

# Battleground

Most of the America's Cup community believe that rigs and sails will be the big factor in Valencia in 2007. We ask sail software specialist Peter Heppel, previously with Oracle BMW, how the perception matches up to the reality

**SH:** Why are so many people so certain that rigs and sails are going to be 'the' big thing during this AC development cycle?

**PH:** Well, think of an F1 car and how finely tuned its wings are. The wind tunnels and supercomputers of the big teams are running 24 hours a day to find the shapes that give exactly the right pressure distribution to maximise down-force. The stronger teams are even now designing the way their wings flex, so that they can make the best of an uneven track.

If they can do it so can we. The design methods are here. We are used to seeing

them in appendage design. The construction methods are here, with the maturing of filament sail technology. Our understanding of what is fast is getting there.

Ask an F1 designer what the three top priorities are, and the answer is 'aero, aero and aero'. I wish the priorities in Cup design were as simple. It's probably more like 'hydro, hydro, aero and moding'.

Moding? Match racers know even more than one-design sailors that straightline speed isn't enough. Flexibility and efficient gear-changing are the keys. You change gear from pointing mode to fast mode

**Stiff and very flat, but these fundamental criteria make the finer nuances of ACC sail design all the more sensitive to minute changes in shape and structural layout**

depending on where the other boat is. Every puff you have to build speed; every lull you have to burn it off.

This need for adaptability (we just call it 'sailing') is what makes a Cup rig harder to design than an F1 wing, and is maybe why we tend to shy away from more formal approaches. But there is much that can be done with a bit of science and clear thinking, especially now that so much mature software is available. We are starting to recognise that the same rigour that goes into hulls and appendages can pay off above the deck too.

**SH:** What does this mean in practice?

**PH:** First of all, before you can move on to the real innovation, you have to get past the basics. Time on the water is always at a premium, even in a four-year cycle. The first thing we designers can do is to win time, much of which is spent on basics like mast tune and steering balance.

Every appendage switch changes the steering balance. Sometimes not much, but all the same you have to retune the headsail depths and the mast rake. When the rake changes you have to adjust the leech lengths and find the new settings. This all takes a lot of time away from innovation.

Another example is setting up a new rig, especially the Millennium Rig. The best designers give a schedule of rod settings derived from a comprehensive engineering study. They really can get it right first time, and save months of tail-chasing. Also, with a new mast you have to refit the luff curves. This is another 'basic' that can now be performed cheaply in simulation.

The engineering software these days is quite good. Designers can get pretty good estimates of sail forces, and work with the VPP to figure the steering balance and the target sail shapes. But that's only half the story. The biggest value of simulation software may well be for communication.

**SH:** Communication?

**PH:** The classic scientist intervention is the perfect solution to the wrong question, like a 'theoretically perfect' low-drag sail that you can't steer to.

Sailors, engineers and analysts each see design questions in their own way. The scientists need to be pointed towards the right question and the sailing team need to understand the physics.

A good interactive graphic tool is a great help in getting everyone onto the same page. One very good example is Sail-Pack-Aero, the practical CFD code written by Mik Kermarec (see box, page 37). Designers and sailors alike can use it to explore and explain what happens when the sail shape changes.

Software that works so easily lets us do much of the tuning and the tail-chasing in simulation, not in precious sailing time, thus freeing up time for training and for the real 'special projects'.

**SH:** Special projects?

**PH:** I don't think you'll see anything as radical as a six-wheel racecar because most radical configurations have been foreseen by the ACC Rule. After responding to the rule changes, it's mainly about finding formal, effective solutions to the perennial sail design questions.

How to get a wider range? This question gets harder every cycle because the target shapes are more and more refined. Now that the sailors and aero team have such a good idea of which shapes work well, the challenge is to make a sail, especially a headsail, that is not just flat uprange and deep downrange, but also hits all the other shape targets for each windspeed, like entry angle, draft position and twist. The answer is in the membrane

engineering; matching the stress and strain so the curvature changes exactly as needed.

How to open the top leech? Pushing it out with the spreader works fine for the headsail, but for the mainsail what is to be done? The answer is in the membrane engineering (see Figs 1 and 2, page 36).

How to make spinnakers more stable? Are the most common instabilities due to wake reattachment, cyclic separation line movement, or something else? An aerodynamicist, a structures person and a good wind tunnel can go a long way here.

Flow separation. Some parts of the sails are always massively separated. Everyone would like to detail this away. Now that the big CFD codes are practical for everyday use, at least we can see why this

when you combine talent, technology, and teamwork with unlimited passion, the result is a group who exceeds your expectations of what you thought possible. it's a mix of these four elements that drives us. so, if you are passionate about your sailing ... who makes your sails?

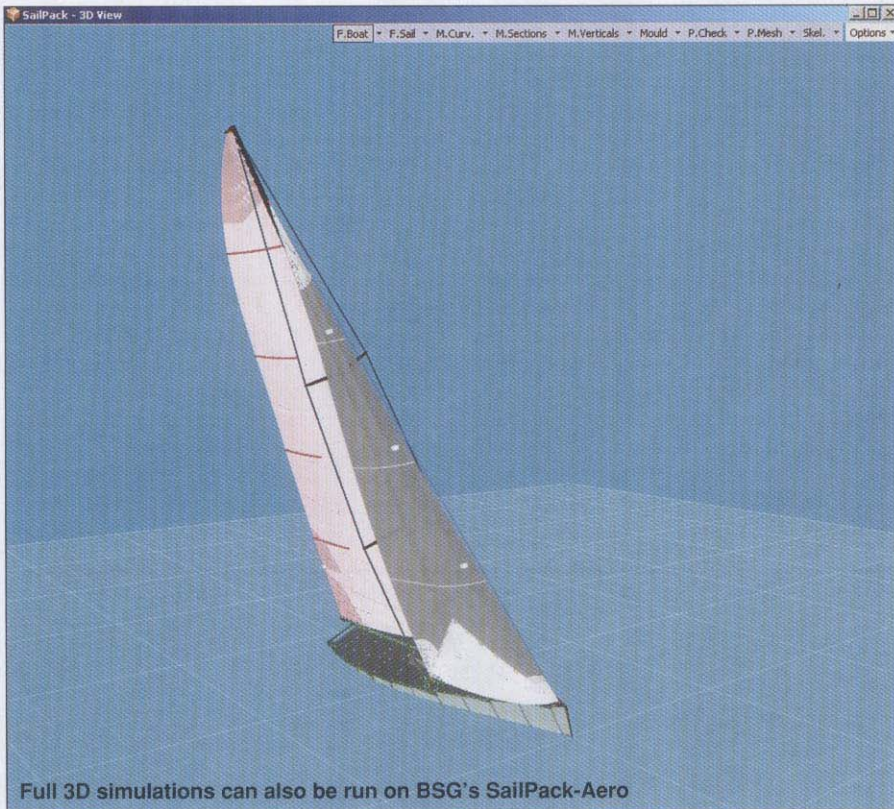
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Full 3D simulations can also be run on BSG's SailPack-Aero

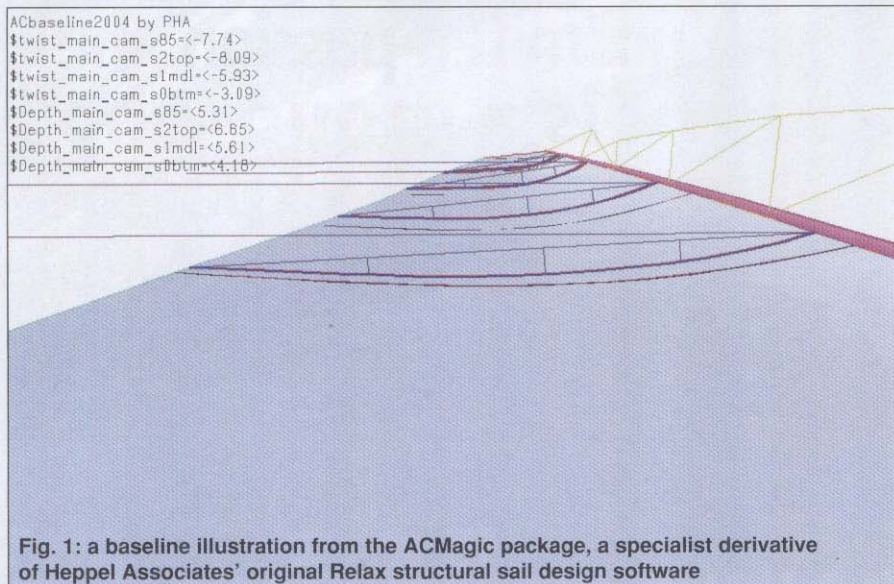


Fig. 1: a baseline illustration from the ACMagic package, a specialist derivative of Heppel Associates' original Relax structural sail design software

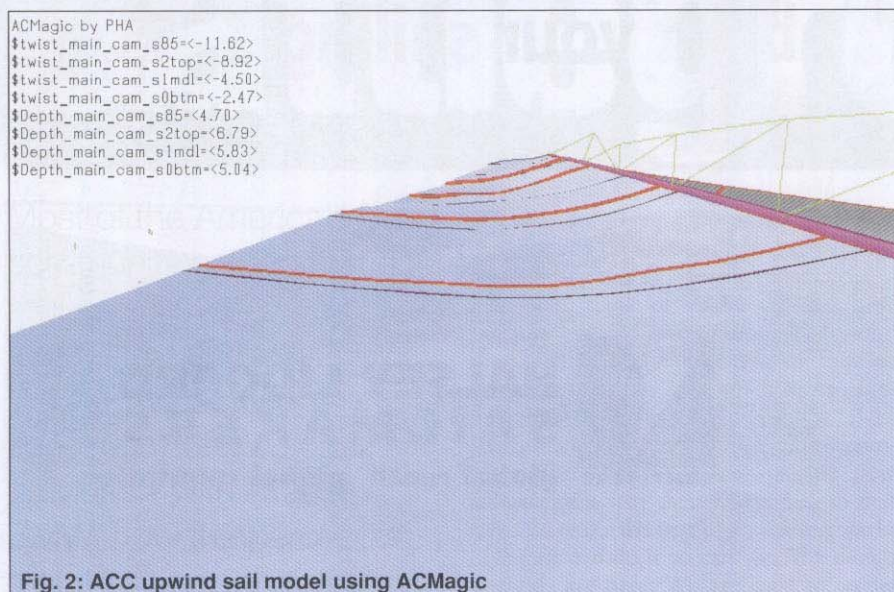
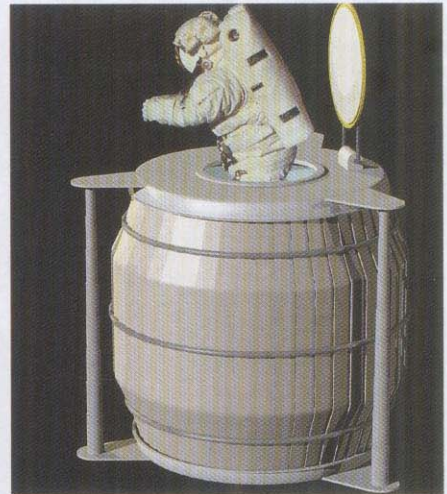


Fig. 2: ACC upwind sail model using ACMagic



Above: Heppel Associates was closely involved in the design of NASA's collapsible air-lock, which uses inflatable batten technology on a giant scale to achieve initial 'inflation' and subsequent rigidity

happens. Which is a good start for figuring out what to do.

Aero detailing. A bit of technology transfer from the aircraft industry; learn from the tricks they use to improve airflow or stability. And then there's dynamics; in engineering terms probably the biggest innovation because it means thinking about frequencies, not just about shapes.

SH: 'Dynamics' is too often a word that just gets thrown around in press releases?

PH: Absolutely. In pure terms dynamics is the science of how things move and vibrate in response to their environment. Though AC boats seem stable, the motion is fast. The sails see a changing wind angle as the masthead slows and accelerates. Everything is in motion – even the masthead wand.

Dynamics is one of those subjects that you can make really hard if you want to. So hard that you scare yourself off. But if you look at one thing at a time, then answers can be found.

For instance, the headsail goes deep every time the bow lifts to a wave. Is this slow? Probably. Why? Let's do a bit of CFD to illustrate the physics, and then make a judgment. What can we do about it? It's either more fibre or a change in orientation. Or just a firmer headstay. Structural computing will show us.

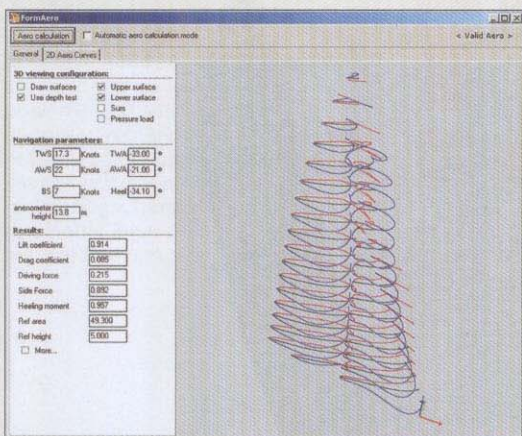
Another example: when the bow goes down, the mainsail upper leech closes and the lower leech opens. You lose power and point at the moment when you need it most.

The real challenge is to extract energy from the pitching motion, rather than to put precious aero energy into it. This comes largely down to the choice of main-sheet load. Is there an upper limit? Can the gear take it? The answer lies in aircraft wing theory, which shows how things behave as a function of frequency, to give guidance on choices like rig stiffness, leech profile and, not least, tension.

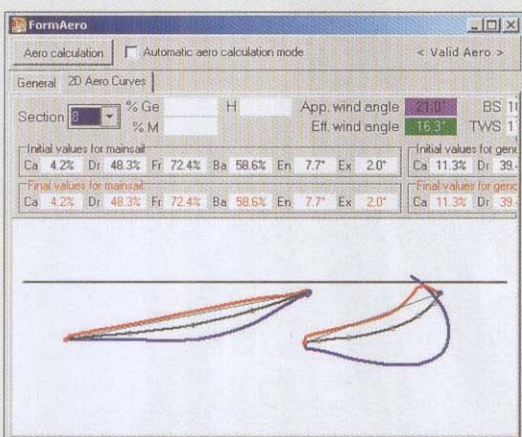
SH: What about the rule changes?

PH: There are some changes affecting the rig: genoas may now have positive roach supported by battens. Battens may now be

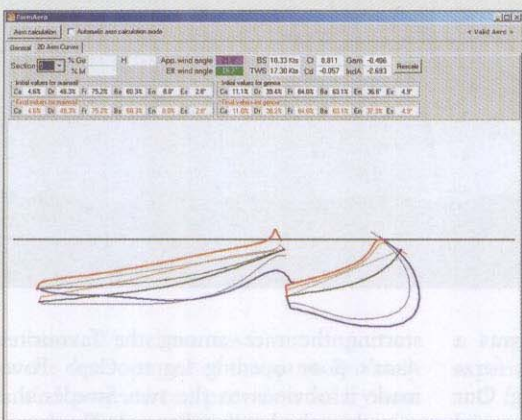
SailPack-Aero is the flow calculation module of the BSG SailPack software package:



SailPack-Aero makes a simulation of the flow of the wind effects on the sailplan in 3D. The sailplan is divided into multiple interacting 'slices', each having impact on all its neighbouring slices. The resulting data, giving a 3D picture, is an integration of these calculations



2D slice from analysis. The red and blue curves show the pressure



The 2D-Aero tool is very helpful in achieving a better understanding of the overall working and aerodynamic outcome of any given sailplan. SailPack-Aero allows you to study each slice in 2D. You can select any slice and modify the treatment of each sail including incidence angle. The impact of any adjustment made on one slice of one sail can immediately be visualised on both sail profiles

SailPack sail design software:  
BSG Développements  
www.bsgdev.com

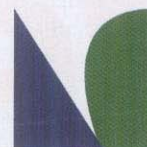
inflatable. The minimum rig weight is lower and the sail area is greater. Stability is still extremely high. The rig designers will be facing a fascinating challenge.  
SH: Are inflatable battens here to stay?  
PH: A well-designed inflatable boat will take knocks like a punch-ball or a car tyre. If the battens were that tough it would be a big help in the prestart in the AC – and in many other wider sailing scenarios.

Headsail overlap is fast. Everyone uses flippers on the top spreader to support a wider sail. The idea in the rule is to use battens instead, but headsail battens on an overlapping sail are a novelty. They have to fold up when you tack, survive hitting the mast and rigging, and not hinder the hoists and drops. The mother of all inflatable battens is NASA's Advanced Inflatable Airlock. Inflatables are straight-forward if you go about them the right

way, but can be really dangerous if you take liberties. What we learned in our work for NASA fits neatly into the needs of the AC. But I wouldn't build AC battens the same way... I'd make the process less industrial and more craft-oriented.

As they say at NASA, it's not rocket science. It's winning time on the water, being clear about your goals and focusing all the skills in the team to win those 10 seconds per mile that are beckoning.

Peter Heppel has long been at the forefront of new sail design software – while also running an unusually diverse structural engineering consultancy in Paris. For the 2003 America's Cup Heppel was engaged by Oracle BMW, but his involvement with the Cup extends back to time spent in Australia working on Iain Murray's Kookaburra campaign in 1986/7



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