A Case for Complexity

How good design, conscientious installation, and consistent maintenance can assure reliability of the most sophisticated onboard systems.

Text and photographs by Steve D'Antonio

This 68' (20.7m) Nordhavn is an example of a complex boat that can offer comfort and reliability even in remote locations. As professional designers and builders we should resist the temptation to simplify under the guise of improving dependability and lowering cost.

I've noticed a recent trend among industry journalists and pundits to embrace the idea of simplicity in new boat design and construction. Their stated thinking is that boats are getting too complex and expensive, scaring away potential buyers and turning off existing owners. Their proposed remedy is to simplify designs and onboard systems.

While I applaud any approach that makes boats and boating more affordable, economical, and efficient, I don't see simplicity, especially in marine systems, as a panacea for what ails boatbuilding in 2012. As a response to real industry challenges, the call to simplify offers only the appearance of addressing the problems of complexity, unreliability, and high expense faced by many boat owners, builders, and service yards. It delivers little in the way of practical solutions to meet the increasingly sophisticated expectations of boat owners. In pursuing solutions to some of the widespread shortcomings in reliability and quality, our industry should take care not to mistake simplicity for reliability, or accept the concept that complexity and reliability are mutually exclusive qualities afloat.

Let's look at a case in point.

A few months ago, I inspected a recently completed cruising vessel. My work with the boat's owner began

The single propulsion engine has exceptionally good access for regular inspection and maintenance. A wing, or get-home, engine provides redundancy and serves as a hydraulic pony motor.

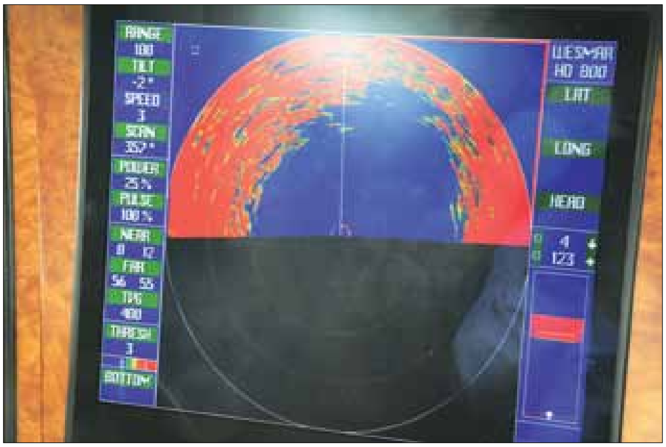
before the keel was laid, and it continues to this day. Among other things, the 68′ (20.7m) Nordhavn fiberglass expedition passagemaker is equipped with: a single main engine (simplicity I can embrace); a wing engine; twin generators of different sizes; a 15-kW true sine-wave inverter capable of operating 50% of the HVAC system while under way; quadruple HVAC chillers; a centrifugal fuel-polishing system; an integrated vessel-monitoring system; twin 1,400-gal-per-day (5,300-l) watermakers; hydraulic stabilizers, thrusters, crane, and windlass; a retractable sonar; 12- and 25-kW radars; and twin isolation and boosting transformers.

You get the picture: this boat is systems intensive—some would say overly complex—but the owner is an experienced mariner. He also lives aboard full time and wants to cruise extensively with as much autonomy as possible without sacrificing the amenities to which he and his wife are accustomed, including: flush toilets connected to a sanitation system that doesn't smell; efficient heating and air-conditioning; refrigerators and freezers; satellite television; and clean hot and cold running water—all fairly standard even in smaller, more-modest modern cruising yachts. From my perspective, the desire for homelike comforts afloat is no sin… unless those choices lead to frequent problems and excessive maintenance costs.

As I write, the boat is moored in Ft. Lauderdale, Florida, having completed a yearlong journey from Florida and the Bahamas to Bermuda; Newport, Rhode Island; to Halifax, Nova Scotia; on a circumnavigation of Newfoundland; and then down the East Coast back to Florida. The trip totaled about 7,500 miles (12,070 km), 1,100 hours on the main engine and on each of the two gensets, and 42 hours on the wing engine, which also serves as a hydraulic pony engine.

I spent 10 days aboard during that trip, cruising Newfoundland's North Coast and getting a feel for how the systems operated, and how functional and dependable they really were—from the retractable sonar transducer installed in the forward engineering space, to the mother of all inverters in the lazarette. What I found affirmed my confidence that complex systems can be reliable.

During the build, the owner and I pored over the various systems



Left—*For critical systems such as fuel distribution, no hose, tank, or filter should be installed until a clear plan has been established. This system is complex, but its clear labels and logical design make it easy to understand and maintain.* ***Right***—*Retractable sonar helps guide the vessel through a narrow, rarely traversed "keyhole" in a remote part of Newfoundland. Not common aboard even larger cruising vessels, for this client the equipment was a necessary complication.*

Left—*Engineroom ventilation was a priority, particularly because the vessel would regularly operate in the tropics. Active vents are fitted with sensors and controllers wired to a readout and control screen (**above**) at the helm.*

specifications, CAD drawings, and related documentation. Our systems questions included everything from domestic plumbing design to engine-room ventilation: Should the water heater receive heat from the engine or from one or both of the generators, as well as being heated electrically? Should such a system rely on a heat exchanger and circulation pump to minimize the risk of losing coolant for the engine? Should we employ standard, generic intake and exhaust blowers, or a more sophisticated, fully engineered ventilation system that monitors and automatically responds to temperature input while maintaining pressure?

We weighed the presumed benefits of each particular design option, including accessibility and serviceability, against the increased potential for failure its added complexity might bring. Serviceability was especially important because the owner wanted to do as much maintenance and repair as possible himself, particularly while in remote locations. Above all, our decisions focused on the greatest possible reliability, redundancy,

Power System Specifics

An interesting exercise is detailing power usage in a snapshot of one leg of the maiden cruise of the 68′ (20.7m) expedition yacht discussed in the main text. The boat departed Newport, Rhode Island, on July 2 and arrived back in Newport on October 18. During the voyage she plugged into shore power for about 36 hours in Halifax, Nova Scotia, and for three days in Lewisporte, Newfoundland. (Note: The vessel's parent shore supply is 100 amp, 240V, along with a secondary 50-amp, 240V inlet.) These were the only occasions the vessel used shore power during this passage leg. The generator hours during that period were as follows:

20 kw—405.3
25 kw—441.1

Power management, including generator use, was of concern to the owner during the boat's design phase. To that end, virtually every light aboard is LED. The large inverter system is designed to derive power from the main engine's twin high-output alternators. As we designed the system, there were more than a few naysayers, who believed an inverter of this size and a system of this complexity could not be made to work reliably. "It's been tried before, and it's failed," they said. I don't fault their skepticism based on past experience. Indeed, our thoroughgoing design process suggests more than a bit of skepticism from our team. An electrical design engineer prepared the technical proposal, which was then reviewed by another electrical engineer. After a few changes, all parties agreed that it should work, but, as with any unconventional

This easy-to-read panel for the ship's 24VDC system belies the unavoidable complexity in an electrical system for a vessel of this size and capability.

The large house battery bank is charged through four integrated 100 amps, 24V temperature-compensated battery chargers delivering ample charge capacity.

ruggedness, safe operation, and, yes, simplicity—when and where that quality made sense.

Real Solutions

My boat-owning clients complain mostly about systems that are unreliable, difficult to maintain, or expensive to troubleshoot and repair. Other owners say they just haven't gotten what they've paid for in the boat. They think simplification is an immediate answer. But while it can treat some symptoms, it doesn't necessarily fix underlying faults.

In my consulting work and vessel inspections, I find that many flaws of substandard vessel systems appear because designers initially ignored the need to integrate these systems. Instead, the crews on the shop floor have had to figure out how to install them during construction. The designer and the installer should figure out how to efficiently exploit space, honor manufacturers' installation requirements, and provide ease of access for service and repair. Too many systems-rich boats afford poor access to critical components, which amounts to playing a delayed dirty trick on the owner and the repair personnel. If you have to remove two pieces of gear to get to another for repairs or routine service, you know someone was shortsighted or cutting corners.

Even minimal early planning ensures that a vacuum pump in the sanitation system doesn't impede access to a seacock or washdown pump, or the air-conditioning compressor doesn't block access to the vacuum pump. When you can't see problems developing under layers of other gear, equipment fails prematurely, and often without warranty, because it was improperly installed. It's up to the designer, builder, and/or installer to think of the seacock that might seize or fail if it can't be accessed for inspection, exercise, or service. The fault isn't the complexity of the systems or components (seacocks are pretty standard hardware) but rather a failure to integrate systems through design and installation. A piecemeal approach to systems design almost inevitably results in unhappy customers who quickly lose faith in their boats.

Another common error is the builder's or installer's failure to provide necessary documentation, schematics, or operation and service instruction for the user. When the gear doesn't work as advertised and there isn't adequate literature explaining it, the end user may be quick to dismiss the system as "too complicated."

In other cases, the problem is component compatibility, which is more subtle than fitting multiple systems into a tight space. For example, installing a large bank of absorbed glass mat (AGM) batteries with a standard off-the-shelf engine alternator and a small dockside maintenance battery charger will result in chronically under-charged batteries—and their premature and costly demise. When such a system fails, it's likely to be faulted for being too big or too ambitious, rather than for being poorly designed.

Electrical systems—charging and battery systems in particular—are a frequent source of frustration for boat owners, because many builders and refit yards fail to design an integrated system whose charge output matches the capacity of the battery bank, and they don't include a relatively easy means to monitor electricity use and rate of charge. Finding the solution usually comes down to answering a few questions and doing the math: What are the loads? How long will they operate? What size battery bank does that require? How much charge does it need for a reasonable recharge interval?

Not all the blame for flawed systems lies with negligent designers and installers, however. Some equipment manufacturers and distributors introduce well-designed, high-quality products that simply lack customer support. I've encountered this scenario with numerous products, from stoves and anchors to battery chargers

The battery bank displays a well-thought-out design. Realistic calculations for power needs, including amperage, duration, and charge capacity are critical steps in ensuring reliability and performance.

system, there were no guarantees.

We sent the plan to two inverter manufacturers, who both agreed their gear could deliver what was required. The one we ultimately selected also agreed to inspect and approve the system as installed, to ensure it would be reliable but warranted as well. Interestingly, when presented with the finished design, the vessel's builder refused to install the system. They weren't prepared to own this design since it wasn't theirs. I believe that was a bold step, but the right one. I often counsel clients on not pushing builders beyond their technical comfort level with untried or cutting-edge systems; and nearly as frequently I counsel boatbuilders to avoid being pushed beyond this point. In an effort to please the customer and to avoid losing the sale, many acquiesce to an installation they are not fully comfortable with. This builder was confident of their abilities and what they would take responsibility for. Though they said no to the proposed system, they agreed to pre-wire the vessel to ease installation of the system as designed. An independent contractor installed the components after the boat was completed.

The system was conservatively designed to operate one of the four chillers to cool select portions of the vessel while under way, thereby reducing generator run time and maintenance. In practice, it will run two chillers without difficulty. The vessel's 1,100-amp-hour battery bank will carry one chiller for about four hours, along with the vessel's other loads; but it was not designed to operate under these circumstances. Its primary goal is to supply power for the HVAC system while under way.

—Steve D'Antonio

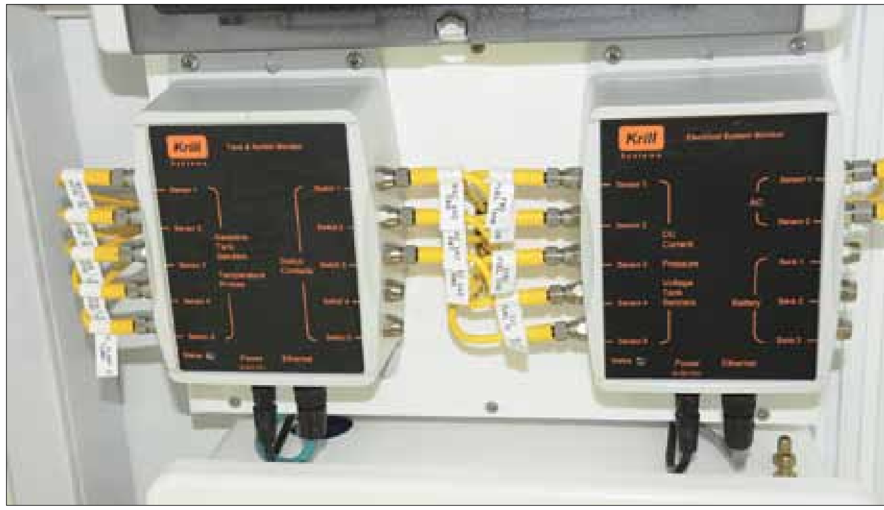
and engines. When I am asked for my take on a new product that a client or contact is considering manufacturing, installing, or distributing, my immediate questions are: "How will you support it? What service literature will you provide? Will literature be available online? Will you have a dealer network? Will you have an expert on hand who knows the product thoroughly? Will you be able to respond knowledgeably to e-mail queries and phone calls requesting installation and troubleshooting support?

When boat owners, builders, and yards lose money and patience on poorly supported products, the word gets out, and the products' manufacturers and distributors may lose business. But the reputation of the marine industry in general is also harmed.

In practical terms, the designer or builder must be responsible for exercising due diligence to ensure the reliability of any system, complex or otherwise. I recommend that builders, yards, and installers base their use of any product, particularly a new one, on how well it performs on the job and on how well it is supported. I've noticed a tendency among industry end users to adopt a new product just because it's new, and when I was a boatyard manager, I too fell prey to this temptation several times. The new products had compelling ads, my peers were using them, so what the heck? I regretted my hastiness. Now I look for manufacturers and distributors of new products to earn my trust by detailing their products' advantages as well as the specific means of support.

Another aspect of successfully balancing complexity, reliability, and comfort is installing gear in strict accordance with manufacturer's installation instructions. I'm amazed at the number of times I review a boat or individual installation and note in my report: "The inverter/watermaker/engine/generator/exhaust system is not installed in accordance with the manufacturer's guidelines and is in danger of failing/collapsing/catching fire/electrocuting crew/etc. See page 05 of the manufacturer's installation instruction manual, available at www.ABCXYZ123.com/installationmanual for the necessary corrective action."

You'll find installation instructions in PDF format on most manufacturers' websites, leaving little excuse for not following them to the letter.



Above—*The integrated vessel-monitoring system from Krill Systems (Bainbridge Island, Washington) allows the operator to monitor a wide variety of gear, from electrical and hydraulic systems to tankage and temperatures.* ***Left***—*Krill Systems current transducers monitor electrical flow in multiple locations throughout the system.*

In Practice

For our systems-rich expedition vessel and her design, the owner struck a reasonable balance with the builder in planning an integrated design and installing multiple complex systems with a goal of high reliability and ease of use. The result is excellent access for service.

In addition to the features already mentioned, the boat is fitted with a whole-vessel monitor to capture and display information and historical data on all systems, such as: hydraulic temperature and pressure; the vital signs of all battery banks (house, start, generator, and wing engine) including voltage and amp-hours; bilgewater levels; the 120/240V electrical system including generators, inverters, and shore power; all exhaust temperatures; fuel-filter vacuum; HVAC raw-water flow/temp; all tank levels; stuffing box temperature; and all four engine instrument sets. The system can monitor more than 50 parameters, and its displays are large and easy to read. Operators can set alarms for virtually any threshold or event frequency.

At the owner's request, the boat was equipped with a so-called sea chest. The intention was to limit or at least centralize through-hull fittings to one location in the engineroom, while providing adequate raw water to all the gear in that space. (It does not eliminate below-the-waterline

The monitor's central readout permits at-a-glance observations for a range of systems, and allows the operator to set and adjust alarms for voltage, temperature, pressure, and levels.

Left—*The tall sea chest in the engineroom is a technical complexity, but it minimizes the number of through-hull penetrations there and allows for servicing a filtering screen for the seawater intake while under way.* ***Above***—*The integrated navigation system shows the vessel's track, made possible with input from the sonar system.*

fittings in other areas of the boat, just in the engineroom.) Located above the waterline, the chest lid incorporates a removable screen that can be serviced while under way. This is the builder's only boat model made with a sea chest like this one.

To provide maximum current when needed, the large house battery bank is charged through four ganged 100-amp, 24V, temperature-compensated battery chargers that can be electronically interlinked—ensuring that they work as a set rather than individually. The main engine is equipped with twin 175-amp alternators and is externally regulated with temperature compensation. Note: The monitoring system reports alternator-case temperatures, too.

On board is a full set of service-and-repair manuals as well as specifications, documentation, and schematics from the builder and for equipment installed after commissioning. The vessel is also equipped with WheelHouse Technologies' cloud-based vessel-maintenance management software, which provides maintenance requirements for every piece of gear aboard and affords access to all owner's and service manuals in PDF format.

While the boat is still new by cruising vessel standards, she has already been run hard in a variety of conditions. On returning from Newfoundland, she weathered her most unsettled seaway yet: 15′–18′ (4.6m–5.5m) seas, with wind speeds steady above 30 knots and gusting to 45 knots for seven hours. (For the crew's sake, the owner sought shelter in Lunenburg, Nova Scotia.) Yet, the vessel and her systems performed well. The only casualties were the aircraft-style twist locks over the athwartships-oriented pilothouse refrigerator drawers that were wrenched free of the joinerwork. While not a failure per se,

A complete set of service literature for all systems and components is kept aboard in printed format.

The sonar transducer is easily accessible for regular inspection and maintenance.

Initially balky, the centrifugal fuel-polishing system is now operating reliably. It cleans fuel at a high rate without the need to stock numerous disposable filter elements for extended voyages.

the hydraulic stabilizers tended to overcompensate in those rough conditions, and they will need to be adjusted. Beyond that, all systems worked normally, and my hat's off to the autopilot and hydraulic steering pump manufacturers, Simrad and Accu-Steer, respectively. Their equipment worked overtime and never missed a beat.

The real measure for me was what didn't happen. In far less dramatic conditions, I've been aboard vessels where leaks developed, bilge pumps clogged, steering systems failed, batteries came adrift, electrical systems got wet and caught fire, appliances walked out of their garage spaces, and more. For this project, one of the design criteria was extreme robustness. While the true test must include the wear of long-term cruising, tumultuous offshore conditions are often a good indicator of whether systems and gear design and installation meet this demanding standard. The number and complexity of onboard systems on this vessel makes the challenge even greater,

For smart redundancy, these two pumps serving black- and gray-water tanks, are identical; and by simply manipulating a set of valves, either one can be used for either application.

but I think—thanks to careful design and proper installation—that challenge has been met. After a year of relatively hard use, the boat's significant systems problems can be counted on the fingers of one hand: the centrifugal fuel polishing system has been balky at times; the sanitation system will likely need a different pump or a larger hose size; and the hydraulic stabilizers still require fine-tuning.

This case study argues against the axiom that if we seek simplicity and reliability, we must avoid complexity in building and refitting vessels, regardless of the declared needs of our clients. Most of our customers expect comfort, safety, reliability, and relative economy of operation, and with reasonable effort and planning, an able boatbuilder or refit yard can deliver the goods. PBB

About the Author: *For many years a full-service yard manager, Steve now works with boat builders and owners and others in the industry as "Steve D'Antonio Marine Consulting." He is a contributing editor of* Professional BoatBuilder, *and awaits the publication (by McGraw-Hill/International Marine) of his book on marine systems.*