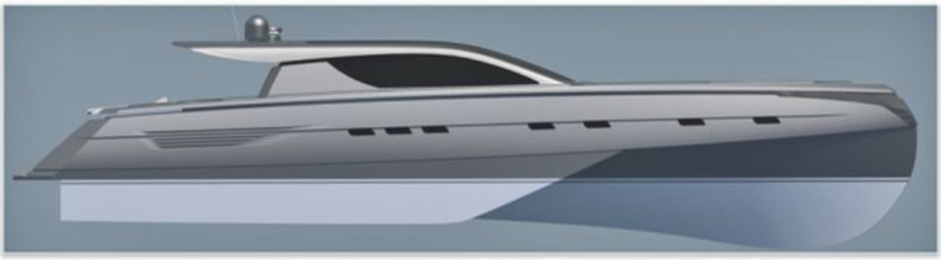
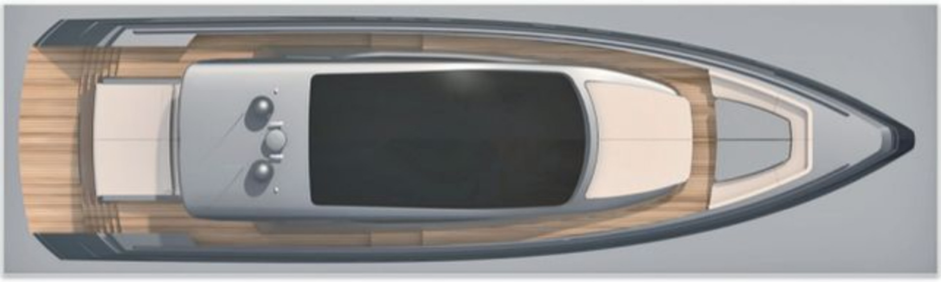
The MONOTRICAT®

By Andrea Mancini

The MonoTriCat® promises to beat the speed limitations of displacement hulls albeit preserving their positive aspects of comfort and thriftiness. Here is a new hull for a new boat that could well provide an alternative to the performing but rather costly "planers".





MonoTriCat®, that is the name of this new and rather unusual hull whose shape seems to be a cross between a monohull, a trimaran and a catamaran just as the name suggests. It is a very special hull not only in terms of shape but also for her innovative hydrodynamics. These are in fact responsible for taking her past that rather critical navigation point where semi-displacing or if you prefer, semi-planing hulls, fail and where 'planers' still don't quite perform to the full. Hence the definition of being a hull-type that promises to surpass the speeds of displacement craft whilst preserving comfort and agility. This is what more than one designer and boat builder has been looking for. After years of seeking ever increasing performance for liners and leisure craft alike, where ferries or yachts with hydro-jets or surface props easily top 40 knots, today, thanks to the global crisis, the production of faster and thirstier boats no longer captures as much demand as it did till recently. There is an increasing number of users who no longer seek hair raising performance rather preferring to move across water savouring sea life at a more sedate pace. This particular type of end user has always been somewhat penalised by the boats on offer, especially when it came to the medium sized motor yachts, the 12 to 24 metre segment to be precise. Hence one should either be content with cruising aboard a displacement yacht of say 20 metres at a top speed of 12-13 knots, or race along on a planing hull at some 30 knots paying the price for speed with freedom of movement by having to remain seated most of the way (Figure 1).

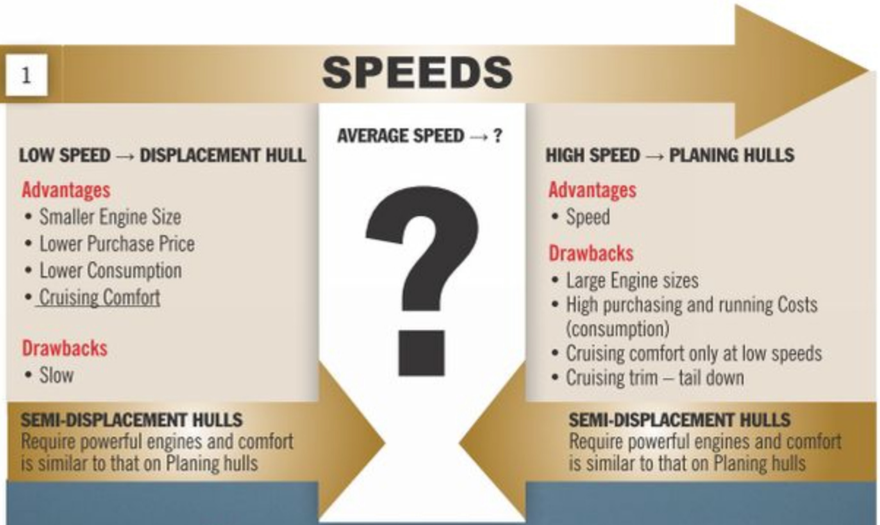
Today though, a happy medium is being seeked, the proverbial compromise. Ferretti was the first to attempt to fill this need, when it produced the Mochi Long Range 23 last year. Her innovative

Figure 1 – Hull type in function of speed: Currently, one should either be content with cruising aboard a displacement yacht of say 20 metres at a top speed of 12-13 knots, or race along on a planing hull at some 30 knots or more whilst losing out on both comfort and pocket.

Figure 2 – Self propulsion trials on a lake at over 22 knots with one of the models over 8 metres with which it was also possible to test manoeuvrability and seakeeping qualities of the MonoTriCat®.

Figure 3 – One of the first MonoTriCat® hulls being tested at the naval basin in Rome (2000).

Figure 4 – One of the latest models of the MonoTriCat® being tested at the Department of Engineering's basin in Trieste. (2008)



Trans-Planing hull was designed with the very purpose of giving maximum comfort when moving at not such low speeds. Hence a new type of hull, faster than a displacement one, that at the same time would maintain trim and ensure a soft ride leaving passengers free to move around to maybe cook, eat or sleep, is what we are looking for.

Lets get back to the MonoTriCat® hull. She is the fruit of an inkling which sparked off in Mr Luigi Mascellaro's mind an aeroplane pilot now retired, who has been testing and retesting this hull for hydrodynamic efficiency on small and large-scale models for the last ten years. The first patent for the invention dates back to 1998 in Italy, before covering Europe and major countries such as United States, Canada, Russia, China, Japan, Australia, New Zealand, Israel etc. in 2002. Indeed over 10 models, in various scales running from 1 to 8 metres, have been produced in order to pin point the correct dimensional ratios and shape. The models have been extensively tested both on tow in naval basins both in Rome and Trieste (Figures 2 and 3), and under self propulsion in protected waters (Figure 4). Furthermore more tests are being carried out to improve performance in conjunction with the Department of Naval Engineers in Trieste. However this hull already presents interesting characteristics in terms of comfort when under way, versatility, original design and, above all, ideal cruising speed extending well above that of a displacement hull. This is all attained whilst containing both purchase and maintenance costs (Figure 5).

What are these hydrodynamic principles that have proven so innovative to warrant a patent? In other words, where is the trick? We asked the most informed source we could find, Mr Mascellaro himself, undoubtedly quite a character, original and with a free ranging mind. Free from traditional naval concepts, he has moved beyond preconceived boundaries of designing thought and to apply aeronautical theory unbeknown to boats but not to the water they float and move upon, water that, like air, is nonetheless a fluid. Here is what he said: " The MonoTriCat® in fact applies a number of physical phenomena that interact with one another to the advantage of greater hydrodynamic efficiency. More specifically, the 'trick' lies in that:

- The very sharp sections of the bows produce a much contained wave motion;

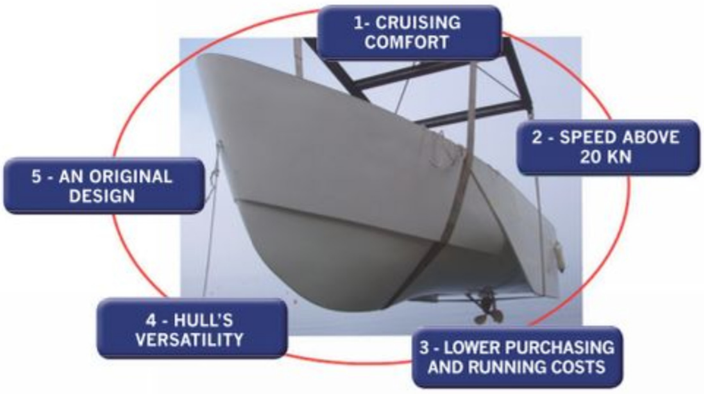
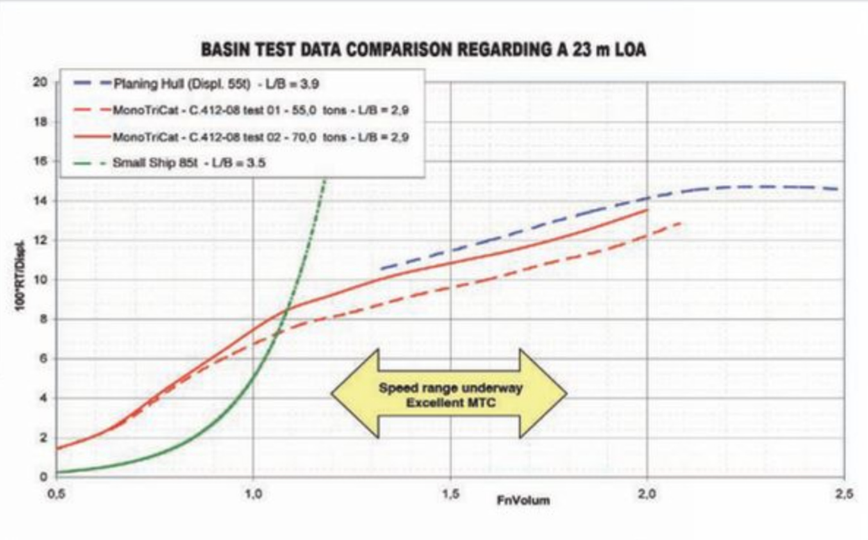


Figure 7a (above) – 4 knots on the 8.1 metre model corresponding to 7 knots on a MonoTriCat® hull with a water line length of 21 metres. We are at a displacement speed.

Figure 5 – Above: characteristics of the MonoTriCat® hull.

Figure 6 - RT/Δ resistance trends as a function of the Froude Volumetric Factor $F_{n\nabla}$ for both the MonoTriCat® and the other types of hull. This hull (red curve) proves to have excellent hydrodynamic values, recording resistance values considerably below those of a typical displacement hull (green curve), or planing hull (blue curve), within a speed range running between the Froude factors of 1 and 2 ($F_{n\nabla}$) of between 13 and 24 knots for a hull with a water line length of 21 metres displacing 55t. In the case of the MonoTriCat® the RT/Δ resistance coefficient recorded for both the lighter displacement of 55 t (red dotted line) and the heavier 70 t (continuous red line).



GLOSSARY

➤ Froude Factor (F_N) – represents speed according to size as a function to length. It is found through the following formulae: $F_N = \frac{V}{\sqrt{gL}}$ where V is the velocity of the vessel expressed in m/s, L expresses waterline length in metres and g the acceleration of gravity in m/s sq.- The ratio is very similar, $\frac{V}{\sqrt{L}}$, it is also indicated as Relative Velocity. They are both used to measure the hydrodynamic rate of displacement hulls: for example an F_N of 0,4 (equivalent to a Relative Velocity of 1,34) corresponds to Critical Velocity, i e the speed which the boat creates a longitudinal wave of equal length as its own water line length, and moves on a crest at both ends (bow and stern). Going over this speed level, the boat 'sits' on its own wave and resistance consequently increases suddenly.

➤ Volume Froude Factor $F_{n\nabla}$ - is very similar to the F_N factor but the speed is in function of the volume under the water, that is, the displacement of the vessel less the specific weight of sea water. It is used to measure the hydrodynamic rate of a hull travelling over critical velocity and is useful when comparing planing hulls of different sizes. As a rule $F_{n\nabla}$ factors below one indicate a displacement regime, whereas a reading above 2-2.5 indicates a planing one. Consequently, given equal speed, a hull with a greater immersed volume (i e heavier) is "hydrodynamically slower" than a less submerged hull (or lighter hull). The formula is the following: $F_{n\nabla} = \frac{V}{\sqrt{g\nabla^{1/3}}}$ Where V is the speed of the vessel in m/s, g is the acceleration of gravity in m/s sq. and ∇ is the volume submerged in m3, that is the weight of the vessel (displacement) divided by the specific weight of sea water.

➤ The Resistance Coefficient or RT/Δ – represents the ratio between hull resistance moving forwards in respect of its own displacement. It is useful in determining hull efficiency.

➤ Wave piercing – is a term used to describe the "sharpness" of the bow's shape. Wave piercing hulls are those that instead of following the flow of the waves, literally pierce them thus allowing the boat to maintain speed even in rough met/sea conditions.

• The energy from the waves produced by the bows, which is usually dispersed, is partially recovered in the MonoTriCat®'s case. This happens because the bow wave channels itself along the lateral tunnels, where, also as a result of the interaction generated through the small side-hydrofoils, it manages to dynamically support the stern area thus avoiding the stern to sit into the water when critical velocity is breached;

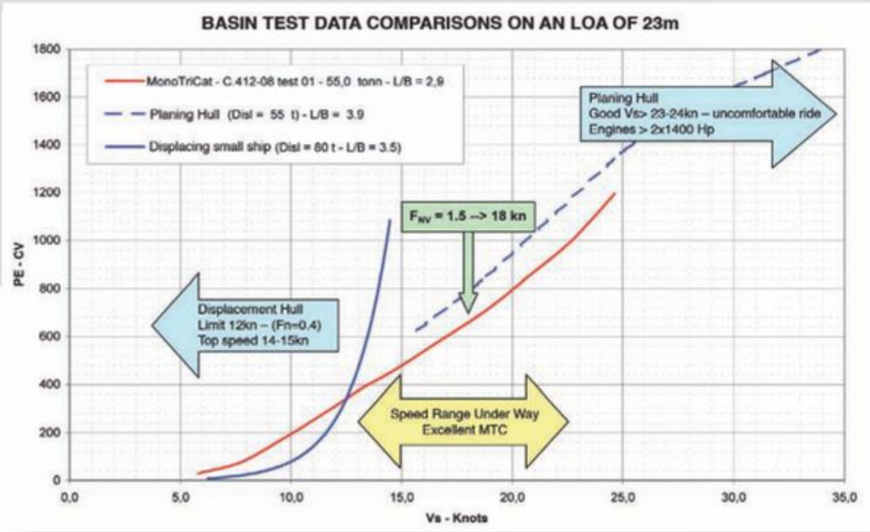
• The turbulant flow and spray generated at the bows, the foam effectively, are collected into the tunnels reaching the stern built to disperse them. Here, part of the kinetic energy is transformed into pressure energy thus generating a hyper hydrodynamic lift;

• The same foam reduces friction by gushing between the hull's surface and the water itself".

Let us examine just how and when the MonoTriCat® becomes a true advantage and in what respect. Let us begin with the hydrodynamic characteristics as drawn up in Figure 6, which show the resistance coefficient trends RT/Δ of various hull types including the MonoTriCat®. It is in fact the

Figure 7b (below) – 14 knots on the 8.1 metre model corresponding to 23 knots for a MonoTriCat® with a water line length of 21 metres. Despite travelling at the top end of semi-planing speeds the wave formation is contained and the trim remains practically horizontal.

Figure 7 – Excellent hydrodynamic values for the three types of hull with a presumed overall length of 23 metres (75 feet).



Planing Hull AZ 75

LOA = 22.60 m
LWL = 18.70 m
Bmax = 5.70 m
Δ = 55 t
Engines = 2x1360 HP
Top speed = 30 knots
Cruising speed = 26 knots
(this data is by courtesy of Azimut Yacht web site)

Displacement Hull Gianetti Star 75'

LOA= 22.90 m
LWL = ~ 20.0 m
Bmax = 6.00 m
Δ = 60 t
Engines= 2x670 HP
Top Speed= 13 knots
Cruising Speed = 10 knots
(This data is by courtesy of Gianetti Star's web site)

MonoTriCat® 75'

LOA = ~ 23 m
LWL = 20.90 m
Bmax = 7,20 m (+1,5 m)
Δ = 55 t
Engines = 2x760* HP
Top Speed = 21,5 knots
Cruising Speed= 18 knots
(Data based on the hypothesis of an 0,60 propulsive performance of the MonoTriCat® 75')

Table 1 – Comparison between the MonoTriCat® 75' with other types of hull of similar dimensions.

MonoTriCat® to record the least resistance in terms of a-dimensional speed running between the Froude factors of 1 and 2 ($F_{n\nabla}$), a speed range equivalent to say 13-24 knots for a 21 metre waterline length of displacing 55 tons. Naturally, different sizes will produce different speed ranges. As we mentioned earlier in this article, this is the very speed range where at present there are no efficient conventional hulls of typical leisure yacht dimensions. In fact, as the graph will show, displacement hulls do not manage to breach what is known as critical velocity, without increasing power tremendously to gain very little. Planing hulls on the other hand, at the same speed, are not out of the water yet consequently perform badly not being able to find hydrodynamic lift. In other words, in deference to conventional hull shapes of similar dimensions, the MonoTriCat® proves to have a practically flat resistance curve (the resistance coefficient in the graph over estimates its own resistance curve values) thus making the craft efficient even at those intermediate speeds (semi-planing or semi displacing) where other hulls just do not succeed in so doing. Furthermore the graph shows RT/Δ coefficients for a 70 t displacement for the MonoTriCat® alone and these only suggest a 10% increase against a 20% increase in tonnage. This means that the hull maintains high hydrodynamic efficiency even with considerable displacement increases.

The following additional characteristics of great interest should also be noted:

- The trim of the boat remains constant at all speeds which compares very favourably with the sort of comfort usually attributed to 'planers' (Figure 7);
- Improved sea keeping qualities by way of the wave piercing effect;
- Better stability (both static and dynamic) thanks to the width of the lateral fins which double-up as stabilisers;
- More room on board (the boat is a good 20 to 40% wider than the average of its competition);
- Greater propulsion efficiency thanks to the

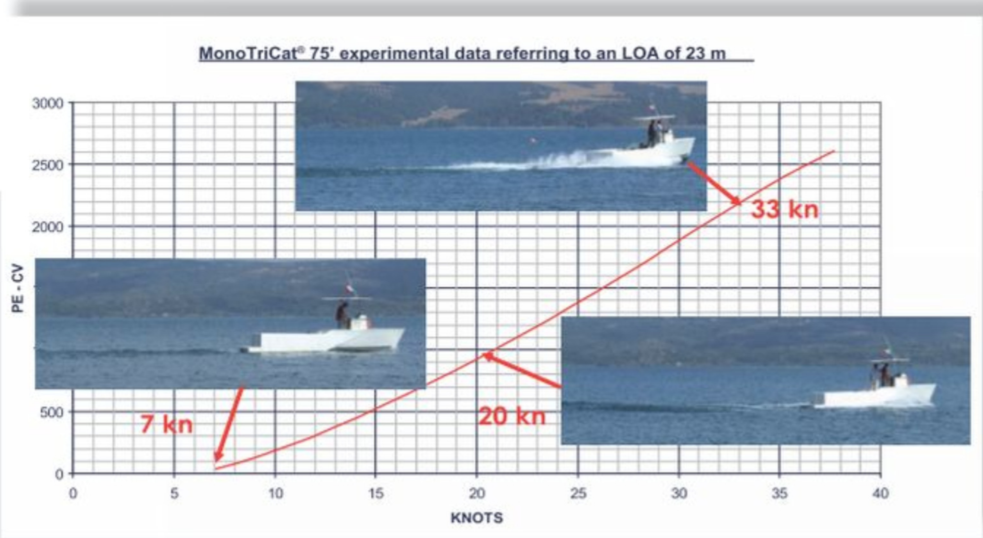
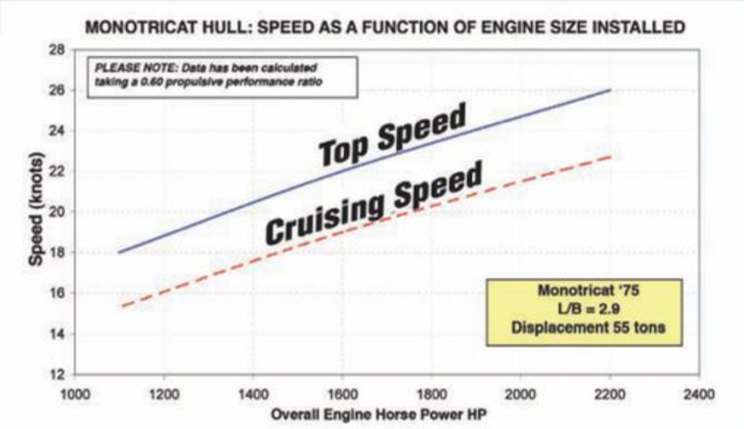


Figure 8 - Photos of the MonoTriCat® hull under way at differing speeds have been plotted on the graph and there is an obvious reduction of wave formation at all speed levels.

Figure 9 – A practically flat resistance curve allows for a direct correlation between engine power installed and the MonoTriCat® 's hull speed as the graph clearly shows. For instance, for the MonoTriCat® 75' with a 55 t displacement fitted with two 600 HP engines, a top speed of nearly 19 knots may be reached whereas with two 900 HP engines the speed increases to over 23 knots. In practical terms this means that owners will be able to pick and choose their engines always being assured of lively performance and of the particular characteristics of the MonoTriCat®.



quick and clean flow of water around the prop areas;

- Less noise thanks to smaller engines than those usually mounted on boats this size;
- The MonoTriCat® maintains its characteristics over a wide spectrum of displacement sizes (±30%).

With these sorts of credentials, this hull could undoubtedly represent a true innovation in the world of nautical design and production which has always tended to be traditional and reticent to risk or novelty.

Which market niche does the MonoTriCat® hope to occupy, who would be its direct competitors? We asked Tommaso De Luca in charge of Hub Design who heads a team of Designers and Engineers who will be taking care of both the production and marketing of the hull.

"I would like to begin with the premise that we have all studied the new shape of the hull very closely and we are convinced that it represents a true novelty in the small to medium craft market not only limited to recreational vessels. We are in fact examining the possibility of fitting the hull to other types of boats such as fast ferries or fishing trawlers. In as far as using the MonoTriCat® in the leisure yacht market, we envisaged building a 75 footer over it, an LOA of 23 metres, which we put against two types of conventional vessels: a typical planing yacht and a small ship. As the data shown in Table 1 clearly illustrates, the MonoTriCat® displacing 55 t, will cruise at 18 knots with a propulsion unit only 10-15% greater than that fitted to a small ship, that only manages a top speed of 13 knots whilst, compared to the 'planers', a much smaller power output is sufficient. Furthermore all this is attained with an extra metre in width making more space available. Effectively these new hull shapes make for a more comfortable yacht that requires less power just as with a displacement yacht but attain higher cruise and maximum speeds which translates into reduced fuel and maintenance costs as in a displacing hull. This is again corroborated by the graph in Figure 7 where the hydrodynamic ranges of the three different hulls are clearly set out on the basis of an LOA of 23 metres."

You have also used the Mochi Long Range 23, the first yacht to embrace this new approach to hull design providing accrued comfort, lower running costs, without the limiting speeds of a displacing one.

"Absolutely. We have compared MonoTriCat® data with the only hull built on the same conceptual lines, the Mochi Long Range 23 by Ferretti, (Table 2). Given equal length, displacement and engines, the MonoTriCat® performs better speed wise, with substantially the same consumption figures. However it does boast an extra metre and a half in width."

How else does the MonoTriCat® differ from conventional hulls?

"Undoubtedly another very important differing aspect, is that the MonoTriCat® manages to maintain its hydrodynamic efficiency over a wider range of speeds compared to

Figure 10 – An example of a yacht fitted with a MonoTriCat® hull (a project by Pierluigi Grilli and Roberta Rocchi presented at the 2007-2008 edition of the Masters in Yacht Design at the Quasar Institute in Rome)

Ferretti's Trans-Planing hull Mochi Long Range 23

LOA = 23 m
LWL = 19.76 m
Bmax = 5.70 m
Δ = 70 t
Engines = 2x800 HP
Top Speed = 16 knots
Cruising Speed= 13,5 knots
Fuel = 7,800 litres
Range at Top Speed = 400 nautical miles
Range at Cruising Speed = 520 nautical miles.
(Data taken from Mochi Long Range 23 brochure)

MonoTriCat® Hull MonoTriCat® 75'

LOA = ~ 23 m
LWL = 20.90 m
Bmax = 7.20 m
Δ = 70 t
Engines = 2x800* HP
Top Speed = 18.7 knots
Cruising Speed = 15.5 knots
Fuel = 7,800 litres
Range at Top Speed = 430 nautical miles
Range at Cruising Speed = 530 nautical miles
(Data based on the hypothesis of an 0,60 propulsive performance of the MonoTriCat® 75')

Table 2 – Comparison between the MonoTriCat® 75' hull with Ferretti's Mochi Long Range based on equal lengths, displacement and engine power.

MAN 500 2 x 550* HP		MAN 800 2 x 800* HP		MAN 1100 2 x 1100* HP.	
Top Speed	→ 55 t = 18.0 knots	Top Speed	→ 55 t = 22.0 knots	Top Speed	→ 55 t = 26.0 knots
	→ 70 t = 14.8 knots		→ 70 t = 18.7 knots		→ 70 t = 22.7 knots
Cruising S	→ 55 t = 15.3 knots	Cruising S	→ 55 t = 19.0 knots	Cruising S	→ 55 t = 22.6 knots
	→ 70 t = 13.0 knots		→70 t = 15.5 knots		→ 70 t = 18.8 knots

Table 3 - The MonoTriCat® 75' hull with two different displacement levels and three different engines giving different performance readings. The Table proves how it is possible to pick and choose the engine unit favouring best performance and maintaining the hull's particular characteristics.

conventional hulls. This is thanks to a practically flat resistance curve as the graph illustrates (Figure 8). Photos of the hull under way at differing speeds have been plotted on the same graph and there is an obvious reduction of wave formation at all speed levels. As a result, the hull may be used for different types of yachts that would be free to cruise at a wide range of speeds, and owners may pick and choose their preferred power block, desired performance levels ensured. This can all be obtained whilst maintaining all the properties true to the MonoTriCat® as shown in Figure 9. Just as an example, we have analysed the characteristics (table 3) of the MonoTriCat® 75' fitted with three different types of engines."

Do you not think the MonoTriCat® is all too "strange" for the nautical market?

The MonoTriCat® hull is undoubtedly a "strange" looking hull as you say, similarly, it is also a hull upon which a conventional looking boat may be constructed that won't be perceived as strange by its future owner. A boat that is, that will have all the dimensional ratios we are accustomed to see or imagine. This is precisely why we didn't choose to bet on a catamaran or a multi-hull more in general, these would be hydrodynamically more efficient but also would entail uprooting typical dimensional ratios and conventional looks that are the main reasons for which they haven't had so much success. The MonoTriCat® hull instead preserves its mono-hull status and conventional yacht accolade, as we have shown with various examples of yachts on a MonoTriCat® hull (see opening figures and n°10) and this is why we believe it will work also from a commercial point of view."

How is this new hull going to be marketed, who is going to build it? Particularly in view of the Patent Rights that protect it.

From an Operations point of view and following the years of study and positive outcomes of Mr Mascellaro's work, we are now ready to offer the MonoTriCat® hull to those shipyards Italian or foreign as they may be, that would like to build a boat capable of breaching the Froude factor that identifies Critical velocity, and for it to perform in the semi-planing/ displacement "dark" area where no other boat works well. To put it more precisely, to perform when upon reaching critical velocity, the resistance of a displacement hull increases with the trim whereas the MonoTriCat® hull resistance continues to increase steadily with the speed and above all without experiencing the so called "hump speed" the typical speed level at which 'planers' "go over the hump". Fitted to a yacht of say 20 metres, our hull smoothly breaches critical velocity at 13 knots reaching 20 without any great increase in power compared to displacement yachts of equal size. Furthermore, in deference to a conventional planing hull, that attempts to plane at 13-14 knots but begins to pull up the bow at around 12 knots, the MonoTriCat® hull will maintain a perfectly horizontal trim throughout the speed range. Thus the final result will be a yacht functioning better over a much greater hydrodynamic range than its conventional counterparts hence its performance will only be down to the power house chosen. Finally, it will also prove to be statically more stable, with limited roll, with better sea keeping ability thanks to the wave piercing properties of the bows. Last but not least it won't only be a new yacht but much more!".

In conclusion the MonoTriCat® may well be the novelty with which to satisfy the changing moods of the market, which, having been stimulated by the economic crisis of present times, is perhaps seeking equally attractive looking fast yachts that are thriftier and more comfortable. Will the MonoTriCat® serve as the platform for the desired new yacht to come?.

For further information please contact:
www.monotricat.com - www. hubdesign.it