erfully rigged, unballasted multihull may potentially capsize, it is less likely actually to founder (since it is generally lighter than water).

Boat speed

Few activities so inspire participants to seek the smallest improvement in speed that sailing does. Indeed, it is the potential for almost infinite improvement that is one of the joys—and at times the frustration—of sailing.

Most sailors are not particularly concerned with going faster than any other sailboat—they're more concerned with getting the most speed out of a sailboat that has been designed with speed-limiting rules. They want to maximize the potential of a boat that has been designed to sail within a class of boats that are all very much the same, if not actually identical in performance characteristics.

This historical limitation of sailboat design has led to a paradox: While sailors have developed the art of boat preparation, sail trim and steering to a high degree of refinement, and yacht designers have squeezed every last fraction of a knot from conventional hulls, keels and sails, the vast majority of sailboats have remained within a narrowly defined set of basic configurations. The imaginative application of pure science and engineering has not had much impact on the activities and experience of most sailors. Nevertheless, the principles that determine how fast a sailboat can go are eagerly studied and applied with an increasing degree of subtlety.

One of the chief enemies of speed for a sailboat, as for any vehicle traveling through the atmosphere, is drag. But sailboats encounter two kinds of drag whose relative importance varies with speed. The first and most obvious is the drag caused by the friction of air and water flowing over large surfaces that can never be perfectly smooth. For that reason, yacht designers take great pains to reduce the wetted surface of the hull. For any given volume, the shape with the least wetted surface is a sphere (that's why soap bubbles are spherical), but a sphere is not very useful for a hull. The next best compromise might be a round tube. Many hulls are developed from that principle and have almost circular cross sections.

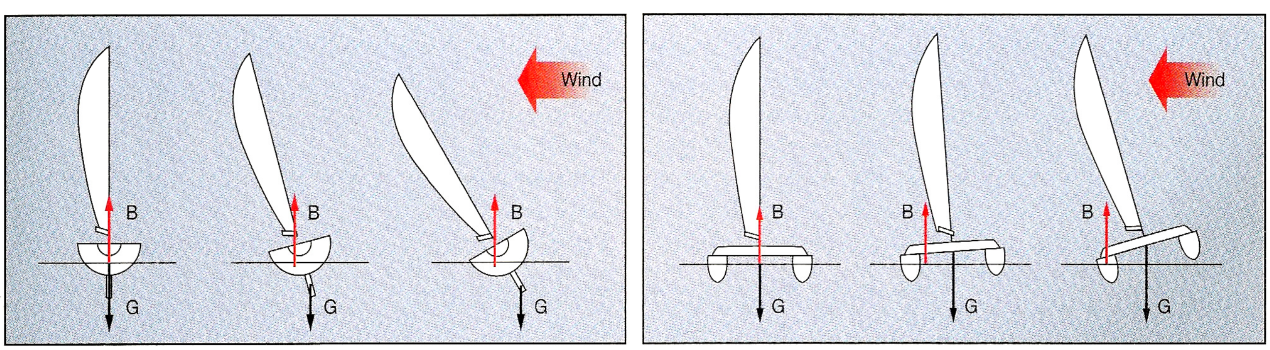
Drag is also caused by turbulent flow around the awkward shapes of deck fittings, rigging attachments, through-hull fittings and even the crew themselves. While attempts are made to streamline these, there are practical and rule-oriented limitations that most sailors happily accept.

Drag from friction and turbulence is most important at low speeds—not because it diminishes at higher speed (it doesn't) but because on the conventional sailboat another form of drag becomes even more difficult to control. This is "form drag," the process of energy loss through the formation of waves.

Imagine a sailboat moving through the water at less than a knot. Tiny wavelets stream from the hull at several points along its waterline. They don't seem to be connected. As speed increases, the wavelets grow into waves and seem to join, the trough of one running up into the crest of the next. At this point, you could measure the boat's speed by measuring the distance between one wave crest and the next: The speed of a surface wave is strictly related to its length. To measure the relationship, in knots, of waves in water, yacht designers use the square root of the wave length multiplied by 1.34.

Three crests along the side of the boat indicate that it is traveling at about half of its maximum speed. As speed increases, the bow wave grows in height and length, pushing the midships wave aft. As the last fraction of a knot is reached, the stern wave is almost falling behind the hull—but it can't. As the stern wave pulls aft, the stern settles down into it. Drag increases because the hull is actually inclined upward against the slope of the bow wave. The hull is trapped.

The implication is that you should always have enough horsepower to climb over the bow wave and convert from a floating or displacement mode of support to a planing mode. That option is available to very light boats that can carry



In the illustrations above, B is Center of Buoyancy and G is Center of Gravity. Boats use either weight *(left),* or width *(right),* to remain upright against the forces of the wind. Hulls stabilized primarily with weight have a very small righting moment as they begin to heel, but it increases steadily as the boats heel farther over. Such boats are initially tender and ultimately stiff. As the wind increases, the ballasted hull will lean over, increasing its righting moment, but the unballasted hull has already achieved its maximum righting moment and will be very unstable.