EUROPEAN
POLICYBRIEF

SILKNOW. SILK HERITAGE IN THE KNOWLEDGE SOCIETY: FROM PUNCHED CARDS TO BIG DATA, DEEP LEARNING AND VISUAL / TANGIBLE SIMULATIONS

It is the aim of this document to describe the evidence found in the SILKNOW project that have policy implications, and to give specific recommendations.

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INTRODUCTION

Silk heritage, an important part of European history, is insufficiently known and appreciated by our fellow citizens. It is incredibly rich as a material resource, but also as an immaterial repertoire of aesthetics, knowledge, craft, and cultural exchange. **Not only is it linked to key characters and institutions of our past; it can play a revitalizing role for the European economy, too.** Our industries are more and more dependent on providing products whose competitive character should lie in creativity and cultural values instead of fighting an ever-losing battle for lower costs.

However, **this heritage risks irrelevance and disappearance**. It is kept by textile museums and other cultural institutions, many of them small in size and resources, that are being severely hit by funding cuts, global crises and institutional instability. Moreover, across Europe, **most silk artisanal industries have disappeared over the last six decades**, with a few struggling now to stay in business. The remnants of these industries are being dispersed and lost as we speak, in ways impossible to recover, not even for historians. **The technical and immaterial knowledge at their core is quickly vanishing**, by the unstoppable aging of the scarce artisans that still keep these crafts alive.

Within this context, **digital technologies offer promising answers to some of those dangers**. Historical pieces of textiles, and their associated information, used to lie hidden in the drawers of specialized institutions, tasked with the material conservation of this fragile heritage. However, it remained largely unknown outside scholarly circles, despite their great relevance in the past, and their undeniable allure for modern audiences. **This heritage can now be safely brought to light, to the screens of our ubiquitous digital devices**. Thus, it can remain meaningful and enjoyable for our communities, inspiring for our designers, and attractive for our tourists. **The requirements and opportunities that lie ahead in this process have been the daily occupation for the**

members of the SILKNOW project consortium over the last three years. This document outlines some of our findings, as well as their implications for policymakers.

<div style="background-color:green;color:white;padding:8px;">EVIDENCE AND ANALYSIS</div>

Based on the work carried out in SILKNOW and on the analysis of our results, we have detected some evidence that have policy implications. Although everything is of course interrelated, for the sake of clarity we have grouped the evidence and the implications under the following 7 headings.

1: The pandemic

COVID-19 has changed the way people collaborate, and the way they seek access to cultural heritage content. In **SILKNOW**, this has become evident at different stages of our work. As regards collaborations, we have been able to evaluate our tools with different targeted audiences (e.g., art historians, designers, etc.), despite the lockdowns and limitations, thanks to the **digital nature of our outcomes**. Also, **we have been able to offer online coaching to 28 museums, two independent scholars and one H2020 project (MINGEI, also related to crafts and digital heritage) on the benefits and requirements of open access to digital information**. More importantly, **the pandemic has pushed many GLAMs** (Galleries, Libraries, Archives and Museums) **to become providers of digital cultural content overnight**, something that many of them had only reluctantly been willing to do, before[1]. Small and medium-size institutions often lack the means and the knowledge to translate their collections into digital forms, to interactive technologies that can be remotely accessed by current audiences. One outcome of SILKNOW exemplifies the kind of tools that museums need in this context: our **Virtual Loom**[2] allows users to view interactive digital replicas of any historical textile they choose (Figure 1, right), including great closeups, changing yarns' colors, weaving techniques, etc. This 3D technology enables new didactic opportunities for textile collections, both on site and remotely.

After the rush towards digital in the first months, GLAMs have understood the need for strategy, for human resources and technical support. However, faced with serious pressure on many fronts - from stringent safety measures to staff or funding cuts, to delays or cancellations in temporary exhibitions, **most of the collections we have dealt with have had to postpone digital transformation in favour of daily operations**, thus sticking to the institutional model they should be moving away from, instead.

2: Traditional textile companies

Textile companies are a valuable source of heritage. In the past, they generated jobs and wealth, and provided opportunities for cultural and aesthetic manifestations. Their historical importance is usually overlooked; for instance, during the 18th century, almost half of the population of the city of Valencia was involved in the silk industry. **Few companies, however, are still producing silk textiles following mechanical processes** (e.g., Figure 1 left), which require the work of artisans. Thus, an **intangible heritage** as the traditional weaving techniques **is in serious danger of disappearing**. Moreover, their artisans do not find generational replacement, and the companies themselves face continuing closures. Their business depends on the small number of consumers that can afford these luxury goods, a tiny fraction of the market in comparison with bigger companies that produce massive amounts of textiles. **In the scope of SILKNOW, we have found such evidence mainly thanks to the involvement of Garín 1820 S.A.**, one of the partners of our consortium, a traditional silk weaving company, 200 years old, that has been under serious

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[1] Grant, D.: Pandemic Pushes Museums Deeper Into Digital Age. The Wall Street Journal, July 31, 2020: https://www.wsj.com/articles/pandemic-pushes-museums-further-into-digital-age-11596196801

[2] Portalés, C., Pérez, M., Casanova-Salas, P. & Gimeno, J., 2021. Virtual Loom: a tool for the interactive 3D representation of historical fabrics, in Multimedia Tools and Applications, 1-26. https://link.springer.com/article/10.1007/s11042-020-10294-w

threat of disappearance in the last decade[3]. Additionally, the pandemic has worsened the situation of such companies, like many others.

Figure 1. Left: a silk fabric produced by Garín 1820 S.A., with a historical design; Middle: fabric with 3D-printed motifs produced by MonkeyFab for SILKNOW, based on Garín's design; Right: 3D model produced by SILKNOW's Virtual Loom.

3: Creative industries

Creativity is a driving force of European economy. According to the EC[4] cultural and creative sectors are important for ensuring the continued development of societies. In economic terms, they show above-average growth and create jobs -particularly for young people- while strengthening social cohesion. It is also one of the best chances for Europe to keep an advantageous position in the global market of manufactured goods. Trying to lower the costs can hardly be a winning strategy for our industries, in the face of a fierce global fight against unregulated markets, and socially or environmentally uncommitted competitors. **Our plentiful heritage, the creative impetus of our designers, and the high-quality standards of our industries, offer much better opportunities for global commercial success**.

Figure 2. Dresses produced by MonkeyFab for SILKNOW, making use of 3D printers. Original design of Patrik Wojciechowski, based on historical silk designs.

[3] Pagán, E.;,Gaitán, M., León, A., Sebastián, J. (2021). El hilo de la historia: del patrimonio mueble al intangible. Rescatando el patrimonio textil sedero. In A. Lerma, V. López-Menchero, A. Maldonado, *Actas del I Simposio anual de Patrimonio Natural y Cultural ICOMOS España*,València, Editorial Universitat Politècnica de València, https://doi.org/10.4995/icomos2019.2020.12513
[4] EC, Culture and Creativity: https://ec.europa.eu/culture/sectors/cultural-and-creative-sectors

For instance, the production of silk fabrics involves the knowledge of traditional weaving techniques and the work of artisans. Additionally, new companies are introducing novel ways of making or decorating fabrics and garments. We have explored them within **SILKNOW, fostering creative collaborations among actors at different levels, including designers, design schools and creative institutions**[5]. These collaborations resulted in **innovative products, such as fabrics or dresses produced making use of 3D printing technology** (Figure 1 middle, and Figure 2)[6].

4: Public awareness and protection towards textile heritage

As repeatedly argued above, **textile heritage bears witness to some of the most important facts and chapters in European history**. The Industrial Revolution, for instance, was built on the mechanization of textile production, thanks in part to the Jacquard silk looms whose perforated cardboards also provided the basis for modern computers. Elites and leading institutions manifested their wealth and power through the production of sumptuous fabrics, clothing, and furnishings. Textile production was also the place where many female contributions to European societies took place, remaining sadly invisible and unappreciated, however. Entire regions or urban neighbourhoods gravitated and flourished around textile production, as attested by so many toponyms. **Textiles, finally, were a key element of global trade, of intellectual, technical, religious, and aesthetic exchange**[7].

Differently from other kinds of heritage -fine and performing arts- it is incredibly close to many of us, since **textiles are an undeniable part of everyday life**. Choosing how to dress, or the furniture in our homes, is a routine act for everyone. However, **this importance and vitality of textile heritage is not matched by an equal recognition and protection of it**, something made worse by its inherently fragile nature. **There is no international declaration or charter devoted to it**. Collections and museums of textile history often are small, local institutions, facing much more hardship than other, better institutionalized kinds of heritage.

SILKNOW has built a network of organizations that share these common concerns. Many of them are research projects or centres. Others are international or intergovernmental institutions. Finally, some others are those small and medium museums, facing common dangers and opportunities. A first networking result is the participation in the COST Action EUROWEB[8] on the side of some members of SILKNOW's coordination team. In due time, we expect this to become the seed for international action for the protection of textile heritage. In the shorter run, we have **started to work with the Spanish government to prepare a national plan on silk heritage**[9] **and are finalizing an application to the Council of Europe for the declaration of a Cultural Route devoted to historical silk cities**[10].

5: Access to data

Most European textile heritage entered the public domain a long time ago. There is no legal reason to hide it from citizens, tourists, researchers, designers, or anyone willing to have access to it for any reason. **Sometimes, nonetheless, heritage institutions still maintain a condescending attitude towards users**, considering themselves as owners of a treasure, and rightly so, but not as facilitators of its enjoyment by as many people as possible. **In SILKNOW, up to date, we have managed to bring into our knowledge graph, records from more than 20 museums and repositories**[11], including Europeana, the Victoria & Albert Museum, or the Metropolitan Museum of Art, together with other smaller collections. **They are all semantically**

[5] SILKNOW. Redesigning the Silk Route https://www.youtube.com/watch?v=eqeIztjFDhA
[6] SILKNOW. A Documentary on Fashion & Technology (2021): https://www.youtube.com/watch?v=vIKgLEaX7Jg
[7] For a good historical introduction to silk, see Scott, P. (1993). The book of silk. Thames and Hudson.
[8] EUROWEB. EuropeThroughTextiles:Network for an integrated and interdisciplinary Humanities: https://www.cost.eu/actions/CA19131/#tabs|Name:overview
[9] https://www.culturaydeporte.gob.es/planes-nacionales/
[10] https://www.coe.int/en/web/cultural-routes
[11] Museums, ADASilk: https://ada.silknow.org/museums

related and accessible through ADASilk[12], an exploratory search engine developed by the project. This invites users to search across separate collections through a single interface and find relationships among previously unconnected objects. It also enables targeted audiences to discover, by means of **spatio-temporal maps**[13], those formerly unknown relationships. However, despite our best efforts, that included several dedicated meetings with institutions or museums, even with the involvement of local authorities, **it was not possible to include many more, as we had always wished, particularly regarding small museums**.

These old-fashioned attitudes clash with the worldwide trend towards open data, also supported by the European Commission's policies, that focus on generating value for the economy and society through the reuse of public sector information[14]. The Directive on open data and the re-use of public sector information (EU 2019/1024)[15], also known as the Open Data Directive, entered into force on 16 July 2019. Content held by museums, libraries and archives falls within the scope of application of the Directive[16]. Therefore, such resistance must and will be overcome. Among other things, adopting data standards and semantic web technologies, which are the building blocks that make data interoperability possible. Open access to digital information offers the promise of unfettered contact with global culture.

6: Artificial intelligence (AI) and digital collections

Recent reports[17] show that **AI has entered the creative value-chain at every level: creation, production, dissemination, and consumption**. The European Parliament CULT Committee has recently produced a briefing with six key findings for the creative and cultural sectors[18]. For instance, AI has the potential to create ways for users to navigate through rich cultural content. **EU institutions also support a human-centric perspective on AI**, one that embraces cultural diversity and supports human creativity, critical discourses, and artistic idiosyncrasy.

In SILKNOW, deep learning techniques have been used to train image and text-based models, in order to predict data lacking from the original cataloguing records. Of course, **users are informed about the automated nature of those new annotations, and about their statistical reliability**. Machine-generated predictions are not intended as a substitute for human experts, but as an aid for them. Our work in this field uses cutting-edge technology and is therefore highly experimental, but it has shown positive results[19].

7: Sustainability

Sustainability is a primary concern in this sector, as the paragraphs above have already made clear. It has many faces:
- **European textile industries face market threats and in many cases disappearance**. Their business and jobs are sustainable, however, if they embrace change -digital transformation, among others- and add value to their customers in novel ways.
- **Textile heritage is kept in institutions devoted to its conservation, study and dissemination**. Again, digital transformation provides great opportunities for them, in each of the tasks just mentioned. Digital sustainability in their case involves proper usage of computing resources, but it mostly requires adequate human resources, capable of creating and managing data for interoperable databases. These repositories greatly facilitate long-

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[12] ADASilk: https://ada.silknow.org/ This tool is named ADASilk after Ada Lovelace, the British mathematician whose connection to the origins of computers is well known by now.

[13] Sevilla, J., Casanova-Salas, P., Casas, S. & Portalés, C., 2021. Multi-Purpose Ontology-Based Visualization of Spatio-Temporal Data: A Case Study on Silk Heritage, Applied Sciences, 11(4). https://www.mdpi.com/2076-3417/11/4/1636

[14] EC, Open Data: https://digital-strategy.ec.europa.eu/en/policies/open-data

[15] EC, Document 32019L1024: https://eur-lex.europa.eu/eli/dir/2019/1024/oj

[16] EC, European legislation on open data: https://digital-strategy.ec.europa.eu/en/policies/legislation-open-data

[17] Caramiaux (2019). AI in the Media and Creative Industries. White paper, NEM initiative: https://hal.inria.fr/hal-02125504/document

[18] European Parliament, Research for CULT Committee -The Use of Artificial Intelligence in theCultural and Creative Sectors (2020): https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/629220/IPOL_BRI(2020)629220_EN.pdf

[19] Clermont, D.; Dorozynski, M.; Wittich, D.; Rottensteiner, F. (2020): Assessing the semantic similarity of images of silk fabrics using convolutional neural networks. In: ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences V-2, pp. 641–648.

term preservation and usage of the existing and new information about their collections, the best way to ensure a sustainable return of the investments made around them.

- **Manufacture of silk fabrics and clothing with traditional techniques can continue to be sustainable, both from environmental and market perspectives**. For instance, the production of fabrics is "on demand", so practically no waste is produced. In this regard, such companies are aligned with the European Green Deal that aims to transform the EU into a modern, resource-efficient, and competitive economy[20]. Sustaining these crafts and their associated techniques can happen thanks to collaborations with design schools[21] that can introduce their students to this creative but quickly vanishing world.

Technical innovation in this field can and must be environmentally aware, too. MonkeyFab (a SILKNOW partner, as already mentioned) produces 3D printers that work on textiles and can run on bioplastics[22].

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POLICY IMPLICATIONS AND RECOMMENDATIONS

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1: The pandemic

The pandemic has shown the urgent need for cultural institutions to become regular providers of digital content about the heritage they take care of, and to do so in a strategic, transformative way, in ways that look beyond the current crisis. **This should be translated, firstly, into support, training and coaching, particularly for small and mid-size museums that usually lack the technical and human resources to provide that kind of services**. For instance, by introducing them to virtual and augmented reality technologies, to digital data management for their collections, or to partnerships with educational institutions, as we have done with Instituto Cervantes within SILKNOW.

2: Traditional textile companies

Small companies create and transfer valuable cultural productions. When these productions become heritage, they often do not fit squarely within established cultural categories, thus risking oblivion and neglect, a particularly serious danger for textile heritage. Collaborations with academia and GLAMs are opportunities to preserve, study and put this "business heritage" to good use. The companies themselves deserve more visibility and appreciation, as a treasured part of our past and -hopefully- our future. **Supporting measures -such as tax exemptions or reductions- against the pressure they suffer from global competitors, helping them to tap into new and better markets, should also be considered as part of European trade and competition policies**. Such policies focus on openness, sustainability and assertiveness[23], and encourage companies to offer goods and services on the most favourable terms to consumers[24].

3: Creative industries

The bonds between creative industries, cultural heritage organizations and educational institutions -particularly, those devoted to design, arts and other creative professions- **should be**

[20] A European Green Deal: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[21] Alba, E..; Gaitán, M.; Pitarch, M.D.; León, A.; Moya, M.; Marín,J.; Vitella, M.; Lo Cicero, G.; Rottensteiner, F.; Clermont, D.; Dorozynski, M.; Wittich, D.; Vernus, P.; Puren, M. From Silk to Digital Technologies: A Gateway to New Opportunities for Creative Industries, Traditional Crafts and Designers. The SILKNOW Case. Sustainability 2020, 12, 8279. https://www.mdpi.com/2071-1050/12/19/8279
[22] Pérez, M.; Casanova-Salas, P.; Twardo, P.; Twardo, P.; León, A.; Mladenic, D.; Massri, B.M.; Troncy, R.; Ehrhart, T.; Cicero, G.L.; Vitella, M.; Gaitán, M.; Gimeno, J.; Ribes, E.; Fernández, M.; Portalés, C. From Historical Silk Fabrics to Their Interactive Virtual Representation and 3D Printing. Sustainability 2020, 12, 7539. https://www.mdpi.com/2071-1050/12/18/7539
[23] EC, Commission sets course for an open, sustainable and assertive EU trade policy (2021): https://ec.europa.eu/commission/presscorner/detail/en/ip_21_644
[24] EC, Competition Policy: https://ec.europa.eu/competition-policy/index_es#:~:text=Competition%20policy%20encourages%20companies%20to,pressure%20exerted%20by%20their%20competitors.

encouraged and strengthened. **Joint educational curricula, research projects, all kinds of interdisciplinary and intersectoral efforts must be welcome and supported**. Business incubators in the digital era provide examples of unconventional collaborations that enable the co-creation of innovative products, that go beyond the anecdotal and transform entire markets or create important social trends.

4: Public awareness and protection towards textile heritage

Since textile heritage is a particularly fragile and unrecognized type of heritage, coordinated action is required to demand and support its protection. Following other examples of normative documents devoted to varieties specific of heritage[25], **an international charter on the Protection and Management of Textile Heritage would spearhead efforts for the conservation and use of this valuable heritage**, that not only comprises textiles or clothes, but also includes factories and neighbourhoods, crafts and techniques, material and immaterial elements, whose relevance for European history and identity cannot be emphasized enough.

5: Access to data

The information society is fuelled by data. Cultural institutions are producers of massive amounts of data. This information, however, is kept in silos, within idiosyncratic, monolingual, heterogeneous repositories and catalogues. The first step towards shared, interoperable repositories is the requirement for open access to that cultural information, as a consequence of the basic human right of access to culture. This is already supported by European and national regulations, but institutional and practical barriers still impede significant progress, in this regard. **These barriers can be overcome by supporting research, training and practice of open access to cultural data, within GLAMs. This will, in turn, enable their widespread and easy dissemination, their usage by designers and creative professionals, their availability for cultural tourism providers, but also for AI applications developers, researchers, educators…** A good example is SILKNOW's knowledge graph: it is 5-stars Linked Data, using a standard GLAM ontology model (based on CIDOC-CRM) and all the best practices recommended by W3C. Our thesaurus is built as a complement to the sector standard (the Art and Architecture Thesaurus from the Getty Foundation), etc.

6: Artificial intelligence (AI) and digital collections

AI has the potential to bring positive change for the EU society and economy[26], but it also brings new challenges that need to be considered in policy making. In this field, the EC is a global leader in providing much-needed guidelines, such as the recommendations made by the EC High-level expert group on AI[27] that served as resources for policymaking initiatives taken by the Commission and its Member States. Recently, the EC has proposed new rules and actions for excellence and trust in AI systems[28], aiming to boost research and industrial capacity and ensure fundamental rights[29].

Within SILKNOW, after analysing the results from computational predictions, we conclude that more data (quantity) and more homogeneity (quality) are the best way forward, when trying to make a reasonable, productive use of AI. Once again, **we need to produce more and better digital content, and to share it openly, as the building blocks for experiments in AI with cultural heritage** (see no. 3 above). All this must be done with due attention to the ethical implications of this work, avoiding cultural biases, disrespect for users' privacy, etc.

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[25] Such as UNESCO Declarations on Illicit Trafficking of Cultural Property, or Restitution of Cultural Property, or the Charters on Architectural Heritage, Archaeological Heritage, Underwater Cultural Heritage, Cultural Routes…

[26] EC, Artificial intelligence, real benefits (2021): https://digital-strategy.ec.europa.eu/en/library/artificial-intelligence-real-benefits

[27] EC, AI HLEG: https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai

[28] EC, Europe fit for the Digital Age: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1682

[29] EC, A European approach to Artificial intelligence: https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence

7: Sustainability

Any effort done around culture must begin by supporting its professionals. The last financial crises have brought significant cuts to the budget of cultural organizations, both public and private. Culture will not thrive without a proper recognition and support system for the staff that makes all those efforts possible. **Funding is not the only key for sustainability: training opportunities are a pressing need, both for current professionals and for those still within the educational system**.

In the textile sector, as seen above, companies play an important role, as producers and economic players, but also as owners of a considerable heritage. **Incentives and avenues for commercial viability will boost not just their survival as businesses or jobs, they will also help many other related industries, such as tourism**.

Finally, digital transformation takes many forms. Collaboration with large repositories, such as Europeana or Wikimedia Commons, is the best answer for long-term sustainability of cultural information. **Information standards, terminology resources** such as the SILKNOW thesaurus[30], Linked Open Data and other systems related to the semantic web **are key elements in any digital effort that intends to turn data into a firm asset for European culture**.

RESEARCH PARAMETERS

SILKNOW has produced an intelligent computational system in order to improve our understanding of European silk heritage. Using pre-existent, digitized information about this endangered legacy, it studies, showcases and preserves through 3D modelling of its weaving techniques, by means of our Virtual Loom. Users can access the resulting information through visual and tangible simulations, and experience enhanced search tools, providing better results through automatic visual retrieval, advanced spatio-temporal visualization, multilingual and semantically enriched access to existing digital data. Heritage, educational and tourism institutions can thus benefit from next-generation ICT research, creating synergies open to later application in creative industries. The project's specific goals were:

OBJECTIVE 1 (OB.1). Advanced searching and semantically relating digitized European silk textile heritage, based on **data interoperability across different collections**. Moreover, we have focused on small to medium size heritage institutions, whose digital data tend to be obsolescent, insufficiently curated and not standardised. This objective has been achieved by:
- Building an intelligent system to automatically extract meaning and relate data from separate collections, by means of data processing and deep learning techniques.
- Creating an ontology for silk textiles, their historic evolution and their relations with society.
- Implementing a text analytic system that allows advanced queries.
- Implementing software tools to automatically analyse and process data of different quality in order to allow cross searching.

OBJECTIVE 2 (OB.2). Building a "Virtual Loom" to clone ancient weaving techniques. This objective allows users to **discover the complexity, artistic and artisanal values of ancient silk textiles and their weaving techniques**, while **preserving them for future generations**. It has been achieved by:
- Collecting knowledge about ancient weaving techniques from collections managed by project members, collaborating institutions and their respective network partners.
- Embedding those techniques in a software named Virtual Loom.
- Making the virtual models tangible using new 3D printing technologies.
- Considering, into the scalable design of the Virtual Loom, its possible future exploitation by textile creative industries.

OBJECTIVE 3 (OB.3). Improvement of the understanding of the European silk heritage. The fulfilment of this objective allows users to **develop their personal or collective memories, by**

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[30] SILKNOW. Silk Heritage Thesaurus: https://skosmos.silknow.org/thesaurus/en/

discovering new connections among silk textiles, thanks to **visual tools that show the spatio-temporal relationships of data**. It has been achieved by:

- Building an open-access, specialized multilingual thesaurus on silk heritage.
- Incorporating in the search engine visual tools to display the spatio-temporal dimension.
- Ensuring knowledge transfer of the project results for different targeted end-users.
- Fostering qualified employment and social cohesion.

The general research methodology followed in SILKNOW was to first **identify the overall requirements**, then to **design and implement** the corresponding algorithms and system architecture, to **integrate** them in a single web-based platform, and finally to **validate the results**. The technological framework was examined against rigorous mathematical and computational algorithms. The intermediate results were constantly monitored by both SSH and ICT researchers in order to detect any areas for improvements that could be fed-back in the next iteration of the technological solution that better met its goals; the theory and algorithms were then re-designed and adapted, and the process was repeated, eventually converging on a final solution. Finally, the implemented algorithms and software realising the optimal solution were tested and validated in relevant environments by considering different groups of targeted end-users to examine their effectiveness with cross-disciplinary actors.

PROJECT IDENTITY

PROJECT NAME

Silk heritage in the Knowledge Society: from punched cards to big data, deep learning and visual / tangible simulations (SILKNOW).

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BUDGET

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WEBSITE

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