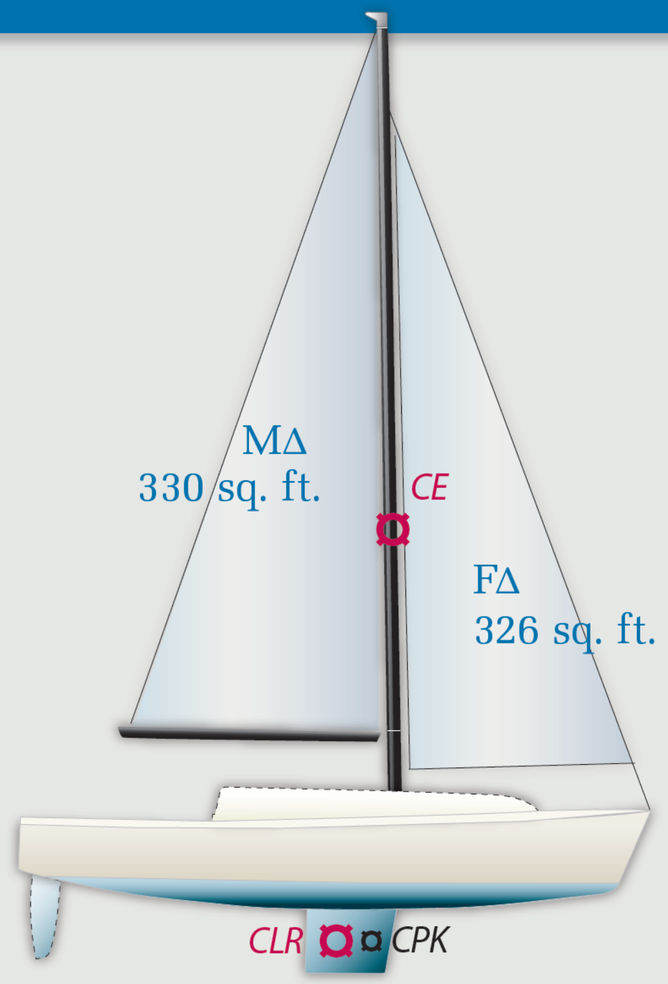
The Modern Hull and Helm Balance

A sharp shift in the boat's centerline can impact the keel's angle of attack.

THE *PS* GENERIC 37	
LOA	37′ 4″
LWL	33′ 2″
Beam	11′ 6″
Draft	5′ 4″
Displacement	13,700 lbs.
Ballast	4,850 lbs.
Sail area (SA)	656 sq. ft.
Ballast/Disp.	0.35
SA/D ratio	18.3
D/L ratio	166
Lead	6%



In keeping with contemporary trends, the canoe-body profile is shallow, with volume pushed outward for accommodations aft. This is the same boat as depicted on the illustration on page 9.

To illustrate what happens when a beamy boat with a modern underbody is heeled sharply in a gust, *PS* roughed out a "generic" 37-footer, within the size range where we've experienced some of the more "spirited" production sailboats. Our target specifications fit within the averages for contemporary designs.

The hull shape we came up with, when heeled 20 degrees (see Figure 2, at right), gave us an almost symmetrical waterline, quite similar in shape to the upright waterline but more slender. This augers well for performance, but—and this could have a significant effect on the boat's handling—its centerline was nearly 5 degrees offset from that of the upright waterline. This raises the question, "What direction is the boat going to sail?"

Normally, and when sailing to windward especially, a sailboat exhibits leeway—it slips slightly sideways at an angle to its steered course. This angle, also called the yaw angle, gives the keel the positive angle of attack it needs to generate lift; think of an airplane wing with its leading edge tilted slightly upward. Lift does reduce leeway, and it works in opposition to the sail force, which is trying to turn the boat toward the wind. The yaw angle at which a boat sails depends on the hull shape and the keel design, and increases with the angle of heel. The modern boats in the table on the facing page would be expected to have yaw angles between 4 and 6 degrees.

Following the line of least resistance, the *PS* 37, will likely attempt to move along the new centerline. This puts the keel at an angle of 5 degrees to this track and with a negative angle of attack. To create a positive angle of attack, the boat has to sail at a yaw angle greater than 5 degrees. In fact, to achieve the same effective yaw angle as when upright, its total yaw angle will be 9 to 11 degrees.

Interestingly, at only 10 degrees of heel, the flotation centerline was already offset by over 3 degrees, about the same amount that a generic hull of the early 1980s would exhibit when heeled 20 degrees.

This rotation of the *PS* 37's axis explains to some extent what happens when it encounters a gust of wind. It's been sailing along, balanced, with the keel generating lift to counter the turning force exerted by the sails, when suddenly the boat heels farther and the keel experiences a diminished angle of attack and can no longer generate lift.

In an extreme case, if a hull is extraordinarily distorted, the keel could have a negative angle of attack. In that situation, the water pressure from the boat's forward motion would be on the wrong side of the keel, working with the sail forces to turn the boat into the wind.

Figure 1: 0° Heel

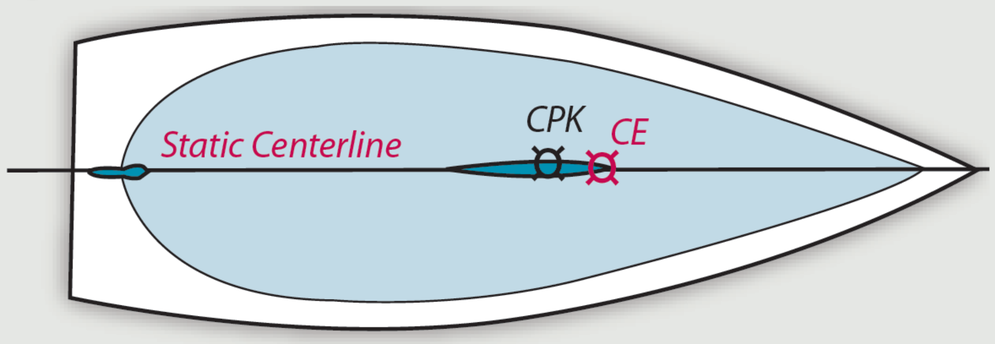
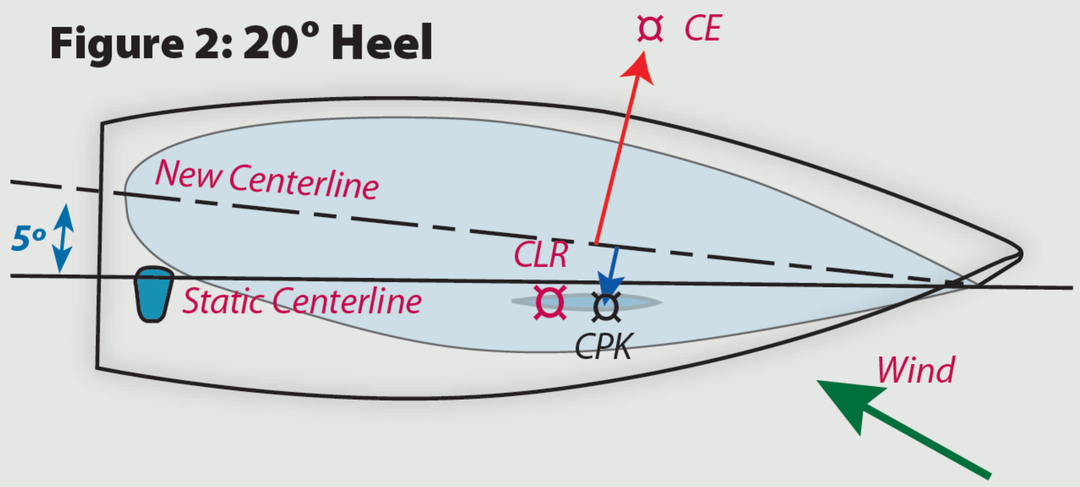


Figure 2: 20° Heel



Represented in blue, the shape of the immersed hull of the PS *37 remains symmetrical even when heeling 20 degrees. As the* PS *37 heels, its center of effort (CE) moves away from the centerline, and the new centerline is skewed 5 degrees.*

Compounding the situation, as the boat heels, the fuller aft sections become immersed. To maintain trim, the stern naturally lifts. On our test design, the boat achieved its new equilibrium with the stern rising nearly 6 inches and the bow remaining at its original immersion. The CLR did not move significantly forward, though on some designs it might, which could also affect the helm. That 6-inch elevation of the stern does, though, reduce the effective depth of the rudder, which can be a real concern on a shoal-draft boat. This change in trim happens to a degree in most hull shapes, but it's more pronounced in those with beamier aft sections.