



# Autopilot Shootout

*In a test of four autopilots mounted on the same boat, the Nautamatic TR-1 performed the best, followed closely by our Best Buy, the Simrad.*

**R**eliable, responsive, and predictable are words that are synonymous with a good autopilot unit. Ever since Wood Freeman patented his small vessel autopilot system in 1935, the autopilot has been charged with controlling the rudder(s) of a vessel to maintain a selected heading.

Until a few years ago, most pilots were designed following the same basic layout: control head, compass, central processing unit (CPU), rudder-drive motor, and rudder feedback unit. A specialized compass would send the vessel's current heading information to a CPU, where it would be compared to the selected heading from the pilot's control head. If the CPU determined that the vessel was off course, it would send commands to the pilot's drive motor to move the rudder, steering the vessel back toward the selected heading. The rudder feedback unit, which was commonly installed in parallel with the vessel's rudder, would provide rudder position information back to the CPU. When the pilot's software determined that the vessel's rudder had been moved to a position that would most likely yield balance between the selected heading and the current heading, a stop rudder movement command would be sent to the pilot's drive motor.

During the past 10 years, many of the recreational autopilot manufacturers have been focusing on improvements to their unit's compasses. The autopilot compass component has evolved from



**Above, from left:** Furuno (Navpilot 511OB), Raymarine (ST6002+G), Simrad (AP16VF), and Nautamatic TR-1 Gladiator. **Right:** All were tested on a 26-foot center console.

a magnetic style with fine wires laid on top of the compass card (like the early Wood Freeman Model 1) to the present day magnetic fluxgate compasses with optional vibrating gyroscope sensors (commonly called rate sensors).

The advances in autopilot compass technology alone have not kept up with the quantum leaps in marine propulsion. With many of today's 40- to 50-foot sportfish battlewagons pushing north of 40 knots and 25- to 35-foot center console boats with triple or quad outboards exceeding 50 knots, the autopilot manufacturers have had their hands full in designing automatic steering systems that can safely handle the increased speed, while accommodating vessels with power steering, water jet drives, Arneson drives, and now rotational pod drives from Volvo and Mercury. (See editorial on Page 2 regarding safe use of autopilots.)

At this juncture in autopilot evolution, the solution to control the plethora of different vessel dynamics appears to rest on the shoulders of the software engineers. And from what we experienced during our in-depth sea-trial of four of the most popular autopilots, the engineers have indeed built a better mousetrap.

The engineers at Simrad broke ground several years ago by applying auto-learning algorithms to their units, whereby the pilot's CPU would



monitor historical trends of its input sensors (compass, rudder position, vessel speed) vs. drive motor activity and current draw. The goal was to identify steering patterns that the vessel was presently experiencing (following sea, quartering sea) while under the control of the autopilot, then apply a calculated range of rudder gain and counter rudder commands and automatically adjust these values until a balance between desired heading and minimal drive motor activity was achieved. The monitoring of steering trends yielded a system where the autopilot could constantly adapt to changing sea conditions. All four autopilots came with **gyro rate compasses** and auto self-learning capabilities.

Once autopilot engineers became satisfied with the control and response that they were achieving with their new learning algorithms, they expanded their reach by adding specialized steering patterns, such as man overboard (MOB), zigzag, circle, U-turn and the newest feature on the

## VALUE GUIDE: BELOWDECK AUTOPILOTS

	FURUNO NAVPILOT	TR-1 GLADIATOR	RAY ST6002+G	*SIMRAD AP16
Model	511-OB	Gladiator	E-12122	AP1603VF
Control Head Dimensions	4.3" x 4.3"	5" x 2.5"	4.25" x 4.5"	4.3" x 4.3"
Control Head Type	LCD Display w/ Rotary Selector	LED Indicator Lamp w/ Push Button Selector	LCD Display w/ Push Button Selector	LCD Display w/ Rotary Selector
Rudder Feedback	Magnetic Linear	None Required	Mechanical Linear	None
Gyro Rate Compass	Yes	Yes	Yes	Yes
Hydraulic Pump Model	Accu-Steer HRP 10-12	Octopus Custom	Hypro Type 1	RPU-80
Hydraulic Pump Quietness	Excellent	Fair	Fair	Good
Calm Water Test	Good	Excellent	Excellent	Good
Open Water Test	Good	Excellent	Good	Excellent
<b>Customer Service Telephone Support/ Minutes on Hold</b>	<b>Good/10 Minutes</b>	<b>Excellent/2 Minutes</b>	<b>Good/12 Minutes</b>	<b>Excellent/4 Minutes</b>
Product Quality	Excellent	Good	Good	Excellent
Warranty	2 Years Parts & Labor	1 Year Parts and Labor	2 Years Parts & Labor	2 Years Parts & Labor
Street Price	\$2,550	\$3,479	\$1,799	\$2,378
Source	Defender.com	ConsumersMarine.com	MAP	Defender.com
* Best Buy				

market: depth contour tracking. DCT, which is currently exclusive to certain Simrad models, is a great fishing aid that allows you to interface a National Marine Electronics Association (NMEA)-compatible depth sounder to your autopilot. You select the depth contour that you wish to follow on the autopilot display, set out your trolling lures, and let the autopilot track the vessel down the contour line.

This year marked the introduction of Simrad's virtual rudder feedback system. Simrad received ample press about coming to market with an autopilot that doesn't require a rudder feedback (in certain applications), Nautamatic's autopilots have been rudder feedback free for more than 12 years.

Because the second most common autopilot failure is due to rudder feedback failure (number one being a customer induced magnetic field on the pilot's flux gate compass, e.g. a tool box) the removal of the venerable rudder feedback device on certain vessels is a big deal. On a boat fitted with outboard motors, the rudder feedback unit is installed onto the aft steering piston, directly exposed to elements, 12 inches from the waterline. Every time the helm wheel is turned, whether the autopilot is on or not, the rudder feedback moves. Every time the outboards are tilted up for storage, the feedback torques and tilts with them. The question is not if, but when the feedback unit will need replacing.

The units we tested without the rudder feedback worked as good as, if not

better than, the conventional feedback fitted units.

### What We Tested

We invited five manufacturers to supply an autopilot system suitable for a 26-foot center console with twin Yamaha F150 outboards. Our intent was to test them head to head in two separate categories: with and without rudder feedback units. Three manufacturers immediately responded with products, Furuno (Navpilot 511OB), Raymarine (ST6002+ S1G), and Simrad (AP16VF). Nautamatic replied promptly but said our test course was too easy and would not highlight the unique abilities of its autopilot. We were able to satisfy the company's concerns and Nautamatic sent us its TR-1 pilot. The fifth manufacturer was Northstar. *PBR* placed numerous calls, left messages, and sent emails to just about every contact we knew of at its Acton, Mass., facility, but we received no response.

### Nautamatic TR-1 Gladiator

Just about everything on the TR-1 Gladiator—the only U.S.-made pilot in this test—is different than the industry norm. Instead of a control head with a standard LCD display, the TR-1 has a waterproof keypad with LED lights to indicate operation. It can be mounted permanently to the helm or on a removable bracket and used as a wired remote. It comes with 15 feet of cable. TR-1 pilots come with a hydraulic pump from Octopus Precision Products, a well-respected autopilot pump manufacturer. Part of the TR-1's

performance relies on the ability to precisely monitor the hydraulic pump motor shaft to determine how much fluid is being pumped to the vessel's steering ram. In effect, the Nautamatic monitors fluid flow—instead of hydro pump run time—to aid in the control of the rudder in a rudderless feedback system.

During our test of the TR-1, we detected loud hammering noises in the steering lines. TR-1's chief executive officer Graham Dorland said that a proper, permanent installation can virtually eliminate this noise. To reduce pump-motor noise, Nautamatic recommends a vibration-isolation mounting pad, which is neither provided nor available directly from Nautamatic. Only the Octopus pump has adjustable flow-control and shut-off valves built into the pump body, which are high-end features. Also exclusive to the Octopus TR-1 design are pump rotation sensor wires that exit the back of the pump. However, the pump sensor wires are only 24 inches long and must be plugged directly into the pilot's Electronic Control Unit (ECU) via a specialized gold-plated mini-plug. This forces the pump ECU to be mounted within 24 inches of the Octopus pump. The ECU, in our opinion, should have a longer cable so it could be installed farther away from the pilot's hydro pump in a more-protected, drier location with better accessibility.

The installation of the hydraulic hoses was different with the TR-1 due to the addition of the shadow drive flow-valve sensor that needs to be in-

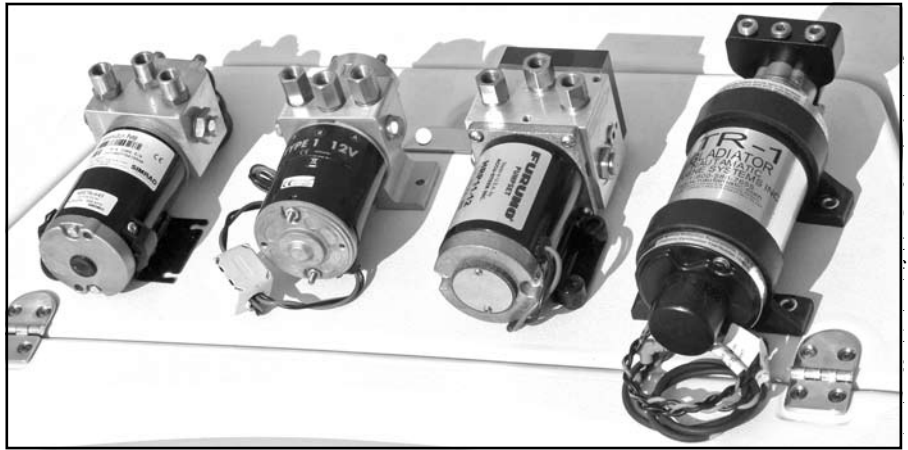
stalled horizontally in either steering line after the steering helm, but before the hydraulic pump. The shadow drive sensor comes on line during autopilot operation and senses if the helm has been turned by hand (presumably for emergency maneuvering) while the autopilot is engaged. This sensor automatically sends a command to the course computer not to counteract observed hand steering, thus there is never any need to switch the Nautamatic to stand-by mode to gain control of the helm. We found the shadow drive to be a great feature that instilled the confidence that no matter what, we were always in control of the helm.

In our opinion, some of the components and installation procedures could be improved, especially considering the unit's \$3,500 price. For instance, the installation calls for using a tie wrap to keep male and female Anderson electrical connectors together. A connector with a locking latch should be used here, in our view. Twice during the TR-1 install, before we permanently installed the wire tie wraps, the connectors in question came apart. Nautamatic said the Anderson connectors are so durable it's worth the tradeoff of having to use tie wraps.

In addition, since these units will be installed on small, open boats, a waterproof remote would certainly be preferable, in our view. (The Raymarineremote is waterproof.) Nautamatic said it is water-resistant and making it waterproof would cause the unit to be non-compliant with FCC regulations.

We also had difficulty mounting the TR-1's control head to our helm, via the flush-mount procedure. If the console is thicker than ¼ inch, a pair of thread extenders need to be used (available from the manufacturer, but not shipped standard with the system). A set of threaded studs or a flush-mount bezel would make the installation easier and faster, in our view. Nautamatic said a very low percentage of these units are flush-mounted.

We felt that the mounting bracket that held the compass ball in place could have been a little more substantial, given the importance of this system component. The retaining ring that keeps the compass ball secured into the holder snaps around the compass and latches down with a plastic thumbscrew. It is almost impossible



**Above:** The hydraulic pumps, from left: the Simrad, Raymarine, Furuno and TR-1. The TR-1's uses a piston instead of a rotary drive (like the other units tested). In our test installation, the TR-1 was louder than the others, but the company says it quiets down in a proper installation on a boat.

At 15 knots, when we dropped out an engine, there was again no change. It appeared as if the TR-1 program algorithms are monitoring the engine RPM's very closely and knew what to expect when we abruptly killed an engine.

Even Nautamatic's GPS interface exceeded our expectations. At 15 knots, when we engaged a waypoint 180 degrees behind us, the TR-1 immediately put us into an aggressive, but controlled, turn. Nautamatic calls this a G-limited turn. All we can say is that within two seconds, we were spun around and tracking back toward the waypoint before the GPS plotter had time to calculate any cross-track error. Just for the heck of it, we repeated the 180-degree test, but this time when we were in the middle of the about face, we pinned the throttles and held on. It felt as though we were riding bare back on a 50 mph cruise missile, straight and true.

**Bottom Line:** The TR-1 autopilot performed flawlessly. A few minor changes to its installation would help further justify its price, in our opinion.

### Simrad AP16VF

The AP16VF is another marquee product from this company's long line of thoroughbred autopilots. The AP16VF "virtual feedback" is Simrad's first recreational pilot fitted with virtual feedback software, eliminating the need for an external rudder feedback sensor on outboard and sterndrive vessels up to 40 feet. The AP16 shares the same gyro rate compass, course computer, and RPU series pump motor as

the other autopilots tested mount from the back-side via studs or screws. The front mount is more convenient, especially if the access to the underside of the helm console is limited, which is common.

For years, Simrad has been tweaking its autopilot compass designs, and the RC36 rate compass supplied with the AP16 has an accuracy rating of 1.25 degrees (rms) or less, which is quite impressive for an electronic compass. Simrad has always been proactive in suppressing stray RFI energy from entering its systems and compromising the steering commands. The AP16 uses an AC10 course computer fitted onto a ¼-inch-thick plate of anodized aluminum, and shrouded with a removable ABS plastic cover lined with foil. The AC series course computers were introduced last spring and features highly advanced program software that lets the installer know not only the amount of magnetic deviation that the compass is encountering at its present mounting location, but also the direction from which the disturbance is coming. This information can be extremely helpful when the pilot's compass has to be mounted in a less-than-ideal location. The AC series course computer will also tell the installer if he has installed the correct size hydraulic pump, via the rudder speed test. During the dockside installation set-up program, the rudder test sequence will run the hydraulic pump through a series of motor speed tests, and will reduce the motor speed if the maximum allowable 8 degrees of rudder movement per second is expe-

## How We Tested

We matched up the two units without rudder feedback—the Simrad AP16VF / RPU80 hydro pump and the Nautamatic TR-1 Gladiator—and the two with rudder feedback—Furuno's Navpilot 511/OB with Teleflex magnetic linear rudder feedback against Raymarine's ST-6002+ S1G outboard pilot with standard linear rudder feedback.

All four autopilot control heads were mounted into a Navpod housing, and the vessel was prewired for the four CPU processors and compasses. However, only the two compasses and two pilot hydraulic pump motors required for the pilot set being tested were physically installed. The boat had Hynautic steering, so cutting into the steering lines and installing a "T" fitting was relatively simple. Because we needed access to "hot-swap" the various autopilot hydraulic pumps, it was decided to extend the steering lines from the "T", aft to a location under the helm seat where we could comfortably work with the pumps.

rienced. At the end of the rudder test, a score will be assigned to the motor speed, as a percentage of motor output. If the score is very low (indicating only a small percentage of the motor's capacity is being used), it would indicate that too large of a hydraulic pump was selected for installation. On the other hand, if the score is very high, it would indicate that the pump was working at or near its maximum rating and may not be of sufficient size to generate the proper flow to move the vessel's rudder

After the pilot hardware was installed and the steering system hydraulic connections were made ready, each autopilot underwent a complete dockside set-up alignment, followed by a sea-trial alignment performed by a manufacturer's certified installer. We wanted to make sure that we had these units "dialed in" prior to the tests.

The tests consisted of a series of autopilot steering routines performed in calm harbor water and another series of routines in open water. Engine trim, trim tabs, boat loading, wind, and sea conditions were held as constant as possible for the duration of the test. Initial heading was the same for all test runs. Testers set the test vessel's WAAS GPS chartplotter to record the position track of each of the routines at two-second intervals. Each autopilot was assigned a specific track color, and at the conclusion of the test, all of the track data profiles were loaded onto an SD memory card, printed, and compared.

On the day that the feedback-less autopilots were tested, the winds were blowing onshore (SW at 15 knots) with a 2-foot

chop—a perfect day for an autopilot test. We had plenty of calm water inside the harbor cove to work the slow-speed tests and enough chop offshore to bounce the hull around but still safely crank it up to 40 knots. On day two, the pilots fitted with conventional rudder feedback units were met with a strong 20-knot west wind, which put the sea predominantly on the beam as we rode offshore. Testers faced more wind inside the harbor during slow-speed tests on day two, but nearly the same amount of calm water as experienced on the first day of testing.

### Calm-Water Test

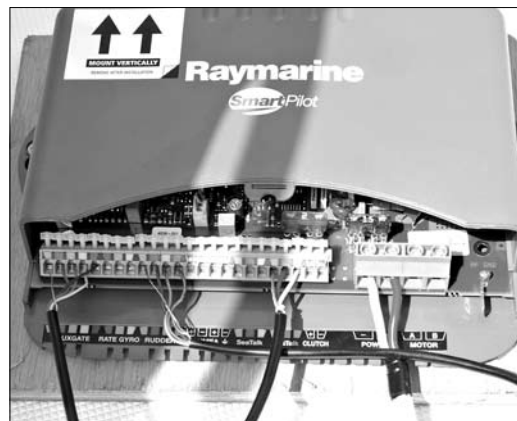
Each autopilot's alignment was engaged on the same straight line course (steer to bearing) at five different speed settings: one engine engaged at idle, two engines engaged at idle, and two engines making way at 4 knots, 12 knots, and 40 knots. After the calm-water tests, each autopilot was set on a straight-line course, with only one engine in gear, making way at about 2 knots. We then walked to the bow of the boat and deployed

der fast enough for proper automatic steering.

On the test course, the AP16VF finished a close second to the TR-1. The Simrad pilot's response at idle speed was a little slow and not completely on top of the low-speed range. Once we bumped the boat above 6 knots, the AP16 came alive and delivered confident steering up to the maximum speed. We talked to the Simrad engineers about our low-speed experience. Apparently Simrad programs the mo-

tor speed on the virtual feedback models a little more conservatively than on its conventional pilots with feedback as a safety feature for customer self-installations. Increasing the motor speed is achieved in the pilot installation set-up via a few quick button presses, and we were told that Simrad's servicing dealers know all about this little trick.

**Bottom Line:** At a price \$1,000 lower than the Nautamatic, with a great-looking and informative LCD display, Simrad's AP16VF has it all.



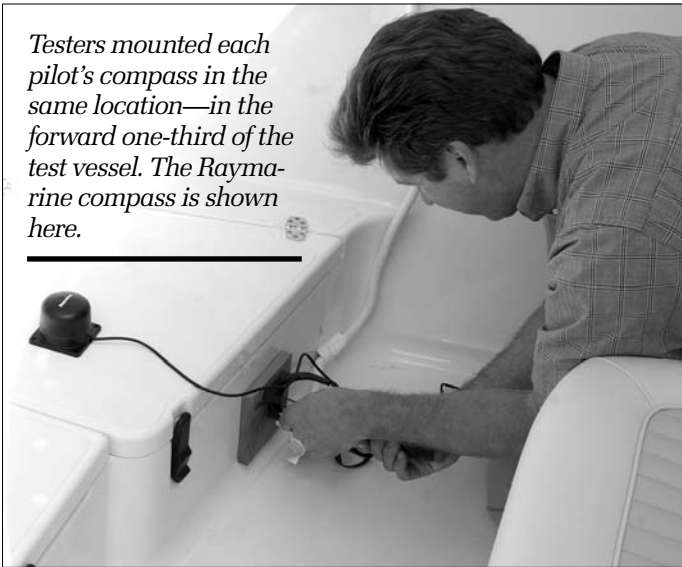
**Left:** The TR-1's course computer is located inside the softball-shaped compass. It has several sets of NMEA data wires, an ECU system wire, and a hydraulic flow switch (shadow drive) wire that exit the bottom of the compass. **Above, left:** The ECU for the TR-1's hydraulic pump must be mounted within 24 inches of the pump. **Above, right:** The Raymarine course computer houses the gyro component of the compass, so it must be mounted vertically (as indicated by the arrows).

### Furuno's Navpilot 511 OB

This autopilot was first introduced in the spring of 2004 as a complimentary component to Furuno's popular NavNet series radars and chartplotters. For years, customers who purchased Furuno helms opted for Simrad Robertson autopilots primarily because the early Furuno autopilots couldn't hold a candle to the performance of the Simrad systems. However, this is not the case with the new Navpilot 500 series. Furuno has produced a commercial-quality product that is very adaptive and seriously overbuilt.

The Navpilot course computer is a large, aluminum frame box (10 inches x 12 inches) with a removable aluminum cover. It

Testers mounted each pilot's compass in the same location—in the forward one-third of the test vessel. The Raymarine compass is shown here.



a small sea anchor and tied it off to the bow cleat. The purpose: We wanted to introduce a large and unexpected disturbance torque. How the autopilot reacted to the immediate pulling of the vessel's bow off course gave us an indication as to how the autopilot

hard speed) while recording the GPS track at two-second intervals and taking notes. After the 40-knot run, the driver throttled back to 25 knots and then commanded the pilot to make a 30-degree starboard turn. Once the vessel's heading became stable, a 60-

would react to a large wake, wind gusts, or current disturbances.

### Open-Water Test

The target sea state for the open-water tests was 2- to 3-foot seas, which we were fortunate to have on the two days we tested. We ran each autopilot for 1 mile at 25 knots (cruise speed) and again at 40 knots (running-

degree port turn was executed. We wanted to see how each pilot reacted to large course changes at speed.

Then we threw a curve ball into the test. We brought the test boat up to 15 knots, engaged the autopilot, and then abruptly throttled back one engine to idle speed and then engaged this engine into reverse and slowly brought the rpms back up to 1500. We wanted to see how well the pilots would respond to a severe rotational disturbance, much like one that would be experienced when skating down the backside of a steep wave in a following sea.

In a GPS interface, waypoint-tracking test, our team brought the boat up to 15 knots and engaged each autopilot for straight-ahead, steer-to-bearing course. While the autopilot was steering ahead, we purposely entered a waypoint 2 miles dead astern of our location and engaged the waypoint tracking option on each autopilot. This steering routine was performed to test the limits of each pilot's waypoint steering capabilities. ■

appears that Furuno has taken an extra precaution by surrounding its processor with aluminum to insure that Electro-Magnetic Interference signals do not enter into or radiate out of the pilot system. The compass that comes with the Navpilot is the top-quality \$800 PG500R rate compass. Although this compass needs to be mounted horizontally, Furuno ships a 1-pound aluminum bracket with the system for vertical bulkhead mounting. The rudder feedback unit that is supplied with the outboard version of the Navpilot is Teleflex's "magic stick" feedback. Teleflex uses a polarized magnet that is clamped onto the outboard's steering cylinder and a receiving sonde stick that is fix-mounted very close to the polarized magnet. As the steering cylinder with the Teleflex magnet moves port and starboard, the receiving sonde keeps track of the position of the magnet, which is in direct correlation to the position of where the outboards are pointed.

During our dockside alignment of the Navpilot, we had difficulty getting the magic stick feedback to respond linearly to our port helm movements. If we turned our helm by hand to starboard, the Navpilot would display a nice linear count from the midships position all the way to 40 degrees hard starboard. However, when we turned the helm back to amidships and

started turning the helm towards the hard over port position, the Navpilot rudder angle display would erratically jump 5-30 degrees. Our phone call to Furuno tech support was answered by a competent technician in about 10 minutes, and after a couple of quick tests, it was determined that the Teleflex rudder feedback was defective. A new feedback unit was shipped from the factory to our local dealer, and the next day, we were back on-line in about 30 minutes.

Once we had the rudder feedback unit aligned, we set the direction and speed of the pilot's hydraulic pump per the installation manual. During the rudder direction test, we were intrigued by the complete lack of noise generated by the Furuno hydraulic pump as it turned the outboards. The only way that we could tell that the Furuno pump was operational was to put our hand on the motor and check for vibration. Furuno uses hydraulic pumps from Accu-steer Co. in Bellingham, Wash. This pump was by far the quietest.

Once we had the Navpilot away from the dock, the compass alignment and the auto-learn procedure were very easy, thanks to well-written set-up aids on the unit's graphical LCD display.

In the calm-water test, the Furuno handled itself very well, with the

exception of when we deployed the drone sea anchor off the bow. We felt that the Navpilot took too long to react to the sudden torque that we applied to the bow, and had to play catch-up to regain control of the vessel. The Navpilot performed very well during our open-water test routine with nice straight tracks. The only time that the Navpilot blinked while we were offshore was when we dropped one of the outboards at 15 knots. During this maneuver, the pilot appeared to react a bit slowly, and as a result, we oscillated a bit before the pilot figured out how to handle the new condition. When we engaged a waypoint 180 degrees behind us, the Furuno responded by turning the boat around via a gentle one-quarter-mile radius turn.

**Bottom Line:** The Furuno Navpilot is a top performing, extremely well-built product that is suitable for a wide range of vessels.

### Raymarine ST6002+G

The heritage of Raymarine's new line of "SmartPilots" dates back to the days when Robertson ruled the powerboat market and Raytheon's Autohelm product dominated the sailboat market. So it is not an understatement to note that Raymarine is very much a veteran player when it comes to autopilots.

Although the fluxgate compass that

comes with the ST6002+ is nearly identical to the old Autohelm compass circa 1990, and the noisy hydraulic pump is still being manufactured by the Hypro Corp., the S1G course computer that this model uses is a brand-new design and is loaded with some very precise steering algorithms. We were a bit disappointed to see that Raymarine's S1G computer is constructed entirely of plastic, but considering that the unit costs \$500-\$700 less than a comparable Simrad or Furuno unit, we acknowledge the cost savings.

Like the Furuno autopilot, the Raymarine also exhibited out-of-the-box hardware failure. Fifteen minutes into the calm-water portion of our test, the Raymarine unit, which passed all dockside alignments and the auto-learn sea trial alignment, sounded an alarm and flashed "over current" in its display window. We quickly isolated the problem to the unit's hydraulic pump and electrically disconnected it from the system. Our suspicions proved correct: Raymarine's pump motor had locked up and put a dead short on the system.

Not to be defeated, we quickly headed back to the dock and arranged with a local Raymarine dealer to loan us another Type 1 hydraulic motor. The technician connected it directly to his power supply and experienced the same over current condition. The tech loosened a few screws and separated the motor from the pump body. What we saw was a chunk of plastic that looked like part of keyway, jammed against the motor shaft. The dealer said he had been installing Raymarine pilots for over 30 years and had never seen this type of a failure.

Once we got the new pump installed, we took the Raymarine back to sea and put it through its paces. The ST6002+ handled all facets of the calm-water test, including the deployment of the sea anchor. With regard to the open-water test, the Raymarine stumbled a little when we dropped out an engine at 15 knots, but managed to quickly recover. At 40 knots, the pilot held a decent course, but we could feel it slightly pushing us around the selected heading. With the vast amount of alignment settings, we could have calmed the rudder action at the 40-knot mark with some tweaking.

We also tested Raymarine's optional E15023 SmartController wireless au-



**Above:** The LCD display control head on the AP16 (right) lacks Simrad's signature round course-change knob. The knob was removed so that the unit would fit into a standard 4-inch x 4-inch instrument space. The TR-1's standard control head does not have an LCD display, but tester report it worked just fine without one. The optional LCD display retails for \$499. The company also offers an optional wireless remote, \$600 retail.

topilot remote (\$599). The SmartController is compact (6"L x 2"W x 1"D) and has a decent-sized LCD display. A wireless autopilot remote on a 26-footer is a bit over the top, but the E15023 also doubles as a Seatalk data repeater, displaying, for example, digital depth information at the transom while we were adjusting our fishing gear.

The ST6002 pilot responded immediately to the SmartController command, and the wireless connection felt strong, almost like the controller was hardwired into the system. We would have preferred to see this remote fitted with a float collar instead of a lanyard, and there isn't any wall charger provided with the unit, which makes recharging inconvenient.

**Bottom Line:** The SmartPilot performed adequately, and with a \$1,799 price, it's a good value.

## Conclusion

The Nautamatic TR-1 won our performance test and would be a welcome addition to any helm (under xx feet). It is, however, significantly more expensive than the Simrad. Nautimatic's Dorland defended the TR-1's pricetag. "We have gold pico connectors. No one in the industry does this; they are expensive. We have fully potted and waterproof components—no one

else can claim their autopilot is waterproof. All of this is more expensive to produce."

Still, we give a slight edge to the Simrad AP16VF because it finished only a hair behind the TR-1 in performance, it has a two-year warranty (the TR-1 has a one-year warranty), and the Simrad line within the AP series can be configured for boats to 60 feet.

Raymarine's ST6002+G pilot is a great value and a solid performer. Raymarine is a bit behind in offering this model with rudderless feedback, although the company does offer a smaller S1000 wireless product that's not on the same level as the units tested here. A quieter hydraulic pump and an upgrade to the flux-compass would improve these pilots. Furuno The Navpilot is definitely ready for primetime. We do not have any reservations in recommending this pilot for most vessels. For those customers who have a complete NavNet helm and are contemplating a Simrad autopilot, there no longer is a reason to breakup the integration and purchase a non-Furuno pilot. ■

**Raymarine**, 800/539-5539, [raymarine.com](http://raymarine.com).

**Furuno**, 360/834-9300, [furuno.com](http://furuno.com)

**Simrad**, 425/778-8821, [simradusa.com](http://simradusa.com)

**Nautamatic**, 800/588-7655,