and accreditations to users at large.	Coursera, the Khan Academy, MOOCS, YouTube tutorials and online classes…	Low accreditation.

The state of the art, summarised above, does not point so much to a gap in terms of availability of software in education, but more so in terms of the efficiency of such software. On the one hand, popular reference websites are used abundantly, both in and outside of formal education environments. On the other, there are complex and exhaustive software packages that are designed for education environments with the intent to as if replicate or extend certain aspects of education processes and activities, including studying, communicating with students and staff, applying one's analytical and critical skills through computational techniques, or extending lab settings through virtual experimental environments, such as in VR or various applications of 3D models. The exact procedure and method to innovate the state of the art will be outlined below, followed by an indication of the utilities this will yield.

Targeted achievements

The objective of the Time Machine in education is to **develop pedagogical content for primary and secondary school educators and students**. Such content could complement existing curricula with additional data for history and history-based courses; offer students analytical tools and big data of the past analysis training; and, by extension, offer students in higher and continued education and general users with seamless and integrated access to history.

Time Machine's personalized, localized access to the Big Data of the Past is ideally positioned for the current trend towards more self-directed learning, whereby the nature of the instructor shifts 'from transmitter of knowledge to facilitator and curator' (EDUCAUSE Horizon 2019, 19). From that perspective, it makes sense to **design an infrastructure that provides direct access to the TM data in ways that makes data from platforms used in education interoperable** and listed under 'State of the Art', and the new opportunities for innovating access to cultural and historical information outlined directly above, under 'How Time Machine Will Innovate the State of the Art'.

Here, it is important to mention the role of users as Citizen Scientists, who can help leverage the impact of TM by being part of the creation of innovation platforms in promising application areas, as developers, users and as connecting points between these. Including non-traditional researchers provides TM with opportunities to show its contribution to development of new job skills and contact networks in response to the disruption of ageism, automation, and outsourcing on the global labor markets of the 21st century.

At the same time, **we need public and private partners to develop and maintain (technically and in providing service) the services that provide access to the TM data in the ways outlined above**. The Time Machine also needs to **invest in engagement of the educational communities, raising awareness of the potential of TM data** (by creating showcases and best practices) **and facilitating interaction** (iterative, user-driven, inclusive, value-sensitive co-design approach to researching and developing the infrastructure).

Given the main objectives of the Time Machine's approach to education, there is a need of intense cooperation with education professionals and education certifying bodies in these fields. To this end, **the Time Machine aims to apply pilot projects in a select number of institutions from a representative sample of the European education landscape, including primary and secondary schools** (European Commission, EACEA and Eurydice, 2018). **Via its Community Interfaces (Pillar 2) the Time Machine will allow us to also test the use of TM in informal learning**. For each of these four areas of learning, we will start **pilot projects** consisting in experimenting and monitoring the uses of Time Machine components, including historical data, training in analysing big data of the past, accompanying analytical software and training in using and developing Time Machine interfaces for big data of the past.

As the Time Machine is centred on the use and application of big data of the past, it aims to consolidate the above with **pilot projects in primary schools, secondary schools, higher education and local volunteer-expert community groups, which will be focused on four core aspects of the educational potential of the Time Machine**:

1. **Encyclopaedic use: granting students and educators at large with access to big data of the past through web-based reference techniques**, such as a "History Look Up" function that can be activated to consult historical background information about various (or any) questions students encounter. Here, the envisioned application is intended to be general and seamlessly integrated in existing and habitual reference consultation practices.
2. **Engaging explorations of and experiences with the past: providing students and educators with specific applications, interfaces and curricula through which to make use and visualize big data of the past, including the simulation of those pasts using advanced visualization techniques.** These applications can include maps with integrated 3D models, AR/VR applications, search engines and other information systems based upon big data of the past. While these applications are not exclusive to students, what is specific are pedagogical approaches to introduce students into historical data analysis and application development.
3. **Critical thinking and digital literacy: supporting these applications are code and big data analysis training, or "Time Machine analytics".** Such training is not intended to be specific or exclusive to the Time Machine, but to all students and educators engaged in studying and teaching historical disciplines through data analysis. The Time Machine can offer use cases and material for educators to teach students how to study history with respects to such data – implying, here, that they also be offered material on how to teach *historical data analysis.* Critical thinking and digital literacy required for using such data (dependency with WP2, 2.3).
4. **Training educators in using and teaching "big data of the past analytics".**

The application of the above-mentioned "core aspects" can result in the following utilities:

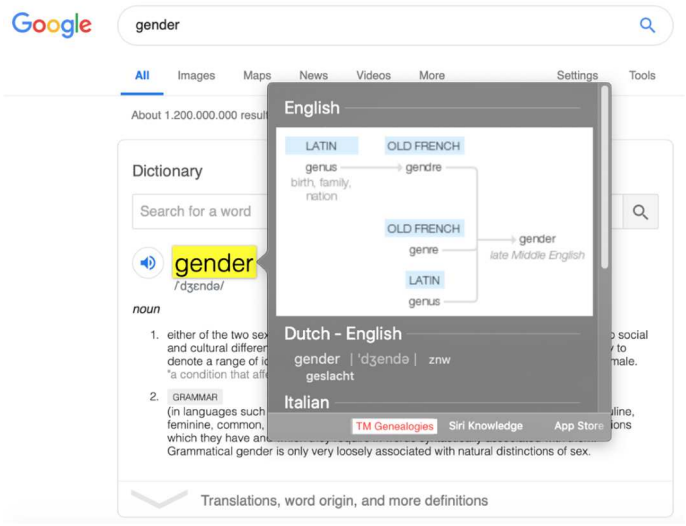
1. *Introducing students and educators to the Time Machine as an open-source platform for big data of the past and cultural information*

   Being open-source, the Time Machine will provide a **much broader knowledge base for teaching history from below, *longue durée*,** supporting democratic, layered, polyvocal historiography. This would **amplify the Time Machine's inherently participatory aspect**: it would allow users to add stories that are not in official archives (e.g., of migrants in a society, or on traumatic events such as colonialism, slavery -- or even those located at 'the other' or the 'wrong side of history', addressing the issue of ideological diversity and deep political schisms). Open data will need to be in compliance with appropriate regulatory frameworks, such as IPR and GDPR.

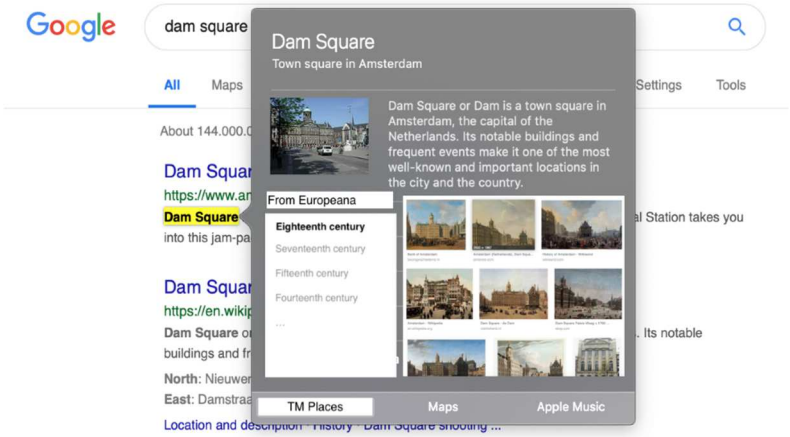
2. *Introducing students and educators to the Time Machine as a third-party source of historical and cultural information for reference tools and features*

   The Time Machine can become an **open-sourced centre-point (or platform) of historical and cultural reference on Europe on the web**, covering and combining, as a result, several of the functions that Google, Wikipedia and YouTube comprise. The data provided in this way can also be used by educational service providers to be integrated in their services, that can then be customized in a flexible and fine-grained way. The Time Machine can outsource its information into various practical reference tools and functions. One example is the (Mac-based) 'Look Up' function, which users can activate by clicking on a word, image or link to obtain further information from sources of their preference, including Wikipedia, YouTube, or language dictionaries. Functions like these are key to UIs, as they immediately provide users with additional information about any object they encounter.

To date, there are no sources providing these functions with historical information – be it (conceptual, family) genealogies, background information about a given object, person or place, or other historical perspectives of information at large. **A "deep reference" feature could provide students and users with the ability to access historical references for various objects they encounter online**. This could include conceptual references, particularly as to grant users the ability to understand the multiverse meaning of keywords they encounter, while it could also include references on individuals, peoples locations, and objects. With regards to concepts, it could provide genealogies and other historical topologies of concepts (e.g., selecting a term such as 'gender' would give the user the etymology of that term, the different times in which it was used, by whom, where, to whom it referred to). A word that refers to locations can be further "looked up" through 2D maps and/or 3D modelling of such locations in the past. With regards to people, it could provide social networks and family genealogies of people related to a given name.



Mock-up of a TM concept genealogy "deep reference" tool



Mock-up of a TM "deep reference" tool to look up words referring to locations, where the data source would be Europeana's collection of

visual art on locations

The Time Machine could propose several student or user-targeted applications (such as the above-mentioned "deep reference" tool, or extensions to Google Maps with 3D models of past locations, and other applications to come), aiming to apply historical data with respects to present contexts**. The Time Machine invests in an idea — to 'thicken' the present temporal dimension of the web with data from the past — with multiple, successive applications,** be they analytical tools, web-based tools, plug-ins, extensions, or more exhaustive software.

3. *Introducing students and educators to the Time Machine as localised history (or, a bridge between the exotic and the local)*

In so doing, the Time Machine could also ease the introduction of students and users at large into historical information they are not knowledgeable of. By providing users with historical background on whatever information they come across, it could help transform the user's perspective of that information as 'irrelevant' or 'noise' to a piece of information that makes its way into the student or user's larger browsing (or, indeed, learning) pattern. This way, **the Time Machine would provide users with "localized" history**: it can offer data that are related to the locality that is relevant for the learners, relating the far and exotic to the familiar and local. This implies that Time Machine applications must offer multi-lingual automatic translation services (thereby forging a dependency with WP 2.2) -- a technique that can be funded from Structural Funds.

Methodology

Our strategy is to develop four pilot projects around these three core aspects, with each pilot addressing a specific level of education. Though our pilots can touch upon all aspects of the "big data of the past" content and analytics, in all levels of education, they distinguish different levels of analysis for each formal stage of student development (primary, secondary, higher, informal education). Thus, the pilots address either (1) one level of education with multiple aspects; (2) multiple level of educations for one of the aspects; or (3) a combination of the above.

Level TM aspect	Primary	Secondary	Higher	Informal
Encyclopaedic	Pilot 1	Pilot 3	Pilot 4	
Engagement				
Literacy	Pilot 2			

Depending on local funding**, TM for Education can use the infrastructure around the existing Local Time Machines to develop the pilots**. The local Time Machines can provide the data and the services for very targeted projects focused on local history (or on the local links to broader historical developments), that they can test in practice with local partners with access to educational institutions.

The pilots will yield best practices and training and dissemination materials which, with the help of the dissemination activities in Pillar 4, will be disseminated among the stakeholder groups in the educational field.

Since the pilots depend on the availability of sufficient Time Machine data and infrastructure, they will start somewhat later in the project. The pilots are preceded by a preparation phase which focuses on stakeholder organization and collection of requirements for the necessary infrastructure via interviews, expert meetings and focus groups.

Our method, as outlined in the milestones Table below, can be broken down in four steps.

1. TM for Education will first consolidate a stakeholder organisation, which will consists in a consultation group with stakeholders from primary and secondary education (e.g., EUROCLIO) and education curricula development (private education package developers and Ministries of Education). From these, it extracts a requirement analysis in order to lay out plans to refine the state of the art.
2. From there, TM for Education goes through a first round of pilot projects consisting of the design and execution of two pilot projects that test TM data and tooling. It focuses on: (1) three types of usage (encyclopaedic, engagement and digital literacy) in primary education; and (2) digital literacy in four levels of learning (primary, secondary, higher and informal). With these pilot projects, it formulates best practices for training and dissemination. It then determines outcomes for a second round of pilot projects to be discussed in Pillars 1, 2 and 4. This will result in updated activity plans across Pillars.
3. TM for Education then sets out in an Implementation phase, whereby it focuses on the development of an Education portal including software packages released for primary and secondary schools, higher education and informal learning.
4. Finally, TM for Education seeks to guarantee sustainability in software updates and education package development. Sustainability is ensured by (consented) tracking of software usage. These actions will form the basis for the rollout of the TM education portal.

Dependencies with other WPs

Pillar 1 - Data:

- “Time Machine analytics” needs to rely heavily on computational linguistics and a well-integrated linked data infrastructure.
- Interface requires clear indication of origin, quality and type of data.
- Open data, in compliance with appropriate regulatory frameworks (IPR, GDPR etc.).
- Curation of the data required: to what level, exactly?
- Services for special needs (hearing or visually impaired etc.); inclusive approach to design (dependency with 2.2, type of descriptive data for visual sources needed for visually impaired).

Pillar 1 - Computing:

- Pilot cases Multi-lingual platforms needed (automatic translation services).
- How to avoid bias in the interpretation/simulation of the data through AI systems (historical chat bots).

Pillar 1 - Theory:

- Critical thinking and digital literacy required for using such data.
- New narrative structures for making sense of the data (e.g., interactive, multimedia storytelling, how to deal with different perspectives in the data/on the phenomena documented by that data).

Pillar 2 - Communities:

- Use of the community interface, community management and community activity monitoring services are required for pilot study 4, TM for informal learning.

Pillar 2 - Infrastructure:

- The RFC tree serves as a pivotal structure to plan expected progress in the different infrastructure elements of Time Machine and adapt exploitation areas use cases in consequence

Pillar 2 – Local Time Machines:

- The development of the LTMs multiplies the opportunity of agile and local pilot studies to test exploitation area.

Milestones

Cluster	Milestone number	Milestone	Means of verification	Due date
1. Stakeholder collaboration and definition of strategy	MS1.1	Stakeholder organisation	Creating a consultation group with stakeholders from: primary and secondary education (EUROCLIO); education curricula development (private education package developers; Ministries of Education)	YR1
	MS1.2	Requirements analysis	Refining analysis State of the Art and points of further improvement from stakeholder organisation	YR2
	MS1.3	Sustainability / Definition of software-curriculum update process	Definition of a sustainable update process based on application-curricula interdependencies. Consolidation with stakeholder organization and other pillars	YR1-2

2. Pilot studies	MS2.1	First round of pilot projects	Design and execution of two pilot projects that test the TM data and tooling: 1) focus on three types of usage (encyclopaedic, engagement and digital literacy) in primary education; 2) focus on digital literacy in four levels of learning (primary, secondary, higher and informal)	YR3-4
	MS2.2	Development of demonstrators	Development of best practices and training & dissemination materials materials	YR4
	MS2.3	Concertation efforts across the TMO Pillars	Outcomes from the first call projects are discussed with Pillars 1, 2 and 4. This results in updated activity plans across the Pillars	YR4
	MS2.4	Second round of pilot projects	Design and execution of two pilot projects that test the TM data and tooling: 1) focus on three types of usage (encyclopaedic, engagement and digital literacy) in secondary education; 2) focus on two types of usage (encyclopaedic and engagement) in higher and informal education	YR5-6
	MS2.5	Improvement of demonstrators pilot studies round 1	Set of improved best practices and training & dissemination materials tested and evaluated with stakeholder organizations	YR6
	MS2.6	Concertation efforts across the TMO Pillars	Outcomes from the second round of pilot projects are discussed with Pillars 1, 2 and 4. This results in updated activity plans across the Pillars	YR6
3. Implementation	MS3.1	Development of TM for Education portal	Amount of software packages released for primary and secondary schools, higher education and informal learning Presenting primary and secondary schools with user guidelines and tracking uses of demo applications	YR7
4. Sustaining	MS4.1	Measuring customer satisfaction	Tracking usage of portal and materials	YR8

	MS4.2	Rollout of TM Education portal	Defining diffusion strategy and business model	YR9-10

Key performance indications

- Number of users (both students and general users) using Time Machine web-based tools for reference and developing applications on the basis of big data of the past;
- Number of non-partnered high-schools relying on TM-supported applications and tools and teaching TM-provided big data of the past analytics;
- Number of national ministries of education to have committed to TM content;
- Number of educational publishers to take up TM content.

4.2 Funding sources

For the pilot projects, dedicated TM funding from European and national funding schemes is required. Where possible, we can benefit from grants obtained by the local Time Machines.

At the higher education level, we can link with existing European programs for knowledge exchange:

- Erasmus program (BA/MA)
- Marie Curie Initial Training Networks (PhD)

There have been fresh proposals to tap onto the Erasmus programme by funding pan-European courses and diplomas. The Time Machine would complement these initiatives well, as it is already equipped with educational facilities and staff and comprises leading institutes in areas such as cultural heritage and the digital humanities. It could standardise a set of BA or MA courses in, e.g., digital cultural heritage, AI for the digital humanities and other methods-based courses.

4.3 Stakeholders

Actors	Areas of impact
Educational publishers (Pearson, etc...)	Creation of textbooks, learning manuals, design of material provided to standard or core courses.
Education technology start-ups	Application development, technique design, and use of larger data of the past.
Ministries of Education	Design of educational programmes in secondary schools; enlargement of scope for history courses, including specialised courses in big data of the past analytics.
Broadcasting corporations	
Libraries/Archives/Museums	Integration of upgraded information-retrieval techniques for big data of the past.
Education workers	Higher levels of data analysis proficiency required of staff.

Future-oriented design institutions, such as urban planners, designers and policy makers	Design of educational programmes designed to teach historical reasoning with creative processes.

4.4 Framework conditions

Framework conditions	Proposed actions
Privacy issues	The idea of the 'historical lookup' layer on the internet entails privacy issues; e.g., the 'personalized, localized references to historical data' are then tied to the location of the user (of e.g., Google search).
Copyright issues	Propose the adoption of RightStatements.org.

4.5 Risks and barriers

Potential risks and barriers	Likelihood	Impact	Proposed risk-mitigation actions
The technology we propose is yet to be developed	Medium	High	Support grassroots/bottom-up development of TM software, techniques and platforms, such as in focused Time Machine data sprints and workshops.
Support from education programs is yet to be found	Medium	Medium	Present Time Machine applications and analytics as fitting within the same domain as informatics and programming courses already offered at secondary schools.
Younger users do not pick up on Time Machine applications	Medium	Medium	Ensure that Time Machine applications are well-integrated within already existing, popular reference platforms.
Education staff cannot pick up on Time Machine applications and analytics due to	High?	Medium	Ensure user-friendliness in *both* Time Machine applications and

Potential risks and barriers	Likelihood	Impact	Proposed risk-mitigation actions
inability to work with digital technologies			analytics (e.g., SPARQL).

5 Specific exploitation & uses platforms

The specific exploitation areas are chosen by studying competitive trends and industry value chains in different sectors of societal and economic activity to achieve a strong boost of competitiveness in key sectors of the European economy.

The selection criteria for the specific areas are:

- The relevance for Europe, including the opportunity to develop European leadership;
- The potential of technology breakthroughs achieved in different stages of TM for disruptive effects;
- The substantial societal and economic impacts that can be expected.

The specific exploitation platforms will be developed, bringing together domain specialists from the fields involved in each case, with adapted tools and processes developed from the TM processing and simulation infrastructure. The exploitation stakeholders may also contribute to highlight unsolved issues and motivate applied research in interaction with Pillar1.

Three relevant points have been taken into consideration approaching the development of a roadmap for these special exploitation avenues:

- The importance of considering the business models related to information and to open data and stakeholders that need to get involved.
- The importance of considering technology readiness and demand readiness; we must mature both science and technology as well as demand.
- The importance of a vocabulary to express the specific exploitation avenues' perspective on TM results, framework, platform, to the pillar 2. This perspective is that of several users as analysed in business models and in innovation fostering (see two previous points).

The specific exploitation avenues are not to be considered as mere silos; hence open innovation can rely on transversal results. Yet this division obeys to the following logic:

- GLAM: With GLAM institutions acting as one of the main contributors in storing, collecting, describing, curating, discussing, exhibiting, and sharing Europe's Cultural Heritage, but also as processors and users of Time Machine data, the interplay between the Time Machine initiative and GLAM institutions is a complex and multifaceted relation.
- Creative industries: the capacity of creating and mobilizing people imagination is key for our future to reach a vision aligned with our values.
- Smart tourism: a specific domain where technology and demand readiness (incl. existence of KPI) are at good levels and TM has a huge potential of return on investment.
- Smart Cities and urban planning: underlining the capacity (individually and as a society) to interact with the environment and design it. Cities concentrate most human activities and are a privileged exploitation avenue.
- Land use and territorial policies: shares the same stakes as smart cities but territories in general are also studied to address sustainable development challenges in a context of climate change.

Consolidation of methodology and roadmaps between these domains will be pursued during the programme. For instance how to interact with other Pillars, how to design use cases or also the definition of thematic time machines.
Despite their sizes, the two last subdomains have been grouped for the following reason. These are domains where cultural heritage is not considered today as a priority and really valuable asset. In these domains, the roadmaps must propose achievements that are at the same time meaningful to representative users and that will benefit from the Time Machine DNA so to say, the valorisation of cultural heritage, the empowerment of digital humanities with a common asset across current silos, the curation of a knowledge graph with a large memory.

5.1 GLAM

Research and Innovation plan

Objectives

GLAM institutions are central in the collection, description, preservation, and making Europe's Cultural Heritage accessible. In the process of the digital transformation, GLAM institutions face multiple complex challenges and operate in completely different contexts concerning societal discourse, economics, and technology. Novel trends in fields like AI, AR, VR, machine learning, automatic or semi-automatic description of digital objects, digital preservation, and immersive experiences provide sheer endless possibilities, yet are only slowly being adopted throughout the GLAM sector. In addition, just a small proportion of GLAM collections have been digitized, being partly due to limited financial and technological resources. Also, institutions are confronted with significantly higher and more diverse expectations from the general public and funders and constantly need to reposition themselves.

Improving the efficiency and processes for the **handling, storage, digitization, description, curation, preservation, exploitation, exhibition, discussion, contextualization, and interconnection** of both analog and digital collections will play an ever-increasingly important role in the digital transformation of GLAM institutions. Time Machine – essentially the Big Data of the Past and its surrounding services – will address all kinds of issues GLAMs tackle today. This research and innovation plan will examine possible fields of application for Time Machine in the GLAM sector.

The overarching vision for this research and innovation plan is to further **strengthen the role of GLAM institutions as central Cultural Heritage providers**; as driving forces for cultural experiences; as platforms and rich sources for education, research, entertainment, creativity, and innovation for current and future generations by adopting Time Machine data, knowledge, processes, services, and tools. In more detail, we propose the following objectives:

- **Promote the adoption of processes and platforms by the Time Machine initiative** as the standardized backbone in enabling GLAM institutions to open up, enrich, share, and exploit their (digital) collection(s)
- **Support GLAMs with tailor-made tools and services to stay relevant** in a world of fast-paced change driven by digital transformation
- **Offer GLAMs a valuable and vast resource for cultural heritage data** that is well-documented, trustworthy, inspiring, and re-usable, e. g. to contextualize entire collections and to strengthen GLAMs as a trusted and reliable source of information
- **Create synergies** between developments and strategies already underway in the GLAM domain and the Time Machine initiative, e. g. connect GLAMs – and especially smaller institutions – with Local Time Machine initiatives
- **Develop the frameworks, pipelines, and business models** to enable GLAMs to actively contribute to and process the Big Data of the Past. Moreover, with the large consortium behind Time Machine, the initiative acts as the missing link to transfer mission-critical expertise from other sectors to GLAMs and vice versa

State of the art, technological monitoring

We will now outline current exemplary challenges for GLAMs and propose scenarios for exploiting potential future Time Machine services and data. This list has been discussed and commented on by participants of the Time Machine GLAM workshop in Amsterdam and has been extended with the help of stakeholder consultations. In each of the following tables in this section, the third column outlines dependencies on developments in other WPs.

<u>Digitization, Data Model, Storage</u>

Digitization potentially covers various aspects that are not solely scanning-related: the selection of objects, their preparation, the actual scanning, live quality control, but further also the data extraction and processes that make sense of extracted data. At each of these steps and in addition to these, Time Machine could play a prominent role in the future. Therefore, the interplay between Time Machine and GLAM could be multifaceted. However, in digitization, there is still a lot of work left to be done for GLAM institutions. In 2017, the ENUMERATE survey[7] reported the progress achieved through the Cultural Heritage Sector towards digitization of objects and collections, and the influencing factors that support and enable this. Unique in its scope and in its 4th edition the survey demonstrates the current trends throughout the sector covering: Collections and Digitization Activity, digital access, participation, digital preservation and expenditure associated with digitization. Highlights from 2017 (1,000 respondents) were the estimate that on average just **22% of institutions collections have been digitized**, and 85% of respondents made their digital collections available in some form. These digital collections are typically made up of a curated range of text-based digital resources such as books and letters, but also 3D material.

Lastly, archiving analog cultural heritage presents another significant challenge: when collecting analog material, physical space[8] is a limited resource.

Examples	Scenario(s) with Time Machine	Dependency on WPs in other pillars / RFCs
Disparate and isolated data storage	Time Machine provides a standardized connection of heterogeneous data storages through Linked Data	• data modelling • data storage and long-term persistence • data acquisition • RFC on TM Box • RFC on Data Graph • RFC on Distributed Storage
Complex data models for heterogeneous datasets	Time Machine streamlines datasets EU-wide with a standardized and robust data model that can be applied to diverse types of collections Time Machine provides a streamlined version control system to be able to tell which version of a digitized object is the most recent and most suitable for any given purpose (e.g. highest quality vs. fastest loading time) or context (e.g. mobile or desktop device)	• data modelling • data storage and long-term persistence • RFC on data lifecycle • RFCs on Data Graph

[7] https://pro.europeana.eu/resources/statistics/enumerate

[8] See KB Vision document for further info: https://www.kb.nl/sites/default/files/docs/kbnb_beleidsplan-eng.pdf

Examples	Scenario(s) with Time Machine	Dependency on WPs in other pillars / RFCs
Diverse modalities of objects, both analog and born-digital	Time Machine provides ways to digitize every object possessed by a GLAM institution – even the ones that cannot be digitized yet	• data modelling • data storage and long-term persistence • RFC on Definition of typologies of digitisation interventions • on Global optimization of digitisation process
Some collections / material types suffer from digitization	Time Machine provides gentler techniques of digitization that require less manual preparation	• data acquisition • RFC on New Scanning Technologies
Back-up routines need to be set in place	Time Machine provides a way to safely and redundantly store digital collections	• data storage and long-term persistence • RFC on TM Box • RFC on Distributed Storage
Digital preservation requires novel paradigms and techniques (e. g. because of versioning)	Time Machine offers smart solutions for digital preservation that takes versioning into account	• data storage and long-term persistence • RFC on TM Box • RFC on Distributed Storage
Offering Linked Data requires a lot of resources and preparation	Digitization does not equal publishing as Linked Open Data, there is an intermediate step. Especially libraries are struggling to produce triples and creating connections with related data elements and data sets. Time Machine could foster a novel approach of interoperability that is less setup-heavy	• data storage and long-term persistence • RFCs on Digital Content Processor (DCP) of Level 1-2-3 • RFC on Data Graph
Digitizing the context of an analog (or even born-digital) artifact lacks standards and is diverse	The context of an object also plays a crucial role for the exploitation of the big data of the past, e.g. the e-mail correspondence between two famous authors that could be exploited in an exhibition, or the Tweets of a media	• data modelling • visualization • digital methods / source criticism (de-

Examples	Scenario(s) with Time Machine	Dependency on WPs in other pillars / RFCs
	artist. Time Machine provides frameworks to deal with these various kinds of modalities and contexts	contextualization of data) • RFC on Mirror World Prototyping • RFC on Mirror World Technical Standards
Digitization requires cost-intensive hardware and resources	Time Machine provides ready-to-use and newly developed hardware rentals to share among multiple institutions in order to save resources Mission-critical digitization know-how and best practices are shared among institutions, facilitated by the Time Machine Organisation	• data acquisition • RFC on Digitisation Hubs • RFC on Global Optimization of Digitisation Process • RFC on On-Demand digitization

Rights Management and Business Models

With a changing landscape of ownership in the digital domain, GLAM institutions find themselves in a position of needing to secure funding and explore novel ways to monetize (digital) collections. Also, GLAM institutions face an already complex situation in rights management for their various collections.

Examples	Scenario(s) with Time Machine	Dependency on WPs in other pillars
Various rights statements for different collections	Time Machine provides a robust rights management model that works EU-wide	• data storage and long-term persistence • RFC on intellectual property rights and licenses
As a data contributor: some collections cannot be opened to the general public	To ease copyright restrictions at GLAMs, Time Machine lets contributors pick a pre-defined “level of openness” of data. Example: This could mean that institutions can contribute metadata for research purposes without providing the corresponding digital artifacts Alternative Scenario: Time Machine goes beyond the institution holding rights and establishes thematic communities based on raw data	• data storage and long-term persistence • RFC on intellectual property rights and licenses

Participatory Initiatives, Experiences, and Novel Curation Approaches

With a rising demand for modern, interactive, immersive, elegant, enjoyable, and contextualized experiences by the public, GLAM institutions' roles as cultural heritage providers shifted. Digital services and participatory initiatives are now commonplace at said institutions: e.g. in the form of labs and creative spaces, crowdsourcing platforms, or interactive installations in museums. They all have one aspect in common: participation. Adopting participatory initiatives transforms a key role of GLAMs: curation.

Setting up these initiatives and aligning them with the digital strategy of respective institutions is a non-trivial task: the conception, design, and implementation of such initiatives demand a strong understanding of digital processes, tools, and services and require expert qualifications. However, standardized software frameworks for these initiatives are still missing – only singular, uncoordinated, and isolated initiatives exist.

Examples	Scenario(s) with Time Machine	Dependency on WPs in other pillars
Participatory initiatives often need to be specifically designed and implemented by an institution and are cost-intensive	Time Machine provides open tools for labs, co-creation platforms, crowdsourcing initiatives, and other spaces of open innovation that can be used by institutions EU-wide Time Machine provides state-of-the-art, modern, and highly flexible crowdsourcing-software for various devices to allow end users to contribute data to Time Machine	• human-computer interaction • visualization • RFC on LTM • RFC on enhancing collaborations • RFC on TM tools for History Research
GLAM institutions may lack the processes necessary to transform (their) data into innovative experiences	Immersive exhibitions are increasingly successful, Time Machine can provide "curated 3D content" for the museums that open their collections to the initiative Also, Time Machine connects the expertise of different sectors (e. g. the creative industries will play a key role in designing these experiences)	• human-computer interaction • visualization • RFC on Virtual/Augmented Reality and Discovery • RFC on Mirror World Prototyping
Analog heritage in museums can be temporarily not available and therefore not on display for the general public (e. g. if it undergoes restoration)	Time Machine provides scans and 3D models enabling immersive representations of the monument as it is being restored	• human-computer interaction • visualization • RFC on Virtual/Augmented Reality and Discovery

Curation mostly lies in the hands of GLAM institutions	With Time Machine, it will be possible to take control through community curation (democratize the data curation process)	• digital epistemology • RFC on LTM • RFC on TM tools for History Research
Curation requires a wide variety of expert skills	Time Machine provides novel ways of automated or semi-automated curation of Cultural Heritage objects	• RFC on Data Graph • RFC on Digital Content Processor 1-2-3

AI, Information Extraction, Enrichment, Query, Digital Collections

Digitization lays the groundwork for further operations that deal with digital objects, e.g. information extraction and (semi-)automated enrichment that possibly leads to improved query mechanisms. Below are a few examples of current topics GLAMs face that could be addressed by Time Machine in these areas.

Examples	Scenario(s) with Time Machine	Dependency on WPs in other pillars
GLAM institutions mostly rely on traditional ways of querying data	Time Machine introduces novel ways to query data (e.g. 3D point clouds) and provides ways to better exploit all available modalities	• human-computer interaction • visualization • natural language processing • indexing and retrieval • RFC on Data Graph • RFC on Large-Scale Inference Engine • RFC on Universal Represensation Engine
Disparate analog collections	Time Machine connects the digitized counterparts of these disparate collections for further exploitation by adopting novel visualization techniques	• Visualization • RFC on Augmented/ Virtual Reality and Discovery • RFC on Mirror World Prototyping
Automated information extraction (e. g. extraction of image features, OCR) is still not completely reliable when applied to heterogeneous forms of digital objects	Time Machine introduces novel, versatile, robust, and highly effective information extraction techniques that can be used on a variety of digital objects (e.g. images, text, video, sound)	• general machine learning • natural language processing • computer vision and audio analysis • RFC on DCP 1-2-3 • RFCs on document extraction pipelines

Examples	Scenario(s) with Time Machine	Dependency on WPs in other pillars
Traditional image processing pipelines for OCR are not applicable in certain areas (e. g., historic material and Arabic script)	Time Machine offers GLAMs a vast pool of training data to improve image processing pipelines for certain documents	• natural language processing • RFC on Named Entities Recognition • RFC on Text Recognition and Processing Pipelines • RFC for Classification and Planning of languages to address
With current technology, some information is difficult to extract from digitized material (e. g., tabular data in newspapers)	Time Machine offers GLAM ways to provide domain expertise and training data sets to the Time Machine initiative to improve technology	• general machine learning • natural language processing • RFC on Structured Document Pipeline
Limited resources to manually extract meaningful information in big data (as a data scientist)	Time Machine introduces highly specialized and versatile self-learning algorithms to feed the Time Machine knowledge graph automatically or semi-automatically	• general machine learning • RFC on Large-Scale Inference Engine • RFC on Universal Representation Engine

The above areas, examples, and scenarios are not exhaustive and exhibit different levels of detail. They need to be reviewed and discussed with stakeholders on a regular basis.

Targeted Achievements

Time Machine will boost, support, and accelerate many developments that are already underway in GLAMs and, in addition, introduce completely new **transformative effects** (e.g., cost-effective digitization techniques and frameworks, a boost in the availability of training data, novel techniques for enrichment, among others). Since **collections constitute a key element of GLAM institutions**, we propose to categorize Time Machine's **transformative effects in four areas dealing with (digital) collection(s)**. This concept should help to cluster Time Machine's various developments and exploitation possibilities in GLAMs.

Collection Custodianship & Enrichment

Nowadays, **digitization** of analog objects is a labor- and cost-intensive process. Copious quantities of analog objects still reside within GLAM institutions that have not been digitized yet. With Time Machine, versatile and affordable digitization hardware and techniques will be introduced. This includes novel 2D and 3D digitization techniques as well as innovative approaches both for large- and small-scale digitization initiatives. Contrary to state-of-the-art digitization techniques, Time Machine provides a more effective way of scanning the context of analog artifacts in order to be used for the Big Data of the Past. Also, born-digital material can be stored and linked as well.

In an ideal scenario, Time Machine's novel digitization techniques will **lead to a larger body of digitized material** that can be made accessible to the public according to FAIR data standards. Also,

since funding for GLAM institutions (and here especially smaller, local organizations) is limited, Time Machine will lead to more affordable and flexible digitization services that still rely on domain expertise provided by GLAM institutions (e. g. in live quality control and object handling before and after the imaging step). Thus, in the long-term, GLAMs face less pressure related to funding and can work more independently within their particular digitization strategies.

The main beneficiaries of these developments are mostly GLAM institutions themselves, mostly through knowledge transfer and hardware innovations.

Collections need to be semantically enriched so that they are satisfyingly queryable. However, the description of collections is a tedious and cost-intensive task that often is undertaken as an isolated initiative. Time Machine will introduce various new methods of **algorithmic enrichment** to annotate, interpret, and describe collections (in various modalities). Crowds will be able to contribute via standardized, modular, and interoperable crowdsourcing-platforms that will play a key role in the Time Machine initiative. This enables easier findability of data (e. g., single objects, collections, or hidden gems).

With a vast amount of newly acquired metadata, the demand for curation will increase. Time Machine provides intelligent tools for helping GLAM professionals to **select, inspect, and further refine metadata**. Again, this is expected to demand new skills and create **new job profiles** in the GLAM sector (e. g., a “data curator”).

Time Machine’s services (for instance, automated image classification or image understanding) advance the **automation of quality control tasks** at GLAMs. This can be especially helpful after the imaging step in an institution’s digitization pipeline.

In understanding objects, Time Machine fosters automated **information extraction**, **machine learning, and AI** as the main drivers of innovation in GLAM institutions.

Automated translations (including translations from ancient languages to multiple modern languages, translations to simple versions, and translations to minority languages) will considerably improve the accessibility and relevance of digital objects for all kinds of audiences and are expected to have a transformative effect not only on education and scholarship but also on tourism.

Lastly, while there exist various training data pools, dedicated and specialized cultural heritage training data is still rare. Unbiased and domain-specific training data is necessary to apply machine learning techniques in the sector. Thus, GLAM institutions hugely benefit from Time Machine’s vast source of sound, robust, and well-documented training data. Vice versa, with their domain expertise, GLAMs are likely to contribute to Time Machine in curating and documenting training data sets (e.g., images that contain tabular data or handwritten text). Ideally, the Time Machine initiative will help GLAMs to prepare, store, and share training data sets by providing clear guidelines for these activities. This area demonstrates the multi-faceted connection between GLAMs and Time Machine.

Connections to other WPs: 2.1 Data Acquisition, 2.1 Data Storage, 2.1 Data Modelling, 2.2 Natural Language Processing, 2.2 Machine Learning

Collection Access

Today, **access to (digital) collections** is limited due to legal, financial, technological, or strategic reasons. Time Machine provides frameworks for dealing with the above aspects and vastly increases the visibility and accessibility of collections by helping institutions to streamline the process of opening (digital) collections. In an ideal world scenario, collections can be accessed with the least number of barriers possible.
Also, information will be easier to find and retrieve by novel query mechanisms. Time Machine will completely rethink and innovate current methods to query both digitized and born-digital content. This includes data types and objects that cannot be even digitized at the current moment. The main beneficiaries, from a stakeholder perspective, will be the general public – daily users of GLAM institutions – and, further, especially researchers.

Two main **interface paradigms** can be distinguished when **accessing digital objects and metadata** stored in the Time Machine Box: APIs (including bulk-downloads) and UIs. The former category will be public, robust, stable, as well as particularly well-documented. APIs will allow both humans and machines to interact with the data.[9] Time Machine user interfaces, on the other hand, will come in various shapes and forms and are expected to be tightly coupled with and integrated into workflows at GLAM institutions. Besides the data itself, users will also be able to **access Time Machine services** (e.g., the Large-Scale Inference engine) via APIs and UIs.

Time Machine will let users retrieve information in **various modalities or languages**, and provide **assistance** based on users' preferences or skill-levels (given the users' consent and paying particular attention to privacy issues). With the unique qualities of a physical, **tangible object** and environmental friendliness in mind, Time Machine data will be dense enough to let users manifest query results in a physical form (e. g., by printing 3D objects from 3D models stored in Time Machine) or reproduce and interact with data via **tactile interfaces**. Especially the blind and visually impaired users of GLAMs will benefit from this.

Connections to other WPs: 2.1 Data Storage, 2.2 Human-Computer Interaction and Visualization

Collection Curation, Engagement & Experience

Today, immersive experiences in GLAM institutions are separate initiatives. Their realization is cost- and labor-intensive and requires an interdisciplinary team of curators, branding experts, storytellers, digital strategists, programmers, technicians, designers, and others.

Time Machine will provide frameworks for enabling institutions to provide richer and more diverse experiences for their users, both in a physical, augmented, and virtual setting. This is not limited to experience collections, it can also include talks, performances, or other events. In the physical realm, this is also not limited to GLAM institutions, it can even extend to urban spaces.

Time Machine will introduce **ground-breaking multisensory experiences**, that are elegant, authentic, nuanced, unobtrusive, and customizable according to the user's needs – a truly positive experience by explicitly adopting multimodal interfaces and feedback mechanisms. In museums, or spaces where physical and virtual worlds overlap, Time Machine lets users experience artifacts by providing room for imagination, the ability to dive deeper or contextualize, and the ability to augment or generalize when needed.

GLAMs face the challenge of incomplete collections, and especially incomplete metadata. Time Machine's solid foundation in linked data helps curators to identify **and presumably fill thin areas within collections**. Moreover, Time Machine's simulation engines present experimental yet plausible scenarios for filling in blanks. Further refinement of these proposed avenues for exploitation will be fostered in expert interviews with stakeholders. Examples for sparking discussions and inspiration in expert interviews could be of the following:

- **Mixing of physical and virtual spaces, GLAMs as smart spaces[10]**: Imagine letting users experience different versions of the same exhibition. This could be achieved by letting users choose context: their time resources ("I have limited time"), knowledge about a topic ("I am familiar with the basics"), level of detail ("I just need an overview"), their mood, emotional state, or even different versions programmed by curators. These user preferences could completely change the virtual and augmented realm of a given space. By exploiting the Big Data of the Past, Time Machine could foster unique experiences.
- **Feedback of user experiences into Time Machine**: to share knowledge among institutions by linking institutions via standardized Time Machine services and tools.

[9] APIs could be of relevance not only when using but also when contributing data to Time Machine.

[10] https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2019/

- **Shift between various modalities of objects**: Since Time Machine provides a huge amount of metadata, users could choose their preferred way of perceiving an object. This could lead to a vast reduction of barriers in GLAMs and a broad range of innovative applications utilizing multi-modality.
- **Digital twins**[11] at GLAMs

Connections to other WPs: 2.2 Computer Vision Pattern Recognition, 2.2 Computer Graphics, 2.2 Human-Computer Interaction and Visualization

Collection Linking, Reuse & Remix

Time Machine will provide services and tools to make objects and collections travel beyond GLAM institutions. In this scenario, Time Machine acts as a **proxy for heterogeneous data sets** and simplifies data communication between GLAM institutions and other sectors significantly. Through the adoption of **automated data linkage** based on customizable parameters, disparate data storages will be able to "communicate" and create **new bodies of knowledge**. These bodies of knowledge will be queryable by the public and institutions alike. Through redundant, reliable, distributed storage with Time Machine, challenges in **digital long-term preservation** will be addressed.

Time Machine provides state-of-the-art and ready to be customized frameworks to **reuse and remix data** in intuitive ways that foster exploration, e. g. by humans on crowdsourcing platforms, GLAM labs, and raw data APIs; or semi- and fully automated using machine learning. These initiatives will further feed data and new knowledge back into Time Machine's databases. Also, these frameworks will lead to **European-wide and transdisciplinary collaborations**.

Beneficiaries of these innovative remix methodologies can be found in education, research, and creative industries.

Further, the **monetization and distribution** of single objects and entire collections will be addressed by Time Machine, including a discussion of "levels of openness". With innovative business models, GLAM institutions will be provided new sources of income. However, when discussing business models, the Open Data Movement and FAIR12 data principles must be considered.

Connections to other WPs: 2.1 Data Storage, 2.1 Data Modelling, 2.2 Human-Computer Interaction and Visualization

Methodology

Despite sharing common characteristics, we propose to not treat galleries, libraries, archives, and museums as a single, unified entity when discussing potential exploitation. With GLAM institutions acting as one of the main contributors, but also as processors and users of Time Machine data, the interplay between the Time Machine initiative and GLAM institutions (as well as neighboring exploitation areas like creative industries and smart tourism) is a complex and multifaceted relation. In general, GLAM institutions interact with Time Machine in three ways, or "roles": **data contribution**, **data processing**, and **data use** (see section 3: "Stakeholders" for more details). Data contribution, processing, and use all refer to the artifact itself as well as its standardized description and metadata. Moreover, GLAM institutions can provide domain expertise to the Time Machine initiative.

We recommend pooling the following tentative roadmap in **thematic clusters** containing various activities for the coming years. Activities and consultations of members of the Time Machine Organization are expected to shape and refine these **tentative roadmap topics**. Some aspects of this tentative roadmap overlap and require coordination (especially with WP3 that deals with

[11] https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2019/

[12] https://www.force11.org/group/fairgroup/fairprinciples

processes of setting up Local Time Machines). Proposed roadmap activities also run in parallel and are not necessarily dependent on each other.

Cluster 1: Vision and Strategy

The goal is to place Time Machine as an essential initiative in the digital transformation of GLAMs. This first cluster not only deals with disseminating Time Machine concepts and developments to relevant stakeholders in GLAM institutions but also governs collaboration between TMO and participating GLAMs. Ideally, this leads to further exploitation opportunities and an overarching, refined understanding of Time Machine's vision, mission, and values.

Tentative activities include:

- **Strategic task force.** Establishing a dedicated think-tank on a strategic level is expected to lead to a jointly shaped vision and strategy for exploiting the Big Data of the Past. We propose that this think tank consists of GLAM institution's key stakeholders and representatives of the TMO and is linked to Local Time Machines where applicable.
- **User stories and use cases.** Formulating generic user stories and use cases within the GLAM domain facilitates the identification and clarification of system requirements on an operational level. We suggest linking user stories and use cases to the proposed GLAM roles (*data contribution*, *data processing*, *data use*) or to the expected areas of impact for GLAM. We plan to establish the definition of user stories and use cases, as formal outcomes of ideation by the strategic task force, as a recurring, iterative process.
- **Dissemination for GLAMs.** Emphasizing and tailoring Time Machine's key benefits and current developments for GLAMs especially is crucial when trying to foster the uptake of the initiative. We propose to base dissemination activities around the principal areas of expected impact for GLAM.

Cluster 2: Experimentation and Exploration

A prototypical framework will allow GLAM institutions to test technological advancements of WP2 and operational breakthroughs of WP3. Activities grouped in this cluster are intended to foster agile experimentation. To minimize the organizational overhead required to enable this cluster, we propose to focus on a few select GLAM institutions.

Tentative activities include:

- **GLAM selection.** Defining a set of criteria to select GLAM institutions for pilot actions paves the way for fruitful results of exploitation. We propose a few preliminary topics influencing selection criteria to be further developed with stakeholders during the CSA-phase and later by the strategic task force in cluster 1. Areas could include the institution's profile (established vs. new player), framework conditions (varying depending on location), and alignment with Time Machine's vision, mission, and values (it could prove beneficial to reach out to GLAMs that are not familiar with Time Machine, e. g. to identify and address pain points that hinder adoption of Time Machine services).
- **Pilot action building-blocks.** Defining distinct scales for pilot actions within the TMO is crucial in serving a range of potential partners in the GLAM sector. For pilot actions, it is essential to reduce entry barriers to allow both established institutions and smaller organizations to participate. For instance, to strengthen GLAMs' role of data contributors to Time Machine, pilot actions could include the application of both top-down and bottom-up digitization pipelines (as proposed in WP3) or the exchange of well-documented and unbiased training data sets.
- **Execution of pilot action / Test scenarios.** This activity deals with executing and handling the pilot action that consists of concrete, tailor-made test scenarios (e. g.: for novel business models and Time Machine services), as well as its documentation for other clusters. These

test scenarios are based both on formulated top-level user stories and on the specific parameters of selected GLAM institutions for pilot actions.

- **Local Time Machines, crowdsourcing-, and co-creation platforms.** We propose to design and setup crowdsourcing initiatives and co-creation platforms and interlock them with Local Time Machines to boost engagement with various audiences.

Cluster 3: Generalization and Sustainability

The purpose of this cluster is to increase the likelihood of adoption of the Time Machine initiative in the medium- and long-term by creating generalized models deduced from learnings collected (in other clusters).

Tentative activities include:

- **Impact assessment.** We propose to establish assessment measures of pilot actions and tests based on the concept of impact, focusing on *digitization*, *indexing*, *connection*, and *experience*. This impact assessment will mainly focus on activities and end users in the GLAM sector. However, also the Time Machine initiative is expected to be impacted by exploitation avenues.
- **Reporting and documentation.** Insights of pilot actions and smaller experiments should be continuously documented in order to be reusable.
- **Model and generalization.** Creating generalized models based on outcomes of impact assessments and pilot actions will enable a large-scale roll-out of the Big Data of the Past.
- **Large-scale roll out.** Based on models and generalized principles, eventually, this activity will allow for large-scale EU-wide exploitation of Time Machine in a GLAM domain and will provide data, services, and tools for the greater good of European society. In conclusion with previous findings and learnings, this activity's objective is to ensure Time Machine's long-term sustainability well beyond 2030.

Cluster 4: Collaboration and Outreach

In collaboration with neighboring exploitation avenues, such as scholarship, education, creative industries, and smart tourism, lies tremendous potential both for GLAMs as well as Time Machine – both in developing business models, as well as sharing resources and synergies. Beyond connecting to other domains, this cluster deals with the engagement of the general public.

Tentative activities include:

- **Creation of a smart cluster.** Based on the S3-framework[13] (Smart Specialisation Strategy), smart clusters will be formed to foster exploitation beyond GLAMs (see "smart tourism" for more details). This activity is intended to involve regional political stakeholders and is planned to be executed together with neighboring exploitation avenues creative industries and smart tourism.
- **Connection to Local Time Machines.** To reinforce Time Machine's sustainability across regions, GLAMs will be profoundly involved in Local Time Machines. We propose to align these collaborations with novel Time Machine business models.
- **Workflow for idea exchange.** Designing and implementing an agile workflow on an operational level within the smart cluster allows sharing ideas, developments, and corrective measures when needed.

[13] http://s3platform.jrc.ec.europa.eu/

- **Engaging the general public.** GLAMs could increase their potential in engaging the general public in a meaningful, truthful, and gratifying way (as already partially achieved with e. g. crowdsourcing platforms or labs). Also, this activity could include the transfer of Time Machine skills as proposed by creative industries.
- **Collaboration with scholarship and education.** The exploitation of Time Machine can also be fostered by linking scholarship, education, and GLAMs, e. g., by sharing intellectual property that can only be opened up through Time Machine.

This methodology outlines an overview of activities and needs to in alignment with the outreach programs of WP7 and the Time Machine Organisation.

Milestones

We propose the following milestones for the GLAM research and innovation plan:

Cluster	Milestone number	Milestone	Due date
1 Vision and Strategy	MS 1.1	Strategic task force established	YR1
	MS 1.2	User stories and use cases formulated	YR2
2 Experimentation and Exploration	MS 2.1	Selection criteria defined based on user stories and use cases	YR2
	MS 2.2	Selection process finished	YR3
	MS 2.3	Concrete test scenarios refined	YR3
	MS 2.4	First pilot action(s) launched	YR4
	MS 2.5	Impact analysis of pilot action concluded	YR6
3 Generalization and Sustainability	MS 3.1	First model derived from experimentation and pilot actions	YR6
	MS 3.2	Large-scale roll-out started	YR9
	MS 3.3	Sustainability plan	YR6
4 Collaboration and Outreach	MS 4.1	First smart cluster set-up or GLAM institution involved	YR2

Key performance indicators

The Big Data of the Past will strengthen (and reposition) GLAMs as innovative players that create a huge impact on society and economics in Europe and beyond. In order to measure impact based on our proposed methodology, we outline a few tentative key performance indicators:

Cluster	Key Performance Indicators
1 Vision and Strategy	• Diversity of stakeholders in the strategic task force (established and new players, various levels of familiarity with Time Machine, different subsectors of GLAM) • Number of use cases for Time Machine in the GLAM sector developed by the strategic task force
2 Experimentation and Exploration	• Number of GLAMs eligible for pilot actions based on selection criteria • Human resources in GLAMs dedicated to connecting GLAMs to TMO • Number of pilot actions launched • Number of test scenarios generated • Number of adopted co-creation and crowdsourcing-platforms for contributing metadata to Time Machine
3 Generalization and Sustainability	• Number of jobs in the sector created that are attributable to Time Machine • Ratio of accessible vs. inaccessible material • Ratio of digitized vs. non-digitized material • Speed of digitization • Number of adopted Time Machine services and tools in GLAM institutions • Number of generalized models derived from learnings in pilot actions • Number of contributed objects to Time Machine • Number of Time Machine API calls from GLAM institutions (API key)
4 Collaboration and Outreach	• Number of GLAM institutions becoming new TMO members • Number of collaborations with other sectors (e. g. creative industries) contributing to providing state-of-the-art experiences in GLAM institutions • Number of collaborations with research institutions • Number of realized Local Time Machines with GLAM institutions being a leading or contributing factor

Funding sources

National Sources

Most GLAMS in Europe are funded through national (or regional) budgets: member states assigning annual budgets for the institutions that are of (inter) national or regional importance. The requirements for funding differ substantially between countries. Most of the national budgets are earmarked within the organization (e.g. staff, collection development, digitization, marketing, etc.). Most organizations rely on projects funding for their innovation needs.

These innovation needs can be funded through national funds that are often developed in project calls, which goes for digitization as well. The Time Machine platform could work as a catalyst for these types of funding, linking national funding to Time Machine funding.

Other GLAMs function with governmental support as independent organisations, e.g. from endowments or entry fees. These cover mainly the basic needs of the organisation.

European Union Funding

The EU funds many research and innovation actions through its R&D programs. This is often done in collaboration between institutions in different member states, linking research institutes, universities with the organizations in the field. There is a huge competition in getting this funding, but it is an important source of income to the GLAM sector (especially research libraries, documentation centres, and large museums).

Funding by non-governmental institutions/individuals

Several non-governmental institutions act as financial supporters for GLAMs. Often, they are of a philanthropic nature or public supported such as (national) lotteries or similar organization. They tend to fund GLAMs for a longer period of time and provide basic income for the organizations. Or they fund specific types of work in the GLAMs (e.g. building extension, website development, marketing, outreach).

Stakeholders

The concept of roles

Galleries, libraries, archives, and museums play a vital role as data contributors for Time Machine – given the institutions possess CH-objects that are of value for the general public and want to contribute them. This initial step requires competent execution of selection, curation and quality control processes – a set of very complex tasks and routines with little standardization. Herein lies great responsibility for GLAM institutions. For this very important step to function properly, novel digitization techniques that not only provide the technical capabilities but also deal with ethical, financial, context-, and content-related issues must be set in place.

However – with the full force of the Time Machine initiative up and running – GLAM-institutions could also greatly benefit themselves: as data processors (enablers) and as data users (end users of Time Machine data).

Stakeholders and end-users

During the Time Machine Brussels workshop, some key stakeholders benefiting from the Time Machine initiative have been identified. Each of the following stakeholders – or end-users – can take on different and multiple roles: data contributors, data processors, or data users. The following list contains internal and external stakeholders because Time Machine will impact both:

- **Researchers, scholars, and education professionals** that rely on GLAM resources and services regularly to cater to their professional needs ;
- **General public** as GLAM clients and customers that take a personal interest in GLAM resources and services: e. g. readers, citizen scientists, hobbyists (like genealogists), (media) artists and creatives, documentalists, library or museum visitors, tourists, … ;
- **GLAM visionaries** rethinking the roles of institutions with a strong strategic focus ;
- **GLAM operational staff** dealing with (digital) collections: e. g. curators, custodians, digital strategists, outreach specialists, digital collection managers, digitization managers and experts, restorers/repairers of artifacts, data scientists, data librarians, event managers, …;
- **Designers and creatives** outside of GLAM institutions that are shaping and envisioning experiences at exhibitions: e. g. architects, branding experts, storytellers, copywriters, media designers, planners, creative coders, … ;
- **GLAM supporters** in organizations that constitute close-knit units with GLAM institutions and act as enablers. Individuals and organizations, that lay the groundwork and frameworks in which GLAMs operate in: e. g. policymakers, funders, collective rights agencies, public or private foundations, umbrella associations (supporting policy makers), … ;
- **Multipliers** creating outreach: e. g. journalists, media professionals, event hosts, education agencies, tourism boards, …

Framework Conditions

Below we propose an initial list of framework conditions relating to policy, legal aspects and ethics that have to be taken into account when further refining the roadmap for exploitation in GLAM:

Framework	Proposed action
IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems14 / AI ethics	Check dependencies on WP2, WP5
Different copyright policies on a national level	Check dependencies on WP5
Data ownership aligning to GDPR15	Set up a process to monitor compliance within TM
Copyright and rights management	Check dependencies on WP2, WP5
Data storage contracts	Check dependencies on WP2, WP5
Compliance to data quality standards	Since GLAMs will also act as data contributors: Align with other WPs to comply with data quality standards

Risks and barriers

The following table contains a preliminary, non-exhaustive list of risks and barriers that possibly hinder the adoption of Time Machine services, tools, and data and provides initial and general risk-mitigation actions.

Potential risks and barriers	Likelihood	Impact	Proposed risk-mitigation actions
GLAM institutions do not see the benefit of Time Machine in their role as data contributors, data processors or data users	Low	Medium	Proper dissemination and roadmap design, proper frameworks
GLAM institutions cannot carry out quality control of contributed data	Low	Medium	Streamline data control mechanisms, standardize processes and workflows and communicate them
GLAM institutions cannot afford to participate in Time Machine for legal, financial or other reasons	Medium	Medium	Provide frameworks and workflows that help mitigate any legal or financial hurdles for institutions, especially aid with copyright clearance
Inconsistent GLAM data and Time Machine data	Low	Low	Establish proper synchronization mechanisms
Concerns that open data could prevent monetizing collections	Low	Medium	Provide best practice examples that show that GLAM institutions can greatly benefit from open data

[14] https://standards.ieee.org/industry-connections/ec/autonomous-systems.html

[15] https://eugdpr.org/the-regulation/gdpr-faqs/

Potential risks and barriers	Likelihood	Impact	Proposed risk-mitigation actions
			Provide a licensing framework that does not interfere with open data paradigms Find a good balance between open source and commercial models, and find ways to monetize the outcomes
Diverse needs/profiles within GLAMs	Low	Medium	During the first few years of establishing Time Machine, different profiles of GLAMs will be addressed
Replacement of the analog object	Medium	Medium	Communicate that the replacement of the analog object with the mere digital representation is not a Time Machine objective
The participating institution wants to withdraw previously contributed objects / data from Time Machine servers	Low	Low	Design a process that allows withdrawal of objects
GLAMs collecting additional forms of analog and digital artifacts besides well-established objects in the future	Medium – High	Medium	Design the Time Machine Box object-indifferent and extensible to make Time Machine compatible with hybrid collection traditions at GLAMs

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5.2 Creative Industries

This section presents the draft roadmap for exploitation in the creative, media and entertainment industries. It presents the results of literature research and consultation with Time Machine consortium members during workshops.

Research and Innovation plan

Objectives

Creative, media and entertainment industries are an integral part of a strong European economy and an engaged society. Time Machine data and services will introduce transformative effects which will offer completely new avenues and innovation prospects for these industries. The Big Data of the Past has the potential to become a rich resource for inspiration and creativity and will be exploited to create new works, experiences and products. Local Time Machines will open opportunities to experiment with this novel data and technologies, create opportunities for cross-sectoral collaborations and foster frameworks that support the remuneration of creative outputs. This will have a transformative impact on the creative value chain across the creative industries and beyond, enabling organisations and individuals to take part in a competitive market and deliver high-quality creative products for commercial exploitation.

The roadmap for exploitation creates pathways for stakeholders in the creative, media and entertainment industries to successfully take up these and experiment with these innovations and materialise the envisioned social and economic benefits of the Time Machine project. The objectives of this research and innovation plan are to:

- Create pathways for creative industries to exploit Time Machine data and services via Local Time Machines;
- Identify and address framework conditions that will enable and accelerate experimentation and exploitation;
- Establish connections with stakeholders in other sectors for cross-sectoral collaboration and scaling.

State of the art, technological monitoring

Exploitation possibilities in the creative, media and entertainment industries are influenced by:

- Development of **immersive technologies and computing possibilities.** With the development of VR, AR, XR, 360 video technologies, creative industries have tools in their hands to create immersive experiences that before could only be offered through a distance and mediation. Visualisation and processing capabilities are opening new pathways to interact with data. To take full advantage of these technologies, the integration of rich data sources is necessary so that engaging narratives and experiences could be created. What is more, these new technologies require new digital literacy skills.
- **Entry barriers and scaling-up**. While the self-employed individuals and SMEs constitute a large part of the creative sector, it is increasingly difficult for small players to compete with industry giants who have the means to invest in innovative technologies and have the resources to develop new skills to quickly harness them.[16] What is more, value assigned to creative works often depends on the reputation of dissemination and publication platforms that set high entrance barriers that prevent smaller players from participating and competing in the market.

[16] 95% of all cultural and creative institutions employ only up to nine people.

- **The subscription economy**. Business models for entertainment consumption (e.g. Video on Demand, music streaming services, subscription models in online journalism) shift away from one-and-done product purchasing to ongoing service-oriented experience.[17] For the industry this means reinventing what it means to sell, making a shift from monetising products themselves to monetising relationships and experiences.
- **The platform society**. This relates to a transition that companies are making from mainly offering products to mainly offering platforms that have a vast macro-economic impact. Many of the most valuable companies globally are now based on a platform business model - the creation of digital communities and marketplaces that allow different groups to interact and transact. This is also relevant for Time Machine, as it is likely that more and more heritage content will reach end-users through such platforms rather than their own channels. However, currently the industry has to rely on cooperation like Apple, Google and Facebook as there are no European alternatives on the market. The EU currently represent only 4% of large online platforms.[18]
- **Open movement**. Open movement models - open access to data, open source software, open design, open science and research - are increasingly competing with and replacing proprietary frameworks. In line with the goals of the Digital Single Market, open movement supports mobility and circulation of knowledge and resources. Commons-based peer production, the model of socioeconomic production in which large numbers of people work cooperatively, has resulted in initiatives such as Wikipedia, Linux and many others.[19] This movement is an important shift that drives creative diversity and contributes to innovation in the private and public sectors.
- **Personalised experiences for engaged audiences**. Digital users online are not passive consumers of linear, static content - they are increasingly seeking personalised, interactive, adaptable stories that respond to their interest and their content consumption habits on the fly. Tools for smart curation and media adaptation for specific platforms and audiences are increasingly gaining prominence in the market. What is more, audiences are increasingly engaged in the co-creation of narratives and can provide an additional level of context from different perspectives.
- **Converging digital and physical spaces.** Creative professionals are increasingly dealing with the convergence of digital data and physical environments, and it is proving to be an effective way to increase productivity, optimise workflows and communication and discover new perspectives from interactions between the two environments. Stakeholders could benefit from finding solutions to seamlessly integrate physical and digital spaces – e.g. use holograms to visualise sketches, design models “on the go”, use digital interfaces that adapt to or incorporate physical features, etc.
- The structured **distinction between producers and audiences is disappearing**. Open communities of practice are more prominent where production and distribution of content is not necessarily market-mediated and where the distinction between producers and users becomes blurred to an increasing extent. The immense popularity of independent content creators on YouTube, Instagram and the abundance of podcast creators are all testament to this.

The *Mapping the Creative Value Chains* report[20] establishes that although digitisation has already significantly impacted the cultural and creative sector, it has not drastically transformed creative

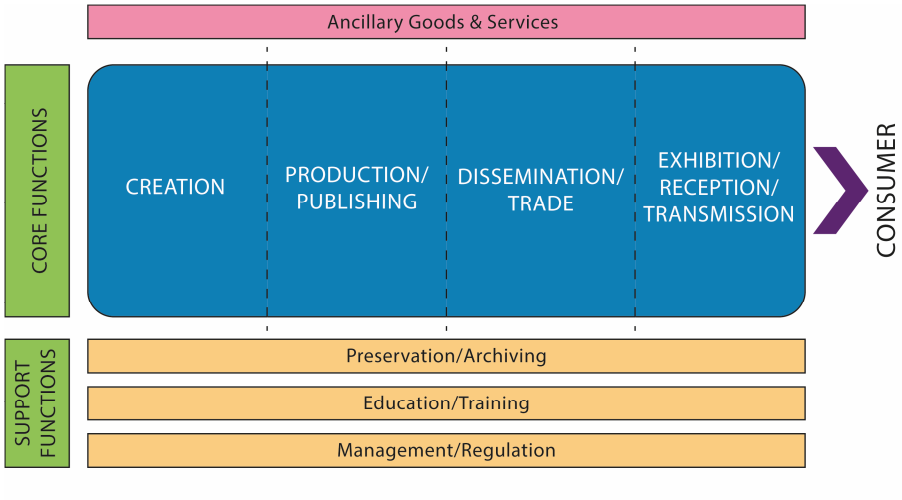
[17] Music industry is at the forefront of adopting subscription models in the creative sector. In 2018, streaming services accounted for 50% of recorded music revenue.
https://www.pwc.com/gx/en/industries/tmt/media/outlook/segment-findings.html
[18] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0288
[19] See https://en.wikipedia.org/wiki/Commons-based_peer_production#Examples
[20] See http://www.keanet.eu/wp-content/uploads/Final-report-Creative-Value-Chains.pdf

value chains. The main challenges that constrain the development of creative outputs and their exploitation possibilities:

- **Lack of skills and capacity** for small scale and individual creators to harness opportunities opened up by digitization;
- **Quality of data** available for reuse limits possibilities to find and retrieve relevant sources. Inaccessibility of audiovisual, multimodal, multilingual resources and inaccuracy of 3D scanning technologies are major barriers for exploitation;
- **Reliance on large-scale (mostly non-European) intermediaries** who control publication, dissemination and exploitation processes and thus can dictate the terms of remuneration which often end up benefiting intermediaries rather than creators. This imposes major bottlenecks for exploitation of creative outputs, especially preventing smaller actors from finding their place in the market;
- **Fragmentation of data sources** across a large number of digital platforms. In addition, often access to good quality content is controlled by gatekeepers who can impose barriers that are not beneficial for the creative sector where production processes are hindered by the lack of interoperability and intergration between data sources and tools;
- **Lack of understanding about the ethics of artificial intelligence** is preventing the sector from taking full advantage of this technology or can often result in the production of outputs that are infused with biases;
- **IPR and copyright** restrictions or lack of clarity about them. It is easier not to reuse data rather than take the risk. There is a **lack of efficient mechanisms that would support the reuse** of cultural data as well as lack of awareness within the creative communities about the reuse possibilities with cultural heritage data;
- **Online piracy** discourages creators to disseminate their works as their efforts are not often met with adequate remuneration. There is a growing need for **smart mechanisms to protect new productions** online and monitor their use online to ensure appropriate compensation for creators. Given that production processes can be rather expensive, the fear of piracy forces creators to impose access restrictions;
- **Lack of contextualisation and mechanisms to ensure authenticity of data sources** result in misinformation or creation of overarching narratives that do not accommodate the coexistence of multiple truths from different perspectives.

Targeted achievements

Creative industries consist of various domains that could benefit from Time Machine in different capacity. We identified the nine areas: Advertising and Marketing, Architecture, Broadcasting, Design, Film and Video, Game industry, Journalisms, Music, visual and performing arts and Publishing (see Annex ‘Domains in the creative, media and entertainment industries’). Time Machine will introduce scientific and technological breakthroughs that will significantly impact the production cycle within these domains. It will challenge the existing creative value chains and market dynamics by introducing new opportunities, roles, activities and business models. We propose to use the steps in this cycle to anchor where Time Machine should concentrate its efforts.



Creative value chain model for the creative industries[21]

The ways 'data of the past' is exploited in these domains is endless - as a source for creative reuse and inspiration, a source of trustworthy data, a training set for developing new tools, etc. The use cases for exploitation developed with stakeholders from the industry will highlight some exemplary uses where Time Machine can have meaningful impact on the European economy and culture, They will make explicit how the orchestrated work in Pillars 1-4 can realise new exploitation avenues and optimise existing ones, galvanising user interest and opportunities provided through actions of TMO and its members.

Against this backdrop, an initial assessment on the relation between TM achievements in the value chains model and map their connection to the development work foreseen in Pillars 1 and 4 is outlined below.

1. Creation - elaboration of ideas, contents and products.

Large quantities of multimodal data made available through the use of advanced computing technologies and data visualisation techniques can support the exploration and retrieval of yet undiscovered patterns, connections and observations from multimodal data which will serve as an inspiration for the development of new creative ideas. For instance, pattern recognition for audio collections would allow musicians to find samples based on specific rhythm or notation and use these archival samples to produce new creations. In the context of journalism and publishing, access to structured data sources (newspapers, current affairs programming, web archives, etc.) will help to explore a topic before delving deeper. Data visualisation tools will make it possible to detect trends, patters and outliers.

The open and interoperable infrastructures for data exploration will enable creative freedom and diversity and offer access to distributed collections. Artificial intelligence will also support new forms of creativity, for instance, in the creation of immersive and personalised experiences and interactive storytelling.

Using Time Machine data as a training set, creative industries will be able to develop new technologies. For instance, advertising companies interested in building algorithms for content personalisation will be able to use Time Machine data spanning through centuries to train more accurate algorithms, instead of relying on datasets provided by major commercial companies.

[21] https://op.europa.eu/en/publication-detail/-/publication/4737f41d-45ac-11e7-aea8-01aa75ed71a1/language-en/format-PDF/source-30933297

Connections to Pillar 1: 2.1. Computer Vision and Pattern Recognition, 2.2. Natural Language Processing, 2.3. Human-Computer Interaction and Visualization 2.4 Machine Learning, 2.5 Computer Graphics.

2. Production/Publishing - the making of original, non-reproducible or reproducible work.

Production processes will be supported by easily finable, high-quality resources. Rich cultural data will be available as assets for creative reuse according to the FAIR data principles (findable, accessible, interoperable and reusable), providing sufficient context and level of granularity. Metadata models will support the ability to combine and seamlessly integrate digital objects in different variations to tell different stories.22 For example, in the context of data-driven journalism, editors will be able to refer to and link to distributed primary sources in their articles in third parties and citizens to check the provenance of data that form the basis of their argument.

Storytelling will be enhanced using groundbreaking simulations and visualisations. Possibilities to query granular properties of digital objects (including spatial, temporal, tactile, visual and aural qualities) will support the emergence of new kinds of storytelling techniques that appeal to different senses. In addition, ability to virtually create complex visualisations from a multitude of sources will assist in reconstruction of authentic historical locations. These locations could then be used to create set designs in films, documentaries and theatre productions, significantly reducing the resources and time needed to recreate historically accurate, detailed and engaging sets.

The increased computational capabilities for big data processing will also reduce the complexity of production processes, e.g. in architecture, interoperability of multimodal data will support complex building information modelling that can accurately reconstruct a building's life throughout history and inform decisions for its future reconstructions and preservation. In addition, Time Machine infrastructures will offer an alternative to the current gatekeepers and intermediaries in the market who set high barriers around access to high-quality content; this will significantly improve opportunities for SMEs and individuals in the creative industries. Reuse of data will be supported by implementing licensing mechanisms that respect intellectual property ownership and take into account special provisions for GLAMS in the most recent EU copyright regulations.[23] Newly developed services and business models will ensure that citizens, communities, innovative businesses and individual creators can benefit from these transactions.

Connections to Pillar 1: 2.3. Human-Computer Interaction and Visualization, 2.5 Computer Graphics, 2.6. Super Computing.

Connections to Pillar 4: 5.2 Policy and Legal issues, 5.4 Exploitation Support Structures.

3. Dissemination/Trade - dissemination of cultural products to make them available to consumers and distributors.

Supported by new business models, licensing frameworks and high-quality resources, creative industry players will have more bargaining power to enter the market and promote and disseminate their creative outputs. Smaller and much more diverse players are likely to emerge, further fostering creative circulation in the digital single market. For instance, mechanisms for fingerprinting and licensing the use of content on a fragment level will increase the reuse of broadcaster content in new productions and ensure its renumeration.

Machine learning and natural language processing technologies will support the delivery of high-resolution experiences at a massive scale for broad audiences and over various platforms. Other

[22] For example, BBC developed toolkit for production teams to create personalised object-based experiences and narratives. See https://www.bbc.co.uk/rd/projects/object-based-media-toolkit

[23] https://pro.europeana.eu/post/explainer-what-will-the-new-eu-copyright-rules-change-for-europe-s-cultural-heritage-institutions#text-and-data-mining

sectors, including the tourism industry, GLAMs and education, will benefit from novel services and experiences designed for their end-users. What is more, building on top of Time Machine resources and infrastructures, creative industries will be able to develop their own platforms suited for their specific needs. For example, designers would be able to build new platforms that provide Time Machine data and external resources and use data processing and visualisation tools to analyse, compare and annotate all this data on a granular level. With more creative products to offer, the role of European online platforms in the digital market will gain a prominent role and attract much more traffic and investment.

Connections to Pillar 1: 2.2. Natural Language Processing, 2.3. Human-Computer Interaction and Visualization, 2.4 Machine Learning.

Connections to Pillar 4: 5.2 Policy and Legal issues, 5.4 Exploitation Support Structures.

4. Transmission/exhibition/reception - provisioning access to creative products for consumption.

Metadata about the Intellectual Property will be managed in a machine-readable way to track copyrighted content on a granular level (tracking of individual elements or excerpts) and support remuneration and reuse. Collective licensing frameworks and other security mechanisms (e.g. smart contracts) will support smaller actors in the sector and provide sustainable revenue streams. Time Machine will also develop models that will help to incorporate user-generated content and crowdsourcing knowledge, in this way increasing cultural participation and raising awareness about the potential of cultural heritage.

In line with "A vision for a shared digital Europe"[24], Time Machine supports the need for decentralised infrastructures for content distribution as a way to bolster Europe's independence from US-based platform. Also, we stress the importance of the right to privacy and the need for more democratic models of data governance and algorithmic transparency. These provisions will need to be included in the design of services. In effect, TM needs to engage in dialogue with innovative SMEs and industry to also sign up to principles of a shared digital Europe and see how they can have a positive effect on their business models.

Connections to Pillar 1: 2.7. Simulation & Knowledge Generation, to be added to WP2 taxonomy - Intellectual Property Rights Ontologies and Mechanisms.

Connections to Pillar 4: 5.2 Policy and Legal issues.

Methodology

Given the broad scope of the creative, media and entertainment industries (see Annex A for a list of domains in the creative industries), each domain might be dealing with different framework conditions and existing infrastructures that would influence their capacity for exploiting the Time Machine data and services. Their level of readiness to enter the Time Machine ecosystem might be very different and cannot be generalised. They need a gateway which would initiate and accelerate exploitation.

The Local Time Machines would act as this gateway, a launchpad for bringing stakeholders from the creative industries to the Time Machine ecosystem, enabling them to exploit the Big Data of the Past and benefit from the tools and infrastructures that it provides. Each Local Time Machine would act a smart thematic cluster that would invite stakeholders from the creative industries to develop products and services around it. Based on their individual strengths, technological developments and regional support, Local Time Machines would build and grow communities of stakeholders from across the creative industries, as well as stakeholders from other exploitation areas, and create the conditions for them to exploit the Time Machine resources. Starting on a local/regional level with local stakeholders, the network of Local Time Machines would expand and support cross-sectorial and

[24] https://shared-digital.eu/

cross-regional collaborations and stakeholders to benefit from the pan-European Time Machine infrastructure and resources.

To bridge the gap between the state of the art and the desired targeted achievements in the creative value chain, Time Machine Organisation will initiate activities that will foster exploitation and ensure its sustainable and ongoing growth. Activities are organised into five clusters:

- Collaboration and Outreach
- Use Cases
- Incubation
- Support Mechanisms
- Sustainability

These activities run in parallel, informing and supporting each other. They run in a cyclical manner, iteratively responding to new use cases, technological developments and changing framework conditions. The outcomes activities will in turn continuously guide work in Pillars 1, 2 and 4.

Cluster 1: Collaboration and outreach

Local Time Machines will position the creative industries as an integral part of the Time Machine ecosystem that can provide new products and services for GLAMs, tourism industry and education as well as other sectors, in this way increasing and opening exploitation opportunities and supporting the Digital Single Market. Local Time Machine will play a key role in facilitating these cross-sectoral connections to embed creative products in other industries as well as reaching new players in the creative industries who could benefit from the Time Machine. The following actions for facilitating collaboration and outreach are proposed:

- **Time Machine Ambassadors**. Identify representatives from the different domains in the creative industries who could offer their expertise to the Time Machine consortium, act as mediators between the Time Machine and the industry, help to mobilise new stakeholders and participate in the ongoing development of standards, legal frameworks and infrastructures that support exploitation.
- **Creative residencies** to connect individual creatives and SMEs to other sectors - in particular, GLAMs, tourism industry and education.
- Training/mentorship/peer-learning programmes that **target creative individuals and SMEs to support collaborative creation and capacity building**. Stimulate cooperation models that help smaller actors join and compete with larger players.
- Collaboration with existing creative hubs and infrastructures that support creative entrepreneurship. Making use of these pre-exiting infrastructures will be an important step in establishing the reputation of Time Machine among its key stakeholder groups and galvanising the exploitation. Time Machine will connect with the creative networks and communities across Europe, offer its resources for testing and exploitation as well as share knowledge and standards.

Cluster 2: Use Cases

It is essential to validate the proposed roadmaps against real-life scenarios that would then iteratively guide more specific developments of the Time Machine tools and infrastructure. To galvanise this process, the Time Machine proposes to **develop use cases for each domain in the creative industries**. Time Machine will invite representatives from the creative industries to develop use cases that address for instance socioeconomic issues or respond to changing user expectations (e.g. journalists tackling misinformation or publishers developing podcasts based on archival material) and showcase immediate exploitation impact on the European society. These use cases will help to refine the roadmap and the proposed exploitation strategies, as well as attract interest and investment in Time Machine.

The realisation of such use cases will serve as a proof of concept that demonstrate the social, cultural and economic impact of the Time Machine. The result will inform activities in Pillar 1: Science and technology for the Big Data of the Past, Pillar 2: Time Machine Operation and Pillar 3: Innovation and Outreach. Furthermore, these use cases will also strategically position and demonstrate the exploitation impact in the creative industries and define priorities that need support from the decision-making bodies.

To give a concrete example, stakeholders from the game industry would be invited to develop a use case where they develop a new product using Time Machine resources and tools. As an industry that holds a prominent position in the European market and already has connections to the cultural heritage sector, game industry is strategically positioned to efficiently embed the innovations introduced by the Time Machine into its exploitation mechanisms and business models. The proven success of video games that reuse cultural heritage resources developed by companies such as Ubisoft, Semantika and DROPSTUFF.nl, point to exploitation potential that other domains in the creative industries could tap into. Video games can unleash the capabilities of the Big Data of the Past to the full extent - using cutting-edge technologies, game developers can take advantage of the multimodal cultural heritage resources to create immersive experiences and build rich historical narratives that provide a great level of detail. In addition, given the large number of independent and amateur game developers, it would also serve as a testing ground to see how SMEs and self-employed actors in the industry could find their place in the market with the help of the Time Machine.

Cluster 3: Incubation

The central role of the Local Time Machine in this roadmap is to act as incubation hubs for the creative industries and provide knowledge, resources and networks of partners and audiences needed to test innovative ideas and exploit the Time Machine data and services. Their role is to:

- Support creative entrepreneurship in each domain within the creative industries;
- Foster experimentation with new data, technologies and business models;
- Provide an environment for testing new ideas (ideation bootcamps) and scaling up;
- Facilitate the exchange between the industry, researchers, decision-making bodies and other related sectors;
- Introduce the potential of the creative industries to other sectors and potential investors, and help to identify new opportunities.

Each hub will position itself as a thematic incubator focusing on specific domains within the creative industries determined by the expertise available and the connection with local stakeholders (e.g. Utrecht LTM could act as an incubator for journalism and media). In this way, Time Machine will develop resources and services that are tailored to use cases specific to each domain within the creative industries.

In setting up the local incubation hubs, Time Machine will build upon insights from tested collaboration models and methodologies. For instance, the Sandbox hub initiated by public broadcasters across the EU has developed a model to validate new technologies.[25] Also, collaborating with EBN, the network of over 140 business and innovation centres, and ImpactHub with more than 16,000 members will help to maximise the impact of the Time Machine.[26]

Real-life scenarios brought by stakeholders from the industry will iteratively challenge and guide technological development of the Time Machine infrastructure. An agile design methodology approach will be followed, as it will enable continuous technological and operation development and

[25] https://www.mediaroad.eu/about-sandbox-hub

[26] Real-life scenarios brought by stakeholders from the industry will iteratively challenge and guide technological development of the Time Machine infrastructure. http://www.ebn.eu, https://impacthub.net/

respond to new user expectations as they emerge. More specifically, well established insights from frameworks such as 'Design Sprint', by GV and 'Future Visioning' developed by Business Models Inc. and 'Design Thinking' will be applied where relevant.[27]

Cluster 4: Support Mechanisms

To support the incubation activities, Local Time Machines will negotiate and establish and infrastructure that foster innovation and experimentation and support the remuneration of creative outputs. These support mechanisms will also ensure that the exploitation activities carried about by the Time Machine consortium and their stakeholders are reaching their objectives. While Local Time Machine will provide targeted support for their stakeholder groups, it is essential that these support infrastructures are coordinated on a pan-European level. The following infrastructures are proposed:

- Clinics that help stakeholders in the creative industries to develop **"Time Machine skills"** (e.g. digital skills necessary to work with the Time Machine data and services). Local Time Machines could offer a certification programme to encourage the development of these skills.
- An observatory that **monitors trends and measures the impact of exploitation**. To ensure that Local Time Machines provide the necessary support for the creative industries, it is essential to continuously monitor technological innovation and trends in the sector. This observatory would provide recommendations that would enable decision-makers and the Time Machine consortium members to respond in time to the changing conditions in the market. The monitoring should be done on a domain-level to ensure that the framework conditions of each domain in the creative industries are addressed.
- Pan-European licensing hubs[28] that **oversee fair licensing regulations**, ensure remuneration for creative products and provide support for individuals and organisations in the industry (e.g. trainings on reuse possibilities with cultural heritage data).

Cluster 5. Sustainability

This activity identifies ways of enabling take-up of project results in order to achieve the expected outcomes in a sustainable way and at scale. Models for running incubation hub will be developed so that exploitation activities could be supported at a large scale across Europe and efficiently adopted by in new Local Time Machines.

Milestones

Cluster	Milestone number	Milestone	Means of verification	Due date
Collaboration and outreach	MS1.1	Hub infrastructure established	Stakeholders in the creative industries approached and strategic collaborations with relevant ancillary networks established.	YR1
	MS1.2	Outreach Strategy in place	The outreach strategy includes: (1) appointing Time Machine Ambassadors, (2) hosting of	YR1

[27] https://www.gv.com/sprint/, https://www.businessmodelsinc.com/strategy-design/future-visioning/

[28] For example, licensing hubs have been successfully established in the music industry: https://www.bmat.com/ and https://www.armoniaonline.com/

			creative residencies, (3) training, mentorship and peer-learning programmes.	
Use Cases	MS2.1	User stories created	Successful development and execution of the first round of use case with all domains from the creative industries.	YR2
	MS2.2	Concertation efforts across the TMO Pillars	Outcomes from the use case are discussed with Pillars 1, 2 and 4. This results in updated activity plans across the Pillars.	YR2
Incubation	MS3.1	Launch of the incubation activities	Methodology established and First incubation activities launched.	YR2
Support Mechanisms	MS4.1	Launching and operating the monitoring observatory	The observatory monitors trends and measures the impact of exploitation.	YR3
	MS4.2	Licensing hubs launched	The hubs oversee licensing regulations, remuneration and provide support to its users.	YR5
	MS4.3	First clinics launched	Content of the clinics co-designed with end-users.	YR2
Sustainability	MS5.1	Large-scale roll-out of incubation activities	Start-ups and scale ups identified, support scheme in place.	YR6

Key performance indicators

The exploitation of the Time Machine data and services will have a significant impact on the European economy and society. Time Machine will give a strong boost to the creative, media and entertainment sector itself but more importantly, it will produce much broader spillover effect. Notably, it will generate new ideas, knowledge and products that will benefit other industries, the public sector and European society at large. The KPIs indicate the impact within the sector as well as demonstrate these much wider effects of exploitation to ensure continuous engagement from the industry and support from the decision-making bodies. The list below is a non-exhaustive list of the most KPI's.

Cluster	Key Performance Indicators
Collaboration and Outreach	● number of cross-sectoral collaborations ● number of stakeholders from the creative industries joining the Time Machine Organisation ● growth in cultural participation and growth in social inclusions (e.g. number of products, experiences and services tailored for the disabled)
Use Cases	● number of use cases developed

	● number of stakeholders involved in the use case development
Incubation	● representation of all creative industries' domains in the Local Time Machines ● number of stakeholders connected to the Local Time Machines ● number of entrepreneurial start-up and scale-up-stage businesses initiated as a result of the incubation efforts ● number of strategic partnerships with relevant ancillary networks.
Support Mechanisms	● creative sector contribution to GDP ● number of items available for reuse (high quality, using correct rights labels) ● number of self-employed individuals and SMEs involved ● employment in the creative industries
Sustainability	● number of products and services developed for other sectors ● income from licensing and use of TMO data and services ● number of Time Machines with long-term financial stability

Funding sources

The creative, media and entertainment industries can benefit greatly from the already existing European and national funding programmes. However, these programmes often concentrate on creative content creation but do not support other activities in the creative value chain, namely distribution/trade and exhibition/reception/transmission, that are key to the exploitation envisioned by the Time Machine. What is more, this funding is often inaccessible to smaller players and self-employed individuals.

The Time Machine infrastructure should advocate for funding that provides support for the following:

- SMEs and individual players in the sector for whom barriers to apply for European funding schemes are often too high;
- Synergies between actors in the creative sector and cross-sectoral collaboration to stimulate capacity building;
- Activities throughout the creative value chain, in particular, distribution/trade and exhibition/reception/transmission.

We foresee four main sources of funding that could support these research and innovation needs in the creative, media and entertainment industries:

- **National Funding Sources**: funding sources vary per EU country. For example, in the Netherlands, the following funding streams are relevant: *Creative Industries Fund NL, NWO, Mondriaan Fund, Fonds21*.
- **European Funding Programmes**: *Creative Europe, Horizon Europe, Digital Europe, ERASMUS+, COSME, SME instrument, Structural Funds.*
- **Private sector investments**: public private partnerships, equity investment, artist in residence.
- **Crowdfunding:** reward-based crowdfunding, tax shelters, match-funding schemes.

Investments from the private sector are of key importance to fulfil the exploitation potential. Funding from the creative industries is needed to support the development of new services and products for the industry using Time Machine resources and to engage stakeholders, especially individuals and SMEs, in the exploitation activities (e.g. organise creative competitions or sponsor residencies in cultural heritage organisations). Time Machine needs to establish its reputation as a provider of high-quality, user-friendly and accessible resources and tools that can fulfil the needs of wide range of stakeholders in the creative industries.

Stakeholders

Following is a list of stakeholder groups and their respective roles in the research and innovation roadmap:

- **Representatives from the creative, media and entertainment industries** will be involved in all stages of the roadmap, actively participating in ideation, experimentation and execution of exploitation scenarios. Prominent innovators in the sector will take the lead in mobilising their respective networks developing infrastructures for exploitation.
- **Policy-makers and representatives from funding bodies** will play a key role in establishing the importance of Time Machine research and innovation needs on the European level and securing sustainable support for it. On a regional and pan-European level, they will be actively engaged in the definition and realisation of framework conditions that support creative industries, Local Time Machines and Time Machine ecosystem as a whole. Establishing ongoing engagement with them from early on and demonstrating the impact of Time Machine exploitation is crucial.
- **Related industries that benefit from the services and products developed by the creative industries,** including GLAMs, tourism industry and education, will be essential collaborators in the Local Time Machines. Together with stakeholders from the creative industries, they will develop business models and initiate experimentation with new ideas.
- **Developers and vendors** offering tools and infrastructures for the creative sector will be invited to the innovation hubs to experiment and test Time Machine resources and tools in order to ensure compatibility and alignment with external platforms and data sources. They will also help to bridge the gap between the novel technological developments and their deployment by players in the creative industries.
- **Research and Development teams** from various sectors with in-depth knowledge about research and innovation trends will be involved during the initiation and execution phases to develop exploitation scenarios, accelerate experimentation with the Time Machine tools and services and promote the take up of these innovations in their respective sectors.
- **Investors and business networks** will be attracted to invest in creative start-ups and sponsor the development of innovative ideas and products. They will also be invited to ideation sessions to help develop sustainable and profitable business models.

Framework conditions

This section considers conditions related to policy, legal aspects and ethics that need to be addressed to successfully implement the proposed roadmap for exploitation.

Framework conditions	Proposed actions
Copyright and IPR regulations	Support take up of RightsStatements.org
Pan-EU support actions for research and business in AI[29]	Demonstrate added value towards decision making
Pan-EU regulations for ethics guidelines with respect to AI[30]	Work with industry to position Time Machine as a leading example of “responsible AI”
Investigate how a good balance between private and public interests can be safeguarded as society is continuing its digital transformation	Short term: how the “Shared Digital Europe”[31] vision can be used to support the vision of the Time Machine Organisation. If this model falls short, look at other options.

[29] https://ellis.eu/letter

[30] https://ec.europa.eu/digital-single-market/en/news/have-your-say-european-expert-group-seeks-feedback-draft-ethics-guidelines-trustworthy

[31] https://shared-digital.eu/

Framework conditions	Proposed actions
Capacity building limitations and fragmentation	Provide opportunities for cross-sectoral collaboration and harmonise EU regulations
Reliance on service providers and vendors	Work with service providers and vendors to develop new standards and infrastructures that support ease of integration and interoperability

Risks and barriers

The following table lists the initial assessment of possible risks and barriers that could influence the exploitation possibilities in the creative, media and entertainment industries. It includes risks related to technical, societal, organisational and resourcing conditions. We evaluate the likelihood and impact of these risks and barriers and proposes actions that need to be included in the roadmap to mitigate them.

Potential risks and barriers	Likeli-hood	Impact	Proposed risk-mitigation actions
Low participation from stakeholders in the creative industries	Medium	Mediu m	From the early stages mobilise key players in the sector and demonstrate the positive economic, social and cultural impact.
Slow uptake of the technological innovation	Low	Mediu m	Connect with groundbreaking industries, startups and entrepreneurs who have the resources and are eager to experiment.
The roadmap does not meet stakeholder expectations	Low	Mediu m	Iterative consultations with stakeholder groups and monitoring of the latest developments in the field.
Political decisions that reshape legal and economic frameworks	Low	Mediu m	Identify ambassadors in different branches of the creative industries who would promote Time Machine initiate and help to lobby for resources needed to realise the exploitation potential.
Unsustainability of infrastructures that connect creative, media and entertainment industries with the data offered by TM	Low	High	Strategically position the innovation needs and continuously measure the impact of cultural data exploitation to secure sustainable support for it.
Lack of awareness about the exploitation possibilities in the industries	Low	Mediu m	Develop strategies for continuous engagement.

Annex: Domains in the creative, media and entertainment industries

Industry	Domains of impact
Advertising and marketing	advertising agencies, marketing agencies, market research and consultancy
Architecture	architectural design agencies, engineering, construction, urban and landscape planning
Broadcasting	television, radio, over-the-top media services
Design	graphic design, software design, fashion, interior design, textile design, product design, internet of things, wearable technologies
Film and video	film production companies, set design, screenwriting, post-production, online video production, documentary makers, film distribution
Game industry	computer graphics agencies, animation studio's, mobile apps
Journalism	news agencies, media portals, publication and distribution agencies
Music, visual and performing arts	live and recorded music, theatre, crafts, media artists, VJs, music publishing and distribution, new music production, photography
Publishing	e-books, digital publishing, publication and distribution houses, newspapers

5.3 Smart Tourism

Research and Innovation plan

Objectives

- Reach out to creative industries (core re-users) defining specific needs for the tourism industry to create technology-driven CH tools and services;
- Use innovative 3S clusters to develop TM tools and services for smart tourism according to local priorities;
- Identify a synergy model for core re-users, enablers and infomediaries to propose TM technology-driven CH products and services to endusers interested in touristic destinations, thus re-shaping their approach to sustainable/responsible tourism.

State of the art, technological monitoring

2018 was a record year for international tourism. International tourist arrivals grew for the ninth consecutive year, a sequence of uninterrupted growth not recorded since the 1960s. Destinations worldwide welcomed 1,4 billion international tourist arrivals, some 77 million more than in 2017. Inbound tourism in the EU-28 reached 713 million international tourist arrivals, 43 million (6% growth, clearly above the 3.7% growth registered in the global economy) more than 2017, a 51% share of the whole sector, with 567,3 billion USD in revenue (source: UNWTO International Tourism Results 2018 and Outlook 2019).[32] In the words of the UN Secretary-General "Tourism has become a pillar of economies, a passport to prosperity, and a transformative force for improving millions of lives". Yet, the previsions for 2030 talk about a decrease of 10% in tourist travellers to Europe while the whole sector will enjoy an average of 3-4% of annual increase with 1.8 billion arrivals, a 2 trillion USD in revenue and the employment of 300 million direct workers.

Maximizing the social economic benefits of tourism, while minimizing any negative impacts on host communities and the environment, is considered today an overarching and shared objective by all stakeholders in the tourist industry. Since the first initiatives in the 80s aimed at managing the sector in a more responsible way, a widespread awareness of the policy has been reached that tourism, despite being a prominent industry in terms of contribution to GDP and employment, if not well planned, managed and monitored and if not considering the destination's carrying capacity and resources (Costa, Manente, 2001)[33] can generate devastating and irremediable economic, environmental and social impacts due to uncontrolled development (Kasim, 2006[34] Akama, Kieti, 2007[35]). Furthermore, the environment, landscape and cultural heritage constitute the primary attractive resources, i.e. those that determine the main motivation for which a tourist chooses a destination (Crouch, Ritchie, 2003)[36]. If these, which are very often unique and not reproducible, are not adequately managed and safeguarded, the locality risks losing its attractiveness and its ability to guarantee quality of the visit with, as a possible consequence, the decrease in the number of tourists willing to pay to purchase the tourism product.

Since the mid-1990s, the concept of Corporate Social Responsibility (CSR) has become part of the international debate on management policies, and an increasingly essential and indispensable element for companies of goods and services, so to remedy the loss of trust of many consumers as a result of incorrect and irresponsible behavior, and to support sustainable development. From a

[32] http://cf.cdn.unwto.org/sites/all/files/pdf/unwto_barometer_jan19_presentation_en.pdf
[33] Costa, P. and Manente M. (2001), *Politica Economica del Turismo*, Milano: TUP Touring Editore.
[34] Kasim, A. (2006), "The Need for Business Environmental and Social Responsibility in the Tourism Industry", in *International Journal of Hospitality & Tourism Administration* 7(1):1-22.
[35] Akama, J.S. and Kieti D. (2007), „Tourism and Socio-economic Development in Developing Countries: A Case Study of Mombasa Resort in Kenya", in *Journal of Sustainable Tourism* 15(6):735-748.
[36] Ritchie, J.R. Brent and Crouch, Geoffrey I. (2003), *The Competitive Destination, A Sustainable Tourism Perspective*, Trowbridge: Cromwell Press.

strategic and governance point of view, the relevant theme is knowing how to realize forms of development that may generate a source of income and employment for the local community (Medina, 2005[37]), also capable to foster business transfer processes in fragile or little appealing sectors such as crafts, fishing, wine production, etc. Thus, the role of stakeholders in the activation and sharing of strategies and actions that pursue objectives oriented to the development of tourism and the management of heritage in a sustainable and responsible way, becomes crucial.

Yet, a clear distinction must be made between sustainable tourism and responsible tourism, above all for the orientation of strategies and actions that concern protection and management of heritage. On the one hand, we can talk about sustainable tourism by adopting a "supply approach", i.e., the development by companies and destinations of management policies and strategies that respect the interests of all the stakeholders involved, including environment and heritage. On the other hand, responsible tourism is defined starting from a "demand approach", i.e., the adoption by tourists of a travel behavior respectful of resources, places and people and that contribute to promoting the well-being of the local community.

The main challenges for the tourism industry today are:

- Attraction of new targets
- Development of new products and of minor destinations
- Differentiation / repositioning of well-known and mature destinations
- A more equal distribution of tourist flows to destinations, encouraging a sustainable development

On October 27, 2017, the EU Commission has launched within the call H2020-SC6-TRANSFORMATIONS-2018-2019-2020, the topic “Innovative approaches to urban and regional development through cultural tourism” (TRANSFORMATIONS-04-2019-2020). The challenge, as synthesized by the EU is: “The various forms of cultural tourism in Europe are important drivers of growth, jobs and economic development of European regions and urban areas. They also contribute, by driving intercultural understanding and social development in Europe through discovering various types of cultural heritage, to the understanding of other peoples' identities and values. However, although cultural tourism by its nature invites cross border regional and local cooperation, its full innovation potential in this respect is not yet fully explored and exploited. The level of development of cultural tourism between certain regions and sites is still unbalanced, with deprived remote, peripheral or deindustrialised areas lagging behind whereas high demand areas being overexploited in an unsustainable manner. There is also a significant knowledge gap in terms of availability of both quantitative and qualitative data on the phenomenon of cultural heritage tourism and on understanding its contribution towards cultural Europeanisation and economic and social development in Europe”[38].

The expected impact of such an action is:

- Improving policies and practices on cultural tourism at various levels
- Providing strategic guidance at European level concerning the efficient use of European Structural Investment Funds

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[37] Medina L.K. (2005), “Ecoturism and Certification: Confronting the principles and pragmatics of socially responsible tourism”, in *Journal of Sustainable Tourism* 13(3): 281-295.

[38] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/transformations-04-2019-2020;freeTextSearchKeyword=;typeCodes=1;statusCodes=31094501,31094502,31094503;programCode=H2020;programDivisionCode=null;focusAreaCode=null;crossCuttingPriorityCode=null;callCode=H2020-SC6-TRANSFORMATIONS-2018-2019-2020;sortQuery=openingDate;orderBy=asc;onlyTenders=false;topicListKey=callTopicSearchTableState

- Contributing to the establishment of partnerships between public and private stakeholders in this area
- Creating innovative quantitative/statistical as well as qualitative tools and methods will improve available data on and understanding of the impact of cultural tourism on European economic and social development and on cultural Europeanisation.

In 2018, the European Year of Cultural Heritage the first real action has been made on a European level to consider cultural tourism as part of a cultural heritage strategy. Within Initiative 5 of the European Year of Cultural Heritage: Tourism and heritage, the NECStouR (the Network of European Regions for Competitive and Sustainable Tourism) developed its objectives for a sustainable cultural tourism and its strategic alliance with the EU's DG GROW, DG EAC European Parliament Intergroup Tourism Manifesto EICR, ETCN, UNWTO) (http://www.necstour.eu/working-groups/Cultural-Tourism-and-Cultural-Sustainability). Yet, a proposal to develop specific technology-driven cultural heritage packages to address the growing experience-based demand of tourists, or to initiate a sustainable management policy based on tourist long-life learning through experience-driven traveling. Nor has the private sector fully grasped the importance and economic potentiality of technology-driven cultural solutions to the tourist industry. A survey departing from the three largest aggregator platforms **Expedia.com** and Booking.com[39] Airbnb[40], reveals the absence of cultural heritage packages to complete the tourist's experience.

A more specific website offering cultural heritage experience (all other websites offer only local experiences): **The cultural experience** (https://www.theculturalexperience.com/) offers international battlefield, historical and cultural tours.

Targeted achievements

1. raising awareness and respect toward CH destinations through TM narratives

2. innovative clusters working with local TMs to create a permanent ecosystem of smart tourism

3. economic sustainability of CH destinations, locations and institutions (GLAM) through TM smart tourism model

4. smart tourism through the TM products and services contributes to smart cities

5. enhance life-long learning programs through the TM smart tourism model

Methodology

Today, awareness to the overwhelming growth in tourism, its economic potential in the context of globalisation (the fourth industrial revolution) and its impact on territorial, urban and social transformations, coupled with the conviction that cultural tourism is tightly linked to education for diversity, to intensification of the European identity and to respect of CH artefacts and sites seems a fertile ground to revolutionize the whole sector by creating through the TM exploitation model a smart CH ecosystem which takes into consideration the whole pipeline: the decision makers creating

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[39] see for example regarding the city of Venice: https://www.expedia.com/things-to-do/search?location=Venice%2C+Italy&latLong=45.434031%2C12.338332&rid=179981&regionType=MULTICITY&countryCode=IT&startDate=04%2F28%2F2019&endDate=04%2F29%2F2019, consulted on April 26, 2019 and https://www.expedia.com/things-to-do/search?location=Venice,%20Italy&latLong=45.434031,12.338332&rid=179981&regionType=MULTICITY&countryCode=IT&startDate=04/28/2019&endDate=04/29/2019&sortBy=ExpediaPicks&categories=HistoryCulture|CulturalHeritageExperiences, consulted on April 26, 2019

[40] https://www.airbnb.it/s/experiences?refinement_paths%5B%5D=%2Fexperiences%2FConcept%2FActivity%2FHistory%20%26%20Local%20Causes%2FHistory%20Tours&search_type=SECTION_NAVIGATION
https://www.airbnb.it/s/experiences?refinement_paths%5B%5D=%2Fexperiences%2FConcept%2FActivity%2FHistory%20%26%20Local%20Causes%2FHistory%20Tours&search_type=SECTION_NAVIGATION

needed legal framework and defining priorities, the creative sector (core reusers) with its technology-driven products, the TM platforms enabling core re users and end-users to enjoy the Big data of the past, the tourist industry's stakeholders who define their type of business model or cultural open data and the Web's infomediaries who reach out to end-users.

TM is based on its local Time Machines which create through technological innovations in AI and machine learning the Big data of the past specifically set to tell the history of specific area (city, site, province, region). Following the 3S (Smart Specialisation Strategies), TM proposes to identify the components of territorial clusters which can be interested in developing specific technological innovations and tools for local TM cultural-heritage experience platforms (SMEs, universities, start-ups, regional administrators) and create the conditions for smart tourism to be considered a local/regional priority. The creation of a "smart cluster" following the 3S framework envisages the participation of regional/municipal political stakeholders which set up the priorities and create the optimal conditions for the formation of the cluster (which is considered a network of start-ups, SMEs, research institutions, cultural institutions, regional/municipal administrators that share common goals and standards and create, on the basis of agreed priorities, tools and services). This "smart cluster" should by no means be limited to cultural smart tourism, as it includes cultural institutions and GLAM and above all, local creative industries that help shape together with GLAM and the local cultural smart tourism policy the output of local TMs. It is highly important to stress that local TMs are the backbone of this local "smart cluster" and that their relationship with TMO is twofold: they are given a TM franchise from the TMO, but also share through it standards, tools and services common to other TMs. The local "smart cluster" is also an enabler as it is responsible for the creation of a local "smart tourism" platform that unites all tools, services and products to be proposed to core-users, end-users and infomediaries.

The example of the Welcome City Lab, a French platform which aggregates various startups whose products are designed for smart tourism[41], is a case in point. Created in 2013, its founding members are the City of Paris, the BpiFrance, the Tourist Office, the DGE (Direction Générale des Entreprises), the Paris Airport, Air France, a Caisse des Dépots, Galeries Lafayettes, Compagnie des Alpes, Paris Inn Group, RATP, Skyboard, Sodexo and Viparis. It is an incubator offering an innovating platform to experiment together ideas and technology regarding smart tourism. Today it has 100 start-up companies, 600 jobs created, and 140.000.000 euro raised. The model has been copied in other cities: Deauville, Angers, Nimes, Aix-Marseille and Troyes and is expanding.

Milestones

Cluster	Milestone number	Milestone	Means of verification	Due date
1. definition of strategy	MS1.1	Pilot case defined	Selection of a region with 3S prioritized strategy to Smart tourism as well as its robust LTM	YR1
	MS1.2	Local 3S and LTM smart tourism cluster established	Local TM and local 3S cluster define priorities regarding targeted tourist profiles, CH prioritized narratives, CH local destinations	YR1

[41] https://welcomecitylab.parisandco.paris/

2. elaboration of scenarios	MS2.1	Reaching out for the local tourist industry	Mapping strengths and weaknesses of local tourist destinations, priorities according to local operators	YR2-3
	MS2.2	CH prioritized narratives refined	Piloting targeted tourist profiles through narratives to specific destinations	YR2-3
3. proof of concept	MS3.1	Collaboration with core re-users: a local creative industries hub	Defining work pipelines, best practices	YR4-5
	MS3.2	Launch of the pilot technology-driven products and services	Testing narratives in pilot apps and technology-driven products and services on targeted tourist profiles	YR4-5
4. sustainability	MS4.1	Approaching infomediaries	Testing products and services' use and diffusion	YR6
	MS4.2	Measuring customer satisfaction	Test on end-users of products and services in destinations and use in a Life-Long Learning perspective	YR7
5. impact	MS5.1	Building a TM smart tourism model	measuring social, cultural and economic impact on local tourist industry according to ETIS	YR8
6. upscaling	MS6.1	3S local hub activity rollout	Defining diffusion strategy and business model	YR9-10

Key performance indicators

Europe has launched in March 2016 ETIS: The European Tourism Indicator System ETIS toolkit for sustainable destination management[42]. The ETIS is a management, information and monitoring tool specifically intended for tourism destinations. It is designed as a locally owned and led process for collecting and analysing data with the overall objective to assess the impact of tourism on a destination.

The ETIS is based on 27 core indicators and 40 optional indicators, subdivided into four categories:

1. Destination management,
2. Social and cultural impact,
3. Economic value,
4. Environmental impact.

The KPIs are designed for any destination wishing to measure the sustainability of the tourist industry:

[42] https://ec.europa.eu/growth/sectors/tourism/offer/sustainable/indicators_en

1. Raise awareness – emphasizing the importance of obtaining relevant local political support for implementation;
2. Create a destination profile;
3. Form a Stakeholder Working Group - there is no one set formula that works for every destination. It is important to be flexible and take an approach that best suits the destination and the group of people involved;
4. Establish roles and responsibilities - It is the role of the local destination coordinator to steer stakeholders towards an agreement on setting targets, taking action and planning how to achieve these aims;
5. Collect and record data - Data collection should simply be a process of bringing the various data sources together in one place to build a detailed picture of the destination's tourism industry;
6. Analyse results and take action on the basis of priorities;
7. Enable ongoing development and continuous improvement - the data collected should help tell a story about the destination that can be integrated into marketing and communication plans, as well as informing long-term strategy and policy.

In the context of the TM Smart tourism, the ETIS indicators can serve as a basis to assess the impact TM and especially LTMs activity would have on the development of sustainable tourism: industry:

1. number of local TM's;
2. number of heritage sites & partners involved in local TM's;
3. number of digital projects & heritage assets disclosed;
4. level of integration of TM tools and services in strategy & operation of cultural heritage partners, tourism partners etc.;
5. number of (unique) visitors & users;
6. qualitative data of users (appreciation, user feedback etc.).

Funding sources

A reasonable balance between public money, especially during the launching phase and further private investment based on the creation of 3S clusters built around local TMs which generate OD is the key to success.

The chain value to be adopted in the case of open data reuse lies in a resource (one or many datasets), released according to OD paradigm (without technical, legal and price barriers) which, if elaborated, becomes the enterprise-specific asset and, integrated into the enterprise's value proposition to the market, is "packaged" and embedded in a bundle of products and services.

The potential business models of each of the actors on the value chain are[43]:

Core re-users (those facing directly the consumer):

1. premium product/service – offering the end-user (*high-end market*) a product or a service characterized by high intrinsic value in two modes: a. à la carte – *pay-per-use*; b. recurring fee – *all inclusive*

[43] Yannis Charalabidis et al., *The World of Open Data. Concepts, Methods, Tools and Experiences,* Cham (CH), Springer, 2018, pp. 115-156.

2. freemium product/service – one of the offerings is free-of-charge and entails only classic features, while customers (*low-end market*) willing to take advantage of refined features or add-ons are charged

3. open source like – costs incurred for free offering of unpackaged open-format data are covered by revenues stemming from supplementary business lines open-data-based

Enablers (those operating behind the front lines):

1. infrastructural razors & blades – the value proposition hinges on an attractive, inexpensive or free initial offer that encourages continuing future purchases of consumable follow-up items or services, characterized by inelastic demand curve and high margins: datasets stored in cloud accessible via APIs and re-users charged only for computing power they employ on-demand

2. demand-oriented platform – platforms capable to convert datasets in data streams by using metadata, harmonized formats exposed through standardized APIs. The earned revenue is in exchange for advanced services and refined datasets or data flows

3. supply-oriented platform – open data holders are charged in lieu of developers. Pen data holders become platform owners making advantage of handy features like cloud-storage, rapid upload of brand-new datasets, format standardization, tagging with metadata and automated exposure of data via APIs and GUI.

Infomediaries (organisations positioning themselves between open data producers and users):

1. Single-purpose apps
2. Interactive apps
3. Information aggregators
4. Comparison models
5. Open data repositories
6. Service platforms

Stakeholders

This part integrates suggestions for expert interviews or questionnaires.

UNWTO, with the support of the Swiss State Secretariat for Economic Affairs (SECO), is currently developing the 'Journey to 2030 – Tourism for SDGs' online platform (http://tourism4sdgs.org/), which will build tourism stakeholders' knowledge, empower and inspire them to act, and accompany them throughout their journey to 2030 and beyond.

The stakeholders identified by the platform are: traveller, public body, international organisation, company, academia & co., and donor. These classical categories are useful for a legal entity's profiling but not for an innovative business model pipeline suggested here.

Core re-users

App designers, 3D digitization companies, gaming/storytelling industry, computational cartographers, Virtual/mixed/augmented reality producers, virtual restoration producers, TV companies, Generative models in 2D, 3D (and 4D) for historic reconstructions, image analysis companies.

Enablers

'Fit-for-purpose' TM platform which hosts core re-users' products and services as a demand-oriented platform.

End-users

City marketing, Hotels / B&B, 'Category' associations, Tourist guides (EU associations), Tourism boards, Gift design/trade, Advertisement agencies, Bloggers, Tourists (Individual or in group).

infomediaries

Aggregating platforms – may help enhancing interest in TM services and propose modular packages for a total tourist experience

Flixbus, GoOpti, cruises, hotels and the likes – may consider proposing to their customers a freemium on-bus/cruise/sojourn experiential 'fit-for-purpose' kit to prepare for excursions (through customers' tablets and smart phones with special apps)

Framework conditions

The Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (GROW) launched in 2007 its policy regarding Sustainable tourism[44] recommending the use of the following principles to address these challenges:

- Taking a holistic, integrated approach;
- Planning for the long term;
- Adopting an appropriate pace of development;
- Involving all stakeholders;
- Using the best available knowledge;
- Minimising and managing risk;
- Reflecting impacts in costs;
- Setting and respecting limits;
- Practising continuous monitoring.

This was the framework within which the European Commission adopted in June 2010, the Communication, "Europe, the world's No. 1 tourist destination – a new political framework for tourism in Europe"[45]. This communication set out a new strategy and action plan for EU tourism.

Four priorities for action were identified:

1. To stimulate competitiveness in the European tourism sector
2. To promote the development of sustainable, responsible, and high-quality tourism
3. To consolidate Europe's image as a collection of sustainable, high-quality destinations
4. To maximise the potential of EU financial policies for developing tourism.

A regularly updated an Implementation rolling plan[46] has been developed that outlines the major initiatives to be implemented as part of the strategy, in collaboration with public authorities, tourism associations and other public/private tourism stakeholders.

To date, the Commission has successfully implemented the majority of the actions set out in the Communication, focusing on the following priorities:

- Increasing tourism demand, from within the EU and beyond;
- Improving the range of tourism products and services on offer;
- Enhancing tourism quality, sustainability, accessibility, skills, and ICT use;
- Enhancing the socio-economic knowledge base of the sector;
- Promoting Europe as a unique destination;
- Mainstreaming tourism in other EU policies.

In a worldwide perspective, on the basis of the 17 Sustainable Development Goals (SDGs) set by the UN for 2020-2030, the UNWTO defined its priorities regarding the tourism industry[47]:

1. Making tourism governance 'fit for purpose';

[44] https://ec.europa.eu/growth/sectors/tourism/offer/sustainable_en
[45] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010DC0352&from=EN
[46] http://ec.europa.eu/DocsRoom/documents/10155/attachments/1/translations
[47] https://www.e-unwto.org/doi/pdf/10.18111/9789284419340

2. Building competitiveness – key to sustainability for tourism industries;

3. New ways of financing sustainable tourism.

The implication for the TM ecosystem is that sustainable tourism should be one of its priorities and that its local TMs offered as 3S ecosystems fit perfectly into the request of both the EU and UNWTO to govern the industry on a "fit-for-purpose" basis (glocal) and not on a global approach which seems to be governed by the agenda of big tourist industry stakeholders which in many cases is not aligned with local policies.

Risks and barriers

The approaches and measures that address any barriers to market entry and/or facilitate the commercial exploitation of research results.

1. local legal framework defending owner's intellectual property rights to images of his own property (mostly buildings or churches) which may hamper crowdsourcing of images for a local TM

2. Multilinguality and multiculturality are barriers that have to be considered in the light of tourist growth from China South-East Asia

3. risk of following the agenda of the tourist sector in local TM rather than set own agenda

5.4 Combined smart cities, urban planning, land use & territorial policies

Research and Innovation plan

Objectives

These subtasks aim at fostering communities collaboration around the exploiting of Time Machine technologies to achieve more inclusive societies as well as sustainable development in our cities and territories and to support the elaboration of common visions and projects for our cities, territories and Europe based on common values.

One of the distinctive characteristics of smart cities is the central role of technology as a means for improving the city's functions, enhancing environmental sustainability and increasing living standards for citizens[48]. Given its aging populations and its historic specificities, European smart cities are challenged to incorporate meaning-making, culture and history in order to prevent further apathy, resistance and criticism towards smart cities. Cultural heritage currently represents a mostly underexploited and under-researched response to these challenges.

At the level of the planet, land use models are a key asset for improving living standards for every citizen on earth. The United Nations have identified 17 sustainable development goals, and land use model requirements to monitor progress towards these goals. Given Europe diversity of past land use, it is challenged to design such dashboards integrating enough of man practices and local culture for these dashboards to guide us towards effi cient regulation and a sustainable planet.

The project will yield innovative solutions to support people in understanding their environment dynamics, identifying what are the choices they have to make when they design their environment (incl. European, regional and local regulations), to support their debating other hypotheses, connecting to other inspiring experiences and people, adopting a critical perspective on figures and learning to use data and state of the art knowledge.

[48] Angelidou, M., Karachaliou, E., Angelidou, T., & Stylianidis, E. (2017). CULTURAL HERITAGE IN SMART CITY ENVIRONMENTS. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, ISPRS Archives (2017) 42(2W5) 27-32

These domains will also benefit from better automation since programmes involved in our smart cities and smart territories in general will be able to learn from the past. Specific applications domains are listed in Annex 1.

State of the art, technological monitoring

We lack tools to integrate cultural items, soft values, and long-term development in smart cities, urban planning and architectural design. The initial technological optimism related to Smart Cities was met with a wave of resistance for being too technology-driven, and for imposing one-size-fits-all solutions. The sentiment grew that smart cities become 'sterile' places devoid of meaning, where citizenship is reduced to consumerism.3 Subsequent 'citizen-centric' smart city efforts have been met with equal scepticism for being rooted in stewardship, civic paternalism, a neoliberal conception of citizenship[49], and empty rhetoric[50]. There is a growing realization that the crucial element of culture has been overlooked. Local governments often fail to successfully incorporate the component of cultural heritage within smart cities. In instances where it is taken into account, it is often in an abstract and fragmented way[51] due to a lack of resources and platforms to communicate effectively across borders and departments[52]. In addition, the available research on the strategic relationship between cultural heritage and smart cities remains limited and fragmented[53]. Geospatial platforms and tools for participatory urban planning can help to link historical research and future design[54]. Cities have no consistent archival policies of sources and projects for them to be reused in the future.

We lack tools to **elaborate and criticize regulations**. Elaboration of urban regulation is a challenge in many domains for local administrations that 1) lack knowledge about latest scientific findings (which tools will have a positive impact, what is the priority), 2) lack the correct concepts to write unambiguous and meaningful regulation 3) have to face contradictory, unclear, plural stakeholders' recommendations 4) lack solutions to involve the new variety of citizens (i.e. different familiarities with data, immigrants with different backgrounds and the gap between the mental representations of the cities by inhabitants and the concepts used in regulations). Elaboration of European policies and their implementation across the different levels: local administrations lack sufficient knowledge to implement regulation at their level especially when the terms are too generic (e.g., a significant number of sick trees, energy efficiency measures, ...). We also experience unsatisfying interactions between public clients and the private sector during calls for tender to select the best answer.

Relating past experience with future transformation is still a challenge. Cities and lands are complex systems which dynamics are difficult to describe, because of the complexity of social phenomena at stake in cities and because also of the complexity and intrication of physical natural phenomena in lands. These intrications are described through "simulation models" like climate

[49] Cardullo, Paolo, and Rob Kitchin. 2018. "Being a 'Citizen' in the Smart City: Up and down the Scaffold of Smart Citizen Participation in Dublin, Ireland." GeoJournal: 1–24. http://link.springer.com/10.1007/s10708-018-9845-8

[50] Interview with Zsuzsanna Tomor (Utrecht University), by Maja Dehouck, Utrecht, 21 October 2019.

[51] Angelidou, M., Karachaliou, E., Angelidou, T., & Stylianidis, E. (2017). CULTURAL HERITAGE IN SMART CITY ENVIRONMENTS. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, ISPRS Archives (2017) 42(2W5) 27-32

[52] Interview with Zsuzsanna Tomor (Utrecht University), by Maja Dehouck, Utrecht, 21 October 2019.

[53] Angelidou, M., Karachaliou, E., Angelidou, T., & Stylianidis, E. (2017). CULTURAL HERITAGE IN SMART CITY ENVIRONMENTS. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, ISPRS Archives (2017) 42(2W5) 27-32

[54] Examples are: the online public consultation for the future of Port Cities, see https://mood.tbm.tudelft.nl/portcityfutures/welcome.

models, air pollution models, fire spreading models for example are laws proposed by some geographers.

Sources of information about cities and landscapes are fragmented and heterogeneous. There is **no universal conceptual model** to build an information product depicting cities or lands. Cities and lands are characterized by natural phenomena, man-made entities but also 'soft' factors such as the use made and experience of these spaces by inhabitants, public and private organizations and the regulatory frameworks established and maintained by the governing powers. When designing a conceptual model to depict a given territory, one must find a **compromise between tractability** (using not too many classes and datatypes**) and expressiveness** (distinguishing local specificities). The technologies used so far in dashboards heavily rely on common taxonomies which cause semantic uncertainties in information products (for example permanent grassland is a fuzzy concept).

As a consequence of the numerous technologies to survey territories, one must find a **compromise between required scope, required accuracy and available resources (funds, expertise and technology**). There is so far no support to help make this compromise and track it. Technologies range from in situ topographic survey or geological survey, statistical surveys, remote sensing (from aerial imagery to current satellites and unmanned aerial vehicles, using optical sensors but also thermal imagery, lidar, superspectral imagery), administration dashboards manual filling, crowd sourcing and collaborative content. These technologies offer different benefits and pitfalls –in terms of cost, coverage, resolution, accuracy-. In order to provide societies with **qualified, trustworthy, authoritative and sustainable information, legally mandated organisations** (like mapping agencies, statistical survey, meteorological institutes) or dedicated committees specify information products and comit to provide them, according to relevant trade-offs between expressiveness and tractability as well as accuracy and cost.

At the scale of Europe, we lack solution to consider at the same time local land specificities, in space and in time, as well as support a European vision and shared objectives related to land use. In 2006, Europe decided to reuse data used for national policies to monitor European policies because it was a way to ensure trust between member states and the commission, as well as to save costs. Yet, the technical solution to support this policiy is still lacking since then.

Digital transformation let our territories often lacking required IT competence as well as face challenges in avoiding alienation, isolation and polarization, and instead facilitating citizen participation, community-building and integration[55]. Some administrations lack IT specialists, money and data. All administrations have to help some population get hold of the digital age.

Authority frameworks are evolving. As soon as data will be produced by machine learning algorithms, what does 'authoritative' mean? New forms of trustworthy content have emerged with the Web2.0 and Wikipedia is the best example of such content.

To exchange and reuse information, **standards** are defined within different industries and communities. For example, an important initiative to enhance interoperability between different land cover and land use products is the metamodel EAGLE. In general, industries involved in cities and lands tend to promote normative vision across space and time, within a given thematic scope like for instance the BIM (Building Information Model) and the GIS standards to describe man-built environment. Standards often are not interoperable across different thematic scopes like these mentioned above, e.g. BIM and GIS. **There is no uniform user-oriented model to manage uncertainty** in geographical data; people need to know the underlying technologies or to use too global accuracy metadata. The documentation of uncertainties in geographical data is currently

[55] Hemel, Z. (2019, October 10). Een nieuwe historische binnenstad: visie op de binnenstad van Amsterdam 2040. Retrieved from: https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/ambities/fijne-buurten/programma-sint/?utm_source=www.amsterdam.nl&utm_medium=internet&utm_campaign=visiebinnenstad&utm_content=redirect, last visit 23 October 2019.

based on complex metadata, difficult to interpret by users. This results from all acquisition technologies, semantic heterogeneities, and the numerous sources of uncertainties.

These sources are not well connected. Discovery, retrieval and combination of available data sets and models to depict earth surface is still much hindered. There is no search engine for datasets as good as there are for Web documents, movies, books, pictures or flight tickets. Scientists who want to study territorial phenomena at multi-scales, like climate change, do not reuse the most accurate and detailed data but rather go for the most easily available; search is often limited to a technological silo. Agencies (e.g. public health) who want to study the correlation between a given disease and the environment of ill people do not have access to the data. The same for cities. Combination of data relies on shared referencing frameworks and on algorithms. **Spatial and temporal referencing frameworks** can be geodetic coordinate systems where each point on earth is described with 3 coordinates for its location and 3 for its speed (for example for tectonic). These can also be indirect core referencing frameworks like placenames, adresses or landmarks (i.e. sailant features like river and road networks that can be identified across several sources). Ontologies are also developed to interconnect different conceptual models.

Yet, to date, **these referencing frameworks are themselves too fragmented across space or time**. Spatiotemporal referencing frameworks are needed, e.g. spatiotemporal gazetteers spatiotemporal ontologies. We lack long term timelines within information products used for territorial policies (historical products or services are not connected with current data). Designing these timelines require for instance interconnecting land cover and land use reference products other time which can be problematic when the segmentations are not the same and also when the indicators change (typically statistical classes definitions**). We lack consistent heritage practice across time, that considers very old times and the future, reuse and outreach.**

These fragmented information pieces or products **cannot be assembled in a seamless manner**. Heterogeneities are caused by differences of products scope in space, in time, or among disciplines and different choices in technology and implementation as well as in licensing. Current **IT solution hardly manage heterogeneities** between different conceptual schemas relevant to city or land use studies (across time or across space) as well as between different information products (differences in projections for example) and can be fed only through a standardised format. This is true even when these heterogeneities are documented in metadata.

Targeted achievements

We target the following main objectives:

Culture friendly city and land information systems with a user legible documentation of uncertainty (whatever the diversity of sources, resolutions, accuracies and technologies). Information system should be “culture ready” in a sense that they can integrate cultural specificities of different information sources as well as of different contexts of use. They must support user assessing the uncertainty of the representation whatever his technical background.

Integrated, inter-connected information systems for cities and lands, across administrations and authorities , across time (the past but also prospective scenarios), space and scales. This should support zooming in and out between the perspective of Europe and more local perspectives, to embrace focus (fine level of details) and context (wider coverage) in analyses. We target intensified and more relevant (smart) information exchange in smart cities with new data sources, including exchange with other cities with comparable infrastructures, and with more focus on historical depth (longitudinal perspective provided by the big data of the past). We target the integration of each city’s historical elements into its modern reality in order to create attractive, competitive and resilient

cities[56]. This objective can be reached by integrating cultural heritage data as a crucial source of information to address culture and identity as transversal, horizontal themes in all smart city developments.

“Affordable and sustainable” solutions to build specific cities or lands information systems (Time machine projects) at affordable and sustainable cost whatever a city (resp rural territory, country, thematic community) resources in terms of funds but also of expertise and of contributing people, incl in emerging countries. It is important that the studied cost comprises ecological footprint as well as how much of private information we are ready to share. Such solutions are strongly connected also to governance, authorities definition, and economic models.

User-centered retrieval of comparable situations to a user study, whatever the distance in space and time, in order to favour exchange and mutualisation as a bottom-up process. To gain inspiration from similar situations but also to learn and get more perspective by comparing to dissimilar ones. These must also include situations when ‘low tech’ solutions were experimented and make them more visible.

Inclusive debating platforms related to cities and territories design and dynamics. These platforms should be ‘polyvocal’, allow for multiple perspectives on the past, creating room for stories of minority groups, including newly arrived citizens who may not share the dominant culture. Employing cultural heritage data as input for including culture and identity as transversal themes offers potential solutions such as conceptualizing ‘smart citizenship’ grounded in civil, social and political rights and the common good[57], countering apathy and scepticism towards smart technologies and including all layers of society (marginalized, aging and migrant communities) in smart city developments. In sum, cultural heritage is a crucial component of a credible, human-centric approach to smart cities.

Recommendations for decision makers to support their planning and design solutions: suggesting connections (e.g. TM can support cities in finding out which other cities are facing similar challenges, e.g., managing tourism, water management, social cohesion, and share data and solutions), presenting relevant situations from the past to get inspiration, engaging artificial intelligence community to learn from the Big Data (cf next point).

Enhanced scienceS-policy interface as well as scienceS-stakeholders interface either in cities or in land management in general: to connect stakeholders who seek a longitudinal perspective on a present-day problem with the relevant scientific communities to sample history and space and design training data set with regards to a given issue, apply machine learning method, trained on these samples from the past, and using Time Machine Knowledge graph to make recommendations on his specific problem. It is important that stakeholders can use an appropriate language to express their questions and visions, soft concepts and not quantitative thresholds. Different scientific communities need to be involved; from digital humanities (e.g., urban historians, information specialists, archaeologists), social sciences (e.g, urban planners, geographers, statisticians), and artificial intelligence. The open access availability of big data of the past creates possibilities for including cultural heritage in bottom-up innovative initiatives. Making this data available for experimentation turns European cities’ historic rootedness and cultural specificities into a competitive advantage in attracting new business and innovation.

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[56] Angelidou, M., Karachaliou, E., Angelidou, T., & Stylianidis, E. (2017). CULTURAL HERITAGE IN SMART CITY ENVIRONMENTS. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, ISPRS Archives (2017) 42(2W5) 27-32. Vattano, S., 2014. Smart Technology for smart regeneration of cultural heritage. Italian smart cities in comparison. In MWF2014: Museums and the Web Florence. Retrieved from: http://mwf2014.museumsandtheweb.com, last visit 23 October 2019.

[57] Cardullo, Paolo, and Rob Kitchin. 2018. “Being a ‘Citizen’ in the Smart City: Up and down the Scaffold of Smart Citizen Participation in Dublin, Ireland.” GeoJournal: 1–24. http://link.springer.com/10.1007/s10708-018-9845-8, last visit 23 October 2019.

Inclusive and transparent platforms to write and revise policies related to territories: supporting interactions for stakeholders with different background and perspectives, considering data available to associate trustable dashboards to the policies.

Methodology

Our methodology to progress towards these ambitious achievements during a 10 years project is grounded on the following items :

- **Rolling specific roadmaps, also called Thematic Time Machines**, are used to implement, illustrate and feed the main roadmap. They are necessary to engage in a consistent way with the wide range of actors to be considered. We are coining the concept of cultural, social and geographical heritage and it is very important that we somehow achieve consistent enough visions among actors and this will be pursued within thematic perimeters. Thematic time machines are defined after specific stakes in Smart Cities or in Land Use as well as after proposition stemming from experts. The consolidation of results and resources between these rolling roadmaps projects will rely on all three pillars of the whole Time Machine project. A thematic roadmaps committee will select and prioritize if necessary these roadmaps in terms of increasing complexity, and in terms of stakeholders' expectations (stakeholders incl. citizens). An important criterion to support a Thematic Time Machine process is stakeholders' awareness of the value of cultural heritage because it has a direct impact on their capacity to contribute to designing the specific roadmap as a contribution to a global Time Machine roadmap. Within these roadmaps, specific **challenges and benchmarks** corresponding to real use cases will be described and illustrated with data, cf right after. We will design specific communication media to engage relevant actors in this Thematic Time Machines program. Current initiatives addressing SDGs, like podcasts promoting "low tech" solutions to climate change, must be approached to see how Time Machine can be used to dicover, publish and share "low tech" practices.
- Iterative specification of **key reference datasets as well as associated production good practices**: metadata and data necessary to integrate data other time and space (spatiotemporal gazetteers, addresses, buildings, elevation models, networks, administrative units, cadastre, metamodel, ontologies, alignements). We will rely on existing networks among data providers to design (identify) a production process of historical land cover products out of archives and associated tutorials, at different representative scales, in Europe but also in Africa.
- **A challenge platform, similar to Kaggle, to design, publish and manage applied challenges or benchmarks** relating to "real world" problems encountered by representative users and that can be shared either with scientists (e.g. scientists working on data alignment, scientists working on simulation, who may not have engineering expertise to prepare the datasets and the infrastructure) or with developers of mature technologies.
- **A collaborative multilingual platform**, similar to Wikipedia, that connect concepts (categories) used in datasets or in regulation related to cities and to land use to textual description and to illustration from the real world meaningful to all citizens, 1) to support user appropriation of data and of regulation, 2) to engage **collaborative curation of these concepts expressiveness and semantic uncertainties** can be engaged. Wikipedia could be a good candidate to start from. There exist several thematic wikis that could be interconnected. A URI policy for objects and for links will be needed and established in a iterative way during the project.

Calls for "TM Land Use Digitalisation Proposals", which will invite submissions of projects asking Time Machine to support (subcontract) the digitisation and structuring of precisely identified archives that the project partners commit to exploit in a way described in the project for Smart cities, for Land Use and Territorial Policies. Selection criteria will include the involvement of humanities in the project.

- **Calls for "TM Land Use Learning From the Past Missions"** which will invite proposals describing current issues that could be solved by learning from the past and that set up machine learning experience. These must include partners who have the competence to identify where to learn from –usually humanities-, and partners who have the competence to evaluate the results. Time Machine will then select proposals, possibly suggest consolidations between them, and mobilise artificial intelligence communities on the selected proposals.
- **European master programs** to train students capable of undertaking Phds on **scientific bottlenecks** underpinning these domains**. Workshops with key** scientists will be organised at the beginning of the project to foster scientific communities around these application specific bottlenecks: similarity measures, uncertainty management, soft values and regulation. Thematics for these workshops will be : uncertainties in decisions based on data, similarities and dissimilarities between different cities or territories -across space and time-, comparing strategic measures and their impacts, including soft values in regulation.

Glue and connectors to integrate existing information systems in place to Time Machine data and technology in a seamless enough way for the user, and to engage these users in the second round of RFC of Pillar 2.

- **A sandbox for a new implementation of European culture friendly spatial data infrastructure** articulated with existing data and metadata (INSPIRE, EEA, Europeana, etc.) with existing national portals, including a broker component to be able to cope with member states heterogeneities and a model to document in a meaningful way the uncertainty of **patchwork European data products. Core TM metadata for datasets** must be identified, an important element will be the documentation of provenance information and quality information from TM digital assets which are needed to support the identification of data set across information systems, and the search for data sets in search engines or data marketplaces like Diamond. Existing models to exchange land cover and land use products like EAGLE must be considered in these Core TM metadata.

Milestones

Cluster	Milestone number	Milestone	Means of verification	Due date
1- Vision and Strategy	MS1	Thematic Time Machines Comittee established	Mandate and composition published, as well as 1st meeting agenda	YR1
	MS1.1	3 Thematic Time Machine roadmaps (1 on Smart Cities, 1 on Land Use, 1 transversale)	Roadmaps aligned with other Pillars and presented at key events of the corresponding domains	YR1
2- Experimentation and Exploration	MS2.1	Definition of Use cases associated to Thematic TM	User story available on teams and validated by other pillars	YR1

	MS2.2	Challenge platform, and one challenge published	Number of participants who take the challenge	YR2
	MS2.3	Knowledge graph associated to samples of reference datasets specified, version 0	Paper in a Semantic Web journal	YR1
	MS2.4	Collaborative platform, and one regulation and related datasets referenced on it	Access to the platform granted to TMO participants for beta testing and then open	YR2
	MS2.5	Sandbox for European culture friendly Smart Cities and Land Use information systems, conneted to Local Time Machines.	Creation of teaching material and prototypes using the sandbox	YR3
	MS2.6	Prototype of TM Land Use debating platform, presented to EC and voting platforms	Feedback from EC and from voting platforms	YR6
3- Collaboration and Outreach	MS3.1	"TM Land Use Digitalisation Proposals first call	Number of submissions, number of selected proposals	YR1
	MS3.2	"TM Land Use Learning From the Past Proposals" first call	Number of submissions, number of selected proposals	YR2
	MS3.3	Knowledge Graph, reference datasets datasets (specifications and first instances), and associated guidelines published	Number of triples in the graph, operations associated with the graph (spatiotemporal queries, similarities), number of places and periods covered by datasets, number of readers of the guidelines	YR2
	MS3.4	Prototyped connections between existing Smart City and Land Use portals and Local Time Machines	Added functions (or scope of existing functions) on existing portals based on the connection with LTM	YR2
	MS3.5	"TM Land Use Digitalisation Proposals" second call issued	Number of submissions, number of selected proposals	YR4
	MS3.6	"TM Land Use Learning From the Past Proposals" second call issued	Number of submissions, number of selected proposals	YR5
	MS3.7	Spontaneous exploitation of TM Knowledge Graph in Smart Cities or Land Use projects out of TMO community	Survey to detect them and report	YR8

	MS3.8	References to TM challenge platform in publications and in projects stemming from outside TMO communities	Survey to detect them and report	YR8
4- Sustainability	MS4.1	Master program	First promotion of students	YR3
	MS4.2	Proposed implementation of INSPIRE historical data, as well as UN GGIM, using TM protocols	Official document issued by INSPIRE Working groups as well as UN GGIM Europe	YR6
	MS4.3	References to historical assets in debate and in regulation and in public debates related to Smart Cities, related to Land Use	Survey to detect them and report	YR9-10

Key performance indicators

In order to measure impact based on our proposed methodology, we outline a few tentative key performance indicators:

- Need to be identified with stakeholders (see UN Habitat, DG Grow);
- Need to select among the indicators associated to the UN Agenda for 2030[58]: in goal 2 (zero hunger), goal 6 (clean water), goal 11 (sustainable cities); goal 13 (climate action), goal 15 (life on land);
- European organizations related to urban planning and land use engaged;
- National government bodies related to urban planning and land use engaged;
- Local government bodies engaged;
- KPI concerning linking and harmonization of land use data;
- KPI concerning linking and harmonization of urban planning data;
- Best practices regarding Big Data of the past for land use;
- Best practices regarding Big Data of the past for urban planning.

Funding sources

For smart cities, urban planning, land use & territorial policies, the potential funding sources to consider are:

- National funding schemes that focus on societal challenges (e.g., the Netherlands National Science Agenda)
- European funding schemes that focus on societal challenges (e.g., relevant calls in the new HE program)
- Bank and fund management dedicated to rural development
- Several bodies fund initiatives in the domain above (energy efficiency etc).
- Crowd funding could also work on this type of solution
- Important programming and funding organisations: EEA

[58] https://www.un.org/sustainabledevelopment/sustainable-development-goals/

- Insurance companies

Stakeholders

Here are listed the main stakeholders:

- Mayors (can be for a rural commune): reputation of the city: they should want to have their own local Time Machine, they should be visible in this national and European context; city marketing
- Politicians and policy makers (local, regional, national, European): save money because of better information on urban and rural infrastructure: better because including longitudinal perspective and because better integration. Engage with citizens.
- Science-policy interface specialists can be more specific in terms of needed platform for collaboration between them based on big data of the past.
- Entities in charge of transforming administration and providing focused lifelong learning modules or peer to peer seminars[59]:
- Administration: Smart City/Territory project managers: Smart Cities (sensor data) is the brain, Time Machine adds the memory part. National ministries in charge of administrative information infrastructure, institutions in charge of publishing regulation
- Planners, engineers, architects, heritage specialists

Lawyers

- Citizens
- Software companies, Software used in the area so far, Open source communities
- Infrastructure designers (protocols, software), legal bodies on standardisation
- Surveyors, authoritative data providers, authoritative information services providers
- NGO Interest Group, Public/private foundations, insurance companies: TM will provide them with the detailed data to make better risk assessments
- Payment agencies, funds management, insurance companies
- Scientists doing applied research
- Innovation fostering organisations

Framework conditions

Below we propose an initial list of framework conditions related to licences, European directives, data categories and legal aspects, that have to be taken into account when further refining the roadmap for exploitation to smart cities, urban planning, land use & territorial policies:

- Solve the licensing issues –open licences are not always consistent, but most scientists do not care which can become a problem later.
- It is crucial that archives describing cities and territories can enter the scope of the Public Sector Information directive in Europe.
- Set up a unifying identification framework for the core data.
- For the crowdsourcing/citizen data: sustainable, fair data management solutions (e.g., the Solid framework by Tim Berners-Lee at MIT, which gives users the freedom to decide where to store and how to manage their own data: https://solid.mit.edu/).
- For the democratic debating platform: an editorial mechanism that respects freedom of contribution but counters misuse of the platform (e.g., discrimination, illegal content, etc.), as has developed on Wikipedia.

[59] Example in France:
https://www.modernisation.gouv.fr/le-campus,
https://www.modernisation.gouv.fr/sites/default/files/infographie-campus-hd.png

- A legal framework for organisations to commit to achieve a compromise between expressiveness and tractability in a brokering process of their heterogeneous sources for a given application.

Risks and barriers

The notion of validity is decisive: some results about land dynamics or urban regulation can be true for some situation but not adaptable to others. This can lead to conflicts. A solution could be to see Time Machine as a solution to get inspiration and not as the mirror of the truth.

We also need to know if some content is too attached to a community and that this aspect could impact the communication strategy about the Time Machine. This risk can be mitigated by having a conceptual framework for assessing the different semantic levels of the data, and a policy and workflow for evaluating data quality and provenance (both automatic and checked via crowdsourcing).

There is a risk to have a bad ecological footprint: solution proposed is to have call for missions (digitalisation or machine learning) to foster these activities on TMProject that have an important added value.

If laws are more and more grounded on data, it is important to preserve data integrity in the law.

ANNEX A: Responses to Project Review Report

Objectives and work plan

1. Is the progress reported in line with objectives and work plan as specified in the DoA? If there are significant deviations, please comment.

Comment	Response
4.1.2 Recommendations to bring the final version up to the expected quality level	
a. Focus on clarity, conciseness and quality of the text, rather than quantity and length. The text is verbose and some passages are unclear and the rigorously applied structure impedes conciseness and readability.	The project would be willing to address specific comments rather than general impressions that might relate to non-objective qualifications of writing style.
b. Focus more on supplying creative industries and value-added service providers with high-quality assets and data, allowing them to build their own end products for clients.	Through the use cases we are developing for D8.4 and D8.5, we elaborate on how to better facilitate back-end access to Time Machine data and code. Time Machine software will be designed for open access, and stakeholders from various sectors are free to clone and alter it for their own usage (e.g., through Github). Our contact with such stakeholders will be consolidated through the pan-European "Local Time Machine Academy" and data sprint events, as well as with regular conferences and possibly user-initiated "meet ups". Two domains in creative industries that could illustrate such needs are media (e.g. the fact-checking NGOs) and architects.
c. Spend more effort on actions required for removing legal (IPR) barriers for creative re-use of high-quality assets and data.	Legal aspects are explored in detail under Pillar 4 and will be integrated in D8.4 and D8.5.
d. Focus on the quality and cost-effectiveness of large scale digitisation, processing digital materials and presenting them to producers and end-users, building only enough finished end-products to demonstrate the concept and value of the TM	The calls for proposals that will be issued in the context of subtasks 4.3.4 and 4.3.5 (for digitalisation, for learning from the past) will foster a European wide digitalisation strategy as well as a European wide -based on the TMO network- curation community of learning collections (this is also foreseen in the GLAM task)
e. Ensure a unified interface for the presentation of historical data and reconstructions. The links from the Time Machine website to the existing Local Time Machines present a fragmented set of websites bearing no obvious relationship to each other in structure, design or functionality. Most local projects have been obviously originated in other initiatives and many are unfinished, or very limited in functionality or content (e.g. a series of links leads to a catalogue number or a non-functioning link to a data set).	Local Time Machine coordinators have recently agreed on standardising Local Time Machine website templates, interfaces (maps, etc.) and data access/exchange protocols. Throughout the LSRI, the Local Time Machine Academy events can serve as the platform for discussing and consolidating these standards, exchange formats and procedures, not only within the network but also with users of all sectors outside the network. It should also be pointed out that a unified interface is not a target for its own sake. Actual interfaces need to stay but become enriched (boosted) by the access to TM infrastructure services. It is important to keep existing interfaces because they correspond to local actors who make the connection with stakeholders in their environments.

Comment	Response
f. Present much more concretely the variety of Exploitation Avenues, how the actors in each avenue will be reached and persuaded to take part, who will do the reaching out, and how the money will flow to ensure that the central and subsidiary parts can be sustainable.	We have recently developed a series of use cases that indicate how the various components of TM will serve particular needs related to the exploitation avenues. These use cases in part build on existing projects and collaborations, which allows us to assess the way in which the TM offerings match the demand. They allow us to articulate in more detail in D8.4 and D8.5 how the actors will be reached and persuaded and how that task will be organised in the overall governance structure. In addition, for the phase in between the CSA and the LSRI, TMO foresees the development of a number of pilot projects where we test these use case scenarios in practice.
g. Provide evidence of demand from end-users; usage statistics from Europeana would be a good start. Pilot projects are a suitable methodology for building demand, but the reliance on spontaneous and self-funded LTMs for those pilots is too uncertain for such a core need.	The project team will examine the different options available to raise demand by actively promoting new models. Our approach is to investigate demand from end-users, first, in the development of specific use case scenarios (interviews with urban planners, local governments, SME's etc. to map their needs and how they can be met by TM) and, second, in pilot projects with core partners in Industry (Ubisoft, Family Search) to explore how TM serves their needs and to collect clear requirements. These efforts are not dependent on the LTMs alone; they are centrally coordinated by the TM Organisation. In the LSRI, we will adopt the RFC framework, which allows us to tap into the broad user base of open source software development and implementation, e.g. the way in which the Wikimedia Commons software is supported by its users, both by contributing to its development and maintenance and by financial donations from individuals and corporations (https://www.feedough.com/how-does-wikipedia-make-money-wikipedia-business-model/).
h. Optimism about future funding streams, whether for the consortium's overheads, or for its actual work-programmes (both technological and community) would be more convincing if there were estimates of costs and funding requirements; and market research data indicating a desire on behalf of individuals and their employers to contribute time/expertise/servers etc. as in-kind funding; the interest of funders and national policy makers to allocate programme funding to this initiative; evidence of serious interest from GLAMs to self-fund to join in the developmental activities and/ or take-up (and pay for) the services, such as high-speed digitisation; and above all evidence of demand by organisations and citizens to make use of the aggregated data, and on what terms.	At this stage, it is very early to make realistic estimations on costs and investment needs. The roadmap presents the important changes and associated benefits of the Time Machine approach for different exploitation avenues. Optimism was generated by the large number and leading positions of representatives of the GLAM/Creative/other business sectors that have accepted to pay entrance and annual fees to the TMO. Business cases will be developed in the course of the initiative. The Consortium is fully aware of the difficulties associated with this process, this is why the roadmaps foresee innovation actions that will test new approaches under realistic conditions, as well as support measures enabling to find ways to fund new business models. Experience gained with bringing to market the Time Machine results will be used for programming further developments.
4.1.3 Additional detailed comments	
a. Some of the material repeats or contradicts or belongs in the other roadmaps: the outcomes and	All matters related to consistency of work proposed in the 4

Comment	Response
their KPIs in the tables on p 7/14ff; the section “State of the art, technological monitoring” (p 9/15ff); the tables about existing infrastructures (p 10/17ff); the targeted achievements (p 11/18); section 3.2 Funding; Digitization, Data Model Storage (p 28/35). Conversely, some of the intentions in this roadmap are not covered in the Science and Technology roadmap, notably incubation hubs and proof of concept studies.	pillars, as well as interdependencies will be addressed in D8.4.
b. The business model canvas (p 5/12) oversimplifies. It misses the point that most GLAMs need financing to take part, and they are providers of data more than consumers of it. The cost structure misses organisational overheads, marketing and costs of providing the central services. The end-users (the general public) are not adequately represented.	The business canvas was used as a brainstorming tool for the draft road map. We decided to remove it from the final roadmap.
c. It is legitimate to measure impact in addition to revenues - benefits such as cheaper digitisation, generic automation, connection, added value interactions such as simulation experiences. But it is necessary to avoid the circular argument that cheaper digitisation will create more new jobs in digitisation: the automation of digitisation removes the need for labour. And even if GLAMs recognise a need for these new benefits it does not follow they have money to purchase them.	Noted. Will be taken into consideration in the final narrative.
d. The KPIs (p 7/14, 8/15, 13/20, 48/55) are not always well-judged. For example, “Development of public and private partnerships” is an action not an indicator; and “Licensing framework” is an output not an indicator. Others are not feasible to monitor, e.g. employment in the creative industries. The relationship between the various indicators needs cleaning up. References to sustainable revenue streams are superficial and need more work, and the assumptions need to be supported by evidence. Some of the assumptions are facile, for example the proposition that virtual tourism will replace real tourism is not convincingly defended.	The WP will prepare the final KPIs to ensure they are better harmonised. Important remark: Nowhere in Pillar 3 is it mentioned that "virtual tourism" (term not used in the text at all) will replace real tourism. Sustainable/cultural tourism is proposed to be developed and not a virtual one.
e. Section 3 Scholarship also needs strengthening. The section on “State of the art, technological monitoring” (p 9/15ff) repeats ideas expressed in the DoA, with insufficient progression beyond them, and much of the text reads like aspirations for impact rather than a roadmap for the actions that will lead to the desired impact. Section 3.2 Funding sources is superficial, and the purpose of section 3.3 Stakeholders is not clear.	Noted. Feedback will be taken on board and action by the task leader to incorporate in D8.4 and D8.5.

Comment	Response
f. The section on the education sector focusses more on the technology than on demand for access to the data resources.	We are currently in contact with stakeholders from the education sector (including Euroclio, Future Memory Foundation) to collect information on the state of the art, their needs for cultural and historical data, and how the Time Machine can address current challenges in this field. We hope to include the specific actions TM can take to address these challenges. Such actions include envisioning relevant software for their field, as well as addressing the financial, legal and other challenges we may face while maintaining such software.
g. Section 5 describing Economic avenues for exploitation (p27/34) is uneven. The target sectors (GLAMs, Creative industries, Smart tourism, Smart Cities and urban planning, Land use and territorial policies) are appropriate and the overview of conditions and barriers to take-up in those sectors is plausible. However, again, there are insufficient estimates of the level of demand in those sectors. The claimed operational advantages are plausible, but not the revenue streams, or the economic impact. Even if it is plausible that smart cities and urban planning might pay for studies and models of extrapolated futures, the roadmap needs an outline indication of charges, revenue streams, cost base etc. It is odd that this section specifically intends digitisation and indexing of existing archives (a very narrow and old challenge quite out of step with the hi-tech vision of the over-arching aims of the project). A further inconsistency is the level of granularity: stakeholders in this section are named individuals.	As with every innovation, the level of demand largely depends on dissemination and promotion. At this stage, the use case currently being developed and an impact assessment are more appropriate and will be presented in D8.4 and D8.5. Use cases, in particular, will cover certain representative scenarios which should outline why Time Machine is relevant to end-users in the exploitation avenues sectors. The following observations should also be taken into account: • Urban planning/smart cities: The level and nature of demand is currently being mapped through interviews with sector representatives, that are used for the development of specific use case scenarios (interviews with urban planners, local governments, SME's etc. to map their needs and how they can be met by TM). Presently the mapping of this demand focuses more on operational advantages • Land use and territorial policies: in the domain of sustainable development goals, there is an economic model to organise in Europe (and on earth more generally) efforts towards the 17 SDGs, and probably identify penalties and rewards with payment agencies. Besides ecological services and food safety, all these services will create more jobs and attract private funds in the future.