VIKING SHIP MUSEUM

Project: Thoroughbred of the Sea
The trial voyage to Dublin

Research Plan

Tinna Damgård-Sørensen
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Introduction

Background

Thoroughbred of the Sea is a combined research and dissemination project whose purpose is to create and communicate new knowledge on Viking longships and society. The project is based on the museum's reconstruction of Skuldelev 2, a 30-metre-long warship on display in the Viking Ship Hall in Roskilde.

The ship was built in Dublin in 1042 and is designed for crossing stormy waters and open seas. It is typical of the highly specialised craft of the Late Viking Age and represents generations of accumulated experience with materials, design, building methods and sailing characteristics. It has an extreme construction, ideal for speed and transporting many men. It is indeed a thoroughbred of the sea!

The project is the most ambitious experiment ever to be undertaken in the field of maritime archaeology. Since it was commenced in 1996, the project has involved the building of a model in a scale of 1:10, the full-scale reconstruction of the ship, and preliminary sea trials with the ship and crew. The project is now entering a new phase: an expedition from Roskilde to Dublin in 2007, and the return voyage in 2008.

The full-scale reconstruction was launched in September 2004 and christened *the Sea Stallion from Glendalough*. In the archaeological experiment, the reconstruction represents:

- A hypothesis, reflecting our interpretation of the original ship and its missing parts.
- An opportunity to obtain basic knowledge of this type of vessel, the Viking longship.
- An 'experimental laboratory', allowing us to investigate the ship and her crew with respect to function, organisation, logistics, etc.

The task

The reconstruction will be tested under realistic conditions in the seas for which she was built, the North and Irish Seas. The investigations will pursue three overall objectives:

- To test the reconstruction – our hypothesis on the original ship
- To test the sailing characteristics of the reconstruction, thus also testing this type of vessel in general
- To investigate the functions, organisation and logistics of the ship and her crew

The challenge

The project's main challenge is to create representative results capable of contributing to our knowledge of Skuldelev 2, Viking longships in general and Viking society.

Ships of this type are unparalleled today and the sailing experience and seamanship required to handle the original ship and its many functions have

been long since lost. Part of the challenge is therefore to train a present-day crew to sail the ship in a way that allows representative quantification of the vessel's sailing characteristics.

The credibility of the results depends on the voyage being completed under realistic conditions, using the original means of propulsion – sail and oars. Sending 65 men to sea in an open boat with no motor is a dangerous undertaking. Completing the archaeological experiment with a high degree of authenticity while ensuring the safety of the ship and her crew will therefore be a major challenge.

It will also be a challenge to accomplish and document the planned investigations under conditions that affect both the people participating in the experiment and those performing the investigations. And finally, it will be a challenge to safely store the recorded data under all possible conditions.

The archaeological experiment

An archaeological shipwreck is a complex and valuable source of information. It provides data on the vessel's design, use and history, and contributes to a better understanding of how the type of ship developed. It also provides valuable information on the times and society from which it originates, especially when such information can be compared with the analysis results of other shipwrecks from the same era.

Ship design and construction reflect the owner's specific requirements on function, speed, sailing characteristics and image. In addition, it reflects the craftsmanship traditions, design comprehension and aesthetics of the times. Analysis of the materials used provides information on the resource base and materials technology, tool marks can be deciphered as primary sources from the boat builder's hand, while wear marks reveal the way in which the ship was used.

To gain the full benefit of such information, the Viking Ship Museum established in 1982 a multi-disciplinary team of academics, craftsmen and seamen who could use their various areas of expertise and experience to interpret and decipher archaeological shipwrecks. The objective is to gain an overall understanding of the original ship's design, function and qualities, and its importance for Viking society.

Today, the Viking Ship Museum is the world leader in experimental ship archaeology and considers the building and testing of full-scale reconstructions to be an integral part of the ship archaeological analysis.

The archaeological experiment at sea

The archaeological experiment consists of various phases, culminating in scientific voyages and sea trials in which the reconstruction/hypothesis itself will be tested, the ship's sailing characteristics will be investigated, and ship and crew functions, organisation and logistics will be analysed. The experiment thus changes element. It is taken to sea, requiring new areas of expertise and experience – in seamanship and ship handling.

The experiment will be performed under the constantly changing forces of nature, and it will thus be impossible to isolate and analyse single factors. The results can therefore not be compared with scientific measurements obtained from experimental setups, which in principle can be repeated indefinitely under controlled conditions. Like other cultural historical research projects, the results will be subject to a high degree of interpretation and their probability will depend on the credibility of the empirical data and the argumentation.

Preconditions

To obtain meaningful research results, the experiments must be based on:

- A scientific reconstruction of a well documented archaeological shipwreck.
- A well trained crew, capable of handling the ship and its specialised functions.
- Voyages and sea trials in the seas for which the original ship was built, and under the geographical, hydrological and meteorological conditions the vessel was designed to face.
- Voyages and sea trials using the ship's original means of propulsion – sail and oars, without the aid of a motor.
- Voyages and sea trials as originally undertaken, with no prearranged arrival times or stopovers along the route.

It is, however, impossible to perform an archaeological experiment that meets such preconditions completely. Reality imposes its own limitations, and the Thoroughbred of the Sea is no exception.

The reconstruction of Skuldelev 2 meets the specified conditions. It is based on a well documented archaeological shipwreck and its building has followed the various phases on which a functional full-scale reconstruction should ideally be based. All the processes involved have also been documented and any initial doubts about the reconstruction's seaworthiness have been minimised after three years of preliminary sea trials.

The ship is crewed by 65 people at a time, chosen from a total complement of 120, mostly volunteers. Crew members come from all parts of Denmark and many other countries worldwide. Most have many years' experience in sailing square-sail vessels and all have participated in sea trials since 2004. The crew is the best currently available but cannot be compared with the crew of the original vessel in terms of sailing experience and seamanship.

The route taken on the voyage has been chosen to test the reconstruction in the waters for which the original ship was built, and under the geographical, hydrological and meteorological conditions the vessel was designed to face. The voyage will take place in summer as this was the time of year such voyages were usually undertaken. The ship has no motor and is powered by means of sail and oars alone.

The voyage will be accomplished under original conditions – when the weather is favourable. No stopovers or events have been planned along the route, but it has been necessary to set a limit of seven weeks for the trip. The ship will also be towed if this is absolutely necessary to complete the voyage on schedule – it would, for example, be unacceptable if the voyage had to be cancelled because of lacking wind.

Safety will at all times be given higher priority than the archaeological experiment. The ship is equipped with state-of-the-art navigation, communication and life-saving equipment and will be accompanied by a support vessel, capable of rescuing anyone who should fall overboard or ensuring communication should the ship founder. The skipper can also alter the planned route whenever he deems it necessary for safety reasons.

Testing the reconstruction/hypothesis

The reconstruction can be seen as an experimental setup, a hypothesis which reflects our preliminary interpretation of the original ship and its missing parts. The voyage will test the hypothesis in a scale of 1:1. If we have added parts which do not function in the entirety of the ship, they will fail, either by breaking or not working as intended. If the ship as a whole, and the many individual parts, function correctly, our interpretations will be verified and the results can be considered representative of the original vessel – and of longships in general.

Testing the ship's sailing characteristics

The speed, sailing characteristics and manoeuvrability of the reconstruction will be tested under realistic conditions in the waters for which the original ship was built, the North and Irish Seas. The tests will take the form of an *experimental voyage* from Roskilde to Dublin and back, and controlled *sea trials* in the Irish Sea. The two types of experiment will focus on different things and will thus produce different results.

The voyage to Dublin will provide an opportunity to test and document the reconstruction's seaworthiness, manoeuvrability and speed under realistic conditions. Rest days and time spent waiting for favourable winds will be included in the data, making it possible to calculate the total duration of the journey and the average travelling speed.

The results will provide evidence of the speed at which longships travelled during the Viking Age and will allow comparison with the results achieved by other ship types over similar distances. Although the long narrow hull of the ship is designed for speed, the cramped space on board may make it necessary to go ashore frequently. It is thus possible that the total travelling time over long distances is no shorter than that achieved by broad-beamed, deep-draught cargo vessels.

Ship performance under various conditions will be investigated by analysing the data for speed, seaworthiness and manoeuvrability from specific stretches. Such results will reveal nothing of overall travelling time but will demonstrate the capabilities of the ship, and her limitations. The results will thus supplement those obtained in the controlled sea trials.

The controlled sea trials will elucidate the performance of the ship and her crew under various conditions. They will be performed as replicate experiments under varying conditions along a fixed route and are designed to test the ship's performance under both sail and oar.

Comparison of the ship's sailing characteristics and performance with other known ship types will put the possibilities the longships offered the Vikings into perspective – both in relation to other ship types and to ships from other historical periods.

Such comparison and interpretation will utilise the Viking Ship Museum's database on the sailing characteristics of other ship types. The database is

partly based on documentation obtained from sea trials with the museum's previous reconstructions of archaeological shipwrecks. In addition, use will be made of the comprehensive basic research performed, in close cooperation with the museum, by the Maritime Archaeological Research Centre in Roskilde from 1993 to 2003.

The results of the voyage and sea trials will provide an insight into the strategic decisions facing Viking naval commanders when sailing vessels of this type from A to B under specific conditions with the highest possible speed and/or safety. Was it, for example, fastest to beat against the wind or to lower the mast and row straight ahead? And how did the decision made affect the crew's condition on reaching the destination, and their ability to perform the tasks expected of them?

Functions, organisation and logistics

The ship and her crew are organised in accordance with the patterns described in Nordic literature from the 12th and 13th centuries. The skipper has overall responsibility, and immediately under him are two mates, one for each watch. The ship is divided into sections, corresponding to the various functions to be performed at sea, and each section has two foremen, one for each watch.

The various ship and crew functions will be investigated during the voyage, including steering, sail handling, mast raising and lowering, rowing and oar handling, communication within the ship, cooking, etc. Everyday life aboard the ship will also be investigated, e.g. crew health and well-being, food and water consumption, ability to sleep, etc. Finally, the logistic challenges involved in preparing and accomplishing a long-distance voyage with a longship and 65-man crew will be investigated.

Issues, scientific method and documentation

Testing the validity of the reconstruction/hypothesis, investigating the ship's sailing characteristics, and analysing the functions, organisation and logistics concerned, involve a number of common issues which, in one way or another, contribute to clarifying the overall questions asked.

Ship flexibility

One of the most challenging issues is the question of ship flexibility and reinforcement. The problem is extremely complex and of crucial importance for the ship's sailing characteristics and seaworthiness, and answers to it have been sought throughout the reconstruction process. The original reinforcement is not fully preserved, making it an uncertain part of the reconstruction.

The clinker-built ships of the Viking Age were light, flexible vessels, capable of twisting in the water as the hewn planks can be distorted and bent without breaking. This also applies to the internal construction, built of frail and slender parts hewn into shape from compass timber. The longer a Viking ship is, the more flexible it becomes, and the greater is the need to control such flexibility by means of reinforcing timbers.

With its 30 metre hull, the reconstruction is so long that it can be riding two waves the one moment and straddling a single wave the next, with both prow and stern lifted clear of the water. In heavy winds, the ship cannot – in the same way as a closed-deck vessel – turn into the wind and wait till the storm has passed. She must run with the wind. In heavy swells and high seas, the ship is designed to respond flexibly to the waves. Such flexibility, however, means that the entire construction is subjected to extreme loads, and all parts of the ship must interact perfectly together as a result. If flexibility is not adequately controlled, the hull may twist so much that the ship cannot recover or, at worst, the joints may spring and the ship collapse.

Flexibility is extremely difficult to investigate. It is inextricably linked to the construction principle itself, to material properties and technology, to the rigging that strengthens the entire construction, and to the ballast that contributes to hull rigidity. It is impossible to isolate these factors singly, but we can monitor the way in which the ship reacts to waves, how the construction absorbs the various loads, and how the ship recovers in high seas. If rivets begin to loosen, planks split or the ship springs leaks, flexibility is too great.

Since preliminary sea trials were performed after the ship was launched in 2004, various adjustments have been made to the construction. Among other things, wash strakes have been added, allowing the freeboard to be increased, and the hull reinforcements have been strengthened. If, during the voyage, parts fail or function poorly with other parts, this will be documented and the shipwright will make any necessary repairs, allowing the expedition to be completed. Ballast will be redistributed and the rigging

adjusted in order to achieve the required balance between flexibility and rigidity. If all parts interact perfectly under all conditions, the assumptions we made during the reconstruction work will be verified.

Whether they do or not will be investigated by one of the shipwrights who helped build the reconstruction. The shipwright will also examine and document the condition of the ship at daily intervals, paying particular attention to any signs of excessive or insufficient flexibility. All observations will be recorded in a special shipwright's diary, and complemented with sketches, photographs and videos.

Trim

The ship's trim is also crucial for its sailing characteristics. The force of the wind is concentrated in the effective sail centre, located at some distance from the edge of the sail, in from the luff. The shear force of the water is similarly concentrated in the effective lateral centre, the location of which depends on the shape of the hull below the waterline and the ballast trim. Correct balance between the hull, rudder and rigging is dependent on these two centres being vertically above one another. The ship must be able to hold an even course with the rudder in neutral position in all wind directions and strengths. In principle, it should be possible to steer the ship using the sail alone. If the sail centre is fore of the lateral centre, the ship will veer to leeward, away from the wind. If, on the other hand, the sail centre is aft of the lateral centre, the ship will veer to windward, into the wind.

When, by means of a suitable quantity of correctly positioned ballast, balance is achieved between hull, rudder and rigging when close-hauled, the ship should, if built correctly, also function well when running free or before the wind, and should lie correctly in the water under any conditions. The ship must also be capable of holding a steady course in all wind directions and strengths with the rudder in neutral position.

During the preliminary sea trials, it was found that the ship gripped the water best and attained the required balance between hull, rudder and rigging when carrying a total weight of 15 tons. The load must primarily be positioned with due consideration to the ship's overall trim. At the same time, the prow and stern must be able to move freely in the water and there must be sufficient freeboard beneath the oars.

It is important for the analysis of the ship's documented performance that the data recorded can be related to the total weight of the load and its position. While ballast stones and equipment have a constant weight and permanent location, the crew can be moved around the ship whenever it is necessary to adjust the trim at sea.

The weight and quantity of provisions are variable. Four litres of water per person per day will be taken on the voyage, and the weight of the load will thus be reduced by some 260 kg every 24 hours. When crossing the North Sea, provisions will be carried for 8 days, and the load will be reduced by up to 3 tons as these are gradually consumed. It must be expected that such

weight reductions will have significant effects on the ship's trim and sailing characteristics.

This issue will be monitored by the skipper and mates, who will continuously adjust the ship's trim while at sea on the basis of the actual balance between hull, rudder and rigging. All relevant data and observations will be documented in the log and supplemented, among other things, by videos shot from the ship's mast and stems, and from the support vessel. The changes in balance that can be ascribed to a reduction in the weight of the load will be documented separately.

Sailing characteristics, speed and tacking/beating ability

The ship's sailing characteristics, speed and manoeuvrability will be investigated under realistic conditions in relation to the wind and weather, the waters crossed, currents, wave height, etc. The ship will be tested under both sail and oars.

Favourable wind for a single-rigged, square-sail vessel is when the ship is sailing at an angle to the wind of between 70° (on the bow) and 180° (dead astern). There will generally be little leeway within this range and top speeds can be achieved at angles of 90-140° to the wind. In comparison with other longship finds, the reconstruction has a relatively upright garboard. This has presumably enhanced the ship's grip on the water and directional stability, thus improving her sailing characteristics in the stormy waters of the Irish Sea. The sea trials will demonstrate, among other things, whether the upright garboard has improved the ship's sailing characteristics in relation to other square-sail vessels.

Compared to other archaeological longship finds, the reconstruction has a relatively compact rowing section, with more oars per metre than usual. This allowed the ship to carry a greater number of men, providing a more powerful 'motor' and probably increasing her ability to achieve sufficient steerage way in current and tidal waters. The compact oar section, however, makes high demands on the crew's rowing technique.

The controlled sea trials will include tests on a course of fixed length and with varying angles to the wind. The tests will provide data on ship speed, leeway and ability to point into the wind under various conditions.

Rowing trials will also be held, with the mast up or down, at various angles to the wind, with varying numbers of oars and stroke frequencies, and over varying distances.

The trials will be performed in such a way as to allow comparisons to be made, e.g. rowing as opposed to beating against the wind.

All data from the sea trials, including the ship's course towards her destination, angle to the wind, speed covering the distance and through the water, and wind speed and direction, will be recorded by the electronic navigation system and stored on a hard disc drive. Such documentation will be supplemented by the ship's log and any observations made by the section foremen regarding ship or crew function.

Ship and crew functions, organisation, logistics and life on board

The data on ship and crew function entered in the ship's log will be supplemented by the foremen of each of the vessel's six main sections. The foremen will observe and document all central functions in their respective sections in foremen's diaries, complementing their entries with photographs and videos. Section foremen will also document the logistic and social challenges faced in each section. How can personal belongings be stowed? Where can crew members find space to sleep? How do the crew react to the various challenges?

The crew's consumption of food and water will be documented by the ship's cooks in the cooks diary. The diary will also be used to record thoughts and observations on food and water storage, food preparation and cooking, and the crew's need for food and water at different times of the day.

The health and well-being of the crew will be checked by the ship's nurse and recorded in the medical diary. This log will pay particular respect to sensitive personal data.

Research contribution

The expedition to Dublin is the climax of the Thoroughbred of the Sea project. Assuming that the expedition is successfully completed, it will primarily provide a general understanding of the design, function and characteristics of Skuldelev 2 and its importance for Viking society. It will also be possible to generalise the knowledge gained to cover all specialised longships of the Late Viking Age.

The tests of the ship's sailing characteristics will provide a better understanding of the travelling speed of longships over considerable distances and allow such data to be compared with information on other ship types – from the same or different historical periods. The trials will also provide information on longship speed over short distances, and will provide an insight into the strategic decisions facing Viking naval commanders when performing specific tasks under given conditions.

In addition, the voyage and sea trials will provide new knowledge on the functions and seamanship required to sail these highly specialised vessels, on the living conditions in the mini-community a ship and her crew comprised, and on the organisation and logistics required for preparing and completing long-distance expeditions in a longship.

Many questions arise when a partially preserved shipwreck is to be reconstructed and tested as a functional entity. Answers can be sought by re-examining the original find or by consulting the broad and comprehensive source material which is available, including archaeological and ethnological parallels and written and iconographic sources. The process thus uncovers questions and issues that require fresh studies of the source material and fresh approaches.

Some of these questions cannot be answered as part of the project itself, but they provide valuable inspiration for subsequent research. The manpower required to build the reconstruction, for example, challenges current opinions on the size of the Viking Age population in Denmark.

Practical aspects of the project have also cast new light on the sometimes rather vague descriptions and concepts given in old Nordic literature and on archaeological finds of single ship parts which, without the rest of the ship, are difficult to interpret and explain.

The project's investigation and research processes will be publicised and communicated electronically, as they occur, on the museum website and in exhibitions (see the Dissemination Plan for further details). The project will thus give an insight into the methods and character of maritime archaeological research and will hopefully generate increased interest in the subject.

The results of the project will be published in 'Ships and Boats of the North', the Viking Ship Museum's English language monograph series.