

Innovation and development of a sailing kayak

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Abstract

Sailing and kayaking are two highly entertaining nature-inspired sports but rarely combined into hybrid solutions. This paper describes the challenge of combining the best of the two sports into an innovative sailing kayak solution. The need for such hybrid solutions mainly arises during multi-day expeditions where both, calm sea and windy periods are often met. Calm sea can be best travelled in a fast touring kayak, and a sailing capacity is very precious during windy days. The basic problem of hybrid sailing-kayaking solutions are numerous contradicting requirements for both sports, therefore the design requirements are quite challenging. The proposed sailing kayak solution strives toward the following objectives:

- (1) capacity for off-shore sailing/paddling transitions which means being able to change between paddling and sailing without landing at the coast,
- (2) ultra-light construction that should be lighter than an average touring kayak,
- (3) very high paddling speed, preferably faster than an average touring kayak,
- (4) good sailing performance that can be average for a sailing boat but exceptional for a kayaking world,
- (5) modular design for a multi-purpose product.

In the presence of only a few existing commercial sailing kayak solutions, innovative design was developed to fulfil the objectives. A novel folding sail system was developed to fit the ultra-light design and to support efficient sailing. The prototype was built in a vacuum-infused vinylester-carbon technology and finally, successfully tested along the Adriatic coast during the summer 2009. The paper describes the individual phases of planning, innovating, managing, designing and manufacturing of the project.

Keywords: kayak, sailing, innovation, design, trimaran, carbon, ultra-light.

1 Introduction

The idea to explore sea by combined paddling and sailing is not new and has roots in many traditional littoral nations where it served for fishing and travelling purposes. Modern vessels that combine paddling and sailing usually serve to the purpose of sport and entertainment and tend to use modern materials and various technical solutions to assist paddling and exploit the power of wind. The need for such hybrid paddling/sailing vessels mainly arises during multi-day expeditions where both, calm sea and windy periods are often met. Calm sea can be best travelled in a fast touring kayak, and a sailing capacity is very precious during windy days. Since the basic problem of combined sailing-kayaking solutions are numerous contradicting requirements for both sports, the design requirements are quite challenging and successful hybrid solutions very rare. This paper describes the challenge of combining the best of the two sports into an innovative sailing kayak solution.

2 About the project

2.1 Motivation

The motivation for such a project was planted during the summer vacation in 2007 while sitting in a touring kayak and enjoying a silent early morning paddling. During the next days, the idea of combining paddling with sailing was transformed into several sketches. The inaccessibility of Internet connection was most probably the good catalyst to generate novel generic solutions without being too early caught into the state of the art. Only later, after returning to the urban world, the existing state of the art was studied carefully. Several existing sailing kayak solutions were already available on the market but did not comply with the complete list of objectives (presented in the next section). The result of this preliminary research was a decision to start a project to innovate, develop and realize the unique ideas, generated during the summer.

2.2 Project objectives

The project goal was defined to create a novel sailing kayak solution that would fulfill the following objectives:

- (1) capacity for off-shore sailing/paddling transitions,
- (2) ultra-light construction,
- (3) very high paddling speed,
- (4) good sailing performance,
- (5) modular design.

Some more comments are necessary to clarify the objectives and to explain the possible solutions:

Capacity for off-shore sailing/paddling transitions is essential for safety. The pilot should be able to change between paddling and sailing on the open sea without landing at the coast. This requires a foldable construction of a complete rig (a sail and a mast) with a design that permits handling from a kayak cockpit.

Ultra-light construction means speed and easy transportation. This is highly valuable feature but not easy to achieve. Expensive constructions, such as carbon or Kevlar composites, and elaborate manufacturing techniques are required. Recreational touring kayaks are usually produced in a cheap but very durable plastic. Such boats are quite robust against contacts with rocks, but the weight of a kayak will easily exceed 25 kg. A combination of paddling and sailing capacity requires additional equipment and construction reinforcements that also add considerable weight portions. Several commercial sailing kayaks or sailing outrigger canoes usually weight 40-50 kg which is already too much for easy single manned handling. Consequently, the objective was defined to reduce the weight of a complete sailing kayak below 25 kg which is a very ambitious requirement.

Very high paddling speed is essential for efficient paddling and long distance traveling. It is a combination of a careful boat design and low weight but usually results in a low stability. Flat-water racing boats are very fast but also very unstable and as such useless for recreational purpose. On the contrary, touring kayaks are very stable but slow. If very high paddling speed is desired for a paddling/sailing hybrid, the hull design should be kayak-based that is optimized for paddling, not for sailing, as an average sailing design is not suitable for paddling.

Good sailing performance is difficult to achieve with a kayak-based design. The basic problem

occurs due to low kayak stability. This can be solved by increasing kayak beam but will reduce hull speed. The other option that is usually applied by various manufacturers is multi-hull design which stabilizes unstable kayak by one or two outriggers and thus creates a catamaran or trimaran construction. An appropriate sail will be needed to exploit the power of wind and the pilot should be able to control the sail and the sailing course from the cockpit.

Modular design requires a multi-purpose product that can be used in several ways. The first is a single-hull kayak without sailing capacity, then a multi-hull paddling boat for open sea paddling, and finally a complete sailing kayak for sailing.

2.3 Organization of the project

The project was initiated as a home-made entertainment and was managed spontaneously and grew organically as it was developed further. The initial single-manned engagement was soon extended to the cooperation with several specialists, mainly in the field of industrial design, boat building, composite material processing, etc. The costs of the project were carefully controlled at all times which resulted in a low-cost project that could be completed without external financial influences. The approximate project schedule expressed in months is shown in table 1.

Table 1 Project schedule

Activity	Months
Brainstorming	1
Prototype I (catamaran)	2
Testing I	3
Prototype II (trimaran)	2
Testing II	2
Team building	2
Industrial design	2
Innovating details	1
Prototype III	2
Testing III	1
Finishing design	1
Master & moulds	3
Manufacturing	3
Testing	1
Project (months)	26

3 Innovating the solution

The initial brainstorming phase was mainly concerned with the innovation of a folding rig which would fulfil the first project objective. The problem of a folding rig on a kayak is that vital parts of the rig are not accessible from the cockpit and therefore an elaborate system has to be

designed to control the rig from the kayak cockpit. The core solution was based on the following presumption: in order to set up and fix a mast, three ropes should be applied. If solid bars are used instead of the ropes, only two are enough to stabilize the mast in an active position. This was the core innovation of the project and during the development of the project, two distinct versions were designed, for a catamaran and for a trimaran construction.

3.1 Catamaran solution

The first sailing kayak solution was designed as a catamaran construction that consists of a main hull with an outrigger attached sideways. The main hull was constructed as a racing kayak which is very fast but also very unstable, therefore the stability was improved by the outrigger. The sailing kayak in a catamaran version was designed as shown in Figures 1-2.

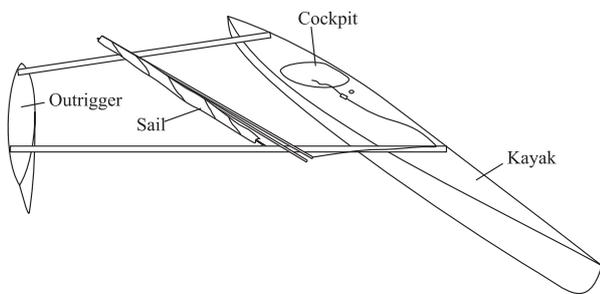


Figure 1 Catamaran design of a sailing kayak, rig in passive paddling position.

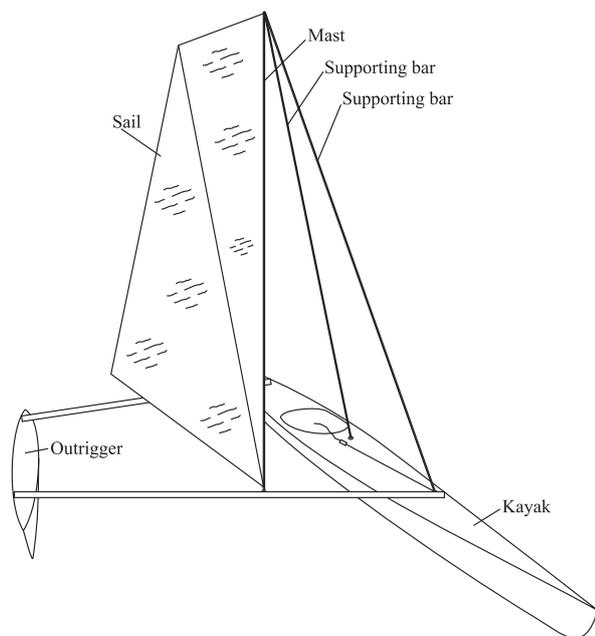


Figure 2 Catamaran design of a sailing kayak, rig in active sailing position.

Extensive testing was quite successful. The catamaran solution was very stable, easy and fast

to paddle, offered sufficient sailing capacity and the innovative folding rig solution was very user-friendly and suitable for off-shore sailing/paddling transitions. But testing also revealed an important safety shortage – strong wind sailing on a starboard tack sometimes caused lifting the outrigger as shown in Figure 3 which can eventually cause capsizing. This was a serious safety deficiency and consequently further innovation was redirected toward the multi-hull trimaran design.



Figure 3 Catamaran design of a sailing kayak in strong wind conditions.

3.2 Trimaran solution

An advantage of a trimaran sailing kayak solution is symmetric design which provides for safety due to stabilizing outriggers on both sides of a kayak. But the proposed catamaran-based folding rig solution was not suitable for a trimaran version and therefore a novel folding rig had to be invented. The basic concept of a tripod mast construction was retained but a new folding system was developed based on a V-frame that supports sail in an active sailing position. The trimaran solution of a sailing kayak is schematically shown in Figures 4-5.

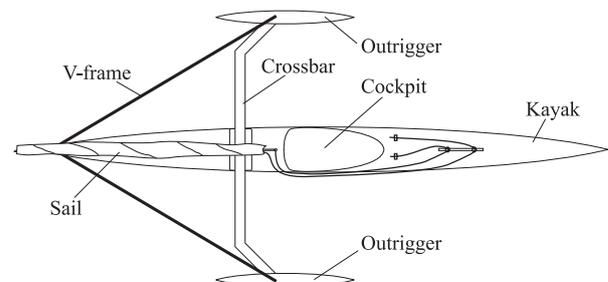


Figure 4 Trimaran design of a sailing kayak, rig in passive paddling position.

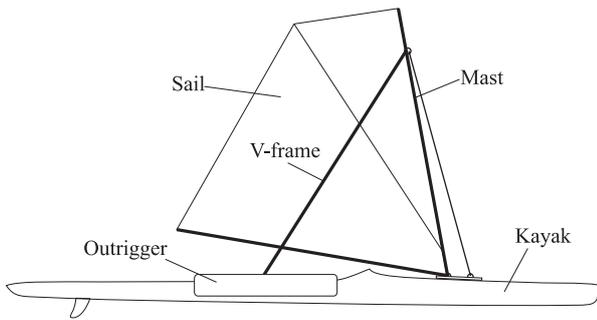


Figure 5 Trimaran design of a sailing kayak, rig in active sailing position.

Next to the folding rig invention, the challenge was to properly design and combine the elements of a sailing kayak: kayak hull, crossbar, outriggers, rudder. Basically, the kayak hull has to be optimized for paddling and this requires a long and narrow hull with small wetted surface. Therefore a flat-water racing kayak with displacement hull was used for the initial experimentation and proved to be quite a good choice. The outriggers were designed through several experimentation phases into displacement shapes in order to reduce stress on the crossbar and to offer lateral resistance during sailing as a replacement for a centreboard. Several versions were constructed and tested, and final prototyping version shown in Figures 6-7 was a good proof of concept, ready for the next level of a product development.



Figure 6 Trimaran prototype testing: paddling.

4 Designing the solution

The prototype trimaran version shown in Figures 6-7 provided practically a complete functionality and also approached close to the project objectives. The next level of product development therefore included design fine-tuning – in terms of both function and appearance. In this level of product development, several experts were involved without whom the sailing kayak would only stay a home-made potato.



Figure 7 Trimaran prototype testing: sailing.

In order to fulfil the modular design objective, the racing kayak hull was replaced by an excellent multi-sport kayak designed by Matjaž Svetek. The new hull was very fast, offered more volume for sailing and expeditions, and was considerably more stable for flat-water application as a single hull kayak.

As next, a complete redesign of a sailing kayak solution was accomplished in cooperation with Martin Šoštarič, Gigodesign. This was a major step in product development and added various functional improvements and a unique appearance. Several design renders are shown in Figures 8-10.



Figure 8 New design of a sailing kayak: folded rig, paddling position.



Figure 9 New design of a sailing kayak: sailing position.



Figure 10 New design of a sailing kayak: front view.

The construction of a complete sailing kayak is foldable for easy transportation and handling. Figure 11 presents separate parts of a construction. The complete setup can be managed in less than 10 minutes. The next step of product development was manufacturing the new sailing kayak in an ultra-light fashion that would comply with project objectives.

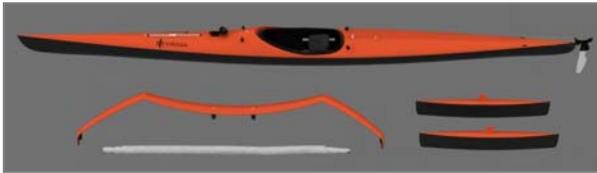


Figure 11 Separate parts of a sailing kayak construction.

5 Manufacturing the prototype

As first, a preliminary low-tech prototype was constructed in order to verify the geometry and properties of the new design. Figure 12 shows the preliminary prototype ready for initial testing.



Figure 12 Low-tech prototype of a new design.

The initial testing proved a successful design and with only some minor modifications, the manufacturing of an actual product was initiated. In order to achieve a stiff ultra-light construction, vacuum infused carbon/vinylester composite was applied. Figure 13 shows vacuum infusion of a main hull.



Figure 13 Vacuum infusion of a main hull.

The outriggers and the crossbar were formed on a CNC machine and then manually finished to obtain hi-quality master pieces. Based on master pieces, appropriate moulds were prepared as shown in figure 14. Then the crossbar and outriggers were manufactured in a vacuum bagging technology.



Figure 14 Moulds for the crossbar and the outriggers.

The manufacturing process also included the design of a sail, completing the carbon V-frame and a mast, mounting the sliding seat option, fixing the rudder with a steering mechanism, and finally finishing the product with marine hardware, compass and appropriate ropes. The final result ready for testing is shown in Figure 15.



Figure 15 Manufactured sailing kayak.

6 Testing results

Extensive testing in various paddling and sailing conditions was carried out during the summer 2009. In summary, the manufactured sailing kayak performed very well and fulfilled the project objectives, as follows:

- (1) Capacity for off-shore sailing/paddling transitions was completely achieved and enabled efficient transitions even in rough sea conditions.
- (2) Ultra-light construction objective was fulfilled with a complete sailing kayak weight of 23 kg.
- (3) Paddling speed is very high due to multi-sport kayak design. The outriggers only slightly reduce the top speed.
- (4) Good sailing performance was obtained in the range of 210 degrees and the sail construction is appropriate for the wind range 2-4 Bf.
- (5) Modular design requirement was fulfilled as shown in Figures 16-19 with three modes of operation: single hull paddling, trimaran paddling, and trimaran sailing.

The sailing kayak also performed well in expedition conditions, carrying the complete provisions for a week-long independent traveling along the coast. Even testing in high wind conditions (5+ Bf), as shown in Figure 19, was successfully completed with recorded GPS speeds up to 18 km/h.



Figure 16 Modular design: single hull paddling.



Figure 17 Modular design: trimaran paddling.



Figure 18 Modular design: sailing.



Figure 19 High wind sailing.

7 Conclusions

The innovation, development, design, manufacturing, and testing of a novel type of a sailing kayak was described. Testing results confirmed that the proposed solution complies with the project objectives. More details about the presented sailing kayak are available on the web: www.viroga.com.

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