



# MAKE YOUR BOAT FLY!

What is AeRowFin™ and why it works – the scientific principles explained

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**AeRowFin** is an amazingly precise and powerful steering system.

Compact, economical, elegant and robust, it increases boat speed by enhancing control, improving stability and reducing overall drag.

These claims are underpinned by solid science, established technology and, of course, by AeRowFin's outstanding, proven performance.

That underlying science is Hydrodynamics, a branch of the rigorous parent science of Fluid Dynamics and close twin of Aerodynamics.

Aircraft wings are optimised by the intelligent application of advanced Fluid Dynamics. By the same procedures, AeRowFin is designed to optimise the performance and control of racing shells.

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- How AeRowFin works
- But how does AeRowFin really work?
- And how does this reduce drag, increase stability *and* improve boat speed?

## WHAT'S WRONG WITH CURRENT STEERING SYSTEMS?

To turn a boat requires a side force. There are two ways to provide this force: deflect a blunt object sideways to increase drag on that side; or use a properly-designed steering foil to generate hydrodynamic 'lift' with no extra drag.

Most steering systems employ two flat plates – a big one to keep the boat heading straight and a small one to make it turn. When turning, the small plate must first overcome the large one's resistance. This conflict is neither efficient nor sensible. First the fin resists the rudder component, then loses its grip and the boat slews. And all the time it spins water into energy laden vortices.

Flat plates have lousy hydrodynamics and steer more by luck than judgement. The uncertain relationship between input and performance (see later) demands constant small corrections, creating a wavy course. The boat slides slightly sideways at each correction and since shells are long and thin to minimise drag and maximise speed, this increases hull drag and impairs your performance. And a sinuous course imposes varying side forces on the crew to upset balance.

## HYDRODYNAMICS PROVIDES A BETTER WAY

Water flowing around a well-shaped object can generate substantial forces but to harness these a designer must fully understand hydrodynamics.

Aircraft combat gravity by means of 'aerodynamic lift' – induced when a fluid (air) accelerates to pass over a wing's more convex upper surface. The air's streamlines pinch closer together at their increased velocity and the local air pressure falls as pressure energy in the air converts into kinetic energy (energy of motion) to power this velocity increase.

The pressure difference between upper and lower surfaces (there is minimal increase under the wing) provides the 'lift' force which supports the plane.

'Lift' is efficiently generated to keep huge aircraft and tiny aero-models in flight. There is a drag penalty, but for a well-designed 'foil' (the term for any wing-like object) this is always small and so are its energy costs.

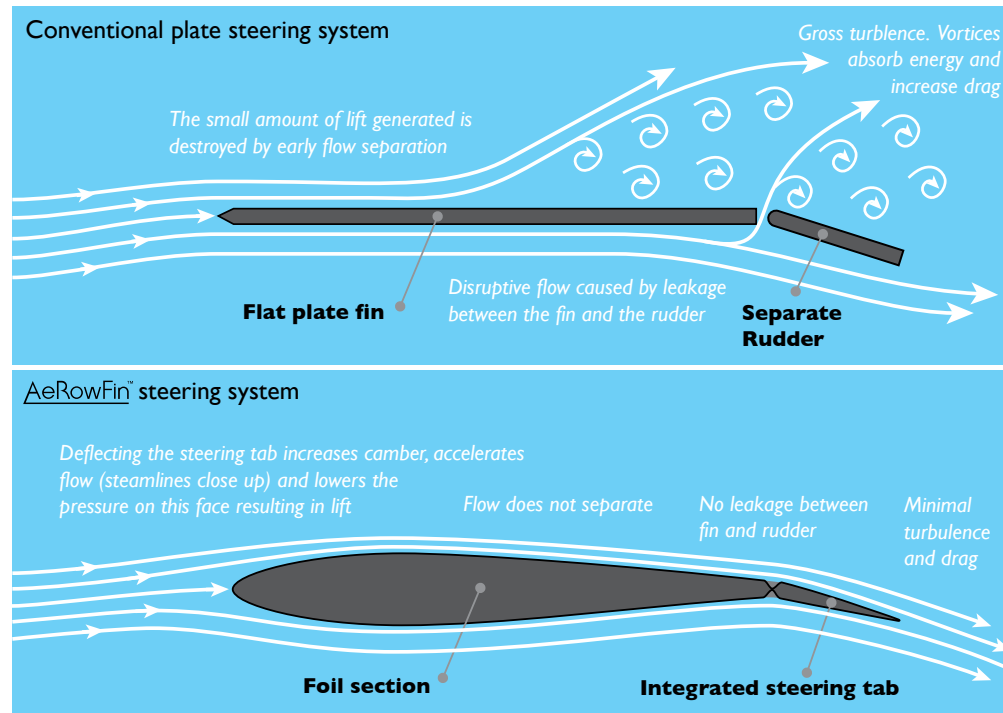
The 'lift' process can generate powerful side forces for steering and control in any moving fluid, including water.

Which brings us to the AeRowFin steering system. With its form optimised for 'lift', AeRowFin creates precise side forces to move the stern but, unlike other systems, does so with great efficiency – precise, with minimal drag. Even when not steering, its drag is less than with conventional systems.

In reality a fin is always steering. It cuts through water which, passing under the boat, is turbulent with fluctuating flow directions. A steering system should resolve this turbulence efficiently. A well-shaped foil smooths turbulent flows whereas flat plate systems (especially with sharp edges) simply carve off the off-axis flows and shed them as large vortices. Shedding vortices increases drag, draining energy from the crew.

Conventional systems often have a central dead zone. As you turn that little rudder, up near the hull, it stalls. Helpless in the slow, messy flow, it cannot generate lift. So the fin retains an erratic grip in the faster, deeper water. Apply more rudder and then you get over-steer or a hesitant response. Over-steer happens when the rudder's small side-force (mostly from side drag) nevertheless becomes enough to separate and stall the flow over the fixed fin, making it lose its grip.

It would be illegal to drive a car with steering like that!



## HOW AEROWFIN WORKS

AeRowFin is particularly well designed.

To steer in either direction a foil should start off symmetrical – like an aircraft’s stabiliser fin.

Simple symmetrical foils can generate large amounts of lift when inclined to the oncoming flow and can be quite efficient. But a large foil mounted on a pivot under a shell’s tightly curved hull has messy flow around its root (against the hull) and weed and detritus can jam in that gap. The steering pivot encounters large side and bending forces and few such systems exist, with few shells built to take them. Even when

geared down, the risk remains of a sudden steering input causing a boat–stopping lurch, possibly breaking off the foil.

AeRowFin is the best way to steer a shell. It is more efficient, both mechanically and hydrodynamically.

AeRowFin needs no special mountings, no changes to the boat. It can be retrofitted to almost any shell. It gives precise and immediately responsive steering. It is powerful or gentle, as required, always precise and well mannered, with no nasty surprises.

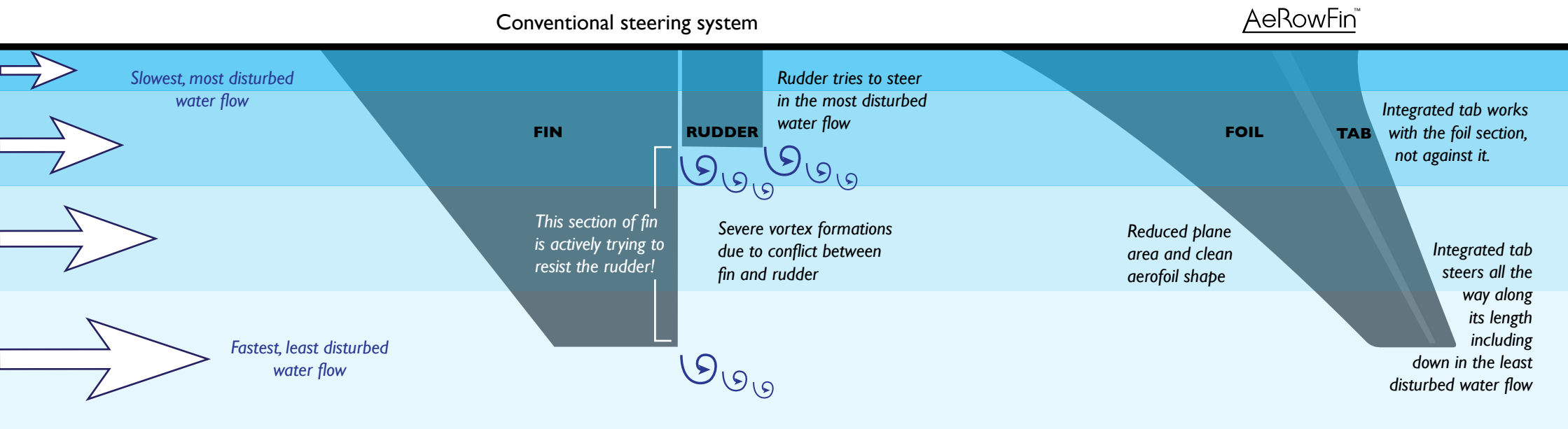
A conventional aircraft wing is more convex on the lift–generating surface and generates lift even at moderately negative Angle of Attack (AoA).

AeRowFin, by dividing its symmetrical foil shape into a fixed leading portion and a smoothly articulated trailing edge, achieves the same asymmetrical effect. Deflecting its steering element increases the curvature/camber of one face to generate lift and steer the boat. Aircraft wings can be trimmed similarly to increase lift, especially at take–off and landing – ailerons (trailing edge sections) are deflected downwards to increase the wing’s upper curvature (‘camber’).

This increases lift more efficiently (lower drag penalty) than changing the wing’s AoA.

Only the aft part of the AeRowFin – its entire trailing edge, with its precise proportions – turns when steering instead of only the root generating lift while fighting against an uncambered part out in the fastest flow.

Thus AeRowFin acts as one, without conflict between different areas of the system, and the lift force for steering is distributed across the foil’s surface in the most efficient and responsive way.



# HOW DOES AEROWFIN REALLY WORK?

The fastest flow over a well-designed foil occurs in the first half of its chord – between leading edge and mid-line. So, contrary to what one might expect, the lowest pressure and thus the greatest side force (lift) is centred at about 25% back from the leading edge, not on AeRowFin's steering element.

But we turn that tab to generate the lift by which we steer, so why will we feel no load there?

Fluid Dynamics can be deeply counter intuitive and this is no exception. We tend to think that rudders “push water aside”, and that it is “air hitting the underside of wings” that keeps planes flying. But once we see how curvature/camber alters flow velocity over a foil, and how that affects local pressure, we can better understand ‘lift’ and how a foil or wing works.

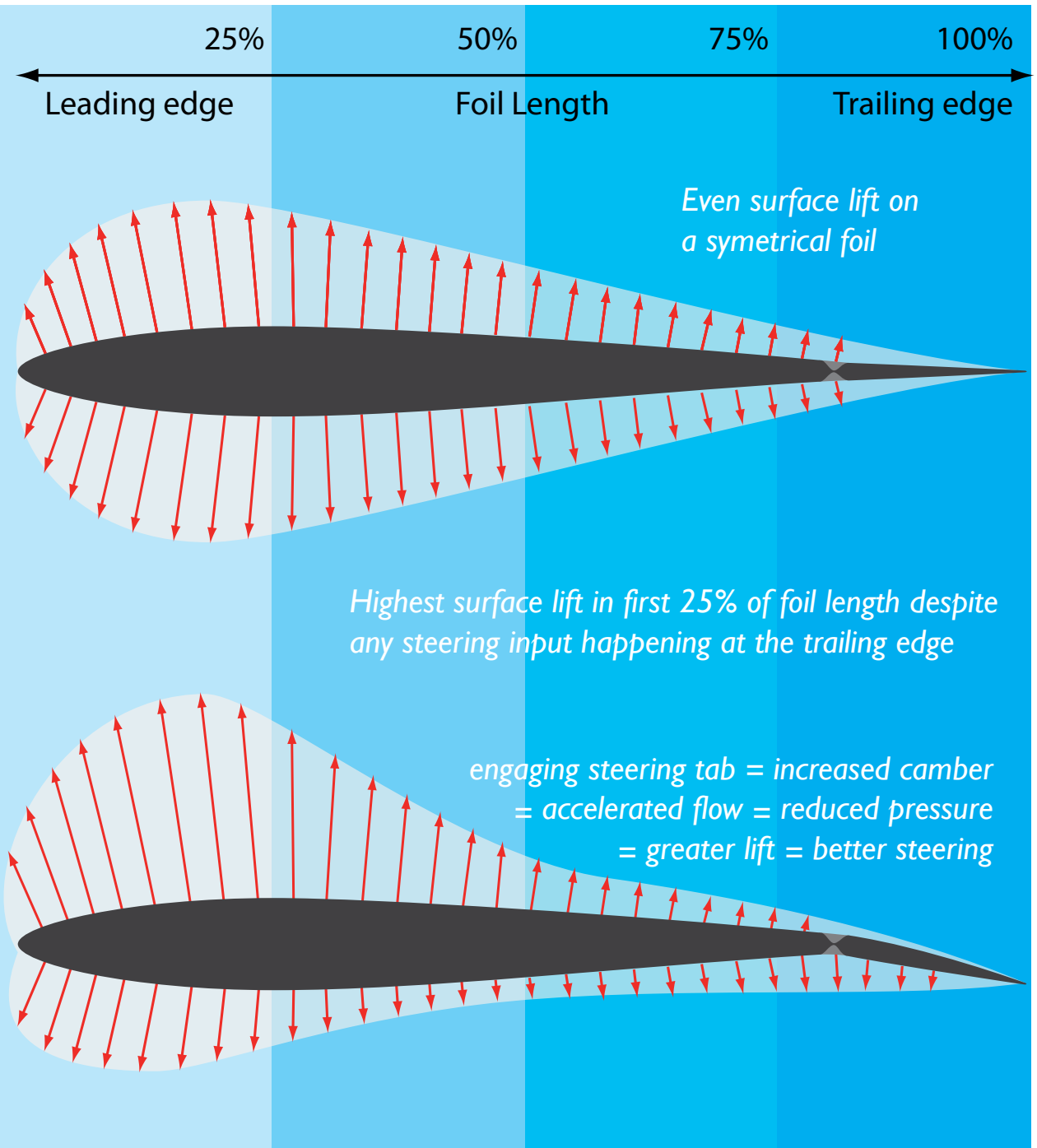
Deflecting AeRowFin's steering element increases the overall convexity/camber of one face. Flow follows this change in shape because of the *Coanda effect* – whereby flowing fluids follow smooth surfaces. AeRowFin's smooth elastomeric joint between its main body and its steering element greatly assists this process.

Having to flow around the more convex surface is what increases the flow velocity near the leading edge, yet the velocity increase near the steering element is rather slight. This implies only a slight pressure difference near the trailing edge.

That is why only the slightest effort is needed to turn the steering element – an almost ‘something for nothing’ effect!

And, of course, the full depth of AeRowFin is working as one to actively control the lift that steers the boat.

Which takes us to the issue of steering and stability...



## HOW DOES ALL THIS COMBINE TO REDUCE DRAG, INCREASE STABILITY & IMPROVE BOAT SPEED?

### DRAG REDUCTION THROUGH COURSE IMPROVEMENT

The poor controllability of conventional systems demands large and frequent corrections to hold a course. These corrections lengthen the distance rowed and impair speed through the poor hydrodynamics of those steering systems and the drag induced as the boat side-slips with each change in direction.

All of the energy thus lost is permanently stolen from the work of the crew.

AeRowFin's efficient action greatly reduces these sources of drag. It ensures that the boat wanders less and less often. It is highly responsive, so corrections happen sooner and are smaller and course deviations are much reduced. And AeRowFin's hydrodynamics when steering are, as discussed, always low-drag.

By reducing these causes of fluid drag, AeRowFin leaves more power for propelling the boat.

### DRAG REDUCTION THROUGH CLEANER STEERING HYDRODYNAMICS

You never see aircraft with crude, flat plates as wings or control surfaces. Every surface, wing and fin is precisely shaped for the best aerodynamics. That is how drag is reduced and performance enhanced.

With its advanced form and smooth lines, together with its ability to better handle and tame oncoming disturbed flows, every AeRowFin generates much lower drag than conventional steering systems.

### REDUCED ROLL WHEN CORNERING

When a shell takes a bend, because the mass of the crew is well above the boat's roll centre the resulting outward force tends to make the boat heel outwards.

AeRowFin generates an outward side-force at every corner acting down the full depth of the fin. The AeRowFin is well below the boat's roll centre. So its side-force significantly counteracts the heeling force on the crew, helping to stabilise the boat.

Also, the steering inputs are far more precise, so with a good coxswain or steers-person there will be no sudden changes in course or rate of turn, again making balancing much easier.

On adding up the savings in crew effort from all the ways in which AeRowFin reduces shell drag, improves course accuracy and enhances stability, it is easy to see how AeRowFin helps you to achieve substantial performance gains.

These gains can save several seconds per 2000m. And all for less than the cost of just one new oar! You cannot argue against the solid value of such a modest investment in a crew's performance.

Of course, existing users would prefer that you didn't fit AeRowFin!

### IMPROVED BOAT STABILITY

With each change of course the boat tends to roll and the crew must work to control this. AeRowFin's precise and swift response means fewer and smaller course corrections. So the scale and frequency of extraneous heeling forces is reduced. This improves balance. The blades catch the water less often. And the stability gained lets the crew focus on rowing.

But it goes deeper than that. Every crew which fits AeRowFin finds it gives them a more stable platform.

That's because, if the boat starts to roll, their AeRowFin, acting down below the roll centre, takes a spiral path through the water. This sets the fin at an angle to the flow, which induces a opposing lift force which slows the roll rate and helps the crew to maintain or recover their balance.

## HISTORY OF AeRowFin™

Coxes in particular, and steers-persons in general, are rowing's poor relations.

Every rower has an oar, rigger, sliding seat, tracks, stretcher and shoes. That is a substantial investment, and rowers naturally demand the latest and best.

To steer this hi-tech powerhouse, cox gets just two bits of flat metal, made with zero design expertise. So the boat is hard to steer.

Yet we all know that bad steering loses races. Crazy? Of course it is!

The very first AeRowFin changed all that. A barely steerable eight was fitted with the first AeRowFin. It became immediately controllable. It then carried the GBR heavy men's crew to Sydney 2000 Gold.

Until 2010 all AeRowFins were made in carbon. Originally they were moulded in composite tooling but to handle increasing demand we then cut new metal tools with our CNC router.

## STEERING WITH AEROWFIN

Your first use of an AeRowFin will be a real eye-opener. Once familiar with AeRowFin you may wonder how you managed before. Here are some useful insights:

- 1 No rudder works if the boat is not moving – without flow there can be no lift and without lift you cannot steer.
- 2 An efficient foil's lift is proportional to boat-speed squared – the faster you go the firmer the steering.
- 3 Steer cautiously. With the boat moving well, apply gentle rudder and observe its effect. Any input gives a proportionate result and a large input has a large, almost immediate effect.
- 4 This is a precision instrument, so steer with your thumbs, not your hands. Do not over-steer! Gone are the days of applying  $> 60^\circ$  rudder! Use small, progressive adjustments and avoid sudden large inputs.
- 5 Over-steering matters. Any hydrodynamic foil can stall, losing much of its lift and causing its drag to rise.
- 6 Stall occurs when boat speed is too low, or when the steering element is rotated too far. In either case the flow cannot follow the more severely cambered surface, so it separates.
- 7 Stall is almost normal for conventional rudders (which may need large inputs

to get the desired results) but stall is not wanted or needed with AeRowFin (which works best and steers powerfully with under  $30^\circ$  input).

- 8 To limit gross over-steer and promote careful steering we offer a special “V” steering yoke. Mounted with the tips pointed forward, this adequately restricts rotation of the steering pin. A few shells have insufficient space or an awkward alignment of steering wires, requiring other measures.

## CARE OF YOUR AEROWFIN

AeRowFins are tough, perhaps tougher than any other steering system, but do not abuse them!

Many conventional fins are in aluminium sheet, easily bent or knocked out. AeRowFins, held by stainless steel roots or bolts, are hard to bend or knock out. So you are less likely to lose or bend an AeRowFin than the device it replaces.

The worst abuse for an AeRowFin is repeated over-rotation. The sealed hinge is not designed for  $90^\circ$  rotation (see earlier advice) and repeated over-rotation may disrupt the seal, even damage the hinge.

There should be no slack between the steering pin and the motion of the steering element or the T-bar or V-yoke (Please contact us to discuss any individual cases or concerns).

## THE NEW AEROWFIN RANGE

Some years ago we installed a CNC milling centre to machine precision parts for our AeRowFin rigger range. The cost and quality benefits were soon evident, and we have developed great expertise in the design and milling of complex and challenging metal parts.



As AeRowFin sales grew we sought better ways to meet the demand, to improve product quality and to control costs. We could see that milling from solid alloy would give the best results in every way. So in 2009 we designed the new AeRowFin range – in three sizes uniquely shaped and proportioned for Pairs, Fours and Eights. This was a big challenge – machining slender plates of alloy to high precision and milling them with closed internal cavities for weight reduction. We had

to develop complex tooling and novel methods of work-holding. And the project was a complete success!

Now all AeRowFins are smoothly milled from high-duty aluminium alloy, hollow cored for lightness and anodised black.

They are perfectly formed, beautiful to see, robust and exceptionally efficient. The first of the new AeRowFin range was delivered early in 2010 and we have heard only praise for their quality and performance ever since.

We hope soon to show the video of AeRowFin parts being machined.

Until we developed AeRowFin, to change an unsteerable boat into the winning platform for Sydney 2000's gold medal eight, the rowing world was content to steer with two slabs of metal, or of ill-shaped plastics, whose form would earn the derision of any competent fluid dynamicist.

When steering cost us the race we used to blame the cox. That was cruel then. It makes even less sense now.

AeRowFin is a genuine race-winner. It is a legal performance enhancer with a proven record. Can you afford to be without it?

ENGINEERING



YOUR SUCCESS