The autopilot is a very valuable device at every short handed boat. In the Mini Transat they are one of the reasons for the speeds currently achieved. Without them the design of a Mini would possible not look the same as right now, sails would be smaller and the sailor even more exhausted. Onboard the top finishers there will be always a top of the bill Autopilot. On the other hand they can be a pain in the .... They use electricity and must be reliable. And a Mini is one of the extremist yachts around, a big challenge for the manufacturers.

So it is time to get more in details;

An Autopilot is a device build out of three main components.
-Compass to now which direction to go to.
-Ram, a mechanical drive unit that actually pushes and pulls the tiller to the needed heading, either electronic or hydraulic.
-In between those there is a computer which gives the feeding (that is information like; course steered-course needed multiplied with forces needed for the ram to change course that much) to the ram engine, which gives a feeding back, which the computer recalculate and then the whole phase is done again.

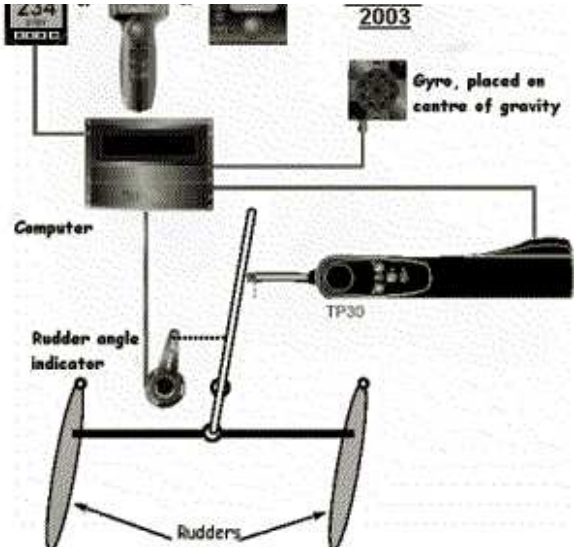
Here the NKE Hydraulic Mini 120 Hydraulic arm (2003).

The black hoses are leading to a oil reservoir and pump down below. The red caps covers nipples to remove air bubbles out of the system. And you can renew the oil that way.
The rod on the other side is the tiller position unit. Together with the computer, display, rategyro and some bundle of wire it completes the system... It is really designed for the smaller boats, a good example of a manufacturer that is idiot of Mini's :)

An electronic arm system, Raymarine.

They have a 4000 arm very suitable for a mini, stear through 6000 or 4000 head.
And a rategyro is available too.

And the schematic overview of the Simrad system. You can use the TP30



without the computer connection, and so without the indicator too :) But you will loose the benefit of the gyro and computer. NO wireless system, the ap21/22 are wired to the computer. The ap21 has a long wire i believe...

Compass

So how more accurate the compass the better the course steered. And how quicker the ram reacts, how better the course. Same for the computer.

The basic fluxgate. As the flux gate is cheaper it is used in most autopilots. They are good for cruising and not to demanding racing. It is a small electronic compass.

But another way is to use a rategyro added to this flux gate.
In short why; A flux gate compass is affected by acceleration, with the movements of the sea, depending on their strength, it's measurement is then false for a short while, and with the inertia comes slowly back to the real value. That's why a standard pilot tend to steer in curves when the conditions are becoming harder. The added rategyro inside the computer detects immediately the accelerations in the horizontal plan, and a gyro is then able to correct the compass value, what gives a good reference to the pilot to steer a more straight course. And an added rategyro creates smaller rudder changes. Every steering reaction creates drag, how bigger the change how more drag. So the rategyro should make your speed higher. And to sail in curves makes your route longer.

And then there is the real Gyro, this are top of the bill compasses, very accurate and expensive. Not used onboard Minis. But KVH is one producer. See below for an explanation of the differences...

The Computer.

The input into the computer comes from the compass, a rategyro creates a better true input. So with a rategyro can have extra additions that works better then with a Fluxgate. And there can be more devices coupled, but some are restricted (chartplotter) due to the Mini rules. Here are listed some additions, some found on other pilots too. Some specific for NKE. Check the information of the suppliers. The computer can be a separate box or being build into the autopilot.

Some aspects of pilots, based on the NKE.

<u>High speed surfing mode;</u>
(NKE; new mode, added after response of Mini sailors)
One of the new functions allows it to connect to the Speedometer. In a surf the boat speed will pick up drastically, the boats planes and suddenly the surf is over. Speed drops and the fluxgate gets victim of centrifugal forces (much like suddenly braking in a car). It could give a steer request to the ram when it is not needed. Ultimate result can be a bit drastic, flogging genaker etc. etc. But what if the speedo is connected in the system. If it measures a sharp drop of speed it sends a signal to the computer. The computer will override the steering request from the compass.

<u>Counter rudder;</u>
You can select different settings for counter rudder. Counter rudder is the compensation after a rudder movement to counter the effect of inertia off the boat after a heading change. If you think at it, it's exactly what the skipper

does when he pushes the rudder and bring it back a bit further then where he started from.

<u>The NKE gyro pilot steers with the speed</u> also, as the boat's reactions are different if you are doing 5 or 12 knots... there is a factory setting of the average boat speed, which counts into the calculation to determine the necessary rudder quantity. This factory setting is at 6 knots, but can be modified. That means that you can tune your gyro pilot to your boat's average speed.

<u>For the wind mode;</u> you can choose to dampen the wind angle from 0.5 sec to 2 min, where the other manufacturers dampen on a fixed value of 1 min. That means that when sailing upwind, if you have 1 minute dampening, your boat can slow down and after a minute adapt to the small wind shift that appeared a minute ago... So we can set 1 second dampening upwind, or a 2 minutes dampening when sailing downwind with a following and rolling sea, when any MHU is a bit crazy!

<u>Remote Control / Safety;</u>

With the NKE system there is an opportunity to have it remotely controlled with a wireless remote control small enough for your pocket. Other manufacturers are using wired remote controls. ***(NOTE- be aware that it has a Man Over Board function, and you carry it in your pocket, you can accidentely put it off, with strange results sometimes... LeoV)***

Hydraulic or electronically ?

An electronically arm is cheaper, but less waterproof due to the electronics out in cockpit. While the hydraulic unit is submersible ;) But cost more, and uses more power. But it is more powerful.

In practice:

Most of the sailors I talked to used a FE Tiller pilot for normal conditions, and the Added Gyro Hydraulic Autopilot for heavier weather, to save power. In 2003 people sailed the Mini Transat with the computer/rategyro of the NKE coupled to tillerpilots off Simrad. It saves power consumption. See the Pogo2 page for more details.

<u>Points to take care of;</u>

1- good electronics, watertight, chafe free.
2- good batterie &charger, the electronic engines are extremely simple and sensitive to low volts...
3- take care to protect the autopilot for water and buffelo sized shoes.
4- read the fucking manual, about calibration requirements and modes. And follow it too ;) reading alone will not help you.... The NKE documentation I have gives even a way to compensate a faulty heading (use a bearing on fixed shorebased points etc etc)...
5- open a pilot and look how simple it is ;), and then buy the spareparts set. And a tube of lubrication for the seals, and use it.....
6- after racing, clean the case with a slightly wet cloth (fresh water)
7- with hydraulic systems, sometimes you have to refill the oil, so normally you only look when it is to late (after a few years or so). Look for airleaks in the system (sharp true deck fitting), rusting connections, seals on the oilreservoir etc.
8- LAST COMMENT, BEST PRACTICE, Love your pilot.....

More info can be read at;
http://www.autonav.com/html/anav4009.htm

NKE has its whole manual published on the website, worth to take a look at... I wished everybody did that.....

LINKS: nke Raymarine ON BOARD SIMRAD

TECH TALK;

How does Gyros work ?
I got this from Max Lynn, thanks.

There are essentially two types of (simple)gyroscopes built; (1) Rate gyros, and (2) Rate Integrating gyros. Neither of these devices, by themselves, are compasses. A simple, single degree of freedom gyro simply reacts to angular motion about its input axis by rotating about a second axis called the output axis. In the case of the rate gyro, this motion about the output axis is restrained by a spring. As the motion about the input axis increases in rate, the force exerted on the spring increases. The magnitude of this force or the amount of torque required to restore the output axis to its original position is measured and is proportional to angular rate about the input axis. This is what is used on Minis.

The Rate Integrating gyro has no spring on its output axis. An angular motion about the input axis causes a proportional rotation about its output axis. Now, in a gyrocompass application, this type of gyro is mounted on a set of gimbals, along with a completely separate but very necessary pendulum(or some other device to sense local horizontal/vertical). As it sits stationary on the earth's surface, the gyro senses only a component of the the rotation of the earth about its polar axis. Assuming the gyro's input axis is in the local horizontal plane(as defined by leveling the gimbal platform using the pendulum or mercury level or ??), the gyro senses a component of the earth's rotation rate proportional to the cosine of latitude(15deg./hr * k * cos lat). The K component is proportional to the cosine of the true heading of the input axis. So what is done is to torque the gimbal platform at a rate opposite and equal to the input rate so as to null or minimize the angle measured at the ouput of the gyro. So the rate required(as measured by the amount of current required to maintain this null) is proportional to the cosine of true heading. This signal is used to drive the compass card and often to provide electrical signals proportional to heading to the autopilot in lieu of a fluxgate input.

Let me digress for a moment; a simple inertial navigation system such as those used on many aircraft are just complicated extensions of the above mechanization. Instead of a pendulum, they have three accelerometers which serve to both level the gimbals and measure changes in velocity along three platform axes. Instead of a single gyro, they have three mutually perpendicular gyros which measure aircraft motion in three axes and maintain platform level. These measurements of angular motion(in pitch, roll and yaw) along with the changes in velocity measured by the accelerometers are fed to a digital computer which processes these inputs to determine present position.

Back to boats - the gyrocompass and the rate gyro are two separate and distinct pieces of gear. Now there's a lot of confusion in the various literature brought about by sloppy or uneducated use of nomenclature. And I noted mixed metaphors. The gyrocompass provides a substitute for the signal from the flux valve. In its older conventional configurations, it needs to be aligned prior to use by allowing it to remain stationary for several minutes prior to significant movement. In a flat sea, they will align underway, but it takes longer.

Now, to rate gyros; as I stated, their output is proportional to the angular rate about their input axis. In the case of an autopilot for a boat, their use must be, I believe(and here's where my inexperience lies, so I stand to be corrected), that they are used in conjunction with the flux valve(or gyrocompass azimuth, if applicable)and the rudder angle sensor to generate an intelligent rudder command. What the rate gyro provides, basically, is an indication of how fast to ramp up(or ramp down) a rudder command in order to

offset a high(or low) rate yaw axis input. The intelligent combination of all these signals to provide you and I with a well-behaved autopilot requires application of a lot of Advanced Control Theory as taught in higher level EE courses. And it involves a lot of knowledge about the physics of motion of small boats(or ships, if that's what the autopilot is driving).

I took a look at the NKE web site. They have a PDF file describing their autopilot, and it seems well-written and I believe verifies what I have set out here. But I'm still learning.

ANYONE WHO CAN LEARN US MORE ????

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