WHITEPAPER

The Marine Industry
NMEA Boat Networks simplified

From 0183 to 2000, Ethernet to Future Net.

CONTENTS

INTRODUCTION

IF YOU WANT TO SELL ICE TO ESKIMOS FIND THOSE THAT DON'T UNDERSTAND ICE.

As boaties we should all understand to a minimal degree what NMEA is and how it affects our boat electronics purchasing decisions.

The core principals are easy, it's basically just a form of telephone network with some bells and whistles.

In this Whitepaper we will demystify NMEA and compare it to other networks and options, explain the choices that manufacturers make that control your paths through your technology's choices, and why.

There is quite a bit to cover, but it will be a short read and only factually deep enough, so you have an understanding.

Depth in detail will be linked so that you can dig deeper if you like, but the main audience for this whitepaper is my admiral - the bar was if she understands this with ease, then it should be within reach of most of my audience who are not technical.

THE PONY EXPRESS, WITH VERY SMALL PONY'S

When boat electronics first arrived, they were completely proprietary devices. Your boat speed device plugged directly into its monitor with a cable that just sent electric signals that no one understood apart from that monitor. There were different monitors for every different measuring device.

But someone thought, "What if we just sent simple information in a message, like a txt, then any device that understood how to read txt's would be able to use the data we sent."

The next thing was to link multiple devices together into a network, so if your boat speed device sent a txt saying you were doing 5kts, every other device that was interested would also receive it and understand it.

This was the dream of NMEA 0183. First published in January 1992 and based on standards for serial communications, think very early modems with dialup and fat plugs that connected your printer on your computer (if you are older than 40 you might remember). 0183 was not a true network in that it was a peer to peer serial connection and to connect multiple devices needed other devices called multiplexers.

Later came NMEA 2000, published in late 1997. It was still a slow network, but 50X faster than NMEA0183. It was based on a technology used for industrial machine communications and still used to program your car computer system today, called CANBUS (Controller Area Network, bus just being an analogy to a bus… carrying packages of information around).

Both 0183 (there were also predecessors) and 2000 (N2K for short) versions used the same data packets transferred around the network so adaptors could connect the two networks together if need be. It's a little more complex than that but not a lot.

Think of 0183 and N2K as being different types of telephone lines. If you need to connect the two together to get a message from a device on one to a device on another, it's not impossible but will need a convertor device in the middle.

So, what is the data that these networks send about?

Think of them like a txt message that has a structure, and you won't be too far away from the truth.

If you thought, the first word must say what the message is, then maybe one or two for who it's from, where it might be intended to go (could be everywhere) and then the data (5kts for instance for boat speed).

If you could imagine a text message structure that would do that, you might just have invented an NMEA packet. It's pretty simple.

Below is an example of a few 0183 GPS packets.

```
$GPGGA,092750.000,5321.6802,N,00630.3372,W,1,8,1.03,61.7,M,55.2,M,,*76
$GPGSA,A,3,10,07,05,02,29,04,08,13,,,,,1.72,1.03,1.38*0A
$GPGSV,3,1,11,10,63,137,17,07,61,098,15,05,59,290,20,08,54,157,30*70
$GPGSV,3,2,11,02,39,223,19,13,28,070,17,26,23,252,,04,14,186,14*79
$GPGSV,3,3,11,29,09,301,24,16,09,020,,36,,,*76
$GPRMC,092750.000,A,5321.6802,N,00630.3372,W,0.02,31.66,280511,,,A*43
$GPGGA,092751.000,5321.6802,N,00630.3371,W,1,8,1.03,61.7,M,55.3,M,,*75
$GPGSA,A,3,10,07,05,02,29,04,08,13,,,,,1.72,1.03,1.38*0A
$GPGSV,3,1,11,10,63,137,17,07,61,098,15,05,59,290,20,08,54,157,30*70
$GPGSV,3,2,11,02,39,223,16,13,28,070,17,26,23,252,,04,14,186,15*77
$GPGSV,3,3,11,29,09,301,24,16,09,020,,36,,,*76
$GPRMC,092751.000,A,5321.6802,N,00630.3371,W,0.06,31.66,280511,,,A*45
```

The $GPGGA tells the receiver that this packet (line here) is a GPS position data packet and the time (092750.000 = 9:27am) was when it was recorded, the latitude and longitude, fix quality, number of visible satellites etc. You get the idea. YOU DON'T NEED TO UNDERSTAND THESE SENTENCES, BUT THE CONCEPT OF HOW THEY ARE PUT TOGETHER IS VERY HELPFUL.

So now imagine you have a sounder, an anemometer, a GPS, and a compass, all sending messages every second around the network that everything is connected to, and you can start to understand that anything on that network can then see the speed, depth, wind direction, heading etc, updated every second.

This is simply how an NMEA network works. 0183 is slower and older. 2000 is faster and newer (but still slow).

These are called low bandwidth networks and are both based on similar industrial standards used elsewhere.

The future calls

NMEA 2000 sounds like it's a fast network, 50X faster than 0183, but in fact it's still a slow, rather industrial network, and not very flexible.

N2K have bandwidth capacities of less than 1Mbit/s. Whereas Ethernet, that passes data around the internet and your home computer, has capacity in the hundreds or thousands of megabits per second.

It also has support for what is called "unstructured" data. To give you an idea of what this means imagine if you had to describe the Mona Lisa via a txt message format. In pixel-by-pixel detail so that it could be presented on the computer screen in high definition as a brilliant colour image…. still think this is simple?

Unstructured data means to send data in a non-readable format that has a structure only understood by the consumer. So instead of describing the Mona Lisa you just transmit a picture or video of it.

This is something NMEA2000 can't do both because of the text format and because the volume of data would be so much higher.

This becomes very important when you start to deal with radar wanting to send geocoded video streams of the radar responses or live sonar images etc.

Enter OneNet, the next generation NMEA standard which is based on … you got it - ethernet and TCP/IP - the standards that drive the internet and your home and work computers.

So, if you understand what you can and can't do with your network at home you already understand the future boat networks.

Oh, if you're wondering why it took so long to get to NMEA OneNet (still not publicly available) perhaps we should consider that Ethernet and TCP/IP were mainstream in 1982 when the US military declared that TCP/IP was the main protocol for military networks and subsequently invented the internet.

This occurred 10 years before the definition of NMEA 0183? But back then they thought that TCP/IP was just simply overkill for a boat network and could not demonstrate sufficient environmental resiliency ("Marine") quality whereas Serial and CANBUS had proved itself in challenging environments.

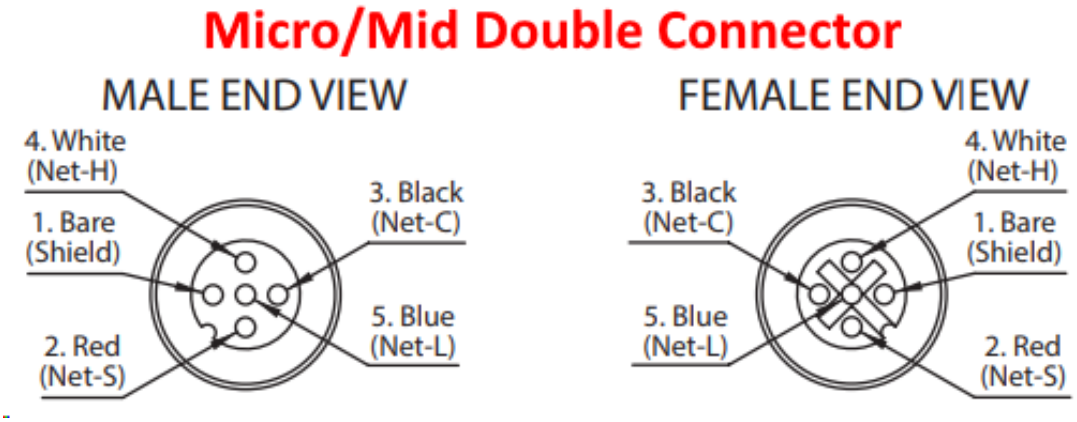
THE GOAL IS INTER-OPERABILITY, MIX AND MAX QUALITY BASED ON VALUE

The goal of NMEA (the National Marine Electronics Association) was to allow customers to choose their components based on individual qualities and be able to mix and match those with other companies components to get a value based system.

For instance, you could buy a B&G or Raymarine MFD because it offered the software and solidarity that you most wanted and have another manufacturers anemometer or sounder etc.

The idea would breed competition at the component level and improve the breed. Smaller competitors could compete in just one area of the boat electronic landscape.

BUT the problem with ideals is who's ideal?



ALL NMEA CABLES ARE NOT EQUAL OR, ARE THEY?

The NMEA standard described and prescribed a lot of the format and physical wiring standards for NMEA but not all. Manufacturers, if they wanted that coveted NMEA2000 compatible mark that indicated they were inter-operable, would need to comply with the basics, but they were, in particular able to add their own design of connectors to the NMEA network.

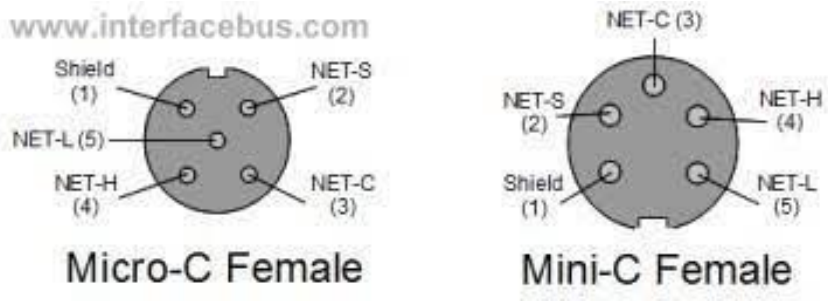
This resulted in a plethora of devices that were marked as NMEA2000 compatible (or 0183) but came with different connectors that meant it was prohibitive to connect different manufacturers products but easy to do so if you stayed within the family.

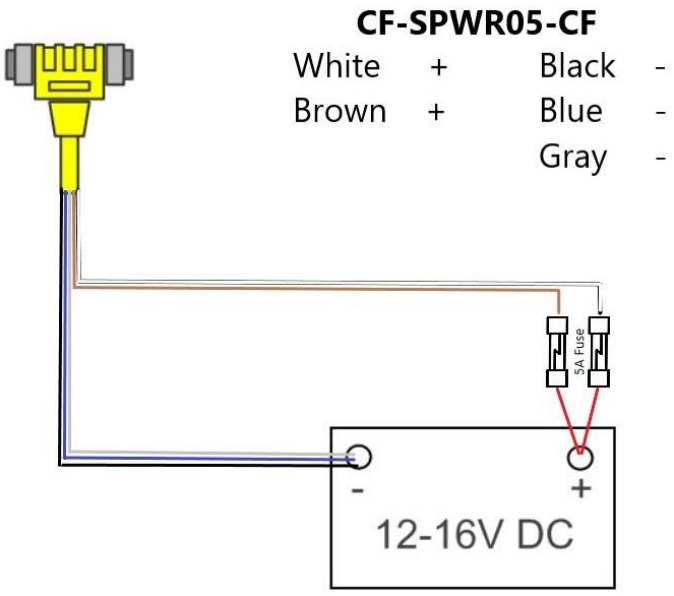
Even within the family different brands would use different connectors, In the Navico family there are at least four different standards of cabling and connectors.

But the thing to understand is that the underlying network is the same,

- Blue connects to blue
- Red connects to Red
- Black connects to Black
- White connects to White
- And shield is also common

The only difference in most of these networks is the connectors.





A QUICK WORD ABOUT POWER

NMEA networks and for that matter, Ethernet networks can provide power to low power device over their network, meaning you don't need separate power leads to some of the devices that connect to the NMEA network.

To accomplish this they have a switched power supply to one of the cables in the NMEA cabling.

Some will, because their power consumption will be too high for the power supply of the NMEA backbone. These will often times use a relay to switch a separate powerline on/off as the NMEA network is turned on/off.

Radar is an example of this style of relay switched power consumption, whilst your Sounder is usually completely powered by the NMEA connection itself.

This difference is only a consideration at install time, but to understand the conceptual information for making choices it is sufficient to understand Power over NMEA is possible, just as is PoE (Power Over Ethernet).

HOW TO IDENTIFY YOUR PARTICULAR NMEA NETWORK CONNECTORS

Raymarine SeaTalk:

Seatalk is an early version of NMEA and does not fully support NMEA gateways. To connect a gateway you need to be able to first get the network onto a SeaTalkNG network, which is more NMEA compatible. This is relatively simple and at worse will require an additional bridge.

Seatalk connector and Micro-c

Seatalk Connectors have a push fit plug with 5 connectors and a end view like this

Description of Seatalk can be found here

A seatalk backbone joiner looks like this

The colors represent what the cables are doing,

Color coded cables

Cables and connectors are color coded for easy identification and have a simple, watertight (IPx6) connection system (plug and lock)

- Backbone cables, terminators, plugs and sockets are marked in blue
- Spur cables, plugs and sockets are marked in white
- SeaTalk to SeaTalk ng converter cables, plugs and sockets are marked yellow
- SeaTalk ng power cables are marked red

Raymarine SeaTalk NG

Is very similar from a hardware point of view but is using protocols and datagrams that are NMEA 2000 compatible.

If you're backbone has yellow cables then it probably already has NMEA 2000 connectors attached.

SIMRAD SIMNET NMEA CONNECTORS

Many boats equipped with Navico products may have SIMNET installed as the backbone. My own boat that is B&G for just about everything has a SIMNET backbone, despite many components requiring a Micro-c Connector themselves.

SIMNET consists of a push to fit (sometimes with a screw faster cap) that is slightly smaller and different from Seatalk as below.

It has 5 connections and a key like slot in the middle. There is a flat spot on one side and the connector will only connect one way.

The sockets will look similar to this.

Micro-C connectors

Micro-c connectors are a standard connector for NMEA. They differ from Seatalk in that they are 4 ourside pins with a central inner pin.

Micro-c can also have its own backbone connectors but is often times required for connection to devices with an adaptor onto the backbone which may be different connectors.

Furuno NMEA Connectors

Furuno appear to come in both 5 pin and 6 pin connectors and possibly with Micro-c in addition.

Garmin NMEA

Later Garmin equipment mostly uses Micro-c compatible connectors to their credit. I am not sure about there earlier connector but will willing update this white paper as or when I learn more about Garmin.

WHY NOT HAVE THE FUTURE NOW?

Interestingly there are numerous NMEA gateways for sale these days that will allow you to plug your NMEA data into one end, but you might need an adaptor to get it to work depending on whether it is Micro, Mid, Mini, Micro-c or perhaps Seatalk NG etc.

In the other end you plug in your standard RJ45 ethernet connection, as in every computer device in the world use it. This will translate NMEA data onto your normal computer network.

Using Wi-Fi, you can then get it onto your iPhone or Android phone, tablet etc, where there are numerous programs that will understand the data format and display all your instruments on a screen for you, or control things or raise alarms when the wind raises too high et al.

A FINAL WORD ABOUT ETHERNET ON A BOAT

You've read that NMEA 0183 is slow and that N2K is 50X faster, but still very slow (<1Mbit/s). So how do marine companies cope with radar and sonar data?

Well, they connect the radar/sonar device using either a) ethernet cables and transmit the data using TCP/IP or b) they use Wi-Fi and TCP/IP, which are industry standards.

But just to keep you on your toes they will call it something like 'Raynet' (Raymarine), 'Navnet' (Furuno), or Garmin 'Marine Network'. B&G call it 'ethernet' to their credit, but it still has a proprietary cable and connector.

In places these connectors make sense. They are weather proofing, but in others they are seriously questionable as to the value to the consumer as opposed to the manufacturer. Garmin for instance have a proprietary weatherproof boot over a standard RJ45 - top marks for that. But others just have completely separate non-standard connectors.

So beware the integration wars and where you might need to re-wire to get things to work for you. The barrier is not as much physical as it is skill based emotional pressure.

P.S. below is a picture of the industry standard (non-marine) weatherproof Cat 6 Ethernet cable.

NEXT STAGES AND BEING READY FOR IT.

In the IT world, proprietary gave way to opensource and networks became universally standardised. Over 20 years ago the last of the proprietary networks (Token-ring networks) disappeared; many of my contemporaries don't even remember it.

After that standardisation, software driven data modelling started to take over and run the world. New features were introduced with new software and datagrams (ways of describing data).

In the marine world SignalK is probably the opensource heir to this throne.

Already we are starting to see marine devices that are expecting a waterproofed Cat 6 ethernet connection and will integrate their data via SignalK messages, through a highly standardised network. The same network we use on shore, but with some physical weather proofing.

High speed networks are the way forward and in the not-too-distant future your boat will require a TCP/IP network of some sort. Best start planning for it now.

KEY FINDINGS

- NMEA is a simple network. Nothing to be afraid of.

- Integrating different NMEA products can be difficult because of different connectors. Pay the price for an adaptor or cut it off and add your correct one on.

- High speed networks for Radar/Sonar et al suffer the very same issues. It can be worked around.

- For small amounts of money (~£200) you can break out your NMEA data onto your normal network and WiFi which opens a plethora of free or low cost high value software options to your boats navigational choices.

- SignalK is very possibly the opensource future of inter-operable marine components.

CONCLUSION

NMEA networks are fairly simple to understand. There is a lot of jargon and proprietary naming, not to mention connectors, around it, but basically, it's a standard network.

Obstacles to integrations of different manufacturers products are mostly able to be overcome with some effort. The degree of effort will determine the ease with which you make your choices.

High speed data networks, Ethernet/WiFi, open a completely different league of possibilities and opportunities for solutions onboard.

Waiting for OneNet to solve this problem is probably NOT worth the effort as it will invariably come with the same limitations and interoperability issues. Cheaper and easier to avoid now.

Key Takeaways

- NMEA is a simple network
- Complicated by differing manufacturers attempting to introduce proprietary connectors.
- Mostly a small barrier to inter-operability that can be overcome.
- The future is in High-speed network solutions and can be achieve now with low cost entry.
- Gateways to the future are already available and offer a lot of benefits.

NOTE: I understand that this can be daunting for the non-IT and as such freely offer my help and invite you to contact me if you need further help or advice. I don't see my time in doing this as anything more than paying back/forward what has already been offered to me for free during my learning curve as a sailor.

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Good luck with your future boat network.