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PRINCIPLES AND PROGRESS IN THE SHIPBUILDING PART OF THE EU INTERREG DTP PROJECT "LIVING DANUBE LIMES"[#]

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In the article, the reconstruction of a Roman lusoria named "Danuvina Alacris" is first embedded in the field of ancient navigation and shipbuilding in general, then in ever narrower circles in Roman navigation, inland navigation, navigation on the Rhine and especially on the Danube. Then the basics of reconstruction, the reconstruction plans based on them, the construction schedule and the place of construction are described. In the second part, the progress of the construction according to Roman craft methods is discussed as well as the parallel actions developed within the frame of the Living History Principle. The progress of the construction is demonstrated until the submission of the manuscript, that is, 24 January 2021.

Keywords: Mediterranean and Gallo-Roman construction, Lusoria, Danuvina Alacris (DUC), Fridericiana Alexandrina Navis (F.A.N.), scientific tests: encaustic painting – sail types – rowing with historical oar suspension, Roman craft, shipbuilding, shield construction, kiln construction, Living History

1. SHIPBUILDING

1.1. ROMAN SEAFARING

When the Romans began to build ships on behalf of the state during the First Punic War, the states and peoples around the Mediterranean had long been building with the Mediterranean boat-building types that were still common in Roman imperial times. When the Romans had previously gone to sea, they made use of the ships of the confederates – for example when crossing the straits from Italy to Sicily.

The rise of Rome as a world power, though, is synonymous with the possibility of the rising power on water. This was achieved in the First Punic War by copying the stranded Punic ships (but certainly also with purchased boat-building know-how). Here, in particular, the Carthaginian tongue and groove construction method was copied, which was certainly not invented by the Carthaginians/Phoenicians (contrary to ancient statements).[1]

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[1] Bockius 2007. 48ff.

It is characteristic that the Roman as well as the Carthaginian boat-building tradition was completely in the lines of the Greek-Hellenistic seafaring tradition. This had long since left behind the sole ramming purpose of the trireme and had moved on to the tetreres and penteres (etc.), in which several oarsmen operated one oar. Long-range weapons were mounted on these larger ships, so that the use of warships had greatly expanded. While the warships were not designed for high seas but rather for shipping close to the coast, the civilian ships, especially those intended for trade and transport, were equipped for high seas for long-distance trade. As a rule, however, ancient shipping was normally coastal shipping, also because of the lack of nautical means (compass, telescope). By the beginning of the 2nd century BC, Roman shipping was increasingly superior to its Hellenistic competitors, so that by the middle of the 2nd century at the latest, one could speak of Roman maritime supremacy, which could also outstrip maritime trading cities such as Rhodes. At the same time, the regulations, for example, on the setting back of Rhodes after 168 BC, were not always to the advantage of maritime safety, for with the disappearance of the local maritime power, which also fulfilled a police function, the control over the coastal stretches, that were difficult to survey, no longer existed. Since then, piracy had flourished, which Pompey was only able to eliminate a century later.[2]

Area-wide control was therefore also difficult for Roman naval supremacy to achieve in the long term, unless the mainland was also clearly under Roman control. This only happened with the political-military control of all countries around the Mediterranean after Octavian's victory over his rival at Actium. This naval "decision" is symptomatic of the epoch-making clash of two different principles of naval warfare. The defeated party of the Egyptian–Roman alliance fleet offered the last achievements of the Hellenistic naval warfare tradition, which consisted of heavy units with ten rows of oars and more. Victorious was the fleet under the leadership of Agrippa, which relied on the smaller, more mobile units (Liburnians), which had rows of oars of 2–4, max. 6 rows. These also made the running afterwards, after the victory of Augustus, after the elimination of any competition and because of the subsequent period of peace. Since then, the fleets were concentrated in large ports, for the east with the supreme command in Ravenna, for the western Mediterranean in Misenum near Naples. Other subordinate stations, also on the Rhine and the Danube, controlled the inland rivers and lakes. With the political-military control of the entire Mediterranean area, the development of naval warfare came to its end. The fleet guaranteed the security of maritime trade, the transport of men and material and controlled the "wet" borders.[3]

[2] Dreyer 2007.

[3] Bockius 2007. 48–51.

1.2. ROMAN SHIPBUILDING TRADITIONS

The Romans absorbed and carried on effectively the shipbuilding traditions of the Mediterranean. With the expansion of the Roman Empire, local traditions of the Mediterranean were adopted, but also those of Mesopotamia and the regions north of the Alps.[4]

A distinction must be made between these and the construction methods documented in the areas east of the Rhine, for example at the Danish Nydam Moor.[5] Here, the clinker construction method is found, which will later be successful in the Viking boats. In contrast, the Mediterranean construction method is caravel. The hull is smooth and the planks are butt-jointed.

There is much evidence for this. We focus on two of the boat types that are best preserved in the region north of the Alps, in Manching and in Mainz.[6] The older version clearly belongs to the Mediterranean building tradition. The find from Oberstimm near Manching on an old tributary of the Danube (Breitlach) belongs, dendrochronologically dated, to a period around 100 AD. The boats were abandoned for an unknown reason and used to fortify the fort mole. Excavation work in the 1980s revealed the wrecks of the two boats, which were lifted in the 1990s and conserved in Mainz. A museum for the Celtic finds of the oppidum and the two Roman boats was then built in Manching on the site of the Celtic oppidum. The excavator was Claus-Michael Hüssen, Olav Höckmann was initially responsible for the boats. The scientific documentation was presented by R. Bockius in 2002. Important for our context is the construction according to the Mediterranean tongue and groove method. As after the finding from Oberstimm, wreck II, currently in the Celtic-Roman Museum Manching, the boat was reconstructed in 2017/2018 (F.A.N.). Grooves were cut out every 30 cm and oak springs inserted. It is locked in place by oak pins driven into the sides, about 6 cm long. The planking was done with pine and the robust side bracing (ribs) and longitudinal stiffening was done with oak.

The archaeological evidence for the later type of boat, which is also the best preserved in Germany, is found in Mainz. During the laying of the foundation stone for a sales building (Hilton) near the banks of the Rhine, several boat wrecks came to light in the 1980s, some of which, especially the almost contemporary wrecks I and V according to the later evaluation (in the Mainz Museum of ancient seafaring), can be assigned to the late antique boat type *lusoria*. The excavation was led by Olav Höckmann, who also made the first interpretations regarding an assumed original length. R. Bockius (2006) then undertook a revision and ultimately the most reliable and last publication for all the finds from Mainz. These ships were part of a Celtic-Roman building tradition – in contrast to the ship types of the older Roman period (the first and second centuries) in Oberstimm, which are clearly indebted to the

[4] Bockius 2007; Bockius 2013.
[5] Bockius 2013a.
[6] Bockius 2002 and Bockius 2006.

Mediterranean (Adriatic according to Bockius) building tradition. Therefore, the younger, Late Antique finds belong to a local building tradition. Local means that these finds can be traced back to traditions that were known in the Celtic area long before the Romans arrived. Roman rule made use of these local traditions – as in other parts of the empire – and, through the new possibilities for communication, also opened up opportunities for knowledge transfer.

The topic of transfer is currently the subject of much discussion in research, since it can be verified that similar craft methods were used along the long-distance trade routes of antiquity.[7] At first glance, this is astonishing, since craftsmanship is usually very conservative and exclusive, i.e. it tends to be constant and then also locally reduced through the transfer from father to son, if only to be able to profitably use recipes for success.[8]

Thus, Caesar[9] already made acquaintance with the Celtic shipbuilding tradition on the Channel coast during his conquests in Gaul. Even though he may have had to contend with misunderstandings,[10] he characterises the enemy boats in brief strokes in the same way as they would have to be distinguished centuries later in Roman times and according to the finds from Mainz. In contrast to the Roman counterparts, Caesar emphasised the robust construction, the manufacture from oak and the connection with iron nails. While his own Mediterranean ships were lighter and more nautical, the Celtic Venetians were convincing with their robust vehicles, which the Roman commander attributed to the harsher weather conditions.

Such observations are important evidence of an attitude towards foreign achievements, which is a prerequisite for the transfer of technology. And clearly, elements of Roman craft know-how also flow into the late antique *lusoria* – while preserving the typical elements.[11] Whereas in the early and middle imperial period Roman military obviously still drew their boat-building know-how from the Mediterranean,[12] the late Roman army fell back on local building traditions in the same boat category,[13] because the reference to skills was "closer" and because the construction method was easier. These boats were mass-produced and had to be manufactured quickly for the range of uses. For long distances upriver, people will have weighed up anyway, whether these distances were covered with muscle power (main form of propulsion:

[7] Bockius in an upcoming article on the F.A.N. building and testing; Bockius 2009.

[8] E.g. Zimmer 1982.

[9] BG 3,16.

[10] For example, with regard to leather sails; however, linen sails are also red, dyed like leather, if treated appropriately. On the other hand, tents can also be made of leather, thus also withstanding the weather. Often no clear distinction can be made between sails and tent fabrics. Even today, craftsmen are working in both sections.

[11] Bockius 2013.

[12] For in the rarest of cases ships will have been transported from the Mediterranean via the river systems to areas north of the Alps; rather, as can also be proved in Oberstimm via the analysed timbers, the ships were built locally: Bockius 2002.

[13] As was also the case with other military techniques.

oars) alone, or associatively with sails or by towing, if new boats were not built immediately further upriver.

In contrast to the earlier counterparts in Oberstimm, we do not have any fully preserved wrecks available in the case of the *lusoriae* from Mainz.[14] While wreck V was almost completely preserved at the time of the discovery and before the lifting, this finding was lost in distance of 8 m from the prow. In the reconstruction, we now have to consider two wrecks (I and V), each preserved to 8 m, from the stern (wreck I) and from the bow (wreck V): thus we have almost the original length of about 18 m. Nevertheless, this is a methodological problem, because even if they are contemporary and similar in construction, they stemmed originally from two different ships. Thus, because of these uncertainties, there has also been a heated discussion regarding the total length to be estimated.

While Höckmann, after various attempts, finally arrived at a length of 21.5 m (initially he too had arrived at a length of about 18 m), Bockius settled on a length of the two wrecks of no more than 18 m.[15] The different reconstructions have also led to different replicas. The first replica of Regensburg, under the constructional direction of Matthias Helterhoff and still under the supervision of Olav Höckmann, was still 21.5 m long.[16] The replica in the Mainz Museum of Ancient Shipping was built according to the same ratio. The two other replicas, the one in Germersheim again under the supervision of the boatbuilder Matthias Helterhoff[17] and the one in Xanten, which is not yet finished, under the supervision of the boatbuilder Kees Sars were made according to the reconstructive line drawings by R. Bockius (2006).

While the longer version of almost 22 m poses ship geometrical problems, the line drawings from Bockius 2006 seem to be closer to reality. It must be taken into account that the lines plan there corresponds to the finds. The two thousand years of storage of the relics under the sediments have had an impact on the stock. Some ribs are dented.[18] With this shape, there would have been a large bend in the chine.

Therefore, we agreed with boat builder Andreas Gronau and Christian Garleff[19] and the editor of the *lusoria* boats of Mainz to aim for the ideal-typical "middle" between a line outline that was drawn according to modern criteria and guaranteed the hydrostatic ideal position in the water, and the traditional found situation, in which individual frames were pushed down. The result is already the basis of this completely new reconstruction, which has already begun with the construction of the templates and has been prepared by felling the oaks (and spruces).[20]

[14] Bockius 2006. 16–53; 160–187.

[15] Bockius 2013. 52–53.

[16] Ferkel–Konen–Schäfer 2004.

[17] Brechtel–Schäfer–Wagener 2016.

[18] See record of discussion with Garleff and Bockius and email exchange, end of November/beginning of December (below).

[19] Head of the maritime department LBS for boat builders / LBS for sail makers; Berufsschule der Handwerkskammer Lübeck, Wiekstr. 5, 23570 Lübeck (Travemünde-Priwall).

[20] See plans and development of the lines plan below.

1.3. RIVER AND MARITIME VESSELS

The purpose of the boats of the type *lusoria*/Mainz, just like the predecessor type Oberstimm, can be determined reasonably well. For the areas of the river boundaries designated with "ripa" in the ancient sources, the rowing boats functioned as patrol boats. Produced en masse, as is recorded for the *lusoriae* in the time of Apostata, for example, these boats served as fast means of transport to quickly move troops and quickly stab an enemy in the back downstream. In both cases of use, successful deployment is attested.

The construction of riverboats and for inland waterway vessels does not differ in principle from seagoing vessels. Those with muscle-powered locomotion, generally designed for coastal navigation and in the military ship type, are attested for Pisa, for example, and probably also for Herculaneum in exactly the same Mediterranean form as in the case of Oberstimm. Here the differences are basically in the height of the freeboard. For Pisa nave C, for example, the sheer passage is replaced by rudder passages that were additionally covered with leather to prevent gout.[21] Long-distance merchant ships, which necessarily had to rely on sails as their main source of propulsion (as in the case of Lauron's 2), had a different design, as they were dependent on stowing spacious merchandise as effectively as possible. All types of ships were part of a long Mediterranean shipping tradition that can be traced back to the 3rd millennium BC.[22]

In the pre-modern era and for a long time afterwards, in some cases even until today, and in many parts of the world, rivers served unrivalled as the fastest means of communication. The term communication is meant in the broadest sense as a medium of all possible interactions, i.e. all possible forms of communication as well as the exchange of goods. In principle, river shipping had the same transport categories available for this as ocean shipping, only with a different focus, and with rafts and dugouts included.

Military ships also navigated on the great rivers, as can be proven archaeologically and on Trajan's Column.[23] The ship units were smaller (double-row rowing ships are attested). The normal patrol service was for the very small ships, the *lusoria*, along the border rivers.[24] This category was so common that Vegetius explicitly did not consider it necessary to mention it in detail at the end of the 4th century.

Transport (of people, troops) was most effectively carried out via rivers such as the Rhine and the Danube. The aforementioned ships in particular could be used for military purposes, but transporters such as prahms also come into question. If the area was otherwise secured against attacks (possibly covered with *lusoria*), then the most effective way to supply people and material, even entire legions, was with prahms.[25]

[21] Bockius 2013. 43–45.
[22] Bockius 2007.
[23] Cichorius 1896–1900. Illuminated by Pogorzelski 2008.
[24] Vegetius IV 46.
[25] Jaschke 2009. 196–202; Bremer 2001; Aßkamp–Schäfer 2008; Eger 2018.

Transport of goods either as part of military supplies and/or for trade along the river lines took place via prahms with a length of between 20 to 35 m, width 6 m, only 1 m below surface, which was far superior to transport over land. With these means 15–80 tons could be transported not only on larger rivers such as the Rhine and the Danube, but large loads could also be transported over rivers such as the Lippe, the Main, as well as over the North Sea rivers, even far into enemy territory.[26] Downstream, transport was reasonably quick and unproblematic (about 20 km for heavy loads a day), using rowing power, sails and stay poles. The towboat method was mainly used for upstream transport (about 15 km a day). On wider rivers, the use of the sail upstream was even possible against the wind. In antiquity, the Danube and Rhine were not only more meandering, but also much wider and flowed more slowly than today in their alternative courses, which can often still be seen on historical maps of the modern era. At narrow points, for example on the Danube (the Iron Gate or the Danube breakthrough at Weltenburg), the typical treatment of the rocks on the banks or entire towpaths carved into the steeply sloping rocks can be seen.

Important for river navigation was the need to be fully operational even in low water. In contrast to ships on the high seas with a relatively high draught (for maximum utilisation of the loading capacity), river ships and ships on inland lakes had to be able to carry their loads far into the shallows to facilitate further distribution on land.

For military undertakings, troops had to be able to advance their offensives far into the country, for example into the source area of the Lippe or the Main (in documented offensives, e.g. the 6 AD Caecina campaign), in order to be able to avoid a lack of infrastructure and enemy ambushes for as long as possible. Supplies and trade overland ran on the large rivers, were reloaded and transported subdivided on smaller barges (prahms) up smaller river courses until camps at the sources (like Anreppen) or further buyers unloaded these goods.[27]

Consequently, it makes sense to categorise the inland boats in terms of their draught.[28] While the boats of the Mediterranean type had a rounded hull, their 4 cm thick pine planks usually had to be bent under steam to fit. These had a draught of up to a maximum of 50 cm – as can be concluded by the replica from Erlangen, the F.A.N. The other ships used on the river systems north of the Alps were the one flatboats like rafts and prahms, the other almost without any bow, like the *lusoria* type of Mainz. The *lusoria* in the Gallo-Roman had planks of about 2.5 cm thickness with moderate bow, which could be bent around the hulls or frames without further aids due to the bending capacity inherent in oak, as they also required less bending around the stringers and frames compared to the Oberstimm type.

Oak in itself does not swim so well, but it is robust. But the planks also bend well thanks to the oak and because they are cut relatively thin (2.5 cm). The shape of the

[26] As attested in Tacitus (Ann. I and II) through the rivers Elbe/Albia, Weser/Visurgis, Ems/Amisia. The fossa Drusiana was built for that purpose even for the Drusus-wars 12–8 BC.

[27] Jaschke 2009. 196–202; Bremer 2001.

[28] Bremer 2001. 62–93.

flat bottom is much chunkier compared to the shape of the Oberstimmer boat, which was built in the Mediterranean tradition. However, the robustness is also due to the fact that the planks and frames were all carpentered with iron nails, albeit butt-jointed, so the outer hull was smooth. This made the boat more than twice as heavy at almost similar length as its older counterpart of the Oberstimmer design, which was assembled with pine planks, oak in the core parts (keel and frames) and with wooden nails (except for bow and stern). All these boats had realised the Mediterranean type of smooth outer hull under direct or indirect influence, while boats of the Germanic building tradition practised the clinker construction method, like the Viking boats later on – this is proven by the ship finds from Nydam Moor in Denmark, all of which had been made with oak, with nails, but not with smooth outer hull.

2. DANUBE SHIPS AND THE EU INTERREG DTP PROJECT "LIVING DANUBE LIMES"

2.1. ROMAN DANUBE SHIPS AND RESEARCH HISTORY

As both a border river and part of the Roman Empire, the Danube has been an important line of communication north of the Alps since the last two decades before Christ. It connected all provinces and played an important role in supplying the burgi, forts and legionary camps along this route, as well as the civilian settlements that established themselves at these locations. While civilian ships and transporters ensured trade and supplies, military patrol boats of the Oberstimm type for the early and middle imperial period and the *lusoria* ships in Late Antiquity provided guard services or ensured troop transports en masse. In the case of military offensives, larger ships (as in the Dacian campaigns of Domitian and Trajan) also sailed the Danube. While downstream journeys could be made quickly (at up to 100 km per day in exceptional cases), upstream a combination of propulsion methods had to be chosen. In the Danube delta, it was possible to profit from the seasonal easterly winds, to cruise further west on the wide, strongly meandering, slow-flowing river against the wind or to tow when the rowers were exhausted.[29]

The history of research on the *lusoriae* as a type of ship has received a great boost from the finds in Mainz, much as in the case of the finds of the patrol boats from Oberstimm. In both cases, these finds are unparalleled even in the Mediterranean. In terms of construction and category, they represent several centuries of shipbuilding and, in addition, in the category of military rowing boats, at least 500 to 600 years of the time when Rome was also present on the Danube. They were built on site, with the wood that the Romans found in the surroundings.

[29] Dreyer 2018/2019.

Roman inland navigation in the Germanic region thus served in addition to civilian use[30], above all as a means of military deployment and supply (see for the Germanicus campaigns[31]), and later for securing the borders, especially on the natural "wet" borders of the Rhine and Danube. The comments of the late antique author Vegetius on the ship "type" of scafae[32], which is the focus here, can serve as an explanation for this:

"The larger Liburnians were accompanied by reconnaissance boats (scafae). They had about twenty oarsmen on each side. The Britanni speak of painted boats. They were used for sudden raids, sometimes intercepting the supplies of enemy warships, and by careful reconnaissance they were supposed to discover the arrival of the enemy and their intentions. But to prevent the reconnaissance boats from giving themselves away by bright colours, sails and ropes are dyed with 'Venetian colour'. This colour resembles the tide of the sea. Even the wax paint used to paint the ships is dyed accordingly. The sailors and marines wear 'Venetian coloured' service clothing to better camouflage them as scouts by day and by night."[33]

Knowledge about Roman inland navigation is based on literary and above all material finds. After the dubiously documented finds in Vechten at the end of the 19th century, the findings in Mainz and Oberstimm in particular have expanded our knowledge, representing a spectrum of previously known boats used for military purposes in Central Europe. The Mainz boats at the Hilton construction site belong to the *lusoria* type, which is also known from literature[34] and was built in Late Antiquity and used in the Germanic region. In addition, there are finds for this type of boat in Cologne "Alter Markt" and Rhine bank, Mainz "Kappelhof" and perhaps "Holzstraße" (Groove and tongue technique), Xanten-Wardt and -Lüttingen, Zwammerdam 4, Vleuten – De Maeern I, Woerden 1 and 7, Druten, Kapel-Avezaht, Zwammerdam 1, 2, 3, 5, 6.

They stand in the so-called Gallo-Roman building tradition, which – as said – Caesar already described (in the first century BC) in essential characteristics.[35] They were robust, built entirely of oak and held together by iron nails.

The other type of vessel was found in Oberstimm on a tributary of the Danube in the Breitlach, which has now dried up above ground. In addition to Vechten (see above), there are finds in Cologne "Alter Markt" for this type. In Mainz "Holzstraße", De Meern Kastell and Xanten Kiesgrube they are flat-bottomed vehicles partly in tongue-and-groove construction (in Xanten even only one dislocated tongue). The

[30] Eger 2018; see also: *Katalog Stadt – Land – Fluss. Römer am Bodensee.* Thurgau 2017.

[31] Tac. Ann. I and II.

[32] Vegetius IV 37.

[33] Transl. according to Baatz-Bockius. *Scafae tamen maioribus liburnis exploratoriae sociantur, quae vicenos prope remiges in singulis partibus habebant, quas Britanni pictas vocant. Per has et superventus fieri et commeatus adversarium navium aliquando intercipi adsolet, et speculando studio adventus earum vel consilium deprehendi. ne tamen exploratioriae naves candore prodantur, colore Veneto, qui marinis est fluctibus similis, vela tinguntur et funes; cera etiam, qua ungere solent naves inficitur. Nautaeque vel milites Venetam vestem induunt ut non solum per noctem sed etiam per diem ficilius lateant explorantes.*

[34] Mentioned by Vegetius in IV 46 and II 1; cf. Codex Theodosianus VII 17.

[35] De Bello Gallico 3,13,1-7.

construction tradition comes from the Mediterranean and is characterised by the tongue and groove construction with a smooth outer hull, which is documented in the Mediterranean world since the 3rd millennium BC. As a result, the boat, which weighs about 2.2 t. empty, has an almost optimal flow behaviour even under modern conditions, which has already been tested on 1:5 and 1:10 models as well as with the 1:1 reconstruction. In this context, the Oberstimm type, which had been in use in inland navigation since the time of Augustus, always proved superior to the *lusoria* boats of late antiquity in terms of speed.[36] Thus, the Oberstimm boat is equal to the hydrostatic behaviour of the Attic warships[37] and also the Germanic clinker boats.[38]

Our knowledge about the purpose of these boat finds comes mainly from historical texts, images and reliefs. However, these were rarely created with the aim of correctly recording technical details. A statement about the performance of the boats used, such as marching speeds, transport capacities or limits of use due to climate and weather, could at best be incompletely deduced from such sources. Questions about the transfer of technology,[39] which is important for the evaluation, are not (consistently) asked. Even if ancient texts – such as Caesar's – weigh the advantages and disadvantages of one's own shipbuilding tradition against those of others, ancient sources and material finds at best reveal the result of a transfer, but not the path and the motives in the case of paths in a glaring and random manner.

Since the end of the 20th century, replicas of historical ships, faithfully reproduced, have offered themselves as an additional, promising means of gaining knowledge. They are based on archaeological finds and supplemented by scientifically founded hypotheses.[40] Such replicas can be justified by gaining knowledge about historical craft methods and by experimentally proving disputed design hypotheses. In addition, replicas make it possible to draw technical conclusions about sailing speed, sailing ability or manoeuvrability – and about technical transfers. Prominent examples of this are the Greek trireme "Olympias"[41], whose replica was based solely on hypothetical conclusions from historical documents, or the Viking ships of Skudelev[42], which were based on an archaeological find near Roskilde, DK.

Our knowledge of the purpose of these vessels has also been investigated for the period of inland navigation of the ancient Roman Empire. The publication of the above-mentioned finds from Oberstimm and from Mainz by R. Bockius (2002 and 2006) provided the basis for the reconstructions, which were carried out in particular by Ch. Schäfer at various sites.[43] The archaeological finds of these ship types docu-

[36] See Caesar above.

[37] Rankov 2012.

[38] The Nydam boats: Bockius, 2013a.

[39] Bockius 2006a.

[40] Coates–McGrail–Brown–Gifford–Tipping–Wright 1995; Crumlin-Pedersen 1995.

[41] Morrison–Coates–Rankov 2000; Rankov 2012.

[42] Nielsen 2016.

[43] In Regensburg (the Regina: Schäfer–Günther–Wawrzyn 2008), in Hamburg (the Victoria: Aßkamp–Schäfer 2008) and in Germersheim (the Rhenana: Brechtel–Schäfer–Wagener 2016), and currently also in Trier – supported for the first time with DFG funding – the Laurons II.

ment the construction of the hull up to the gunwale, as well as the position of the mast base (in the front third). Additional superstructures and attachments such as the rudder, oars, rigging and sails were hypothetically implemented on the basis of contemporary parallels (for the oars, for example[44]).

The tests on these replicas have brought the conclusion that the sails can become a problem.[45] In any case, the type of original sails is not clear. The square sail was the most common; however, square sails, for example with a spriet, are quite possible. Latin sails are only documented later, first in the East (Byzantium), although they are not ruled out for earlier times.[46] Further problems arise due to the low lateral plan. Tests on replicas of the *lusoria* – which is considerably heavier but has an even lower lateral plan because it has a flat bottom – and on replicas of the earlier type of boat showed, however, that under favourable conditions, sailing up to almost 90° on the wind is possible.

Conversely, the analysis of ancient boat types by Whitewright (2013) and Palmer (2009 and 2009a) virtually presupposes the need for a forward mast base for propulsion and manoeuvrability on courses close to the wind. In the case of the square-rigged sail, the centre of gravity is lower than that of the square-rigged sail, which has been extensively tested so far. Furthermore, propulsion (with the same sail area: 25 m^2) is better ensured in crosswind conditions as well as on courses harder to the wind – as first tests in October 2018 on the Altmühlsee proved with the new reconstruction, which is truer to the original in terms of material and belt suspension and offers alternatives with regard to the unproven fundamentals (rudder, belt, take-off position, sails). On this new basis, new investigations are possible.

The FAU has built a ship of the type Oberstimm (wreck II) in 2017/2018 under the direction of the Professorship of Ancient History. Additionally, within the frame of the new EU Interreg DTP Project "Living Danube Limes", the FAU will build a new boat, the late Antique Danuvina Alacris. At the end of June 2020, a team of FAU went to the Ancient Maritime Museum in Mainz to record the wrecks I and V, which originate from different ships but are of the same design. The boats stand in Gallo-Roman ship building tradition. The 3D reconstruction, based on these recordings, can be used as a basis for the reconstruction of the boat. The edition of the finds and discussion of the finds of wrecks I and V by Roland Bockius (2006) are the second basis for the reconstruction. The lines plan forms the basis of the reconstruction work of the boat builder Mr. Gronau. His preliminary construction plan (Gronau/Garleff) is the first starting point (see below). With the two boats built, both vessels are tested to achieve optimal performance of the Roman boats.

Therefore, further investigations are necessary: on the one hand, further findings must be obtained to validate the assumed hypotheses (design of the sails, determination of the rudder depth, length of the hull, oar dimensions, length or geometry, etc.), and on the other hand, alternative hypotheses (spritsail, position of the masthead)

[44] Valkenburg Excavations 1993.

[45] Aßkamp–Schäfer 2008. 111–113; indicated by Bockius.

[46] Two incidents are attested: see Weski in an upcoming article on the F.A.N.

must be tested. Even the late Latin sail must be evaluated as an alternative. All these examinations and further fluidic studies have direct consequences for the subsequent historical questions that must be pursued: Which (auxiliary) sails make the most sense, if any, for inland navigation in the river systems of Germania? Which combinations of oars and steers come into question in terms of the best possible maneuverability? How was a perfect "technical package" obtained by adapting the "foreign" boatbuilding traditions with the advantages of one's own boatbuilding techniques? What then follows for the usability of this type of boat in the phase of the Roman offensive and in the phase when these boats were used for border security? What were the verifiable functions of these boats: control, escort, transport of troops and/or material? How did the use of the legionaries as helmsmen affect their use in the offensive and defensive context? What stages were conceivable? Which performance spectra were possible for rapid troop deployment on the two main routes Danube/Rhine (and tributaries) downstream and upstream?

2.2. PLACEMENT OF SHIP IN THE LIVING DANUBE LIMES-PROJECT

The EU Interreg Danube Transnational programme, which focuses on support in the Danube region has approved a 30-month project with a total of 19 partners and their respective associated partners, at the beginning of July 2020. All partners have a specific goal that serves the whole project. The project entitled "Living Danube Limes" aims to call back in mind the common Roman past and the common Roman heritage of all the countries along the Danube and to establish this memory at a high and sustainable level as permanently as possible. This includes, among other things, to foster a sustainable and eco-friendly tourism as well as the protection of the cultural sites in the Danube Limes Region. The exciting thing, or rather the challenge, is to show how we succeed, with the various focal points of our work, interlocking with each other, in solving the tasks we have set ourselves and which have been approved and supported by Brussels. The aspect of Living History is of central importance here. All activities are to be recreated as closely as possible to Roman living conditions, thereby involving a broad section of the population and winning public sponsors and political representatives for a commitment that is as lasting as possible.

We, as the westernmost partner in this large project, will reconstruct a Roman *lusoria* close to the former small Roman fort in Gunzenhausen on the former Raetian Limes strictly according to scientific criteria and as close as possible to Roman craft conditions. For this we have won a boat builder and will carry out all parts of our boat building with volunteers from the region, first at a temporary building site in Arberg, but then also near Gunzenhausen, at the Altmühlsee, which is not antique, but which will be an ideal test area for the boats (the already reconstructed F.A.N. included) and an excellent public attraction.

A double hall will be built there, where boat building will continue in spring 2021, accompanied by a public programme as intensive as possible. In this aspect, already

established programmes will be expanded and developed in the sense of a high-quality and sustainable tourism. The experience of the association "EGEA" (www.egea-ev.de) will be widened with the help of the newly established Roman boat unit. Bonds of cooperation with Gunzenhausen Tourist Office will be fostered, also by the expertise of the experts of the German Limes Commission (Deutsche Limeskommission), the Bavarian Historic Preservation Society (Bayerisches Landesamt für Denkmalpflege) and the District of Central Franconia (Bezirk Mittelfranken), as well as with the museum directors of Ruffenhofen and Weissenburg in particular.

The ship being replicated has been given the name Danuvina Alacris, after the Living Danube project: "winged Danube", "living Danube". The abbreviation DVC or DUC is also the abbreviation of the university in charge of the project, the Danube University Krems (DUK).

Naming ships that even visually had the shape of a living creature (fish or similar) was common practice in antiquity. Perhaps the most famous ship gave its name to the mythical enterprise of the hero on the way to the Golden Fleece: Argo, which was later placed in the sky as a constellation. As in other times, the naming of the ship was subjected to a ceremony (the baptism) in Roman times, where a priest usually uttered a prayer to the god in charge (often Poseidon) after a sacrificial pour from a bowl. With the other, older boat, which was reconstructed by the FAU (2018), the 500 to 600 years of Roman presence with boats on the Danube are thus represented.

3. CONSTRUCTION PLAN FOR DANUVINA ALACRIS

Figure 1 shows the first version of the lines plans (as total overview) before discussion between Bockius, Garleff and Dreyer on 26th October.

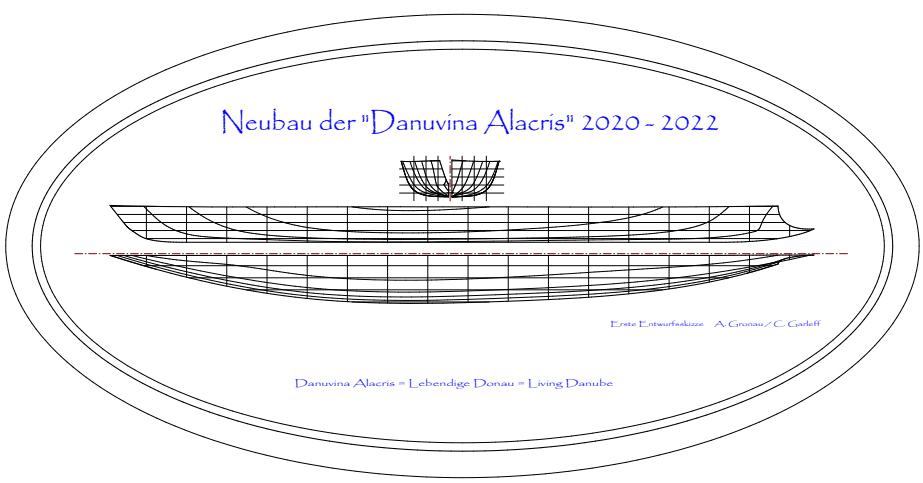


Figure 1. Total overview of the lines plans

Figure 2 shows the lines plans (version 17.12.2020) more detailed.

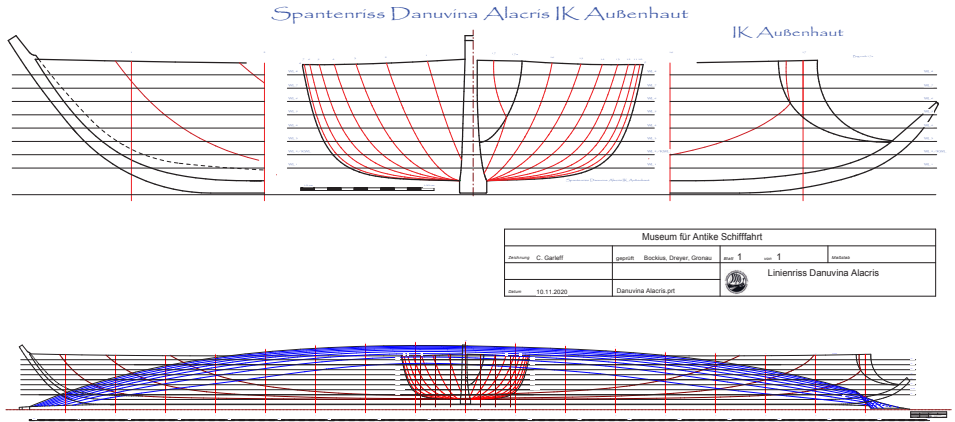


Figure 2. Final lines plans

The Lines plans (Linienrisse) represent the starting point for the design of the templates. The first drawing (in *Fig. 1*) shows the frame plan (Spantenriss) (i.e. the vertical cuts in transverse direction). The right side shows the view of the foreship, the left side the view of the stern. The middle drawing and the lower drawing divide the boat horizontally. The middle drawing divides the boat into sections (Schnitte),

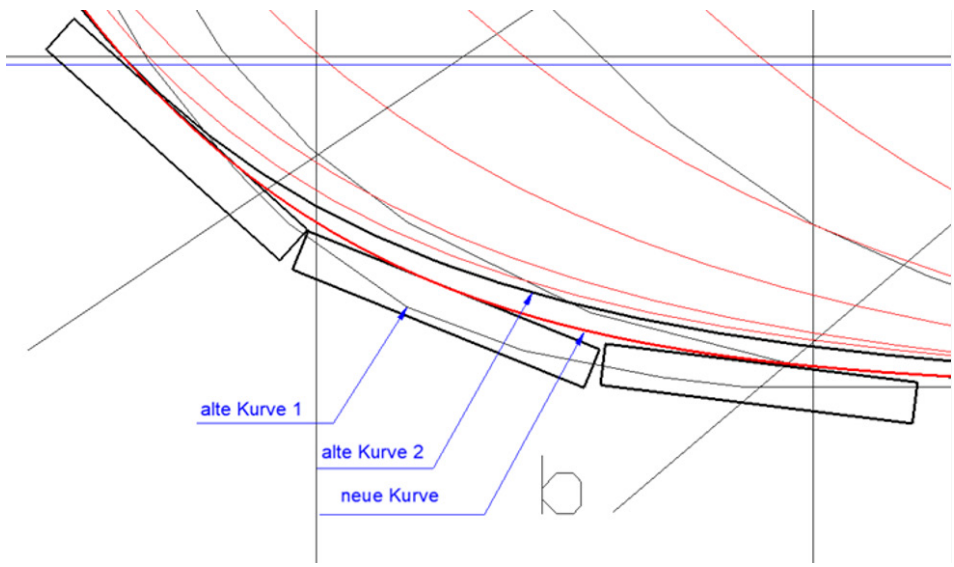


Figure 3. Discussion of hull

Table 1. Schedule of the construction

Work	**Time**	**Research questions**
1. section: preliminary works for building of the lusoria	Jul 20, Mar 21	
1.1 construction of the different lines plans		discussion of the possible original lines plan; discussion of the length
1.2 building of the spiers (round wood)/ oars/rudder)		discussion of the optimal length for spriet, yard, Latin spar, in order to fit the various sails
1.3 templates loft (Schnürboden)		optimising of lines plan and template plan
1.4 wood for building (cutting, preparation, conservation)		discussion of width, length and shape of oak, in order to get the ideal number of truncs especially for the planks; number of Krummholz that will fit the crooked frames
2. section: erection of hull in the boat hall/ planks	Mar to Aug 21	
2.1 new hall: preparation of the construction site; moving into boat hall		architectural work; professional drawings and professional building company
2.2 positioning of keel		discussion on length of boat (see lines plan)
2.3 positioning of templates		
2.4 planing and fitting of planks, part 1		discussion on width and length of each plank, see lines plan
2.5 planing and fitting of lower and upper frames, part 1		see frame plan
3. section: completion of hull	Aug to Dec 21	
3.1 planing and fitting of planks, part 2		discussion of width of each plank, see original finding and plan
3.2 planing and fitting of lower and upper frames, part 2		selecting the Krummholz according to frames plan; discussion, which Krummholz fits best to the various frames of plan
3.3 finish of hull		
4. section: fitting out and finish	Jan to Jul 22	
4.1 planing and fitting of longitudinal connection (e.g. stringer)		the position of stringers can be inferred by the lines and frames plans
4.2 cutting, planing and fitting of gunwale		last part of each side according to the lines plan
4.3 construction of pavement		measurements, discussion of the remains in Mainz
4.4 construction of front/prow		measurement of wreck 5 in Mainz; drawing of original shape of prow
4.5 rowing seats and all inner connections/ floor		measurements of the remains in the wreck I, sternpart; drawings of the possible original shape
4.6 all inner equipment/bottom of mast, etc.		position of mast according to plans and remains of wreck V
4.7 caulking and conservation		
4.8 encaustic painting of antiquity		discussion and tests of best receipt for painting according to encaustic method
4.9 rigging of boat		best possible rigging for spriet, yard and Latin sail altogether
4.10 launching of boat		testing of tightness of boat; corrections; watering

right bow, left stern. The last drawing is a waterline plan / Wasserlinienriss. The aim is to determine the positions of the templates and later the frames and to position the planks so that they are streamlining. The lines plans are then the basis for the creation of the templates loft (Schnürboden), which determines the positioning of the templates (Schablonen) to be created.

The drawings of *Fig. 3* show lines plans as a basis for the reconstruction of the *lusoria* Danuvina Alacris in its development. The first line plan ("alte Kurve 1") is that of the publication of Bockius 2006 and the second of C. Garleff sought an optimisation with regard to the hydrodynamic capabilities of the boat to be built ("alte Kurve 2"), in intentional deviation from the findings of wrecks I and V (see picture). The discussion led to the final "design" ("neue Kurve", see the recorded discussion and final lines in *Fig. 2 and 3* plans above) (17th December).

The final outline from December 2020 represents a compromise between the calculable ideal line and the compressed findings.

The following schedule is based on the plans of the boat builder Andreas Gronau. The plans are preliminary and depend in some detail on external factors. There can be shifts, especially due to COVID-19 *(Table 1)*.

4. RECONSTRUCTION SITE

Roman ports and shipyards, like Greek ones, differed in importance, scale and design. Large maritime trading cities and naval powers such as Athens and Carthage had solid stone buildings that allowed year-round repair and new construction. This was similarly true for Rome. But there were also shipyards everywhere in the Roman Empire, which were also quite casual and not at all roofed over (or built with perishable material).

We have literary (Polybios, Thucydides) as well as archaeological (Carthage/Athens) information about the large (military and also protected from spying) shipyards. We also know about the Roman shipyards (for the large fleets at Misenum and Ravenna) from literature and archaeology. Small shipyards are less well known (but see Haltern[47]), because they were made of perishable material, but could be assumed to be used for almost every port and transshipment point (construction and repair).

Little is needed for a shipyard: a possibility to pull ships in need of repair on wooden rails ashore (via winches or with animals) and – just as every ship was pulled ashore, for example for wintering – a (wooden) roof.

We can assume that such shipyards existed at all legionary camps if they were located on the river. Land yards replaced such repair sites in the times when organised defence was established along the "wet borders".

River shipyards also differed from seaports and shipyards only in degree, not in principle; ships with a greater draught were also built and maintained in the latter.

[47] Schäfer, in: Aßkamp–Schäfer 2009. 203–209, esp. 207.

This was, for example, the reason for replacing the old harbour at Phaleron with a shallow sandy beach by the new (three) harbours at Piraeus with a greater draught in Athens in the 490s and 480s BC.

The community Gunzenhausen and the Zweckverband Altmühlsee are about to build a double hall *(Figs 11–12)* according to modern working and safety standards. The mostly voluntary workers have to do the repairing work in the winter, so we need heating. Additionally, safety regulations have to fit, otherwise we would not have gotten the approval for the ship building and an insurance. Last but not least, the hall is financed by the community, the district Middle Franconia and local sponsors. The experience gained from the first construction (with a 10×20 m construction tent) convinced us to plan longer-term for the second boat construction. But also in terms of content, we can benefit from the experience of our own boat building and due to the good ties with those responsible for the predecessor buildings and current projects (Regensburg, Hamburg, Germersheim, Xanten).

Preparatory work has been carried out at the provisional working place in Arberg. The "flying parts" of the boat are in the progress of production: 44 oars are pre-cut (and one third is finished), blocks have been produced, mainly with Roman planes. The rest will happen in 2021 at the site of the new hall at Schlungenhof.

At the Altmühlsee we have an ideal area to test the two boats scientifically and to provide a good and sophisticated tourist programme:

Figures 4–5. Wreck V and I of the Schifffahrtsmuseum in Mainz

a) With respect to the tests of two boat categories, the F.A.N. and the Danuvina Alacris, the principals of future scientific approaches are the following:
In both cases, not everything on the boats has been preserved. Even the existing foundations of our reconstruction work are based on two wrecks, both about 8 metres, one beginning with the stern and one beginning with the prow, but from two different ships *(Figs 4–5)*.

One of the wrecks (wreck V) was originally much longer before it was lifted. Therefore, the preserved base of the Mainz wrecks led to different reconstruction possibilities.

Contrary to that, the reconstruction work of the F.A.N. 2017/2018 was based on a nearly 100% preserved length of wreck II in Oberstimm *(Fig. 6)*.

Furthermore, we have to derive the other boat elements – roughly speaking beyond the gunwale, which did not exist even in the case of our F.A.N. – from parallel finds.[48] For the tests, it is important that the parameters of both boats are similar or, if possible, the same in those parts that have not been preserved, so that the comparative tests can be based on them.

Figure 6. Wreck 2 in front in the "kelten römer museum manching"

[48] See Weski in an forthcoming article on the F.A.N.

These tests will then be carried out for rowing, sailing and painting, supported and accompanied by the chairs of fluid mechanics, sports medicine, on one part as well as by the chair of organic chemistry II and the academy of arts in Stuttgart and psychology of perception in Bamberg on the other.

The tests on the F.A.N., partly already supported with third-party funds (HRK/BMBF), have been running for two years and will be announced in a publication in 2021.

Even more promising is that both ships can be tested, as soon as the Danuvina Alacris will be finished. Numerical tests are already underway at the Chair of Fluid Mechanics, which enable to provide the best possible packing of the goods that have not been preserved and are to be added to. Additionally, flow and wind tunnels can be used, to test the 1:10 models of the boats. Consequently, this may approximately emulate the experience of many generations of boat builders who have passed on their trade from father to son, which would ultimately be cost-effective for us.

If we can now use the same parameters to supplement the parts of the ship that have not been preserved in a historically plausible and correct way, we have a secure basis for a comparison of the two ships, if we can still put together a homogeneous crew.

We then intend to test the maneuverability of the two boat types with the alternative oars and the different sails with authentic material (linen, wool) and the same sail surface.

These include the square sail, which is the most frequently used in the case of sailing, the less frequently used sprit sail and – in one or two uncertain cases, for the time of the two boats also used – the Latin sail. The latter, however, seems attractive to me, especially in order to "catch" the unsteady wind conditions in the inland optimally *(Figs 7–8)*.

We are also experimenting in a completely different field. In the case of the F.A.N. we used antique encaustic painting for the first time. We know that the so-called naves pictae – according to the most probable Vegetius' text reconstruction – had or could have had a painting. We know that this was then encaustic, as Pliny the Elder

Figures 7–8. F.A.N. with yard- or sprietsail

Figure 9. Photo with encaustic painting of F.A.N.

reports. We also know a little about the execution of the encaustic painting and have some information about the ingredients. During the first painting of our F.A.N. we worked with resin under expert guidance, which is not handed down by ancient authors *(Fig. 9)*.

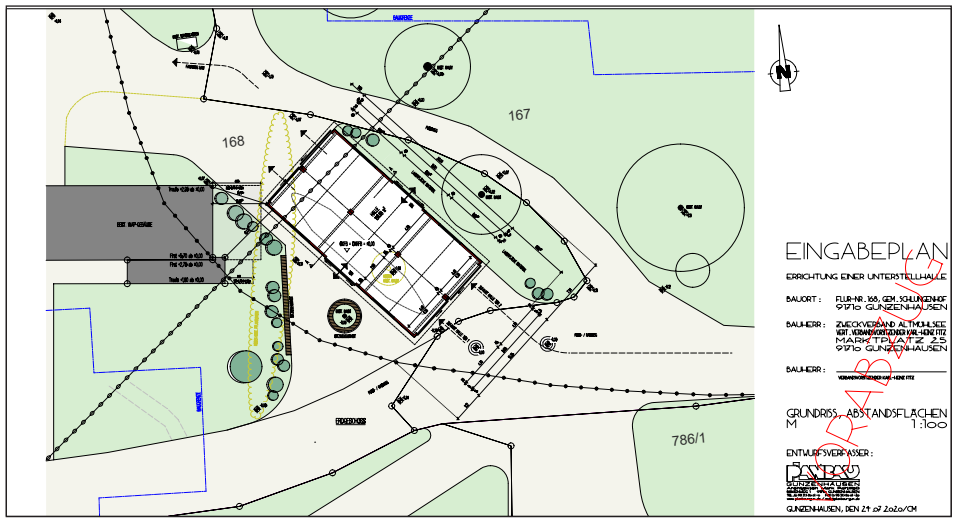
Despite extensive empirical tests in advance, we were always confronted with the difficulty that the colours melted already at outside temperatures below 30 degrees – which is neither satisfactory for us today nor, according to Pliny, was it the case in antiquity, because – according to Pliny – the colours were wind, water and heat resistant.

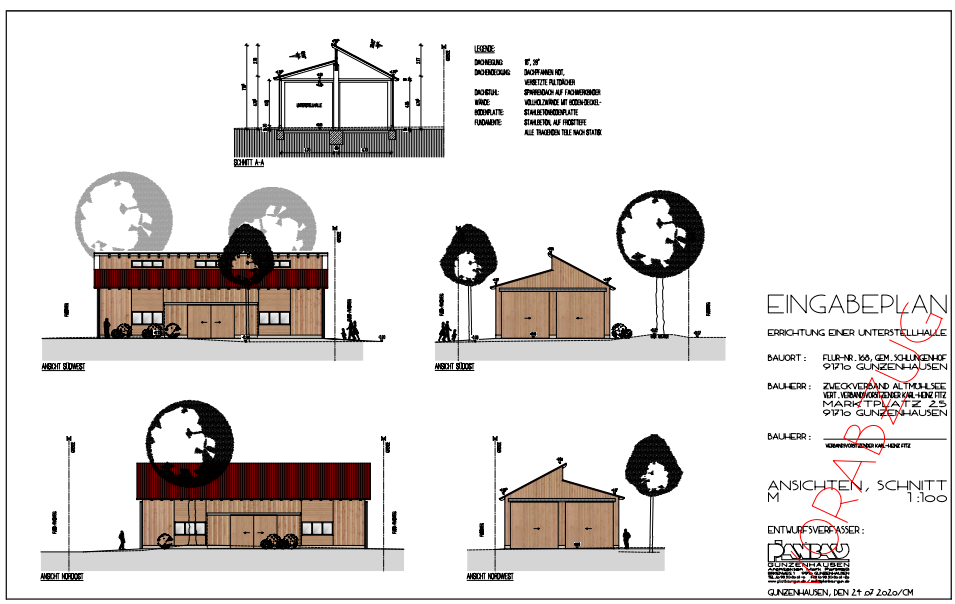
For some time now, the FAU's organic chemistry department has been testing under the direction of Marcus Speck on a better, historically even more verifiable version of encaustics, supported by the State Academy of Fine Arts in Stuttgart (Krekel, Schmädecker). There was also support of a perceptual psychologist (Claus-Christian Carbon of Bamberg), who is evaluating the combinability of the different impact intentions, attested in ancient sources. The empirical tests are continuing and should culminate in the painting of the *lusoria*, in a year and a quarter. Meanwhile, the tests are being accompanied by repair work at the F.A.N., and as early as December 2020 we were able to come up with a mixture that has a melting point of about 60 degrees *(Fig. 10)*.

Figure 10. New encaustic painting on F.A.N.

Finally, it is an attractive idea to bring together both painted boats on the Danube at least in sections on the network trip, which both represent the entire river navigation in this one small boat category (patrol boats) – as far as we know – with two 25 sqm sails.

b) tourist- and broader audience-activities:
Already earlier, when building the Danuvina Alacris, we will reconstruct a Roman *lusoria* close to the former small Roman fort in Gunzenhausen on the former Raetian Limes strictly according to scientific criteria and as close as possible to Roman craft conditions. For this we have won a boat builder and will carry out all parts of our boat building with volunteers from the region, first at a temporary building site in Arberg, but then also near Gunzenhausen, at the Altmühlsee, which is not antique, but which will be an ideal test area (see above) for the boats (the already reconstructed F.A.N. included) and an excellent public attraction *(Figs 11–16)*.





Figures 11–12. Plan of the new hall

Figures 13–16. Sample of tourist programs and two of rollups of the exhibition on the reconstruction and tests of the F.A.N.

5. AUTHENTIC MATERIAL AND METHODS

The *lusoria* DVC will be approx. 18 m long, 3.8 m wide in the middle, weighing 6 tons (empty).

The wood for shipbuilding was selected according to the local stock. As a rule, according to local possibilities, more robust tree species (pine, oak, etc.) are taken for the "load-bearing parts" of the boat, while the other parts, which must also withstand a certain amount of bending, can be made of softer tree species.

The choice of wood is based on the findings in Mainz. The wood of the parts that have not been preserved is selected according to the parallels that are as contemporary as possible. Spruce is also used as wood for the mast, spars and oars. However, this type of wood is also suitable because of its affordable price.

With the help of professional support, we were already able to select the trees we needed in mid-July *(Fig. 17)*.

Figure 17. Oaks were selected

The spruce was felled immediately, which was to be used for the parts of the boat that have not been handed down: the mast, the spar for the yard, the Latin sail and the spriet-sail. By the end of the month, the spruce had been felled, and then a week later the spruce was cut with modern equipment *(Figs 18–19)*.


Figures 18–19. Spruce

Nevertheless, 9 spruce trunks of up to 19 metres were piled up finally, under the aegis of our boat builder, to dry properly. We also ordered 44 spruce squared timbers from which our oars will be made. These squared timbers had a dimension of 10 cm per 5 m and, as it turned out later, were not always completely straight or completely dry, because the squared timbers rotated around their core during the drying process. Anyway, we have now a wide variety of oars, some are 4.10 m, some 4.70 and 4.40 m long *(Fig. 20)*.

Figure 20. New oars for DUC

Figures 21–27. The lines plan 1:1 and sample of templates

Figures 28–32. Transport of oak trunks and selection of oak-Krummholz (modern and Roman)

The shape is like those which are preserved in Valkenburg and Nydam (the latter not Roman). The oars are of course very important regarding a boat primarily driven by muscle power – unfortunately they are not preserved in Mainz.

The important preparatory work at our provisional site is also continuing at full speed. In cooperation with Dr. Bockius, Mr. Garleff and Mr. Gronau, our boatbuilder, we worked out an optimized lines plan.

This is the basis for the construction of the 18 templates frames, which are now made of structural timber and thus determine the shape of the planks of the boat, which are later replaced by the frames and stringers *(Figs 21–27)*.

The wooden material is also ready for this, now. Since 9th November we have been cutting down the 75 cubic metres of oak and cutting the crooked wood for transport *(Figs 28–32)*.

This work lasted until 19th November with several actions on site. We have also been there with horses, which after the laborious sawing work also moved the trunks in the Roman way. Eighteen oak trunks have now been laid, most of them more than 50 cm thick at a height of two metres (diameter) and up to 21 m long, 5–6 tons each trunk, a huge undertaking. In addition, there are the 60 Krummhölzer, curved trunks. Here the expertise of the boat builder, Mr. Gronau, is called for, who can see which crooks with their non-straight grain are suitable for the crooked frames, which therefore have greater stability. Also, the trunks are not straight, but slightly curved. The trunks should be branchless if possible.

This action, which is also not easy to shoulder in terms of price, has now to be cut as soon as possible. This means that the trees had to be transported to the final place of work in Schlungenhof near the Altmühlsee. This took place before 4th December.

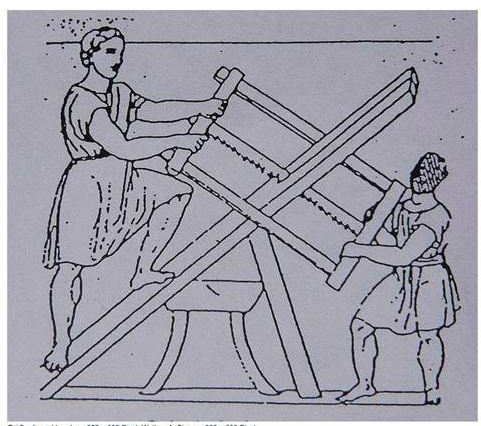


Figure 33. Kastensäge.


Figure 34. Replica. **Figure 35.** Roman sawing of oak




Figures 36–39. Cutting of Oak

We need our own mobile cutting machine that cuts planks to this length (up to 18.80 m). This is not available everywhere in Germany. By 18th to 20th January 2021 the trees were cut. But as in every stage of the reconstruction we also saw planks and crooked wood in Roman style. Our blacksmith has currently produced fitting saws according to evidence *(Figs 33–39.)*

When all the oaks and spruces have been latticed, we want them to dry well protected during the winter, so that we can continue to use them in the spring, when – as promised – the hall will be built. Then, plank by plank they will be mounted for the

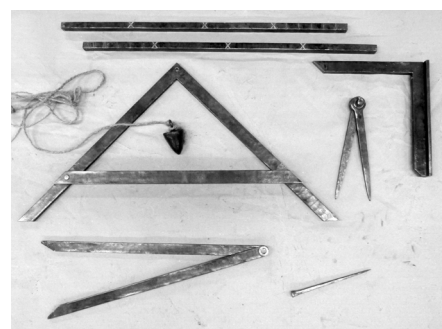
Figures 40–43. Experimental shield production, Roman kiln, Roman tunica, catapult-tests (up to January 2021)

Danuvina Alacris, frame by frame they will be adjusted. This is hard work, but also fun because it is done using Roman methods.

The work requires many hands, of all ages and at all times, i.e. for the construction of the boat, for painting, for the associated activities, that is to say for the building of shields, etc. – all actions in the context of the Living History to mobilize the public, which will accompany the building process *(Figs 40–43)*.

We are fairly well informed about craft activity in the 4th century. For example, a boat builder's bowl attested in several specimens *(Fig. 44)*.[49]

Figure 44. Shipbuilder 4th century AD



Figures 45–46. Ancient forging techniques and Roman measuring tools

[49] The Art Collections of the Biblioteca Apostolica Vaticana Rome, 1969. Fig. 30.2.


Figures 47–48. Sample of craftsmen tools and detail of axe (with seam)

The craftsmen working on the shipbuilding are, besides the boatbuilders themselves, blacksmiths and woodworkers. Our work is done in modern clothes but as far as possible with Roman tools, especially during show dates and possibly outside the hall if COVID-19 conditions require it.

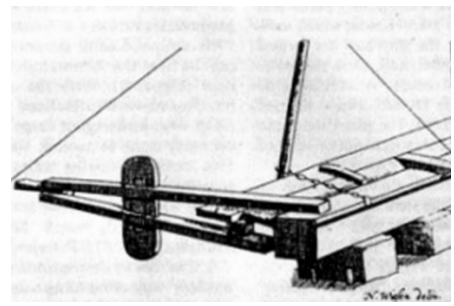
The blacksmith Thomas Hürner fabricated the necessary Roman tools. He prepared a number of planes, axes with hard iron tips, hammers and other special tools according to ancient forging techniques and ancient findings and paintings *(Figs 45–48)*.[50]

The sample of pictures shows first results demonstrated by the blacksmith to the project leader; the fabricated axe for example has a seam, which shows the technique of "fire forging" to connect the hard part (cutting edge) and the soft iron part.

Many specific conditions of Roman craftsmanship are not documented, though, either because they were taken for granted by contemporaries or because they had to be kept suspiciously secret as a valuable recipe. So, we still do not know, how craftsmen fixed the goods to be treated: Clamps, which we know today to fix object of every kind, have not been preserved. Scientific literature is silent. Kellermann in his cultural history of the screw (orig. "Die Kulturgeschichte der Schraube") knows no evidence of the screw for fixing in antiquity.[51] Clamps have to be used, though, which, regarding traditional shipping, are also documented in illustrations, copied in the construction of Viking clinker ships and then also used by us. Here we still have to improve our tools, because those kinds of clamps are much easier to use for clinker ships than on carvel boats – as in our case –, when planks were constructed without overlap *(Figs 49–51)*.

[50] E. g. Gaitzsch 1980. Vol. I. and II.

[51] Kellermann–Treue, Kulturgeschichte der Schraube, München 1962.



Figures 49–50. Norwegian boatbuilding.
Figure 51. Reconstruction

Some of the crafting methods were already shown at our kick-off on 24th September 2020 at the Altmühlsee, which, in addition to the displayed activities, was intended to introduce boat building, the new building hall and the new home of the boats at the modern lake Altmühlsee near the Gunzenhausen Roman fort *(Figs 52–57).*

Such activities will continue to take place over the next two years, in close cooperation with the German Limes Commission, the Bavarian Monument Conservation Society and the Limes expert advisory service of the district of Middle Franconia. We also want to involve the local population, and this is also happening with the founding of a Roman naval unit which can serve both ships, advised by a taskforce familiar with Roman clothing. The response has been already great and we may be able to act properly dressed and equipped in 2021.

The exciting thing, or rather the challenge, is to show how we succeed, with the various focal points of our work, interlocking with each other, in solving the tasks we have set ourselves and which have been approved and supported by Brussels. The aspect of Living History is of central importance here. All activities are to be recreated as closely as possible to Roman living conditions, thereby involving a broad section of the population and winning public sponsors and political representatives for a commitment that is as lasting as possible.

The start is promising, the public is already attracted, by the building activities, the kick off and workshops – reported also by the press and media, disseminated by the social media. The aim is that the further activities and workshops will be held in in presence of an audience (despite COVID 19) if possible.

Figures 52–57. Kick off at Gunzenhausen 24th September 2020

6. LITERATURE

6.1. LITERATURE ON BOAT RECONSTRUCTION AND TESTING

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PRINZIPIEN UND FORTSCHRITT DES RÖMISCHEN SCHIFFSBAUS IM RAHMEN DES EU INTERREG DTP PROJEKTS „LIVING DANUBE LIMES“

Zusammenfassung

Im Aufsatz wird zunächst der Rekonstruktionsbau einer römischen Lusoria mit Namen „Danuvina Alacris“ in die Antike Schifffahrt allgemein, sodann immer engere Kreise ziehend in die römische Schifffahrt, die Binnenschifffahrt, die Schifffahrt an Rhein und besonders Donau eingeordnet. Sodann werden die Grundlagen der Rekonstruktion, die darauf basierenden Rekonstruktionspläne, der Bauplan und der Ort des Baus beschrieben. Im zweiten Teil werden die Fortschritte im Bau nach römischen Handwerksmethoden erörtert sowie die parallelen Aktionen im Sinne des Living History Prinzips entwickelt. Der Fortschritt des Baus bei Abschluss der Redaktion wird bis 24.1. 2021 vorgeführt.

Schlüsselwörter: Mediterrane und gallo-römische Bauart, Lusoria, Danuvina Alacris (DUC), Fridericiana Alexandrina Navis (F.A.N.), wiss. Tests: Bemalung – Segeltypen – Rudern mit historischer Ruderaufhängung, römisches Handwerk, Schiffbau, Schildbau, Ofenbau, Living History

A „LIVING DANUBE LIMES” ELNEVEZÉSŰ EU INTERREG DTP-PROJEKT HAJÓÉPÍTÉSI SZAKASZÁNAK ALAPELVEI ÉS FOLYAMATA

Összefoglalás

A tanulmány a „Danuvina Alacris” nevű római lusoria rekonstrukcióját tárgyalja az általános ókori hajózás, majd a római hajózás, a belvízi hajózás, a rajnai és különösen a Dunai hajózás témaköreiben. Ezt követően bemutatja a rekonstrukció alapelveit, az alapelvek szerint készült rekonstrukciós terveket, az építési programot és az építkezés helyszínét. A tanulmány második fele az élő történelem alapelvei szerint tárgyalja a római kézműves módszerek szerinti párhuzamos építkezési folyamatok előrehaladását. Jelen összefoglaló a rekonstruált hajó építésének előrehaladását a tanulmány leadásáig, vagyis 2021. január 24-ig követi.

Kulcsszavak: Földközi-tengeri és gall-római építkezés, Lusoria, Danuvina Alacris (DUC), Fridericiana Alexandrina Navis (F.A.N.), tudományos vizsgálatok: enkausztia – vitorlatípusok – evezés történeti felfüggesztett evezővel, római kézművesség, hajóépítés, pajzsszerkezet, égetőkemence-szerkezet, élő történelem

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