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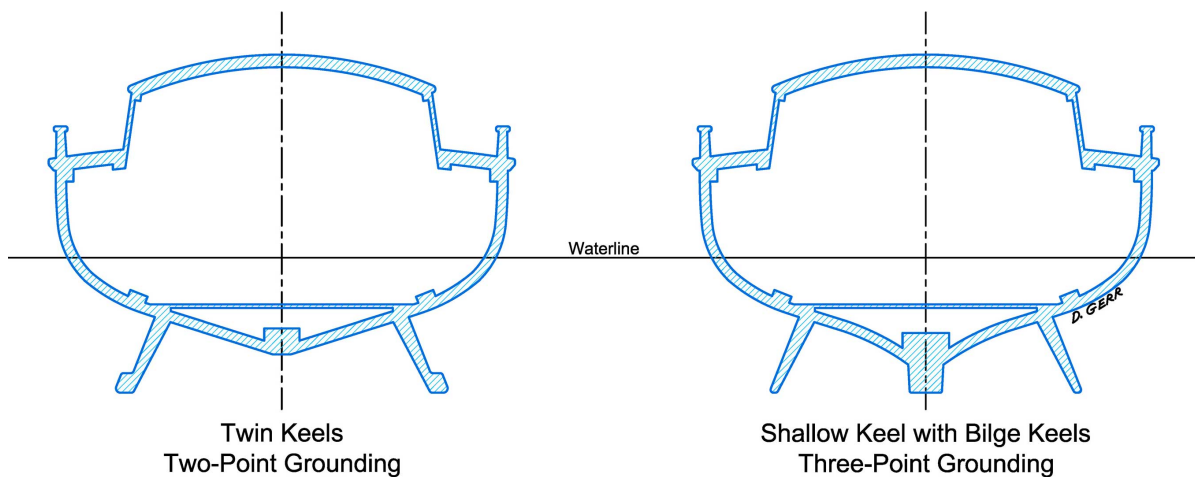
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Two Good? Notes on Twin Keels and Twin Rudders

By Dave Gerr, CEng FRINA, © 2012 Dave Gerr

Twin Keels

Want shoal draft and the ability to take ground upright, stable, and level? Twin keels are one good way of achieving this. Like everything in boat design, twin keels involve trade-offs, however. First there are two basic types of twin keels:



Twin-Keel Configurations

One is twin keels, port and starboard, with no external centerline keel at all and with the hull body at the centerline well above the bottom of the twin keels. Such twin keels each contain ballast like any standard fin keel, and often even have bulbs at their bottoms. The boat takes ground on two points—both keel bottoms. This configuration generally has the lowest wetted surface for the best performance.

The other form of twin keel is a hull with either a body as deep as the keels or with a shallow external centerline keel in addition to the twin keels. In this configuration, the ballast is in the hull or the centerline keel bottom and the twin keels are unballasted fins, essentially like non-retractable centerboards (of course strong enough to take ground). The other term for these is “bilge keels.” Bilge keels are also used on powerboats for roll reduction. In any case, this configuration gives three-point grounding—the centerline keel and the two bilge keels or twin keels. The three-point grounding provides the maximum strength on grounding, and the deeper hull usually corresponds to greater displacement and more interior cabin volume. The shallow keel with bilge keel approach is thus generally more suited to heavier cruisers.

In addition to taking ground upright and level, you can see that heeled draft is deeper than upright draft. That means that—if you take ground when sailing—you'll get quite a nice warning. There will be a sizable but relatively harmless thump as the lee keel grounds and the boat

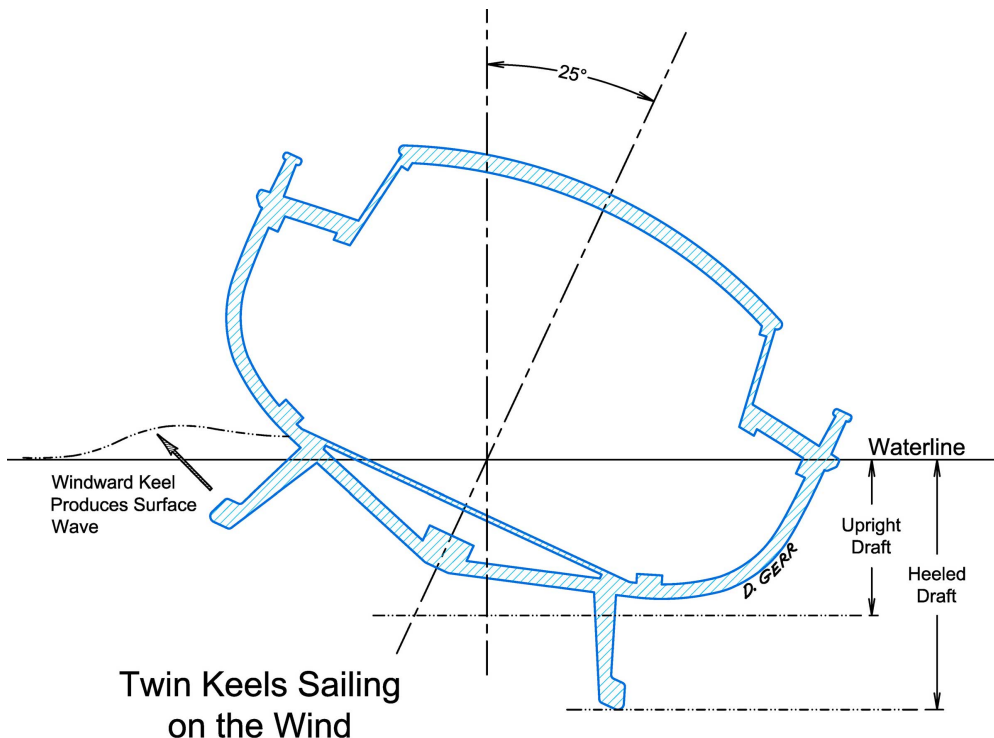
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bounces level. Fall off and the boat comes upright, reducing draft and sailing out of the shoals.



"Bilge keeled Konsort" by Nosyard

With regard to pure sailing, though, twin keels are always at least somewhat less efficient than a single fin keel. Why? When the boat is heeled and sailing upwind, only the lee keel is doing any useful work. The windward keel is just along for the ride. This means that each of the individual twin keels needs to have close to the same fin area as a single keel. (The one effective leeward keel or fin is somewhat more efficient because it's more nearly vertical than a single fin keel would be, but this effect is not large.) You can see right off that means that twin-keel boat have about twice the keel wetted surface and thus roughly twice the keel-surface drag as a comparably single-keel boat.



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There's more. When I was at the MacLear & Harris office, we did tank tests on twin keels vs single keels on the same hull. It was found, when heeled, the windward keel picked up a considerable surface wave, which is still more wasted energy—drag. You can reduce this effect with careful design, but it's always there to some degree.

Does this mean that twin keels are bad? *Absolutely, positively not!* I've designed several twin-keel boats and will continue to do so. For cruising grounds like Northern Europe and Nova Scotia, where tidal ranges can be 20 feet or more, the ability to take ground upright and level is well worth the trade-offs. Add the shoal draft and you can safely explore places a deep-draft, single-keel boat would never venture.

Twin Rudders

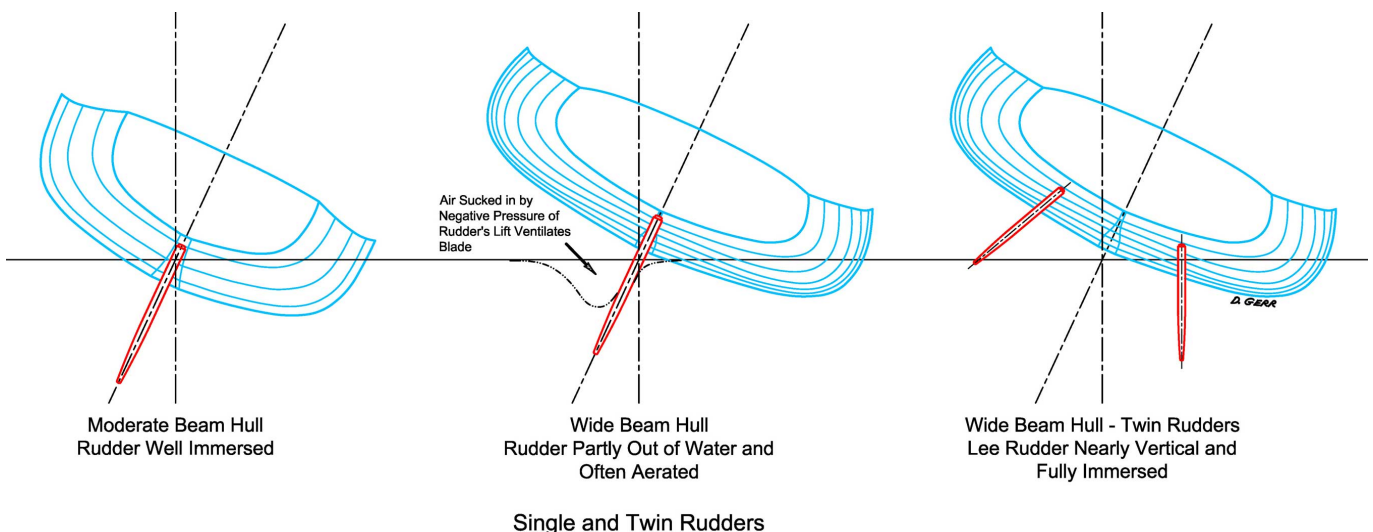
Thirty years ago a monohull sailboat with twin rudders was a rarity. Today, twin rudders are becoming more and more common. Why? Are two rudders better than one?

The real impetus behind twin rudders is hull form. It used to be that most boats had what would be considered "good" or "well balanced" proportions. In particular—with regard to the rudder—the stern of the boat wasn't too broad and flat in relation to the rest of the hull. And boats in general were not as wide and beamy as many vessels are today.

There are two reasons for this trend. One is that making a boat wide, beamy and shallow bodied, gives it great sail carrying power. The unlimited offshore monohulls, with canting keels and shifting ballast (BOC racers, unlimited 60s, Volvo racers, and so on), use exactly such hulls to get the absolute maximum in sail-carrying power for their length and displacement.

Almost the flip side of this is that some production builders have been making their boats beamier to work in more accommodations at the same length. They'll carry the extra beam far aft to the transom, to add even more volume.

In either case, there's a rudder problem. A single rudder on a moderate-beam hull, with a moderate transom, will be well immersed even when the boat is sailing hard and rail down. On a wide beamy boat (particularly with a wide transom) a single, centerline rudder will lift well out of the water. This is because the hull "rolls out" as the boat heels. You can see this on the drawings. Further—with the hull rolled out—the rudder will be lifted high enough so there's no hull in the water directly ahead of it.



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In fact, this lifting the rudder out is made worse on a wide-stern boat. Not only does the hull lift out (roll out) sideways, but the narrow bow—boats come to point up there— will depress as the stern lifts. That's because there's so little buoyancy in the narrow bow compared to the wide stern. This will more than double the usual "roll-out" effect at the stern on such a wide hull as opposed to that experienced on a hull of moderate proportions—moderate beam and a moderate transom.

With the single rudder lifted so high, it is also subject to ventilation. Indeed, air from the windward side is almost always sucked down onto the rudder blade. There will be a visible trough at the surface on the windward side, even extending a bit to the lee side of the rudder. You can see this in the drawing. With so much rudder aerated, steering response will be dramatically reduced and unpredictable.

Twin rudders correct this problem and return reliable steering to wide, shallow hulls. You can see that the lee rudder is nearly vertical and well immersed. Further—as with the single rudder on a moderate hull—there's lots of boat directly ahead of the lee rudder to help minimize aeration. This is the reason to have twin rudders on monohulls, and really the only reason. Twin rudders will have somewhat more wetted surface and so more drag, and—in the wrong conditions—there can be pretty intense pounding under the bottom side of the windward rudder.

There isn't one firm answer for twin-rudder area versus single-rudder area. Theory says the lee rudder is doing all the work and the windward rudder not much; but that's upwind. Downwind, both rudders are working most of the time. In extreme cases, though, it might be just one, rather than none with a single rudder.



Volvo Ocean Racer with twin rudders.

If you figure the average maximum heel angle is 30 degrees, the lee rudder will be close to vertical at that angle while a single centerline rudder would be at 30 degrees. Accordingly, the lee rudder can be reduced to the area that the centerline rudder would project horizontally to the

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water. So the area of the one lee rudder could be cosine 30 times usual single rudder area. That's 86%. But then you particularly need rudder area off the wind, but you'd have two rudders (most of the time) and that would be 1.72 time the total rudder area—too much. The usual compromise is about 1.3 to 1.4 times the area of a single rudder for both rudders combined. This makes each rudder profile area about 66% of a normal, single rudder for the same boat.

Another conundrum is how much of the combined twin-rudder area to use when determining the lateral plane of the underbody. In my office, we figure with both rudders full area and with one rudders full area and then plot both and see how the lead works out relative to the rig for proper helm balance.