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MAKING SAIL

Are hi-tech membrane sails now within reach of regular sailors?

+ Words Guy Waddilove

Over the last fifteen years sailmaking has undergone a radical change. The days of sailmakers sitting cross-legged on the floor of the sail loft with a leather palm on one hand and needle and thread in the other are fast fading. Traditionally-built panelled sails are being replaced by membrane sails and each of the major sailmaking companies has developed their own system for building them.

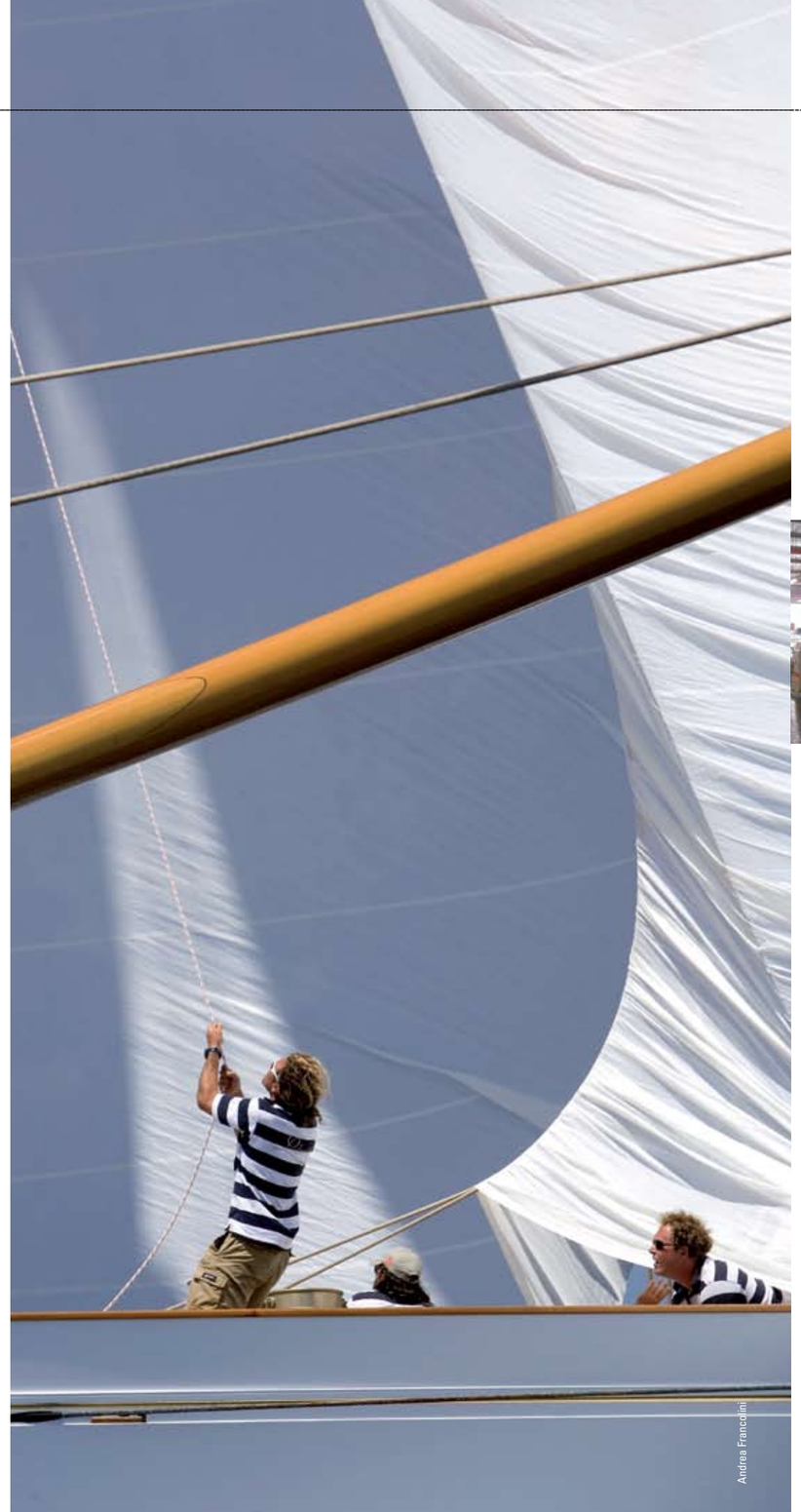
The difference between building membrane sails and traditional 'panel-built' sails is akin to the difference between building a boat out of planks of wood and moulding one from fibreglass. Panel sails are assembled from shapes cut from a roll of cloth. The cloth is flat and the shapes or panels cut from the roll are therefore also flat; it is the stitching together of the triangular and curved edges of the panels that gives the sail its three-dimensional form.

A range of weights of cloth are specified for the requirements of the sail, and as the threads within the cloth are laid out at 90 degree angles, the sailmaker will try to align each panel so that it is orientated to take the loads off the sail and minimise stretch.

Membrane sails do not use sailcloth from a roll, instead the cloth is formed by the sailmaker as part of the sail building process. Different sailmaking companies have different ways of building membrane sails but the basic principle remains the same: an outer skin is laid out; on top of this the yarns which have been soaked in a glue or resin are laid out by a computer driven gantry; another layer of outer skin is added on top and the lot is then compressed by either vacuum or 'steam roller'.

Membrane sails are lighter, less prone to stretch and have a better flying shape than their panelled counterparts. They are lighter because each sail is engineered to have the yarns oriented to share the load of the sail so less yarns can by used. A panelled sail will have

many superfluous yarns as the cloth coming off the roll is standard and when the panel is working in the sail, not all of the yarns take an equal load as the loading of a sail is not uniform. Membrane sails improve on this by aligning the yarns with the predicted loads of the sail so that every yarn is working efficiently. This yarn alignment means sails should stretch less as the yarns are configured to exactly match the load characteristics of the sail. With a panelled sail, weaker spots develop where loads are higher as the fibres are not optimally aligned to address the loads. A membrane sail should also have a superior flying shape to a panel sail with better airflow across it because as the sail is formed in one piece a smooth curve is formed and seams, which interrupt the smooth airflow, are avoided.
As with a lot of hi-tech sailing equipment, membrane sails were originally aimed at Grand Prix racers but are now being used by cruisers, cruiser-racers and superyachts. With the development of sailbuilding equipment, technology and design, membrane sails can now be produced at a lower cost than previously, making them affordable to a wider market. They have also been adapted to offer greater durability as although membrane sails with Mylar outer skins offer the best performance, their durability would not suit the cruising sailor. To increase longevity, a further outer skin or taffeta is normally added to either or both sides of the sail for protection from chafe and damaging ultraviolet light.
A cosmetic advantage that membrane sails offer over traditional panel sails, and one that was probably never planned, is resistance to mildew. Panel sails tend to suffer from mildew growth particularly along seams where moisture penetrates into the holes created by stitching. As membrane sails do not have the amount of stitching of panel sails, mildew dows not penetrate between the layers.
North Sails developed their 3DL sailmaking process in 1990 to produce three-dimensional laminated sails for high-end applications. (North uses the term laminate to describe the build process as this is how the membrane is formed, it should not be confused with the term laminate which is used also for panelled sails where the cloth on the rolls is formed as a laminate using Dacron or Mylar outer skins and yarns of Spectra, Vectran or aramid).
North builds their sails over three-dimensional moulds set up specifically for each sail project.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Quantum Sails


Quantum Sails

The articulating mould shape is controlled by software from the sail designers' CAD files. Once the shape of the mould is set up, a layer of Mylar film is tensioned over it and the adhesive coated yarns are laid in place following the curvature of the mould surface. The yarns are laid to match the anticipated loads of the sail, radiating from the corners either to the other corners or the edge of the sail. After the yarns are laid, another layer of film is laid over the top and vacuum pressure is applied between the layers. The sail is then heat-treated to 'shrink' all the components together and then left to cure for five days. After curing, batten pockets, luff tapes and corner reinforcements are added to finish the sail.
North has used this technique successfully for a number of years now and the developments have been with the materials within the membrane. Depending on the how the sail is to be used, a selection is made from a variety of materials. America's Cup yachts use a high modulus carbon fibre yarn for their sails, whereas for a cruising yacht North's Marathon range with aramid yarns and Dacron taffetas would be more cost-effective and suitable.
North is continuing with the development of its next sailbuilding technology called 3DR. With 3DR the sails are moulded on an articulating cylindrical drum, leading to further cost savings in production.
Doyle Sails produces membrane sails under the name Stratis. Whereas North Sails form theirs over a three-dimensional male mould, Doyle form their membranes on a flat floor. Doyle is using the same process of laying yarns in a mapped pattern to address the load requirements of the sail, but as the sail is built on a flat surface, they build large panels which are then stitched together to create the sail's three-dimensional shape. Although stitching panels sounds like the process is closer to traditional panel sail construction than 3DL construction, it is not because within each panel the fibres are planned and laid out to take the loading of the sail. The panels are engineered so that when joined, the yarn paths are aligned. So although the yarn paths are discontinuous as the panels are joined, they are aligned to create the same effect. The sail will also gain a small amount of its three-dimensional shape from the placement of the yarns as they are laid out in curves. Doyle designs its sails in-house and produces Stratis sails

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at its plant in Auckland. Production at the plant is flexible and Doyle builds anything from one-design 5.5 square metre dinghy sails up to the 783 square metre reacher and 654 square metre mainsail being built for the 52 metre *Red Dragon* currently in build at Alloy Yachts. Doyle's Stratis system is an affordable way for non Grand Prix yacht owners to gain the benefits that yarn path membrane sails can offer.

Quantum Sails also produces membrane sails at its plants in Malaysia, South Africa and Mallorca. Quantum recently took over the Mallorca plant from Vela 2000, a sailmaking company who were one of the first to adopt this technology and who were probably the most experienced membrane sailmakers for superyachts. Quantum's membrane sails differ from the others on the market because of their yarn layouts within the sails. Quantum has developed what they call the Isostrain 'Smart Sail' structure where the predicted loads of the sails are addressed with more crossed fibres than their competitors. Following wind tunnel testing and strain testing at Massachussetts Institute of Technology, Quantum believe they have developed a yarn layout offering better shape retention and, acknowledging that all sails stretch to some degree, more even stretch characteristics. The sails apparently 'load up' more evenly with the Isostrain layout making the sail easier and more consistent to trim. Quantum's sails use marginally more yarn than their counterparts from other companies, but this apparently does not mean a weight increase as less glue is used within the laminate, and it is the glue rather than the yarn that generally contributes to weight. Quantum produces racing sails – Fusion M, and cruising sails – Fusion X. Across the range the fibre layouts are consistent. The difference between the ranges is in the choice or fibres and the addition of taffetas to the cruising range.

Dimension Polyant is a company closely tied in with membrane sail production as it supplies membranes produced at its plants in Germany, USA and here in Australia to sailmakers worldwide. The membranes are marketed under the trade name D4 and each membrane is specifically built for a particular yacht to the specification of the sailmaker. The sailmaker can specify the fibre combinations for the yarns from a range of carbon, aramid, Technora, Vectran and Pen, and also the films and taffetas that they require for each particular sail.

One area that Dimension Polyant is concentrating on is protection from ultraviolet rays which reduce the strength of the materials and allow stretch to occur. The company is experimenting with thousands of samples of deep dyed films and advanced taffetas with coatings and additives to protect from degrading UV rays.

Although Dimension Polyant is a relatively unknown name to the general boating public, as an industry supplier it is the largest manufacturer of sailcloth in the world. In Australia and New Zealand, Dimension Polyant-supplied membranes are used by sailmakers including Doyle, Hood, Ullman, MacDiarmid, Quantum and Taskers. Their products can be seen on yachts including Hardy's *Secret Men's Business*, the TransPac 52 *Wot Yot* and *Beau Geste*.

With the continued development of membrane sails and the economies being achieved through the establishment of reliable plants, the price difference between traditional panel-built sails and membrane sails is narrowing. Building membrane sails is less labour intensive than building panelled sails, so once the machinery is installed and set up, running costs are reduced because unskilled labour can be employed. All of the major sailmaking companies have adopted this technology and it is probably not long until the only sails stitched together from panels of cloth from a roll will be spinnakers and asymetrics.