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On Dogs and Ferries

By Christopher D. Barry, P.E.

Perhaps the best and certainly the oldest reminder of the advantages of design for environment and mission is the diversity of dog breeds. The Nova Scotia Duck Tolling Retriever, for example, is not only suited for the Canadian Maritime climate, but also is specifically adapted for Nova Scotia hunting practices and waterfowl species: It "dances" along the shoreline to entice (toll) curious ducks into the hunter's range and is small enough to work from a canoe.

My wife and I chose a "Toller" as a companion animal because they have the genial disposition and the intelligence of Labs and Goldens, and a playful nature due to their "tolling" behavior, but are not so large - they are the smallest of the retrievers. However, we had to accept that the "Nova Scotia" part gives a thick double coat and furred feet, which means lots of grooming. Dogs aren't available other than "off the shelf" or maybe "proven parent" (literally), so when a dog is used outside it's original intended environment and mission, there are compromises. You can't get a dog custom designed to your exact wishes.

What does this have to do with ferries? (Or even yachts for that matter?)

One of my great frustrations as a naval architect is that so many boat owners insist on "off the shelf" designs or "proven parent", (or more often "proven parent, but"). In some cases, it is even required by law. This is understandable, but wrong. People are used to buying things like a cars or computers by going to the store and selecting one "off the shelf". Such products are made in huge numbers so it is feasible to spend lots of money on machinery and tooling to reduce the cost of making them through mass production techniques like automation – the tooling for a new model SUV is typically over a billion dollars, but the factory builds one every two minutes.

Boats, especially commercial boats, are not made in large numbers, though, and there aren't too many "Ferries 'R Us" outlets. Last year WorkBoat magazine's annual survey of new construction listed a total of 442 self-propelled commercial and military boats and small ships built by 45 different shipyards, so each yard only averaged ten boats. Even in any one shipyard, this comprises several different designs, so it isn't common to see more than three boats built to any one design. (One of the few large orders that year was for remote controlled target boats - for some reason they are needed in large numbers.)

A well-proven method of estimating the cost reduction in shipbuilding for follow-on vessels suggests that after about a twenty percent reduction from the first to the second, (which covers engineering, initial setup, bid preparation and so on), the cost drops by four percent each time production doubles, and this only applies to certain categories of costs (metal, for example, doesn't get any cheaper once you have bought about half a boat's worth). Thus for even thirty identical vessels, the average cost for the first two dropped to 89% of the first, but the average for 30 is still 75% of the cost for the first one. Even this doesn't work out to a lot of savings in the overall picture. The first cost of the ship itself is a relatively small part of the lifetime operating expenses (just like a dog, oddly enough), because this cost is spread over the entire life of the vessel. At a recent workshop on ferry economics, it was pointed out that three employees added as much expense as $1.5 million of vessel first cost.

The obvious conclusion from this is that it doesn't take much optimizing to beat any economics of mass production. A relatively small savings in fuel, for example, covers a lot of first cost - saving one gallon per hour (probably less than 2%) is worth nearly $100,000 in first costs. Since the key to optimizing is designing for the specific service and environment, an "off-the-shelf" boat is probably a false economy. For example, a very important aspect of optimization is speed. There are differences between a twenty knot hull and a twenty-five knot hull that make a difference in power and fuel, and a boat designed for twenty-five knots will use more fuel at twenty knots than one designed for twenty knots in the first place.

This is especially the case for commercial craft that have to be meet regulations. Various regulations can make a big difference in operating costs. Each country has some peculiarities that provide hard restrictions on the design. By exceeding a certain parameter a boat may change from one class of regulation to another, resulting in a major change. US rules, for example, have a break at 100 gross tons admeasurement from a “small passenger vessel”, essentially a boat, to a large one, essentially a ship. Admeasured tonnage is the internal space of the vessel with certain peculiar exceptions and exemptions (under the unique US system) that can be exploited by a knowledgeable designer. If you are reading this on a ferry, look around for a panel held on by strange looking bolts, probably at the rear of the vessel. It may be marked "tonnage door – keep clear". This door exempts the volume it encloses and as far as the rules are concerned you are sitting in a "temporary covered space", none of which counts for tonnage. If you could get inside the hull, you would find some special very large frames. The space outboard of the inner face of these frames doesn't count either. Even the way the stern of some ferries slants forward is often part of a scheme to reduce admeasured tonnage; the door trick works best if the deck above the door is not the longest. Tonnage dictates the number of crew, their licenses and many other aspects of operation and construction cost, so most ferries are very close to 99.9 gross tons (find the certificate of inspection – it’s posted somewhere in the main passenger area). A design intended for some other country will have been designed to another set of rules and will have to be modified to achieve the savings from these peculiarities (and to eliminate weird things to meet the regulations it was designed to) and this can have other consequences that move the design off an optimum.

Owners also fear that a new design is somehow unproven and high risk. This is only true if the whole concept is entirely new, but like new dog breeds, most saltations in fast craft design are hybrids of one sort or another. They thus can be analyzed pretty reliably from data on the pieces that were combined. A friend and I have developed a new design concept for a high-speed hybrid planing hull that uses aft mounted hydrofoils. (Some people may remember a sort of dumpster with wings undergoing sea trials on the southern San Francisco waterfront a few years ago.) This concept is sufficiently new that I would be reluctant to advise an owner to adopt it without some significant trials and research, but it was still reasonably predictable from combining hydrofoil data and planing craft data. It is also important to realize that there isn't much new under the sun as regards ship design - after all, we naval architects think of either Noah or God as the first ship designer (too bad the discussions about contract change orders have been lost). In the case of our radical design concept, when we sought a patent, we found that it had been patented over fifty years ago, and similar hybrid hydrofoils may have seen service in the German Navy in World War II.

The design of just about any monohull or catamaran is pretty routine, especially with current techniques of computer aided engineering. I have to reluctantly admit that naval architects are just another flavor of engineer, not some sort of magical maritime Harry Potter, and that ship design is just routine engineering. (I always wonder if people who want an off-the-shelf boat also want an off-the-shelf building, freeway or bridge.)

Most designers use an integrated design system that allows exact definition of the hull shape, which is then transferred to structural, hydrostatics and hydrodynamic analysis software to verify safety and performance. Modern structural software can then automatically optimize hull structure for weight or cost (which in turn depends on the shipyard's practices) as well as ensuring freedom from failure. Finally, the ultimate (and usual) proof is model tests. A scale model is run in an instrumented basin. These tests can be done with or without waves, and can model steering and waves and wind. It is expensive - typically a good test program might cost $50,000 or more, but that is a fraction of the cost of the boat, and less than the cost of that gallon of fuel per hour. It is worth noting that recent tests I ordered for a modification to an existing patrol craft produce enough fuel savings to pay off the tests and the modification in less than three years.

Actually, a proven design is often higher risk than a new one, because it is usually "proven design, but". An owner likes a boat already in service with some other owner and wants one just like it, with just a "few minor changes". The changes usually add weight, adversely impacting speed and stability, or they can have other unforeseen consequences, but the design is "proven", so no one checks it out carefully. One of my favorites was an owner who needed a large hydraulic winch (among other things) added to the aft deck of a workboat. The parent design didn't have enough room to put the new power pack in the equipment space aft of the living quarters, so it had to go in the engine room forward of the living quarters. The high-pressure hydraulic lines ran through the overhead of the captain’s cabin, and of course, they constantly leaked. Weight additions especially are a very high risk for higher speed craft, which depend on dynamic lift – fast craft are weight sensitive, and it is easy to add just a little bit too much weight so the overloaded hull loses speed all out of proportion to the added weight.

The computer has also reduced the cost of specialized design and construction. The same model developed for analysis is transferred to a detailed structural and equipment design package, which provides all sort of automatic tools for doing the routine development of the structure, piping and other details. The result is a three-dimensional "product model". Before modern drafting was invented, an "Admiralty Model", an actual scale model, was used to develop the wooden ships for that period's "Iron Men". We have gone full circle and now "Silicon Person" has replaced paper drawings with an electronic 3D scale Admiralty model. However, the new model "talks" directly to computer controlled equipment that cuts metal (or foam for fiberglass molds) automatically. The model also provides data to material and work control software and does all the various e-business stuff (ship design and construction collaboration over the Internet is now routine). There are lots of other improvements, mostly enabled by computers, that have radically improved productivity as well, and any reader not yet bored can find out more in *Journal of Ship Production*, *Transactions* of the Society of Naval Architects and Marine Engineers or *Marine Technology*. However, this all means that the cost of a boat to a new design is much lower than it used to be. One shipyard, which was already using computer steel cutting, reduced construction labor costs by 20% by adopting a product model and other improvements on the first 160' offshore supply vessel (OSV) they used it for - without any increase in design costs.

The bottom line is that if an existing vessel or design provides exactly what you want, fine, but otherwise, don't compromise and don't be afraid to get just what you want. It won't be very expensive or risky in the short run and will be well worth it in the long run.

Readers interested in more information on modern ship production can go to http://www.sname.org or http://www.usashipbuilding.com. A typical suite of ship design software can be seen at http://proteusengineering.com. Those interested in Nova Scotia Duck Tolling Retrievers can go to http://www.nsdtr-usa.com or http://toller1.com

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