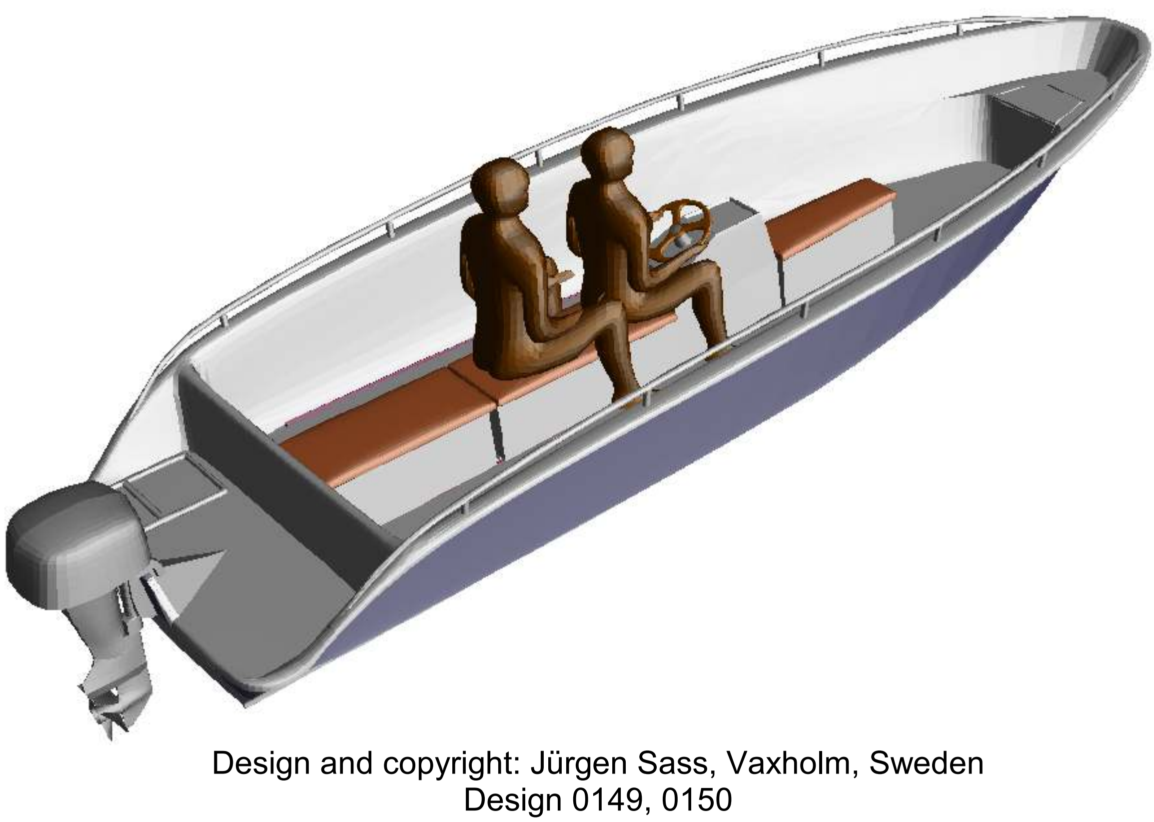
Design Challenge 2009
Professional BoatBuilder

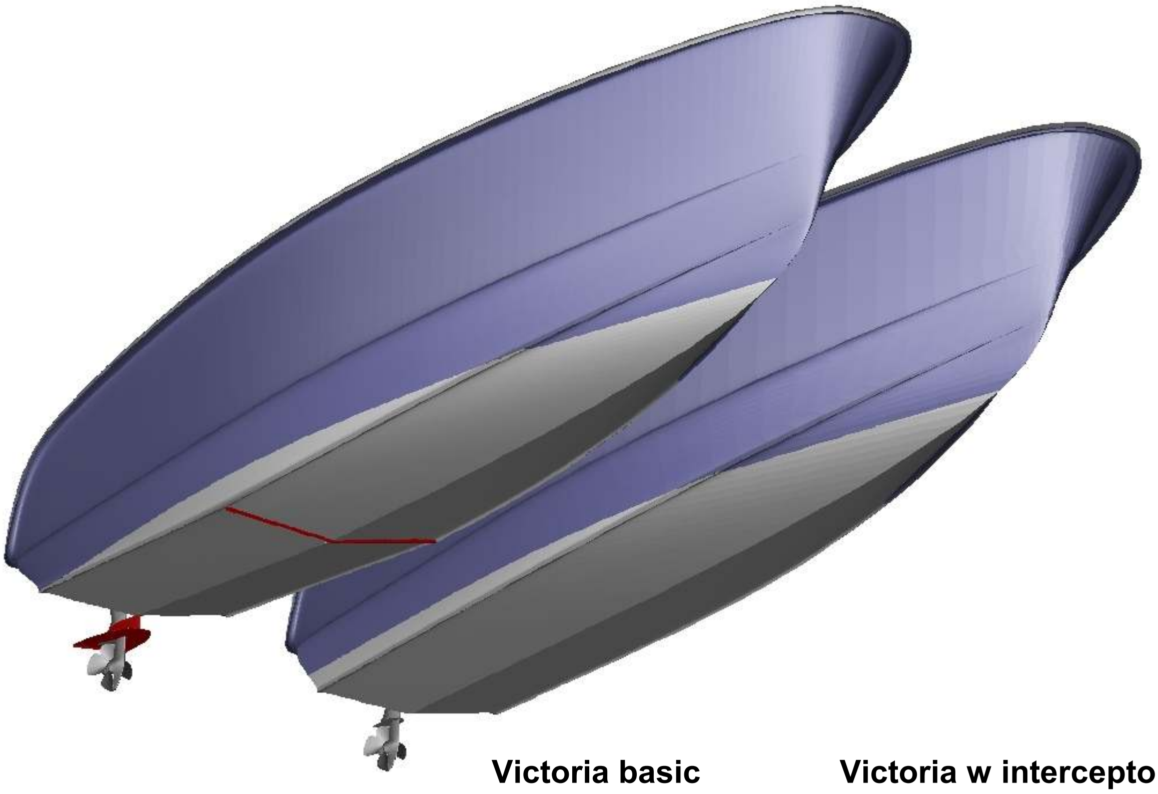
*Vision of **Victoria** with midship interceptor at 19 knots with only 8 horsepower*

Victoria

an efficient, comfortable and versatile boat
in both flat water and rough sea
at both low and high speeds
with both low and high load



Design 0149, 0150



		Victoria basic		Victoria w interceptor	
Length over all	m	5.60	5.60	5.60	5.60
Length in waterline	m	4.92	5.05	4.99	5.09
Beam over all	m	1.76	1.76	1.76	1.76
Beam in waterline	m	1.15	1.24	1.14	1.23
Draft	m	0.15	0.19	0.17	0.22
Waterplane area	m^2	4.41	4.90	4.47	4.93
Displacement	m^3	0.40	0.60	0.40	0.60
Hull weight	kg	140	140	145	145
Transport efficiency 15 knots		4.3	4.1	4.5	4.3
Transport efficiency 19 knots		3.9	3.8	5.2	5.1

Abstract

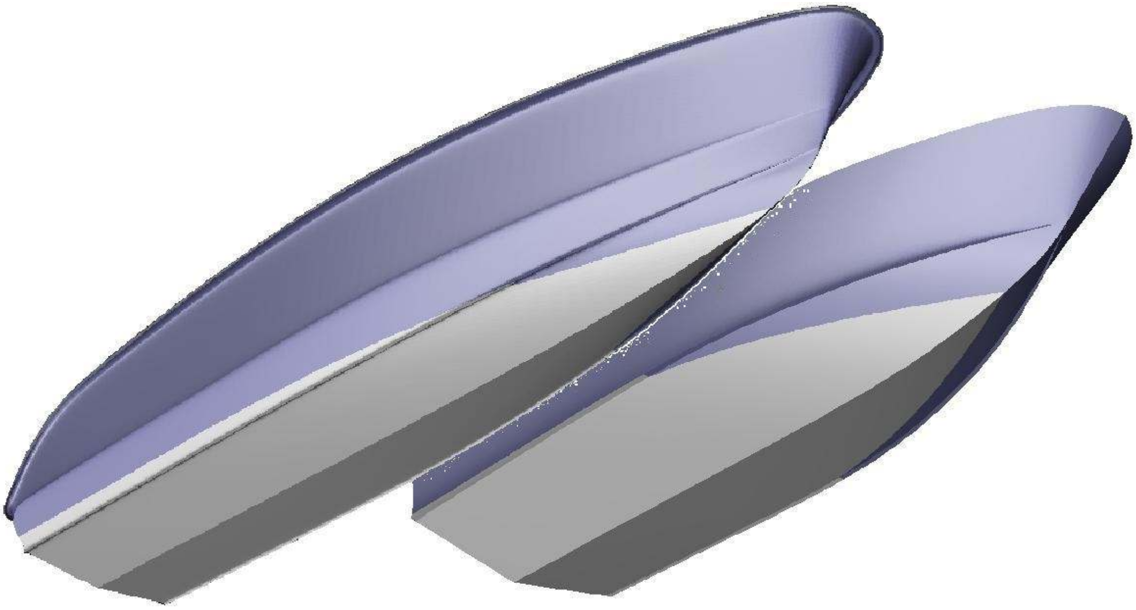
Victoria's hull with double chine, narrow bottom and fine waterline entry creates a boat that has low fuel consumption and a soft motion in waves. The upper chine and the flared stem complement each other so that the boat will remain dry in rough seas. In addition, this shape has good qualities in sharp turns.

With an adjustable midship interceptor and an aft stabilizer, the boat becomes even more efficient at higher speeds. The planing surface area is limited to a small part of the bottom in front of the interceptor. The entire aft bottom is dry. With the aft stabilizer the trim angle will be optimally controlled. (Patent pending)

A conventionally designed boat would need a roughly 50% larger engine and therefore higher fuel consumption.

All parts are built in sandwich laminates for low weight and high strength. All parts are stackable in order to streamline the transport and storage during production. The large floating tanks, the sandwich core and the scuppers make the boat unsinkable.

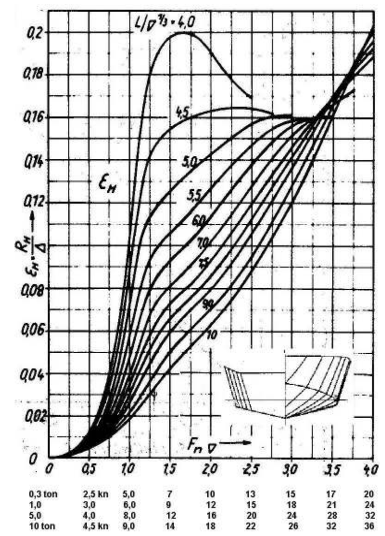
The flexible interior consists of separate elements to be fitted to the longitudinal rails integrated in the floor. The interior can be customized completely to the consumers' actual needs and wishes.



General design

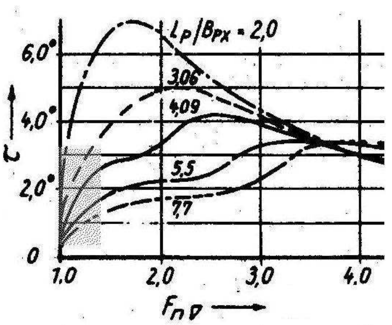
In this study, two boats are compared to show that it is easy to create a boat with much better properties than what is common today. Both boats have been built around the same volume, total weight and speed. The standard model, called here C400/600, is a common, well-proven boat with slightly better properties than the market average. The new boat, called here Victoria 400/600, is a development from a boat with a similar bottom design which has proved to be very efficient and seaworthy. To get a fair result, the boat’s weight is considered to be equal. In reality, the C-hull is slightly heavier due to its simpler construction.

			C600	C400	V600	V400
Length hull over all		m	4.98	4.98	5.62	5.62
Length	Lp	m	4.50	4.50	5.30	5.30
Length waterline	Lwl	m	4.16	4.02	4.97	4.77
Beam hull at sheer		m	1.83	1.83	1.57	1.57
Beam in waterline	Bwl	m	1.64	1.49	1.20	1.12
Chinebeam	Bpx	m	1.64	1.64	1.04	1.04
Depth mid		m	0.20	0.16	0.18	0.14
Deadrise		dgr	12.0	12.0	8.0	8.0
Displacement	Disp	m^3	0.60	0.40	0.60	0.40
Centre of gravity	CG	m	1.55	1.49	1.82	1.72
Waterplane area	Wla	m^2	5.37	4.87	4.91	4.39
Speed		knots	15.0	15.0	15.0	15.0
Lp/Disp^1/3			5.3	6.1	6.3	7.2
Lwl/Disp^1/3			4.9	5.5	5.9	6.5
Ap/Disp^2/3			8.5	11.2	6.4	8.4
Wla/Disp^2/3			7.4	8.7	6.7	7.8
Lp/Bpx			2.8	2.8	5.1	5.1
Lwl/Bwl			2.5	2.5	4.1	4.2
CG-Cap % Lp			7.9%	9.4%	8.2%	10.0%
Speed FnD at 15 knots			2.7	2.9	2.7	2.9
Tranport Efficiency			3.4	3.4	4.1	4.3



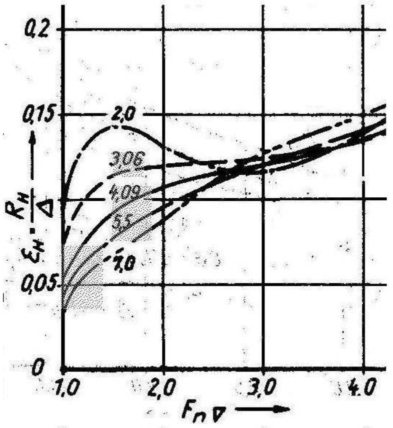
The adjoined diagram can be a guide to estimate the hull efficiency. The charts are general, relative and should be used with discretion and not for absolute calculations. Combinations of all the parameters can give different results than those shown here. On the horizontal scale is the relative speed read. On the vertical scale is the relative drag read.

The length to weight degree, $Lp/Disp^{1/3}$, $Lwl/Disp^{1/3}$, is affecting the boat's performance at the most. Most of today's boats are relatively heavy in relation to their length. They usually have a length to weight ratio around 4.5. C600 has a rate of 4.9, C400 has 5.5, which contributes to the fact that the boat is slightly different from the average.



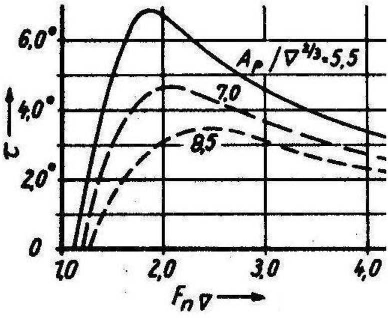
By increasing the effective length for V600, the length to weight ratio will be 5.9 and 6.5 for the V400. The result is a much higher efficiency, especially in the low-speed range.

Length to beam ratio, Lp/Bpx, on the dynamic lifting bottom affects the drag and the trim angle significantly, especially at low speeds. C600/400 has a Lp/Bpx of 2.8. The longer Victoria-hull bottom has a Lp/Bpx of 5.1.



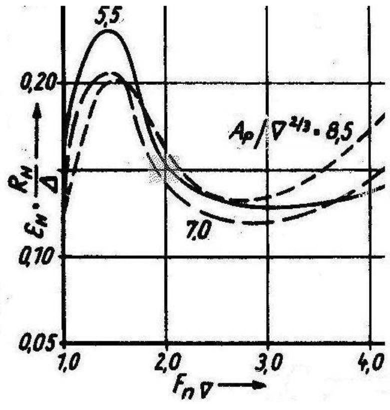
The trim angle of the standard model can at most be five degrees. The Victoria hull has the most moderate two and a half degree trim angle at speed around 15 knots. The Victoria-hull has no significant planing hump.

At the lower speeds, the need for power differs greatly. The differences at the higher speeds are affected more by other characteristics than the length to beam ratio, such as the ability to meet waves.

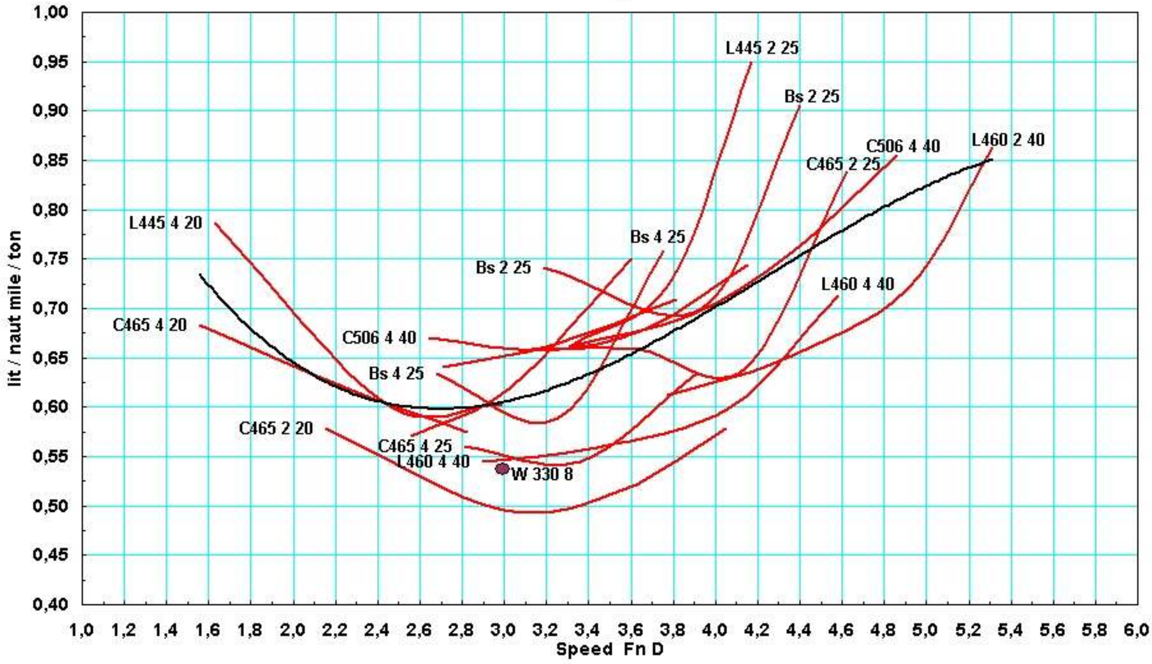


The bottom load, $Ap/Disp^{2/3}$, is closely linked with the above. To get the boat to be lifted up to higher speeds, bottom load value should never be lower than 5.5. Many of today's boats are dangerously close to that limit and need to have unnecessarily high fuel consuming engines to overcome the planing hump.

The bottom load for C600 is 8.6 and for the C400 it is 11.2. This means that the boat has good value at full load, and it has an exceptionally high value when it goes with a low load. The Victoria-hull has been optimised so that the values are between 6.4 and 8.4 in order to cover as wide a load and speed range as possible.



In general, the Victoria-hull could have been slightly longer and able to run a little faster, than the requirement of 15 knots to have optimal efficiency.



Minimum fuel consumption

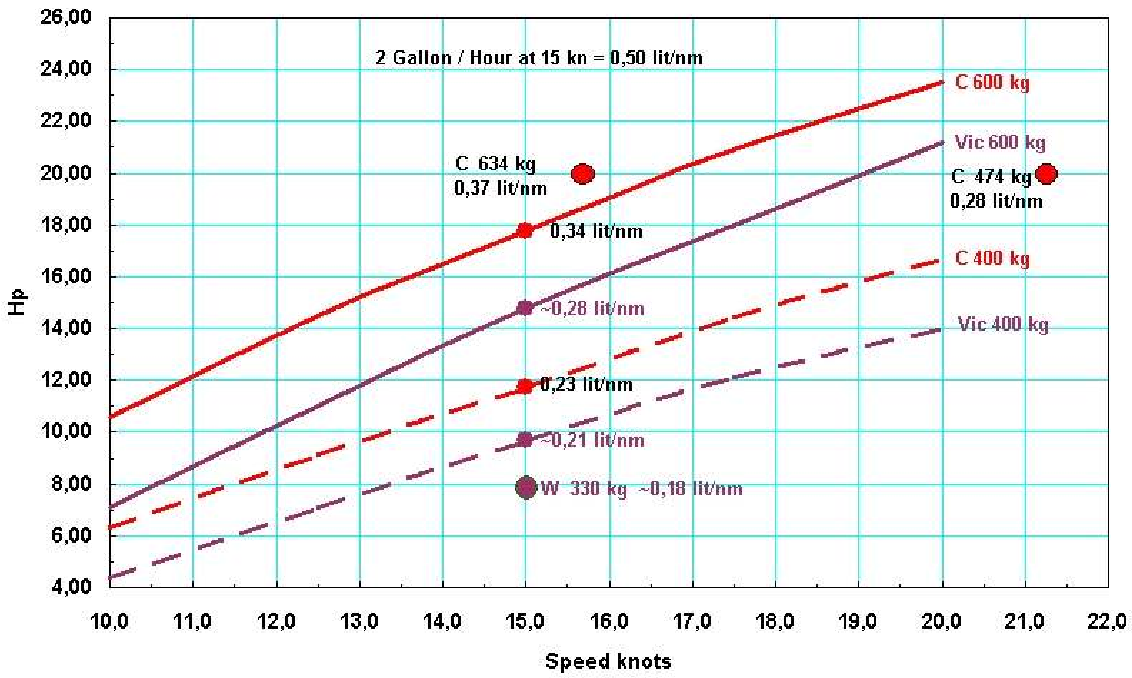
The above chart is a compilation of some craft measured fuel consumption. The speed is expressed in the dimensionless figure FnD, speed in relation to displacement. Similarly, the fuel consumption is reported in litres of gasoline per nautical mile per ton displacement. In this way, different boats may be compared with each other and fuel consumption for new boats estimated.

For this chart boats have been chosen to calculate fuel consumption for a 5.0 – 5.5 meters open boat with outboard and a weight between 400 and 600 kilograms.

From this compilation it is clear that there is a minimum between FnD 2.6 and 3.2. For this boat, that would be a speed between 14 and 17 knots. This is the speed just above what is known as the planing hump speed. It also shows that the boat's total weight is of great importance in lowering fuel consumption.

From the chart it can be seen that fuel consumption can be 0.50 - 0.65 litres / nm / ton. The differences are in the boat's shape, the bottom load, the centre of gravity and the propeller choice.

For the current size of the boat the fuel consumption in flat water would be between 0.20 and 0.42 litres of gasoline per nautical mile, depending on design and total weight.



Maximum efficiency

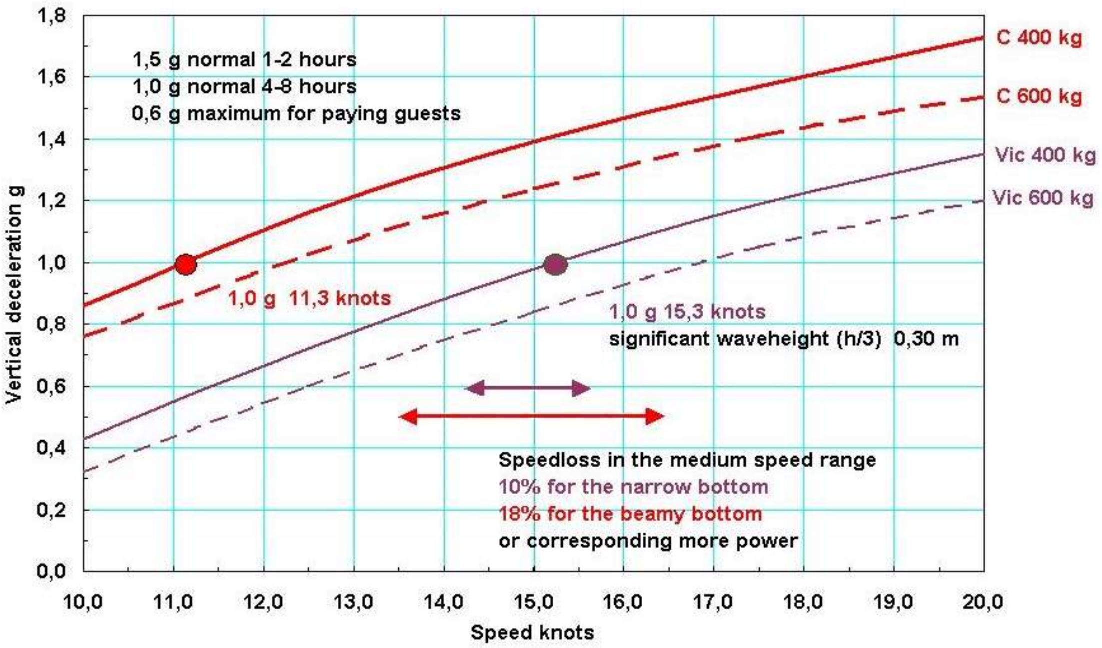
The above power/speed chart is based on the following: calculations according to J.A. Mercier, D. Savitsky, J.M. Almeter, other's measurements; my own model tests, calculations and full-scale tests. The graph shows the actual values of C-boat with red dots as a check that the calculations are reliable.

To get a fair result, the boat's weights are considered to be equal. In reality the C-hull is slightly heavier because of its simpler construction. Engine power is assumed to be used to 56%. This value has been calibrated against the actual measured values of the C-boat and the W-boat.

Based on the actual measured values recorded, the fuel consumption for Victoria is calculated for 15 knots.

To the above, to the Victoria-hull has 1.5 horsepower to be added in order to meet the requirement of 15 knots in 0.9 meter waves. For the C-hull, an addition of approximately 3.0 horsepower and the corresponding fuel consumption has to be made.

To get the best values calculated here, Victoria should be equipped with a twenty horsepower engine and a propeller adapted to the real need. With such an engine there are also large reserves for a possible overload. With the corresponding tolerance requirement would the C-hull require a twenty-four horsepower engine.



Optimized seaworthiness

This part of the investigation indicates the possibility to design a hull for good seaworthiness ability while preserving efficiency. The background is the investigations for planing boats by J. Koelbel and M. Hoggard. The above examples are based on significant wave height (h/3) of 0.3 meter. This corresponds to a maximum wave height of 0.9 meter, which is the requirement in this project.

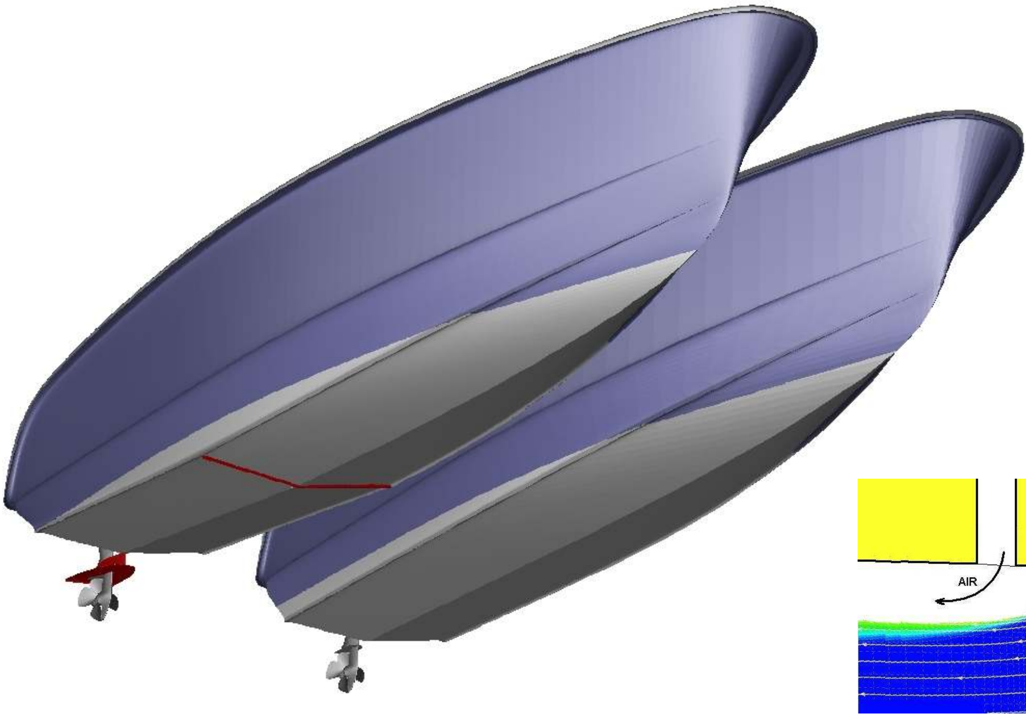
$$g = 0.0004622*(12*h_{1/3}/b+1.0)*\tau*(50-\beta)*V_k^2*b^2/\Delta$$

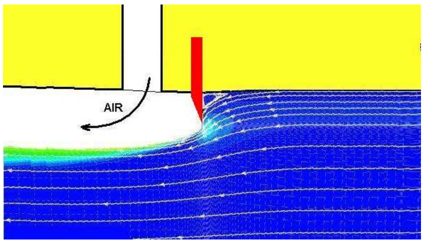
The average g-force is affected by the wave height, the speed, the total weight, the trim angle, the deadrise and foremost, the bottom beam. Just changing the deadrise gives a very marginal effect in the end, because the trim angle increases significantly with increased deadrise. Merely creating a light and thus easily driven boat leads directly to a hard run in waves. A boat with narrow bottom is always smoother and more efficient in waves.

The Victoria-hull bottom beam and deadrise has been optimized so that it can run efficiently and smoothly in all situations.

If Victoria 400 goes in 15.3 knots, then the average g-force will be 1.0, which should be acceptable for four to eight hours for most people. If we require the same comfort with C 400, we have to reduce the speed to 11.3 knots. The slim Victoria-hull needs about 1.5 horsepower more than in flat water to retain 15.3 knots. The beamier C-hull needs about 3.0 horsepower more and correspondingly higher fuel consumption, to retain 11.3 knots. With a full load, speed can obviously be slightly higher while maintaining comfort.

In conclusion, the Victoria-hull is far superior to the usual C-hull in all circumstances and under all conditions. With very simple means it is possible to create an efficient boat with low environmental impact without sacrificing speed and seaworthiness.





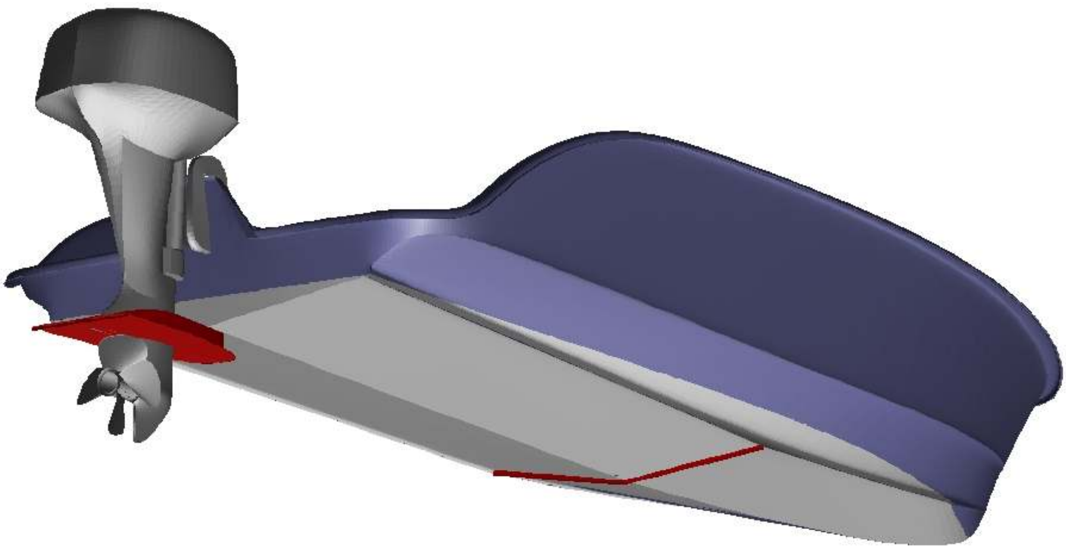
Midship interceptor function

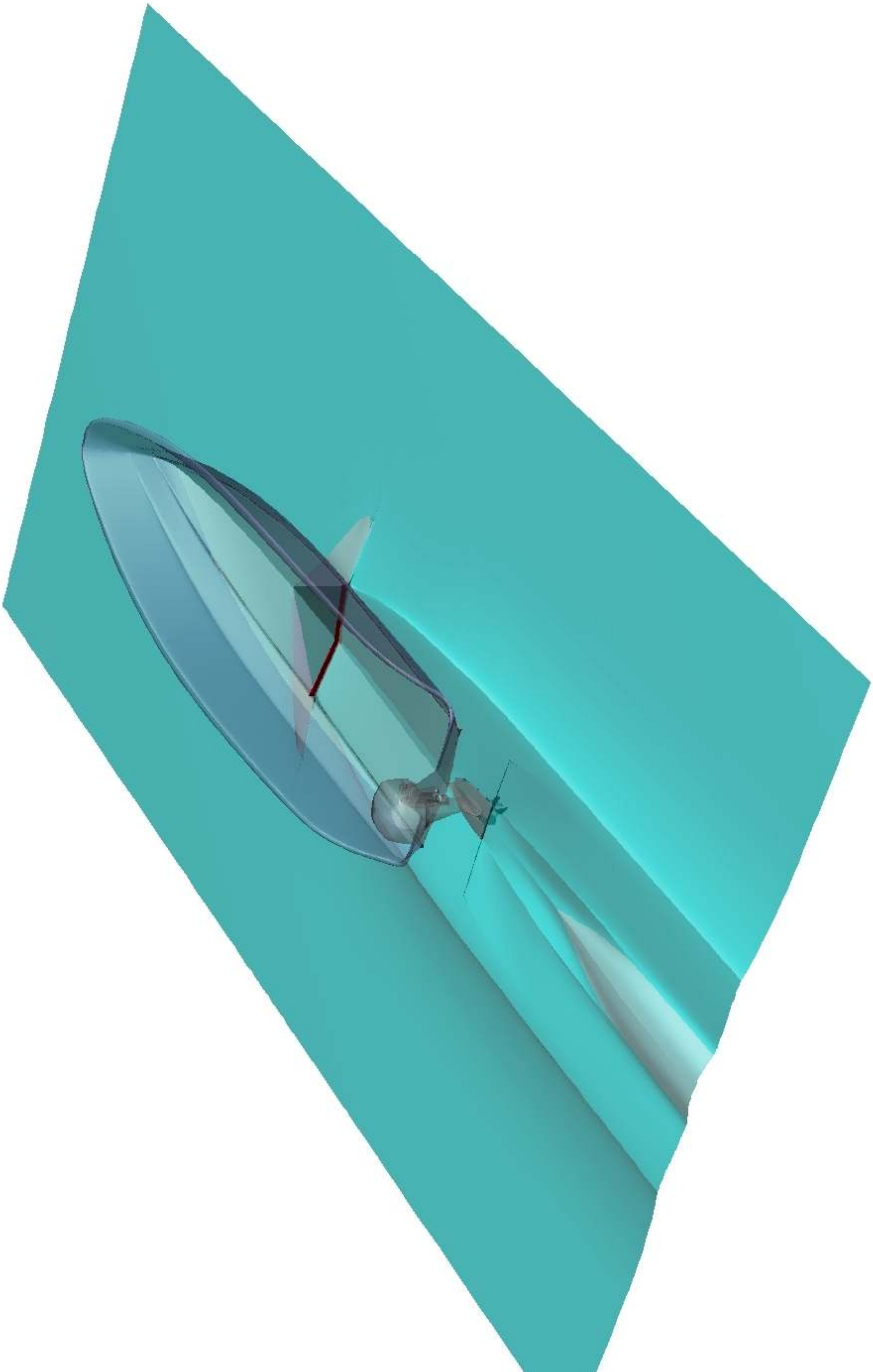
If the boat has a slightly modified bottom, a midship interceptor and an aft stabilizer, it will be even more efficient at all speeds. The interceptor is a vertical plate that is pushed down under the planing surface. This creates a high pressure in front of the interceptor. (Patent pending)

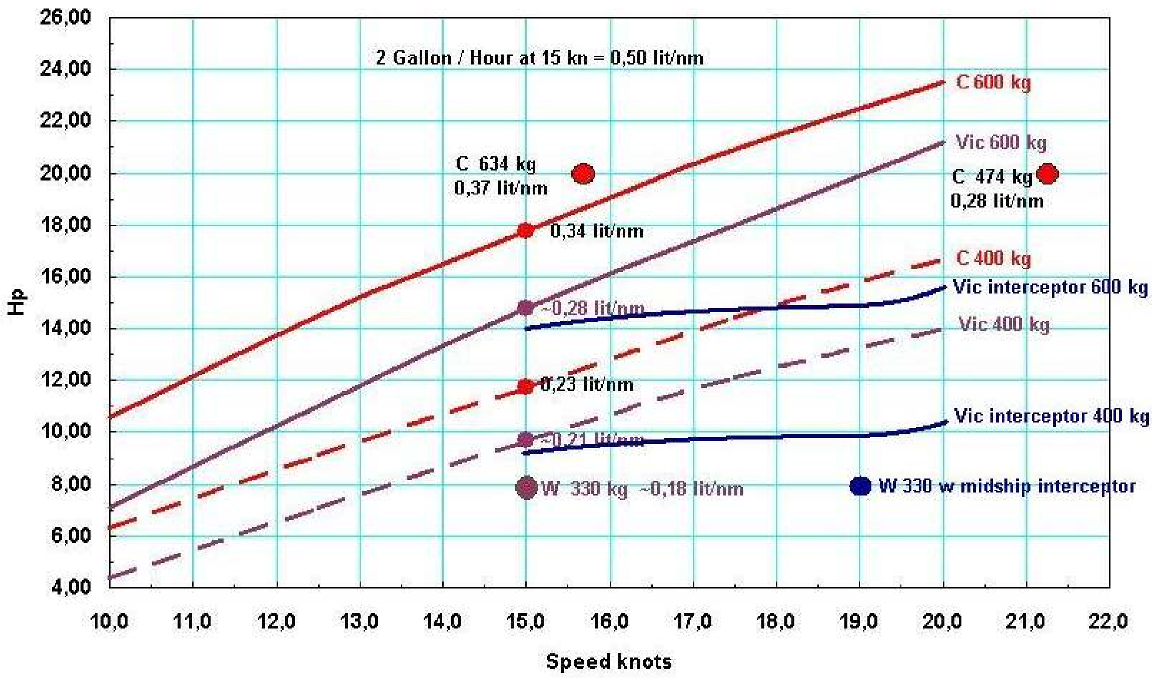
To exploit the interceptor to the maximum, the bottom is lowered amidships and the stern is lifted up slightly. This creates a significant transversal knuckle in the bottom. There will also be a stabilizing plane aft and a ventilation tube aft of the interceptor. The aft plane also has an interceptor to strengthen the lifting power. Both the interceptor and the aft stabilizer are adjustable to adapt to load, speed and waves.

Already at moderate speeds, the entire aft is completely dry. At higher speeds, the front part is lifted up and the friction is further reduced to a minimum. At low speeds this bottom design, with its advantageous displacement distribution and minimal transom area, has very low wave drag, which means that this boat is also easy to row.

This concept is based on the positive experience of many model tests and practical experience from a boat of similar size and shape. See presentation and video on www.sassdesign.net.







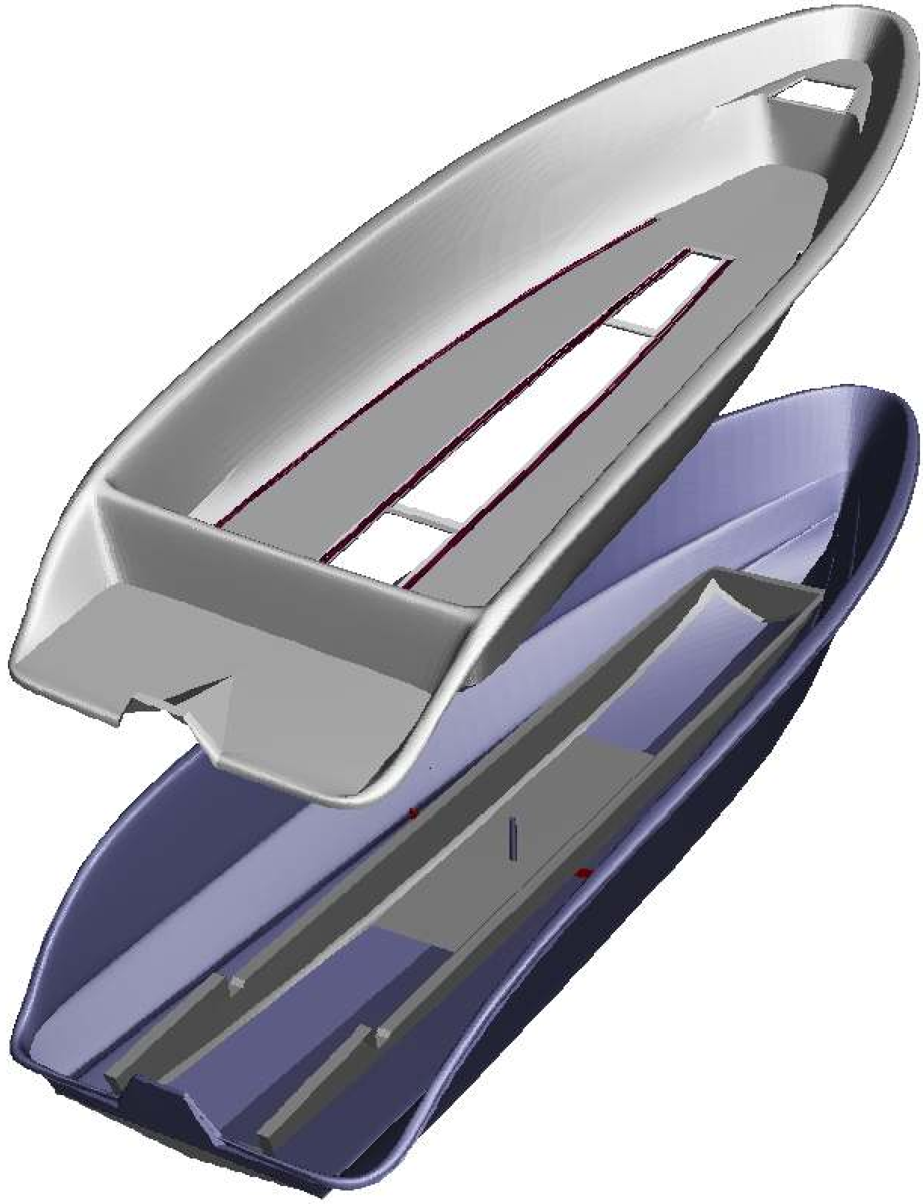
Midship interceptor effect

The above diagram has been extended by Victoria equipped with midship interceptor and aft stabilizer. W 330 kg is the actually measured values of the boat on which the Victoria-hull is based. It turns out, that the C-boat at 19 knots needs a roughly 50% larger engine than Victoria with midship interceptor. The higher weight of the C-boat, due to a larger engine and larger fuel supplies, has not been factored into this comparison. So Victoria with midship interceptor is in reality more efficient than shown here.

At 19 knots, the C 400 with 16 hp has a TE (Transportation Efficiency) of 3.2 and C 600 with 23 hp, 3.4. This compared with Vic / Interceptor 400 kg with 10 hp that has a TE of 5.2, and 600 kg with 15 hp that has a TE of 5.1. The seaworthiness ability has proved to remain comparable with the basic design without interceptor.

The efficiency at higher speeds is in the class of hydrofoils of the same size. At the lower speeds, before the foils work, Victoria is much more efficient. In addition, a boat with midship interceptor is much simpler and more robust than the vulnerable hydrofoils.

Test 081128 with W 330 with midship interceptor at 19 knots with 8 horsepower



Rational production

For a boat to be easily driven, it must be light and strong. Through minimizing the bottom width the free range decreases and therefore becomes strong and rigid in relation to weight. Both the hull and inner hull are built entirely in sandwich construction, with a core of higher density than normal in order to cope with point loads. The basic design is based on positive experiences from similar boats. With a basic interior, the weight could be as low as 140 kilograms.

The hull has a longitudinal bottom reinforcement, which, together with the inner hull floor, creates two large floating tanks. This makes the boat unsinkable and stable even when flooded. This reinforcement is installed by the manufacturer, after which the hulls can be stacked within each other for storage and transportation. Even the inner hulls can be stacked within each other.

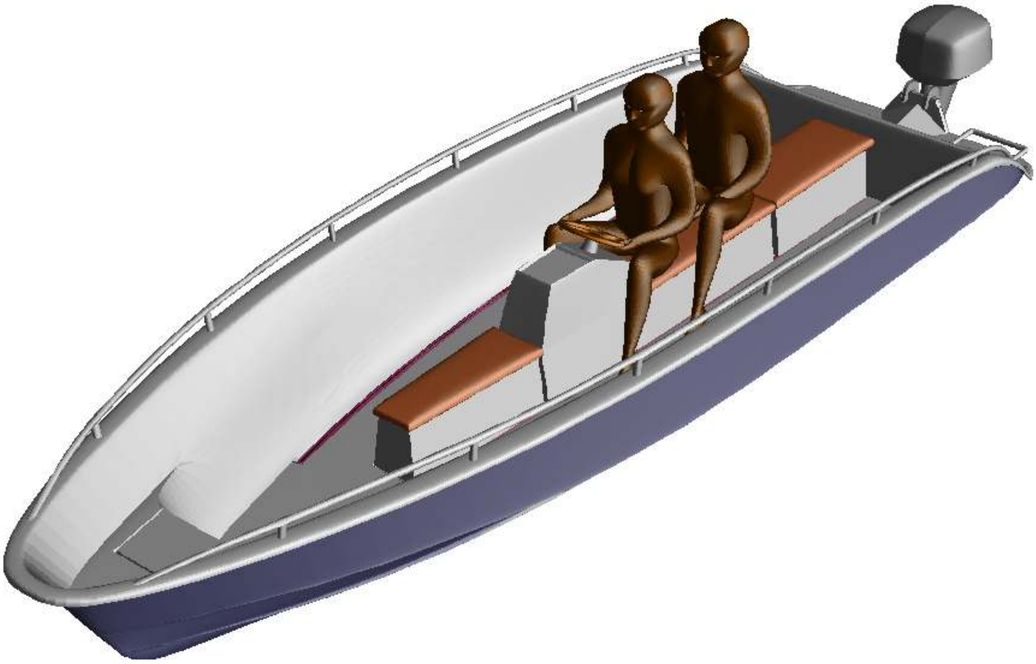
After transport, for example to the wholesaler, the four longitudinal rails, where the flexible interior shall be attached, have to be mounted in the inner hull. When the inner hull and the hull are fit together and completed with a trapdoor bailer, the boat can be transported to the dealer.

The dealer assembles the interior and equipment to the end user’s wants. Obviously, customers can also receive all parts to be able to assemble the boat by themselves.

Customized flexible interior

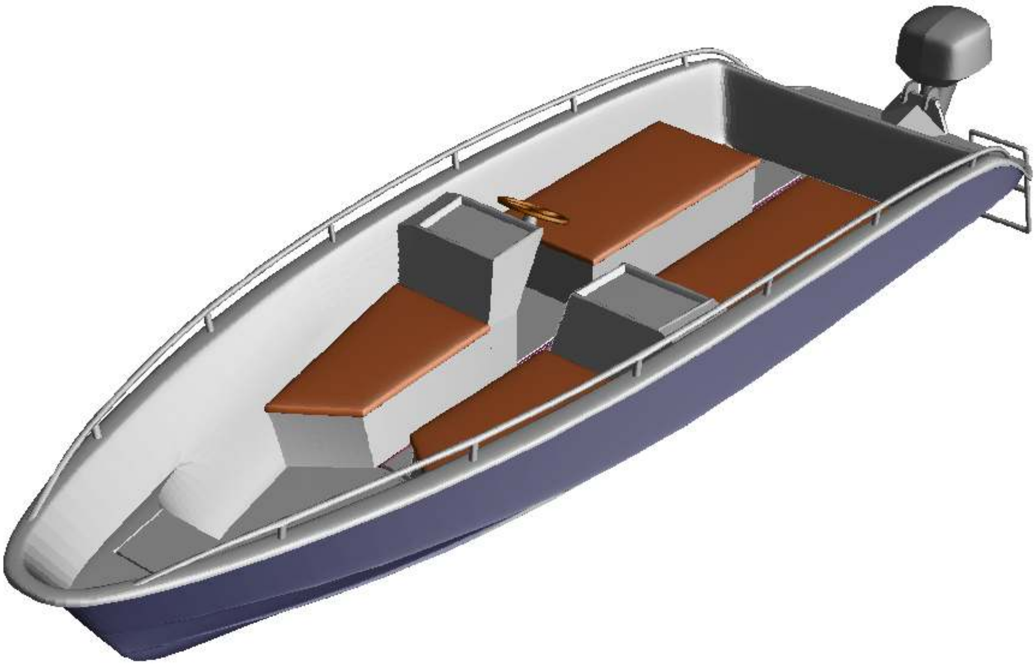
The flexible interior is built by L-shaped stackable light sandwich elements. They will be assembled to boxes, which in turn are attached to the floor in the integrated longitudinal rails. The interior can now be adapted completely to the consumer's needs. It can be completed afterwards or replaced, if needs change.

In its simplest design the boat has only a small central saddle shaped steering console. This version is best suited for transportation of goods or for fishing.



The boat can be supplemented with more longitudinal benches for passengers and stowage. On the flared gunwale a grab rail can be retrofitted with through bolts. On the aft deck, a swimming and rescue ladder can be placed. In this layout, the boat's use in a simple manner is increased considerably.

If the user would prefer transversal benches, it is easy to satisfy even such a need. With the adjustable midship interceptor any uneven load can be compensated for.



Of course it is also possible to create an alternative with longitudinal benches and a mid gangway if preferred.

The flexibility in interior design choices will meet the most consumers' requests for an efficient, comfortable and versatile boat.

Vaxholm March 23 2009

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