# THE GALILEO MUSEUM AND THE DIGITAL WORLD

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**Abstract**

The Galileo Museum has been on the digital path for about thirty years in the belief that information technology is an indispensable tool for the scientific research and enhancement of cultural heritage. This essay illustrates some applications that show the state of the art of the initiatives undertaken by this institution in the field of digitization. In particular, we present two thematic digital libraries conceived as environments for research and scientific exchange between scholars, and two virtual exhibitions or, better, digital explorations of historical documents that are difficult to read and interpret.

**Keywords**

Digital library, virtual exhibition, digital applications, Galileo Galilei, Leonardo da Vinci, Martin Waldseemüller, Fra Mauro, cartography

## 1. Introduction

The recent pandemic emergency that has forced the world to close the doors of schools, productive activities and places of culture, has forced a radical rethinking of the methods of communication on a social and professional level. Thanks to information technology that has rapidly perfected remote communication platforms, we have been able to continue studying, working or simply chatting with relatives and friends through the computer screen. The spotlight has inevitably turned on the digital world that government institutions have immediately indicated as a fundamental tool for places of culture and education. And this issue has been given due attention by large organizations serving the museum heritage, such as the Associazione Nazionale dei Musei Scientifici (National Association of Scientific Museums) which dedicated the last annual congress to it, and the ICOM Italia Digital Technologies Commission which launched an investigation targeted on the digital content of museums (ANMS, 2020; ICOM Italia, 2020). Finally, the recent establishment of the Central Institute for the Digitization of Cultural Heritage as an office with special autonomy at the Ministero per i Beni e le Attività Culturali e per il Turismo (Ministry for Cultural Heritage and Tourism) is a tangible sign of the renewed importance attributed to this aspect of culture.

The Galileo Museum has been active in the digital world since the nineties of the last century, that is, since the first advent of the web, already considered at that time as the privileged place for the communication of historical-scientific knowledge. The first home page of the institution dates back to 1994, a period to which the first digital cataloging of the museum heritage also dates back; the latter was then merged into an extraordinarily effective multimedia catalog accessible via the web or through an app downloadable free of charge on each visitor's smartphone (fig. 1).

The virtual tour, developed internally by the multimedia laboratory of the Museo Galileo, was recently implemented by Google Street View (fig. 2) which, with the usual modality of this platform, allows visitors to virtually walk around the museum rooms; an option that on the occasion of



**Fig. 1:** Free app for visiting the Galileo Museum.

the recent lockdown allowed the museum to maintain its international visibility high.

Over the course of more than twenty years, the Galileo Museum has added a series of highly respected digital collections to its material collections: more than 7,000 files on museum objects, over 50 online exhibitions, over 350,000 metadata of books, manuscripts, documents and objects, more than 50,000 digitized books (for a total of over 2.5 million pages), and more than 70,000 photographic images. In short, a heritage that today represents a point of reference for scholars from all over the world, also because it is totally usable in open access.

The entire digital heritage was built internally thanks to the organization of a multimedia laboratory which currently includes about twenty units, one third of the institution's overall staff: computer scientists, archivists and digital graphic designers who interact daily with curators and scholars in the design of the now numerous multimedia applications accessible from the institutional website. The decision to invest resources in information technology, not only for the purpose of cataloging the collections, was certainly determined by the fact that the Galileo Museum is also a research institute that has over time become an international reference point for historical and scientific studies on the early modern age. In this way, the decisive role of digital technology has gradually been added to the traditional method of promoting research through printed scientific journals, with the task not only of making research results accessible but also of creating shared environments for meeting and scientific exchange between scholars. The library specializing in the history of science is now supported by a digital library structured in thematic digital libraries conceived as digital research environments. The thematic digital libraries are integrated archives that manage connections between texts, objects and images, allowing users to profitably navigate the great sea of data made available to scholars today. The museum collection is an integral part of the dense network of documents and thematic relations managed by the thematic digital libraries, and it is precisely in this close relationship with research that the museum finds its essential lifeblood.

## 2. The thematic digital libraries

The state of the art of digital applications put by the Galileo Museum at the service of scholars is represented by two thematic digital libraries dedicated, respectively, to Galileo and Leonardo as key figures of Renaissance scientific culture. Compared to the general digital library that



**Fig. 2:** The virtual museum with Google Street View.

actually reproduces the model of a material collection of printed books, the thematic digital library intended as an integrated archive fully exploits the potential of digital resources by combining the skills of different professionals: computer scientists, systems engineers, librarians, scholars and researchers. The operation is complex and requires various processing steps, such as the digital acquisition of documents, the processing of data and metadata, the creation of multimedia equipment, and the adoption of a solid storage and web publishing infrastructure.

Galileo//thek@ was the first application of this kind to be developed. It is an integrated archive of Galilean resources made up of texts, images, documents, bibliographic records, lexical tools, and indexes; all of which can be queried both for each thematic segment and in an integrated way (fig. 3) (Museo Galileo, 2016). In the virtual drawers of this digital study there are nine archives that interact with each other forming an extraordinarily rich data network that the scholar is called upon not only to consult but also to implement with suggestions, corrections and updates.

The Manuscripts Archive contains the catalog of manuscripts relating to Galileo's biography and work, allowing scholars to consult the documents
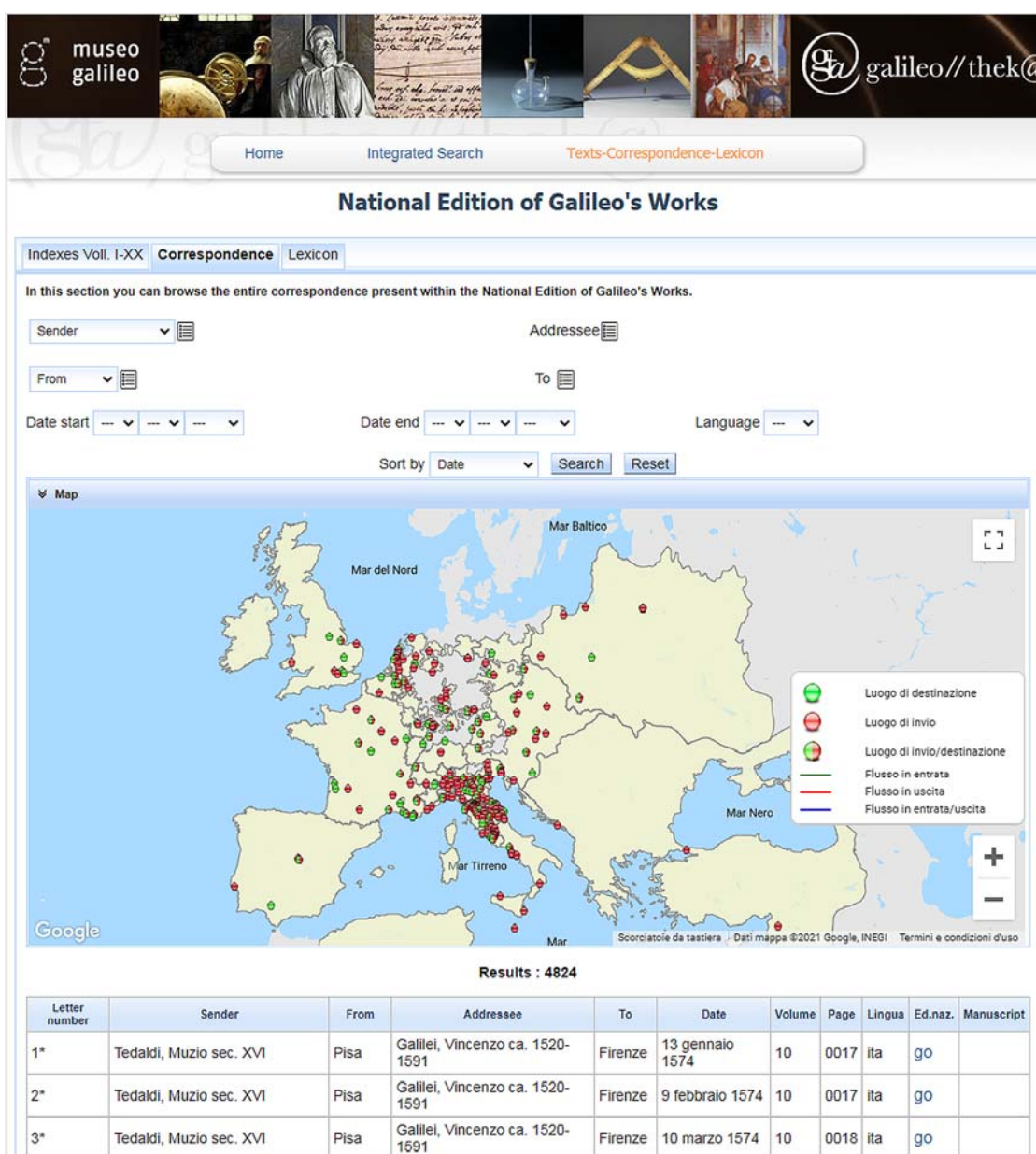
**Fig. 3:** Galileotheca: map of correspondence in the National Edition of Galileo's Works (senders in red, recipients in green).

kept in the Galileian Collection of the National Central Library of Florence and those of Galilean interest kept in the State Archive of Florence (M. Camerota, P. Ruffo, 2015).

The Galileian Bibliography collects the printed editions of Galileo's works and the contributions on the Tuscan scientist published from the end of the sixteenth century to the present day (over 25,000 bibliographic records).

The Galileo Library includes an accurate bibliographic description of the more than 600 works in Galileo's private library, almost all of which can be consulted in digital reproduction.

The Index of names and notable things - published by Antonio Favaro in vol. XX of the National Edition of Galileo's Works - represents an impressive digital repertoire with more than 50,000 direct references to the pages of the volumes of the National Edition, which can be consulted here in digital format.

The Virtual Museum presents the observing and measuring instruments invented and/or perfected by Galileo in a virtual environment in which the objects appear placed in spaces that evoke the contexts in which they were conceived by the scientist (Padua and Florence) and where they were exhibited for the first time in public (Museum of Physics and Natural History of Florence).

The Places Archive allows users to explore over 450 places, accessible by list and map, linked to the biographical events of Galileo.

The Iconography Archive reproduces in digital format the content of the Galileo Iconography volume of the Update of the National Edition of Galileo's Works (F. Tognoni, 2013).

The Myth and Fortune Archive allows scholars to 'explore and measure' Galileo's fortune through the editions and translations of his works, the publication of praise and biographies, the dissemination of studies on the process and iconography[1].

Finally, the Indexes-Correspondence-Lexicon section allows the easy and detailed interrogation of the Index of the National Edition of Galileo's Works, of the entire correspondence of the Tuscan scientist (almost 5000 letters, available in manuscript form and in the print edition) and the Lexicon of all his works, Italian and Latin. In the part dedicated to the Lexicon, both the works and the correspondence can be interrogated by headword and form.

The Integrated search option (simple and advanced) also allows users to query the archives across the board. This means, for example, that it is possible to know all occurrences of the term "planet" in the cataloging fields of manuscripts (letters, documents, works or annotations), in the texts of biographies or events in the chronology or in the fields of bibliographic records (both of the Galilean Bibliography and of the works owned by Galileo), obtaining the results divided by repertoire ready to be compared. The integrated search features allow you to overcome the natural boundaries imposed by the analog world, allowing users to simultaneously access heterogeneous materials located in different and disparate places, such as museum objects, books, and archive documents. The digital resources are displayed through the Teca Digitale, an advanced system for the consultation of texts and images developed and adopted by the digital library of the Museo Galileo for the consultation of the texts present in the National Edition of the Works of Galileo, for a total of over 8000 indexed pages.

While offering an organic complex of data that tends towards completeness, Galileo//thek@ is by its nature a project in progress, which is constantly enriched thanks to the contribution of users, who can leave comments and integration proposals up to the level of the single record. In this sense, the application offers itself not only as a rich space for research but also as an immaterial place for meeting and scientific exchange.

The Leonardo//thek@, the integrated archive devoted to Leonardo's codes and related critical devices[2], is of a similar approach. It is a powerful search engine with which to explore the Da Vinci manuscripts through multiple access criteria: dimensions, watermarks, writing, drawing techniques, gaps, presence of other hands, dating, personal names and places mentioned. The high resolution of digital acquisitions also allows scholars to study the images down to the smallest detail, activating the transcriptions and translations of the text blocks on request.

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[1] This archive was added thanks to the MIUR - PRIN Project: "The Science and Myth of Galileo between the 17th and 19th Centuries in Europe".

[2] The project was curated by Paolo Galluzzi with the editorial coordination by Andrea Bernardoni and Iolanda Rolfo, in collaboration with Commissione Nazionale Vinciana e the Leonardiana Library at Vinci. The project was funded by MIUR (*Scienza, storia, società in Italia. Da Leonardo a Galileo alle "case" dell'innovazione*) - Fondo Integrativo Speciale per la Ricerca (FISR) –CIPE Resolution 78/2017.

**Fig. 4:** Reference page of a sheet of the Codex Atlanticus in Leonardo // thec @.

The first version of this powerful study tool is being published with the data relating to the Codex Atlanticus, whose sheets can be consulted with the critical notes taken from the editions of Pedretti (1978-1979), Marinoni (1975-1980), and Govi (1872), and from the cards of the 24 volumes published on the occasion of the exhibitions on the Codice Atlantico edited by Pietro C. Marani for the Ambrosiana Library between 2009 and 2015.

The Atlantic Code is a particularly significant test bed for this type of application as it is a complex and disordered work. 'Ordered' for the first time at the end of the sixteenth century by the sculptor Pompeo Leoni who dismembered Leonardo's codices to collect the drawings according to homogeneous categories - in many cases cutting out portions of paper to separate the figurative drawings from the technological ones (fig. 4) - the codex was dismembered and rearranged in the sixties of the last century following an imprudent restoration which accelerated the deterioration of portions of texts and drawings. It consists of over 2200 pages that collect Leonardo's writings and drawings made between 1470 and 1519, the year of his death. Their dismemberment and Leonardo's way of proceeding, who returned to add notes and drawings in the empty spaces even after many years, make it extremely difficult to establish the link between the individual sheets, enormously complicating the scholar's work.

The relational database developed by the Museo Galileo allows to archive not only the digital reproductions of each sheet of the Code and the transcription of the texts, but also the enormous quantity and variety of data and information produced in the last 150 years of international studies. In the system it is possible to consult the thematic indices in an integrated way or by single repertoire, interrogating as many as 11,000 items extracted from the indices drawn up by Marinoni (2004) (2463 items), Marcolongo (1939) (5349 items) and Galbiati (1939) (3553 items). The digital acquisition of over 7000 photographic plates made at the beginning of the twentieth century by the Vincian Commission also offers an added value to the study of Leonardo's sheets since in them the legibility of the graphic and textual signs is perfectly preserved, often strongly compromised in the originals by the wear of time and from the restoration mentioned above.

Through the *Lexicon* of the Codex Atlanticus it will also be possible to query the transcriptions by headword and by form, with the results contextualized directly on the sheet. A part of the database is instead intended to host the metadata relating to the acquisition of watermarks, the study of which can provide decisive information for the history of the Leonardo manuscripts. The scholar will be able to access the individual sheets on the basis of their physical and paleographic characteristics (marginal gaps or interruptions in

the text on the margins), and in any case regardless of the foliation system adopted by the various editions which have done nothing but complicate the consultation of the codex. No less important is the possibility of accessing critical literature, which is not always easy to find in libraries. The bibliographic section allows access from the bibliographic citations contained in the critical notes to all the related sheets and records of the Leonardian Bibliography of Vinci for a total of almost 5000 links. Of these, about half refer to resources that can be consulted through the Digital Library of the Museo Galileo.

Finally, the activation of a discussion forum allows users to be an active part of the project, both by initiating targeted discussions on individual manuscripts, and by reporting updates, corrections or philological interpretations. For this purpose, the possibility of dialoguing with the web resources of other institutions is also crucial, as is currently the case with the link to Leonardo's bibliography edited by the Leonardian Library of Vinci and to the e-Leo digital platform.

## 3. *Virtual exhibitions*

While Galileo//thek@ and Leonardo//thek@ are integrated archives conceived as research environments, other recent multimedia applications are proposed as development models

exploration, knowledge and publication of research results. The book or document is not simply available in digital format but can be explored in all its aspects (iconographic, textual, cultural context, relationship with similar documents) in order to provide the user with a digital edition that the user himself - in this case a scholar - can help refine with suggestions, clarifications or corrections. Digital is expressed through images in a more effective way than can be obtained with traditional printing, and it is through this way of communication that we have chosen to convey information of a technical-scientific nature according to the model of the virtual exhibition dedicated to the enhancement of selected items in the collection.

Two recent virtual exhibitions have been dedicated to as many masterpieces of Western cartography which stand out for their historical importance and reading complexity: the planisphere printed in 1507 by the German cartographer Martin Waldssemüller, and the mappamundi designed around 1450 by the Venetian cosmographer Fra Mauro. In both cases, although they are works owned by other institutions, the virtual exhibition tends to enhance the collections of the Museo Galileo. In the case of Waldssemüller's planisphere - the result of the explorations of Amerigo Vespucci - the conspicuous collection of nautical charts and
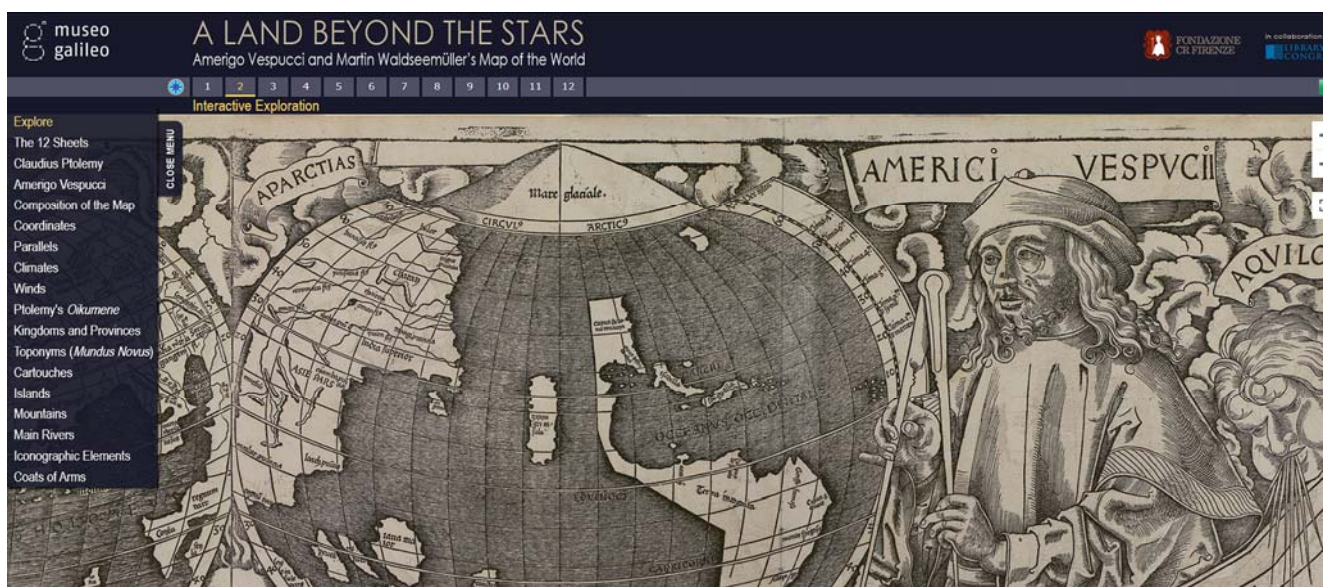


**Fig. 5:** Digital exploration of the planisphere by Martin Waldseemüller (1507).

of the concept of digital library that from a simple 'container' of documents becomes a tool for

planispheres of the Medici era is enhanced; in the case of Fra Mauro's world map, the museum
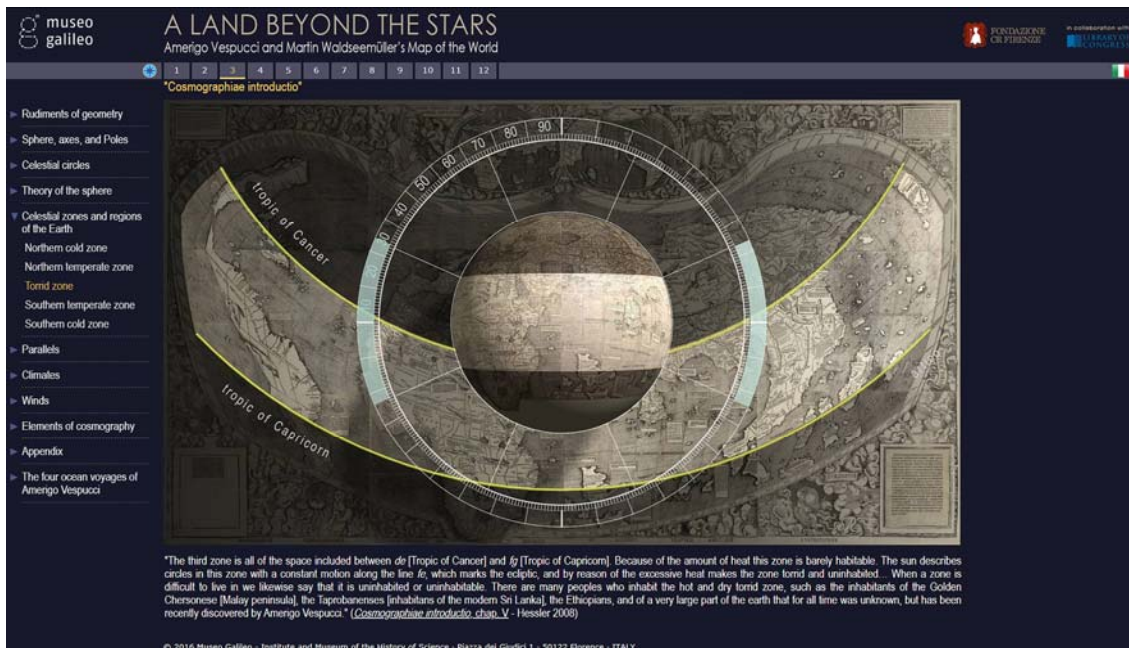
**Fig. 6:** Visualization in images of the Cosmographiae Introductio by Martin Waldseemüller (1507).

preserves a facsimile copy made by Fratelli Alinari in 1942 for the Universal Exposition in Rome.

Waldssemüller's planisphere - the only surviving copy of which is kept at the Library of Congress, in Washington (fig. 5) - is a large map printed on twelve plates and rich in geographic and cosmographic information. It is known as the 'birth certificate' of America because the name "America" appears for the first time in it, coined by the humanists of Saint-Diè des Vosges (place of production of the map) in honor of Amerigo Vespucci, the first who was able to recognize the lands discovered by Spanish and Portuguese navigators as a new continent. The Florentine navigator is portrayed together with Ptolemy in a celebratory form that enhances his cosmographic skills, also associating his person with the discovery of the new world iconographically.

The digital edition aims to allow the wider public to appreciate the density of the geopolitical, historical and commercial information contained in the map, decipher its structure and graphic symbols, and understand the historical and cultural context that favored its execution; a complexity of information that only the multimedia is able to convey effectively to every category of users, from students to scholars[3]. The twelve plates that make up the map appear on the home page as access doors to as many exploratory sections: twelve sections divided into about two hundred paragraphs that include forty-one videos and twenty-five 3D animations, for a total of over two hours of navigation.

The organization of the themes follows a precise path, but the user can move freely by consulting the site map and choosing the topics of interest. After the introductory section, the visitor accesses the interactive exploration of the map of which a very high-resolution reproduction is provided (54000 x 30000 px) and a detailed reading of all the Latin inscriptions, duly translated into Italian and English: 159 cartouches, 185 kingdoms and provinces, 100 toponyms of the New World, and numerous cosmographic indications present on the graduated frame surrounding the geographical representation. Particularly effective is the visualization of the Ptolemaic ecumene through the selection of the twenty-six regional maps illustrated by Henricus Martellus Germanus for an edition of Ptolemy's Geography which was almost certainly one of Waldseemüller's main sources.

The third section illustrates in images the contents of the Cosmographiae Introductio, the cosmographic book printed together with the map in 1507 (fig. 6). Each image illustrates the content

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of a chapter and refers the reader to consult the original text in the digital library accessible in the last section of the site. The choice to translate the text into images derives in part from the desire to synthetically communicate the content of the chapters, using a language more appropriate for multimedia communication, in part from the need to make clear the concepts and geometric definitions that sometimes result in translation as well hardly understandable to non-specialists. In the case of Ptolemy's Geography, for example - a fundamental text of ancient and modern geographic knowledge - multimedia has allowed us to animate the geometric procedures described by the Alexandrian geographer for the design of his cartographic projections (fig. 7), rendering a useful service not only to students but also to those scholars educated in human sciences and not familiar with graphic procedures.

In the following sections we find a rich collection of maps illustrating the cartographic sources and the fortune of the Waldseemüller's map (section 4), a brief history of geographic knowledge, from the ancient world to the New World (sections 5-8), and a presentation of the scientific knowledge necessary for cosmographers, from cartographic projections, to navigation techniques, to astronomical knowledge (sections 9-11). The ninth section on cartographic projections, in particular, effectively tackles the by no means trivial problem of how to draw a map of the world; that is, how the spherical configuration of the earth's surface is transformed in plane shape. A series of 3D animations teach to draw, step by step, the Waldseemüller's planisphere and the three types of cartographic representation described by Ptolemy, providing an indispensable educational tool for those who are preparing to study the problems of historical cartography. An educational tool that, more generally, exemplifies how the concept of 'digital library' can extend to the analytical study of a particular historical document, enhancing and disseminating the results of scientific research through multimedia.

The website dedicated to Fra Mauro's world map, one of the most complete and significant representations of the mid-fifteenth century imago mundi (fig. 8), has a similar layout. Preserved as a manuscript in the Marciana Library in Venice, the map is painted and decorated with very bright colors within a circle of about two meters in diameter. The geographical representation is enriched by over three thousand cartouches, many toponyms and hundreds of images of cities, temples, roads, ships and a beautiful earthly paradise illuminated by Leonardo Bellini. The earthly paradise is a legendary place that medieval geography placed in
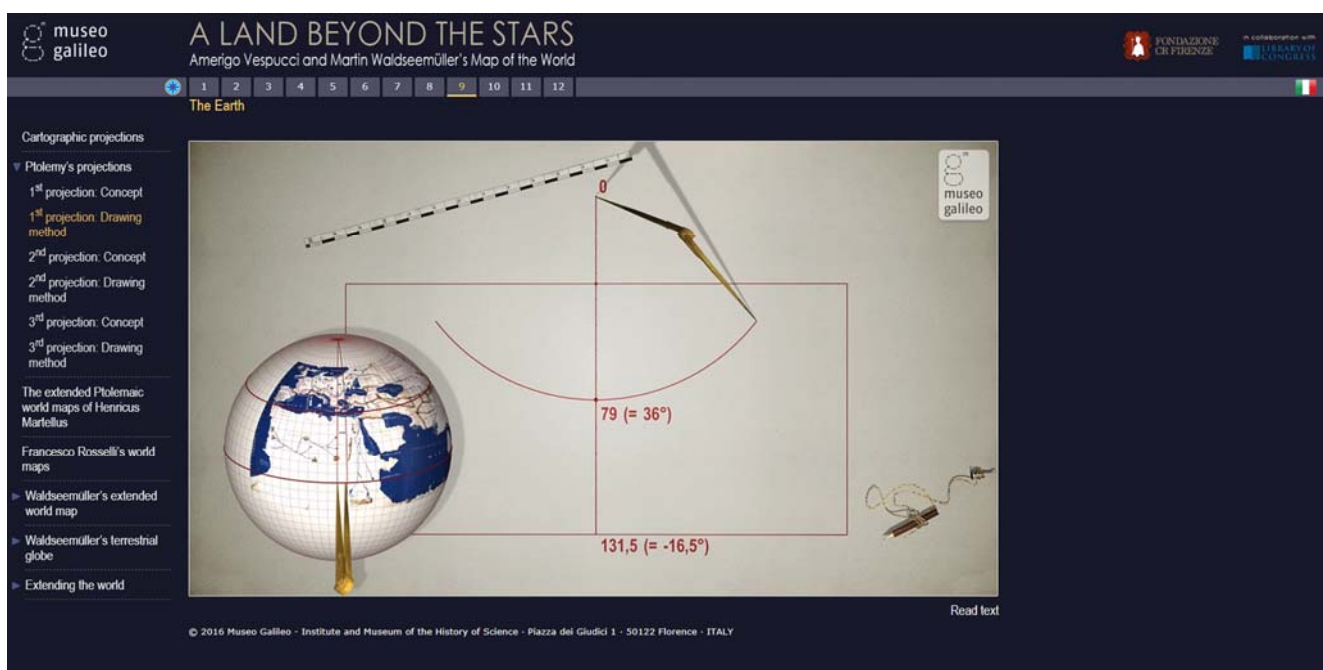


**Fig. 7:** Digital animation of Ptolemy's first cartographic projection.

**Fig. 8:** Digital exploration of the world map of Fra Mauro (ca. 1450).

the Far East, in the direction of the sunrise; Fra Mauro places it in the cosmographic space, depicting it outside the ecumene, together with celestial diagrams that illustrate the spheres of the planets, the elements, the theory of tides and other themes of natural philosophy. The whole - that is the historiated map and the diagrams of the sky commented on by cartouches which summarize famous medieval philosophical texts - constitutes a sort of figurative treatise on cosmography.
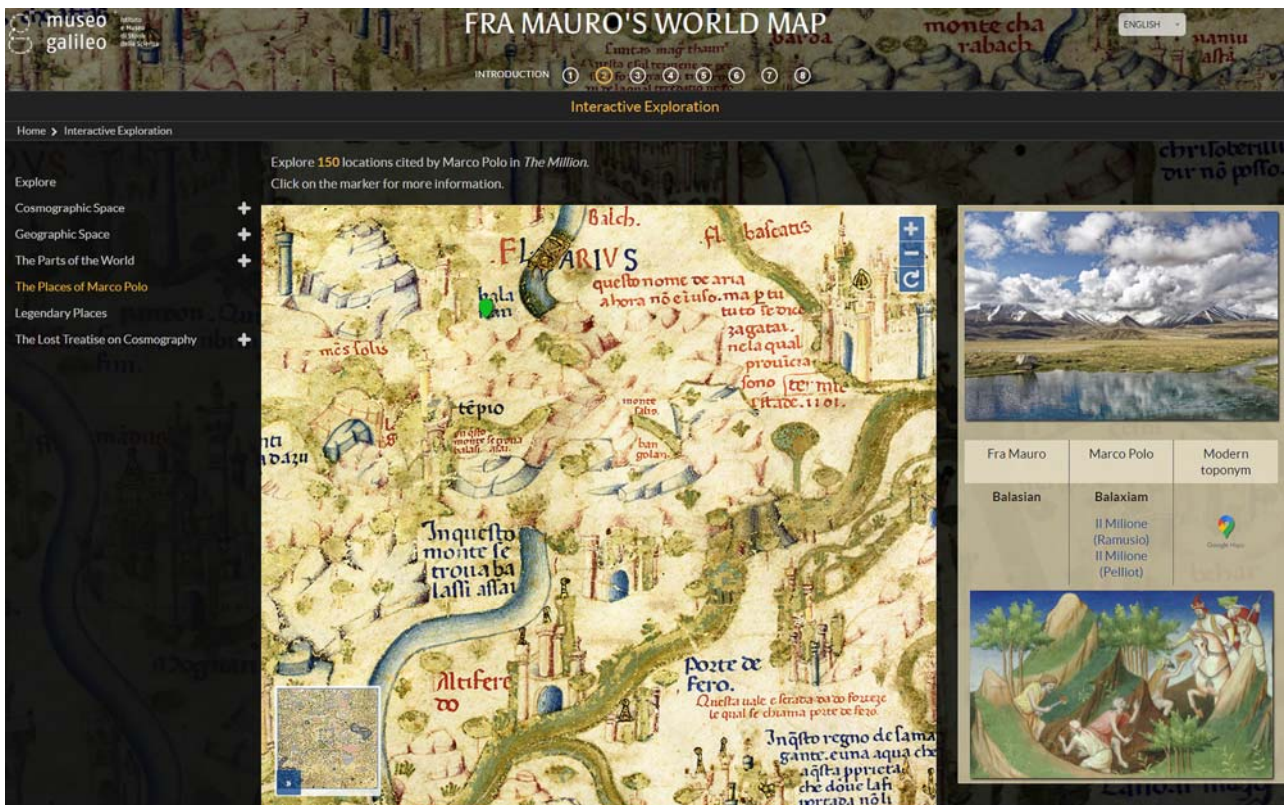


**Fig. 9:** Exploration of the places of Marco Polo from the website on the world map of Fra Mauro.

The mappamundi outlines an image of the world that precedes the navigations of the Portuguese and the Spanish by a few years, integrating the Geography of Ptolemy (about 100-about 175 AD) with the travel stories of Marco Polo (1254-1324) and Niccolò de 'Conti (1395-1469). The ancient ecumene expands eastwards to Japan - depicted here for the first time based on the story of Marco Polo - and southwards to the southernmost latitudes of Africa which clearly reveals the possibility of its circumnavigation.

After Fra Mauro's death, the map became known as the 'Marco Polo's map' because it was believed that it had been drawn up on the basis of a map of the world drawn by the famous Venetian merchant during his long journey to Cathay. The name of Fra Mauro was rediscovered only towards the middle of the eighteenth century in the context of historical studies on the Camaldolese Congregation of the Order of Saint Benedict, and since then he has been subjected to careful critical studies whose results flow into the website designed and built by the Galileo Museum.

The site allows users to explore in detail the rich textual and graphic information of the world map, displaying the approximately 3000 cartouches that describe kingdoms and provinces in Venetian vernacular, selecting seas and rivers, roads and commercial routes, both land and sea, and 1296 cities. Most of the places described by Marco Polo (150 toponyms) have been identified and geolocalized on the Google map in order to reconstruct the travel itinerary of Marco, his father and uncle (fig. 9). In the same way, the travel itinerary of Niccolò de 'Conti has been visualized, as well as the routes of the Portuguese who shortly after the drawing up of the map were able to reach the Indies by sea, rounding the Cape of Good Hope and connecting to a route, reported by Fra Mauro, who from that extreme southern point the Chinese junks had already traced up to the coasts of India and Cathay. The Turkish blockade of the Mediterranean, imposed with the fall of Constantinople in 1453, had in fact forced the maritime powers to look for an alternative route to the East and Fra Mauro's map was certainly the most suitable cartographic document for the elaboration of such a commercial project. It is no coincidence that the king of Portugal commissioned a copy, now lost, which was sent to Lisbon before 1459.

A hundred videos illustrate the history of this cartographic monument, its graphic and textual construction, its critical fortune, and since it is a very important work also for the history of oriental culture, all the texts - titles, videos and cartouches - are presented in Italian, English and Chinese, with the possibility of switching from one language to another at any time without losing the exploratory path undertaken.

Although produced in different times and places, the Waldseemüller planisphere and Fra Mauro's mappamundi could have a link in the work of a famous German cosmographer active in Florence at the time of Lorenzo the Magnificent, Henricus Martellus, author of a planisphere drawn little before the discovery of the New World but fundamental for the drafting of the Waldseemüller's map. The planisphere of Martello was drawn up around 1490, when in the Palazzo dei Medici there was a handwritten copy of the world map of Fra Mauro, presumably made a few years earlier for Lorenzo the Magnificent. Like Fra Mauro's map, the Martello planisphere illustrates the coastal profile of the entire African continent, perhaps deriving it from Portuguese maps drawn up after the circumnavigation of Bartolomeu Dias in 1488, or precisely from the world map of Fra Mauro which prefigures that navigation route thirty years before that famous journey. Like Fra Mauro's map, moreover, the ecumenical space extends beyond the geographical limits indicated by Ptolemy, to the still unknown island of Cipango, Marco Polo's Japan which Fra Mauro represented for the first time.

## 4. *Educating through heritage*

The mission of a museum, in addition to preserving and enhancing, is to educate through the heritage of its collections. The educational activities carried out online during the closure for Covid-19 are constructive experiences to be refined and re-proposed even after the end of the pandemic emergency. It is probable that caution in gatherings will remain a good rule to follow in the years to come, and therefore it is foreseeable that at least schools will reduce attendance visits. In this case it is desirable that the school/museum relationship can continue to take place through distance learning activities, or even in presence in the schools of the city. And it is also desirable that the resources of local administrations are partly

destined for this noble, as well as necessary, mission.

Another form of projection of the museum beyond its walls is that of traveling exhibitions: temporary exhibitions to be exported to other institutions in order to disseminate scientific knowledge through museum activities (thematic projects on specific works of the collections, or on pertinent themes). The exhibitions set up over the years by the Galileo Museum are characterized by a strong didactic component which always involves the construction of material and digital models to be combined with original works (drawings, books, tools) in order to facilitate their reading and understanding. Explaining Galileo's telescope without giving visitors the opportunity to observe through the lenses of a replica may in fact be a futile operation. Touching the replica of an instrument, seeing the model of a machine designed by Leonardo and observing its operation through multimedia is an educational experience that only an exhibition can offer. But for the models to have a high educational profile, it is necessary to build them with a philological approach that implies a research project. And therefore, exhibitions are always opportunities for study that allow those who work in museums to deepen their knowledge. Far from being just a place for the conservation of scientific heritage, the Galileo Museum is a specialized research center that for years has been addressing the world of school in an increasingly structured way, while continuing to offer itself as one of the main points of reference for the international community of scholars of the history of science.

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