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

Deliverable D4.1
Exploitation Avenues (Pillar 3) Roadmap-draft

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.

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Main Author	Harry Verwayen, Julia Fallon, Valérie Gouet-Brunet, Dorit Raines
Contributions	Julia Noordegraaf, Emillie de Keulenaar, Stefan Meysman, Paul Sommersguter Johan Oomen, Rasa Bocyte, Max Kaiser, Bénédicte Bucher
Reviewer(s)	Frédéric Kaplan, Victor-Jan Vos, Mara Manente, Giovanni Vaia, Flavia De Rubeis, Carola Hein, Gabriele Bitelli, Didier Richard, Iason Jongepier, Robert Hecht, Jesus Angel Garcia Sanchez, Tino Mager

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Disclaimer

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.
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.

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

Table of Contents

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 development methodology foresees the elaboration of draft roadmaps for each pillar by working groups, followed by a round of consultations with relevant external stakeholders. These consultations will enable the Consortium to finalise the pillar roadmaps in a way that reflects the needs and expectations of a pan-European ecosystem that has been built around Time Machine and is currently expanding at fast rate.

The roadmap for the TM exploitation avenues is developed in WP4. This document is the formal deliverable D4.1 presenting the draft roadmap for Pillar 3. The emphasis at this stage is on describing the qualitative aspects of the proposed research and innovation actions in a sufficient level of detail, enabling informed feedback to be received during the consultations that will follow. The final roadmap is planned for Month 8 (October 2019).

The working groups in each exploitation area, composed of project partners and a range of stakeholders identified during the CSA, developed a research & innovation plan. They also identified funding sources and stakeholders along with the framework conditions needed to enable the approach, and finally the risks and barriers involved. Within the research & innovation plan, the state of the art & technological monitoring is described as a background to a set of targeted achievements and methods, which Time Machine should aim to meet, supported with preliminary estimates of milestones and key performance indicators.

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

Rational

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 and 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.

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 and to offering services to European citizens and consumers.

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

[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)

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 unimaginable 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 evolve to address bigger issues, allowing new interpretative models that can smoothly transition between the micro-analysis of single artefacts and the large-scale complex networks of European history and culture.
- Moreover, Time Machine will:
  - Be a driver of open science, as well as open (public) access to public resources.
  - Provide a constant flux of knowledge that will have a profound effect on education, encouraging reflection on long trends and sharpening critical thinking.
  - 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.

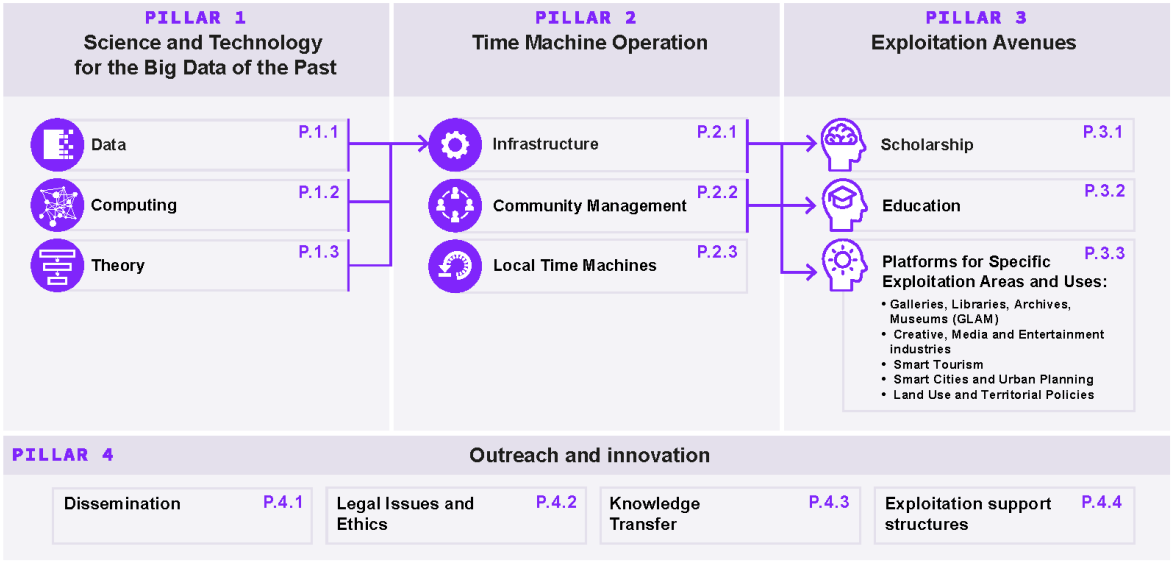


Figure 2-1: Time Machine Pillars & Thematic Areas and their interrelations

2.2 Pillar 2 approach

Objectives

The preliminary 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.

A preliminary model for the Time Machine exploitation avenues

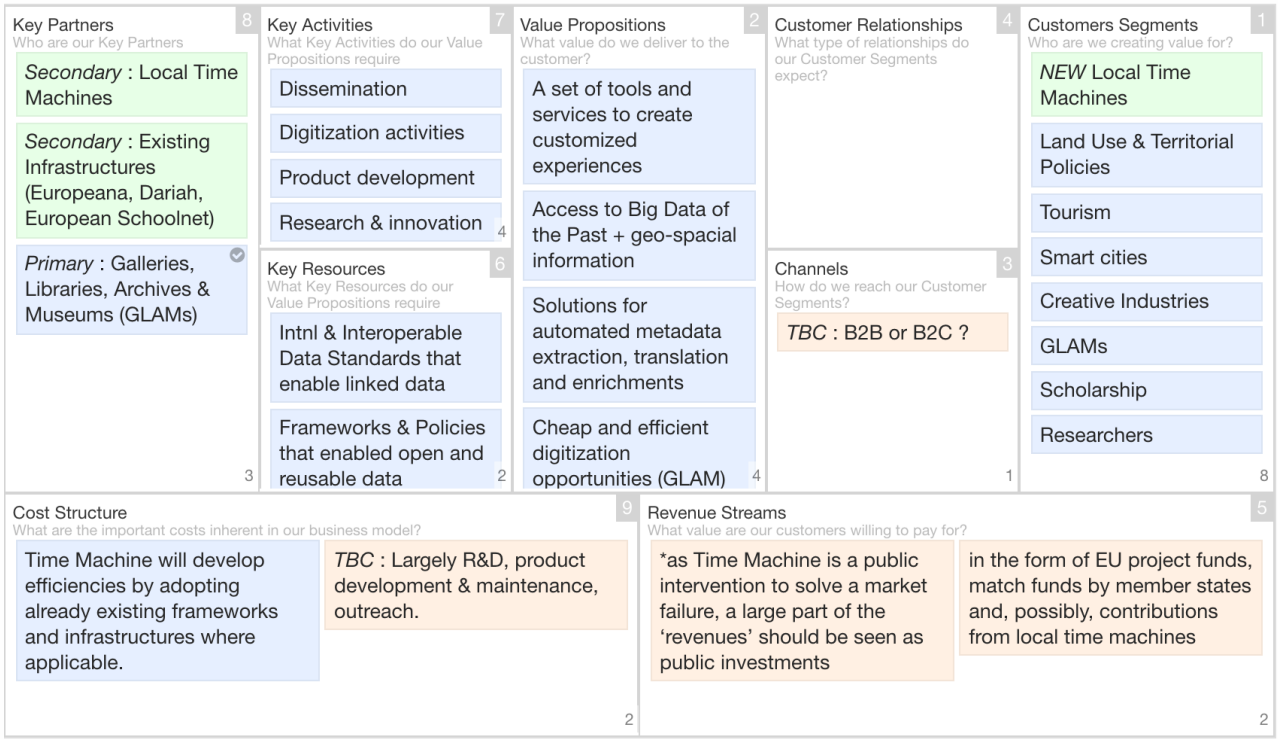
The vision for Time Machine centres around creating opportunity through access to the Big Data of the Past, understood as a huge distributed digital information system mapping the social, cultural and geographical evolution.

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)[2].

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.

To meet these challenges and consider the business model that would address them, we have used Strategyzer's Business Model Canvas to build a preliminary picture of the model for Time Machine, as shown in the figure below. From this modelling, we can derive that the fundament for creating value for this diverse group of potential audiences is to provide easy and unobstructed access, developing the Big Data of the Past as dense, **interoperable, standardised (linked data, preferably open)** and localised **(marked up with spatial-temporal information)** social, cultural and geographical heritage resources.



Business model Canvas for the Time Machine Exploitation Avenues

[2] https://pro.europeana.eu/post/charting-trends-in-digitisation-of-heritage-collections-read-the-enumerate-survey-results

Potential for impact of Time Machine

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 or economic conditions that are enabled through exploitation of the digital assets made available through Time Machine.

Using the Business Model Canvas for Time Machine, we identified 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.

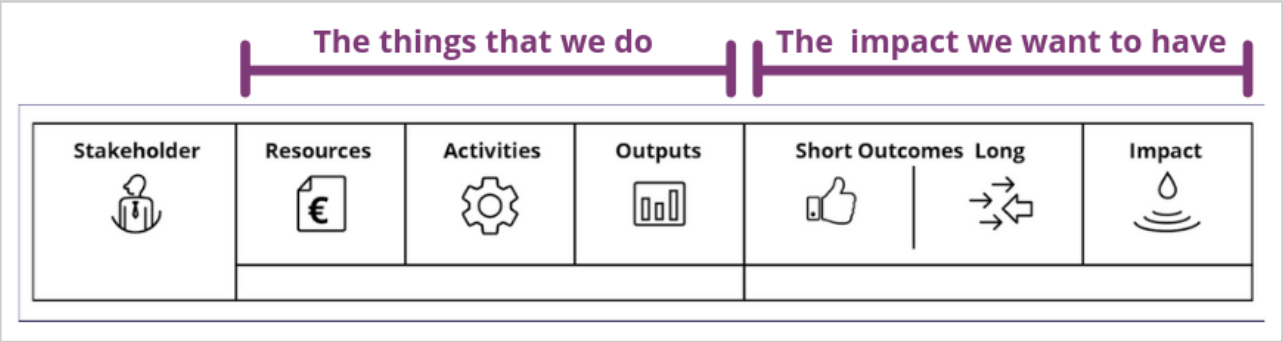
O2: *Generic Automation*: Enable the automation of the mark-up of these resources tagging concepts, named-entities, relations and rules.

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[3] 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. These ideas will serve to guide discussions with stakeholders and shape the final ideas that will be presented in the final roadmap for Pillar 3 (Month 8 – October 2019).

[3] 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

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**	
	Collection Access (i.e. Rethink and innovate existing methods of information retrieval at GLAMs)		
	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	

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	Metadata about the Intellectual Property of new works will be managed in a	Collective licensing frameworks and other security mechanisms (e.g. smart contracts) will support	Implementation of standardised right framework i.e. Europeana

Stakeholder	Activities	Outcomes (to 2030)	Indicators (of Impact)
	machine-readable way to track copyrighted content on a granular level (tracking of individual elements or excerpts) and support remuneration and rescue.	smaller actors in the sector and provide sustainable revenue streams	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	Interoperability between cross-domain components through time	Technological solutions for the understanding of the environment and its dynamics, for the citizen up to the policies (regulation)	Development of Public & Private partnerships

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 and tools for local TM cultural-heritage experience platforms and create the conditions for smart tourism to be considered a local/regional priority.	Innovative clusters working with local TMs to create a permanent ecosystem of smart tourism	Tbc
Smart cities, urban planning & land use	Collaborative and debating platforms based on data to collaboratively describe places, to share and defend hypothesis related to land dynamics	Integration of cultural items, soft values, and long-term development in urban planning and architectural design.	Tbc

3 Scholarship

3.1 Research and Innovation plan

Objectives

The TM platform will make available a macroscopic observatory for cultural history where cultural production can be studied as a four-dimensional macro-object, as opposed to the microscopic scale which is nowadays common in SSH. The TM thus has the potential to realize a radical expansion of the "zooming" capabilities of scientific research: from the microscopic level of historical anecdote to the macroscopic level of high-level cultural patterns and their interrelations with socio-economic trends.

The TM for Scholarship platform will host projects that allow researchers to navigate history in radically new ways, ranging from:

- "Google Street View"- like augmented reality experiences,
- Agent-based simulations of large-scale virtual re-enactments of major historical events,
- Ontological aggregators which extract multiple layers of metadata and content to cross-reference multiple sources for trustworthy scholarship.

These interfaces will allow accurate modelling procedures with a *longue durée* perspective that opens the way for new and more critical methods of analysis, with the aim of developing meaningful outlooks for the future.

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. Efficiently exploiting available datasets as linked open data in SSH still requires a considerable degree of expert domain knowledge, for example in ancient languages, which prevents scholars from answering large-scale research questions.

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, 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. 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.

Finally, many (digital) data collections exist as project outcomes, 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). Some remain hidden on institutional servers, others might be deposited as open source, often without a proper strategy or user-community. 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[4]	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
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

[4] 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[4]	Specialty
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
Git	Widely popular web-based, code-sharing infrastructure
Various DH tool repositories, including DiRT or the MIT recommendations for tools in digital humanities[5]	

Infrastructures/facilities for digital literacy:

- Training in digital methods: MOOCS (e.g., Europeana one)

Targeted Achievements

- First and foremost: the amount of connected, multimodal data and its accessibility in/through TM will in itself reduce the limitations listed under State of the Art, in a wide array of disciplines that employ historical data (most SSH fields) – most crucially since it **remedies the current fragmentation of the data and tooling**. As such, the TM **will provide SSH scholars with a much more comprehensive knowledge base for the study of longitudinal trends across various sectors and locations**.
- Because of its integrated approach (i.e. digitisation, interpretation & data gathering and management, as well as methodological innovation), **the TM infrastructure will drastically speed up advances in the state of the art in most SSH fields (and probably also in ICT). The pace and explanatory power of scholarly & scientific progress will multiply.** This innovation will be supported by the conceptual and methodological framework developed in pillar 1, for SSH research that combines the strengths of the tradition of hermeneutic research (interpreting the complexity of human culture and society at the microlevel of individual sources, places, people or events) with the advantages of quantitative methods (seeing patterns in large datasets and analysing those with statistical methods). This 'scalable' approach to SSH research methods will innovate scholarship in three ways:
    1. The methods can be used heuristically, whereby the patterns observed lead to new hypotheses on the phenomenon under investigation, that then subsequently are analysed with traditional, interpretative methods;

[5] 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/).

2. The analyses based on Big Data of the Past can be used to empirically test existing assumptions based on smaller, sample data;
3. The quantitative methods (including simulation) allow for the combination of different types of data and thus for more complex analyses.

- The location-based approach of TM allows scholars to query datasets of different origins and types, and relating historical data to present-day data on a particular location. This **facilitates research geared towards present-day societal challenges**, providing those challenges with a longitudinal perspective on their historical roots. **This will significantly boost the societal value of humanities research**.
- **Conjectural prediction of the future becomes possible** because of huge training data for the prediction algorithms that TM will provide, and which can be tested through predictions based on past data (then we can check the results against the existing historical knowledge of the past). Simulation of alternatives past(s) becomes possible because of vast data and trained simulation engines.
- Sustainable access to tools, that are also maintained – focus on specific software solutions that are also maintained by community of users.

Specific strengths of TM in boosting scholarship include:

- The integration of existing fragmented resources (examples architectural images and databases like SAHARA, ArtStor, geospatial databases);
- International reach (our project focused more clearly on connecting historical information in a supra-national way);
- The localization of historical information (ability to use the sources in relation to the locations to which they relate, which now has to be manually added);
- Direct access to non-textual content;
- Infrastructures for integrated research with multimodal sources (text, images, AV, 3/4D etc.).

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?

In order to achieve the foreseen impact on SSH scholarship, we will adopt the following strategy:

1. Conduct a number of **predefined 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;
2. On the basis of the use cases, we will generate a **set of best practices and training and dissemination material for SSH scholars**, that we will distribute via the relevant research infrastructures (DARIAH and CLARIN, as well as their national representations (e.g. CLARIAH-NL, CLARIAH-LUX, CLARIAH-VL, CLADA-BG); EHRI; E-RHIS) and via domain-specific professional organizations (including papers and workshops at their annual conferences, e.g. the European Urban History Association, Digital Humanities, etc.)
3. Subsequently, we will issue 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.

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)

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

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

M1	2020	Use cases selected
M2	2020-2023	Use cases executed
M3	2023-2025	Development of best practices and training and dissemination material
M4	2024	First open call for proposals
M5	2027	Evaluation CfP projects round 1 & implementation results
M6	2027	Second open call for proposals
M7	2030	Evaluation CfP projects round 2 & implementation results

Key performance indicators

Social impact is most relevant for scholarship; could be assessed by looking at:

- 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, https://registries.clarin-dariah.eu/courses/)
- Monitoring the impact of SSH publications on crucial topics (e.g. as evidenced by attention in the media)

Economic impact:

- Could be measured by looking at increase in number of startups that initiate in the SSH field (e.g., via Venture Labs as this one at UvA in Amsterdam: https://www.uva.nl/en/faculty/faculty-of-humanities/humanities-in-the-city/humanities-lab-avs/humanities-lab-avs.html)

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 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, 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 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 access the TM ecosystem.	Medium	High	Ensure that TM data is easily accessible outside of TM interfaces, via, e.g., more user-friendly and popular interfaces. Ensure that linked data literacy not be a requirement for TM usage.
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

Current challenges in the field of education comprise inclusiveness and life-long learning, designing customised educational material, information competency as well as an increasing complexity and change rate of knowledge intensive labour requirements. Facing these challenges, the TM platform for Education will offer unique enquiry and experience-based blended learning, citizen science infrastructure and approaches based on revolutionary digital technologies (VR, AR, AI).

TM for Education will focus on developing pedagogical content for schools, universities, and lifelong learning in a mix of free, sponsored and paid services. Content will be largely based on the Big Data of the Past and associated simulation technologies. Important objectives will be to accelerate the learning of SSH, through swift availability of many facts on a single 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 learn informed decision-making, considering and balancing relevant facts, interests, values, costs and benefits.

Teaching and research is also considered as a third exploitation domain (after private use and professional use), for which TM can enrich teaching material associated to SSH, the sciences, health and practical technologies.

State of the art, technological monitoring

Definition of **scope**: The Time Machine exploitation avenues for education are geared to all forms of learning: pre-school, primary, secondary and higher education; lifelong learning; vocational training; informal learning.

Our **main target group are the educators**, and our goal is to enable the developers of educational materials to develop new tooling within education platform to enhance learning (e.g., secondary self-learning (courses, tourism etc.)).

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 managed 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 social media platforms like Facebook and Twitter are all in the ranks of the most popular websites in Europe and worldwide (see Alexa 2019), and are as such a select number of centralised (indeed, platformed), global sources of reference. These three platforms serve an educational purpose that has 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). However, 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 information through in their products and user interfaces.**

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, iTunes University and MOOCs 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 popularly prefer more options to access, extract, combine and repurpose granular data for educational purposes.** What the report calls 'mobile learning' then refers to making software ready for mobile accessibility and transaction, inviting 'course content with stand-alone applications' to 'a strategic consideration for course access and delivery' and pushing 'course content' to be available on 'all platforms, with mobile being a key consideration.' (EDUCAUSE Horizon 2019, 21). **We may also add, to this same category, 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 (a crowdsourced adaptive platform for recommending learning activities), the Jefferson Competency Assessment Tool (designed to monitor student performance and provide "a holistic view of performance to students, faculty and administration") (EDUCAUSE Horizon 2019, 23), the University of Sydney's Student Relationship Engagement System (which gives instructors abilities to capture and analyse data on student's study performance) (EDUCAUSE Horizon 2019, 27), the AdmitHub (used to contact "prospective and incoming students") (ibid), and Edulai, which is "designed for university students and teachers to help monitor and measure the development of skills such as critical thinking, communication, collaboration, leadership, problem solving, and interculturalism." (ibid). 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. 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 equally 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 interactive gaming tool accessible from mobile devices to provide instantaneous	The latter type – games – are particularly informative, in that, partly due to

Type	Description	Examples	Cons
		feedback and class data to keep students motivated." (EDUCAUSE Horizon 2019, 22).	their interactive nature, 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.

Targeted achievements

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.

Methodology

The objective of the Time Machine in education is to **develop pedagogical content for different groups and institutions**. 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 and users at large with seamless and integrated access to historical data.

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 match the infrastructures for education currently in use** 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'.

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, technical schools, universities and other** (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 primary schools, secondary schools, higher education and local volunteer-expert community groups within pilot project, focused on three 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) information 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 and interfaces 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 are specific 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).

Our strategy is to develop four pilot projects around these three core aspects, with each pilot addressing a specific level of education. The pilots address either:

- one level of education with multiple aspects;
- multiple level of educations for one of the aspects;
- a combination of the above.

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

Example of how the pilot projects may be distributed

Organizationally, we will 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 [#], will be disseminated among the stakeholder groups in the educational field.

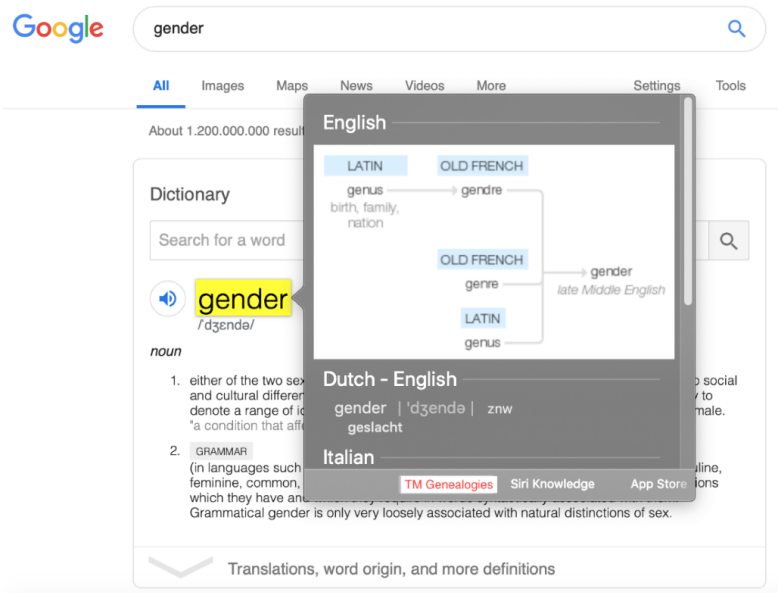
Since the pilots depend on the availability of sufficient Time Machine data and infrastructure, they will start somewhat later in the project. The pilots are preceded by a preparation phase which focuses on stakeholder organization and collection of requirements for the necessary infrastructure via interviews,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

The application of this pilot project can result in the following utilities:

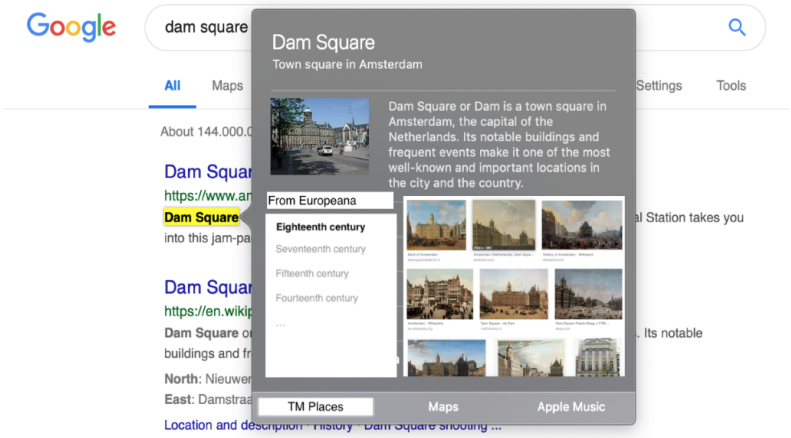
1. Introducing students to the Time Machine as a platform of big data of the past and cultural information. The Time Machine can become an **open-sourced centre-point (or platform) of historical and cultural reference on Europe on the web**, covering and combining, as a result, several of the functions 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.
2. 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 perpetuated by over-personalised information). Open data will need to be in compliance with appropriate regulatory frameworks, such as IPR and GDPR.

3. 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 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 'history look-up' 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, that different times in which it was used, by whom, where, to whom it referred to). With regards to places, it could provide any location found on the web can be explored via, e.g., Local Time Machine at different levels: through 2D maps or and through 3D modelling. With regards to people, it could provide social networks and family genealogies of people related to a given name.



Example of a TM 'Genealogy Look Up' feature



Example of a TM 'History Look Up' feature for words referring to locations, where the source of historical information would be Europeana

The Time Machine could propose several student or user-targeted applications (such as the above-mentioned 'Look Up' feature, 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.

4. Introducing students and educators to the Time Machine as localised, personalised 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, personalized 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).
5. Using the Time Machine as a source of new engagements with historical information.
   Using Time Machine applications and data would facilitate participatory forms of education, particularly through new forms of engagement, such as VR/AR, historical chat bots, and multimedia storytelling.
   Interfaces for Time Machine applications will require clear indication of origin, quality and type of data (forging dependency with 2.2). They will also be embedded with services for special needs (hearing or visually impaired etc.) and an inclusive approach to design (dependency with 2.2, type of descriptive data for visual sources needed for visually impaired).

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 is required for pilot study 4, TM for informal learning.

Milestones

M1	2020-2022	Preparation phase: stakeholder organization, requirement analysis
M2	2022	Selection of pilot projects round 1
M3	2023-2025	Pilot project 1 & 2 executed and monitored
M4	2025	First round pilot projects evaluated
M5	2025	Development of best practices and training and dissemination material
M6	2025	Selection of pilot projects round 2
M7	2026-28	Pilot projects 3 & 4 executed and monitored
M8	2028	Second round pilot projects evaluated
M9	2028	Refined best practices and training and dissemination material
M10	2030	TM infrastructure for education in place

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

Industry	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.

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 / academy workshops.

Potential risks and barriers	Likelihood	Impact	Proposed risk-mitigation actions
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 inability to work with digital technologies.	High	Medium	Ensure user-friendliness in *both* Time Machine applications and analytics (e.g., SPARQL).

5 Economic avenues for exploitation

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.

5.1 GLAM

Research and Innovation plan

Objectives

GLAM institutions are central in the collection, description 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, 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 constantly need to reposition themselves.

Improving the efficiency and processes for the **handling**, **storage**, **description**, **exploitation, exhibition, discussion, and interconnection** of digital objects will play an ever increasingly important role in the digital transformation of GLAM organizations. Time Machine – essentially the Big Data of the Past and all of 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, services, 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)
- **create synergies** between developments and strategies already underway in the GLAM domain and 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, process and/or re-use the Big Data of the Past

In the following months, stakeholder consultations are expected to shape our common vision and objectives.

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**.

Digitization, Data Model, Storage

Digitization potentially covers various aspects that are not solely scanning-related: the selection of objects, their preparation, the actual scanning, 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 an important 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[6] 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 analogue cultural heritage presents another significant challenge: when collecting analogue material, physical space[7] is a limited resource.

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

[7] 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	Check with corresponding work packages (WP2)
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
Complex data models for heterogeneous datasets	Time Machine could streamline datasets EU-wide with a standardized and robust data model that can be applied to various types of collections Time Machine provides a streamlined version control system in order to be able to tell which version of a digitized object is the most recent and best 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
Diverse modalities of objects, both analogy and born-digital	Time Machine provides ways to digitize every object possessed by a GLAM institution – even those, that cannot be digitized yet	• data modelling • data storage and long-term persistence
Some collections / material types suffer from digitization	Time Machine provides gentler techniques of digitization that do not even require objects to be manually prepared	• data acquisition
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
Offering Linked Data requires a lot of resources and preparation	Digitization does not equal publishing as LOD, 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
Museums displaying built heritage often rely on outdated archives documenting the construction	Time Machine could provide consolidated datasets including archives integrated into 3D models	• data modelling • visualization
Digitizing the context of an analogy (or even born-digital) artefact lacks standards and is very 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 artist. Time Machine could provide frameworks to deal with these different kinds of modalities and contexts	• data modelling • visualization • digital methods / source criticism (de-contextualization of data)

Examples	Scenario(s) with Time Machine	Check with corresponding work packages (WP2)
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 could be shared among institutions Time Machine delivers means of digitization that are much more efficient in use	• data acquisition

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	Check with corresponding work packages (WP2)
Various rights statements for different collections	Time Machine provides a robust rights management model that works EU-wide	• data storage and long-term persistence
As a data contributor: some collections cannot be opened to the general public	Time Machine lets contributors pick a pre-defined "level of openness" of data. Example: This could mean that institutions can contribute data, without providing this raw data to the general public – or the other way: provide training data for Time Machine without providing the actual images Alternative Scenario: Time Machine goes beyond the institution holding rights and establishes thematic communities based on raw data	• data storage and long-term persistence

Participatory Initiatives, Experiences, and Novel Curation Approaches

With a rising demand for modern, interactive, immersive, elegant, enjoyable, and contextualized experiences by the general 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. By adopting participatory initiatives, a central role of GLAMs – curation – has already been transformed.

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	Check with corresponding work packages (WP2)
Participatory initiatives often need to be specifically designed and implemented by an institution and are cost-intensive	Time Machine provides open tools for labs and other spaces of open innovation that can be used by institutions EU-wide Time Machine could provide state-of-the-art and highly flexible crowdsourcing-software in order for end users to contribute data	• human-computer interaction • visualization
GLAM institutions may lack the processes necessary to transform (their) data into innovative experiences	Immersive exhibitions are increasingly successful, TM can provide "curated 3D content" for the museums that open their collections to the project	• human-computer interaction • visualization
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 delivering immersive videos providing an experience of the monument as it is being restored	• human-computer interaction • visualization
Curation solely 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
Curation requires a wide variety of expert skills	Time Machine provides novel ways of automated or semi-automated curation of Cultural Heritage objects	• N/A

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 the current situation GLAMs face that could be tackled by Time Machine in these areas.

Examples	Scenario(s) with Time Machine	Check with corresponding work packages (WP2)
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 of the available modalities	• human-computer interaction • visualization • natural language processing • indexing and retrieval

Examples	Scenario(s) with Time Machine	Check with corresponding work packages (WP2)
Disparate analogue collections	Time Machine connects the digitized counterparts of these disparate collections for further exploitation by adopting novel visualization techniques	• visualization
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
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

Next steps: Above areas, examples, and scenarios are expected to be modified after stakeholder consultations. Also, the connections to other WPs will be iteratively checked.

Targeted Achievements

Time Machine will boost, aid and accelerate many developments that are already underway in GLAM and introduce completely new **transformative effects.** 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 Machines various developments and exploitation possibilities in GLAMs.

Collection Custodianship & Enrichment

Nowadays, **digitization** of analogue objects is a labour- and cost-intensive process. Large quantities of analogue 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 analogue artefacts 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 general 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.

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

In order for collections to be queryable, they have to be semantically enriched. However, the description of collections is a tedious and cost-intensive task that often is undertaken as an isolated initiative – and: by humans with special expertise. With Time Machine, various new methods of **algorithmic enrichment** will be introduced to annotate and describe collections. This enables easier findability of data, e. g. single objects and collections.

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 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".

Also, Time Machine fosters automated **information extraction**, **machine learning, and AI** as the main drivers of innovation in GLAM institutions. **Document understanding** and **automated translations** (including translations from ancient languages to modern languages) will vastly increase the accessibility for all kinds of audiences and is expected to have a transformative effect not only on education and scholarship but also tourism.

Lastly, GLAM institutions will hugely benefit from Time Machine's vast source of sound and robust **training data**.

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.

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 labour-intensive and requires an interdisciplinary team of curators, branding experts, storytellers, digital strategists, programmers, technicians, among 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 collections, it can also tackle 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.

Time Machine services let users experience collections by providing the ability to dive deeper, augment or generalize when needed, the ability to set in a context and provide room for imagination.

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**[8]: Imagine to let 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

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

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.
- **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.
- **Digital twins**[9] 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. 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 general public and institutions alike.

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 through the use of machine learning. These initiatives will further feed data and new knowledge back into Time Machine's databases.

Monetization and distribution of single objects and entire collections are further main focuses that 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 FAIR[10] data principles have to be taken into account.

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

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

Next Steps: Align above proposed Targeted Achievements with other WPs and check for completeness. Depending on expert interviews and further desktop research, the above-mentioned clusters are expected to be further refined.

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: "Stakeholder" for more details).

We recommend pooling the following tentative roadmap in **thematic clusters** containing various activities for the coming years. Stakeholder consultations 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

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

[10] 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. At this point in the CSA-phase, we suggest to link 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 (*digitization*, *indexing*, *connection*, *experience*). 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 main areas of expected impact for GLAM: *digitization*, *indexing*, *connection*, and *experience*.

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).
- **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 and co-creation platforms.** We propose to design and setup co-creation platforms and interlock them with Local Time Machines.

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 as a whole 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[11] (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.
- **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.

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

Next steps: This initial methodology outlines an overview of activities and needs to be further discussed with stakeholders.

Milestones

At this stage in the CSA-phase, we propose the following milestones that outline dependencies:

Cluster	Milestone number	Milestone	Due date
1 Vision and Strategy	MS 1.1	Strategic task force established	2020
	MS 1.2	User stories and use cases formulated	2021
2 Experimentation and Exploration	MS 2.1	Selection criteria defined	2021
	MS 2.2	Selection process finished	2022
	MS 2.3	Concrete test scenarios refined	2022
	MS 2.4	First pilot action(s) launched	2023
	MS 2.5	Impact analysis of pilot action concluded	2025
3 Generalization and Sustainability	MS 3.1	First model derived from experimentation and pilot actions	2025
	MS 3.2	Large-scale roll-out started	2028
	MS 3.3	Sustainability plan	2025
4 Collaboration and Outreach	MS 4.1	First smart cluster created	2021

Next steps: Milestones will be refined after consultations with stakeholders, as well as coordination with WP2 and other subtasks in WP4.

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. We generally propose a few KPIs to measure this impact:

- **Heritage Accessibility:** Ratio of accessible material vs. inaccessible material (according to FAIR data principles)
- **Cultural and Economic impact:** Number of jobs in the sector created that are attributable to the Time Machine Initiative
- **Heritage Digitization:** Ratio of digitized vs. non-digitized material; Speed of digitization
- Levels of adoption of **Linked Open Data**

- **Impact on Creative Industrie**s: Number of collaborations with (local) creative companies contributing to providing state-of-the-art experiences in GLAM institutions
- Number of **adopted Time Machine services** and tools in GLAM institutions
- Number of **realized Local Time Machines** with GLAM institutions being a leading or contributing factor

Next Steps: For defining key performance indicators on a more detailed and operational level, further research and coordination with other WPs are required.

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 TM platform could work as a catalyst for these types of funding, linking national funding to TM 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 through its R&D programs many research and innovation actions. 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's 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 function that support 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. In order for this very important step to function properly, novel digitization techniques that not only provide the technical capabilities but also tackle 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, the following 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. This initial list has since been

further clustered and extended. Since Time Machine impacts both internal and external stakeholders, we do not differentiate between end-users and stakeholders.

- **General Public** as GLAM clients and customers that make GLAMs part of their daily lives: e. g. researchers, hobbyists (like genealogists), teachers, students, readers, (media) artists and creatives, documentalists, exhibition-goers, 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, 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 …

Next steps: This complex interplay of GLAM institutions with Time Machine will be outlined in the final roadmap in more detail. Also, since some of these stakeholders will be consulted in expert interviews, the above list may be iterated if needed.

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 Systems[12] / AI ethics	Check with WP2, WP5 in the upcoming months
Data ownership aligning to GDPR[13]	Set up a process to monitor compliance within TM
Copyright and rights management	Check with WP2, WP5 in the upcoming months
Data storage contracts	Check with WP2, WP5 in the upcoming months
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

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

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

Potential risks and barriers	Likelihood	Impact	Proposed risk-mitigation actions
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 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
Different needs/profiles within GLAM	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

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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. The document serves as a basis for the final roadmap and will be further developed during consultations with relevant stakeholders from the industry.

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[14], 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. 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.

[14] 95% of all cultural and creative institutions employ only up to nine people.

http://ec.europa.eu/growth/content/boosting-competitiveness-cultural-and-creative-industries-growth-and-jobs-0_en

- **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.[15] 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.[16]
- **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[17]. 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[18] establishes that although digitisation has already significantly impacted the cultural and creative sector, it has not drastically transformed creative value chains. The main challenges that constrain the development of creative outputs and their exploitation possibilities:

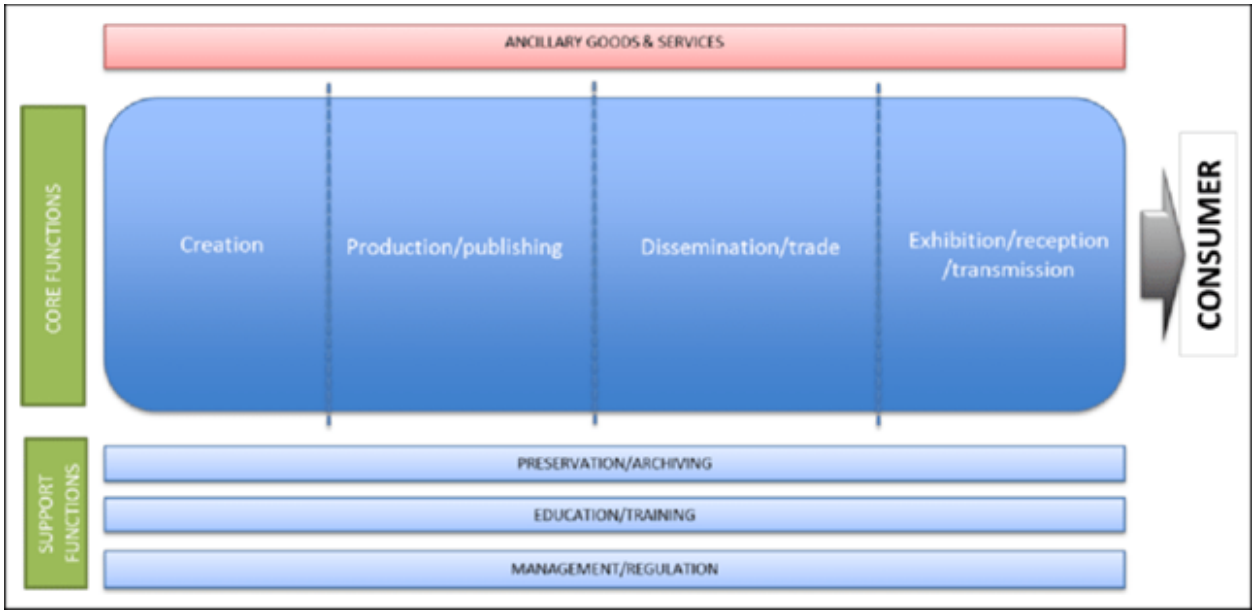
- **lack of skills and capacity** for small scale and individual creators to harness opportunities opened up by digitisation
- **quality of data** available for reuse limits possibilities to find and retrieve relevant sources. Inaccessibility of audiovisual, multimodal, multilingual resources and inaccuracy of 3D scanning technologies are major barriers for exploitation

[15] 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
[16] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0288
[17] See https://en.wikipedia.org/wiki/Commons-based_peer_production#Examples
[18] See http://www.keanet.eu/wp-content/uploads/Final-report-Creative-Value-Chains.pdf

- **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 the intermediaries rather than the 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
- **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 inflicted with 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
- **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** results in misinformation or creation of overarching narratives that do not accommodate the coexistence of multiple truths from different perspectives

Targeted achievements

Time Machine will introduce scientific and technological breakthroughs that will significantly impact the production cycle of the creative, media and entertainment industries. Time Machine innovations 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[19]

[19] https://publications.europa.eu/en/publication-detail/-/publication/01c92f2a-45ad-11e7-aea8-01aa75ed71a1/language-en/format-PDF/source-30933297

Below, we briefly outline the Time Machine interventions to the creative value chain and map their connection to the development work foreseen in WP2 and WP5.

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 will support the exploration and retrieval of yet undiscovered patterns, connections and observations which will serve as an inspiration for the development of new creative ideas. The open and interoperable infrastructures for data exploration which will enable creative freedom and diversity. Artificial intelligence will also support new forms of creativity, including computational creativity.

WP2: 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. Smart metadata models will support the ability to combine and seamlessly integrate digital objects in different variations to tell different stories.[20]

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. The increased computational processing capabilities for big data processing will also reduce the complexity of production processes (e.g. use 3D visualisations and modeling in design).

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 clear copyright acquisition and licensing mechanisms. Newly developed business models will ensure that both data providers and creators can benefit from these transactions.

WP2: 2.3. Human-Computer Interaction and Visualization, 2.5 Computer Graphics, 2.6. Super Computing.

WP5: 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.

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 sectors, including the tourism industry, GLAMs and education, will benefit from novel services and experiences designed for their end-users. 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. Sectors

WP2: 2.2. Natural Language Processing, 2.3. Human-Computer Interaction and Visualization, 2.4 Machine Learning.

WP5: 5.2 Policy and Legal issues, 5.4 Exploitation Support Structures.

[20] 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

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

Metadata about the Intellectual Property of new works 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, rescue 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, in this way increasing cultural participation and raising awareness about the potential of cultural heritage.

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

WP5: 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 into 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 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, the role of the Local Time Machines is to act as incubators or living labs for the creative industries. This will be achieved in two phases:

1. First, the proposed exploitation scenarios and frameworks will be **validated through Proof of Concepts** and **collaboration and outreach activities** will be conducted to engage relevant stakeholders.
2. Building on the outcomes of this, Local Time Machine will **establish incubation hubs that enable creative industries** to exploit Time Machine data and services.

Initiation phase

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 ideation for the roadmap.

- **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.

Cluster 2: Proof of concept

As a starting point, it is essential to validate the proposed roadmap actions that support the creative value chain as well as strategically position and demonstrate the exploitation impact in the creative industries and define priorities that need support from the decision-making bodies. To galvanise this process, the Time Machine proposes to run **Proof of Concepts with one domain in the creative industries** and through this process, refine the roadmap and the proposed exploitation strategies that will pave the way for exploitation in the creative industries at large.

In order to achieve the greatest impact in a short period of time, we propose to invite stakeholders from the **game industry** to take part in the Proof of Concept stage. As an industry that holds a prominent position in the European market and already has connections to the cultural heritage sector, it 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. Given the large number of independent and amateur game developers, it would also serve as a testing ground to see how they could smaller and individual players find their place in the market with the help of the Time Machine. In addition, 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.

A number of well-established as well as smaller players in the game industry would be invited to experiment with a number of scenarios that correspond to activities in the creative value chain.[21] Based on the realisation of exploitation scenarios in the game industry, business case studies and user stories will be developed to serve as a source for inspiration for other stakeholders in the sector, demonstrate the gains and impact as well as challenges related to exploitation that need to be addressed.

The results of these initial experiments **will inform the activities** in (1) "Pillar 1: Science and technology for the Big Data of the Past and (2) Pillar 2: Time Machine Operation". Furthermore, the Proof of Concept phase will inform the realisation and strategy for setting up Local Time Machines as innovation hubs for the creative industries to support stakeholder engagement and exploitation models.

Execution phase

During the execution phase, Local Time Machine will (1) **facilitate incubation** of new ideas and tools for the creative industries, (2) establish **infrastructures that support reuse and exploitation** of the Time Machine data and services and (3) **ensure sustainability** of these activities on a pan-European level. Collaboration and outreach activities (see above) within the creative sector as well as with other industries in the European market will continue.

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

[21] These will be defined in coordination with other work packages and depend on the resources and infrastructure available.

- 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

In setting up the 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.[22] 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.[23] With respect to design methodology used, insights from frameworks such as 'Design Sprint' by GV and 'Future Visioning' developed by Business Models Inc. will be used.[24]

Cluster 4: Support infrastructure

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[25] that **oversee fair licensing regulations**, ensure remuneration for creative products and provide support for individuals and organisations in the industry.

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.

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

[23] http://www.ebn.eu, https://impacthub.net/

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

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

Milestones

Cluster	Milestone number	Milestone	Means of verification	Due date
1. Collaboration and outreach	MS1.1	Hub infrastructure established	Partners in the Game Industries approached and strategic collaborations with relevant ancillary networks established.	YR1
	MS1.2	Outreach Strategy in place	the Outreach Calendar published and the marketing strategy is in place. The marketing strategy includes: (1) appointing Time Machine Ambassadors, (2) hosting of creative residencies, (3) training, mentorship and peer-learning programmes	YR1
2. Proof of concepts	MS2.1	User stories refined	Successful execution of the Proof of Concept in the Gaming Industry.	YR2
	MS2.2	Concertation efforts across the TMO Pillars	Outcomes from the Proof of Concept are discussed with Pillar 1: Science and technology for the Big Data of the Past and Pillar 2: Time Machine Operation. This results in updated activity plans across the Pillars	YR2
3. Incubation	MS3.1	Launch of the incubation activities	Methodology established and First incubation activities launched.	YR2
4. Support infrastructure	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
5. 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.

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)

Proof of concepts

- number of scenarios tested
- number of stakeholders involved in Proof of Concepts

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 infrastructures

- 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 consortium 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.

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.
- **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 businesses offering tools and infrastructures for the creative sector** will be invited to the innovation hubs to experiment and test new services and products in collaboration with the stakeholders from the creative industries. They will also help to bridge the gap between the novel technological developments and their deployment by players in the creative industries.
- **R&D 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[26]	Demonstrate added value towards decision making
Pan-EU regulations for ethics guidelines with respect to AI[27]	Work with industry to position Time Machine as a leading example of "responsible AI"

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

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

Framework conditions	Proposed actions
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"[28] vision can be used to support the vision of the Time Machine Organisation. If this model falls short, look at other options.
Capacity building limitations and fragmentation	Provide opportunities for cross-sectoral collaboration and harmonise EU regulations

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 the industry	Medium	Medium	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	Medium	Connect with groundbreaking industries, startups and entrepreneurs who have the resources and are eager to experiment.
The roadmap does not meet stakeholder expectations	Low	Medium	Iterative consultations with stakeholder groups and monitoring of the latest developments in the field.
Political decisions that reshape legal and economic frameworks	Low	Medium	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	Medium	Develop strategies for continuous engagement.

Annex: Domains in the creative, media and entertainment industries

Industry	Areas of impact
Advertising and marketing	advertising agencies, marketing agencies, PR, brand management, market research and consultancy
Architecture	architectural design agencies, engineering, construction
Design	graphic design, software design, fashion, interior design, textile design, product design, internet of things, wearable technologies

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

Industry	Areas of impact
Film and video	film production companies, set design, screenwriting, post-production, online video production, documentary makers, film distribution, exhibition production
Game industry	computer graphics agencies, animation studio's
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)[29]. 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)[30] can generate devastating and irremediable economic, environmental and social impacts due to uncontrolled development (Kasim, 2006[31] Akama, Kieti, 2007[32]). 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)[33]. If these, which are very often unique and not reproducible, are

[29] http://cf.cdn.unwto.org/sites/all/files/pdf/unwto_barometer_jan19_presentation_en.pdf
[30] Costa, P. and Manente M. (2001), *Politica Economica del Turismo*, Milano: TUP Touring Editore.
[31] 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.
[32] 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.
[33] Ritchie, J.R. Brent and Crouch, Geoffrey I. (2003), *The Competitive Destination, A Sustainable Tourism Perspective*, Trowbridge: Cromwell Press.

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 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[34]), 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"[35].

The expected impact of such an action is:

- improving policies and practices on cultural tourism at various levels

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[34] 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.

[35] 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

- providing strategic guidance at European level concerning the efficient use of European Structural Investment Funds
- 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.

Yet, to date, even though papers and conferences underline the future role of technology and innovation in tourism, no real action has been made on a European level to develop specific technology-driven cultural heritage packages to address the growing experience-based demand of tourists, nor 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 two largest aggregator platforms **Expedia.com** and **Booking.com** gives the following results: Booking.com does not have any cultural offer or experience while Expedia.com offers sometimes hotels or destinations by experience category (beach, snow, northern lights) or "things to do" in a location (usually a city) where guided tours are offered[36], a self-guided tour through an app or browsing by Interests/history/cultural & heritage experiences which suggests guided tours, serenade evening with dinner or a cooking class[37], but have no cultural heritage packages to complete the tourist's experience. **Airbnb** also has a category called "Experiences" where people can choose guided tours of "the secret life of historical places"[38].

A more specific website offering cultural heritage experience (all other websites offer only local experiences):

The cultural experience (https://www.theculturalexperience.com/): "The Cultural Experience is a leading international battlefield tour, historical tour and cultural tour company offering expert led holidays to destinations throughout the world. We offer a wide range of scheduled escorted tours including archaeology, military history and general history tours all of which are accompanied by leading historians, academics or senior soldiers.

We are also a leading provider of school trips to many schools in the UK and Ireland and organise bespoke battlefield studies and staff rides for The Army, RAF, Royal Navy and other MOD establishments. We can also create a wide range of tailor-made tours for individuals, small groups and organisations ».

Offered categories for selection: Tours by: Theme; period in history; destination; date; tailor-made 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

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[36] 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

[37] 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

[38] 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

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 needed legal framework and defining priorities, the creative sector (core reusers) with its technology-driven products, the TM platforms enabling core re users and endusers 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 endusers.

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[39], 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

After 1 year – Local TM with local 3S cluster define priorities regarding targeted tourist profiles, CH prioritized narratives, CH local destinations

After 3 years – first set of technology-driven CH narratives to be tested on targeted tourist profiles

After 4 years – infomediaries to be approached with customer satisfaction test results

After 5 years – measuring social, cultural and economic impact according to ETIS

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

Key performance indicators

Europe has launched in March 2016 ETIS: The European Tourism Indicator System ETIS toolkit for sustainable destination management[40]. 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:

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

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[41]:

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*

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

[41] 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 (graphical interface).

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 customer a freemium on-bus/cruise/sojourn experiential 'fit-for-purpose' kits 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[42] 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"[43]. 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[44] 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[45]:

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[42] https://ec.europa.eu/growth/sectors/tourism/offer/sustainable_en
[43] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010DC0352&from=EN
[44] http://ec.europa.eu/DocsRoom/documents/10155/attachments/1/translations

[45] https://www.e-unwto.org/doi/pdf/10.18111/9789284419340

1. making tourism governance 'fit for purpose'

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 Smart cities, urban planning, land use & territorial policies combined

Research and Innovation plan

Objectives

These subtasks aim at exploiting 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. 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. 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.

We target the following main objectives:

I**ntegrated, inter-connected information systems for cities and lands**, across time, space and scales, across administrations, across authorities and citizens, that supports not only browsing (in a way Wikipedia does) but also queries. 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).

Multi-scale and culture friendly city and land information systems. 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 can adapt their interface and functionalities (iterative, co-design approach to development of responsive interfaces). They should support *zooming* in and out between the perspective of Europe and more local perspectives as well as to embrace focus (fine level of details) and context (lower level of details but wider coverage) in analyses.

"Affordable and sustainable" solutions to build specific cities or lands information systems (Time machine projects) that integrate into a wider framework, whatever a city or rural territory or country resources (in terms of funds but also expertise and communities), incl in emerging countries, and available also for transversal themes (e.g. Glaciers Time Machine, Wetlands Time Machine, etc). It is important that the **studied cost comprises ecological footprint as well as how much of private information** we are ready to share. In particular promoting a shared knowledge graph and delivering new archiving principles and strategy.

User-centered retrieval of facts and data in Europe history (other cities, other territories) to favour exchange and mutualisation as a bottom up process to find solutions to sustainable development challenges, that may complete existing a top-down process using the state or using the European Commission. Users also need **meaningful documentation of uncertainties and hypotheses**.

Recommendations for decision makers to support their planning and design solutions : suggesting connections, presenting situations from the past that are related to the present-day experience of specific localities and phenomena can support and inspire decision makers, citizens, scientists to invent new solutions and approaches, e.g., regarding choices in urban development or land use. TM can also 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.

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 stake holders 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.

Debating platforms related to cities and territories design present historical information and heritage in the contexts that are relevant to the experiences of the different audiences (bringing history and heritage to the people, rather than the other way around). As such, these platforms can be leveraged to connect present-day experiences and problems to different past events that *make sense* to different citizen groups. These platforms should be 'polyvocal', allow for multiple perspectives on the past, creating room for the often unrecorded stories of minority groups, including newly arrived citizens who may not share the dominant culture. These platforms will also benefit from the capacity to share and compare hypotheses, thanks to story-telling functionalities.

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.

State of the art, technological monitoring

A key S&T domain is the human capacity to observe and understand the transformations of landscapes and built environment, including long-term developments. Cities and lands are characterized by natural phenomena (terrain, vegetation, climate, underground), man-made entities (roads, bridges, buildings, especially in cities) 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. Social practices are intimately connected to the physical form of cities and landscapes. **As a whole, sources of information about cities and landscapes are fragmented, heterogeneous and not well-connected**.

Available sources and acquisition technologies: in situ topographic survey or geological survey, statistical surveys, remote sensing, administration dashboards manual filling. Remote sensing, from aerial imagery to current satellites and unmanned aerial vehicles, using optical sensors but also thermal imagery, lidar, superspectral imagery, is especially precious to design land cover description as it supports systematic survey with a given spatial and temporal scales. Another technology is crowd sourcing and collaborative content, e.g. to survey biodiversity. An issue is the comparability of these sources. All these technologies **generate data silos**.

Conceptual models to structure information: there is **no universal conceptual model** to depict cities or to depict lands. This semantic heterogeneity occurs in time and in space. When proposing conceptual models, one must find a **difficult compromise between tractability and expressiveness of a geographic representation**: tractability requirements lead to use not too many classes and datatypes whereas expressiveness requirements lead to distinguish local specificities and semantics. Classes used today in

European land description like permanent grassland, refer to different realities. This is also true when applied to other areas like Africa. Sometimes, even scientific communities do not agree on what are relevant concepts to study land. This is the case for instance for land take (soil artificialisation).

Land cover and land use products: an important information product to establish objectives and monitor progress related to land is the land cover and land use product that describes lands through millesimal snapshots where space is divided into portions homogeneous enough with respect to indicators. Integration between such products is problematic when the portions (also called the segmentation) are not the same and also when the indicators change (typically statistical classes definitions). Yet we lack long term timelines within these information products used for territorial policies (historical products or services are not connected with current data). At the level of the planet, the United Nation created a special working group for Geospatial Information Management (UN GGIM) that identified necessary core data to monitor progress towards 17 sustainable development goals. These core data take the form of Land cover and land use products.

Probably as a result of all acquisition technologies, of the semantic heterogeneities, and the numerous sources of uncertainties, the documentation of uncertainties in geographical data is currently based on complex metadata, difficult to interpret by users. 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.

Information exchange or consolidation between different sources and different products is important to reach description at the required spatial and temporal coverage, or for supporting change analysis, comparative studies, multiscale analysis as well as for reducing the cost of information production and maintenance. This requires interoperable protocols (see below) as well as **spatial and temporal referencing frameworks**. These can be **geodetic coordinate systems,** the integration consists in identifying for each information the coordinates in a mathematical referencing framework, 3 coordinates for the location, sometimes 3 for the speed (for example for tectonic). When direct coordinate systems are lacking or are not enough, **indirect core referencing frameworks** are needed, these are placenames, adresses or landmarks (i.e. saillant features that do not change like river and road networks). Ontologies are also needed to align and compare information products that use different conceptual schemas. Spatiotemporal referencing frameworks are needed, e.g. spatiotemporal gazetteers spatiotemporal ontologies.

Interoperability between information components involved in city and land management, data sources and software, must consider different industries that did not interact historically even though their perimeters are overlapping, like for instance the BIM (building information model) and the GIS standards to describe man-built environment. In a city, there are different information systems that are not integrated together (silos). Most cities and administrations also lack IT specialists, money and data. Event when ontologies exist, IT solution hardly manage heterogeneities between different conceptual schemas relevant to land use studies (across time or across space) and can be fed only through a standardised format. In land, an important initiative to enhance interoperability between land cover and land use products is EAGLE. Yet it does not consider so far historical classes.

Having **qualified, trustworthy, authoritative information** is crucial and leads to **mandate organisations** to survey space, acquire raw data and propose relevant conceptual models to derive semantically rich products and to document metadata necessary to interpret the data. Important stakeholders participating to the description of our territories are the **legally mandated organisations** (like mapping agencies, statistical survey, meteorological institutes). In Europe also, after world war 2, the Allied forces set up an intelligence unit to reuse military planes to survey Europe and the Mediterranean basin. Later, the European Environment Agency was created and produced Corin Land Cover products. 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, reaching a compromise between local specific information products and a required pan European product is still complex. Besides, as soon as data will be produced by machine learning algorithm what does 'authoritative' means? It is still important that organisations take the responsibility for the data describing accurately land, even if the production process has changed. Last, most cities have no consistent archival policies of sources and projects for them to be reused in the future. **We lack consistent heritage practice across time that consider very old times and the future, reuse and outreach.**

New forms of trustworthy content have emerged with the Web2.0 and Wikipedia is the best example of such content.

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. Hence relating past survey with future transformation is still a challenge. These intrications are described through "simulation models" like climate models, air pollution models, fire spreading models for example. Some disputed descriptions of space dynamics are laws proposed by some geographers.

Discovery and retrieval of available data 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 in terms of license and of interoperability. 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.

Lately the concept of **open data** has gained importance for our societies and the concept of **FAIR** has been developed to list requirements for an information infrastructure. Among administrative data, geographical data are often seen as core data supporting an infrastructure of open data (data.gouv.xx; https://amsterdamsmartcity.com/projects/dataamsterdamnl). The big data is already applied efficiently in some domains like commercial domains (recommending a restaurant, ...), or public service (crime prevention, ..). This has intensified the production of data in cities and the need for framework to integrate and correlate these data as well as to check their validity as some actors now poison data sets that are used in machine learning. At the level of Europe, there starts to be a political decision to open data (Public Sector Information directive, redesigned in January 2019 to embrace more data, incl. local geodata). Yet we lack an economic model associated to these open data.

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 the regulation (for example for some phenomena like soil sealing we lack shared unambiguous concepts in Europe, or in cities they have to use quantitative thresholds, standardized systems and static models) 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.

We need to integrate cultural items, soft values, and long-term development in urban planning and architectural design. Soft values/spatial cultures are not always considered for value deliberations and future design and citizen participation, while they are crucial for citizen's well-being and for stable, cohesive societies. Geospatial platforms and tools for participatory urban planning can help to link historical research and future design.1

Expected achievements and methodology

On **scientific bottlenecks** like "heterogeneities management", "unifying uncertainty framework design", "knowledge graph design", "recommandation models", "including soft values in regulation", we need to engage scientists to work on this. This can be done with task 4.1 but also task 4.2 if we think of setting up European master program to train students capable of undertaking such phd. Pluri-disciplinary benchmarks to study models supporting the identification of similar cities' states -across space and time-, models to compare strategic measures and their impacts -between different cities and possibly different states-.

We want to set up **specific Time Machine calls** (see milestones year 1 and year 4) to fund the digitalisation and indexation of existing archives based on proposals made by communities who describe what they will do with the data, the same way European Space Agency is doing before launching satellites[46].

The core infrastructure components needed must be confronted to the existing information systems in place. Very soon **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. These metadata will support the search for data sets in Diamond.

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.

Very soon in the project, we will draft a **collaboration platform** based on words and more natural language that supports dialogues and debates using local concepts in connection to European concepts (words, mail, basecamp, picking one pivot language... aren't enough), either on an asynchronous way or associated with translators. Wikipedia could be a good candidate to start from. There exist several thematic wikis that could be interconnected. A key item is to have unambiguous URIs to align objects as well as a model to store links between comparable places.

At the level of Europe, we target at a **new implementation of European culture friendly spatial data infrastructure** articulated with existing data and metadata (INSPIRE, EEA, Europeana, etc.) new sources (remote sensing, collaborative content) as well as with needs from scientists (AI, Humanities) and **with EAGLE**, 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.

Methodologies to foster innovations are needed and we will rely on our participants experience in the organisation of challenges and hackatons around data:

- A framework to design application oriented scientific challenges: relating to actual, present-day challenges (so that representative users can assess the value of a demonstrator even if it is not exactly their specific problems) and that can be used by scientists in their work (e.g. scientists working on data alignment, scientists working on simulation, … may not have engineering expertise to prepare the datasets and the infrastructure) and incentive for them to do so. e.g.: in domains such as recommendations, or integration
- A framework to design application-oriented development challenges: relating to a range of actual, "real-world" problems (so that representative users can assess the value of a demonstrator even if it is not exactly their specific problem) and that can be used by developers of mature technologies. e.g.: collaborative design of historical land cover products out of old maps, integrated information system

And prior to this we target in 2020: 3 days Lab, using teams or a platform supporting collaborative solution design between different stakeholders that will aim at:

- · Selecting and prioritizing use cases in terms of increasing complexity, and in terms of stakeholders' expectations (stakeholders incl. citizens): this will be done based on highly generic scenarios sent one month before
- · Listing relevant technologies for territory description and the associated uncertainty: paper maps, statistics, classifications, remote sensing, digital vector databases, gazetteers; ...

We will need communication media to evangelize the SDG (sustainable development goals) because they really concern everyone (eradicate poverty on planet earth). We also need media to explain why they are monitored through land cover and land use data and criteria. An idea could be to organize escape games, YouTube video on these.

[46] http://sci.esa.int/cosmic-vision/60498-call-for-a-fast-f-mission-opportunity-in-esa-s-science-programme/

Milestones

After 1 year: "TM Land Use Digitalisation Missions" call for proposal template, which will invite proposals to get digitalisation, interconnection of given archives for Land Use and Territorial Policies (selection criteria will include the benefit compared to the cost)

After 3 years: Mockups of TM Land use integrated and multi-scales information systems adapted to selected thematic areas and to local stakeholders in similar places.

After 4 years: "TM Land Use Learning From the Past Missions" call for proposal template, which will invite proposals to set up machine learning experience (incl. Identify with correct scientific communities what are the relevant places and data to learn from, curating the data, running deep learning algo)

After 5 years: Mockup of TM Land Use debating platform, presented to European politicians and voting platforms

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 47 : in goal 2 (zero hunger), goal 6 (clean water), goal 11 (sustainable cities); goal 13 (climate action), goal 15 (life on land)

X European organizations related to urban planning and land use engaged

X National government bodies related to urban planning and land use engaged

X Local government bodies engaged

KPI concerning linking and harmonization of land use data

KPI concerning linking and harmonization of urban planning data

X Best practices regarding Big Data of the past for land use

X Best practices regarding Big Data of the past for urban planning

Funding sources

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

Insurance companies

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

- UN Habitat : Paulius Kulikauskas

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

- EC Directorate for Agriculture, for Environment. Katalin Toth
- European deputy, tbd (on-going contacts)
- DG Grow : Timo Pesonen
- DG Regio Advisor for urban policy : Wallis Goelen
- Committee of Region and rapporteur for Digital Cities : Markku Markkula

Science-policy interface specialists, can be more specific in terms of needed platform for collaboration between them based on big data of the past.

- Association Science Policy interface, independent, http://knowledge.unccd.int/science-policy-interface.
- Director in charge of policies support at new french organisation in charge of research and innovation in agriculture, environment and water (merging of INRA and IRSTEA) (Patrick Flammarion)
- http://www.iass-potsdam.de/en/research/sdg-platform . Platform to connect SDGs with scientific agendas (german agenda 2030

Entities in charge of transforming administration and providing focused lifelong learning modules or peer to peer seminars[48]:

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

- French ministry of agriculture : JP Grelot
- French ministry of sustainable developpement and of solidarity between territories : Stephane Grivel from the research departement, knows very well water directive.
- The 27th region (French) : a laboratory for the transformation of administration
- French state administration in charge of digital administration information system : DITP and DINSIC
- Person in charge of the Information System of the project “Métropole du grand Paris”
- Paris agency for urbaine ecology
- French agency for biodiversity

Planners, engineers, architects, heritage specialists

Citizens

Make.org : platform to organise citizens votes (cf weeuropeans.eu)

Software companies, Software used in the area so far : Grass, ESRI ArcGIS (ESRI : Nick Land), QGIS, Jan Schoenig of Siemens (Smart City project), Martin Klein (SAP), Jose Antonio Ondiviela (Microsoft), Willem Joncker of EIT Digital, ARDANS (Knowledge management companie)...

Infrastructure designers (protocols, software), OGC, W3C,

Surveyors: mapping agencies, cadastral agencies, statistical institute, geological survey,.. Umbrella associations

- United Nations and especially Global geospatial Information management group, and european stakeholders platform https://ec.europa.eu/info/strategy/international-strategies/sustainable-development-goals/multi-stakeholder-platform-sdgs_en
- National mapping agencies in charge of designing historical national products : IGN France production contact in charge of organisation the production of historical land cover products

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

- Archives in charge of old maps and old surveys (national or cross country) (e.g., the Cultural Heritage Agency of the Dutch Ministry of Education, Culture and Science)
- Statistical Institutes : Eurostat, french statistical institute contacted
- Meteorological institute; specific contact in Roumania using old maps, project to understand moder floods using historical maps : http://www.geo-spatial.org/file_download/29689
- European Environment Agency : Stefan Jensen (contacted)
- EuroSDR, Eurogeographics :
- La Dila : french institution in charge of publishing national official text (Journal Officiel), has digitized the journal back from 1950. There is the equivalent for Europe.
- Légilocal : french institution supporting local administration publishing local regulation
- OpenLaw

NGO Interest Group

WWF and weactforgood.org

Public/private foundations

Association in charge of surveying finely forest evolution and preserving forest in Cameroun

Media

Wikidata

Copernicus

Contact in a fact checking NGO funded by journalists https://eufactcheck.eu/about-us/ ?

Wikipedia

Legal bodies, standardisation

Lawyers

Insurance companies: TM will provide them with the detailed data to make better risk assessments

Investors

Payment agencies, funds management, insurance companies:

European project leader for the new PAC project (NIVA), which consortium entails numerous national payment agencies

La caisse des dépôts

Scientists

- Research Data infrastructures :Research data alliance (sections working on Land use), Flood observatories, Seismic data observatories, past projects (Enviedan, LandMark), current project (LandSense, URCLIM)
- Geographers : ESPON program leader
- Agricultural : leader of the task “Data” in the european LandMark project
- Scientists studying Landscape archeology in the labex PastsInPresent
- Valéry MAsson, MétéoFrance, leader of a european project studying urban climate change URCLIM (NB: these are scientists designing simulation algorithms), see also Future Earth (X-treme Earth) consortium
- Historians and social science scholars
- Open source communities:
- OS4Go, FOSS4G

- geo-spatial, cf project eHarta49

Professional in domains: (see also Pillar 2 communities)

Automobile industry, Mobility industry (bicycle, electric scooter, …), Data industry

agricultural, health, forestry, water management

- Private organisation in charge of managing geoinformation projects, in particular in African countries
- Lawyers
- Advocates
- Danube river company
- Cluster around the Rhone river
- Budapest 100years houses feast
- Lisbon procedure to preserve heritage –when digging, when renovating-
- Portuguese consultant company that recommand solutions froml the past to be smart
- French company api-agro.fr in charge of managing data exchange in the sector of agriculture (infomediary)
- Private sector engaging in Data provision like ESRI

Innovation fostering organisations

- Vivatech
- ThePlace: house of startups in Luxembourg

Framework conditions

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 (pillar 2?)

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

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: some results about land dynamics or urban regulation can be true for some situztion but not adaptable to others. This can lead to conflicts. A solution could be to see TM as a solution to get inspiration and not the mirror of the truth.

We also need to know if some content is too attached to a community and that this could impact the communication strategy about the Time Machine. This risk can be mitigated by having a conceptual framework

[49] project eHarta: a collection of thousands of old georeferenced maps, published and documented with the help of the geo-spatial.org community. The eHarta maps are freely available for download as georeferenced files and accessible through a number of web services that fit a broad range of users (e.g. Zoomify tiles or KML files for ordinary users; OGC compliant geospatial web services like WMS/WMTS/WMS-C/TMS/CSW for users with advanced geospatial skills). A webmapping application, which integrates all the old maps published within eHarta project, was implemented on geo-spatial.org. In 2011, the eHarta project won the "Better Data Award" at "Open Data Challenge" at the Digital Agenda Assembly

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 : solutions proposed is to have call for missions (digitalsation 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 i: Specific thematic application domains

- buildings and infrastructures preservation, renovation and management
- recommendations for risk mitigation
- Social housing assets management
- (Re)design of public spaces
- Law about common good and next generation
- Health in connection with soil pollution
- Adaptation to climate change : urban heat islands, energy
- Land uptake
- water management, soil sealing,
- biodiversity, forest management
- Food safety as well as ecosystemic services,
- Land ownership

Annex ii: Suggestions of questions for expert interviews

- Do the notions of Time MAchine and Big data of the past ring a bell to you and inspire you wrt to unsolved issues and problems you are facing that a TimeMachine or Big Data of The PAst Information Systeml would meet ?
- Note : need to get back to WP7 to ensure we have very clear way of communicating our vision and positioning it wrt existing solutions
- What information systems do you use and what are their limits in your opinion?
- What would be relevant scope of a Time Machine in your domain : spatial and temporal coverage, spatial and temporal resolution, themes?
- What inspiration would you search for from “similar” use case?
- Where do uncertainty lie in data you use today and what precision is required in the resulting figures you handle?
- Are the phenomena you study ruled by physical laws only –to your knowledge- or do human behaviour interfer ?
- With what scientific communities do you collaborate or would you like to?
- With what education institutions do you collaborate or would you like to?
- Among the following domains, which do you collaborate with or would like to : GLAM, creative media, Smart Tourism, Smart Cities, Urban Planning, Land use, Territorial Policies
- Are you engaged in innovation projects, do you have some experience of successful methods and of specific obstacles?
- Where do money come from in your domain?
- What are important licences and IPR in your domain ?
- What could be the contribution of lots of historical (linked) data on land use (ownership, useage, policies) for your filed?