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# The brief history of early marine-navigation

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**ABSTRACT**

The aim of this study is to examine in the beginnings and development of early navigation systems and to reveal their relationship with disciplines such as astronomy, cartography, horology and map-making. Since prehistoric times, people have been travelling using waterways and highways. Before the transporting by air, oceans was the only way for early intercontinental transportation. Thus, people learned building simple boats to cross seas. As progressing of marine-navigation technologies, the importance of calculating route made it necessary to measure time and distance. Early navigators sailed by observing the celestial bodies such as the sun, moon and stars through the astronomical information. Especially the transition from the earth-centered universe model to heliocentric (Copernican) has astronomically affected the entire early navigation period. Moreover, navigators used early navigation tools such as dead reckoning and cross-staff. And also, they made nautical almanac called ''parapegmata'' in Greek and used primitively designed compasses. Despite all these developments sailors mostly have lost their route due to misinterpreted rotations. Also it has not been easy to make accurate measurements on ships until the eighteenth-nineteenth centuries.

## 1. HISTORY OF NAVIGATION

Transportation has been necessary since the beginning of human history. Human populations who initially settled near rivers, needed to travel more as their population grows and new settlements are needed. Travelling by road was possible up to limited distance because there were not sufficient highways. In addition, oceans was the only way of the intercontinental travel. Thus, travelling on water could be improved faster. The only thing that matters in the first place was to stay on the water and dry. Human firstly learned how to make raft to cross rivers. But as time passed, people learned to build larger boats and galleys, and it became extremely important to take these vehicles from one point to another. So, the history of navigation has begun. Navigation term etymologically derived from the verb Navigare[1], which means traveling in Latin, especially traveling in the sea. Today, navigation word is used in both sea and land. One of the most important tools of navigating on the sea are maps in addition to navigational instruments throughout the history. People were able to divide the land they lived on into meaningful pieces thanks to the maps. Major terms such as ''map'', ''charta'' or ''karte'' and ''mappa mundi'' stand out in the history of cartography. It is important to separate these terms from each other for reading history. While the map represents maps made in a more general sense, charts in most sources represent nautical charts. It comes from the word - χάρτης (kartes) which means paper in Greek. The term '' karte'' was first used in the history of cartography by the German cartographer Laurent Fries. And the map term come from the word ''mappa'' in Latin, meaning a napkin, table-napkin or cloth. The term of '' mappa mundi''[2] in Late Latin, it may represent the boundaries of the known world of that time, and this mappa could

[1] Navig/o, are, avi, atum. (Lat.)

[2] Mundus word could be used to mean the world in Vulgar Latin but that is the meaning of "order" in Latin.

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contain texts, surveying notes and pictures. The term ''mappa'' was used because of them who called Gromatici in Latin, recorded drawings and notes of their surveying on cloth, parchment or pieces of vellum[3].

## 2. DEVELOPMENT OF NAVIGATION INSTRUMENTS

The development of technology over time, the distance traveled on the sea has begun to be measured. Primitive measurements on the sea are based on determining time intervals starting from a certain point. Lack of instruments measuring time as we know it today required calculations over time intervals. Instruments such as the hourglass and sundial play an important role in ancient navigation as primitive timers for measuring time over elapsed time. One of the most primitive scientific instruments for measuring time are water clocks called Clepsydra (κλεψύδρα)[4] in Greek. The most primitive form of water clock is a bowl-shaped outflow form date back to Egypt. One of the most advanced examples of water clocks in ancient times belongs to the famous mechanist and inventor of principles of pneumatic science Ctesibius. The instrument developed by Ctesibius also works over time intervals and an alarm system. Measuring certain time periods is not enough for journey on the sea. In order to achieve a useful result, the starting point must be positioned. This is exactly the point that expresses the inseparable part of the history of cartography and navigation. We cannot create a route on the sea without knowing where we are right now. And confirming this thesis, we can witness that mapmaking and navigation technologies are growing simultaneously on the stage of history. It can be said as follows to be more precise: Mapmaking made the development of navigation possible. Besides the science of cartography, astronomy and horology have been the main supporters of navigation science.

The oldest known maps are attributed to the Middle East. Greek geographer Eratosthenes, made one of the earliest scientific world maps. He is also the inventor of the geographic coordinate system (GCS). Eratosthenes has determined latitude using stallers and longitude with the lunar eclipse method. GCS is vital in development of sea navigation. Although the science of astronomy emerged and developed in civilizations such as Egypt, Mesopotamia and China, Ancient Greek offers a wider field to research in terms of the abundance of written sources that have survived to the present day. Greek philosophers/scientists[5] travelling to Egypt and China, they learned the science of astronomy and mathematics belonging to that geography and carried it to their hometown. The final step is the transfer of all this knowledge to the west by the Romans and so the historical background of the scientific revolution is almost formed.

The beginning of Ancient Greek Astronomy dates to the Ionian Age. Mesopotamia is rarely mentioned in the Ancient Greek writing sources, but astronomy studies in the Mesopotamian Seleucids era and Ionian age were on the same period. (Unat, 2013). The Greeks who first explained planetary motions with geometric-kinematic systems, were able to describe planetary systems at a level that could explain astronomical phenomena (Unat, 2013). Thus, it did not take long for the μῦθος (myths) and λόγος (logos) to separate in Ancient Greek. People used myths and epics for knowledge (getting information, and oral tradition. Information from mythological narratives remained valid even after the emergence of sciences. The term '' logos '' (reason) represents scientific thinking. Logos word was used in various meanings.[6] It was used especially by the Sophists and Greek philosopher Heraclitus in the sense of the first power, the first principle in the universe. It was the force that brought order to the primordial chaos. This corresponds to the first people thinking over the epic tradition. In this sense, it represents the cosmic flux in the meaning of a transition from chaos to order corresponds to the human thought which evolving from mythos to the logos phase[7]. Scientific thought and rational knowledge fully formed in Greek created a background that Western science. Greek curiosity (periergia)[8] creates the roots of the tree of science. Theories about the cosmology of philosophers can be accepted as the beginning of astronomy in Greek. It has an important role to play in history of astronomy. The image of perfection reached the peak in Ancient Greek and it was accepted and carried to later times, especially through Aristotle's universe and Platonic ideas. The main reason why geocentric universe model cannot be rejected is expulsion of human from center of the universe. This means acceptance of heliocentric universe model (Copernican).

Tens of thousands of years ago, peoples sailed across open oceans. More recently, within the past four thousand years, Egyptians and other peoples in the Mediterranean Sea, Persian Gulf, and Indian Ocean dared longer-distance sea travel. Early mariners navigated from island to island by observing the sun and stars, the wind and waves. They noted some objects such as large rocks as guiding points. They observed the behavior of fish and birds. They sailed into the winds, making use of

[3] Vellum, i (Lat) : a cloth or calf.

[4] Clepsydra : Water Thief; water-clock, a water-butt with a narrow orifice underneath, through which the water trickled slowly, for measuring periods of time, used to time speeches in the law-courts. (Liddell & Scott, 2009), [κλέπτω (kléptō, "steal") + ὕδωρ (húdōr, "water"].

[5] φῑ́λο- (philo-, "beloved, loving") + σοφός (sophós, "wise") – the term of φῑλόσοφος in Ancient Greek includes the title of scientist in today's sense

[6] reason, word,expression

[7] For more reading : Kahn, C. H., Heraclitus, ., & Kahn, C. H. (2004). The art and thought of Heraclitus: An edition of the fragments with translation and commentary. Cambridge [England: Cambridge University Press]., Dürüşken, C., & Bayrak, M. F. (2014). Antikçağ felsefesi: Homeros'tan Augustinus'a bir düşünce serüveni.,
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winds that blow east to west just north and south of the equator.

The navigation benefitted from the position of the sun with the knowledge of astronomy. Early navigators prepared handbooks of recorded ocean routes and nautical almanacs. Almanac, known as parapegmata in Greek, had been composed for centuries. Parapegmata or nautical almanacs are the publication describing the cyclical phenomena such as stellar phases, weather, lunar cycles, and more. The Almanacs or parapegmata as astronomical diaries, were not enough alone to travel by sea. Therefore, various technological instruments and navigational systems were additionally used.

Dead reckoning is one of the primary and oldest method of marine navigation. It was first developed by Mediterranean navigators. The oldest dead reckoning chart is Carta Pisana dating back to thirteenth century. The oldest surviving nautical chart called Carta Pisana, because it was acquired by the Bibliothèque Nationale from a family old-established in Pisa. Dead reckoning that preferred method when celestial observation is unavailable, is a method of navigation relying on estimating one's current position using a previously obtained position. In earlier versions of reckoning, during the cruise, a floating object was thrown into the sea from the fore and the time of this object until it reached the stern of the ship was determined. Then, with the proportionality method, the distance the ship traveled in an hour, in other words its speed was calculated. In later times, different instruments using properties such as hydrodynamics and electromagnetic, have been made to determine the speed of the ship.

Development of navigation instruments continued throughout the history of ancient maritime. The backstaff is one of them that was used to measure the altitude of a celestial body. Scientific navigational instrument that especially used to measure the altitude of the moon and sun, was invented by English navigator John Davis (Seaman's Secrets in 1594). Therefore backstaff was called Davis quadrant which is the most dominant tool in the history of navigation instruments evolved from the Cross-staff. And Cross-staff also called Jacob's Staff or '' baculum'' (bone) or '' radius'' (staff) in Latin words (Rossi & Russo, 2009).

Compass also was one of the major instrument for marine navigation. Term of ''compass'' etymology derives Latin verb ''compassare'' (in italian and also may be in Vulgar Latin) combines with ''com'' (with) and the ''passus'' (step). In addition to meaning such as measuring with steps, it can be thought to be etymologically related to circular motion because of the name similarity with the drafting compass. The compass as an instrument of navigation and measuring based on stones with magnetic properties. Loadstones which referred to as ''magnetum'' in Late Latin writings, made the development of the compass with magnetized needle possible. Loadstones and their properties were known in Greek. The first known compass is dated to China, during the Han Dynasty (between 2nd c.BC - 2nd c.AD). Chinese realized that the lodestone always points in the same direction when floated in water but it isn't unclear whether the Chinese understood that this direction was north, as little was known about global direction finding at that time. Also, it is not certain that the earliest knowledge about lodestones is dated to China. Fundamental property of the lodestone of attracting iron was certainly known before. The close of the seventh century B.C, loadstones and their magnetic properties were known by the Ancient Greek. Even a legend attributed to the Ida Mountain confirms the existence of information about magnets (the legend of magnes the shepherd). 9In the texts of many ancient authors such as Thales (640-546 B.C.) and Pliny (23-79 A.D.), the mentions of ''loadstones'' were frequently cited. But the first reference to the use of the compass for navigational purposes is found in a Chinese encyclopedia in probably during the Han or Tsin Dynasty. But there was no definite mention of the use of the compass until ''De Utensilibus'' written by an English monk, Alexander Neckam. This work occurs in middle ages around the twelfth century (Author, 1919). It became difficult to find the first inventors for advanced compasses (as mariner's compass or advanced magnetic compasses), which spread over many geographies and was developed by different people after the middle Ages and the period of discoveries. Peregrinus is the first that describes the compass with pivoted needle. The first writer to attribute a special knowledge of the compass to the Amalfians was Flavio Biondo, was later cited in other works as the inventor of the mariner compass (Nelson, 1962). The four chief improvements applied to Peregrinus compass in late times: the cap-and-pivot support, the movable fly, the divided needle, and the gimbal suspension (Nelson, 1962). Next developments of compass extend to modern period and technologies developing in time of war.

## 3. RESULT

In this study, main issues were how navigation in the sea emerges and develops. Related astronomical concepts, traditions of thought and primitive navigation instruments such as compass, cross-staff and system of dead-reckoning were especially examined. Research on instruments only in technical terms does not bring historical integrity. Furthermore, it is not possible to investigate to the history of navigation without examining their relations between other disciplines such as astronomy, cartography, horology and map-making. Philology and History sciences help to see all these in a meaningful framework. In addition to the given instruments, there were early instruments that we cannot include in a brief study, used in marine-navigation such as the mariner's quadrant, armillary sphere and astrolabe. These historical navigation instruments will be examined in future studies.

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