A mixed NMEA2000 and Seatalk^{ng} network. The joined T-pieces form the NMEA2000 bus; the Seatalk^{ng} bus uses the block at the top

Interfacing demystified

David Pugh shows how to link old and new electronics

Many of the electronics questions we receive for our Ask the Experts pages relate to interfacing. We live in a fast-changing world where technology is obsolete almost as soon as it leaves the shelf, but for most of us budget constraints, inertia, lack of time and reluctance to hack the boat around mean that we replace our electronics piecemeal, as and when required. The problem is that new systems do not necessarily converse easily with old ones, so if you hope to take advantage of some of the advantages offered by modern instrument networks, you need to find a way to get them talking.

Why interface?

Networked instruments are firmly in the 'nice-to-have' rather than 'essential' list for most sailors (with the possible exception of serious racers). Nasa Marine produce a range of instruments which, with the exceptions of their compass, wind indicator and GPS repeater units, do not offer any means of communicating with other devices yet still provide all the essential navigation information at a competitive price. Others, such as those made by Advansea, offer limited networking but advise that their own transducers are used for best performers.

Spending more buys you better screens, faster processors and smart graphics, but also buys you the ability to interconnect. Modern high-end instruments share all their data, so that every item of navigational information is available to every instrument, transducer or processor on the network. This has a clear benefit to the user in that they can access information at any screen (really handy if your crew are in the habit of sitting in front of your instruments), but the advantages go further than that.

Additional sensors can often improve navigational data, and it makes sense to make their outputs available for more than one application. For example, if you fit a heading sensor to your boat, it will provide a digital compass readout, can stabilise your autopilot and will enable your plotter to calculate tidal set and drift and overlay radar information on the chart. A speed transducer will allow your wind indicator to accurately display true wind, while sharing depth information with your plotter can assist it to chart depths to supplement the original cartography.

Early networking

Historically, there have been two strands to developing instrument networking: proprietary systems developed by manufacturers, and the open protocols set out by the National Marine Electronics Association (NMEA).

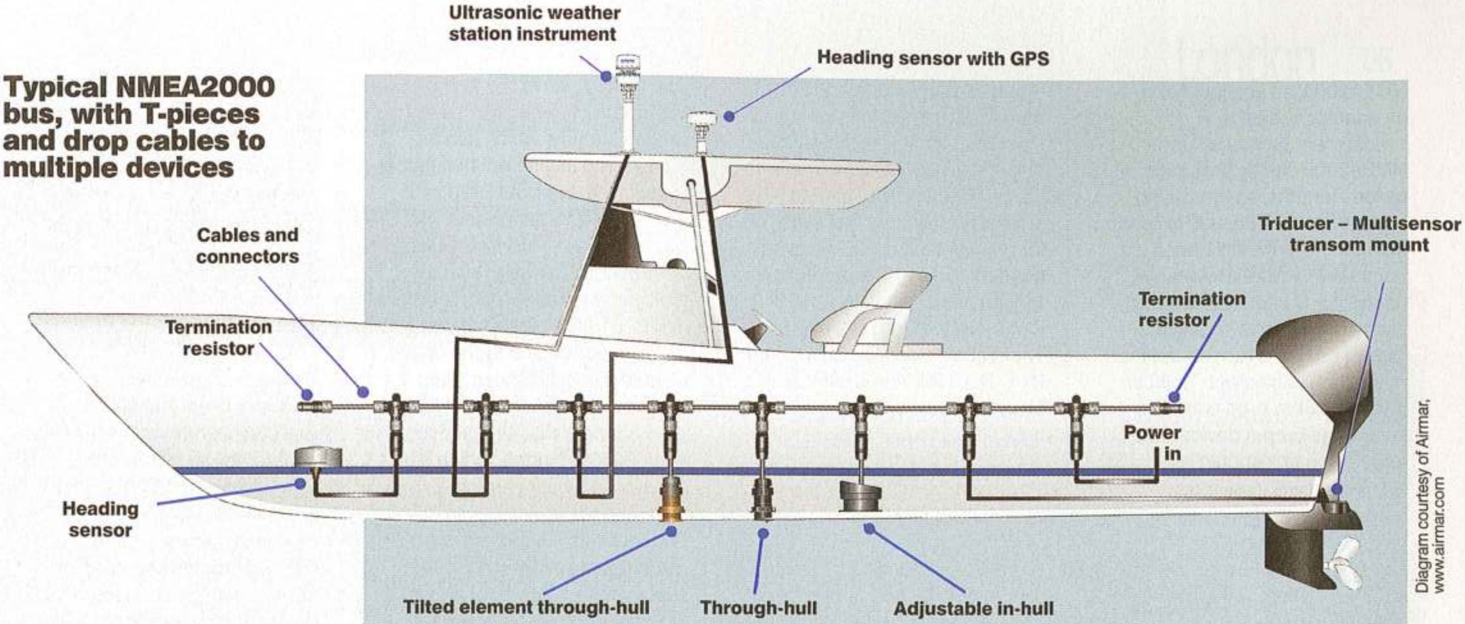
There are two early versions of the NMEA protocols which you may come across: NMEA0180 and NMEA0182. These are very similar in operation, and offer a rather slow serial method of sharing navigational data from a GPS and/or autopilot. The information transmitted is limited to position, cross-track error and bearing to next waypoint. These two standards are now thoroughly obsolete.

ABOVE Nasa Marine primarily make stand-alone instruments...

LEFT ...but one of their wind transducers outputs NMEA0183

BELOW Advansea's range uses a custom network, but also accepts NMEA0183

Typical NMEA2000 bus, with T-pieces and drop cables to multiple devices



Their successor, NMEA0183, is still very much with us and was the first open protocol to allow marine instruments to share a wide range of data. It uses text-based sentences of up to 82 characters, which includes a two-letter code to indicate the data source and a three-letter code to denote its contents, followed by the data itself. For example, a sentence beginning $GPGLL comes from a GPS (GP) and contains lat/long information (GLL). NMEA0183 is four times faster than NMEA0180 (4.8kbit/s compared with 1.2kbit/s), and thanks to its structure can be expanded to accept data from any source: for example, MWV denotes wind speed and angle, and RSA is the rudder sensor angle. The system also allows manufacturers to use proprietary sentences, prefixed with the letter P.

NMEA0183, which is currently at version 4.10 (published 2012), uses the RS422 serial protocol and is easily understood by computers, although modern machines will need a USB converter.

Older Raymarine instruments use Seatalk, now branded Seatalk[1], a customised version of NMEA0183 which is not cross-compatible.

Raymarine's rectangular Seatalk[1] connectors are easily spotted

Modern networking

Although NMEA0183 offered a great step forward in providing a viable means for instruments to communicate, the demands of modern systems started to outstrip its capabilities for two reasons: speed and the ability to support multiple 'talkers'. The first point was partly addressed by a high-speed version of NMEA0183 which operates at 38.4kbit/s and is used by many AIS units, but the second required a complete rethink: NMEA2000.

NMEA0183 is a single-talker, multiple-listener network. This works well for simple systems where, for example, you just want to share GPS information, but if you have more than one data source it becomes necessary to add further electronics in the form of a buffering multiplex box to avoid messages transmitted at the same time from interfering with one another.

NMEA2000 solves this by abandoning the RS422 architecture for one based on CAN-bus (Controller Area Network). Initially developed by Bosch, CAN is commonly used on cars to link their complex networks of sensors, actuators, lights and controllers. In essence it consists of a two-wire bus around the vehicle, with input and output devices connected via drop cables from the bus.

Operating at 250kbit/s, NMEA2000 is 52 times faster than NMEA0183, and the CAN architecture on which it is based is good for 1Mbit/s on networks shorter than 40m, offering room for further speed increases.

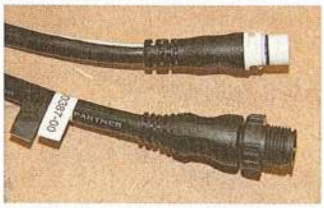
CAN is a multiple-talker, multiple-listener network which resolves the problem of messages interfering by using priority bits. All the devices (nodes) are listening at all times, and when transmitting they compare the bit they just transmitted (logical 0 or 1) with the bit received. In CAN, logical 0 is dominant, so if a node transmits a 1 but receives a 0, it knows that another node is transmitting and has priority, so it will drop out and wait for 6 blocks before trying again. This allows CAN to interleave messages from multiple sources over a single serial bus with minimum delay, and also gives it a means to prioritise messages for essential commands.

So NMEA2000 offers a good solution to get instruments talking to one another with good speeds and scalability. But it took some time to be widely adopted and did not initially do everything manufacturers required of it, which combined with commercial self-interest led some manufacturers to develop their own proprietary networks to link their instruments: Raymarine Seatalk^{ng} and Simrad's Simnet are notable examples. The good news, however, is that these systems are strongly based on NMEA2000 and can easily be converted, and the tendency today is for manufacturers to fully adopt NMEA2000.

Interfacing modern systems

In terms of interfacing then, NMEA2000 and its derivatives are by far the easiest to deal with. The network uses micro-C connectors as standard, so compliant devices from any manufacturer can be easily connected to the same bus. At the time of writing, B&G, Furuno, Garmin, Lowrance and Simrad products can all be directly linked using micro-C cables and T-pieces. Airmar provide NMEA2000 transducers for all these manufacturers.

Raymarine is a special case, as



Seatalk^{ng} plugs (top) are slimmer than NMEA2000's micro-C

they use Seatalk^{ng}, a proprietary system which uses a smaller plug, scarcely thicker than the cable, making installation easier. In theory it also frees Raymarine from adhering to the requirements of NMEA2000, but in reality

Termination resistors should be used at either end of the bus

Seatalk^{ng} sticks closely to the standard, so with the aid of a Seatalk^{ng} to micro-C adaptor cable the two can be easily interconnected. The same goes for older Simrad instruments – Simnet will interface directly with

NMEA2000, so you just need an adaptor cable.

Most manufacturers supply NMEA2000 cables pre-made to various lengths, so there is no need to solder. The only exception to this is often the masthead transducer, where a rewirable connector is used to allow the cable to easily pass down the mast. The bus is run around the boat using cables with T-pieces added to allow drop cables to each input/output device. The ends of the bus should be terminated with resistors (supplied as plug-in units), and power supplied via another T-piece (see diagram on p79). Most devices can be powered from the bus, but high-current units such as plotters may need their own power cabling.

Actisense's NDC-4 can mix NMEA0183 streams at different bit rates

Seatalk[ng] wiring is virtually identical, but Raymarine remove the need for rewirable connectors thanks to their tiny plugs, and they offer some multi-port connectors which help to neaten wiring in situations where many devices are used in the same location.

Interfacing older systems

If your instruments are stand-alone with no network ports there's nothing you can do to interface with them which doesn't involve significant surgery and programming knowledge. NMEA0183-compatible units can be linked, and the method depends on the complexity of your requirements.

The simplest and most common requirement is to link a plotter or GPS to a VHF to enable DSC functionality. Even those with NMEA2000 instruments and plotters may need to do this, as many leading VHF brands have yet to adopt the standard.

To begin, you need to find out how to extract NMEA0183 from your plotter or GPS. This is likely to be via a proprietary cable with a moulded plug at one end and bare wires at the other, which most manufacturers supply with the unit. It may be combined with the power cable, but should have at least two (usually four or more) thin wires at the end. These may be marked Tx+, Tx- for transmit (positive and negative); NMEA Out+, NMEA Out-, or similar. The receive side may be marked Rx+, Rx-; NMEA In+, NMEA In-, or similar. If the wires are not marked you may need to look in the user manual to decipher the colour codes.

The VHF should have a similar set of wires on a similar cable. Using choc-block, crimps or solder, connect the GPS Tx+ to the VHF Rx+, and Tx- to Rx-. This will give the VHF a position for sending a distress call: if your VHF is able to communicate back to the plotter you'll need to connect the VHF Tx wires to the plotter's Rx wires.

This technique works perfectly if you're only sharing data between two devices, or if there is only one transmit device – usually the GPS. If you have more than one, you'll need a multiplexer: searching online for 'NMEA0183 multiplexer' will yield several, but one of the best-known marine brands is Actisense. These devices will typically take four or five inputs and combine them into a single data stream; some will also provide a USB output to allow you to share the data with a PC.

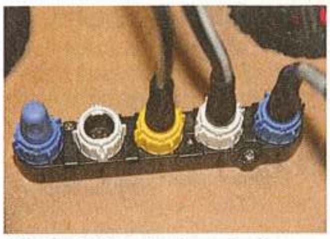
A complication is introduced if you install AIS. The NMEA0183 versions operate at a higher data rate (38.4kbit/s), which can be sent to a plotter to allow targets to be charted. Most plotters can be set to accept this data rate via their user interface, but if you need to send additional information which originates at the lower, 4.8kbit/s rate, you'll need to upconvert it so that all the data is sent to the plotter at the same bit rate. The Actisense NDC-4 multiplexer mentioned above is a good all-rounder for this, with two output streams which can be configured at different data rates. Expect to pay about £180, or if you fancy a winter project you can save some money by using a Raspberry Pi or similar mini-computer to multiplex and convert NMEA0183 streams: various instructions can be found online.

Interfacing NMEA0183 with Raymarine Seatalk[1] is trickier. Raymarine's solution used to be their E85001 bridge, which has now been discontinued but may be available second-hand. Alternative solutions are the Brookhouse NMEA multiplexer, which has a Seatalk[1] option, or if you have an older Raymarine ST60 Multi instrument they have both Seatalk[1] and NMEA0183 connections and will convert between the two.

Mixing old and new

The bad news is that because NMEA0183 and NMEA2000 use completely different structures, there are no circumstances in which you can simply wire an older device into a new one. The good news is that converters exist to help. Actisense produce a converter (NGW-1), and Amec have a similar product. These allow you to convert your NMEA0183 data stream into NMEA2000, and can be simply added as a node to the NMEA2000 network.

On this topic,


This Seatalk[ng] adaptor outputs Seatalk[1] from the yellow socket

it's worth mentioning that Garmin's latest GMI20 instruments have an NMEA0183 port as well as NMEA2000. They won't convert the data to share via the network, but do at least offer a means to display it. Older Raymarine instruments using Seatalk[1] can be connected using Raymarine's Seatalk[1] to Seatalk[ng] converter, priced at around £100.

Connecting to a computer, as mentioned before, is relatively straightforward for NMEA0183. You'll need an RS422 to USB adaptor, easily available from Farnell and other electronics specialists from about £25. Install the drivers, connect your NMEA0183 source to the adaptor and you're good to go.

For connecting NMEA2000 you'll need a proprietary adaptor. Actisense offer a converter to USB (about £110), or you can take the modern route of using an NMEA2000 to Wi-Fi gateway. These are pricey, starting from about £350, but have the advantage that the data is accessible to more than one device, including phones and tablets.

NMEA0183 to 2000 converter (top) and NMEA2000 to Wi-Fi bridge (bottom)

PBO conclusion

The overriding factor in choosing how to upgrade your system is cost. For small boats the advantages of a network are reduced, so the significant cost saving offered by going for stand-alone instruments may decide you.

On the other hand, if you want to future-proof, then NMEA2000 is the way to go. Adding and removing nodes is extremely easy, and we're seeing increasing integration with other onboard systems, eg engine management and lighting.

Mixed systems should be an area of caution. NMEA0183 is still commonly used for VHF connections and is hence still available on most plotters, but few will forward the data further over NMEA2000, so if you're trying to mix and match old and new it's worth working out the cost of the converters you need and offsetting them against newer, compatible kit. Converters have their place, but if further upgrades will make them redundant in a year or two then they could work out expensive.

Simple NMEA0183