Ferries may seem to most people to be a mature technology, with a few well-known areas for innovation. Generally, these include designs for higher service speeds, lower operating costs, or reduced environmental impact. Our purpose here, however, is to explore a much broader range of opportunities for innovation. My thesis is that innovative vessel designs may be agents for social change, tools for economic development, and opportunities for technological progress.

Historically, innovation in ship design has been a matter of applying emerging technologies to mission needs. Thus, the march from sail to steam was an application to the mission need of reliable movement, and the march from timber to steel included a desire for reliability of structure. It may be argued that, in the marine industries, it is requirement pull that leads to innovation, and it is rare for technology push to be successful. We make changes because they advance some goal, and we are rather conservative as we ask “what’s in it for me, the mariner?”

Considering future opportunities for innovation in ferries, it therefore seems to me to be appropriate to look at mission needs and see if there are new technologies that appear to offer new levels of performance in some way. I will start with prosaic and well-known needs, but I will quickly move into areas that many will dispute calling “needs” at all—and this dispute, or rather conversation, is part of my purpose here.

A wise naval architect once summarized ferry design requirements as “Keep the water out of the people, keep the people out of the water, and keep the mossy side down.” This forms the starting point for our discussion of needs.

“Keep the water out of the people” and “keep the mossy side down” both speak to the need for structural integrity. Wooden ships are composed of myriad separate parts, all...
Tachek, a 49 m car and passenger ferry operated by British Columbia Ferry Services, Inc., underwent a major refit in 2013 that included installation of an innovative hybrid battery system. Photo courtesy British Columbia Ferry Services, Inc.

trying to move separately, but each pinned to its neighbor at discrete points. In fact, as an instructor, it is tempting to suggest that a wooden structure could be modeled as a sophomore-year linkage problem, but one with a thousand parts.

Riveted iron ships replace the thousand parts of the wooden linkage with a hundred parts of iron, and pin these parts together much more frequently. Welded steel construction fuses the parts so that, finally, the structure can be considered to be a single whole.

But a dugout canoe is a single whole too, and we have consciously chosen to move away from that. This is because we wanted to use our structural material more sparingly. As a boy, I owned a dugout canoe, and it was a beast, having an inch thick Mahogany shell everywhere in its nine-foot length. A modern canoe would have a millimeters-thick shell, and some frames relatively widely spaced. We gained efficiency in material use (and a weight reduction), but we lost the advantage of monocoque structure.

Design evolution

So how might structural design evolve? I can visualize two possibilities that could grow from the evolution of 3D printing. First, the mobility of the 3D print head means that structural members need not be patterned on straight lines, but instead could be aligned more precisely with the loads. This is already fashionable in sailmaking and in aviation structure. Look at the photos of the sail and the aviation manufacturing equipment, and contrast these with the rectangular grid that is ubiquitous in shipbuilding. Optimizing the placement of the material means that all of the material is fully utilized. Full utilization translates directly into weight savings, payload increase, and economic gain. The benefits appear to be one-for-one, at the expense merely of employing the automated construction.

Second in my list is an innovation I haven’t yet seen: the expansion into a third dimension of this idea of material placement, in the form of knitted structures. As engineers, we are all familiar with the principle of the I-beam, where there is relatively little material near the neutral axis, and more material at the flanges where it can do some good. This type of structure is found in many other variations as well. In
fact, sandwich structure is a realization of this same principle, with strong face skins separated by a core material that acts like the web of an I-beam.

Today’s sandwiches are made by joining disparate materials, such as polymer foam with fiber reinforced plastic (for example, fiberglass) skins. However, nature builds sandwiches by simply varying the density of the same material, as it progresses from dense skin, through porous core, and back to dense skin. Bone is an example of this.

Is it difficult to imagine a bone-like structure created using 3D printing technology to lay down a solid skin, followed by a knitted or sponge-like core mass, finally topped by another solid skin? In fact, some of today’s home hobbyist 3D printing machines work rather like hot glue guns mounted on an X-Y carriage. Most people who have used hot glue guns at home also have experienced inadvertently making cobwebs of glue filaments—usually winding up with a mess. What I am imagining in the shipbuilding case is the creation of intentional “birds nests” of filaments, and employing these in the role of low-density core material in a sandwich structure.

Moving from structure, let’s consider the relatively simple issue of keeping the mossy side down. It is intriguing to realize how simplistic our understanding of ship stability really is. The concept of the metacenter, invented in 1746, is still our primary tool for evaluating stability. And the metacenter is a useful model of the static problem; I plan to continue teaching it. But let’s also realize that many stability problems of the 21st century are actually dynamic problems, due to shifting water on deck, inertia due to rolling, transient wave impulses, and so forth. This is an area where we may expect the computer revolution to produce an innovation in the drawing office, where stability analyses may become increasingly complex and reflective of the real complexity of the ship’s situation—replacing a good 18th century model with a more comprehensive and realistic one.

We’re only beginning to see the intrusion of full dynamic modeling into the design process. Under the name of “fluid/structure interaction,” we’re seeing the emergence of a new analytical capability. This capability marries structural finite element analysis with computational fluid dynamics. It also marries the mathematical complexity of these tools too, requiring substantial amounts of computer horsepower.

But I believe that this new analysis capability has interesting possibilities for ship design improvement. Specifically, we may be able to replace simplistic deterministic beam wind cases or passenger crowding models with models that are actually representative of conditions that can reasonably be encountered onboard.

Speaking of the mossy side of the ship, I wonder when the nano-tech and bioengineering communities are going to come together to create a non-pollution bottom coating that achieves anti-fouling properties by simply being nasty tasting to marine organisms.

Propulsion possibilities

Let me now propel my 3D-printed ship. The propulsion problem will continue to be one of achieving thrust through minimum consumption of resources. But our definition of resources is evolving. Heretofore, and throughout my career, the definition of resource began and ended at the ship’s fuel tank, and the requirement to consume less resources meant simply to burn less fuel. But now we recognize that there are resources upstream that are being used to provide us with the fuel, and that there may be onboard technologies that are less efficient on the micro scale, but are actually more efficient on a global scale. I’ll sketch this idea further.

Consider the idea of battery-powered shipping. Using current battery technology, this is only marginally viable for a short route, and even in that case the weight of batteries carried would be many times the weight of fuel replaced. Why would one even consider such an option?

The answer might lie in the location where the fuel is burned. Imagine a river barge train, with an electric push boat, where the first barge in the train is the “battery barge.” (The image that comes to my mind is something like the coal tender behind a steam locomotive.) This battery barge provides the energy to drive the train from port A to port B, at which point it is dropped off and a new fully-charged battery barge joins the train. The dead barge is then recharged pierside at port B.

This scheme still requires fuel to be burned to recharge the batteries. And, because of the weight and conversion efficiencies, it requires more fuel than if it were simply burned on the push boat. But it enables the use of fuels and economies of scale that are not possible on the push boat. It enables the fuel to be burned hundreds of miles away from the river, at the power plant. It allows for the use of hydroelectric power to propel the barge train. It even enables the barge train to be driven by acres upon acres of solar panels, in a manner that would be totally infeasible upon the river’s surface.
Another area of particular interest to me lies outside a discussion of ferries, and that’s remotely operated shipping. It is several years since I published an article suggesting that “North Pacific tours for sailors” is a product that is in nobody’s interest—neither the shipowner nor the sailor—and that both parties would be well served by operating the ships remotely; for example, from a nicely climate-controlled office building that is not climbing up and down seven-meter seas.

The point of the run

But while that image may not be applicable to a passenger vessel, as I do want a crew onboard if I am onboard, it opens the door to another new way of thinking: What is the point of the ferry run? Historically, the purpose of a ferry run is to get from A to B. We have seen some attempts to make the ferry a destination in itself, with the greatest success of this type of thinking being the proliferation of duty-free sales opportunities on European ferries. But even absent a tax novelty such as that, there exist cases in which the simple act of transport may become secondary, or if not secondary, may share primacy with some other goal.

Consider the case mentioned by Gary Dunzelman and Rik van Hemmen in “Ferry Revival” (beginning on page 68 in this issue). Rik is organizing a trip for a class reunion, which will split time between New Jersey and Newport, Rhode Island, and has chosen a ferry to move the attendees between these two cities. He describes this as “a weird conundrum from a sustainability point of view. This is a big ferry and will burn an impressive amount of fuel... much more than buses between the two points and probably more than airplanes and buses between the two points. Time-wise, it will be exactly break even. It will take five hours in any of the modes. Buses will be cheaper, and planes will be more expensive, but when regarding the whole trip, the ferry is a no-brainer.

“This is what happens with the ferry. It starts with a short school bus ride between New Jersey hotel and the ferry. The boat trip then takes us under the Verrazano Bridge, past the Statue of Liberty, past Manhattan, past the United Nations into the Long Island Sound, right to the berth in Newport next to the hotel.

“Meanwhile aboard, we can have lectures, a narrated tour of the Manhattan sights, drink ourselves silly, eat, sit on the upper deck in the sun or whatever else one can do on a ferry. On top of that, we can drop the need for a circle line tour of Manhattan (with associated buses and bridge or tunnel crossings), and the rental of a conference room for a lecture with associated bus transport.
“Bottom line, bus or plane transport is a piece taken out of your life and has no further benefit except point-to-point-transportation. The ferry trip is an enhancement to your life.”

This realization is an interesting one, and I can’t predict how common it will be, but it does provoke thought. Perhaps it is my age, but having flown enough miles, the thrill of air travel is gone. I would happily take a leisurely boat ride if that meant I had a restaurant and a pub at hand.

In fact, let’s consider the case of car-carrying ferries. Certainly we recognize that the ideal ferry route will dovetail perfectly into the land transit network, such that there is no need to bring your car onto the boat with you. But people bring their cars anyway, and I wonder how often this is because they are planning on some other duty that they have to perform—pick up the dry cleaning, swing by the post office, and so forth.

Given that I have those duties to perform, and given that I am “trapped” on the ferry for an hour, can I combine these and make lemonade? What if those services were located onboard? A dry cleaning service need consist of nothing more than a bellman’s cart. A post office can be as small as a mail truck. And many a 60-minute commuter would love to be working his stair machine rather than staring at the back of the passenger in front of him.

Take it a step further and imagine a ferry as a sort of mobile strip mall, complete with UPS store, nail salon, and take-out restaurant for home-bound commuters. Now we’re talking about ferries as engines of social change. We’re describing an infrastructure scheme that helps move toward a car-free commute. What other contributions can ferries make as engines of change?

Ferries are portable infrastructure. Because a ferry is inherently repositionable, it offers a sort of halfway step before committing to building a bridge. We can place a ferry on the route while the tax base grows, letting wealth accumulate until we can afford to commit to a bigger (and more efficient) bridge. By the time this has occurred, some neighboring area will have risen to “stage ‘A’” in its economic growth, so off goes the ferry to this new location to aid in their development. While it is laudable that some states fund their ferries on an equal basis as their roadways, it is blindness to think that a ferry route must remain a ferry route in perpetuity. Thinking of a ferry as a ten-year temporary measure may have merit.

On the other hand, it may be argued that the ferry is promoting sprawl, because it permits the distribution of population into outlying areas. My reply is that, while this may be true, the size of the investment that a ferry (and terminals, and parking, and so forth) represents is so large that it will necessarily be a public investment, and will therefore be made via a conscious process. It’s hard to imagine some sort of “one farmstead at a time” sprawl taking place that has a ferry as its link. The act of putting a ferry in place will, instead, serve to re-concentrate a population that is already sprawling, by defining the ferry terminal as a new urban hub, in the most literal sense.

I’m confident that there are many more innovations possible. I have only attempted to sketch a few here, and those few were purposely selected to be extreme. But by considering the extreme, I hope that I’ve shown that innovation can mean much more than simply faster or cheaper, and that the opportunity for creativity in ferry design is as robust now as it has ever been. MT

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Fiber placement is the aviation structure practice of orienting material to the loads. Photo courtesy University of Stuttgart.