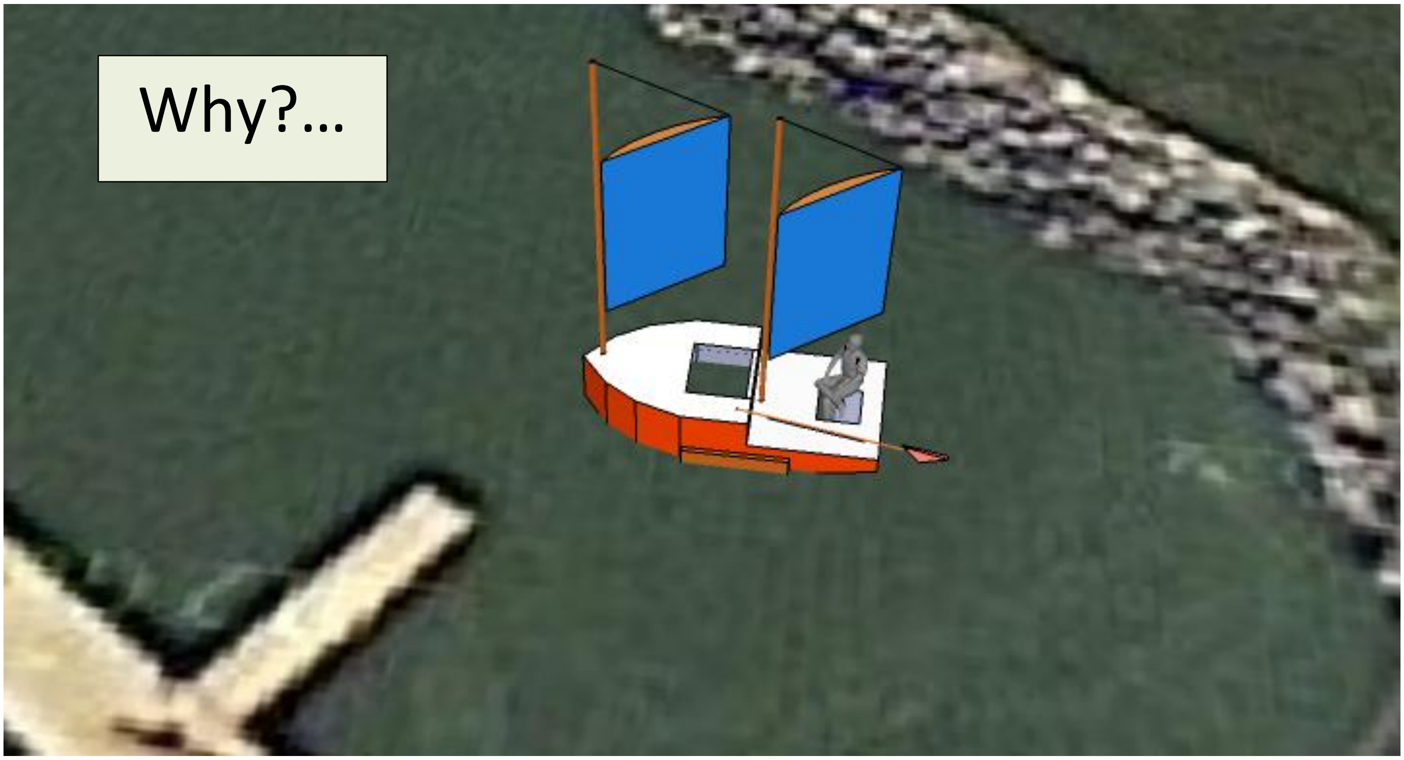

I don't know where to publish this. The physics is correct; I am certain. But the engineering is speculative, and some aspects of the proposed use of this boat verge on pure fantasy.

Why build a "plate boat" instead of a conventional "bent wood" boat?

All published designs for home-built plywood sailboats are for what we at WSU-Lake call **"bent-wood"** boats: the hulls are shaped by bending the wood (usually without steam). To put it bluntly, we chose not to investigate these "bent-wood" boats because all engineering and scientific questions associated with them seemed to be either (1) already understood, (2) not much fun to investigate, or (3) beyond our ability to tackle. Going off the beaten path is a tried and true way for professors to publish (albeit usually without accomplishing anything significant). We refer to our boats as **plate-boats** because they are constructed from thick flat plates of exterior grade plywood, using polyurethane glue from a local home improvement store. Though we have never done this, these plates could be framed and glued up separately one piece at a time to minimize the number of required clamps. Subsequent assembly into an entire boat could then occur outside, in one day.

You could build the components in a small dorm room that you share with a roommate, but that is probably a bad idea. I think you could cross an ocean in such a boat, but that is also a bad idea. But as people sail pass you in faster boats as you ply safer waters, you will smugly know that your plate-wood boat is probably not only the cheapest, but also the most seaworthy boat in sight.

Why thick wood?

A primary consideration is cost – a layer of thick exterior grade plywood does not require a fiberglass/epoxy coating. Construction of a plate boat is simple and uses very little glue. In contrast to stitchn-glue, there is no reason to glue up the entire hull at once. Though only somewhat cheaper than epoxy, polyurethane glue can offer significant savings because one generally mixes more epoxy than is used, and because most people will want to practice before they use epoxy. My only rules for polyurethane glue are: (1) use lots of it, and (2) do it quickly before it sets, (3) don't touch it for 24 hours while it sets, and (4) don't do it on wet or dirty wood. I am not sure I trust polyurethane glue below the waterline, but all the joints can be backed up with stainless steel bolts.

Why two sails?

A boat this size should probably have only one sail; and the choice of two was a forced compromise. The cheapest sailcloth is blue polytarp, which is too flimsy to serve as proper sailcloth. As explained in the appendix, the use of two small sails alleviates the problem, somewhat. The use of two masts also permits a simple reefing system because a storm jib can be hoisted between the two masts after the two sails are doused. A plate boat can have extremely wide beam, so stability while performing these maneuvers should not be a problem.

Why the ugly rectangular sails?

Polytarp sails won't last for even one sailing season, if it is sufficiently glorious. It is important that a polytarp sail can be replaced mid passage, and that sailing seasons are not interrupted or do not begin with complicated sail-making efforts. The tarp comes square, so we should use it square. The figure above depicts two luan plywood (3/16 in.) panels above and below each sail that I believe will give the sails nice camber, though I lack a wind tunnel or the computational resources to verify this.

For regattas, use brown polytarp, and experiment with topsails, although I doubt that topsails will much improve light air performance. For really serious regatta work, hoist your storm jib as the fifth sail. As they say,

"Less is more… unless more is more."

Where is the outboard motor?

An outboard motor would be nice, but the sculling oar should provide about ¼ horsepower, if I can trust what I read on the internet. I am convinced this oar could be integrated into a self-steering system.

What about rogue waves and the hole he is sticking his feet into?

The boat shown above is configured for shoal waters on a sheltered lake. In more difficult seas, the aft port is sealed shut and you sit on top of the deck. Our minimalistic offshore pocket cruiser has no cockpit! In deep water, two ballasted and very deep sideboards are used for stability. This flexibility allows one to sail "deep water" to a distant port carrying two unballasted shallow sideboards on deck. When you arrive, leave the ballasted deep sideboards in the custody of curious onlookers as you gunkhole amongst the natives.

How big is the boat?

The one shown above is 14x6 feet. It could have been 16 feet long, but the absence of a motor and flimsy sailcloth renders anything much larger unsuitable. And, there is no reason to build a long thin boat using plate-wood methods. By keeping the length under 14 feet, we avoid some of the Ohio state registration. But make no mistake about it, this will be a slow, heavy boat designed for serious offshore ocean cruising.

Why so short?

Our plate boat concept created the classic "solution looking for a problem". The building of *Malaspina* (14x4 ft, 190 lb) taught me that the plate-wood boat was not yet a useful concept because the savings from glue and fiberglass costs were overwhelmed by other costs. I needed a reason to build plate-wood boats, and the only unfilled niche I could find is the very small micro cruiser, like Bolger's *Micro* or Michalak's *Blobster*. Such boats are not easy to build strong because one must either bends thick wood, or laminate two thin layers at great cost. The central 420 pound keel of the Micro must be cast as one solid piece, while my plate boat divides the weight between two side boards. It is essential to match an ultra-low cost hull with ultra-low cost sails, inexpensive rigging, and of course, no motor. Do it any other way and all you have is a cheap hull that requires expensive "attachments".

In summary, I did not deliberately intend to design a microcruiser, but arrived at it via the following sequence: (1) We can make a strong heavy hull at minimal cost. (2) The advantage of low cost is not expressed unless all components of the boat are correspondingly cheap. (3) The only cheap sailcloth is polytarp. (4) As explained in the appendix using dimensional analysis, polytarp sails should be as small as possible.

Small is cheap. Furthermore, since there are costs and consequences to spending your allocated funds at the beginning of a project, I consider the option to postpone the use of deep-water weighted sideboards and proper sails to be important cost saving features.

What about the harsh corners?

A 14 ft boat near hull speed at 5.8 mph has the same Reynolds number as a car going through air at 58 mph. If a boxy shape is good enough for truck drivers and owners of minivans, it should be good enough for cruising. Except for a nasty lee helm that we hope to fix by moving the mast, our *Malaspina* seems to have acceptable windward performance, though handicap races with members of the local boat club should be performed to establish this.

Appendix: Why small boats can have harsh corners and use polytarp sails

Dimensional analysis is an educated guess based on the "units" (or "dimensions") used in physical models. The underlying principle is that if one can write down the equations of motion, one can scale them by changing variables. The dimensions (length, time, mass, force) just serve to help keep track of this scaling. On the Reynolds scaling, I am ignoring two important considerations: (1) wake drag, and (2) the fact that turbulent drag MIGHT be more critical for a sailboat than for a truck on the highway because sailboats are attempting to sail against the wind. The angle through which a sailboat must tack cannot be near 180 degrees, for obvious reasons. As discussed below, the proper scaling of required sailcloth strength is not clear without a better understanding of how polytarp fails.

Harsh Corners: The hull speed of a 14 ft boat is $(gL/6.28)^{1/2}$ = 5.8 miles/hour, where g is the acceleration of gravity. Reynolds number is, $Re = LV/k$, where L is length, V is speed, and k is kinematic viscosity. For convenience we consider a temperature of 47F for both air and water, where the kinematic viscosity of air is 10 times that of water. So our 14ft boat at hull speed faces the same kind of turbulence as a car moving at 58 miles per hour. The actual physics is different, because the boat is only partially submerged, and because wake-driven drag is not being considered. But the fact than many vans and trucks are not shaped like ship hulls suggests that the impact of rounded corners is minimal.

Polytarp Sails: Let us tentatively denote the strength of sailcloth by, S, defined is the force per unit length required to rupture the sail: $S=F/L$, where F is force and L is a characteristic length. This force is caused by the wind, and therefore associated with pressure, P, via a term that contains, $P = mV^2$, where m is the mass density of air, and V is wind speed. But pressure is force per unit area, so that $P = F/L^2$. Solve for S, and conclude that the required sailcloth strength is proportional to: $S = mV^2L$. Since S is small for polytarp, people should restrict the use of polytarp to low wind speed and small boats. Note that S scales as the square of wind speed, but only as the square root of sail area. Doubling the wind speed quadruples the required sailcloth strength. To compensate for this doubling of wind speed, you need to cut the length of your boat by four. That is a drastic change that converts a 32-ft livaboard into an 8-ft one-person dinghy! If polytarp has a place in offshore sailing, it can only be on wee little boats.

The aforementioned scaling is pessimistic for those wishing to advocate polytarp for small sails. If the sail already has a tear, then strength is characterized by the force acting on the point of tear. Now we have a more optimistic scaling law, with S' = F as the fundamental parameter. Since $S' = mV^2L^2$, doubling of wind speed is fully compensated by just halving the length of the boat.

Of course, experienced sailors already know polytarp sails cannot take strong winds, and that polytarp is dubious even on small boats. So why calculate this fact? I once heard or read something concerning the development of the steam engine that helped trigger the industrial revolution:

"The steam engine did more thermodynamics than thermodynamics did for the steam engine."