Maritime skills and astronomic knowledge in the Viking Age Baltic Sea

George Indruszewski (Viking Ship Museum, Roskilde, Denmark) and Jon Godal (Rissa, Norway)

The issue of orientation at sea is discussed in relationship to archaeological, historical, linguistic information and new data obtained from experimental archaeology. The Viking Age sailors, regardless of their ethnic affiliation prowled the Baltic Sea with their ships, orienting themselves after celestial bodies such as the sun and the North Star. The vocabulary of most Slavic languages contains terms referring to time count and spatial orientation points in relationship to the position of the sun. The archaeological evidence, most specifically the discovery of an 11th century incised wooden disc, seems to reinforce the impression that astronomic orientation was used during and after the Viking Age Baltic Sea in the creation of mental, cognitive maps that served to orient sailors in a largely illiterate society.

Orientation at sea: theory and practice

The issue of orientation was never an easy subject even nowadays with the advance of satellite-based positioning systems and other radio- or sound-based navigation instruments.

This change, however, does not make any easier the task of defining what navigation is, especially when it comes to navigation in the age of the Vikings.

Modern navigation places an ever-increasing reliance on radar, satellite receivers, radio communication, and other means to steer ships that become bigger, faster, and more prone to disaster in and out of the trafficked deep-sea navigation lanes. For modern sailors, navigation has become an exact science, where the classic method of dead-reckoning is sophisticatedly computerized to the extreme, and where the formula 'range of estimated outcomes' is replaced by the motto 'secured navigation'.

According to type and scope, there are different kinds of navigation: celestial navigation, pilotage (where the navigator makes heavily use of landmarks and navigational aides such as lighthouses, buoys, beacons, etc), dead reckoning (DR), waypoint navigation, position fixing, radio navigation (for automated navigation systems) and radar/sonar navigation.

The first three kinds are rooted in mankind's seafaring history, while the rest is basically the scientific output of our modern times. Worth to note here, that the name dead reckoning (DR) coming to us from Elizabethan times implies a contrast between the instruments used for navigation: the 'dead' navigation with map and compass, as opposed to the 'live' navigation with the help of celestial bodies, mainly the Sun, the North Star, and the Moon.[1] As mankind developed more technology, the trend seems to have been towards an increased

[1] 'Dead' may also have derived from 'deduced', but the word 'dead' was and is used commonly. For navigation knowledge at the end of the Middle Age period and onwards see Waters 1958: 39-77. For definitions of 'DR' see

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reliance on the 'dead' method of navigation. Therefore, it is perhaps no wonder why in the modern process of education, young navigators start with the mastering of dead reckoning navigation method, strongly backed by other modern navigation types, and only thereafter they pass to a 'higher' level of instruction, the celestial or astronomic navigation.[2]

But before our times, navigation was not a science it was an art. It was the art of applying a multifaceted knowledge, a techno-scientific knowledge[3], to the practical task of leading a vessel from its departure point to destination on a selected route. It was the exclusive and unique skill of a Viking Age *stýrimaðr*, who 'carved the sea with the prow'.[4] In scientific terms, navigation was and is 'the process of determining and maintaining a course or trajectory to a goal location'[5] or the 'art of directing ships in any waters.'[6] This implies determination of position and direction of travel any time anywhere.

The problem, thus, for both scientists and the larger public, was and still is how this illiterate helmsman, often fulfilling the captain's role on board, was able to 'carve the sea' so that his ship not only reached the planned destination, but, through repetition, it gave also birth to sea routes and shipping lanes.

Since the successful Atlantic crossing in 1893 of the Gokstad ship copy, the *Viking*, a vast amount of writing was spent on Viking Age navigation, and several theoretical currents were profiled over the published and unpublished material. These theoretical constructs, though, do not necessarily contradict each other, and they may even run in parallel by describing complementary features of Viking Age navigation.

A wooden disc found in 1948, in the ruins of the Benedictine Convent from Uunartoq, Greenland constituted the event that triggered the formation of a main current of opinion within the research field of early medieval navigation (fig. 1). C. Sølver's interpretation in 1953 of the find, as the remnant of a sundial was supported and furthered mainly by T. Ramskou, C. Roslund, and S. Thirslund.[7] The mainstay of their arguments was to prove that the Uunartoq's wooden disc was a Viking Age navigation instrument that was successfully employed in direction finding on the open seas. In addition to that, T. Ramskou published several times his arguments regarding Viking Age navigation, which in a nutshell, state that the Vikings mastered non-instrumental, coastal navigation where bearings on land and local knowledge were the main prerequisites for successful voyages.[8] For Ramskou, Wulfstan's voyage, like Ohthere's, was a *de facto* coastal sailing.[9] With the

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Mixter 1979: 136-139. For practical limitations of DR navigation see Sølver & Marcus 1958: 18-34. For details see http://www.wordiq.com/definition/Dead_reckoning.

2 A good example is given by the education system employed by the Danish Seafaring Authority (Søfartsstyrelsen), which divides these two levels into two patent-earning categories: skipper of the 3rd rank, followed by skipper of the 1st rank. For details see http://www.fritidssejler.dk/. Nevertheless, Mixter (1979: 142) in his *Primer of Navigation* points that experience based on astronomic navigation 'cannot be taught in books'.

3 As Schiffer & Skibo (1987: 592-622) pointed out, the term techno-science includes among the products of technology, those facts drawn from the interaction with material matters and which constitute a prescriptive mental body of knowledge. This knowledge is learned through personal experience and shared with others.

4 This sentence is characteristic of skaldic stances depicting the headway of a ship. For details see Jesch 2001: 177.

5 Franz & Mallot 2000 at http://www.wordiq.com/definition/Navigation_research

6 Mixter 1979: 1; also the Webster's Revised Unabridged Dictionary defines navigation as 'the science or art of conducting ships or vessels from one place to another, including, more especially, the method of determining a ship's position, course, distance passed over, etc., [..].'

7 Thirslund 1995, 1999

8 Ramskou 1969: 39-74, 1982: 14-50

9 Ramskou 1982: 39-40

Fig. 1. The Uunartoq disc fragment (after Thirslund 1987: 38).
Sl. 1: Odlomek lesenega diska iz Uunartoqa (po Thirslundu 1987: 38).

advent of deep- sea voyages to the North Atlantic islands this knowledge, according to Ramskou, expanded to include the use of instruments, such as the wooden sundial (from Uunartoq) and the *sólarsteinn* (the polarizing crystal) mentioned in St. Olaf's Saga from the 13th c. AD.[10] A. L. Binns supported in 1972 the idea of instrumental navigation by presenting the so-called 'Canterbury Portable Sundial', a metal rectangle with holes and abbreviated Latin letters, tentatively dated in early 11th century, as a reliable proof of Viking Age navigation instrumental aids.[11] Another proponent of instrumental navigation is S. Larsen, who rejected most navigational instruments, with the exception of the wind-vane who helped the 'Vikings' in addition to their astronomic navigation (sun mostly).[12] L. Karlsen follows nowadays his predecessors in earnest, when he, in his book, explains practically 'how the Vikings used their amazing sunstones and other techniques to cross the open ocean'.[13] For all purposes, one can call the mentioned proponents and their theories, as the 'school of thought' of Viking Age instrumental navigation. Their arguments were in principle based on practical interpretation of archaeological evidence.

In 1953, G. J. Marcus continued H. Falk's position[14] when he strongly advocated a non-instrumental navigation in the Viking Age.[15] The Viking navigator was educated within a strong oral tradition encompassing all the knowledge needed to steer a ship to its destination; this knowledge included reckoning bearings on land, celestial navigation, and the observation of natural phenomena at sea. In this way, the Viking helmsman was able to *deila ættir* that is to distinguish the airts and steer the course.

E. G. R. Taylor's book, printed for the first time in 1956, provided a thorough presentation of navigation knowledge at a global level that went back to the Phoenician times.[16] For the Norsemen and the Irish, Taylor reserved an entire chapter titled 'Navigation without compass or chart' where she appealed to historical sources ranging from Dicuil's 9th

[10] For discussion on the *sólarsteinn* see Ramskou 1969: 59-79, 1982: 21-29, also a comprehensive survey in Schnall 1975: 92-114.
[11] Binns 1972: 23-34
[12] Larsen 1975:52-60
[13] Karlsen 2003
[14] Falk 1912: 15-23
[15] Marcus 1953: 112-131. Like Haasum later, he erroneously uses the term 'dead reckoning' in describing the process of spatial orientation at sea. He, nevertheless, alternates it with 'reckoning', which is acceptable from a theoretical point of view.
[16] Taylor 1958: 65-85

century *De Mensura Orbis Terrarum* to the early 13th century King's Mirror (*Konungs Skuggsjá*) in order to argue for an astronomic, non-instrumental navigation type used in the Viking Age Northern Europe.

S. Haasum published her thesis in 1974 where besides her negative arguments about the ability of Viking ships in sailing to windward the navigation theme occupied quite a central place. After stating that the Vikings did not use compass, wind-vanes or any other instruments, she erroneously described their use of celestial bodies, landmarks, and other seascape features for orientation and way-finding at sea as '*död räckning*'.[17]

U. Schnall published in 1975 a comprehensive survey of historical sources about Viking Age navigation where each issue pertaining to both instrumental and non-instrumental navigation was approached from an analytic perspective. After strongly disqualifying the arguments for instrumental navigation, the author proposed coastal navigation as the main type of knowledge 'at work' in Viking Age Northern Europe, knowledge that was supplied by crude astronomic orientation for deep-sea navigation.[18] The sum of these publications give thus an idea of the other theoretical construct built through the critical analysis of medieval written sources, mainly the saga literature. The main idea of this construct was the omnipresence and omnipotence of non-instrumental navigation in Viking Age Northern Europe.

In 1983, O. Crumlin-Pedersen pioneered a specific theoretical construct in the ongoing discussion about Wulfstan's navigation, namely the idea of sounding navigation, where the ship would follow a pre-selected bathymetric line (in this case, the author chose the –10 and –20 m depth lines respectively) that would run along the southern Baltic coastline from the mouth of the Schlei to the mouth of the Vistula.[19] In other words, the author argued that the orientation system for the Viking Age navigator was below the waterline and not above it, and that coastal sailing was the main type of navigation knowledge for that period.

Besides these three main currents of opinion, there are some other thoughts that embrace or reject more than one of the aforementioned theoretical constructs. A. E. Christensen, for example, strongly favors non-instrumental navigation in the Viking Age, but also points out that navigation by soundings is of little help along the Norwegian coastlines, since the abrupt changes of sea bottom depths are detected too late to help in steering the course of a vessel.[20] J. H. P Barfod, in his defining notes on navigation, has practically embraced all theoretical constructs, by mentioning the non-instrumental, instrumental, and the sounding as types of navigation knowledge available to the Vikings.[21]

A peculiar place is occupied by M. Vinner who drew on his practical experience in sailing copies of early medieval vessels, when he argued that Viking Age navigation can be dealt in two co-existing parts: a 'natural' navigation type where human senses and intuition are used to develop an instant orientation system, and an instrumental type of navigation ranging from Flóki's ravens[22] to the late medieval solar stone from Albuen, on

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17 Haasum 1974: 97
18 Schnall 1975: 181-183
19 Crumlin-Pedersen 1983: 42-43
20 Christensen 1993: 155
21 Barfod 1967: 260-263
22 Hagland 2002: 37

the Lolland island. For him, though, the most important element in navigation was the human sense of spatial orientation, called by him the 'cognitive instinct'.[23]

Spatial orientation in early medieval times

In its own narration, Wulfstan's geography is a maritime orientation system with the ship as the central point. He does not orient the coastlines and islands in relation to each other, but in relation to the ship. This system contrasts with Alfred's *Orosius* own orientation system(s) (Korhammer 1985: 251-269), and is unique also in the historical sources in general. And paradoxically, but not unexpected, it levers the least amount of error in terms of cardinal directions. When Wulfstan said that the islands that belong or accepted Danish suzerainty are left on the port side, and that Weonodland was on starboard all the way until the Vistula Mouth, there is no room for error in interpreting that his ship was actually eastbound, and that he sailed on a rough course line from west to east.

In addition, Wulfstan's account uses the language of cardinal points: the Elbing comes from the East, the Vistula from the South, and then the Elbing or the Vistula flows into the sea West and North. Thus, Wulfstan's travel account includes all cardinal points, and moreover and in contrast with the rest of Alfred's *Orosius*, it actually corresponds with the 9th century geophysical settings in the Vistula Lagoon as reconstructed recently by M. Kasprzycka (Kasprzycka 1999: 148-151). Needless to say that parallels are found in the Skaldic Corpus if one wishes to use them (Jesch 2001: 134, 174-175, 176).

But, was this really the navigator's system of orientation while on board that sailing ship? One can deduce from the Wulfstan's text that the horizon was divided at least in four parts: the heading of the ship, the point of departure lagged behind, and the two sides of the vessel, port and starboard. This primary division of the horizon line could have been furthered by the next four directions (northeast and –west, southeast and –west), and in this manner, one arises at a total of eight direction points identical with the eight Old Norse cardinal points (clockwise these are *nordr*, *landnordr*, *austr*, *landsudr*, *sudr*, *utsudr*, *vestr*, *utnordr*), or the eight winds from the later King's Mirror (*Konungs Skuggsjá*). This kind of reasoning is very tempting, especially when one knows that it reverberates in a vast literature that supports it.

However, there are two major objections besides the fact that the text does not refer to these points directly. The first is the 'Scandinavian' origin of the eight-point directional system. As Taylor mentioned a long time ago, the eight-point directional system was known since the Classical times in the Mediterranean (Taylor 1958: 7-8) and so it is quite possible that this system was 'imported' in Northern Europe through the works of literate monks. One important aspect, neglected by those seeing only Viking Age roots in saga literature, is the fact that this literature was written after the Scandinavian societies were imbued by Christian horizons of knowledge, which mediated actually the Classical World knowledge and values into the local cultural realm (Hollander 1962: 18-19). A quick look into the Classical World meteorology convinces almost immediately that the Ancient World knew not only about the horizon division into 12 equal parts (Aristotle's description) but also used this division to define Mediterranean wind-roses, such as the 2nd to 3rd c. BC marble anemoscope from Rome (Taub 2003: 105-108) (fig. 2). The other

23 Winner 1998: 1-40

objection point was explained by M. Korhammer in 1985, and sets quite clearly Ohthere's orientation system in terms of sectors or arcs of horizon instead of directional points (Korhammer 1985: 251-269). If this is the situation, and saga and other Norse literature are utterly 'contaminated' by Southern European knowledge, then what is there left for a reconstruction of a Viking Age orientation system?

The most 'risk-free' avenue is by way of mythological and linguistic research combined with first-hand ethnographical knowledge. For all practical reasons, Scandinavia

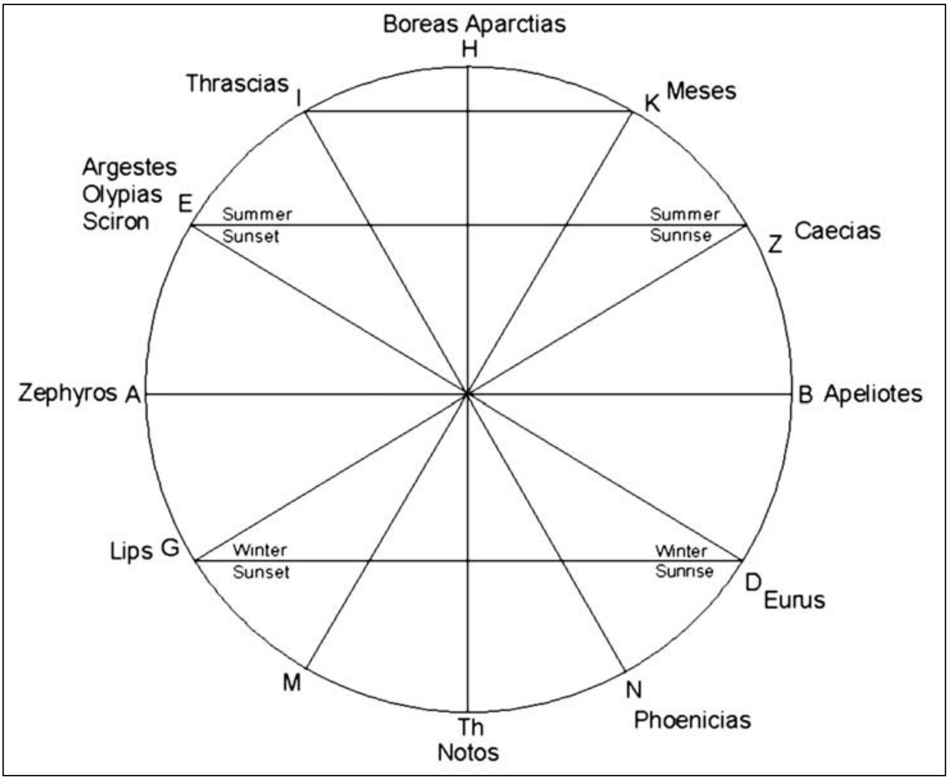


Fig. 2. Classical World's wind-rose according to Aristotle (after Taub 2003: 105, fig 3.2).
Sl. 2. Aristotelova veternica klasičnega sveta (po Taubu 2003: 105, sl. 3-2).

remains a region where warm and cold are not only life-bearing sensual perceptions, but also matters of life and death. For Scandinavians (no ethnic connotation here) South (as a fixed direction) was where the Sun was at its highest and warmest during summer time, and from this point one could be deriving thus the first orientation axis (North-South). It is probably not incidental that in the Scandinavian mythology, the primordial chaos, *Ginnungagap*, was actually a world divided between the icy North and the glowing South. And looking at the geographical 'arrangement' of the Norwegian and Danish coastlines, this directional axis makes more sense, since it defines (not in the modern acceptation of accuracy) the direction in which one can travel and communicate with others (from north to south and vice versa). Finally, there is the etymological explanation of cardinal points, which clearly distinguishes the relationship South-Sun among the other cardinal points. Literally **east** is the point on the horizon where the sun rises. It comes from the Indo-European base *aus* which has a dual meaning of 'east' and 'dawn.' It is also the name of the prehistoric Germanic peoples dawn goddess, *Austron,* whose festival occurred in the spring. In Old English she was called *Eastre,* and is the origin of the English *Easter.* The Greek word for east is *eos.* It is not known for certain where **north** came from, but it has been suggested that its origin is *nertru,* which means 'left' in an extinct language of Italy known as *Oscan-Umbrian.* The underlying meaning is that north is 'to the left as one faces the rising sun'. *Nord* in German, Swedish and Danish stands for 'north' while the Irish 'north' was based on *tuaisceart, clé* meaning left. **South** comes from the Germanic *suntha,* and may have been derived from the base of *sunnon* or 'sun' - in which case *south* would literally mean 'region of the sun, side on which the sun appears.' This represents the direction to the right of the observer as the sun at sunrise. Descended from the Indo-European *wes,* **west** is literally the direction in which the sun goes 'down.' This also produced the Latin *vesper* and the Greek *hesperos* or 'evening' and is related to the Sanskrit *avas* or 'down' (http://www.jesusisamyth.net/glossary.html and Falk & Torp 1996: 875).

As mentioned before, historical studies are of limited use when searching for the origin of navigation knowledge, and it may be we will never know exactly how much navigation knowledge is due to orally-transmitted tradition and how much came from the Mediterranean-based knowledge. Nonetheless, these sources could be regarded as measures of reflectance of several key issues, such as the notion of measuring time. Time in the Viking Age was related seemingly to the sun movement, and there are words where the meaning signify both time and direction (to the sun). Although late, medieval written sources mention two concrete occasions when measuring the altitude was done *ad hoc* by using whatever was available at hand, without prejudicing the accuracy of the measurement:

The first mention was made in the 12th century Icelandic *Grågås* Law

Then the sun is a handle high if a man is standing on a beach when sea is middle between ebb and flow looking the sun on her way down. If it looks as if a spear is placed under the sun so far that a man can reach it and the point of the spear just reach the lower edge of the sun, but the lower end of the handle goes down to the sea surface if the sky is clear.[24]

The second mention comes from Greenland where an expedition sailed in 1266 to *the bottom of the ocean* (Næss 1954). Three days on the way south from the *bottom of the ocean* (that means the edge of the permanent polar ice) a crew on a six oared boat reached Kroksfjardarheidr on the 25th July:

*It came ice on the sea at night, but sun was shining day and night and was not higher when in south that if a man was laying crosswise the boat and his head with the board, the shadow of the board nearest the sun would fall in his face. At midnight the sun was as high as home in (*nearest?*) settlement when it is in northwest.*[25]

These accounts indicate how early navigators measured the sun altitudes, established bearings and directions according to the sun, counted time and probably also north-south

[24] Translated by J. Godal from the Icelandic *Grågås* Law.
[25] Translated by J. Godal.

distances by using simple devices available on hand, in this case the spear and the boat's side.

Thus it seems that the time-direction concept is older than the information provided by early medieval written sources, taking different meanings already in Old Norse language. The concept seems to have been born as a practical matter, because when following the sun during the day one automatically recognizes the altitude as well. The day is at its highest, *høgstdags* in New Norse and *hādegi* in Old Norse, and one sings about *sprouting of the sun in east*.

A similar situation is perceived when looking at the Baltic Slavs, who used for orientation seemingly East and West as major cardinal points, and the diurnal trajectory of the sun. Until today, some of the major Slavic languages hold for the engl. 'west' terms that define actually sunset (Pol. *zachod*, Cz. *západní*, Rus. *Западный*, hsorb. *zapadny*) or evening (Cz. *večerní*, hserb. *nawječorny*), while for the engl. 'east' there are terms depicting rise, sunrise, dawn (Pol. *wschód*, Cz. *vychod*, Rus. *Восточный*, hsorb. *wuchodny*) or morning (hsorb. *narańši*, *rańši*). If east and west are similar or identical in most modern Slavic languages, not the same can be said about the other two cardinal points. For languages other than Polish, 'north' is Cz. *sever*, Rus. *Северный*, hsorb. *sewjer* and 'south' is Cz. *jih*, Rus. *Южный*,

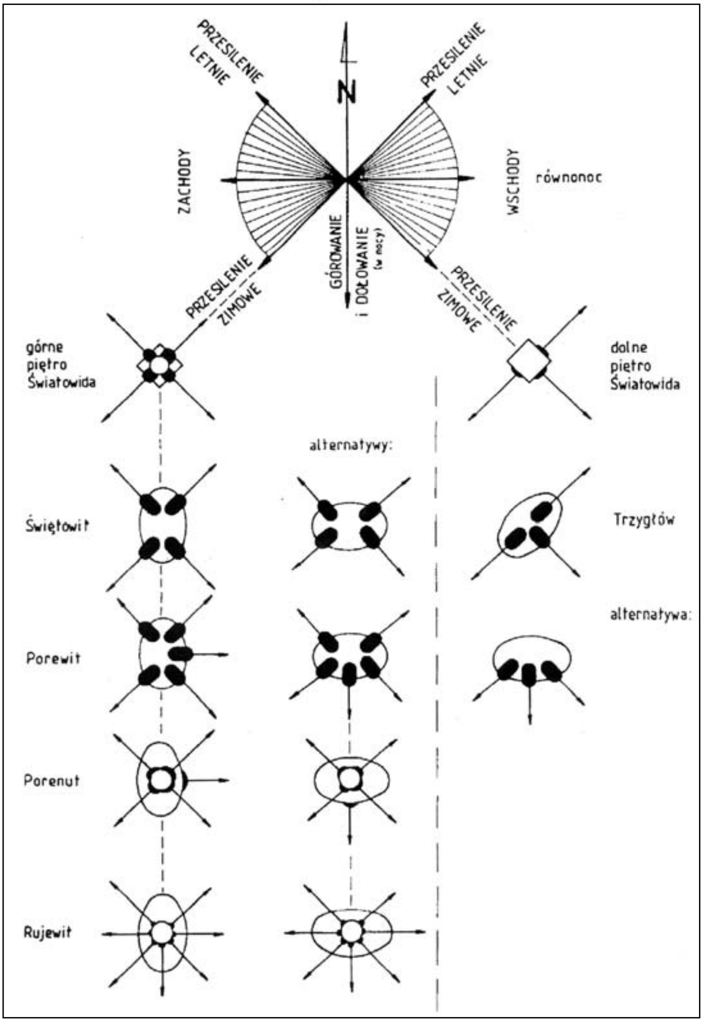


Fig. 3. The solstice orientation of the 4-faced Slavic deities as proposed by Kotlarczyk (Kotlarczyk 1993: 62, fig. 2).

Sl. 3. Solsticijska usmeritev štiriobraznih slovanskih božanstev kot jo predlaga Kotlarczyk (Kotlarczyk 1993: 62, sl. 2).

hsorb. *juho*, *južno*. In Polish, though, the word '*północ*' means 'midnight' which is to be related to the other important celestial body, the North Star (Pol. *Gwiazda Północna*). The North Star, is named in the Czech language after its direction pointing, to the North (Cz. *Polárka*, *Severka*). Besides that, 'south' is Pol. *południe*, which is a composite term between *pół*, the half, mid-, and *dnia*, the day, literally means the time of the day when the sun is at its zenith and points towards the geographic south.

The orientation system was rooted, as in the Scandinavian case, in Slavic mythology. Saxo Grammaticus' Svantevit (*Świętowit*) from Arkona and the statue of *Światowit*[26] from Zbrucz each had 4 faces/heads that can be related to the sun position at the summer and winter solstices (fig. 3).[27] J. Kotlarczyk's interpretation seems all the more convincing if the statue of Svantevit is placed in its original location in the temple from Arkona. The temple, recently identified during the salvage excavations carried out several years ago, was located somewhat in the middle of the fortified compound, but had a clear view of at least 180° horizon line (due to erosion, the area today is in the immediate vicinity of the edge of the high cliff). From this location both sunrise and sunset could have been observed in relation to the sea horizon. It is interesting to note, that the temple and the fortified compound at Arkona faced the open Baltic Sea towards northeast, and in days with clear skies, the location of the Bornholm Island (situated at about 92 km or 50 Nmi from Arkona) can be seen as a cloud formation at the horizon line (fig. 4).

If we take into account that an early medieval Arab historical source informs that holes were made in the walls of Slavic temples so that the Sun could be observed during

Fig. 4. Arkona.
Sl. 4. Arkona.

its diurnal journey in the skies[28], then it is apparent that Arkona's temple could not have been better positioned for such solar observations. From this perspective, one can perceive Arkona's temple as a marine sanctuary related not only to the movement of celestial

[26] The connection of this deity with the sun & the sky is present in all Slavic cultures. In the Baltic Slav mythology the sun-deity appears under the name of *Światowit*, *Triglav*, *Jarowit*, while in other Slavic cultures he is known under the name Swarog, Swarożyc (Lat. Zuarasiz). L. Niederle even found an etymological link between these last names and the indo-european names *svar* meaning sun, and *svargas* meaning sky. For details see Jedlicki 1953: 346-348.

[27] Kotlarczyk (1993: 56-64) makes the point by setting each of the carved faces towards that azimuth the sunrise or sundown has during the two annual solstices.

[28] Kotlarczyk 1993: 61. Al-Massudi informs about holes in Slavic temples for observing the sunrays.

bodies but also to the sea. Thus, the spatial orientation system in the early medieval times can be reconstructed as being based on at least four directional points corresponding to modern cardinal points, points which nevertheless were parts of horizon sectors, or arcs.

Time measurement

Another important element in the orientation system was how time was measured. **Reckoning time** after Sun, Moon, and star movements is as old as the beginning of the history of mankind. These celestial bodies were closely observed and their diurnal/nocturnal movements well recorded, especially by the priests, Christians and pagans alike. The periods of light and darkness were divided by Greek and Romans, as well as by other people, in twelve equal parts (Healy 1999: 361). The parts, however, were not equivalent with one hour. To facilitate time calculation, sundials, water-clocks, star clocks, and shadow-tables spread from the Near East throughout the Antique World throughout the centuries, especially during the *pax romana* period.[29] They were used to assess the position of the sun in relation to the observer, who could afterwards divide the horizon in four equal parts along the two major axes: the east-west *decumanus*, and the north-south *kardo* (Chouquer & Favory 1992: 65, 68-76). This allowed the observer to work with a combined notion of time and spatial orientation, without having to use the accuracy of modern time division and spatial orientation.

Since the advent of the Greek method of time computation, the diurnal/nocturnal periods were divided in eight equal parts, three hours each. As in the case with the medieval saga literature, this method of dividing the day and night in 3-hours blocks was spread throughout Europe, being common not only in Viking Age Scandinavia[30] but also in the British Isles[31] and throughout Northern Europe. This method might have been used by Wulfstan and in spite that his account stops at 'days and nights', it actually tells us that that his sailing time was divided according to the Earth's cyclical rotation.

This issue is, however, intrinsically related to the combined time-distance concept, and how was this concept practically measured. The nautical heritage in Scandinavia has the Danish *uge søs* and the Old Norse *viku sjofar* translated directly into English *week at sea*. The ON. *viku* is etymologically related to inlet (Nor. *vik*) and departure (Nor. *vike*). As in the case of Nor. *Lid*, here too there are several meanings such as: shifting, time, and distance. The meaning distance probably came from the time accounted for, and in this case *viku sjofar* reflects a combined time-distance concept similar to Nor. *døgr sigling* ('day sailing') and Nor. *døgr haf* ('day at sea'). Translated in modern parlance, that would correspond to expressions such as *a day walk* or *one hour by car*. 'Day sailing' on the coast of Norway tends to account as double the 'day rowing', that being about 72 Nm distance. Discussions about distances and about distance-time concept were carried out by several

[29] For details of sundials and other time-measuring devices see Schaldach 1998.

[30] Falk (1912: 189) citing from the mythical *Volsungasaga* (12) and the later (10th to 12th c.) *Fornmanna Sogur* (IV, 381) stated that the *eykt* (corresponding to three hour-blocs) was the main time division in Viking Age Scandinavia without detailing how this came into being, and without mention of Southern European time measurement systems. Karlsen (2003: 115, 189-190) uses basic Old Icelandic dictionaries and also the King's Mirror to name the Old Norse division of time: *midnætti*, *ótta*, *midur morgunn*, *dagmál*, *hádegi*, *eykt* (*nón*), *midaftan*, *náttmál*.

[31] The Anglo-Saxon Chronicle notes that in AD 795 a moon eclipse occurred between three o'clock in the morning and dawn (http://sunsite.berkeley.edu/OMACL/Anglo/part2.html)

authors, including A. Næss and R. Morcken (Morcken 1977). Not going into details, it is necessary to stress here the difficulty of reading medieval sailing information dealing with the combined time-distance concept, because one has to conclude how much it is about time, how much it is about distance or how much it is about both.

One short example illustrates this problem: Ohthere said that his voyage along the Norwegian coast from his home place to *Sciringesheal* lasted 30 days. If one accounts for 36 Nm travelled each day, then the total sums up to 1080 Nm, which leads us to figure a route between Tønsberg (near Sciringesheal) and the northern border of growing grain at that time – on western part of Kvaløya in Trøms. Here we are left wondering if he was accounting for distance when talking about time. The main point illustrated here though, is not the distance itself, but the way of thinking in that period. There is a time-distance concept based on a speed assessed as normal. For scientists and other modern-minded persons this is a problem, since the well-known mathematical relationship between speed, distance and time cannot be applied here. In addition, distance was difficult to measure on the open sea at that time. Today, modern sailors use the clock and other devices to calculate the speed, but the mechanical measuring of time is quite a new feature in the history of navigation.

Cognitive mapping

Besides these astronomically-based methods of spatial and time orientation systems, Wulfstan offers in his account plenty of geographic information, which ought to be related to the process of DRAWING A MENTAL MAP OF THE ROUTING. This passage is important, particularly because it strives to describe in few words the geographical sense of the world, the accuracy of spatial distances and perspectives reflected in an early medieval cognition, and besides all the image of the 'mental map' of the Baltic Sea and the surrounding lands that guided Wulfstan (or the navigator in his account) to safe arrival in Truso.[32] The process of drawing such a map, based on existing knowledge, can be described here as a sequential chain:

1. The first task is to recognize peculiar features from the surrounding sea- and landscape as one sailed out of the port *at Hæðum*. Vital for the recognition process is the shape, the location, and the timing each specific feature has within the visual field of the observer. A major role is played here by weather (visibility) and time of observation (day, night).

2. The second step is to transform these land- or seamarks into points of sailing or bearings. For example, the cliff at 135 m high (*Queen's Throne*) on the Møn Island is visible in good weather from 20 km offshore distance, thus being an excellent bearing 'due north' for vessels hugging the eastern coast of Falster.[33] In the same manner, the high cliff at Stævn, on Sjælland, was a visible bearing 'due west' for vessels crossing the Baltic from Scania to Rügen (fig. 5).[34]

[32] For medieval manuscript depictions of 'mental maps' and seafaring perceptions, see J. Flatman, Medieval Perceptions of Maritime Space, http://www.arch.cam.ac.uk/%7Efcs22/register.htm.

[33] For practical observations with the Skuldelev 1 replica, *Ottar*, in the summer of 2004 see Englert & Ossowski report, Wismar Seminar September 2004, in press.

[34] This observation was taken by the author during sailing with *Nidhug* from Scania to Hiddensee in the summer of 1999.

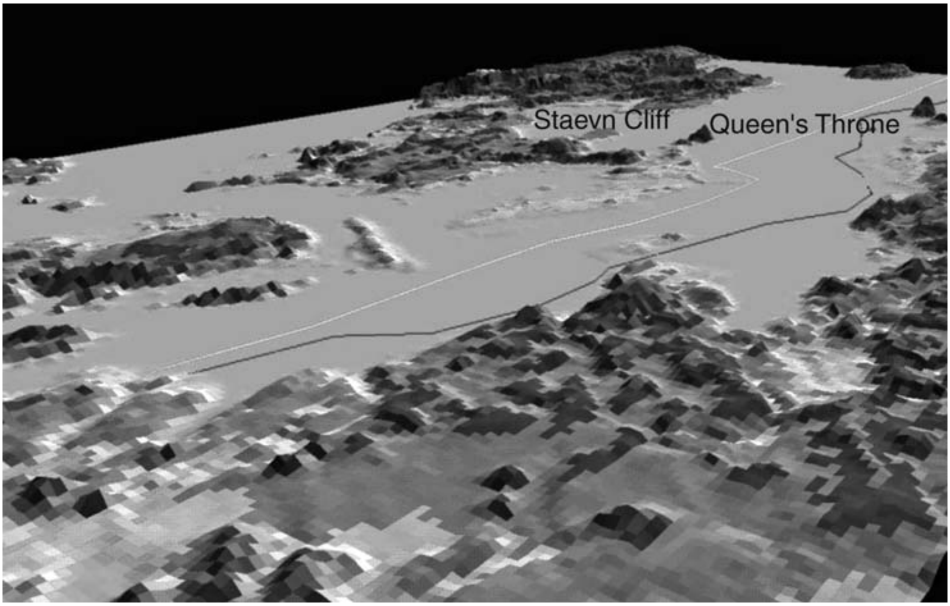


Fig. 5. A 'birds-eye view' towards Scania on a 3D model of Wulfstan's routing in the Western Baltic region.
Sl. 5. Pogled na Skanijo s ptičje perspektive na 3D modelu Wulfstanove trase na področju zahodnega Baltika.

3. The next step is to insert these points of sailing into a more complex and general orientation system based on objective (astronomic observation) and subjective (human instinct) inferences. This system had to be reliable to such an extent, as to enable the navigator to reach the same or nearly-identical result repetitively.

4. The last step is passing the information in a kind of 'mode of transmission' to another person, be it the helmsman from the second watch, or simply the one who would inherit the task of steering ships on that particular route.

In Wulfstan's account, we have actually a changed version of the last step, since his narration has come to be written by a learned scribe from Alfred's entourage. In spite of this added difficulty, one can try to trace back the 'mental map' of the region. Thus, the account states clearly two main seascapes: the area which practically could have been seen from the sailing ship, that is the actual sailing area, and the 'beyond the sailing horizon' area which was not visible but was known to be there. The very existence of this latter part in the historical account is a secure sign that Wulfstan (the navigator) was depicting to Alfred's scribe from his own 'mental map' of the Baltic region. He did not and could not see Möre, Blekinge, Öland and Gotland from the deck of his ship, but he knew they were there somewhere on the port side, north of his route (step 3). Going further back (step 2), one can reasonably assume for all practical purposes that for each mentioned 'land' the navigator had some specific bearings, not mentioned in the text, which nevertheless were used *in praxis*.

Navigation method

The navigation method and type can be deduced first of all from the historical sources, and especially from the comparison between Ottar' and Wulfstan's accounts in

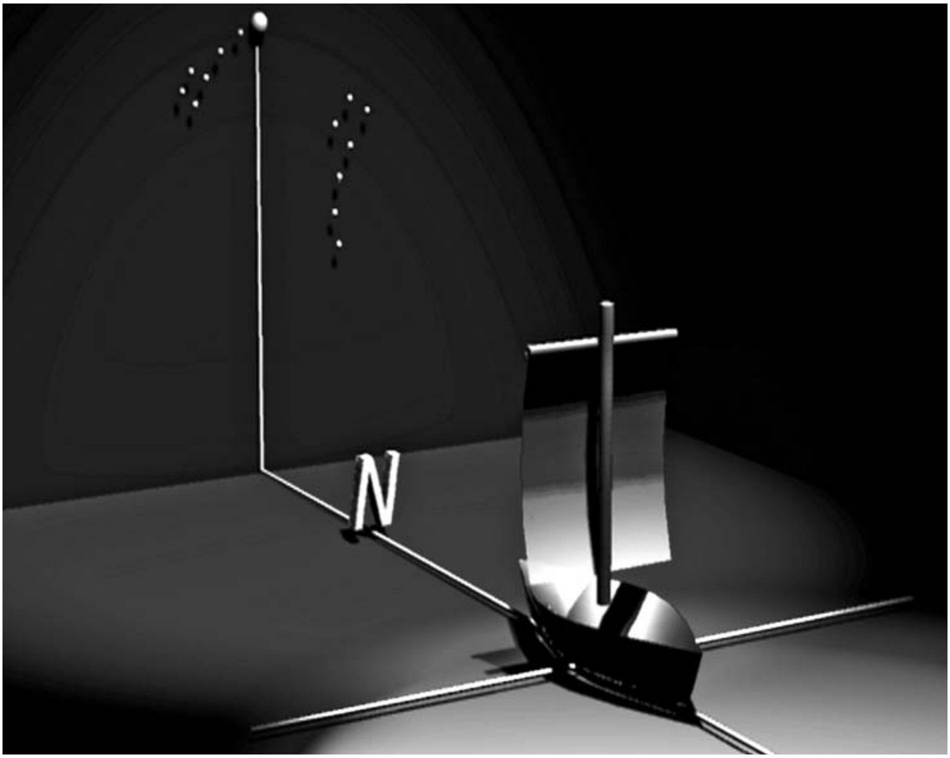


Fig. 6. Astronomical night sailing and direction-finding.
Sl. 6. Astronomsko usmerjanje med nočno plovbo.

Alfred's *Orosius*. There are two types of navigation mentioned in the text: coastal navigation with night-stopping (Ottar's account on sailing along the Norwegian coastlines), and non-stop navigation (Wulfstan's account). The account of Wulfstan, in fact, stresses this by repeating in the text that the ship *wæs ealne weg* sailing. Here, we have one of the earliest and clearest informations that Viking Age voyages were not only pure coastal navigation no matter how often this method was practiced. Another important piece of information hidden in Alfred's text is the expression *yrnende under segle*, which occurs in two more instances throughout the Anglo-Saxon Corpus, once under an entry for year 1046 and a second time in a poem.[35] In both instances the combination of these words means actually driving the ship by sail only, and most importantly running it before the wind. Thus, in our case, one can venture to say that Wulfstan (the navigator) was actually implying that his ship was running with the westerlies under the sail all the way out to the Vistula Mouth Area. This information and the fact that sailing was carried out by day and by night points actually not only to the method of navigation but also to the route Wulfstan may have chosen to sail to destination. By day, he was probably orienting himself after the Sun, the visible landmarks, and other navigational signs known to him, and by night he was using the North Star as a fixed celestial point from which a horizon heading could be deduced in order to position/orient the ship in relation to the four cardinal directions (fig. 6).

[35] J. Bately, pers. comm. Roskilde, September 2004.

Navigation aids: the wooden disc from Wolin

Navigation aids found in the **archaeological context** are very rare, but a recently-found artefact from Wolin seems to posses the attributes of a sundial. Archaeological excavations carried out on the path of the present bridge that by-passes the town of Wolin unearthed in the summer of 2000 a wooden disc at about 2 m ground depth (Stanisławski 2001: 163). The peat and vegetation layer that contained the artefact covered also the remains of two residential structures and remains of shore reinforcements. The double pole-layer of the shore reinforcements showed signs of a wattle construction onto which fragments of ship planks were laid. The first residential structure displayed vertical rows of poles as main structural wall components. The filling between two occupational levels marked by clayish floors contained ceramic sherds of the Menkendorf type, osteological remains of mammals and fish, ship-related fragments (parts of a ships bow, fragments of ship planks, framing treenails, repair laths with rivets), a cultic wooden figurine, fish floats, one Saxon coin, a wooden disc with incised lines, and other metal, wooden, and textile artefacts (Stanisławski 2001: 164). The wood used in the construction of the house and that used in the shoreline reinforcement was dated dendrochronologically to between 935 ± 7 and 1011 ± 9/8 AD, while the secondarily-used ship planks were dated to between 938 ± 7 and 995 ± 9/7 AD (Stanisławski 2000: 164). The dating ranges seem, thus to converge quite well, showing the beginning of the construction before the first half of the 10th c. AD, continued afterwards towards the end of that century into the beginning of the 11th c. AD. The author concluded on the basis of the dendrochronological dating that the house and the shoreline reinforcements were built at the end of the 10th and beginning of the 11th c. AD. The presence of ashes and the thickness of layer nr. 4 made him to assume an occupational period for the entire first half of the 11th c. AD ended by the historically-mentioned attack on Wolin by the Danish king Magnus the Good in 1043 AD. The presence of a Saxon coin, dated to the end of the first half of the 11th c., together

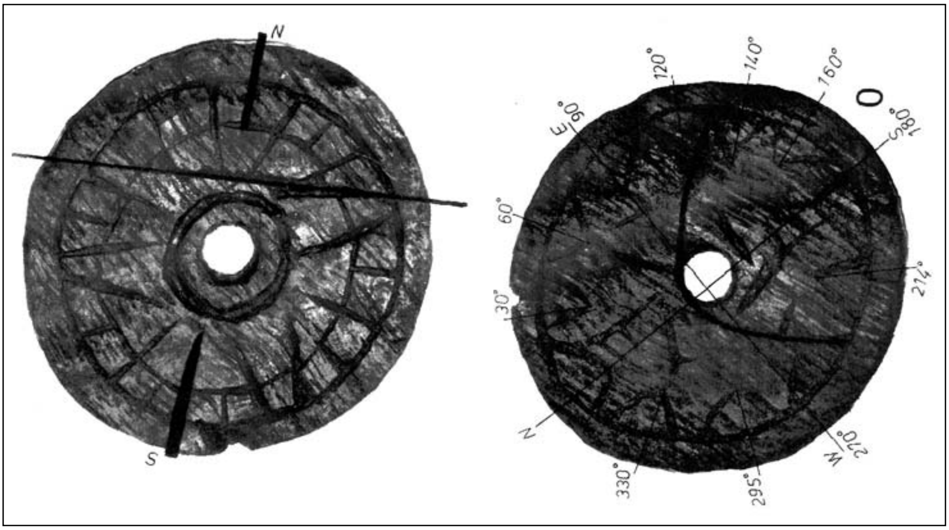


Fig. 7. The wooden disc from Wolin (after Stanisławski 2001: 172-173, figs. 5.7-5.8).
Sl. 7. Lesen disk iz Wolina (po Stanisławskem 2001: 172-173, sl. 5.7-5.8).

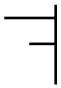
Fig. 8. The replica of the 11th century sundial from Wolin.
Sl. 8. Kopija lesene sončne ure iz Wolina.

with an ornamented fibula (Ringerike style) in the same layer nr. 4 were further arguments for the selection of the end of first half of the 11th c. as the probable date for the wooden disc (Stanisławski 2001: 164-165). The wooden disc, thus, can be said to post-date this dating range, being used after all probabilities within the first half of the 11th c. AD. The fact that the investigator preferred to date the wooden disc at the end of the first half of the 11th c. AD is to be seen as a purely archaeological dating, marking the end of the use of the artefact rather than the time span when the artefact itself was actively used. After consulting several specialists from Sweden and Denmark, B. Stanisławski cautiously interpreted the find as a possible sundial, although he concluded that the main aim of his article was the presentation of the unusual artefact that may become the topic of further analysis and scholarly interest in the future (Stanisławski 2001: 174).

The wooden disc, made of oak, has a diameter of ca 8.3 cm, a thickness of about 0.9 cm (fig. 7). Its irregular circular shape seems to have been more the result of deposition circumstances, than of deliberate wood-carving. The disc has a central hole of about 1 cm diameter that cuts through the disc surface. Both faces show lines of irregular width incised into the disc surface. On one face, named by the investigator face A, there are two concentric circles, the space between them being divided by twenty-four separator lines. The lines can be classified in short- and long-lines; the short ones do not trespass the limits of the inner circle. There is an apparent pattern, where long-lines seem to encompass the shorter ones. However, this pattern is broken in four distinct locations, placed seemingly in opposite directions (up and down, left and right). Stanisławski drew a line through the longest long-line and interpreted it as a gnomon line for equinox time (late March and October). In the same time, he arbitrarily took a long line as the southern indicator and a short line as a northern indicator. He further divided the other face of the wooden disc, designated as face B, in compass degrees and established a short inner line intersected by two shorter lines as the 'north pointer'. On this face, the concentric circles are replaced by a large circle drawn along the disc edges. Triangle apexes were constructed inside this circle by incising shorter oblique lines that join each other in a seemingly regular pattern. There are twelve of such small triangles within the larger circle, but their pattern seems disturbed in at least three locations. The most characteristic line, however, on this face, is a curved line that unites the edges of the large circle, the middle of the curved line being tangential to the centre-hole of the disc. This line was interpreted as a gnomon line for the 60° N latitude (Stanisławski 2001: 173).

The most convincing argument for interpreting the Wolin-wooden disc as a sundial comes from a small experiment with replicating and using the artefact, experiment which was carried out in the summer of 2004 on the island of Møn. Four wooden discs have been set up for this experiment, three 'blanks' and the copy of the Wolin artefact (face B only) (fig. 8). In addition, the bandwidth of a wooden sundial marked at Haithabu, Germany in the same time period was used as a control device. The three blank discs had their central pin set at different heights: the first disc had the pin at 0.6 cm height above the disc face; the second disc had the pin at 0.8 cm above the disc face and the third disc had the pin at 1 cm above the disc face. The experiment was carried out as detailed below:

5:53 am	-	set up the discs at even intervals and levelled with the sea surface.
6:05 am	-	set up disc nr. 1: 4: 0.3 cm pin height
	-	marked shadow at both times
	-	shadow on disc nr. 4 is fully on the disc face
	-	shadow on discs nos. 1, 2, 3 is still on the edge
6:20 am	-	sun azimuth: 75° N
	-	set Wolin copy and Haithabu discs
7:00 am	-	marked shadow on all discs
	-	sun azimuth: 81° N
7:30 am	-	on the Wolin disc-copy the pointer end is at intersection between the curve of the gnomon shade and the first zigzag line to west
8:00 am	-	marked shadow length on all discs
	-	the shadow length touches now the range line drawn on the Haithabu disc
	-	sun azimuth: 93° N



This incised sign (above) cannot be a 'North pointer' for the Wolinian disc-copy. If oriented to point North, then the line shown below does not point to East.

The pin shadow jumps over to the 'northern' side of the curve.

9:00 am	-	marked shadow length on all discs
	-	Wolin disc is asymmetric: shrinkage and deformation seems to have taken their toll after more than 1000 years in the wet ground
	-	sun azimuth: 95° N
10:00 am	-	marked shadow length on all discs
	-	sun azimuth: 116° N
11:00 am	-	marked shadow length on all discs
	-	sun azimuth: 119° N
	-	Wolin disc-copy has the end of the shadow right on the incised curved line
	-	disc nr. 4 has shadow in the edge of the hole

12:00 am	-	marked shadow length on discs nos. 1-3
	-	Wolin disc-copy has shadow on incised curved line
	-	sun azimuth: 150° N
1:00 pm	-	marked shadow length on discs nos. 1-3
	-	Wolin disc-copy has shadow on incised curved line
	-	the shadow on disc nr. 4 is in the pin-hole
	-	sun azimuth: 177° N

The tip of the pin shadow was marked, thus, on all blank discs in the same timing sequence. That enabled the drawing of radial lines of sight through all the shadow points before noon (fig. 9). These points were, afterwards, united through a continuous line and the discs were partitioned by a permanent North-South axis (fig. 10). The last step in the construction of the experimental sundial was the extension of the gnomon line on the other shadow points in the afternoon, and the marking of daytime hours at the end of each radial line (fig. 11).

The experiment has shown further that there is a relationship between the pin height (H) and its diameter (D). If pin height is less than pin diameter H<D (0.3 cm<0.5 cm), then the end of the pin shadow around noon time sinks in the pin's hole. If pin height is greater than the pin's diameter H>D (1.7 cm>0.5 cm) (the case of the Haithabu disc), then the shadow will trespass the disc edges. The optimal height of the pin was shown to be at 1 cm for a pin diameter D of 0.5 cm. From this relationship, there is the ratio H – D of 2:1 or lower.

Based on these considerations, one can analyse further the wooden disc from Wolin. The Wolin disc has a hole with a diameter of 1.1 cm, but for the dimensions of the disc (diameter of 10.9 cm) this hole-diameter is too large since the pin ought to have been as high as its diameter in order for the shadow to be kept out of the pin's hole. But it could not have been too tall in order not to trespass the disc edges. The only possible explanation is that the diameter of the centre-hole on the Wolin disc shows the diameter of the base of the pin and not the diameter of its pointer end.

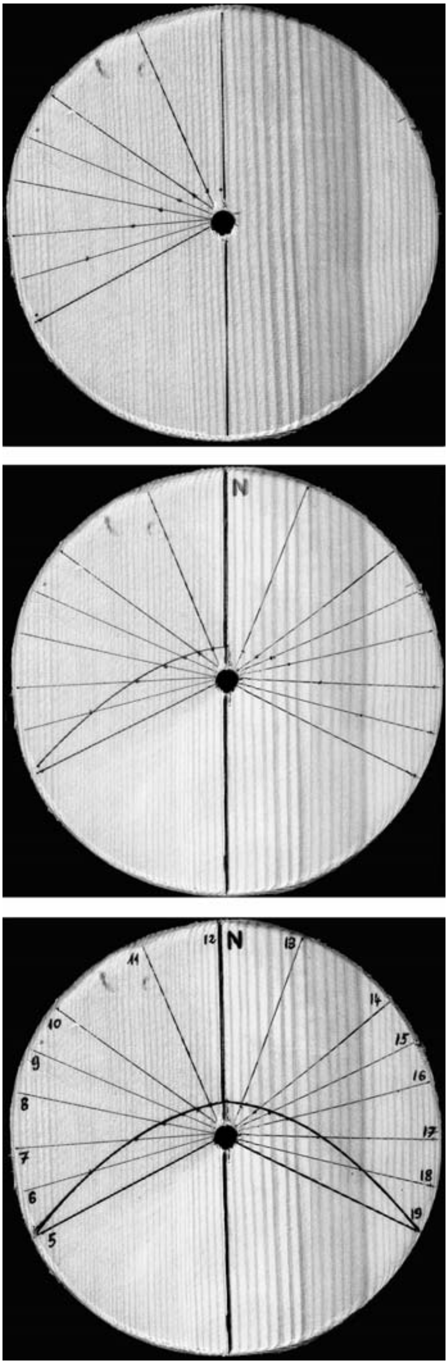
The experiment has shown that the curved line on face B of the Wolin disc corresponds with the trail of a gnomon shade for the 55° N latitude for the month of July. The time of the year corresponds with earlier estimates, but the latitude has changed. The curved line on face B of the Wolin disc is a gnomon curve that matches a solar band at the end of July on or around 55° N latitude. This confirms that:

1. the disc is a sundial

2. the disc has been manufactured and used in the Baltic and possibly the North Sea for non-stop voyages on the same latitude.

3. the 12 tacks on the face A could be orientation marks which divide the horizon in 4 quarters each with 2 bearing tacks within major cardinal points. In this case, the 12 tacks carved along the edge of the disc might, represent sectors of horizon.

The experiment points also to another interesting detail. Observations for this experiment were made at the position of 54° 57.921 latitude N and 12° 33.157 longitude E. The 55° N latitude line, which crosses not far from this point, has an interesting geographic incidence with known historical places related to navigation and seafaring (fig. 12).



Figs. 9-11. Sequential steps in replicating a sundial for the 55 ° N latitude.
Sl. 9-11. Zaporedni koraki posnemanja sončne ure pri 55° severne geografske širine.

The line passes through the mouth of Tyne on the eastern coast of England, through Aabenraa, Svendborg on the southeastern coastline of Fyn, Vordinborg on Sjaeland, Møn, the southernmost tip of Bornholm, it crosses just above the Sambian landspit, and touches the Dniepr River near Smolensk. All these areas are connected with seafaring activity both in the Viking Age and in the Middle Age. Some activity can be ascribed to the Scandinavian Vikings, but it should be stressed here that not all Viking Age seafaring activity needs to be connected to ethnic Scandinavians. The Newcastle upon Tyne lies south of the Holy Island, an area that witnessed the earliest documented piratical activity ascribed to the *Northmen*, the people from Scandinavia. The monastery at Lindisfarne, located on this island, experienced towards the end of the 8th c. AD the destructive action of Viking piratical actions, and the whole region was within the action range of the Viking fleets reaching the British isles.

In the Danish archipelago, both Svendborg and Vordinborg became during the High Middle Ages strategic locations from which offensive actions were taken against the Wendish Vikings. The isle of Møn is one of the Danish isles where Wendish settlements were established. On Bornholm, which constituted a landmark for the Baltic shipping on the east-west axis at all times, the latitude line passes just south of the southernmost tip of the island where a concentration of Viking Age settlements and burial grounds with Slavic artefacts have been excavated (excavations at and near Grødby). The line passes also along the Sambian landspit, which was a landmark for reaching the rich amber grounds of the pagan Prussians, while Smolensk is well-known for its trading importance in the early medieval times. Its Viking Age predecessor was the settlement complex from Gnezdovo with its ten burial grounds ex-

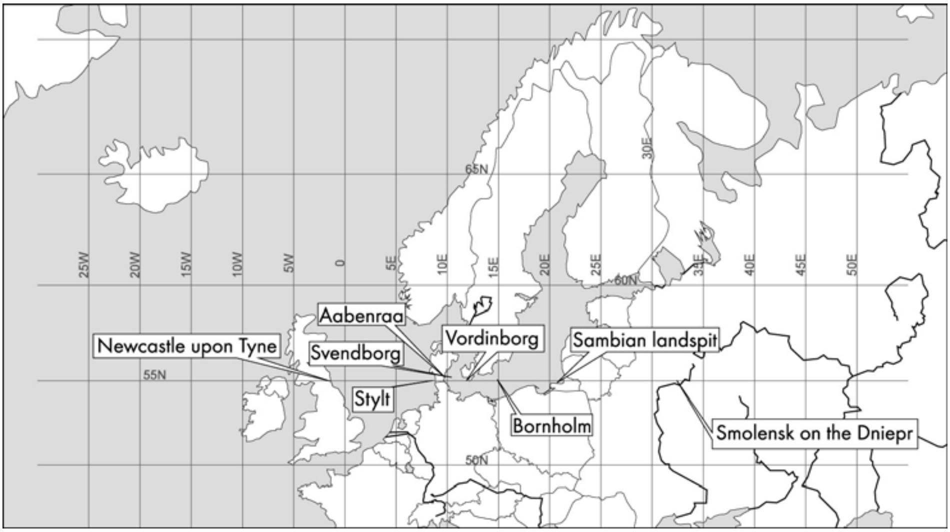


Fig. 12. The 55° N latitude line across Northern Europe.
Sl. 12. Črta 55° severne geografske širine po severni Evropi.

hibiting thousands of burial mounds. Stalsberg counted at least one hundred burials with Scandinavian grave goods, half of which she counted as Scandinavian. Among these, she included a simplified list of eleven graves with incinerated graved-boats, all dated to the 10th c. AD (Stalsberg 1999: 437, 444-448). Although it is not certain that the dead incinerated with or in these boats were ethnic Scandinavians, the simple presence of these features point to the multifaceted cultural environment at the Upper Dniepr in those times. Coupled with this, one should note that the Dniepr was the main 'highway' for voyages headed towards the Black Sea and the magnificent Byzantine capital, Constantinople. The 55° N latitude line, thus, seems to be rather vital for communication and transport where navigation played a major role on the east-west axis on both the Northern and the Baltic Sea, as well as on mainland Russia. Thus, a sundial fashioned for this latitude should not be seen as an exquisite article since long-distance sailing actually depended on making as less contact with land as practically possible.

The sundial from Wolin should be seen also in the context of other finds in order to give an idea about the possibility of instrumental navigation in the Viking Age Baltic Sea area. These finds, all made in the Oder Mouth area consists of :

1. the miniature wind-vane from Menzlin dated approximately to the 10th c. AD (Lamm 2002: 57-63).

2. Adam of Bremen's *olla vulcani*, the unique 'lighthouse' from Wolin running on 'Greek fire' dated to the 11th c. AD is an example on how night navigation might have been made safer in the Southern Baltic (Filipowiak 1985: 91-102).[36]

These two finds coupled with the wooden sundial from Wolin, seem to point again to the importance of the Oder Mouth Area for the navigation and long-distance seafaring in the Viking Age. In addition, these finds altogether indicate that navigation in that period

[36] For its navigational purpose, see Indruszewski 2004: 110.

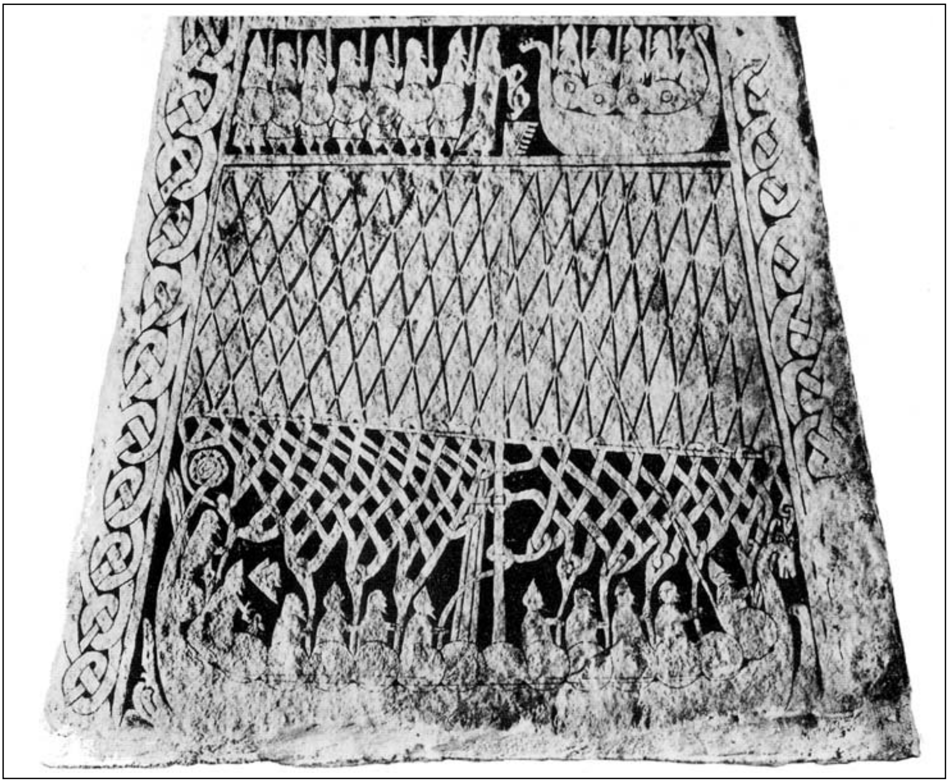


Fig. 13. The Stenkyrka runic stone (after Lindquist 1941, fig. 97).
Sl. 13. Runski kamen iz Stenkyrke (po Lindquistu 1941, sl. 97).

was an art based on human senses and cognitive estimates of an orientation system that took advantage of stored knowledge about celestial bodies, landmarks, and other navigational benchmarks employed at sea or during inland navigation.

Conclusion

The progress made in navigation and spatial orientation ought be related directly to the progress made in the introduction and performance of sailing technology in the Central Baltic area from the 8th c. AD onwards. The unique ship representations carved on the Gotland runic stones stand as a conclusive argument. The windvane from Stenkyrka Smiss 1 (fig. 13), the bowline from Lärbro St. Hammars 1 and Hejnum Riddare, the tacking boom depicted in Klinte Hunninge 1, and the general trend in the sail aspect ratio *Ar* are all indicative of the technological development that happened sometime between the 8th and the 10th c. AD (Indruszewski 2001: 261-269). Although the dating of these ship representations still remains a debatable issue, they clearly show that navigation and sailing in the Viking Age Baltic Sea were greatly influenced by the introduction of sail as a major method of propulsion. In other words, the discovery of a sundial in Wolin matches in terms of navigation the progress made by the introduction and the use of sail in sailing, both items being indispensable for long-range travel at sea. It seems that the 8th

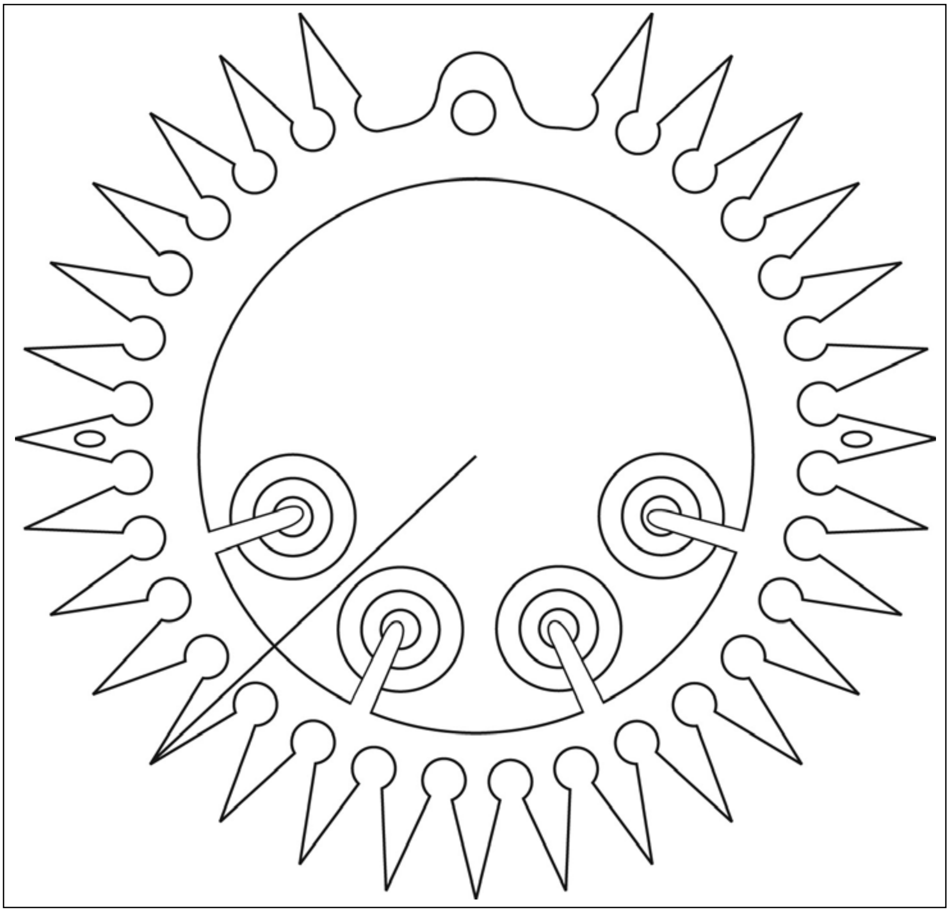


Fig. 14. Metal disc from Ile de Groix (after Müller-Wille 1970: 192).
Sl. 14. Kovinski disk z Ile de Groixa (po Müller-Willeju 1970: 192).

through the 10th c. AD was the period when long-distance sailing transformed the Baltic Sea into a veritable communication and transportation hub. This trend does not seem specific only to the Baltic, but can be also perceived from everywhere around Europe, starting with the Byzantine and Arab seafaring in the Mediterranean and ending with the Viking raiding and conquest in the British Isles, Normandy and Ireland. The seafaring activity in the latter area has left also traces similar to that found in Wolin. The best example comes from the Gulf of Biscay, specifically from the *Ile de Groix*. Besides the incinerated ship-remains of hundreds of rivets and nails from the 10th century burial ground, the isle came to be known also for the discovery of a metal disc (Müller-Wille 1970: 192) that presumably represents a sundial with four concentric circles symbolizing the sun at different positions during its diurnal trajectory (fig. 14). These artifacts come to complete an entire range of archaeological artifacts, historical information, and linguistic evidence that point altogether that Slavs, Scandinavians, Balts, and other people engaged in long-distance travel on sea and land during and after the Viking Age (8th through 11th c. AD) possessed a multifaceted knowledge of their natural environment including the movement of stars and of the sun. This knowledge left seemingly imprints in the mythological and supernatural beliefs, as well as in the mundane vocabulary of modern languages. People of that time were more inclined to use the natural means at their disposition to orient themselves spatially than the modern man and the scholarly circles of today like to think of. In fact, the use of the sun during the daylight and of the stars during the night time for marking time and spatial location continued throughout the Middle Age up to the modern times, when sundials were displaced by clocks and other time-keeping devices. In this respect, it is perhaps not incidental that Olaus Magnus'es historical information from the mid 16th century on the use of the magnetic compass in Northern Europe is utterly confusing (Seaver 2001: 235-254), since it reverberates a situation when Late Medieval navigators were relying more on their sundials for orientation at sea than on the 'relatively-new' magnetic compass.

Bibliography

Barfod, J. H. P. 1981: Navigation. *Kulturhistorisk Leksikon for Nordisk Middelalder*. Viborg. 260–263.

Binn, A. L, 1972: Sun Navigation in the Viking Age, and the Canterbury Portable Sundial, *Acta Archaeologica* XLII, København, 23–34.

Chouquer, G. & F. Favory. 1992: *Les Arpenteurs Romains. Théorie et pratique*. Paris.

Christensen, A. E. 1993: Vikingernes Verdensbilde, skipsbyggning og navigasjon. Norsk Sjøfartsmuseum Årsberetning 1992, 151–164.

Crumlin-Pedersen, O. 1983, Skibe, sejlads og ruter hos Ottar og Wulfstan, in J. Skamby-Madsen ed., *Ottar og Wulfstan, to rejsebskrivelse fra vikingetiden*, Roskilde, 32–44.

Falk, H. 1912: *Altnordisches Seewesen*. Heidelberg.

Falk, H. & A. Torp, 1996: *Etymologisk ordbog over det norske og det danske sprog*. Oslo.

Filipowiak, W. 1985: Garnek Wulkana, najstarsza latarnia morska nad Bałtykiem w XI wieku. *Nummus et Historia*, 91–102.

Franz, M. O. & H. A. Mallot, Biomimetic Robot Navigation. In T. Arai, R. Dillmann, T. C. Henderson, eds.) *Robotics & Autonomous Systems*, vol. 2, Issues 1–2, 133–153 (internet summary at http://www.wordiq.com/definition/Navigation_research)

Haasum, S. 1974: Vikingatidens segling och navigation. *Theses and Paper in North European Archaeology*. Stockholm.

Hagland, J. R. 2002: Landnåmabok etter Hauksbók. Stavanger.

Healy, J. F. 1978: *Mining and Metallurgy in the Greek and Roman World*. Thames & Hudson London.

Hollander, L. 1962: transl. *The Poetic Edda*. Austin.

Indruszewski, G. 2001: Technical Aspects of sail representations on Gotland's runic stones: a non-parametric approach. In E. Wilgocki *et al.* (eds.). *Instantia est mater doctrinae*. Szczecin, 261–269.

Indruszewski, G. 2004: *Man, Ship, Landscape. Ships and Seafaring in the Oder Mouth area AD 400–1400. A case-study of an ideological context*. Copenhagen.

Jedlicki, M. Z. 1953: *Kronika Thietmara. Biblioteka tekstów historycznych* 3. Poznań.

Jesch, J. 2001: *Ship and men in the late Viking Age: the vocabulary of runic inscriptions and skaldic verse*. Woodbridge.

Karlsen, L. K. 2003: *Secrets of the Viking Navigators. How the Vikings used their amazing sunstones and other techniques to cross the open ocean*. Seattle.

Kasprzycka, M. 1999: Tło paleogeograficzne osadnictwa Żuław Elbląskich w pierwszym tysiąclecia naszej ery. In P. Urbańczyk (ed.) *Adalbertus – Tło kulturowo/geograficzne wyprawy misyjnej św. Wojciecha na pogranicze polsko-pruskie*. Warszawa, 7–185.

Korhammer, M. 1985: The orientation system in the Old English Orosius: shifted or not? In N. Lapidge & H. Gueuss (eds.) *Learning and Literature in Anglo-Saxon England*. Cambridge, 251–269.

Kotlarczyk, J. 1993: W poszukiwaniu genezy wielotwarzowych wyobrażeń Światowita, Świętowita, Rujewita i innych. In M. Kwapiński & H. Paner, Wierzenia przedchrześcijańskie na ziemiach polskich. Gdańsk, 56–64.

Lamm, B. 2003: Die wikingerzeitliche Miniaturwetterfahne aus Menzlin. Bodendenkmalpflege in Mecklenburg-Vorpommern Jahrbuch 2002, Band 50. Lübstorf, 57–63.

Larsen, S. 1975: *Vikingernes hav*. København.

Lindquist, S. 1941–1942: Gotlands Bildsteine, Kungl. Vitterhets Historie och Antikvets Akademien, Uppsala.

Marcus, G. J. 1953: The Navigation of the Norseman. *Mariner's Mirror* 39, 112–131.

Mixter, D. 1979: *Primer of Navigation*. New York.

Morcken R. 1977: *Veien mot nord*, *Sjøfartshistorisk Årbok* Bergen 1977, 334–379, Bergen.

Müller-Wille, M. 1970: Bestattung im Boot. Studien zu einer nordeuropäischen Grabsite, *Offa* 25/26: 7–203.

Næss, A. 1954: *Hvor lå Vinland*. Oslo.

Ramskou, T. 1969: *Solstenen – primitiv navigation i Norden før Kompasset*. København.

Ramskou, T. 1982: *Solkompasset*. København.

Schaldach, Kh. 1998: Römische Sonnenuhren. Eine Einführung in die antike Gnomonik. Frankfurt a. M. (Harri Deutsch).

Schiffer, M. B. & J. M. Skibo, 1987: Theory and Experiment in the Study of Technological Change. *Current Anthropology* 28 (5): 595–622.

Schnall, U. 1975: Navigation der Wikinger. *Schriften des Deutschen Schiffahrtsmuseums* 6. Oldenburg, 5–207.

Seaver, K. A. 2001: Olaus Magnus and the 'Compass' on *Hvitsark*. *Journal of Navigation* 54, 235–254, Cambridge University Press.

Stalsberg, A. 1999: Skandinaviske båtgraver fra vikingetiden i Rus'-riket: oversikt og tolkning, *AmS-Rapport* 12B, 419–450, Stavanger.

Stanisławski, B. 2001a: Wczesnośredniowieczna ceramika słowiańska oraz bałtycko-wendyjska z Wyspy Bornholm, *Materiały Zachodnio-Pomorskie* XLVI, 107–123.

Stanisławski, B. 2001b: Dysk drewniany z Wolina jako kompas słoneczny – następny krok w badaniach nad wczesnośredniowieczną nawigacją? *Materiały Zachodnio-Pomorskie* XLVI, 157–177.

Sølver, C. V. and G. J. Marcus. 1958: Dead reckoning and the ocean voyages of the past. *Mariners' Mirror* 1/44, 18–34.

Taub, L. 2003: *Ancient Meteorology*. Routledge. London and New York.

Taylor, E. G. R. 1958: *The Haven-Finding Art – A History of Navigation from Odysseus to Captain Cook*. London.

Thirslund, S. *Træk af Navigationens historie – Fra oldtiden til 1530*. Helsingør.

Thirslund, S. 1995: *Viking Navigation*. Humlebæk.

Wagnkilde, H. 2001: Slawische Relikte in Bornholmer Gräbern aus der Zeit der Einführung des Christentums im 11. Jahrhundert, in C. Lübke (ed.) Zwischen Reric und Bornhöved. Die Beziehungen zwischen den Dänen und ihren slawischen Nachbarn vom 9. bis ins 13. Jahrhundert, Stuttgart, 57–77.

Waters, D. W. 1958: *The Art of Navigation in England in Elizabethan and Early Stuart Times*. London.

Winner, M. 1998: *Kompendium i Vikingetidens Navigation. Roskilde. Manual for use in the Museums Course Centre*. Unpublished. Roskilde

Pomorske spretnosti in zvezdoslovno védenje v vikinškem času na Baltiku

George Indruszewski (Viking Ship Museum, Roskilde, Denmark) and
Jon Godal (Rissa, Norway)

Človekovo prostorsko orientacijo na morju v zgodnjem srednjem veku severne Evrope so v večini 20. stol. z večjim ali manjšim uspehom premlevali znova in znova. Širok spekter hipotez in rešitev so ponujali tako mornarji kot zgodovinarji, arheologi, ladjedelci in drugi zainteresirani znanstveniki. Vrteli so se predvsem okoli sprejetja ali zavrnitve navigacije z inštrumenti, glede na uporabo znamenj v pokrajini in nebesnih teles za določanje položaja in iskanje smeri na morju. Leta 1948 so v Uunartoqu na Grenlandiji našli leseni disk z gravurami (*sl. 1*). Nekateri raziskovalci in mornarji so ga razlagali kot sončno uro. To je sprožilo ostro debato. Taka razlaga je odprla možnosti za drugačen pogled na orientacijo na morju.

Članek prikazuje orientacijo na morju v povezavi z arheološkimi, zgodovinskimi, jezikoslovnimi podatki in novimi spoznanji, ki jih je prispevala eksperimentalna arheologija. Morjeplovci iz vikinških časov so se ne glede na etično pripadnost s svojimi ladjami klatili po Baltiku in se orientirali s pomočjo nebesnih teles, kot sta sonce in Severnica. Besedišče večine skandinavskih in slovanskih jezikov obsega izraze, ki se nanašajo na merjenje časa in na točke, ki omogočajo orientacijo v prostoru glede na položaj sonca, kar nakazuje, da so zgodnjesrednjeveški mornarji uporabljali enovito predstavo o prostoru in času, ki je danes skoraj povsem zatonila v pozabo. To "skrito" védenje se odraža tudi v arheoloških najdbah, ki se navezujejo na poganska verovanja baltskih Slovanov, posebno na prostoru najpomembnejšega svetišča v Arkoni (*sl. 4*) na Rügnu. Njegova lega kaže, da je bil njegov kultni pomen neločljivo povezan z določeno ravnijo zvezdoslovnega védenja, ki je v vsakdanjem življenju lahko služilo tudi plovbi na velike razdalje. Uporabo zvezdoslovnega védenja nakazujejo tudi skandinavski poznosrednjeveški zgodovinski viri, za katere se zdi, da predstavljajo mešanico evropsko-krščanskega védenja o orientaciji v prostoru in času ter zgodnejšega izročila, ki odseva v mitološki temi *Ginnungagapa*, prvobitega kaosa.

Arheološki dokazi, še posebej odkritje graviranega lesenega diska iz 11. stol. v zgodnjesrednjeveškem trgovskem središču v Wolinu na Poljskem (*sl. 7*), krepijo vtis, da so tako v vikinšem času kot po njem na Baltiku uporabljali astronomsko orientacijo in z njo ustvarjali duševne, miselne zemljevide, ki so pomagali mornarjem v sicer večinoma nepismeni skupnosti, da so se znašli. Disk je postal predmet proučevanja leta 2004, ko so izdelali kopijo in jo preizkusili na danskem otoku Møn. Članek opisuje rezultat poskusa (*sl. 8-11*), in kaže, da leseno ploščico iz Wolina v resnici lahko razlagamo kot sončno uro, ki so jo uporabljali pri navigaciji vzdolž 55° severne geografske širine (*sl. 12*). Ta vzporednik je prikazan, ker zajema področje, kjer so delovali Vikingi – oznako avtor uporablja kot opisno in ne etnično ime – večino vikinškega obdobja (8. do 11. stol.).