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ANCIENT LOGISTICS – HISTORICAL TIMELINE AND ETYMOLOGY

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Original scientific paper

The phenomenon of logistics has an exceptional genesis. According to the findings presented in this paper, logistics dates back to Late Bronze Age (LBA), to ancient times. The bases for logistics development were an evolution of metrics systems, first of all numerical systems. The grounds of Mesopotamian and Egyptian numerical systems were used for commercial purposes by the Phoenicians. In that time the numbers were not displayed as symbols but as pictures. Primary meaning of the word logos was to count. The etymology of the word logistic was drawn from two words, the counting and the picture or the knowing of "numeracy skills through images". The detailed analysis of the oldest known shipwreck – Uluburun, proved intensive production and commercial activities in the LBA period in the Mediterranean. These activities could be realized only with the support of intensive logistic activities. The analysis of the logistics change, given below, shows that the definition of logistics starts far in the period of BC. The famous Pythagoras was the first logistician to be appointed.

Keywords: *definition, etymology, Late Bronze Age, logistics, Phoenicians*

Drevna logistika – povijesna distanca i etimologija

Izvorni znanstveni članak

Fenomen logistike ima iznimnu genezu. Po nalazima koji su prikazani u radu, logistika datira iz razdoblja kasnog brončanog doba, iz antičkog doba. Uvjet za razvoj logistike bio je evolucija metričkih sustava, prije svega numeričkog sustava. Osnove mezopotamijskog i egipatskog numeričkog sustava Feničani su prilagodili u trgovačke svrhe. Tadašnji fenomen broja nije imao odgovarajući simbol, nego je predstavljen kao slika. Primarno značenje riječi logos je računati. Etimologija riječi logistike je izvedena iz sinteze računanja i slike, "vještina računanja pomoću slika". Detaljna analiza najstarije olupine broda – Uluburun, dokazuje intenzivne proizvodne i trgovačke aktivnosti kasnog brončanog doba na Mediteranu. Takve aktivnosti su mogle biti realizirane samo uz podršku intenzivnih logističkih aktivnosti. Prikazana analiza pomiće definiciju logistike daleko u razdoblje p.n.e. Čuveni Pitagora je bio prvi imenovani logističar.

Ključne riječi: *definicija, etimologija, Feničani, kasno brončano doba, logistika*

1
Introduction
Uvod

The capital work "Logistics Systems" [1] synthesized all human activities and demonstrated that each was a separate logistic sub-system. Furthermore, the origin of the word "logistics" is based on the view that its genesis temporally correlates with the invention of steam engine in the eighteenth century (1764). Thus, the genesis of the concept of logistics is directly related to industrial revolution, although the phenomenon of production and trade dates back to much earlier times.

Presently, the prevalent view is that the term logistics was first used by the Swiss General Baron de Jomini (1779 – 1869). There are two versions of the genesis of the word logistics, both of French origin. The first, *"logistique"*, is derived from military rank *"Marechal de logis"* and refers to the organization of the military support troops. The other, *"loger"*, refers to a spatial military organization – camping.
At the end of the nineteenth century, the term logistics "arrived" to the United States, and their military literature adopted the term "logistics", referring to the science of military support services, i.e. transport and supply for the troops. In the Second World War, the term "logistics" was used in relation to the planning and management process in providing (re-populating) and supplying the allied troops.

During the 1960s, the term logistics was first used in the civilian sector in the trade industry.
In the United States, the term logistics referred to planning and implementation of physical distribution. In 1974, Hans-Christian Pfohl provided the characteristic areas of logistics tasks, conceptualized and shaped logistic axiomatics and developed logistics as a science.

The obvious ancient genesis of logistics contains in its root the Greek word "logos", primarily used in the context of principles of correct thought and action. It is often forgotten that one of the meanings of the word "*logos*" is *account*! The second part of the word logistics has origins in the Greek word "icon", which means – painting. In the literal translation from Greek, logistics means "art of calculus with pictures". Thus, the compound word "logos + icon" is a phonological and morphological adaptation which yielded its current international form.

The earliest written records on logistics were preserved in the history of the famous Greek philosopher and mathematician Pythagoras of Samos. From Chaldeans and Egyptians, he learned astronomy, mage mystic rites, and the Phoenicians informed him on logistics [2] and geometry. According to this source, the famous Pythagoras was the first appointed logistician, and the concept of logistics moved to 500 BC, almost 2200 years later than its actual etymology.

For an explanation of the theory that Pythagoras was the first appointed logistician, it is necessary to go even further back in history, 3000 years BC, to the beginning of the Bronze Age.

2
Early temporal and spatial metrology
Rana metrologija vremena i prostora

During the fifth and fourth millennium, in the late Neolithic period (Ubaid period, 5500 – 4000 BC) the advanced communal and societal planning appeared on the banks of major rivers of Africa and Asia – Nile, Tigris and Euphrates. The inception of their characteristic epistemic foundation is still a subject of many anthropological discussions.

Sexagesimal system dates back to the Sumerians. There are several theories on the origin of the numerical system with base 60. One of the practical reasons could be the fact

that 60 is the smallest number divisible by 1, 2, 3, 4, 5, and 6, so the number of divisors was maximized. The second has the astronomical origin and is based on the fact that the Sun's average daily trajectory is equivalent to the length of its 720 diameters. Division of the day to 12 hours dates back to the Sumerians, and probably has the anatomical basis of the 12 hand phalanges (without thumb opposition). Furthermore, during the day, sun traverses its 60 diameters in one hour, hence, during the equinox it covers the distance equivalent to its one visible diameter in exactly one minute. Sumerians were probably familiar with the axiom that six secants of radius length circumvent the circle.

In the sexagesimal positional system, each position has an interval of 59 numbers. For example, the number (1, 1, 1, 1) in positional sexagesimal notation is equivalent to 219,661 in the decimal system, the number (2, 2, 2, 2) is 439,322, (3, 3, 3, 3) is 658,983, etc. The number formation (n_3, n_2, n_1, n_0) is represented by the following sum:

$$(n_3, n_2, n_1, n_0) = n_3 \cdot 60^3 + n_2 \cdot 60^2 + n_1 \cdot 60^1 + n_0 \cdot 60^0 = \sum_{i=0}^{3} n_i \cdot 60^i.$$

One of the main problems in the Sumerian sexagesimal numerical system is the lack of empty positions, which logically correspond to the number 0. Significant improvement of this numerical system was achieved in Babylon.

Sexagesimal number system was later replaced by more efficient decimal positional system. However, the impact of sexagesimal numerical system on modern life is still evident in measuring time and has been the basis of the metrics of basic chronomes for more than 4000 years. The day has 24 hours, and an analog clock marks 12 numeric positions. Each hour is 60 minutes long, with 60 seconds in every minute. In geometry, a circle has a radius of 60 degrees, each degree 60 minutes, with 60 seconds in each minute. A full circle has 360 degrees.

Sexagesimal number system was adapted for astronomical calculations. Today, the most visible stars are given Babylonian names. However, this number system required a particular skill for its practical applications, in particular in the geometry and construction, as well as in the orthogonal concepts. The forms of basic ceramic tokens representing the cardinal numbers of Babylonian mathematics are dominated by circles (clips with tokens), and the astronomical associations with the eclipse (Fig. 1) [3].

At the same time, the Egyptians developed a numeric system based on hieroglyphics. Egyptian architectural, construction and irrigation feats far outweigh Mesopotamia, especially in the definition of cadastral land partitioning. The more advanced Egyptian system for the ratio of a circle and its diameter according to Archemes's papyrus was equal to 3,16 and is much more accurate than the Babylonian approximation which was 3,00.

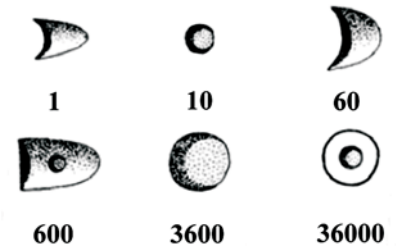


Figure 1 *Cardinal token of Babylonian mathematics*
Slika 1. *Simboli babilonske matematike za glavne brojeve*

The Egyptian number system had seven main digits, which were degrees of 10, and were a precursor of the modern decimal positioning system. These are numbers (symbols): 10^0 (vertical stroke), 10^1 (hell-bone arch), 10^2 (coil of rope), 10^3 (lotus flower), 10^4 (pointing finger), 10^5 (burbot fish) and 10^6 (astonished man) (Fig. 2). In practical applications of metric bijections, the Egyptian system was much more convenient to use, especially in algebra.

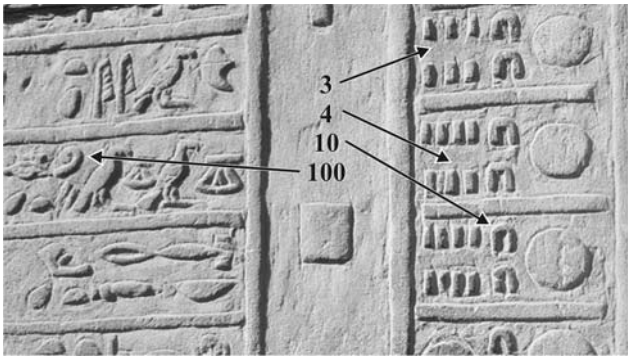


Figure 2 *Examples of the symbols of Egyptian hieroglyphic numbers*
Slika 2. *Primjeri simbola egipatskih brojeva na hijeroglifima*

Through their differences, Babylonian and Egyptian number systems provided two metrologic bases − Babylonian for temporal, and Egyptian for spatial measurements. This is the foundation for measuring spatial-temporal transformation of material goods. These transformations are fundamental to logistics processes. The analogy of spatial transformation is transportation, whereas storage represents temporal transformation. Thus, the synthesis of these two number systems provided the platform for the evolution of logistics.

3
Uluburun shipwreck and the Bronze Age logistics
Olupina broda Uluburun i logistika brončanog doba

The Mediterranean is an area where the earliest civilizations, the main religions and cultures were formed. Development of Mediterranean civilizations and their progress has always been intrinsically linked to the production in qualitative and quantitative terms. Geographic distribution of resources defined the domination of one civilization in the production of particular commodity groups. Trade as the phenomenon appears with the aim to enable purposeful civilizational interaction − exchange of goods. Mediterranean civilizations were the first to establish organized trade. Bronze Age and intensive metallurgy advancements have also prompted an intensive development of trade. The earliest civilizational interactions within an established trade network in the Mediterranean date back to 5000 BC [4] and are linked to port infrastructure in the Middle and Late Bronze Age (LBA) [5, 6].

The excavation of a LBA (1200 BC) cargo vessel off southern Turkey's Cape Gelidonya in 1960 was the world's first scientific underwater dig. It was located in 1954, and the excavation began in 1960.

The excavation of Cape Gelidonya shipwreck asked for significant reconsideration of the history of nautical commerce in the LBA Mediterranean. The presumed domination of Micenae culture was moved toward Phoenicians and the history of the nautical commerce was moved to the farther history.

Significance of this knowledge redefined the central commerce zone on the east coast of the Mediterranean − with ports of Ugarit, Bilbos, Sidon, Tyre, Akko, Ascolon and Tell el-Ajjul, due to the continental links with Babylon. The network of other major Mediterranean ports includes Micenae in the present day continental part of Greece, Troy, Miletus, Bodrum and Kas, Knossos and Kommos on Crete, Kyrenia and Kition on Cyprus, Mersa Matruh in the northern Egypt. Inevitably, the River Nile at Amarna (Upper Egypt) joins these Mediterranean sites, as the most important inland port (Fig. 3).

Figure 3 *Major commercial Mediterranean cities, Phoenician trade routes and colonies with the location of the Uluburun ship*
Slika 3. *Glavni trgovački gradovi na Mediteranu, feničanske trgovačke rute i kolonije s lokacijom broda Uluburun*

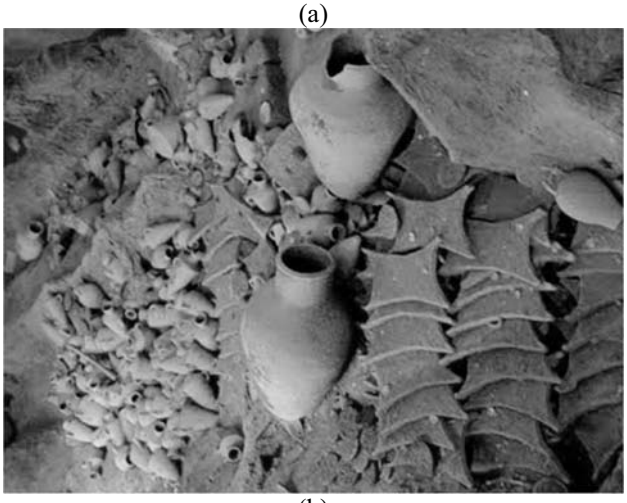
The exploring results from Cape Gelidonya shipwreck significantly moved forward and gave direction to the further archeological knowledge of the LBA period. The value of these results is at the same time the basis for the real historical dates and the ground for the reconstruction of the LBA period. The significance of the shipwreck concept was a starting point for further explorations in the Mediterranean and in the meantime a great number of shipwrecks was discovered. Two very new significant discoveries were made in 1997 and 2007.

In 1997, the U. S. Navy submarine NR-1 searched for the lost Israeli submarine, *Dakar, in* the eastern Mediterranean Sea. The NR-1's crew did not find *Dakar*, but did locate two ancient shipwrecks from the 8th century BC off the Levantine coast, west of Gaza. These two ships were found in the depth of 400 m. In the year 2007 the newest exploration of 2000-year-old shipwreck was realized by Kizilburun, 322 km away on an island in Turkey's Sea of Marmara.

The most concrete information about the Bronze Age market system in the Mediterranean is provided by the famous *Uluburun shipwreck* [7] from the LBA (14th century BC), discovered off Uluburun, located about 6 miles due southeast of Kas (Fig. 3), in south-western Turkey. A boat, 15 to 16 meters in length (Fig. 4a), was submerged at a depth of 44 to 52 meters (Fig. 4b).

Eleven consecutive campaigns of three to four months duration took place from 1984 to 1994 totaling 22,413 dives, revealing one of the most spectacular LBA artifact collections to have emerged from the Mediterranean Sea.

(a)



(b)

Figure 4 *Wooden model ship Uluburun (a) the conditions of the Uluburun shipwreck cargo at the time of discovery (b)*
Slika 4. *Drveni model Uluburun broda (a) i zatečeno stanje tovara s Uluburuna (b)*

The ship cargo included 354 ingots of raw copper and 121 oval copper ingots, one ton of tin, 149 Canaanite jars, Blackwood from Africa and unprocessed ivory (tusks). In addition, ostrich eggshells, Cypriot pottery and oil lamps, amber pearls of Baltic origin, quartz, agate, stone anchors, 175 glass ingots of cobalt blue turquoise and lavender (the earliest intact glass ingots known), and many more items were found.

Based on the cargo content analysis, the bronze total weight was determined to be 11 tons. Quantity and weight of amphorae contents was not established. The reconstruction of load distribution indicates the concentration of copper ingots towards the aft (stern) of the ship.

The total weight of copper ingots (Fig. 5) was about 10 tons, and the balance was established by other heavy payload: amphorae, tin, glass ingots, anchors, etc. Thus, the approximate Uluburun ship cargo weight was probably over 20 tons!

The formation of lading (bill of loading) of a complex assortment of 20 tons of cargo, even in the modern times, would require knowledge and skill, responsibility and routine.

Three samples of the glass ingots from the Uluburun shipwreck show a common trace element composition, consistent with glass manufactured in Egypt. This evidence shows a direct link from general regional location of manufacture, through the production of ingots, to the end

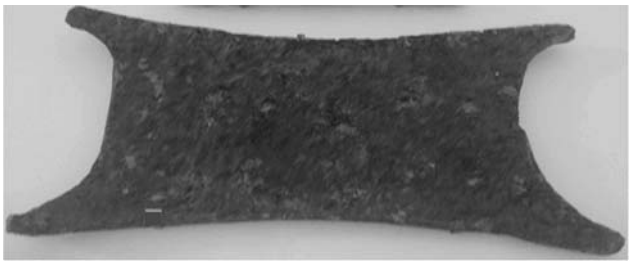


Figure 5 *Copper ingot from the Uluburun shipwreck*
Slika 5. *Bakarni ingot s Uluburuna*

Figure 6 *Glass ingots from the Uluburun shipwreck*
Slika 6. *Stakleni ingoti s Uluburuna*

-product, and suggests one possible trade route for the glass ingots [8, 9] (Fig. 6).

Detailed analysis of resin found within Canaanite amphorae further leads to Upper Egypt, Amarna [10]. Using modern comparison techniques, combined with archaeological and historical sources, the analysis of the mouse molar skeleton found within the remains of the Uluburun ship, revealed the last port the ship docked in before it sank − Minet el Beida [11], natural harbor located 1 km west of Ugarit, north of Bilbos. Cypriot copper identified during the analysis reveals the third destination. The complex assortment of items from Uluburun further increases the number of possible navigation routes and enables the analysis of transit operations in the Mediterranean ports. This finding has important implications in defining the transit bill of lading, a combination of old and new assortment.

Work with the Bill of Lading transit plan involves complex navigation, careful planning of transfer operations

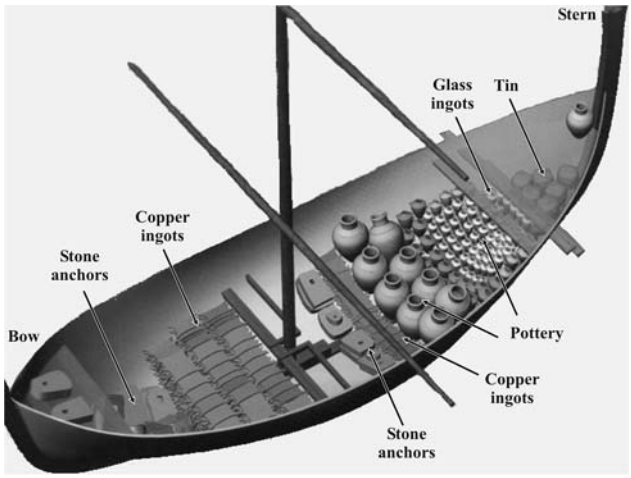


Figure 7 *The reconstruction of payload distribution in the cargo hold of the ship Uluburun*
Slika 7. *Rekonstrukcija rasporeda artikala u tovarnom prostoru Uluburuna*

Figure 8 *The Uluburun Museum with ship cargo reconstruction*
Slika 8. *Uluburun muzej s prikazanim rasporedom brodskog tereta*

at ports, establishing a new balance of the ship (Fig. 7) regular reconsolidation of cargo and so on. These complex activities required a synthesis of skills and knowledge of the navigation and weather conditions, the ship technical characteristics, expert knowledge on the properties of the wide range of goods, organization of transfer (four handed copper ingots customized for reloading), market demands for raw materials, intermediate and finished products, trading preferences, risk assessment and much more.

Despite this deficit, the system of transport activities, handling, storage, packaging and order delivery was successfully carried out by the Uluburun ship (Fig. 8). All the key elements of modern logistics can be found in this example from the LBA.

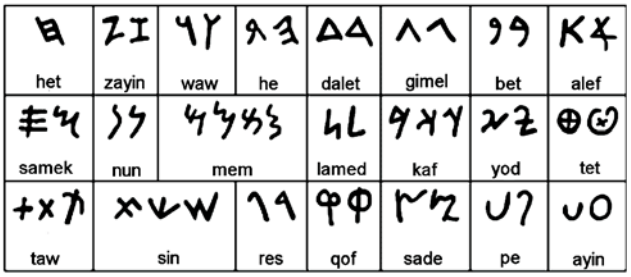
4
Phoenician logistics
Feničanska logistika

The *Phoenicians* were named after a purple color they extracted from seashells. The Greeks called them Phoiniki - *Φοινίκη* or purple. The famous purple of Tyre was the most expensive product of their time, trading in the ratio of one measure of purple to 60 measures of gold (sexagesimal ratio).

The Phoenicians are credited for the invention of the slender ship channel, anchors, many achievements in cartography and navigation, establishing colonies in the Mediterranean Sea (Cadiz, Marseille, Sardinia, Corsica, Carthage, etc.) as well as exploratory missions in search of tin, which had taken them through Gibraltar to the North Sea.

Most importantly, the Phoenicians introduced a universal medium of exchange − money. First, the shells were used, then gold, and later, due to its reduced wear, silver was introduced into circulation. These most progressive and versatile traders of ancient times were characterized by the absence of honest business conduct. As a nation, they were unpopular among the other Mediterranean nations.

Their trading skills were supported by the sophisticated new alphabet (Fig. 9a) and the number system (Fig. 9b). The innovation in the Phoenician numerical system was the introduction of duodecimal basis that combined differentiated number symbols. These ranged from the Egyptian numerical system that represented numbers under nine with vertical lines (I, II, III, IIII, ..., IIIIIIII), to the symbol for the number 10 and the symbolic analogy of



(a)

(b)

Figure 9 *Phoenician alphabet (a) and a number system with the numbers 10 and 20 (b)*
Slika 9. *Feničansko pismo (a) i brojčani sustav s oznakama brojeva 10 i 20 (b)*

number 20 (Fig. 9b). Only three images were used as number symbols, which is a far more advanced approach than the Babylonian and Egyptian number recording systems.

Higher numbers were formed by simple combinations and multiplications of the three images. Although by using this number system it was not possible to represent very large numerical values, the Phoenician alphabet and number system was an effective device for commercial calculation and establishment of marine bill of lading.

The concept and representation of numbers in the ancient times was essentially different from modern conceptions. The number symbol of the Phoenician numeral system was complex; it required special images and demanded high level of skill for conducting calculations. Nevertheless, it is this art of synthesis of calculus and images that gives meaning to abstract forms of numerical expressions. This skill brings us to an etymological basis of the definition of logistics: "numeracy skills through images". The above numerical skills through images had the predominant application in the trading process.

5
Conclusion
Zaključak

Even at a time of global communication, satellite positioning of transport and multiple navigation systems, electronic commerce, advanced security systems and insurance for transportation systems and cargo, as well as other advanced elements of the transportation system, the essence of logistics remains unchanged. Only its form is extended to the inclusion of modern numerical system and data processing. The root is still the same, "logos" whereby the images are replaced by electronic records. Logistics has precise etymological semantics, which is not easily discerned and can be understood only after the analysis of the evolution of the numerical system and by expanding knowledge of trade system of ancient times.

The extensive analysis has proven that logistics has ancient origins. Over time, the priority of the original meaning of the word "logos" has taken secondary position and is primarily placed in the context of philosophy after the discovery of Plato's works. As Pythagoras (575 − 495 BC) was older than Plato (428 − 348 BC), given the information that Pythagoras was familiar with the logistics, it can be concluded that the primary meaning of the word "logos" was account!

Logistics is largely responsible for the evolution and advancements in the numerical system. Its history is tied to the great ancient times, mainly to Pythagoras, and probably dates back to 600 BC − as indicated by the findings from the Uluburun shipwreck.

However, due to the theoretically most complete analysis of the phenomenon of logistics, the systematic approach remains the dominant choice [1]. The detailed analysis of the concept of the Uluburun shipwreck extends beyond an isolated trading process and has all the characteristics of the current logistics systems. In ancient times, the logistics streamlined production-distribution processes, generating quantum leap in the scientific knowledge.

Quantum leap in the previously isolated scientific fields of ancient times was, in fact, made possible by the development of logistics. At the same time, the increased body of knowledge prompted the need for differentiation of science, during which philosophy took precedence over logistics. Thus, in the scientific differentiation, philosophy completely absorbed logistics, even though the logistics was the foundation of philosophy.

The dialectic connection and integration of individual scientific disciplines in the nineteenth and early twentieth century excluded logistics until the mid-twentieth century. However, the philosophical platform was insufficient for meeting the complex demands of the modern production and distribution systems. The solution was achieved through the development of logistics systems with the greatest degree of integration of differentiated sciences.
Thus, the modern logistics systems bring us back to the beginning of scientific development – the period of unity – albeit with much higher quantum of knowledge.

Despite the unquestionable value of philosophy, logistics – as a science – is back to the well-deserved pedestal. The differentiation of logistics systems, combined with the internal quantum of knowledge on logistics, now plays a dominant role in all processes and spheres of life, as was the case in ancient times. Therefore, the etymological genesis of logistics is essential and fully applicable in the modern times.

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6
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