The Catamaran Miss Nylex

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Introduction

The catamaran Miss Nylex was developed to compete in the International Catamaran Challenge Trophy Race. This competition is decided every 2 years for what has become known as The Little America's Cup. The trophy was donated in 1960 by the Sea Cliff Yacht Club of New York initially for competition between England and America. It was won from Denmark by Australia in 1970, and in 1972 the Sorrento Sailing Club had to mount a defence of the trophy against a challenge from America. This became the beginning of the story of Miss Nylex, when, in early 1971, a syndicate was formed under the sponsorship of the Nylex Corporation to build a boat to enter for selection to contest defence of the trophy in 1972. The story stretches out over a period of 5 years and has led to the development of a rigid aerofoil rig which is close to the optimum for windward performance. In this paper I shall concentrate on the differences between Miss Nylex and other C-class catamarans so as to give the maximum amount of detail regarding those features which are unique.

Trophy courses and design criteria

Before going on with the description of the boat itself and the special features of its rig and construction I will describe the nature of the competition, and the basic type of boat which is used. In Fig. 1 I have shown a sketch of a C-class yacht. This particular sketch was used in our original proposal to Nylex Corporation for sponsorship and as can be seen we did not at that stage contemplate using a wing mast. We illustrated a boat which was very similar to Quest III which had won the trophy from Denmark the year before. In designing a boat of this type one only has to take account of a few basic rules as shown in the first illustration.

- The overall length must be a maximum of 25 feet.

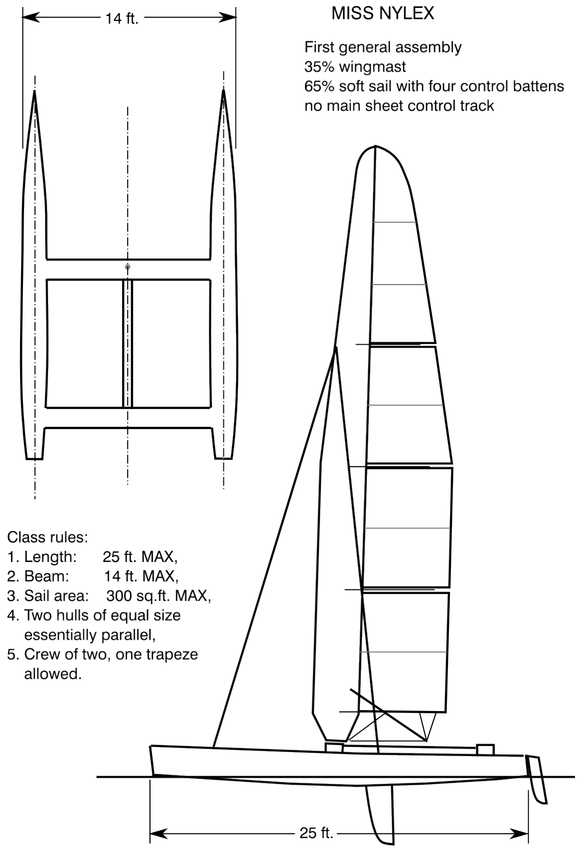
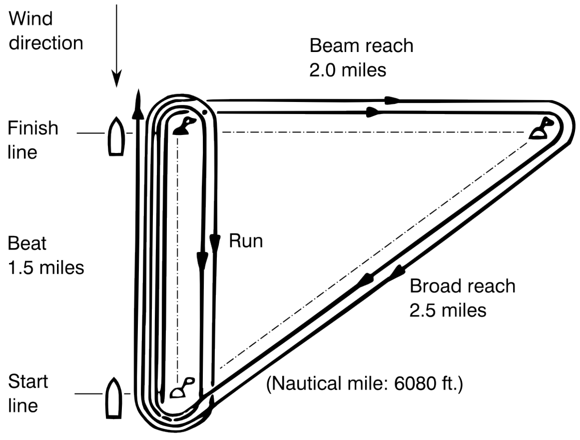


Figure 1: Original proposal.

- The overall beam must be a maximum of 14 feet.
- The area of the rig must be a maximum of 300 square feet.
- The hulls must be parallel and equal in size.
- One of the two crew members is allowed to use a trapeze.

Within these broad restrictions the designer is free to create any configuration which he feels will outperform his competitors. The match is sailed over a set course. This is shown on our next illustration (Fig. 2).

*This is a re-creation based on a very poor photo-copy of the original article in The SAE-Australasia.



Point of sailing:	Distance:	Time %:
Beating	7.5	43
Beam reaching	4.0	15
Broad reaching	5.0	25
Running	3.0	17
Sum	19.5	100

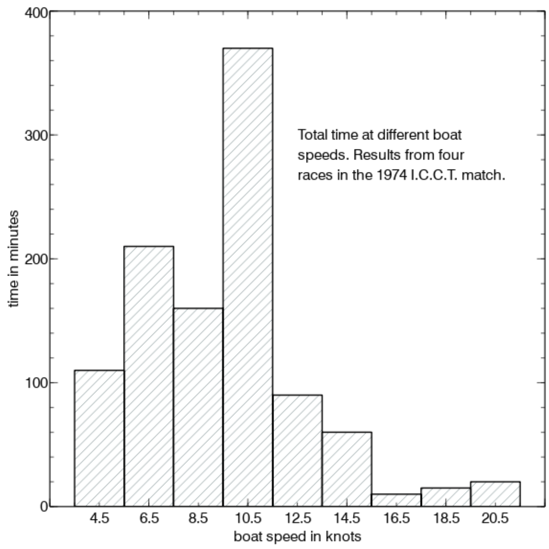


Figure 2: Race course.

Every challenge match since 1965 has been conducted over a course of this shape and length. Basically it is a 3, 4, 5 right angle triangle and the total race distance is 19.5 nautical miles (21.5 statue miles or 36 kilometres). It is carefully laid in relation to the wind so that from the first to second mark the boats have to sail directly into the wind, they then sail on a beam reach at right angle to the wind for 3.2 km (2 miles) and back to the starting point on a broad reach for a distance of 4 km (2.5 miles). The legs of the course are then traversed in the order shown, until the boats complete the full race distance.

The first important criteria in designing the boat is to understand fully the demands of this particular type of course. From the results of previous matches we have determined the proportion of total race time for which the boat has been on each point of sailing. This is shown in the column at the right hand side of the table in Fig. 2 and it will be seen that nearly half of the time is spent beating directly into the wind and the next longest time is spent broad reaching. Also in this illustration is a chart which is showing the length of time spent at different boat speeds. The C-class catamaran is capable of a speed of 44 km/h (27 or 28 miles per hour), that is about 24 knots, but it will be seen from this chart that most of the time is actually spent sailing in the vicinity of from 6–14 knots. The very high band at 10–11 knots is due to the time spent beating to windward. Together these charts illustrate that having a boat which will perform well when beating into the wind is a primary requirement. In the initial design stage of Miss Nylex the syndicate agreed that we should make every effort to build a boat which would excel in this area.

The first detailed task in the design was to analyse the drag force acting on the boat when beating to windward. Of necessity many of the values established are approximations. No reliable data exists for many of the small factors involved in the summaries but as with many such engineering exercises a reasonable estimate of the absolute value coupled with a fair guess of the differences between the various types of configuration is sufficient to direct a decision as the most likely direction in which to improve design.

Before discussing these factors I should point out one of the basic relationships between the forces acting on a catamaran. In any given boat the weight of the boat itself and crew are fixed. There is then a maximum total sail force moment which the righting moment exerted by the weight of the boat and crew can resist. It follows that there is a set maximum force which can act on the sail, otherwise the boat will capsize. The drag force figures which are shown Table 1 are related through a simple vector diagram, which we need not concern ourselves with here, to the maximum driving force mentioned above.

We compared our proposal with similar estimates for Quest III as we knew it at the time. In the first proposal the figures are related to the boat as shown in Fig. 1. This is with a rig consisting of a large mast in front of a soft sail with a mast of

Table 1: Drag comparison for 12 mph boat speed, 40° true wind angle and 15 mph true wind speed. Drag is measured in lbs.

		First estimates				Revised estimates			
Components		Quest III	diff	Miss Nylex	%	Quest III	diff	Miss Nylex	%
Hulls	Form drag	20	-2	18		19	-2	17	
(flying a hull)	Skin friction	25	0	25	58.7	25	0	25	60.3
	Air drag	5	-1	4		5	-1	4	
Centre plates		24	0	24		24	0	24	
Cross beams		16	-15	1		16	-15	1	
Deck gear		2	0	2	2.5	2	0	2	2.6
Traveler		5	-5	0		5	-5	0	
Sail	Form	9	0	9		20	-11	9	
	Induced	24	-4	20	25.6	25	-6	19	25
	Parasitic	2	0	2		2	-1	1	
Rigging	Standing	5	0	5	6.6	3	2	5	5.2
	Running	3	0	3		2	-1	1	
Crew		8	0	8	6.6	8	0	8	6.9
	Total	148	-27	121	100	156	-40	116	100

1/3rd of the area and the sail 2/3rds. The analysis indicated that we had a proposal which could perform better than Quest III when sailing to windward because the drag forces generated by hull and rig were lower, meaning that the boat could either sail faster on the same point of sailing, or point closer into the wind at the same speed, either of which would result in a shorter time on all windward legs.

From the outset of the design studies I had been worried by a number of factors relating to this type of rig. Firstly, it had its origin many years before and I felt that Quest III represented a fairly high level of development which would be difficult to match in the short time at our disposal. We only had a year in which to completely design, build, and tune the boat.

We knew that in America and in Denmark people had been experimenting with boats on which the soft sail had been completely eliminated. To illustrate the trend of development Fig. 3 shows the sequence through the different types of rig used on C-class catamarans from 1959 up until 1971. In 1970 in Denmark a boat was built with a solid rig and a plain flap. This broke up only after a short time of sailing, due presumably to inadequate stress assessment, but had proved that it was actually very efficient. Similarly in America Patient Lady II had been built with a rig with a section similar to a conventional section of an aircraft wing but supported by a tubular frame and with a complicated system of wires which enabled it to be flexed from one side to the other, depending on the tack in which the boat was being sailed. Patient Lady II sailed with this rig for most of a season. It was very hard to tune, and eventually broke up when sailing, but when everything was set correctly it could outperform all other competition to windward.

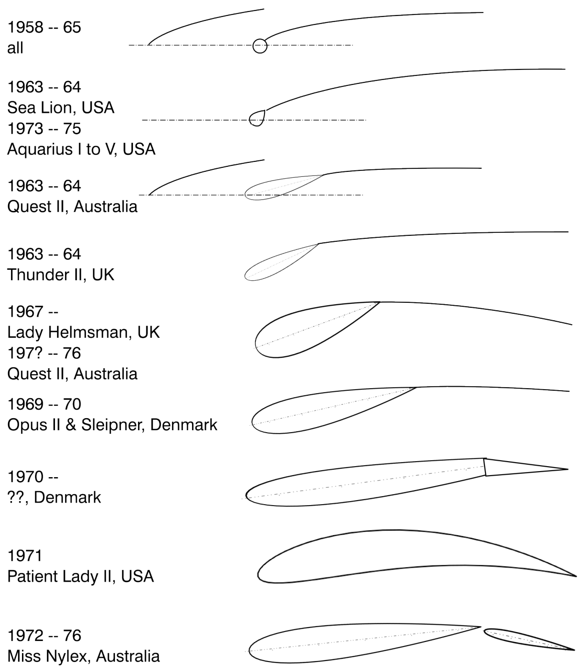


Figure 3: C-cat rig evolution.

After a long and fairly difficult assessment of the technical situation in relation to the probable challenger from America we concluded that it was almost certain that Quest III would be able to defeat any potential challenger thus giving us the opportunity to pursue something different without jeopardizing Australia's ability to defend and in view of the time at our disposal we began to look at the possibility of designing a rig that would be quicker for us to design and build than one of the Quest III type. I was also very concerned with reliability. Quest III was known to have experienced fairly continuous troubles with gear and equipment. The reason was revealed by a mathematical analysis of the forces acting on the rig.

The relationship between the wing mast and the soft sail is critical for optimum performance. Twist between the top and bottom must be limited, and the camber of the soft sail has to be adjusted for different wind strengths. Loads of many hundreds of pounds were being applied to the numerous control wires, guide pulleys, levers and cams used in the control system. As a result, continuous adjustment was necessary to take up stretch in wires, and there was an ever present risk of wires fraying or damage to the hardware. I then examined a number of different ways of controlling the soft sail in relation to the wing mast. In every case the forces on the control wires, guide pulleys and levers were still extremely high and there was no way I could see of reducing them.

I also began to look to see if there was any reliable theoretical characteristic data relating to wing sections of this type, from which we would be able to establish if there were any better type sections to use, and in particular which would enable us to eliminate the high control forces inherent in the Quest III type rig. It is difficult to describe in a few words the process by which this happened so I shall not labour the point. However, a fairly lengthy search revealed that there was in fact a large body of data referring to practical wing sections which could be applied directly to the job at hand. By this time it was very obvious that we had to get started soon, otherwise there would be no point in proceeding. In Fig. 4 and Table 2 is the summary which I presented to the syndicate at this time. Type 1 is essentially the Quest III type. Type 2 is similar to Patient Lady, whilst type 3 is the type which appeared from all available data to be the most likely choice for development.

In this summary there are a number of pertinent points. First and foremost was the excellent aerodynamic efficiency. It appeared possible even at that early stage to see that the performance of a rig with such a section would be better to windward and on all other points of sailing. We could foresee one major disadvantage from a purely practical point of view in that it would be big and clumsy to handle. However, since the competition was to be held close to home at Sorrento, we felt that it would be worthwhile putting up with difficulties of rigging and storing to gain the obvious potential of

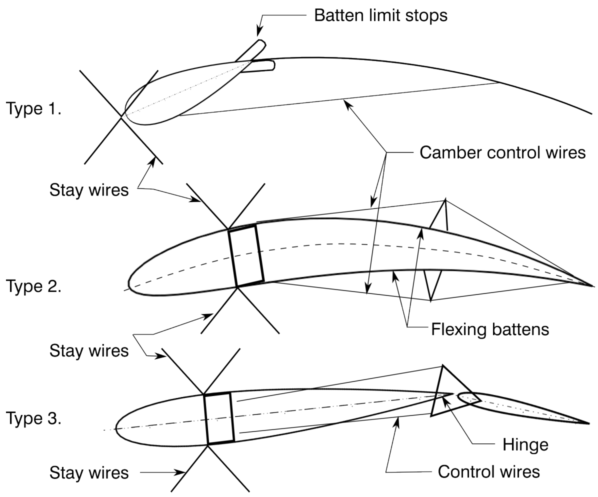


Figure 4: Wing section types.

increased efficiency.

It may seem inconsistent that we thought it possible to build a rig of this type weighing no more than the Quest III type rig. However, the reasons for this are simply that it does not have to withstand any of the high control forces mentioned above, and the large radial traveller track and bracing could be eliminated. By comparison, the forces on the high lift flap hinged on the trailing edge are very much lower. Also, because of the thickness of the wing, it is inherently stiffer with load carrying members of similar proportions.

Choice of wing section

With a rig in which part of the section is soft sail it is possible to vary the shape by trial and error until the optimum is found. Certain limitations are imposed by the shape of the mast section but the amount of camber can be varied from practically flat to a very deep curve.

In a rig of the solid aerofoil type this is not possible. The choice of wing section is therefore quite critical because once the wing is built the section cannot be changed. The only adjustment available is the angle between the flap and the main section. This caused me to undertake another fairly long investigation through the literature to see how close we could get to an optimum section. I looked at scores of different sections and in the end selected for the main wing NACA 0015 and for the flap the symmetrical section NACA 0012 with the flap approximately 25% of the chord of the total wing. For largely practical reasons the chord of the main wing was selected as 7 feet 6 inches making the flap chord 2 feet 6 inches. These were both reduced slightly when we added a small plain flap between the two.

Table 2: Wing section type comparison

	Type		
	1	2	3
Aerodynamic efficiency	Moderate	Good	Excellent
Maximum lift coefficient	1.8	1.7	2.5
Stall angle with max camber	14° to 15°	14°	23° to 25°
Camber adjustable	high	limited	high
Control forces – camber control	high	very high	low
Ease of mast rotation	difficult	easy with four wire system	
Ease of tuning	difficult	difficult	easy
Ease of control in sailing	fair	fair	easy
Construction and repair	satisfactory	difficult	satisfactory
Weight	100%	110%	100%
Difficulties in rigging	complex	very complex	???

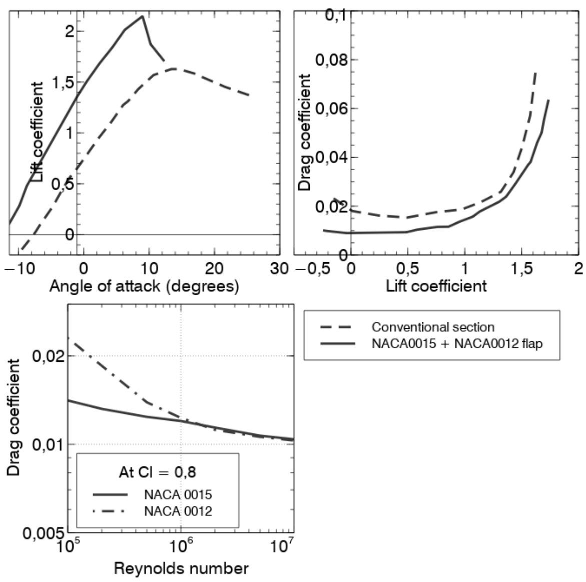


Figure 5: Wing section drag comparisons.

In Fig. 5 is shown the lift and drag curves for a section of this type together with our best estimates of the lift and drag curves for a rig of the Quest III type. The two most significant factors that are shown by these curves are:

1. That the profile drag coefficient of the Miss Nylex section is very low. Even with the flap deflected at 30° it is not excessive.

2. As a result of the very high flap deflections of up to 30° it is possible to obtain a maximum lift coefficient in the vicinity of 2.2 compared with approximately 1.75 for the more conventional section.

The first characteristic of low profile drag is of primary importance in obtaining high performance to windward whilst the high lift coefficient ensures high performance on reaching and broad reaching. From the outset we felt that these characteristics would guarantee that even if we had to compromise in other areas in building the boat, we would be able to build a boat capable of beating Quest III as we then knew it. The other major advantage was that all the control gear would be simplified and while we might spend a good deal of time developing the structure of the wing itself, the ancillary equipment would be very simple and could easily be designed and built within the time available.

In examining all the aerofoil data one possible area of weakness revealing itself. It is unfortunate that symmetrical aerofoil sections stall very abruptly, and suffer a rapid deterioration in performance at moderate to low Reynolds numbers including the lowest area in which we would expect to sail.

Also shown in Fig. 5 are curves of the profile drag coefficient of NACA 0012 and NACA 0015 at a lift coefficient of 0.8. This lift coefficient is about average for a boat sailing into a wind of 18 km/h (10 or 12 mph). Above this the lift coefficient would be lower, and below this wind speed the coefficient would be higher but when fully analysed the data in Fig. 2 indicates that the rig would be operating at an average lift coefficient of 0.8 for a lot of the time.

These curves clearly illustrate the fine dividing line between success and failure in the selection of the section. At an effective Reynolds number of 500,000 to 600,000 the profile drag coefficient of a section 12% thick is 50% higher than the profile drag coefficient of a section 15% thick. In simple terms one would only have to make the wing of Miss Nylex 3% thinner than it is to reduce its performance in light weather quite drastically. In the design of the wing a number of other such critical areas were discovered. These related to the positioning of the flap in relation to the main wing and various angles of attack to suit different wind strength and in the choice of plan form and taper of the whole wing with a rig of this type. It is difficult without introducing a lot of mechanical complication to obtain the twist between the bottom of the top wing and top which is desirable for optimum performance when broad reaching, but it was found that by choosing the correct ratio of the tip chord at the very top of the mast, and the point at which the mast tapered from the bottom section, to minimise the effect of down wash which causes an apparent change in the angle of attack of the top cord. Together they reduced the effects of having no twist to a minimum. If the tip had been made much more of a point it would have suffered in three ways. The effective Reynolds number would have been reduced to a critical level, the effective angle of attack could have been changed by 5 or 6 degrees which would have caused it to stall earlier over a wide range of wind speeds, and the induced drag caused by the tip vortex would have been much higher.

After examining a number of reports in which the scale effects which give rise to varying characteristics had been researched at some length, I found that I was able to construct the curves which are illustrated in Fig. 6. These show the maximum lift coefficient and hence the maximum driving force which can be generated by the sail over the range of wind speeds which we would encounter. The lower limit of wind speed in which the race would be conducted is 4 mph. The lower curve represents fairly closely the maximum lift coefficient which a rig of the Quest III type can reach. It should be particularly noted that the maximum lift coefficient of a simple aerofoil is about 1.8, regardless of cross section or camber.

It is very good at the low wind speed end of the scale but does not increase as the wind speed increases. For windward work this is not a serious problem as the total lift that can be developed is proportional to the square of the wind speed and hence the actual forces on the rig soon increase to more than the crew can handle anyway, but it is a limiting factor in the ultimate performance of this type of rig off the wind. However, the potential of the type of section with the external aerofoil flap, is obvious from the curves showing the lift available with different flap deflections. Quite obviously this type of aerofoil has far more potential for high racing performance in wind speeds of 16 km/h (10 mph) and over, but there is a range between 6.4 and 13 km/h (4 and 8 mph) in which the flap angle setting of the Miss Nylex type of rig is very critical. Not only that, the tendency of the main wing section to stall is so pronounced at these very

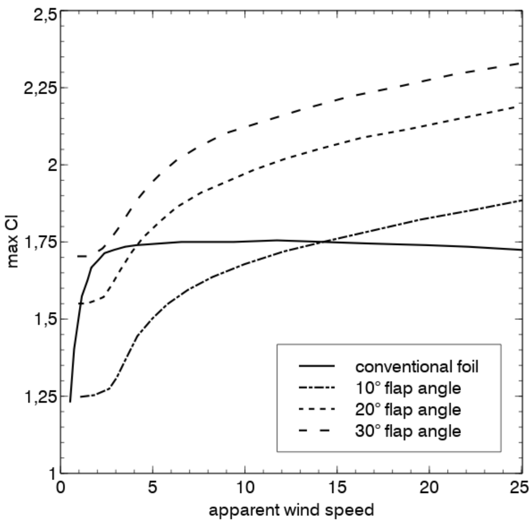


Figure 6: Maximum lift coefficient vs. wind speed.

low speed that if the air flow is disturbed when the boat moves around in choppy water, early stall can be precipitated. This is the characteristic of a boat which has been widely discussed and was particularly evident during 1976 match against America. It is at least rewarding to us to know that we were able to foresee it so long ago.

Hull design

The hulls are relatively conventional for a C-class catamaran and it is therefore unnecessary to spend too much time in describing how they were designed, but to illustrate the state of the art in this area we shall look at two illustrations. In Fig. 7 I have shown the wetted surface area of different types of hull section. These are taken through the hull at the point of maximum fullness. I have chosen to illustrate the wetted surface area as a primary requirement because in the main range of sailing speeds the hydrodynamic friction on the hull causes about 2/3rds of the total resistance. Wave making resistance accounts for about 1/3rd of the total. When a catamaran is sailing over a wide range of wind speeds, its attitude on the water can vary from having both hulls almost equally immersed, to having one hull completely clear of the water and the whole of the weight of the boat carried on the other hull. As can be seen from these curves there is a big difference in the wetted surface area between different sections. Sections 1, 2 and 3 have wetted surface areas considerably higher than the remainder under nearly all conditions. Section 4 is the best when sailing on one hull, but is not good when level.

There is relatively little to choose between sections 5, 7 and 8, but we used section 8 for Miss Nylex since this has the lowest wetted surface area of any other section over the widest range of angles of heels. All of the top boats have sections which are very similar.

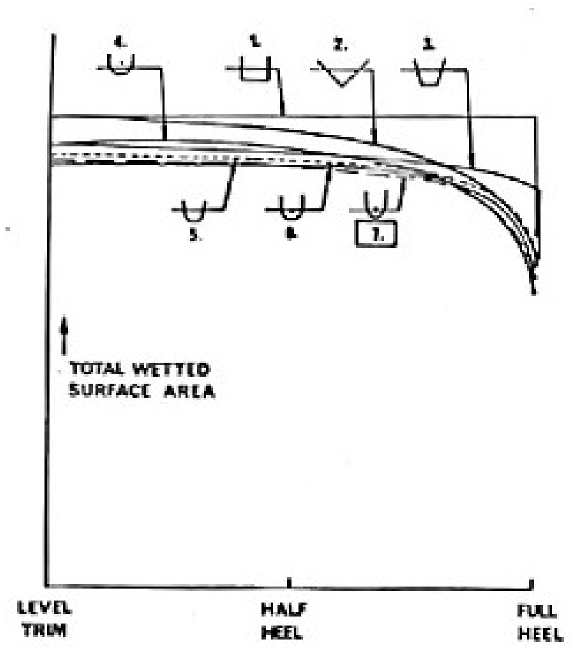


Figure 7: Hull section comparison.

The longitudinal distribution of section areas is a characteristic of hull design which has been a fundamental design tool for many years. Its shape governs the wave making resistance of the hull. There has been considerable variation in this area of design between boats built over the years, but again, nearly all of the top boats today, including Miss Nylex, have become very similar to one another. In these, the point of maximum fullness is at about 60% of the waterline length from the bow and the shape terminates in a small transom which gives the effect of a hull approximately 3 feet longer than the actual length. One might be tempted by increasing the size of the transom to further increase the effective length, but in practice it has been found that the wetted surface area is increased and there is considerable turbulence in the water leaving a broad transom so that performance is reduced. The one significant refinement that I adopted in the design of the hull shape was to arrive at the curve of underwater areas for the immersed sections by mathematically integrating from the second derivative of the area curve.

This approach yields a very precise set of hull lines. The dimension of the sections can be calculated accurately and enables the builder to produce a very fair mould straight from the drawing.

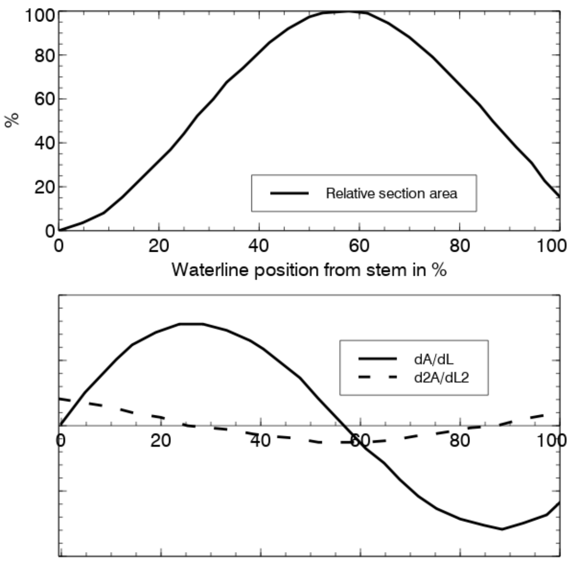


Figure 8: Section area distribution above. First and second derivative below.

It has been found that the second derivative curve is a very sensitive indicator of the basic shape and fairness of the hull. As a tool for future design one could construct a whole family of area curves simply by altering the assumptions made regarding the section derivative curve. There would thus be a theoretical link between such hulls enabling their behaviour in the water to be compared more accurately.

There are many subtleties of hull design which are difficult to qualify, such as ability to tack easily, static and dynamic resistance to pitching moments, and behaviour in waves. These and others were taken into account during the design. We have been quite pleased with the hulls, to the extent that when building a second pair last year, we decided to reproduce the original lines without change.

Fig. 9 shows a general arrangement of the final design of Miss Nylex together with a list of the weights of the major components. Due to the limitations of reproduction I have not shown anything in the way of detail construction but the main points of interest in the hull and the rig are as follows:

For the hulls we chose to use a sandwich construction of fibreglass with an end grain balsa core. This proved to be a particularly difficult medium in which to work but the stiffness of the hull has been worth the effort. The total thickness of the laminate is 7.6 mm (.30 of an inch) and has a stiffness factor of 45,000 compared with the maximum stiffness factor that could be obtained from a sheet plywood or moulded ply hull of 10,000 and also compared with solid fibreglass of the same weight

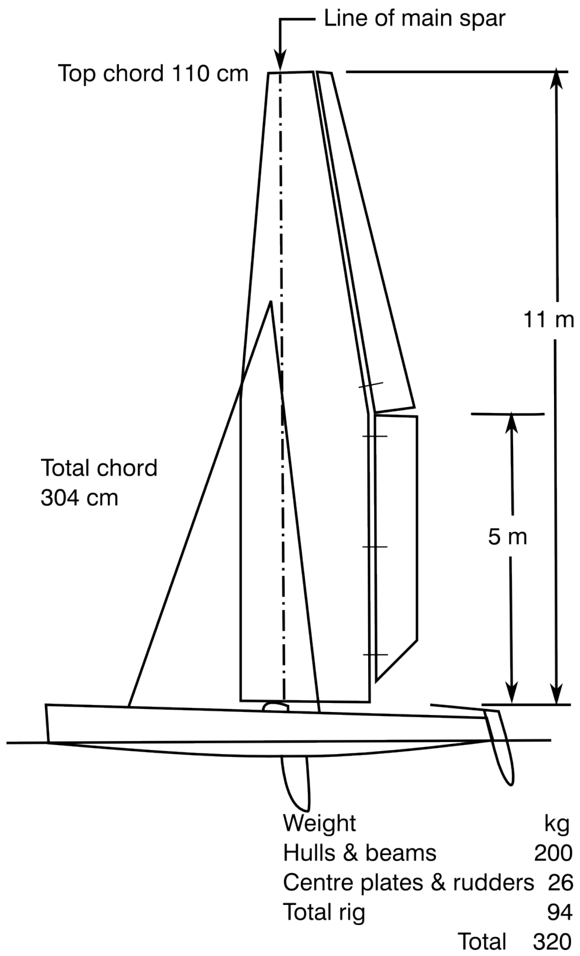


Figure 9: Final design of Miss Nylex.

of 5,500. As mentioned earlier, we actually made 2 sets of hulls. In the first set the finish was quite poor and required a lot of resurfacing to obtain a good smooth finish and they ended up too heavy to be competitive. A second set of hulls was built last year by Commonwealth Aircraft Corporation in which we were able to reduce the weight much closer to that of our original target. In these, we used the glass/balsa/glass laminate for the decks too, increasing the thickness in between the cross beams to 9.5 mm (3/8ths of an inch).

We have had no trouble whatsoever with the hulls due to structural weakness and we believe that the choice of this medium has been a major factor in the success of Miss Nylex, because it enabled us to concentrate all of our attention on the tuning of the rig.

The hulls are joined by two 100 mm (4 inch) diameter high strength aluminium alloy tubes. The main beam is enclosed by a built up fairing to reduce wind resistance. The use of this fairing reduced air drag by about 6.4 kg (14 lbs) and is considered to be worth the penalty in weight which it incurs. The deck of the boat is fabricated from heavy terylene cloth. This is conventional practice in all high performance catamarans.

Both the centreboards and rudders are made of wood and again hydrofoil sections were selected very carefully to obtain optimum performance. They are 9% thick derived from the 66-series of NACA sections and are highly polished for minimum drag.

The design and construction of the wing presented us with many challenges, but in its finished form is in fact quite simple. It is an all timber structure with no metal fastenings, built around a main spar of 3 mm (1/8") plywood with 19 mm x 19 mm (3/4" x 3/4") flanges of aircraft quality spruce. The ribs are of 9 mm (3/8") balsa, covered on the leading edge with 1.6 mm (1/16") plywood to the level of the hounds and with 5 mm (3/64") plywood from the hounds to the tip. The after pare of the wing is covered with terylene sailcloth adhered to the structure by applying Goodyear Pliobond. The whole of the wing surface is finished with a white durathane paint system. Some plywood ribs were used to carry the concentrated loads at the flap hinge points. There is a heavy concentration of loads at the pivot point, and on the lower part of the after section due to the torsion generated by the flap loads. Structural failures have occurred in both areas, but racing results were not affected. In design we applied a safety factor which varied from 1.5 in non critical areas to 2.5 at major load carrying points. The flap construction is similar.

The whole of the wing structure was designed on the simplest possible basis both to facilitate initial construction and also to enable quick repair in case of damage. This policy has paid off several times in competition. As a result of accidental damage we have had to repair different parts of the wing and since we used readily available materials throughout, repairs were effected simply and quickly.

The flaps are controlled by a simple bell crank attached to the leading edge of with control wires leading down to a simple lever system at the base of the wing.

The total weight of the boat is a little over 318 kg (700 lbs). During the 1976 match we were competing with a boat which weighed under 227 kg (500 lbs) largely brought about by the use of a conventional rig. From the lessons learnt with this boat we believe that it is possible to reduce the weight of a boat with a wing mast rig to well under 273 kg (600 lbs). This will be essential for future competition.

Operation

In the operation of the boat the crew have very few controls to work. In this respect the initial design concept has been completely satisfactory. The main wing control systems consist of:

1. A main sheet for controlling the angle of the complete rig relative to the boat. This is constantly being adjusted by the helmsman;

2. A control on the flap angle which is operated by the crew each time the boat changes from one tack to the other; and

3. A variable stop control which enables the crew to set the maximum flap angle which is to be used.

In a normal beat to windward only the first two are in use. The stop control is set at the beginning of each leg of the course. The flap angle is varied from 10° for beating in fresh breezes, up to 30° for broad reaching and running. When beating, the flap angle is increased progressively as the wind strength decreases.

In addition there are controls operable by the crew to enable the centreboards to be raised and lowered quickly, the main back stays to be pulled back for on the wind work, and the shrouds to be released so that the sail can be set at the maximum possible angle for broad reaching. These controls are all based on standard yacht fittings and very little in the way of special components had to be built to equip the boat. This is in sharp contrast to the rig on Quest III and similar boats in which practically all of the operating equipment had to be specially made. In the case of breakage or failure, replacement of that gear entailed a considerable amount of work and effort. Also on Miss Nylex, the forces from the rig were well distributed into the hulls. All of the gear proved to be very reliable, and we have not had any significant failures at any time throughout the 4 years in which the boat has been sailing. Many hours were devoted to refining the gear for maximum control and ease of operation, but generally the team was free to concentrate most of their efforts toward keeping all of the gear in top working order and in developing special techniques necessary to handle such radical departure from practice under racing conditions. To assist the crew in sailing the boat, wind indicators are mounted on each bow and on the leading edge of the wing, and windows are placed in the wing and the flaps to enable the crew to see woollen streamers on the lee side of the rig. These were all needed to assist them in maintaining optimum airflow at all times.

In all moderate wind speeds Miss Nylex is an extremely simple boat to sail which enables the crew to concentrate their efforts on both boat handling and tactics without being overworked. At higher wind speeds Miss Nylex, like all other C-class, starts to become a real handful for two people. The forces which can be generated by such a large wing area are enormous and it would be an understatement that only crews with very good reflexes can be entrusted with a boat of this type in active competition, when the breeze is over fifteen knots.

Racing performance

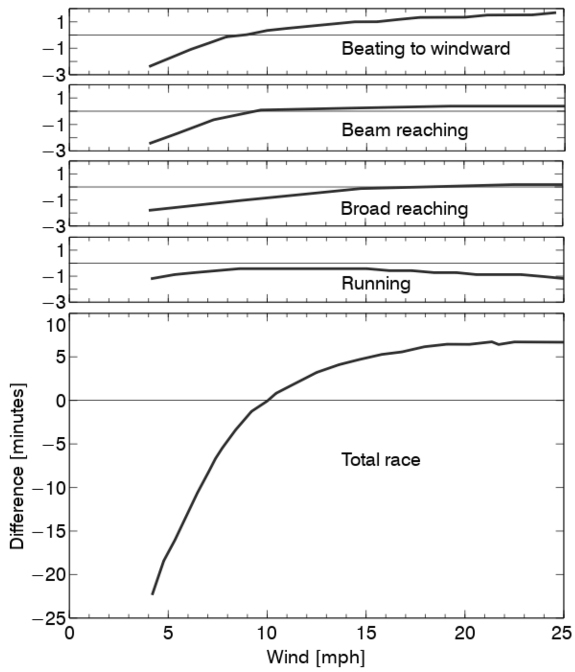


Figure 10: Performance comparison with Aquarius V based on results from the 1976 ICCY match. Positive numbers means Miss Nylex is faster.

To conclude this description of Miss Nylex we shall examine its performance in relationship to Aquarius V. In Fig. 10 we show the difference in the performance of the boats at different wind speeds and on different points of sailing. The four upper curves show the time differences for individual legs, and in the bottom graph the overall winning margins are predicted by summing the differences for all of the legs of the course.

A good deal has been said concerning the superiority of Aquarius at the low end of the wind range. It is unfortunate for us that the winds prevailing at Sorrento this year should have been so light, but without apology we would say that we took a calculated risk that the wind strength would be generally above 10 mph knowing that we did in fact have an area of weakness in lighter winds. Before the match we considered many alternative ideas to offset this weakness, but eventually decided to leave the rig basically unchanged. This was a very hard decision to make, but until this year, the true potential of the original concept of Miss Nylex had not really been established. We decided that there was no point in making significant changes to the initial concept until there was complete information on its capabilities and deficiencies.

Thanks to the precise manner in which the courses are laid we have been able to construct curves which show not only the gain or loss of one boat relative to the other but also curves of absolute boat speed in different wind strengths. The latter are not shown here but reveal the same relationship between the performance of the boats above and below 16 km/h (10 mph). I would like to emphasise in showing these curves and in talking about the relative performance of the boats that whilst in winds below 16 km/h (10 mph), the performance of Miss Nylex is obviously not a match for Aquarius, this covers a wind range of only 9.6 km/h (6 mph) whereas the competition allows for sailing in a wind strength up to 40 km/h (25 mph) and therefore Miss Nylex has a measured superiority in wind strengths over a range covering 24 km/h (15 mph). With this relationship the outcome of any series of races is entirely dependent upon the prevailing wind strength. These curves have confirmed the performance characteristics predicted from the maximum obtainable lift coefficient as shown in Fig. 6 and the low profile drag coefficient shown in Fig. 5.

Here then, we have a very satisfactory correlation between theory and actual racing performance. It gives us confidence that we have material which will enable us to move positively towards the development of new wing sections to improve the performance in the range of wind strengths under 16 km/h (10 mph), without losing the advantages in higher wind strengths.

Future development

This leads us to a comment on the likely future development of C-class catamaran rigs. There are two obvious lines of development:

1. The weight of the boats with all wing masts must be reduced considerably. This will improve the performance in all wind strengths, but particularly in lighter breezes.
2. The wing sections must be modified to improve the performance in light weather, particularly for off the wind work.

The American team which developed Aquarius V have said that they can see no immediate prospect of further improving the performance of a boat of that type. They have already reduced weight as low as they can with modern high strength materials, and they can do little to improve the tuning of their rig. On the other hand there is considerable scope to refine and lighten the structure of a wing mast by using materials other than wood and painted fabric. Now that the concept has been shown to work, the cost and time involved in further development can be more easily justified. The use of honeycomb panels and carbon fibre in areas of high load concentration will certainly permit considerable weight reductions to be effected. The wing of Miss Nylex was prone to moisture absorption and we avoided unnecessary exposure to minimise any increase in weight. This did not pose a serious problem to us at Sorrento as we were able to store the wing inside at all times. This luxury would not be available to many people. Consequently it would be highly desirable to design a structure which could be made from non absorbent materials. Probably the two requirements of weight reduction and making the structure resistant to exposure will go together.

The principal requirements as regards aerodynamic properties of the rig will be to introduce some camber into the main wing section, adjustable for varying conditions. I believe that the technical knowledge exists to achieve all of these objectives together and provided the resources are available to enable development to continue, there is little doubt that a boat with a wing mast can be built that will be superior to the soft sail rig over the full range of wind strengths.

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