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Practical Cosmography in Early Modern Iberia
Alonso de Chaves and his *Espejo de Navegantes*[1]

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Abstract

Ancient cosmography had to adapt to new historical circumstances during the early modern period in Europe, leading to a proliferation of roles and even a sort of identity crisis. This entailed the revival of cosmography as a new and modern science, which, however, was neither unitary nor homogeneous. Cosmography was not associated with a single epistemic community, a certain scholarly profile or a specific corpus of literature, but with different groups and practitioners who produced diverse kinds of documents. Numerous practices emerged, and knowledge circulated in several forms. The article explores so-called practical cosmography in the Iberian world from the early sixteenth century. This will be illustrated not by the classical works of the period (Faleiro, Medina, Cortés, Oliveira) but by the lesser-known figure of the Pilot Major Alonso de Chaves and his nautical encyclopaedia Quatri partitu en cosmographia pratica (c. 1530). Chaves' responsibilities as cosmographer of the Casa de la Contratación in Seville, the subjects and structure of his treatise, the intended audience and the style and language used show that there were substantial differences between the cosmography practised in Seville and Central European cosmography. The characteristics of this cosmography will be interpreted from the perspective of artisanal epistemology.

Keywords: *Artisanal Knowledge, Art of Navigation, Cosmographers, Navigators, Sixteenth Century*

1. *Introduction: Practical and Maritime Cosmography*

The sixteenth century was the golden age of new European cosmography. There are several reasons for this, among them

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the humanist rediscovery of Claudius Ptolemy's *Geography* at the beginning of the fifteenth century in Florence and the discovery of a New World at the end of the same century, but also the application of mathematics to new fields of knowledge such as oceanic navigation and cartography. These historical circumstances went beyond the etymological limits of the word κοσμογραφία, which referred to the 'descripción, traza, y pintura del mundo' (Apiano 1548, 1v).[2] Consequently, cosmography was redefined and established as a new and modern science with fresh challenges, a new discipline that had to integrate the novelty of geographical discoveries into the hegemonic conceptions of classical science. Assembling the pieces of this great puzzle was an immense and multifaceted task. The result was not a completely homogeneous knowledge, but rather a polyphonic and hybrid corpus subject to various epistemological tensions that developed and were manifested in different ways (Lestringant 1991, 162).[3] This article distinguishes between two of the most common ways of doing cosmography in early modern Europe: scholarly and encyclopaedic cosmography on the one hand, and practical and maritime cosmography on the other.[4] The first was a more academic, mathematical and theoretical cosmography that developed in university-learned and humanist environments. The second, more experimental and utilitarian, developed in a maritime environment and required the collaboration of different communities of knowledge with diverse skills and abilities. Both had a strong presence in Europe, and throughout the sixteenth century we find the term cosmography used in both traditions. This article analyses the second of these, namely early modern practical cosmography, in the Iberian Peninsula and in terms of an artisanal and even Zilselian reading.[5] To do so, I will rely on the exceptional and not so well-known case of Alonso de Chaves and his *Quatri partitu en cosmographia pratica y por otro nombre llamado espejo de navegantes*, c. 1537.[6]

It was the cosmographer and Pilot Major Alonso de Chaves who introduced – probably for the first time – the notion of 'practical cosmography' in his *Quatri partitu en cosmographia pratica* when he worked at the Casa de la Contratación in Seville. Thus, practical cosmography emerged mainly in southern Europe, in the principal maritime cities of the Portuguese and Spanish empires, such as Lisbon and Seville, but also in Venice and Dieppe. In these cities, a

[2] (description, tracing and painting of the world). Unless otherwise stated all translations are mine.

[3] Lestringant has called this tension between ancient and modern, theory and practice, old pure mathematics and new applied mathematics, experiment, and authority, direct testimony and scholarship 'the crisis of cosmography'.

[4] In an illuminating article, Adam Mosley argues that the word cosmography – understood as a 'combination of astronomy and geography' – was associated 'with a broad range of things'. Mosley distinguishes between 'cosmographic authorship' and 'cosmographic practice' to classify the different types of cosmographers in early modern Europe. Among the former, he includes authors continuing the Ptolemaic tradition, 'university-trained and pedagogically-active scholars, typically concerned with the study and promotion of mathematics' such as Apianus, but also with the 'encyclopaedic cosmography' of Münster. Among the latter were navigators working with what he calls 'maritime cosmography', or individuals such as Mercator who was a 'courtly' cosmographer (and others such as Ignazio Danti), whom Mosley considers the best example of a cosmographer in the sixteenth century (2009, 427). The notion of practical cosmography that I use in this article is similar to Mosley's notion of maritime cosmography.

[5] The so-called Zilsel thesis contends that modern science emerged around 1600 when the social barriers between artisans and scholars were broken down because of the rise of early modern capitalism. According to this broad argument, collaboration between the two groups was facilitated by intermediate figures that Edgar Zilsel called 'superior artisans'. Perhaps as a consequence of his early death, Zilsel did not develop his thesis by explaining how this interaction took place and by identifying these superior artisans (see Zilsel 1942). After the pioneering work of Zilsel in the 1930s and 1940s, in recent decades, scholarship on the artisanal dimension of knowledge in the early modern period has grown thanks to the work of Raven 2000; Smith 2004; Long 2011; Cormack 2017, among others. A recent study on the Iberian world and artisanal knowledge can be found in Leitão and Sánchez 2017a and 2022.

[6] (Practical Cosmography in four parts otherwise known as Mariners' Mirror).

new class of artisans and practical men emerged, that of oceanic pilots. New institutions of applied cosmography, new cosmographic trades, new cartographic models and a new nautical literature were inaugurated there to meet the needs of navigators. It was in non-university spaces such as the Casa de la Contratación or the Armazéns da Guiné e Índia in Lisbon, that the practical dimension of the new cosmography prompted the development of a maritime cosmography. One of the most original characteristics of this maritime cosmography is precisely that it spread in new scientific institutions. The Casa and the Armazéns constituted new spaces of knowledge characterised by the direct interaction between the different practitioners who worked there, with their different status and social backgrounds, but also with their different systems of knowledge and skills. Following Pamela O. Long's recent contribution to the field of artisanal studies of science, both institutions can be considered as 'trading zones', arenas where there was a mutual and reciprocal influence between artisans (skilled men) and learned individuals, pilots and cosmographers, and the blending of both cultures.[7]

Thus, practical cosmography was the set of tools and knowledge that an ocean navigator needed to know. It was adapted to the needs of navigation and the daily work of navigators, a body of knowledge of various kinds now suited to the experience of pilots. This direct, utilitarian and pragmatic approach to the study of nature offered a new understanding of the cosmos, a new cosmography. We can say that, in a few decades, the οἰκουμένη became *mundus*, a totality, empirically tested by seafarers (see Leitão and Sánchez 2017b, 168-173).[8] The new cosmographic knowledge stemmed from navigators and explorers and took on an experimental dimension. These navigators were the direct witnesses of a new epoch and were to become authoritative voices in the pyramid of knowledge. Thus, between 1488 (when Bartolomeu Dias rounded the Cape of Good Hope and opened up access to the Indian Ocean) and 1522 (when the first voyage round the world was completed), a great cosmographic revolution took place that altered the geographical scheme of antiquity and broke the epistemic inequality between practitioners and theoreticians, artisans and scholars. This revolution brought humanist scholars – mostly geographers, astronomers and mathematicians – as well as navigators into contact (Cosgrove 2001, 95-100; Vogel 2006, 471). Both were obliged to understand and adapt to each other if they were to offer a complete, renewed and reliable image of the cosmos (Dainville 1969; Broc 1986; Besse 2003).

[7] Long defines 'trading zones' as 'arenas in which artisans and other practitioners (trained as apprentices in workshops or in hands-on instruction at, say, construction sites) and learned men (trained in Latin at universities and other institutions) engaged in substantive communication and shared their respective expertise' (2015, 842). As Long highlights, 'trading zones' are an excellent solution to Zilsel's limits in demonstrating collaboration between artisans and scholars (see also Sánchez 2017).

[8] To these ideas should be added, to a lesser extent, the revival of Archimedean mechanics, one of the great achievements of sixteenth-century mathematics.

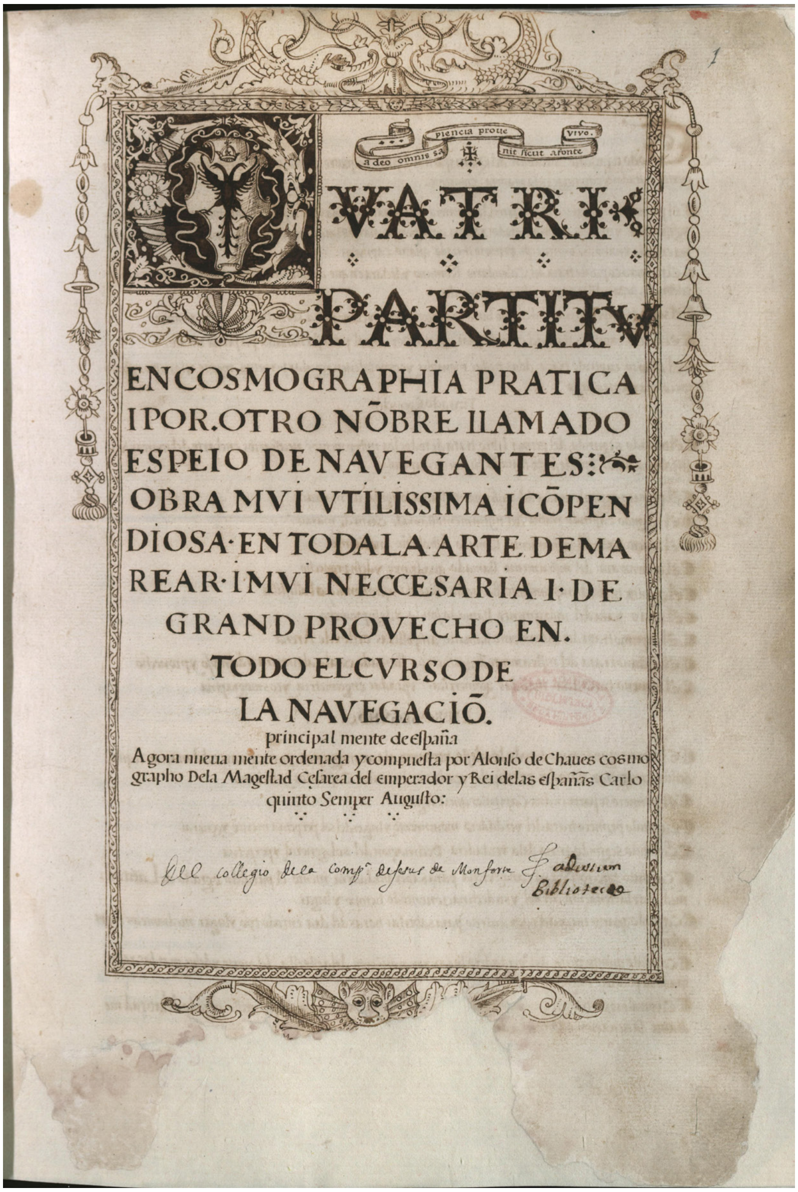


Figure 1 – Manuscript cover of Alonso de Chaves' *Quatri partitu en cosmographia pratica*, c. 1537. It bears the full title of the work and the imperial arms in a typeface that imitates printing. Real Academia de la Historia, 9/2791. Courtesy of the ©Real Academia de la Historia, Madrid, Spain.

The main aim of this article is to contribute to defining this particular form of cosmography, a knowledge linked to the world of navigation and understood as the result of the interaction between two knowledge communities. Some of the main characteristics of this kind of cosmography will be identified in Chaves' *Espejo de Navegantes* (Mariners' Mirror), an encyclopaedia of nautical knowledge that remained unpublished until the last quarter of the twentieth century (figure 1).[9] I will argue that the practical, maritime-oriented cosmography propounded by Chaves was substantially different from the theoretical and mathematical cosmography that dominated academic and humanist circles in the rest of Europe in the same period. This raises some important questions which need to be addressed. Why use an unpublished text to talk about early modern Iberian cosmography? How widely was that knowledge circulated? How might it have been disseminated even though it was not published? More generally, what does Chaves' *Espejo de Navegantes* teach us about cosmography, and what do we learn about the type of knowledge produced, taught and practised in the Casa de la Contratación? In the following pages I will try to demonstrate that the practical, even artisanal, cosmography illustrated by Chaves was a type of knowledge that circulated through teaching rather than publication, i.e., from the (sometimes tacit) interaction between different practitioners and professionals.[10] I argue that this particular case serves to illustrate, and perhaps to resolve, Zilsel's thesis on the artisanal origins of modern science. If we assume that Zilsel's interpretation of the emergence of modern science is at least as plausible as others, then we can recognise that the maritime cosmography practised in Portugal and Spain during the second half of the fifteenth century onwards may clarify some of the gaps in Zilsel's thesis. Although the Austrian philosopher and sociologist's thesis did not provide sufficient empirical evidence showing the collaboration between artisans and scholars, I believe that the case of Iberian cosmography offers several insights that favour this interpretation. The creation of spaces of exchange or trading zones, the appearance of intermediate professionals, the elaboration of cosmographic devices with different levels of understanding, the mathematisation of nautical problems, the criticism and correction of the authority of the ancients, and the use of the vernacular are some examples that justify this approach.

2. *Biographical Elements*

Who was Alonso de Chaves (c. 1492-1587), and more importantly, why is he a good representative of Iberian cosmography? He was a Spanish cosmographer who worked for much of his life at the Casa de la Contratación de las Indias – a commercial and scientific agency created in Seville in 1503 by the Spanish Crown to manage its colonial empire –, where he held various positions, first during the reign of Charles V, and later under his son Philip II (see Fernández de Navarrete 1851, 16-17). In 1527, he took over the post of Pilot Major on an interim basis, together with the Portuguese cartographer Diogo Ribeiro, to make up for the frequent absences of the Venetian cosmographer Sebastian Cabot, who had held the post since 1518.[11] In April

[9] The detail and beauty of the writing lead us to believe that Chaves' aim was not to leave it unpublished.

[10] In *Secret Science* (2009), Maria Portuondo presents cosmography as a science subordinated to the secret state projects of the monarchy. Thus, cosmography was a useful science for the international strategy of the Spanish monarchs. Personal aspirations which did not serve the needs of the monarchy or were subordinate to the interest of the State had to be abandoned. Without denying this interpretation, the present article suggests that this science was useful to the extent that it solved the new problems of oceanic navigation. These problems could only be solved through the collaboration of individuals belonging to different communities of knowledge and with distinct professional skills. The results of this interaction did not appear in universities nor were they published in cosmography books, but materialised in lessons, voyages, maps and other types of documents, such as pilot exams, questionnaires or even logbooks. In that sense, it is a practical, even artisanal, cosmography. Chaves' text, in the form of a systematically written treaty (and not a loose and untidy document such as those mentioned above), is a wonderful exception.

[11] Archivo General de Indias in Seville (AGI), Patronato, 251, R.22.

1528, Chaves was appointed Pilot and Cosmographer of the Casa.[12] He was thus in charge of teaching pilots to use the astrolabe, the quadrant and the nautical chart, as well as participating in the Casa's most important scientific debates and disputes, such as the one that arose in the late 1530s about the making of nautical charts with multiple scales of latitudes to correct the effects of magnetic declination.[13] It may have been during these years that Chaves wrote the *Espejo de Navegantes* with the intention of renewing nautical knowledge and teaching it to new pilots. Over the years, Chaves became an authoritative voice among the Casa's cosmographers. Perhaps for this reason, and in recognition of his knowledge and experience in matters of cosmography and navigation, in 1557 he was appointed Pilot Major, the most prestigious scientific position in the Sevillian institution.[14] Chaves thus replaced Cabot, who had left for England (see Sandman and Ash 2004), and he held this position for almost thirty years until he was replaced by Rodrigo Zamorano in 1586.[15] During these years, he trained several generations of pilots and kept the Padrón Real (Royal Pattern Chart) up to date, among other tasks.[16] When Zamorano replaced him, Chaves had been linked to the Casa for more than half a century, which made him one of the most emblematic figures of the institution. He was therefore a man of great science and experience – as acknowledged at the time –, that is, a practical cosmographer. Science was represented by geographical, astronomical and mathematical knowledge. Experience embodied the ability to construct navigational instruments and to solve nautical problems. Chaves materialised this hybridisation in his *Espejo de Navegantes*, leaving us with one of the earliest testimonies of sixteenth-century Iberian cosmography, the only one that brought together all the nautical knowledge known up to that time (except for knowledge about shipbuilding). For a similar text with encyclopaedic claims, we would have to wait until 1570, when Fernão de Oliveira wrote his *Ars nautica* in Latin, which he included several pages on shipbuilding. Oliveira's work is a compendium dedicated to navigation, naval warfare and shipbuilding.[17]

In short, Chaves was one of the witnesses and protagonists of the new cosmography. Following Zilsel's terminology, he can be considered, like other renowned figures connected to the Casa, a 'superior artisan', versed in geographical sciences, who wrote in the vernacular for other 'plebeian workers' (pilots), and who, in short, represented the prelude to modern science (1942, 554). As cosmographer and Pilot Major, he updated the new image of the world through the Padrón Real and taught the art of oceanic navigation to dozens, perhaps hundreds, of pilots. He spent most of his working life – some sixty years – in contact with pilots of the Indies, cartographers and other cosmographers. His experience as a cosmographer in this maritime environment was recorded in a text that remained unpublished for centuries. This does not, however, mean that the document is insignificant and that its contents were not circulated, quite the contrary. Chaves' *Espejo de Navegantes* reliably illustrates the particularities of what he called 'practical cosmography'. In other words, it demonstrates a reality that is not to be found in any other nautical publication of the 1530s. This text is the most complete guide to maritime cosmography of the first half of the sixteenth century. It articulates the vision of the

[12] AGI, Contratación, 5784, L.1, 49v; AGI, Indiferente, 421, L.13, 82r(1); AGI, Indiferente, 421, L.13, 82r(2).

[13] On the teachings of Chaves, see AGI, Indiferente, 421, L.13, 295v. On the pilots' participation in the debates on the charts with multiple graduations, see Pulido 1950, 91-96; Sánchez 2013, 243-244.

[14] AGI, Contratación, 5784, L.1, 112; AGI, Contratación, 5784, L.1, 112v; AGI, Indiferente, 1965, L.13, 380v.

[15] AGI, Contratación, 5784, L.3, 40v-41r.

[16] The Padrón Real was a continuously updated cartographic model created in 1508 from which all the nautical charts produced in the Casa de la Contratación and used by the pilots of the Carrera de Indias were extracted. Therefore, all these charts were copies of the Padrón Real. On the Padrón Real, see Sandman 2007; Sánchez 2013; García 2018.

[17] On Oliveira's *Ars nautica* and other nautical treatises, see Contente Domingues 1985.

longest-serving Pilot Major of the Casa de la Contratación, a cosmographer whom the Spanish Crown kept in office until the end of his life. In this work, Chaves takes stock of the different dimensions of maritime life. On the one hand, he highlights the technical dimension, which attributes great importance to the way of organising time, of making mathematical calculations and astronomical observations, of constructing and using different nautical devices, of solving problems related to the determination of latitude and longitude, and so on. On the other hand, he gathers information that corresponds to a more social dimension of the maritime world, such as the hierarchy and functions of seamen, their knowledge, as well as the details of life on board.

3. *Cosmography and the World of Navigation in Seville*

The world of navigation appropriated the term 'cosmography' in early modern Iberia.[18] Thus, in institutions such as the Casa de la Contratación, new professions were created during the first half of the sixteenth century, among them the Pilot Major (1508), the Cosmographer for making nautical charts and instruments for navigation (1523), and the Chair of Cosmography (1552).[19] Similarly, in the Armazéns da Guiné e Índia in Lisbon, the post of Chief Cosmographer had existed since at least 1547 (Teixeira da Mota 1969; Sánchez 2016). These positions articulated the collaboration between the knowledge of university cosmographers and the technical skills of navigators, cartographers and nautical-instrument makers. In most cases, the posts of Pilot Major and Chief Cosmographer – the most important ones – were occupied by 'intermediate professionals' (Leitão and Sánchez 2017a, 203) possessing both practical and theoretical knowledge, men such as Sebastian Cabot, Pedro Nunes, João Baptista Lavanha, Rodrigo Zamorano, Andrés García de Céspedes and Alonso de Chaves (*ibid.*).[20] The responsibilities of these individuals, designated by the Crown, made it possible to connect seemingly distant spheres of knowledge.[21] This type of cosmography had little to do with the cosmography of Apianus, Münster and the humanists of Salamanca such as Francisco Núñez de la Yerba, Pedro Ciruelo, Antonio de Nebrija, Pedro Margallo and Fernán Pérez de Oliva, among others.[22]

This practical cosmography overlapped with the art of navigation.[23] In a maritime environment, the term 'cosmographer' referred to the construction of charts and other navigational instruments, to participation in scientific debates on territorial disputes – as was the

[18] One of the first texts to use the word 'cosmography' in the context of Iberian navigation was Duarte Pacheco Pereira's *Esmeraldo de Situ Orbis* (c. 1508).

[19] Throughout the century, the Spanish Crown would appoint other cosmographers and create new offices related to cosmography, such as the Cosmographer-Chronicler of the Indies, the Cosmographer of New Spain, the Cosmographer of the Philippines, and the Cosmographer of the Navy of the Indies, among others. On this and other scientific offices of the Casa de la Contratación, see Pulido 1950. There is an extensive bibliography on this subject. Among them, see Lamb 1995; Sandman 2001; Portuondo 2009; Sánchez 2013.

[20] The emergence of dozens of intermediate professionals in the Iberian world addresses issues raised in Zilsel as related to the analogous figure of the 'superior artisan', namely, the person who establishes links between artisans and scholars.

[21] The Portuguese Crown laid out the functions of the Chief Cosmographer in detail in the Regimento do Cosmógrafo-Mor (1592) (Regiment of the Chief Cosmographer), an official document containing a set of guidelines to regulate the scientific activities of the Chief Cosmographer. See Teixeira da Mota 1969; Sánchez 2016.

[22] On the humanist cosmography of Salamanca, see Flórez Miguel, García Castillo and Albares Albares 1990.

[23] There is an extensive bibliography in Spanish historiography on the relationship between cosmography and navigation. In this article, I will only cite the references that are directly related to my argument. For more on this subject, see, among others, Víctor Navarro, María Isabel Vicente Maroto, Mariano Esteban Piñeiro and Nicolás García Tapia.

case with the Treaty of Tordesillas and the Moluccas quarrel – and to the training of pilots in non-university environments. In Lisbon and Seville, a cosmographer had several functions. He was an instrument-maker; he reviewed and evaluated the instruments made by other cartographers and nautical instrument-makers; gave his opinion on cosmographic debates, such as the establishment of the meridian and antimeridian of Tordesillas, or the location of a territory; he instructed pilots on everything they needed to know about their craft. Sometimes, these cosmographers wrote treatises on cosmography and the art of navigation, the main addressees being navigators, although not exclusively.[24] Some of these cosmographers had a university education, others had had a military career, most belonged to families of cosmographers, and a few had experience in navigation. The common characteristic was that they did not work in humanist and academic environments. At a remove from classrooms and libraries, their daily work was carried out in nautical spaces and institutions. In this way, Iberian cosmography offered a stable and lasting institutional framework that made it possible to bridge the social – and epistemic – gap that separated scholars and artisans, a gap that, according to Zilsel, had prevented the emergence of modern science before 1600 (Leitão and Sánchez 2017a, 203-204).

3.1 *A New Genre: Nautical Literature in the Vernacular*

The considerable body of navigational treatises written by sixteenth-century Iberian cosmographers represents an extraordinary testimony to this practical and maritime cosmography. These texts responded to the need to provide teachers, students and anyone interested in the art of navigation with easy-to-consult materials that contained all the necessary information on navigation. This extensive literature reflects a systematic effort by Portuguese and Spanish cosmographers to collect and collate the knowledge of a large group of practitioners. The socio-cultural background of these navigators, who constituted the main readership of the treatises, conditioned the form and style of the texts. In general, these treatises were written for use on board ships or during sailing lessons and were intended for navigators, cartographers, instrument makers and other maritime professions. Most of the trades related to maritime culture were carried out by people of modest means and of humble origins who had not had access to formal education and were therefore unfamiliar with Latin.[25] Hence, all these treatises were originally available in the only language the pilots knew, the vernacular. The classical works of astronomy, mathematics, geometry and trigonometry by authors such as Ptolemy, Euclid, Archimedes, Sacrobosco, Peuerbach and Regiomontanus, among others, were also progressively translated into the vernacular by Iberian cosmographers. Thus it was that a new audience, a maritime readership, precipitated the production of a large corpus of scientific-technical literature in the vernacular (Schotte 2019, 18). From this moment on, men who could just about read and write would become familiar with concepts and notions

[24] The word 'cosmography' appeared in the titles of the many treatises on geography and navigation that were written throughout the sixteenth and seventeenth centuries, for example, the aforementioned *Quatri partitu en cosmographia pratica* by Alonso de Chaves, or *Libro de Cosmografía* (1538) and *Suma de Cosmographia* (1561) by Pedro de Medina, *Dos libros de cosmografía* (1556) and *Cosmographia y Geographia* (1570) by Jerónimo Girava, among others. This set of texts, together with the other copious nautical literature of the period, constitutes a very significant corpus on practical cosmography.

[25] The first pages of the Spanish edition of Apianus' *Cosmographia* (1548) refers to the importance of translating these works for the benefit of the common people who did not know Latin but who were governed by the stars, such as shepherds, farmers and sailors.

that had previously circulated among the intellectual elites, and with this knowledge they were able to solve complex, practical problems.

As was the case in fields of knowledge such as agriculture, fortification or even shipbuilding, this nautical literature in the vernacular took the form of manuals and instructional books. Their authors organised the content as a set of rules and instructions that usually ranged from the most general to the most specific. The explanations adapted and clarified the basic theoretical principles of astronomy and mathematics of authors such as Sacrobosco so that they could be used to solve problems which might arise in navigation. In that sense, they had an operational function. The knowledge had to be executable and easily put into practice. To this end, they employed a clear, concise and direct style, sometimes accompanied by images of instruments to facilitate understanding. Their aim was to transmit the knowledge necessary for making an observation or carrying out an operation on board ship without having to study the theoretical foundations of the cosmos. These treatises were thus a response to the requirement to quickly educate a poor and untutored public (Leitão and Sánchez 2017a, 205-206). The genre was probably inaugurated by the Portuguese cosmographer Francisco Faleiro in Seville with his *Tratado de la esfera y del arte de marear* (1535), written in Spanish. It reached its peak around the middle of the century with the works of Pedro de Medina and Martín Cortés.

The task of creating a genre with these characteristics was not an easy one. However, the genre's success was considerable as it spread rapidly throughout Europe in the sixteenth and seventeenth centuries as a result of the translation of works into other European vernacular languages. In 1554, the geographer Nicolas de Nicolay published in Lyon the French version of Pedro de Medina's *Arte de navegar* and in 1561 the alchemist Richard Eden produced the first English edition of Martín Cortés' *Breve compendio de la sphera y del arte de navegar* (1552). Both treatises would be translated and edited into other languages in the following decades. In 1578, the merchant John Frampton was responsible for the publication of the English version of Martín Fernández de Enciso's *Suma de geographia* (1519). Frampton dedicated the translation to the natural philosopher William Gilbert, author of the famous *De magnete* (1600). At the end of the century, Rodrigo Zamorano's *Compendio del arte de navegar* (1581) also appeared in English, this time as an appendix to *Certaine errors in navigation* (1599), in which Edward Wright explains the mathematical foundations of Mercator's famous cartographic projection of 1569 (López Piñero 1986; Basterrechea Moreno 1997). This phenomenon, namely the diffusion of Spanish nautical science, led some historians to assert that 'Europe had learned to navigate from Spanish books' (Guillén Tato 1943).

Among this considerable corpus of nautical literature is Chaves' *Espejo de Navegantes*, the first to use the notion 'practical cosmography' to refer to the nautical science of the sixteenth century. However, while it is possible to situate Chaves' text within this new literary genre, there are also important differences between the *Espejo de Navegantes* and other treatises belonging to the same genre. Despite not being published, Chaves' book is more than an art or regiment of navigation: it is an encyclopaedia for sailors.

3.2 *Chaves'* Espejo de Navegantes*: A Nautical Encyclopaedia*

Unlike the treatises mentioned in the previous section, Chaves' appears to have been preserved but largely ignored until 1895 and remained in manuscript form until 1983, which seems to have prevented its circulation.[26] However, in 1599, Richard Hakluyt claimed to have had access to a nautical treatise by Chaves, which suggests some (limited) circulation.[27] Despite Hakluyt's words, no translation, not even partial, is known. Nor do we know when Chaves may have written his treatise. It is thought that he may have completed it around 1540 and that it may have been a work produced over several decades.[28] The reasons that prevented its publication are unknown; however, it could be conjectured that, as in other similar cases – such as the *Libro de cosmographia* (written in 1538) by Pedro de Medina and the *Itinerario de navegación* (written in 1575) by Juan Escalante de Mendoza –, it may have been the victim of the rigid control the Crown exercised on this type of text, based on the fear that such expertise could fall into the wrong hands.[29] If this was the case, then the fact that Chaves' treatise was not published does not decrease its value or originality, quite the contrary. As in the case of Escalante, the fact that it was not published makes it even more interesting, illustrating a way of practising and teaching cosmography which had to be kept secret. Alternatively, it may simply be that it was not published because it was incomplete, as the second and third parts of the work indicate. Though unpublished, Chaves' *Quatri partitu* is among the first works written in Spain on the art of navigation, and undoubtedly the first with an encyclopaedic character. In the first decades of the sixteenth century, only Martín Fernández de Enciso's *Suma de geographia* (1519) and the aforementioned Francisco Faleiro's *Tratado de la esfera y del arte de marear* (1535) had been published, in addition to Pedro Nunes' *Tratado da Sphera* on mathematical problems applied to navigation and nautical cartography which appeared in 1537 (as well as the unpublished work by Medina referred to

[26] Alonso de Chaves, *Quatri partitu en cosmographia pratica i por otro no[m]bre llamado Espeio de Navegantes: obra mui vtilissima i co[m]pendiosa en toda la arte de marear i mui neccesaria i de grand provecho en todo el curso de la navegacio[n] principalmente de España*. Real Academia de la Historia (RAH), 9/2791. After a long time in the Monastery of Monforte de Lemos (Lugo, Galicia), Chaves' text passed to the Biblioteca de las Cortes (Library of the Parliament) in the 1830s. Later, in 1850, it passed to the Royal Academy of History in Madrid. Once there, it was the Captain and Perpetual Secretary of the Academy, Cesáreo Fernández Duro, who discovered the existence of this treatise in 1895, publishing only some parts of the work. According to Ursula Lamb, in 1929, Edward Luther Stevenson made an English translation of the fourth part of Chaves' work, which remains in manuscript in the Yale Historical Manuscript Collection (1969, 3). Finally, the full edition of the manuscript was completed in 1983 (Castañeda, Cuesta and Hernández 1983). Fernández de Navarrete reports on another of Chaves' writings, a report requested by the judges of the Casa de la Contratación, entitled *Relación de la orden que observaba en el examen y admisión de pilotos y maestres de la carrera de Indias* (1851, 17).

[27] 'The late Emperor Charles the fift … established not onely a Pilote Maior for the examination of such as sought to take charge of ships in that voyage, but also founded a notable Lecture of the Art of Nauigation, which is read to this day in the Contractation house at Siuil. The readers of which Lecture haue not only carefully taught and instructed the Spanish Mariners by word of mouth, but also haue published sundry exact and worthy treatises concerning Marine causes, for the direction and incouragement of posteritie. The learned works of three of which readers, namely of Alonso de Chauez, of Hieronymo de Chauez, and of Roderigo Zamorano came long ago very happily to my hands' (Hakluyt 1599, 3r). With these words, Hakluyt revealed to the English public some of the most significant aspects of the nautical education system of the Casa de la Contratación. The writer alludes with some admiration to the position of Pilot Major, to the lessons that were taught on the art of navigation, to the training and examination of pilots, and to three of its main exponents: Alonso de Chaves, Jerónimo de Chaves, and Rodrigo Zamorano. Of them, he says that they wrote 'exact and worthy' nautical treatises that would guide and stimulate in posterity. Hakluyt ended his praise by taking pride in the fact that the works of these three cosmographers had happily come into his hands. However, nothing more is known about the texts Hakluyt claims to have read.

[28] Its drafting must have begun before 1520 and must have been completed around 1537 (Carpi 2001, x).

[29] Medina's *Libro de cosmographia* was written in 1538 and published in 1972 by Ursula Lamb. See Medina 1972. Escalante de Mendoza's *Itinerario* was written in 1575 and published in 1985 (see Escalante de Mendoza 1985).

above).[30] Not long after, Pedro de Medina's *Arte de navegar* (1545) and Martín Cortés' *Breve compendio de la sphera* (1551) would be published.

Chaves' *Quatri partitu en cosmographia pratica* is a summary of navigation, cosmography and cartography written in Spanish by a man who was an expert in the field and was aimed primarily at navigators on their way to the Indies. In this treatise, pilots could find all the necessary information on the intricacies of their profession. This was the main function of the literary of the sub-genre 'mariners' mirror', works which detailed the daily activity of pilots as navigators. The word 'mirror' in the literary sphere of the Middle Ages corresponds to a political genre called *speculo* or *speculum*, which took the form of manuals with moralising instructions, generally aimed at the good government of kings and princes. The word was also used as a synonym for encyclopaedia or compendium in the late medieval Christian tradition, the most notable example of which is the *Speculum majus* (thirteenth century) by the Dominican friar Vincent de Beauvais, a collection of all the scientific and historical knowledge of the time. Chaves could have used either of these two traditions to inaugurate a new sub-genre in the field of navigation, long before Anthony Ashley translated the Dutch pilot Lucas Janszoon Waghenaer's nautical atlas *Spieghel der Zeevaerdtal* (1584) into English under the title *The Mariner's Mirrour* in 1588. When Chaves alludes in the title of his work to the notion of 'practical cosmography', he is merely equating it with the art of navigation and the genre of *speculum*, and not with the humanist and theoretical notion of cosmography referred to above. The principal maxim of practical cosmography was, as Chaves himself indicates, to be useful and helpful to navigators.

> Obra muy utilísima y provechosa a todos, muy principalmente a los navegantes que han de tratar en las dichas Indias y en los lugares susodichos. La cual obra, otra semejante y de tanto provecho antes de esta nunca se ha visto ni escrito a este propósito. La cual asimismo ordenó y compuso con sola su industria y trabajo el dicho Alonso de Chaves, cosmógrafo de la majestad cesárea. La cual dicha obra es aprobada por los otros cosmógrafos de su majestad y conforme al voto y parecer de los más y más sabios y experimentados pilotos que navegan y han andado y residido en todas las dichas partes. (RAH, 9/2791, 74r)[31]

Chaves was well aware of the requirements that an individual had to meet to become a good pilot, having examined several dozen applicants over the decades. At a time of change in the history of navigation, where in just a few decades there had been big developments in estimated navigation and oceanic navigation, this may have been the main reason why he decided to write his treatise: nautical knowledge had to be revised and pilots had to be trained in the new knowledge. Being a good cosmographer required understanding pilots' problems and offering them solutions. According to Ursula Lamb, Chaves' text is an ideal document for the training of pilots in the *Carrera de Indias* (the West Indies fleet) and provides didactic material that is

[30] Enciso's *Suma* can be considered the first Spanish manual of geography, especially of the New World, in which questions related to the art of navigation are analysed (see Melón Ruiz de Gordejuela 1950; Fernández de Enciso 1987). Faleiro's *Tratado de la esfera*, unlike Enciso's *Suma*, is not a book of universal geography, but a treatise devoted to the sphere and the art of navigation that devotes special attention to the nautical problem of magnetic variation. Faleiro may have been the first navigational theorist in Seville and his treatise may have served as a model for other later treatises on navigation produced in Iberia (see Gil 2009, 391-392; Collins 2013).

[31] (This work is very useful and profitable to all, especially to navigators who have to deal in the Indies and in the aforementioned places. Another such work, similar and previously useful, has never been seen or written for this purpose. This very same was also compiled and composed by the said Alonso de Chaves, cosmographer of the Caesarean Majesty, with his industry and labour alone. The said work is approved by the other cosmographers of his majesty and in accordance with the vote and opinion of the wisest and most experienced pilots who navigate and have travelled and resided in all the said parts).

halfway between improvisation and rigorous organisation, scientific education and practical training (Lamb 1969, 3-4). The direct and simple style employed by Chaves made his treatise appropriate pedagogical material for pilots. Its classroom materials and problems affecting pilots are organised systematically in a single treatise. It is evident that the work was written by someone who worked continuously in the Casa between the 1520s and the 1580s, and in the most responsible of positions. These decades coincide with those of the greatest scientific productivity of the Casa de la Contratación and represent the golden age of Spanish nautical cartography.

As its title indicates, the *Quatri partitu* is divided into four parts or books, further split into various treatises and chapters. The first book (3r-28v) consists of two parts, one devoted to Christian calendars and the other to a rigorous examination of the instruments necessary for navigation, as well as their use and manufacture. Here Chaves places special emphasis on the nautical chart. The second book (28r-44r) deals with 'todo lo celeste y tocante a la cosmografía y arte de marear' (28r),[32] that is, astronomical knowledge adapted to oceanic navigation. The contents of these first two books are decidedly scientific. The third book (45v-73r) is devoted to the more practical side of navigation and some of its problems, such as the dangers, misfortunes and battles that can occur at sea and how to respond to them. In this third book, Chaves includes a succinct technical dictionary of the nautical jargon then used by Spanish sailors. The fourth and final book (74v-150v) deals with the Indies of the "Mar Océano, sus partes y navegaciones tanto particulares como generales' (74v)[33], which is a *derrotero* (rutter) or nautical guide. It is made up of a set of geographical data necessary to navigate from one place to another across the oceans. In particular, we may argue that this last book together with Chaves' description of the nautical chart in the first book, and the nautical vocabulary in the third book, are the most original and significant parts of the work compared to previous and contemporary treatises such as Enciso's *Suma* (1519) and Faleiro's *Tratado de la esfera* (1535). Overall, Chaves' treatise offers a reliable and comprehensive picture of the world of ocean navigation as it was practiced in Seville in the sixteenth century, as its author touches on each component in the art of navigation. In short, it is an encyclopaedia for sailors containing all the nautical knowledge known to date.

The first part of the first book is composed of four chapters. In them, Chaves offers some basic rules and tables that enable sailors to organise the duration of a voyage and to identify the main fixed and movable feasts through the civil and ecclesiastical calendars (figure 2 and figure 3). The devout Chaves begins his work with this subject because he considered it of vital importance for navigators and discoverers for two reasons. Firstly, because they were absent for a long period 'de los lugares donde se celebran los divinos oficios' (RAH, 9/2791, 4v).[34] Secondly, because the majority of these people were illiterate ('carecen de letras', i.e., unlettered) (*ibid*.). Since a high percentage of pilots had no basic education and therefore could not read and write, they did not know the rules of the Christian calendar. For this reason, Chaves incorporated twelve tables that made it possible for the pilots to know the movable feasts throughout the year in a graphic way. Although navigators must have been familiar with the calendar in one way or another, not all authors devote as much attention to the subject as Chaves does.

[32] (everything celestial and concerning cosmography and the art of seafaring).
[33] (Ocean Sea, its parts and navigation both particular and general).
[34] (from the places where the divine offices are celebrated).

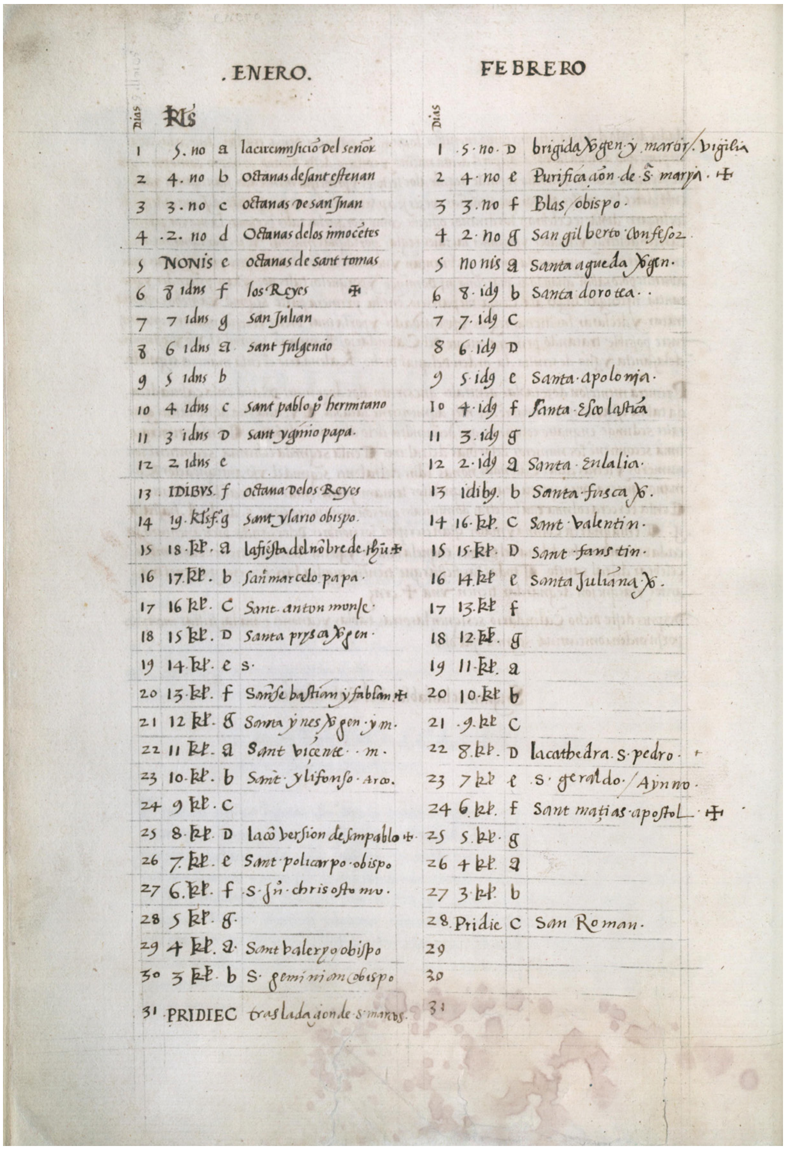


Figure 2 – Alonso de Chaves, *Quatri partitu*, 9r. Calendar tables for the months of January and February. The table is composed of four columns indicating the days of the month; the numbers and letters of the calendas, nonas and idus of the Roman calendar; the seven Sunday letters from A to G; and the names of the saints for each day. Courtesy of the ©Real Academia de la Historia, Madrid, Spain.

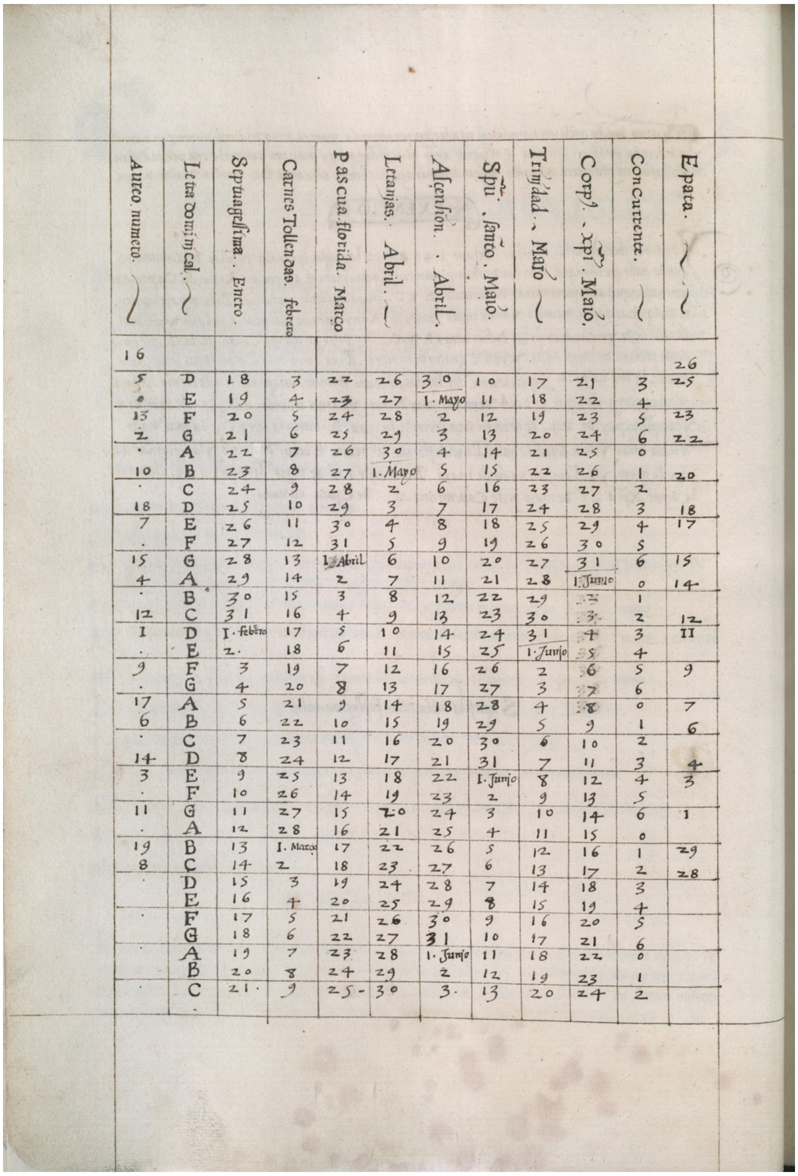


Figure 3 – Alonso de Chaves, *Quatri partitu*, 4r. Table of movable feasts.
Courtesy of the ©Real Academia de la Historia, Madrid, Spain.

In the second part of the first book, divided into ten chapters, Chaves carefully explains the main nautical instruments used on board, in their order of importance in navigation. The first of these is the compass, intended for the correct orientation of pilots (figure 4). Chaves states that this instrument should be called the 'guía del marear',[35] as it is 'el más necesario en la navegación … el que nos guía y nos enseña el lugar y parte donde queremos ir y de dónde venimos. Su virtud y fuerza … es divina' (*ibid*.).[36] Here Chaves synthesises the explanations anticipated by João de Lisboa in his *Tratado da Agulha de Marear* (1514), the oldest known text on the compass. The second is the nautical chart of latitudes, essential for identifying the most appropriate course, the distance travelled and the location of the ship. In third, fourth and fifth place respectively, Chaves places the nautical astrolabe, the quadrant ('la perfecta cuarta parte de un astrolabio') (RAH, 9/2791, 19v.)[37] and the cross-staff, indispensable tools for astronomical navigation that allowed the latitude or altitude of the stars (such as the sun and the North Star) to be known in order to 'echar el punto' (know the position) on the chart (figure 5, figure 6, and figure 7).[38] Due to the simplicity of its construction and its easy handling, the cross-staff was a very popular instrument among pilots, even more than the astrolabe and the quadrant. In sixth place, there is the sounding line, consisting of a rope and a ballast (lead weight), which was necessary to know the depths of the sea, especially when navigating in unknown areas.[39] Then, in seventh place, is the hourglass, used to measure courses and routes, i.e. the distance travelled over a period of approximately twenty-four hours, as well as the timing of the watch to handle the sails (RAH, 9/2791, 22r). In eighth place, Chaves writes about the altimetric scale, an instrument of practical geometry similar to a quadrant that was used to calculate the height of a tower, the length of a river or the distance between two points (figure 8).[40] This eighth chapter includes a small treatise on practical geometry where Chaves explains how to determine altitude, latitude, longitude and depth.[41] He ends this first book with a chapter on 'las medidas geométricas usadas en geometría y cosmografía' (mile, league, etc.) (RAH, 9/2791, 27r-28v).[42] The chapters of Chaves' work devoted to nautical instruments constitute the most comprehensive study at that time. Those devoted to the cross-staff and the nautical chart were completely new. No other treatise had provided such a detailed explanation of all the instruments used in ocean navigation.

[35] (sea guide).

[36] (most necessary in navigation … the one that guides us and shows us the place and part where we want to go and where we come from. Its virtue and strength … are divine).

[37] (the perfect fourth part of an astrolabe).

[38] The most common Spanish word used in sixteenth-century nautical circles to refer to the cross-staff is 'ballestilla', although it was also called 'báculo astronómico' and 'báculo mensorio'. It seems that the first time this word was used in a nautical treatise was in the work of Chaves. It would later appear in *Arte de navegar* (1545) by Pedro de Medina and in *Breve compendio de la sphera* (1551) by Martín Cortés (see Aguiar 2019, 9).

[39] The sounding line, writes Chaves, is a very useful tool in navigation, for 'nos descubre las celadas y engaños encubiertos que muchas veces nos roban las haciendas y las vidas' (RAH, 9/2791, 22v) (it uncovers the covert tricks and deceptions that often rob us of our estates and lives).

[40] Some of the instruments referred to in Chaves' *Espejo de Navegantes* have been described previously in other studies. See Davies 2003; Aguiar 2014 and 2019. Davies has compared the Chaves instruments with the instruments depicted in Diogo Ribeiro's Vatican planisphere of 1529. Aguiar has emphasised the Arabic provenance of these instruments.

[41] Chaves makes an interesting distinction between theoretical geometry and practical geometry. The first is related only to understanding, 'cuando especulamos y componemos alguna cosa y su cantidad y proporción' (when we speculate and compose something including its quantity and proportion). The second 'es cuando de alguna cosa no sabemos su cantidad y la queremos saber midiéndola con alguna cosa sensible' (RAH, 9/2791, 24v) (is when we do not know the quantity of something, and we want to know it by measuring it with something sensitive).

[42] (the geometric measures used in geometry and cosmography).

Circulos en tal manera que dexen algund espacio entre si y el vno este consunto ala circunferençia Dela Rueda Despues deue deser el espacio contenido entre los dichos circulos dimidido en treynta & dos partes yguales. poniendo primero la punta del compas direta mente sobre la punta del hierro que debaxo esta y el diez & seis punto del compas sobre la otra punta del hierro contraria ala primera. Despues con vna regla afixada sobre el centro dela Rueda & aplicada acada vno delos puntos dela Rueda se señalen lineas en el dicho espacio que es entre los dos circulos ya dichos Primero trayendo vna linea recta sobre el centro de la rueda. desde el punto .A. en punto .B. y otro que la corte angulos rectos enel dicho Centro. luego otras quatro lineas intermedias destas que pasen por el dicho centro y seran ocho lineas luego otras ocho intermedias destas que procedan del dicho centro y ternas diez & seis lineas que proceden del Centro ala circunferencia luego señala enlos otros diez & seis puntos que son intermedias destas dichas lineas. Solamente el espacio ~~solamente~~ que es entre los dos circulos no mas y no vayan al centro como las otras diez & seis ya dichas y asi ternas treynta & dos lineas las diez & seis que proceden del centro y las otras diez & seis solamente enel espacio entre los dos Circulos las ocho lineas primeras Denotan los Ocho vientos principales y las otras .8. ocho intermedias los ocho medios vientos que dizen las Diez & seis breues que son enel espacio Dela circunferencia denotan las quartas de vientos o Rumbos.

Asede hazer asi mismo enla Linea que pasa por el centro dela Rueda y sobre el hierro en aquella parte que esta tocado dela piedra y man junto ala circunferencia vna señal ade notar la parte que esta el hierro tocado Dela piedra y esta señal acostumbran hazer vna flor de lis. Asi mismo es de notar que cada vna destas lineas suso dichas Representa vn viento o rumbo que llaman algunos / y el nombre del tal viento sera escripto cerca dela tal linea. acostumbranse hazer estas dichas lineas de diuersos Colores por ser mas presto Conoscidas a las ocho primeras seles da cierta Corpulentia / o anchura cerca del centro y con sus Colores a fin de ser mas presto Conoscidas. las otras ocho intermedias Destas son lineas rectas desde el centro ala circunferencia y son llamadas medios vientos. Las otras Diez & seis son intermedias de todas las ya dichas señaladas enla circunferencia solamente y De colorado y so llamadas quartas De vientos y asi es acabado todo el artefiçio dela rosa Dela Dicha aguja en ambas superficies segund paresce en esta figura presente y la declaracion delos Dichos vientos.

Figure 4 – Alonso de Chaves, *Quatri partitu*, 12r. Wind rose with 32 courses and the fleur-de-lis pointing north. Courtesy of the ©Real Academia de la Historia, Madrid, Spain.

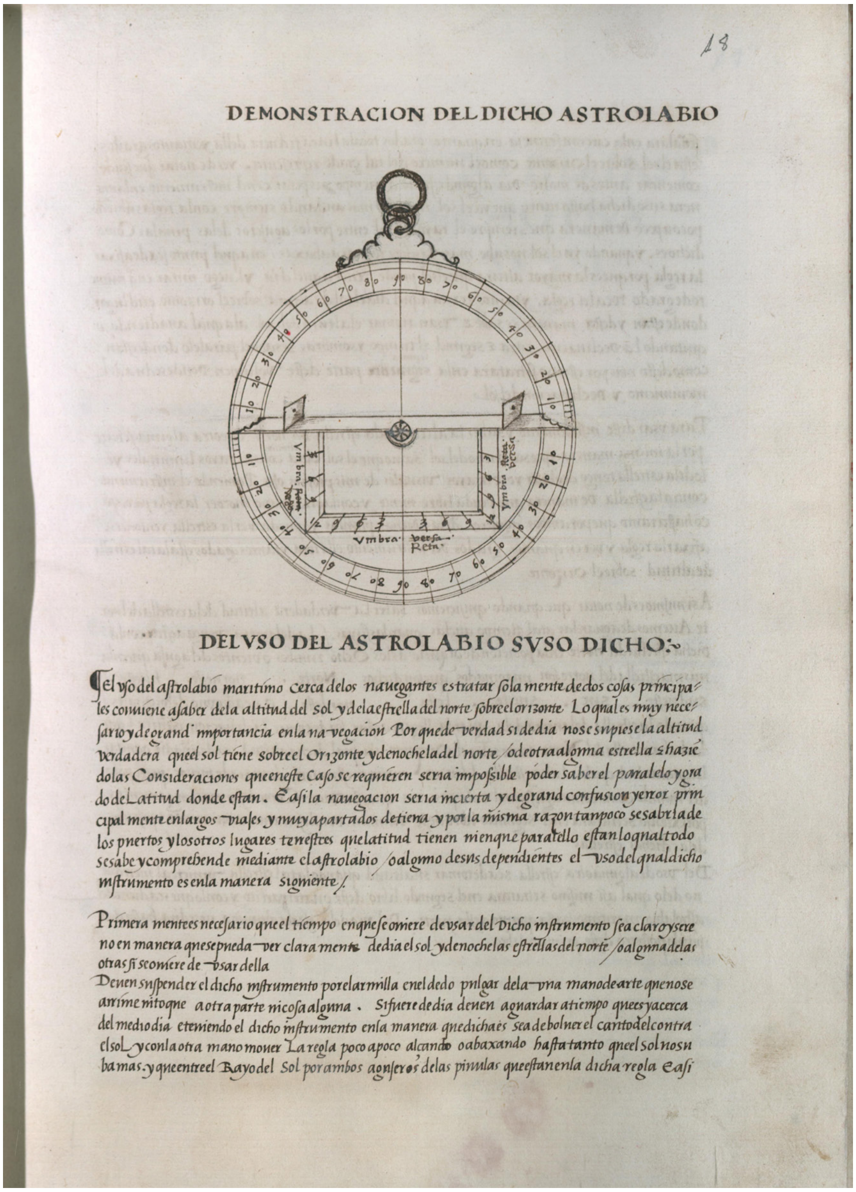
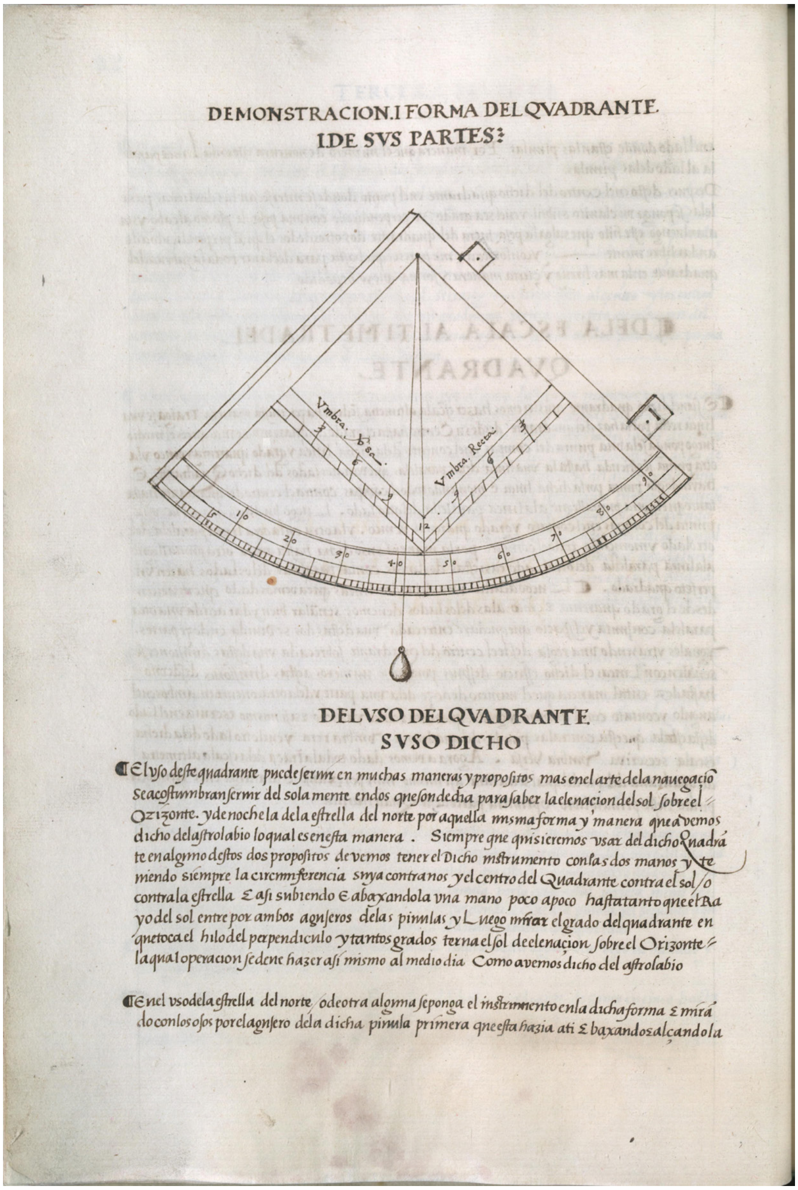


Figure 5 – Alonso de Chaves, *Quatri partitu*, 18v. Nautical astrolabe. Courtesy of the ©Real Academia de la Historia, Madrid, Spain.



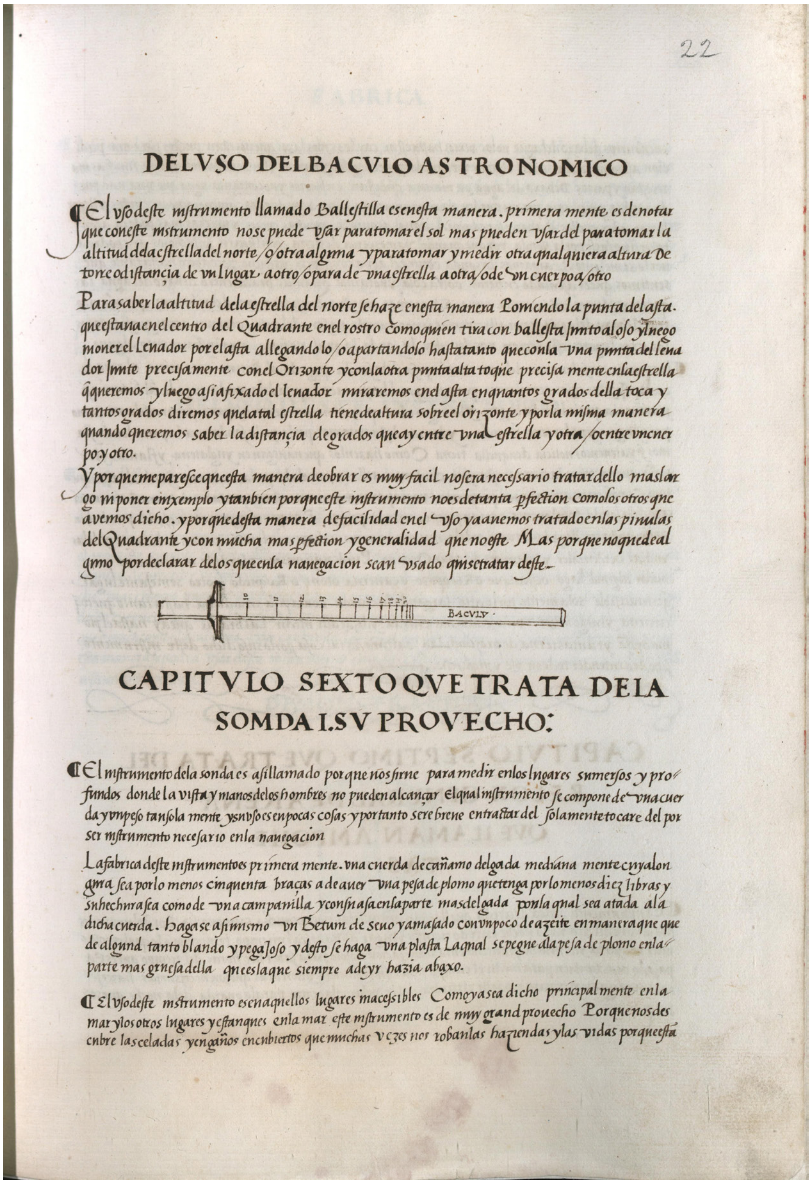
DEMONSTRACION. I FORMA DEL QVADRANTE.
I DE SVS PARTES:

DEL VSO DEL QVADRANTE
SVSO DICHO

El uso deste quadrante puede servir en muchas maneras y propositos mas enel arte dela nauegació se acostumbran servir del sola mente endos que son de dia para saber la elevacion del sol sobre el Orizonte. y de noche la dela estrella del norte por aquella misma forma y manera que avemos dicho delastrolabio loqual es en esta manera. Siempre que quisieremos usar del dicho Quadrá te en alguno destos dos propositos devemos tener el Dicho instrumento con las dos manos y teniendo siempre la circunferencia suya contra nos y el centro del Quadrante contra el sol o contra la estrella E asi subiendo E abaxandola una mano poco apoco hasta tanto que el Rayo del sol entre por ambos agujeros delas pinulas y Luego mirar el grado del quadrante en que toca el hilo del perpendiculo y tantos grados terna el sol de elevaçion sobre el Orizonte la qual operacion se deue hazer asi mismo al medio dia Como avemos dicho del astrolabio

En el uso dela estrella del norte o de otra alguna se ponga el instrumento en la dicha forma E mirá do con los ojos por el agujero dela dicha pinula primera que esta hazia ati E baxando E alçandola

Figure 6 – Alonso de Chaves, *Quatri partitu*, 20r. Quadrant.
Courtesy of the ©Real Academia de la Historia, Madrid, Spain.



22

DEL VSO DEL BACVLO ASTRONOMICO

El uso deste instrumento llamado Ballestilla es en esta manera. primera mente es de notar que con este instrumento no se puede usar para tomar el sol mas pueden usar del para tomar la altitud dela estrella del norte / o otra alguna y para tomar y medir otra qualquiera altura de torre o distançia de un lugar a otro / o para de una estrella a otra / o de un cuerpo a otro

Para saber la altitud dela estrella del norte se haze en esta manera Poniendo la punta del asta. que esta naenel centro del Quadrante en el rostro como quien tira con ballesta junto al ojo y luego mouer el Lenador por el asta allegando lo / o apartandolo hasta tanto que con la una punta del lenador junte preçisamente con el Orizonte y con la otra punta alta toque precisa mente en la estrella que queremos y luego asi afixado el lenador miraremos en el asta en quantos grados della toca y tantos grados diremos que la tal estrella tiene de altura sobre el orizonte y por la misma manera quando queremos saber la distançia de grados que ay entre una estrella y otra / o entre un cuerpo y otro.

Y porque me paresce que esta manera de obrar es muy facil no sera necessario tratar dello mas largo ni poner emxemplo y tanbien porque este instrumento no es de tanta pfection como los otros que avemos dicho. y porque desta manera de facilidad en el uso ya auemos tratado en las pinulas del Quadrante y con mucha mas pfection y generalidad que no este Mas porque no quede alguno por declarar delos que en la nauegacion se an usado quise tratar deste.

BACVLY

CAPITVLO SEXTO QVE TRATA DELA SOMDA I SV PROVECHO:

El instrumento dela sonda es asi llamado porque nos sirue para medir en los lugares sumersos y profundos donde la vista y manos delos hombres no pueden alcançar El qual instrumento se compone de una cuerda y un peso tan sola mente y su uso es en pocas cosas y por tanto sere breue en tractar del solamente tocare del por ser instrumento necesario en la nauegacion

La fabrica deste instrumento es primera mente. una cuerda de cañamo delgada mediana mente cuya longura sea por lo menos cinquenta braças a de auer una pesa de plomo que tenga por lo menos diez libras y su hechura sea como de una campanilla y con su asa en la parte mas delgada por la qual sea atada ala dicha cuerda. hagase asimismo un Betum de seuo yamasado con un poco de azeite en manera que que de algund tanto blando y pegajoso y desto se haga una plasta La qual se pegue ala pesa de plomo en la parte mas gruesa della que es la que siempre a de yr hazia abaxo.

El uso deste instrumento es en aquellos lugares inacessibles Como ya se a dicho principal mente en la mar y los otros lugares y estanques en la mar este instrumento es de muy grand prouecho Porque nos descubre las celadas y engaños encubiertos que muchas vezes nos roban las haziendas y las vidas porque esta

Figure 7 – Alonso de Chaves, *Quatri partitu*, 22v. Cross-staff.

CAPITVLO OCTAVO QVE TRACTA DEL INSTRVMENTO GEOMETRICO .O. ESCALA ALTIMETRA I DE SV prouecho y Vso:

¶ Geometria quiere tanto dezir como medida dela tierra o del mundo Ca el mundo y la tierra se mide con instrumentos y reglas de geometria esta sciencia es vna delas artes Liberales de mayor importancia y necessidad enel mundo Ella tiene sus instrumentos y reglas con que rige asi como numero y regla y compas medida y peso por esta Sciencia y sus instrumentos nos podemos saber las Distançias del lugar al lugar y la longitud y latitud y altitud y profundidad De qualquiera cosa porque todo lo comprehende por lineas rectas y obliquas y por medida y peso. Por esta sciencia son entendidos y fabricados todos los edificios. E artificios E instrumentos que ay enel mundo E ninguno se puede hazer sin ella ni puede ser Comprehendido

¶ Esta sciencia fue hallada primera mente en egipto y desto es testigo alforabio la qual sciençia descubrio

Figure 8 – Alonso de Chaves, *Quatri Partitu*, 23r. Altimetric scale.
Courtesy of the ©Real Academia de la Historia, Madrid, Spain.

The most original part of this section is the one in which Chaves describes in considerable detail the second most relevant instrument of navigation, the nautical chart. It is one of the oldest descriptions known of the construction and use of this instrument, for which he, unfortunately, does not provide any images, unlike the other nautical instruments described.[43] No previous nautical treatise had devoted so much attention to the nautical chart, not even Faleiro's *Tratado de la esfera* (1535), which does not contain a single chapter on this nautical instrument. Later, other cosmographers such as Medina and Cortés would dedicate entire chapters to the nautical chart.[44] Chaves begins the second chapter by alluding to the different virtues of the chart's orientation and location. The nautical chart, Chaves states, shows 'lo que hemos andado (navegado), y lo que nos queda por andar hasta llegar al lugar que queremos, y […] nos muestra la distancia que hay de un lugar a otro, y la situación, y posición, y caminos que todos los lugares marinos y terrestres tienen entre sí' (RAH, 9/2791, 14v).[45] Chaves goes on to praise the capacity for synthesis that the representation permits, thus enabling the navigator to survey and visualise the space around him (Latour 1985, 21).

Ella [la carta náutica] nos representa los límites y términos por donde el mar se aparta de la tierra, y cuanta sea la distancia y grandeza de cada una de ellas; y, asimismo, nos muestra en los límites de mar y tierra la verdadera descripción y los verdaderos lugares y formas de todas sus particularidades. Es a saber, de todos sus puertos, bahías y senos, ríos y promontorios y cabos, y también nos representa los caminos y vías que hay de las unas partes a las otras, y cada una de ellas con todas. Finalmente, la carta de marear es así como un espejo, en la cual se nos representa la imagen del mundo por ausencia suya de él, y nos da a entender por su traza, escritura y pintura, la misma traza, semejanza o posición que el mundo guarda consigo mismo. Y así, por este instrumento, en breve cantidad o espacio, comprendemos todo lo que por otras vías no podríamos con muy grandísimos volúmenes de libros y escrituras. Y tal instrumento hallaron los sabios antiguos ser el más cómodo y provechoso para la navegación, y para representarnos en breve figura lo que no se puede dar a entender por muchas palabras. (RAH, 9/2791, 14v)[46]

According to Chaves, nautical charts could be constructed in the form of a globe or of a 'carta plana cuadrangular'.[47] The former, in spite of their conformity – 'porque es la misma figura que lo figurado'–,[48] were not used in navigation, because, according to Chaves, navigators were not learned people and did not understand 'la teórica ni la razón, ni proporción que la tierra

[43] Chaves describes the making and use of all the other nautical instruments, which will not be analysed in this article. Similar explanations will appear later in other treatises, such as those of Cortés and Medina.

[44] See chapter VII and XIII of book three of Medina's *Arte de navegar*; and chapter II of the third part of the Cortés' *Breve compendio de la sphere*.

[45] (what we have walked [sailed], and what we have yet to walk until we reach the place we want, and … shows us the distance from one place to another, and the situation, and position, and ways that all marine and terrestrial places have between them).

[46] (It [the nautical chart] shows us the limits and boundaries where the sea departs from the land, and how long are the distances and the extent of each of them; and it also shows us at the limits of sea and land the true description and the exact positions and shapes of all their features. Those being, all of their harbours, bays, inlets and rivers, promontories and capes, and also the roads and ways from one part to the other and from each of them with all. Finally, the nautical chart is thus like a mirror, in which the image of the world is represented to us, and gives us to understand by its outlines, writing and colouring, the same outline, likeness or position that the world itself has. Thus, by this instrument, needing few in number and little space, we understand everything that we could not by other means do with very large volumes of books and scriptures. In addition, this instrument was found by the wise men of old to be the most convenient and useful for navigation, and for representing to us in illustrated form what cannot be understood by many words).

[47] (quadrangular flat chart).

[48] (because it is the same figure as the figurative).

tiene con el cielo' (*ibid*.).[49] Thus, 'el instrumento más usado en la navegación'[50] were charts '(en forma plana cuadrangular, como una tabla y por tanto es dicha mapamundi, que quiere decir manteles en que está labrada y tejida la figura del mundo' (*ibid*.).[51] These were, in short, nautical charts drawn according to magnetic bearings and observed latitudes, that is, nautical charts of latitudes. Chaves explains carefully how these charts were constructed:

Es la traza de la dicha carta en principio descrito, un círculo mayor que representa nuestro hemisferio, y aquel divido en treinta y dos puntos equidistantes entre sí, y todos a un centro. Después de esto, tiradas las líneas rectas que procedan de cada uno de los dichos puntos a todos los otros, y del centro a todos ellos, y así quedarán divisos cada uno de ellos con treinta y dos líneas, con las cuales todos los dichos puntos son comunicados los unos con los otros, y el centro con todos ellos. Todas las cuales las dichas líneas en común acostumbran diferenciar en tres colores: negras, verdes y coloradas. Por esta manera las primeras ocho que se cruzan todas entre sí, sobre cada una de los dichos puntos, son negras, y éstas son llamadas los ocho vientos principales. Luego entre medias de éstos, otras ocho líneas verdes que son dichas medios vientos, y así hacen dieciséis luego intermedias de todas estas otras dieciséis de colorado, que son dichas cuartas. Y así es cavado todo el lineamiento de dicha carta que en común se dice *arrumbado*. (RAH, 9/2791, 14v-14r)[52]

After drawing the rhumb lines and the network of meridians and parallels, the division into 360º of longitude and 90º of latitude was drawn. The equatorial line, the tropics and the polar circles were then drawn.[53] Once the geometry of the chart had been designed, Chaves explains in detail the next and final step in the construction of a nautical chart, namely, how the earth was represented on it:

Queriendo dar principio a la descripción, se tomará … un punto muy notorio, así como promontorio, o cabo, o río principal, del cual se debe notar primeramente la vera latitud que tiene, y tomando de la carta un paralelo que pase puntualmente por semejante latitud … se dé un punto … y allí formará la figura de tal cabo o río … Después de esto, buscará … otro punto muy notorio, y no muy apartado del primero, del cual se debe notar su latitud y tomar otro tal paralelo en la carta. Luego mirar en qué longitud o distancia y por qué viento o rumbo de la carta [está con respecto al primer punto] … Y de esta manera se puede ir procediendo hasta acabar la carta. (RAH, 9/2791, 15v)[54]

[49] (the theory nor the reason, nor the proportion that the earth has with the sky).

[50] (the instrument[s] most used in navigation).

[51] (in a flat quadrangular form, like a table and therefore called mapamundi, which means tablecloths on which the figure of the world is carved and woven).

[52] (The outline of the said chart as described above is a great circle representing our hemisphere, and one that is divided into thirty-two points equidistant from each other, and all to the centre. After this, the straight lines proceeding from each of the said points to all the others, and from the centre to all of them, and thus each of them will be divided into thirty-two lines, by which all these points are connected to each other, and the centre to all of them. All of which, these lines in common, are usually differentiated in three colours: black, green and red. In this way, the first eight, which all cross each other, on each of the said points, are black, and these are called the eight principal winds. Then, in between these, eight other green lines which are said half-winds, and so they make sixteen, then intervals of all these other sixteen of red, which are said quarters. And so is carved out the whole outline of the said chart, which is commonly said to have been *arrumbado* [(tracing courses on the chart]).

[53] Despite Chaves' early explanations of the nautical chart – traditionally considered as a map or as a cartographic representation –, the fact is that the construction and nature of this nautical instrument remained unclear until very recently. The main function of the chart is to establish the location of the ship, not to represent the world. In other words, it is the accuracy of the geometric grid based on latitudes that is important, not the geographical contours of a territory (see Gaspar and Leitão 2018 and 2019).

[54] (Wanting to begin the description, he will take … a very visible and recognisable point, like a promontory, or cape, or main river, of which he must first note the true latitude it has, and then taking from the chart a parallel that passes punctually through such a latitude … he will give a point … and there he will form the figure of such

Where the cartographer's work ended, the pilot's work began. That is why Chaves also explains how a nautical chart of latitudes was to be used, bearing in mind that its principal function in the field of astronomical navigation was to help the pilot to locate his ship in the middle of the ocean. In other words, it was about knowing the position of the ship on the chart by observing the meridian height of the sun during the day and the height of the Pole Star at night. To do this, it was necessary, writes Chaves, to have 'dos compases de un tamaño cuya grandeza no exceda a un palmo'.[55] In addition, he adds, 'deben ser perfectos y de amoroso juego en abrir y cerrar' (RAH, 9/2791, 15r).[56] We know that charts of latitudes were constructed in the Iberian world as early – if not earlier – as 1502, the date of construction of the so-called Cantino planisphere, the first known chart with this geometry. However, not since the introduction of astronomical methods in navigation in the mid-fifteenth century had anyone explained how to use a chart based on observed latitudes. In short, these pages devoted to the nautical chart constitute a brief treatise on the cartography of latitudes and reveal the importance of nautical cartography for practical cosmography.

The second book is devoted to the art and science of astronomical navigation. Of the five treatises listed in the index, only two, the first and the last, were completed by Chaves.[57] The first is devoted to the movements of the main celestial bodies used as a reference in navigation, with special mention of the sun and the use of the tables of solar declinations (figure 9).[58] Chaves, however, was not the first to write on this subject. Beyond the various references to the use of astronomy in navigation from 1460 onwards, it is in the so-called anonymous nautical guides of Evora and Munich, the *Regimento do astrolábio e do quadrante* (c. 1509) and the *Regimento da declinação do Sol* (c. 1517), that the procedures for finding latitude are first explained (Albuquerque 1965). The more original fifth and last treatise deals with the natural signs or signals (rain, thunder, lightning, birds, fish, sea plants, etc.) as natural indicators that navigators had to interpret through observation and experience, two essential elements of practical cosmography. The correct reading of these signs allowed pilots to both predict meteorological phenomena and know the distance still to be covered between, for example, the sighting of a certain seaweed and a specific point on the coast. It is one of the earliest extant accounts of the role of signals in navigation. Compelling accounts of these signs would later appear during the voyages on the route of the Manila Galleon (Bernabéu 2013). As Chaves reminds us towards the end of the third book, 'en este arte de la mar, la experiencia es más maestra y mejor que la teórica' (RAH, 9/2791, 68r).[59]

a cape or river … After this, he will look for … another very noticeable point, and not very far from the first, of which its latitude must be noted and another such parallel taken on the chart. Then, he looks at what longitude or distance and by what wind or course of the chart [it is at with respect to the first point] … In this way one can proceed until the chart is finished).

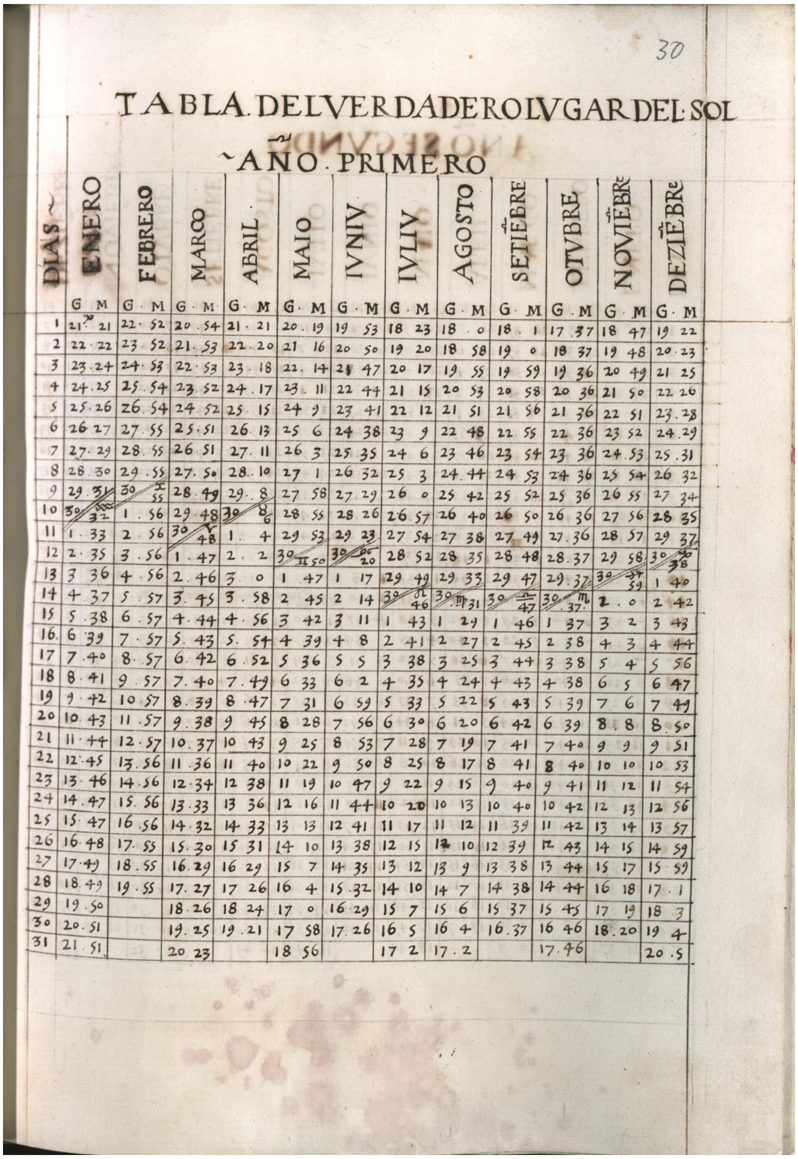
[55] (two compasses of a size not exceeding a span).

[56] (they must be perfect and a joy in opening and closing).

[57] The other three treatises of the second book would be dedicated to the conjunctions, oppositions and quadratures of the sun and the moon; to the eclipses that took place between 1532 and 1569; and to the division of climates and parallels.

[58] Of the nine chapters of this first treatise, the first four have survived. The others would have been devoted to the Pole Star and other fixed stars.

[59] (in this art of the sea, experience is more masterly and better than theory).



DIAS	ENERO G M	FEBRERO G M	MARCO G M	ABRIL G M	MAIO G M	IUNIU G M	IULIU G M	AGOSTO G M	SETIEBRE G M	OTUBRE G M	NOVIEBRE G M	DEZIEBRE G M
1	21 21	22 52	20 54	21 21	20 19	19 53	18 23	18 0	18 1	17 37	18 47	19 22
2	22 22	23 52	21 53	22 20	21 16	20 50	19 20	18 58	19 0	18 37	19 48	20 23
3	23 24	24 53	22 53	23 18	22 14	21 47	20 17	19 55	19 59	19 36	20 49	21 25
4	24 25	25 54	23 52	24 17	23 11	22 44	21 15	20 53	20 58	20 36	21 50	22 26
5	25 26	26 54	24 52	25 15	24 9	23 41	22 12	21 51	21 56	21 36	22 51	23 28
6	26 27	27 55	25 51	26 13	25 6	24 38	23 9	22 48	22 55	22 36	23 52	24 29
7	27 29	28 55	26 51	27 11	26 3	25 35	24 6	23 46	23 54	23 36	24 53	25 31
8	28 30	29 55	27 50	28 10	27 1	26 32	25 3	24 44	24 53	24 36	25 54	26 32
9	29 31	30 ♓ 55	28 49	29 8	27 58	27 29	26 0	25 42	25 52	25 36	26 55	27 34
10	30 ♒ 32	1 56	29 48	30 ♉ 6	28 55	28 26	26 57	26 40	26 50	26 36	27 56	28 35
11	1 33	2 56	30 ♈ 48	1 4	29 53	29 23	27 54	27 38	27 49	27 36	28 57	29 37
12	2 35	3 56	1 47	2 2	30 ♊ 50	30 ♋ 20	28 52	28 35	28 48	28 37	29 58	30 ♑ 38
13	3 36	4 56	2 46	3 0	1 47	1 17	29 49	29 33	29 47	29 37	30 ♐ 59	1 40
14	4 37	5 57	3 45	3 58	2 45	2 14	30 ♌ 46	30 ♍ 31	30 ♎ 47	30 ♏ 37	2 0	2 42
15	5 38	6 57	4 44	4 56	3 42	3 11	1 43	1 29	1 46	1 37	3 2	3 43
16	6 39	7 57	5 43	5 54	4 39	4 8	2 41	2 27	2 45	2 38	4 3	4 44
17	7 40	8 57	6 42	6 52	5 36	5 5	3 38	3 25	3 44	3 38	5 4	5 56
18	8 41	9 57	7 40	7 49	6 33	6 2	4 35	4 24	4 43	4 38	6 5	6 47
19	9 42	10 57	8 39	8 47	7 31	6 59	5 33	5 22	5 43	5 39	7 6	7 49
20	10 43	11 57	9 38	9 45	8 28	7 56	6 30	6 20	6 42	6 39	8 8	8 50
21	11 44	12 57	10 37	10 43	9 25	8 53	7 28	7 19	7 41	7 40	9 9	9 51
22	12 45	13 56	11 36	11 40	10 22	9 50	8 25	8 17	8 41	8 40	10 10	10 53
23	13 46	14 56	12 34	12 38	11 19	10 47	9 22	9 15	9 40	9 41	11 12	11 54
24	14 47	15 56	13 33	13 36	12 16	11 44	10 20	10 13	10 40	10 42	12 13	12 56
25	15 47	16 56	14 32	14 33	13 13	12 41	11 17	11 12	11 39	11 42	13 14	13 57
26	16 48	17 55	15 30	15 31	14 10	13 38	12 15	12 10	12 39	12 43	14 15	14 59
27	17 49	18 55	16 29	16 29	15 7	14 35	13 12	13 9	13 38	13 44	15 17	15 59
28	18 49	19 55	17 27	17 26	16 4	15 32	14 10	14 7	14 38	14 44	16 18	17 1
29	19 50		18 26	18 24	17 0	16 29	15 7	15 6	15 37	15 45	17 19	18 3
30	20 51		19 25	19 21	17 58	17 26	16 5	16 4	16 37	16 46	18 20	19 4
31	21 51		20 23		18 56		17 2	17 2		17 46		20 5

Figure 9 – Alonso de Chaves, *Quatri partitu*, 30v. Table of solar declinations.
Courtesy of the © Real Academia de la Historia, Madrid, Spain.

The third book of the *Quatri partitu*, also incomplete, is composed of three treatises, of which the second and third have survived.[60] Its principal subject is the work of navigation, namely all aspects of the life of the seafarer on board ship. The first of these contains information on the

[60] The first treatise was to be devoted to 'todo lo teórico y práctico tocante a la aguja de marear' (RAH, 9/2791, 2v) (all that is theoretical and practical concerning the seafaring needle).

effects of the moon on the tides, as well as on the tides and sea currents. Knowing when the tides occur makes it possible to predict the behaviour of the oceans and facilitates the organisation of trans-oceanic voyages. The second is devoted to Spanish vessels, especially the 200-barrel *nao* (ships), as well as to 'los lenguajes y maneras de hablar que usan los navegantes' (RAH, 9/2791, 61v-62r):[61] the author provides a sixteenth-century Spanish nautical dictionary (see Woodbridge 1951; Carpi 2001; García-Macho 2007). This dictionary would later be expanded by Diego García de Palacio who, at the end of his *Instrucción náutica* (1587), incorporated an extensive vocabulary on the art of navigation. Surprisingly, Chaves does not devote a single page to shipbuilding.[62] The first texts on this subject were written by the Portuguese friar Fernão de Oliveira – *Ars nautica* (c. 1570) and *Livro da fabrica das naos* (c. 1580) – and later (1587) by the aforementioned García de Palacio. In addition, Chaves offers information about maritime culture and life on board the first ships of the *Carrera de Indias* – the maritime and commercial network that existed between Spain and its colonies (especially in America) from the early years of the sixteenth century –, including details of the trades of the some fifty men who made up the crews, in what was a very well-organised and hierarchical world of navigation. It stretched from the master, the boatswain and the pilot to the cabin boys and the pages, as well as the scribes, carpenters and *buzones* (divers), among many others.[63] The cosmographer attaches particular importance to the skills of the pilot, especially in adverse weather conditions. He also devotes a few pages to provisions, both organic and inorganic. It was necessary to have non-perishable food to satisfy the navigators' nutritional requirements and thus avoid the dreaded scurvy, but also sufficient weapons and ammunition, should there be call to use them. According to Chaves' description, the ship resembled a big machine whose correct functioning depended on the collaboration and harmony of all its component parts. Nothing was to break this harmony, so the entertainment and distractions of the sailors were controlled, which is why, Chaves reminds us, the presence of prostitutes on board was not permitted.[64] Chaves ends this third part with a masterly lesson in military strategy on the art of war at sea. Apart from Oliveira's *Arte da Guerra do Mar* (1555), published a few years later, no other treatise of the period provides such information.

The fourth and last book is, as already mentioned, a nautical *derrotero* (rutter), the 'main' book of the *Espejo de Navegantes* according to Chaves, which he refers to as a practical and even 'modern' cosmography.[65] It is both a notebook that describes the maritime route that a pilot must follow to sail across the Atlantic between Spain and America and a description of all known lands, with their latitudes, from Florida to the Rio de la Plata and Peru. Chaves' rutter, like others that would appear throughout the century, technically sets out the quickest and safest way to go from the Barra de Sanlúcar de Barrameda (Cádiz) to the Indies, following the main islands, capes, coasts, ports and other geographical features. Long-distance voyages demanded and required a text, a cartographic representation of the earth in prose, both because of the dimensions of the enterprise itself and because of the need

[61] (the languages and manners of speech used by sailors).

[62] In Chaves' favour, it must be said that shipbuilding was not strictly speaking part of a pilot's remit. It was a different professional field.

[63] To underline the importance of the pilot, Chaves states that he is to the ship 'como el ánima en el cuerpo humano' (RAH, 9/2791, 63v) (like the soul in the human body).

[64] Before departure, the captain was to make a final examination and 'no consentir que vaya alguna mujer pública en la nao' (RAH, 9/2791, 65r) (not allow any public woman to go on board).

[65] By 'modern' Chaves may have meant both new (as opposed to old) and adapted to ocean navigation (RAH, 9/2791, 74r).

to standardise and regulate a route. It is, in short, the perfect complement to the nautical instruments described by Chaves, especially the nautical charts. This type of itinerary not only served to guide pilots and train navigators, but also to correct and improve the Padrón Real, the Casa's most important cosmographic artefact. Lamb considers this fourth part to be the earliest preserved copy relating to the Padrón Real (Lamb 1969).[66] She maintains that Chaves' description retains some parallels with the Padrón since, according to her, the cosmographer used this section to examine the pilots and to correct the charts made at the Casa before the visit of the licentiate Suárez de Carvajal in 1540. This was the year when all charts were ordered to be made according to the Padrón. Lamb suggests that for this reason the contents may well have been modified after Suárez de Carvajal's inspection, which would explain the non-publication of the work (Lamb 1969, 6). Whatever the case, Chaves' *Espejo de Navegantes* presents one of the many facets of early modern European cosmography in general, and at the same time, illustrates in detail each aspect of Spanish maritime culture, a truly practical and maritime cosmography.

4. *Conclusion*

In an Iberian context, we must think of cosmography as practical and even artisanal (although not exclusively); a cosmography built around nautical knowledge accumulated by navigators over decades of experience. It was a practical cosmography insofar as it collected together all the technical and scientific problems related to ocean navigation with a purely pragmatic and profitable purpose, to facilitate the lives of pilots and to make navigation safe and lucrative. In other words, cosmography was a science applied to the needs of navigation and, in that sense, it was a mirror for mariners. It was also an artisanal cosmography insofar as it was produced through social and epistemic interaction – ordered by the Iberian crowns – between different communities of knowledge, namely pilots and cosmographers, but also cartographers, mathematicians and astronomers in new institutional frameworks. This cosmography was necessarily different from scholarly and theoretical cosmography, both mathematical and descriptive, that circulated in the universities and humanist circles of the rest of Europe through lavish books written in Latin. The maritime context (eminently experimental), the geopolitical dimension of long-distance voyages (which was conducive to a certain secrecy) and the people involved in this enterprise – often poor and illiterate seafarers – conditioned the type of cosmography that had to be produced and the way in which this knowledge circulated, even in limited ways. This artisanal cosmography circulated through teaching, through the experience of pilots on ocean routes, and through the interaction between pilots and cosmographers in spaces of exchange as much as of publication. Chaves' compendium, as well as the Padrón Real, are excellent examples of cosmographic devices that are part of this practical cosmography and its alternative forms of circulation. Both were produced in a decisive context of the development, implementation and expansion of the maritime routes to the Indies. Improving conditions on these routes was the monarchy's foremost objective. Everything else was secondary and even dangerous (especially in the case of the publication of confidential information). For this reason, the main task of a cosmographer like Chaves was not to write books on cosmography but to train pilots and check that the nautical instruments manufactured at the Casa de la Contratación were suitable

[66] Recently, José María García Redondo has reinforced this idea by considering this book to be an extract from the Padrón Real (García 2018, 88-97).

for navigation. Even so, he wanted at least once in his lifetime to collect everything he knew and everything he taught in a single volume, in the most complete nautical encyclopaedia of his time, a reference work on maritime affairs. Chaves was convinced of the usefulness of this knowledge for navigators and even for other pilot majors and cosmographers, as well as for kings and princes or other interested readers. However, and despite the detail and beauty of the writing – which would seem to suggest Chaves' desire to publish his treatise –, his *Espejo de Navegantes* never went to press. We do not know why. What we do know is that its contents did circulate in the classrooms of the Casa de la Contratación, guiding hundreds of pilots, and it quite probably also circulated in the courts of other European powers through isolated cases of scientific espionage, as Hakluyt's case seems to suggest.

Works Cited

Manuscript Sources

Archivo General de Indias in Seville (AGI), Patronato, 251, R.22.
Archivo General de Indias in Seville, Indiferente, 421, L.13, 82r(1).
Archivo General de Indias in Seville, Indiferente, 421, L.13, 82r(2).
Archivo General de Indias in Seville, Indiferente, 421, L.13, 295v.
Archivo General de Indias in Seville, Indiferente, 1965, L.13, 380v.
Archivo General de Indias in Seville, Contratación, 5784, L.1, 49v.
Archivo General de Indias in Seville, Contratación, 5784, L.1, 112.
Archivo General de Indias in Seville, Contratación, 5784, L.3, 40v-41r.
Real Academia de la Historia Madrid (RAH), 9/2791.

Printed Sources

Aguilar Aguiar Maravillas (2019), 'Los primeros instrumentos de navegación que viajaron a América. Un estudio del *Quatri partitu* o *Espejo de navegantes* (ca. 1528) de Alonso de Chaves', *Mélanges de la Casa de Velázquez* 49, 1, 223-244, doi: /10.4000/mcv.9915.

Aguilar Aguiar Maravillas (2014), '*Quatri partitu en cosmographia pratica i por otro nombre llamado Espejo de navegantes* by Alonso de Chaves: A navigation manual for the instruction of Spanish pilots in the sixteenth century', in D.A. Agius, T. Gambin and A. Trakadas, eds, *Ships, Saints and Sealore: Cultural Heritage and Ethnography of the Mediterranean and the Red Sea*, Oxford, Archaeopress, 41-59.

Albuquerque Luís de (1965), *Os guias náuticos de Munique e Évora*, Lisbon, Junta de Investigações do Ultramar.

Albuquerque Luís de (1991), *Historia de la navegación portuguesa*, Madrid, Editorial MAPFRE.

Apiano Pedro (1548), *Cosmographia*, Enveres, En casa de Gregorio Bontio.

Basterrechea Moreno J.P. de (1997), *Traducción al inglés de obras españolas de arte de navegar del siglo XVI*, PhD Thesis, Universidad del País Vasco.

Bernabéu Albert Salvador (2013), 'La "Audiencia de las Señas": los significados de una ceremonia jocosa en la Nao de China', in S. Bernabéu Albert, ed., *La Nao de China, 1565-1815: navegación, comercio e intercambios culturales*, Seville, Universidad de Sevilla, 91-117.

Besse Jean-Marc (2003), *Les grandeurs de la Terre. Aspects du savoir géographique à la Renaissance*, Lyon, École Normale Supérieure de Lyon.

Broc Numa (1986 [1980]), *La Géographie de la Renaissance (1420-1620)*, Paris, Les Éditions du CTHS.

Carpi Elena (2001), *El l*éxico del *'Quatripartitu en cosmographia práctica' de Alonso de Chaves*, Madrid, UNED.

Carriazo Ruiz J.R. (2003), *Tratados náuticos del Renacimiento. Literatura y lengua*, Valladolid, Junta de Castilla y León-Universidad de Salamanca.

Castañeda Delgado Paulino, Mariano Cuesta Dominigo and Pilar Hernández Aparicio (1983), 'Estudio preliminar', in A. de Chaves, *Quatri partitu en cosmografia prática, y por otro nombre, Espejo de navegantes*, Madrid, Museo Naval-Instituto de Historia y Cultura Naval, 15-62.

Cerezo Martínez Ricardo (1994), *La cartografía náutica española en los siglos XIV, XV y XVI*, Madrid, Editorial C.S.I.C.
Collins Edward (2013), 'Francisco Faleiro and Scientific Methodology at the Casa de la Contratación in the Sixteenth Century', *Imago Mundi* 65, 1, 25-36.
Contente Domingues Francisco (1985), 'Experiência e conhecimento na construção naval portuguesa do Século XVI: os tratados de Fernando Oliveira', *Revista da Universidade de Coimbra* 33, 339-364.
Cormack L.B. (2017), 'Handwork and Brainwork: Beyond the Zilsel Thesis', in L.B. Cormack, S.A. Walton and J.A. Schuster, eds, *Mathematical Practitioners and the Transformation of Natural Knowledge in Early Modern Europe*, Dordrecht, Springer, 11-35.
Cortés Albacar Martín de (2005), *Breve compendio de la sphera y del arte de navegar*, Zaragoza, Institución Fernando el Católico.
Cortesão Armando (1964), 'Cartografia portuguesa e a Geografia de Ptolomeu', *Boletim da Academia das Ciências de Lisboa* 5, 36, 388-404.
Cosgrove D.E. (2001), *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination*, Baltimore, The Johns Hopkins University Press.
Dainville François de (1969), *La Géographie des Humanistes*, Geneva, Slatkine Reprints.
Davies Surekha (2003), 'The Navigational Iconography of Diogo Ribeiro's 1529 Vatican Planisphere', *Imago Mundi* 55, 103-112.
Escalante de Mendoza Juan (1985), *Itinerario de navegación de los mares y tierras occidentales, 1575*, Madrid, Museo Naval.
Falero Francisco (1535), *Tratado de la esphera y de la arte arte de marear*, Seville, Juan Cromberger.
Fernández Duro Cesáreo (1894-1895), 'De algunas obras desconocidas de cosmografía y de navegación, y singularmente de la que escribió Alfonso de Chaves a principios del siglo XVI', *Revista de Navegación y Comercio* (progressively published from issue 144 to 152).
Fernández de Enciso Martín (1987 [1519]), *Suma de geografía*, Madrid, Museo Naval
Fernández Navarrete Martín de (1851), *Biblioteca Marítima Española*, vol. I, Madrid, Imprenta de la viuda de Calero.
Flórez Miguel Cirilo, Pablo García Castillo and Roberto Albares Albares (1990), *La ciencia de la tierra: cosmografía y cosmógrafos salmantinos del Renacimiento*, Salamanca, Caja de Ahorros y Monte de Piedad de Salamanca.
Fontoura da Costa Abel (1933), *A marinharia dos descobrimentos*, Lisbon, Imprensa da Armada.
García-Macho M.L. (2007), 'El vocabulario marítimo y las expresiones relacionadas con el mar en algunos textos del XV al XVI', *Cuadernos del Cemyr* 15, 109-128, <https://core.ac.uk/download/pdf/214828531.pdf>, accessed 1 February 2023.
García Redondo J.M. (2018), *Cartografía e Imperio. El Padrón Real y la representación del Nuevo Mundo*, Madrid, Ediciones Doce Calles.
Gaspar Joaquim Alves and Henrique Leitão (2018), 'What Is a Nautical Chart, Really? Uncovering the Geometry of Early Modern Nautical Charts', *Journal of Cultural Heritage* 29, 130-136.
Gaspar Joaquim Alves and Henrique Leitão (2019), 'Early Modern Nautical Charts and Maps: Working Through Different Cartographic Paradigms', *Journal of Early Modern History* 23, 1, 1-28.
Gil Fernández Juan (2009), *El exilio portugués en Sevilla. De los Braganza a Magallanes*, Seville, Fundación Cajasol.
Guillén Tato J.F. (1943), *Europa aprendió a navegar en libros españoles*, Barcelona, Instituto Historico de Marina.
Hakluyt Richard (1599 [1589]), *The Principal Navigations, Voyages, Traffiques and Discoveries of the English Nation*, London, George Bishop, Ralph Newberie, and Robert Barker.
Lamb Ursula (1969), 'The "Quatri Partitu en Cosmographia" by Alonso de Chaves. An Interpretation', *Agrupamento de Estudos de História e Cartografia Antiga, Série Separatas* 28, 2-11.
Lamb Ursula (1995), *Cosmographers and Pilots of the Spanish Maritime Empire*, Aldershot, Variorum.
Latour Bruno (1985), 'Les "vues" de l'esprit. Une introduction à l'anthropologie des sciences et des techniques', *Culture Technique* 14, 5-29.

Leitão Henrique and Antonio Sánchez (2017a), 'Zilsel's Thesis, Maritime Culture, and Iberian Science in Early Modern Europe', *Journal of the History of Ideas* 78, 2, 191-210, doi: 10.1353/jhi.2017.0010.

Leitão Henrique and Antonio Sánchez (2017b), 'Too Much to Tell: Narrative Styles of the First Descriptions of the Natural World of the Indies', *History of Science* 55, 2, 167-186.

Leitão Henrique and Antonio Sánchez (2022), 'Social and Epistemic Interactions Between Artisans and Scholars in Iberia. A Zilselian Reading of Early Modern Maritime Expansion', in D. Romizi, M. Wulz and E. Nemeth, eds, *Edgar Zilsel: Philosopher, Historian, Sociologist*, vol. XXVII, Cham, Springer, 285-301.

Lestringant Frank (1991), 'The Crisis of Cosmography at the End of the Renaissance', in P. Desan, ed., *Humanism in Crisis: The Decline of the French Renaissance*, Ann Arbor, The University of Michigan Press, 153-179.

Long P.O. (2011), *Artisan/Practitioners and the Rise of the New Sciences, 1400-1600*, Corvallis, Oregon State University Press.

Long P.O. (2015), 'Trading Zones in Early Modern Europe', *Isis* 106, 4, 840-847, doi: 10.1086/684652open_in_new.

López Piñero J.M. (1986 [1979]), *El arte de navegar en la España del Renacimiento*, Barcelona, Labor.

Medina Pedro de (1545), *Arte de navegar*, Valladolid, Francisco Frenandez de Cordova.

Medina Pedro de (1972), *A Navigator's Universe: The* Libro de Cosmographía *of 1538*, trans. by U. Lamb, Chicago, The University of Chicago Press.

Melón y Ruiz de Gordejuela Amando (1950), 'La Geografía de M. Fernández Enciso (1519)', *Estudios geográficos* 11, 38, 29-43, doi: 10.1353/jhi.2017.0010.

Mosley Adam (2009), 'The Cosmographer's Role in the Sixteenth Century: A Preliminary Study', *Archives Internationales d'Histoire des Sciences* 59, 2, 423-439.

Obras españolas de náutica relacionadas con la Casa de la Contratación de Sevilla (1992), Madrid, Museo Naval.

Portuondo M.M. (2009), *Secret Science: Spanish Cosmography and the New World*, Chicago, The University of Chicago Press.

Pulido Rubio José (1950 [1923]), *El piloto mayor de la Casa de la Contratación de Sevilla: pilotos mayores, catedráticos de cosmografía y cosmógrafos de la Casa de Contratación de Sevilla*, Seville, CSIC-Escuela de Estudios Hispano Americanos.

Sánchez Antonio (2013), *La espada, la cruz y el Padrón: Soberanía, fe y representación cartográfica en el mundo ibérico bajo la Monarquía Hispánica, 1503-1598*, Madrid, CSIC.

Sánchez Antonio (2016), 'Science by regimento: Standardizing Long-Distance Control and New Spaces of Knowledge in Early Modern Portuguese Cosmography', *Early Science and Medicine* 21, 2/3, 133-155.

Sandman A.D. (2001), *Cosmographers versus Pilots: Navigation, Cosmography, and the State in Early Modern Spain*, PhD Dissertation, University of Wisconsin.

Sandman A.D. and E.H. Ash (2004), 'Trading Expertise: Sebastian Cabot between Spain and England', *Renaissance Quarterly* 57, 3, 813-846.

Sandman A.D. (2007), 'Spanish Nautical Cartography in the Renaissance', in D. Woodward, ed., *The History of Cartography: Cartography in the European Renaissance*, vol. III, Chicago, The University of Chicago Press, 1095-1142.

Schotte M.E. (2019), *Sailing School: Navigating Science and Skill, 1550-1800*, Baltimore, Johns Hopkins University Press.

Smith P.H. (2004), *The Body of the Artisan: Art and Experience in the Scientific Revolution*, Chicago, University of Chicago Press.

Teixeira da Mota Avelino (1969), 'Os regimentos do Cosmógrafo-Mor de 1559 e 1592 e as origens do ensino náutico em Portugal', *Memórias da Academia das Ciências de Lisboa, classe de ciências* 13, 1-69.

Vogel K.A. (2006), 'Cosmography', in K. Park Lorraine Daston, eds, *The Cambridge History of Science*, vol. III, Cambridge, Cambridge University Press, 469-496.

Woodbridge H.C. (1951), 'A Tentative Bibliography of Spanish and Catalan Nautical Dictionaries. Glossaries and Word Lists', *The Mariner's Mirror* 37, 1, 63-75.

Zilsel Edgar (1942), 'The Sociological Roots of Science', *American Journal of Sociology* 47, 4, 544-562.
Zilsel Edgar (2000), *The Social Origins of Modern Science*, ed. by D. Raven and W. Krohn and R. S. Cohen, Dordrecht, Boston and London, Kluwer Academic Publishers.