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Actisense®
Award Winning NMEA Specialists
Webinar #1
Demystifying
NMEA Data Conversions

Andy Campbell

- Chief Engineer at Active Research Limited since 1998
- Actisense brand name created in 2001
- Over 20 years experience in designing, manufacturing and supporting NMEA products
- Over 12 years experience with NMEA Conversions
- Member of NMEA 0183, NMEA 2000 and NMEA OneNet Working Groups for more than 10 years

Thank you for taking the time to read/listen in to this webinar, it covers one of my favourite subjects and I hope you find it interesting.

My name is Andy Campbell and I have been the Chief Engineer at Active Research Limited since 1998, although we are better known by our Actisense brand name that was created in 2001.
We have over 20 years experience in designing, manufacturing and supporting a wide range of NMEA products in many markets around the world.
That includes 12 years of experience in today's subject of NMEA Data Conversions.
Finally, I have had the pleasure of sitting on each of the NMEA 0183, NMEA 2000 and NMEA OneNet Working Groups over the past 10 years.

In this training session

- Fundamentals of NMEA 0183 & NMEA 2000
- Hybrid networks and the need to convert data
- Introduce the Conversion data matrix
- Periodic and Unique message types
- Deep-dive into Conversion examples
- Discuss Conversion grey areas
- Request feedback for future Conversions

Whilst this training session cannot hope to demystify all questions regarding NMEA Conversions in the time available, the aim is to cover as many as possible and get feedback from you on any remaining points, which could become topics of future webinars or help us pick up these points with you offline.

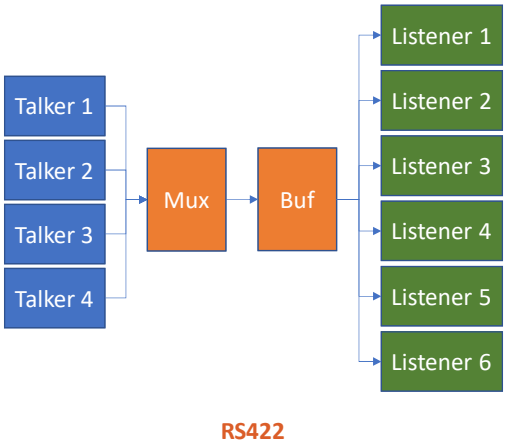
We will…

- Discuss some of the fundamentals of NMEA 0183 & NMEA 2000
- Detail hybrid networks and the need to convert data
- Introduce the conversion data matrix
- Discuss the difference between Periodic and Unique message types
- Deep-dive into a few data conversion examples
- Discuss some areas where data conversion is difficult or tricky
- Finally, there will be an opportunity for you to offer feedback on any questions that remain and ideas on future conversions you would like to see

NMEA Protocol fundamentals

NMEA Protocols

NMEA 0183



- Multiplexer is required for all networks of more than a single Talker device
- Isolating Buffer is required to keep devices electrically isolated whilst sharing NMEA 0183 data
- Multiplexer and Buffer topology creates a unidirectional data sharing network
- Data bandwidth (linked to baud rate) is very limited and must be managed
- Large number of NMEA 0183 devices still in use around the world
- RS422 networks can have section lengths up to 1000m
- Prevalent in Commercial Marine vessels

NMEA 0183 fundamentals

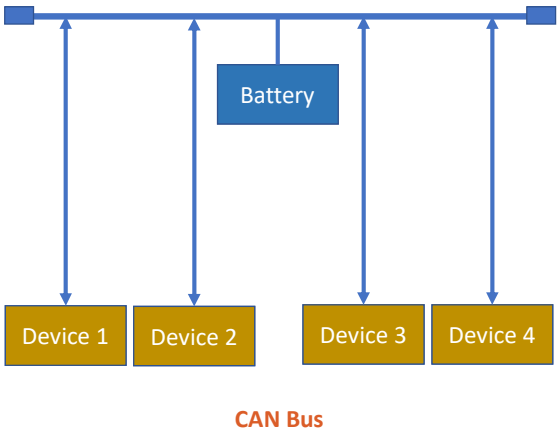
- A Multiplexer is required for all NMEA 0183 networks of more than a single Talker device
  – which can sometimes be a forgotten extra cost of NMEA 0183 installations
- A fully isolating Buffer (with floating outputs) is required
  – to keep NMEA 0183 devices electrically isolated from each other whilst sharing data
  – our experience has shown that this is a critical element of any high-reliability NMEA 0183 installation that should not be overlooked
- The topology of Multiplexers and Buffers create a unidirectional data sharing network
  – the diagram hopes to highlight the fact that typically data flows from left to right, Talker to Listener
  – the knock-on effects of this simple point can be unappreciated: it can hinder data sharing or greatly increase network complexity if bidirectional sharing is attempted
- Data bandwidth, which is dependent on baud rate, is very limited
  – this creates the necessity to manage data flow in order to prevent the overload condition
- There are still a significant number of NMEA 0183 devices in use around the world

– customer desire for these device to still be part of the data network is driving the need for hybrid NMEA networks

- The RS422 electrical layer of NMEA 0183 offers the ability to create network sections of up to 1000 metres
  – this ability is a key NMEA 0183 network strength
- Prevalent in Commercial Marine vessels
  – the inherent network length capability fits well to the physical distance requirements of the Commercial Marine environment

NMEA Protocols

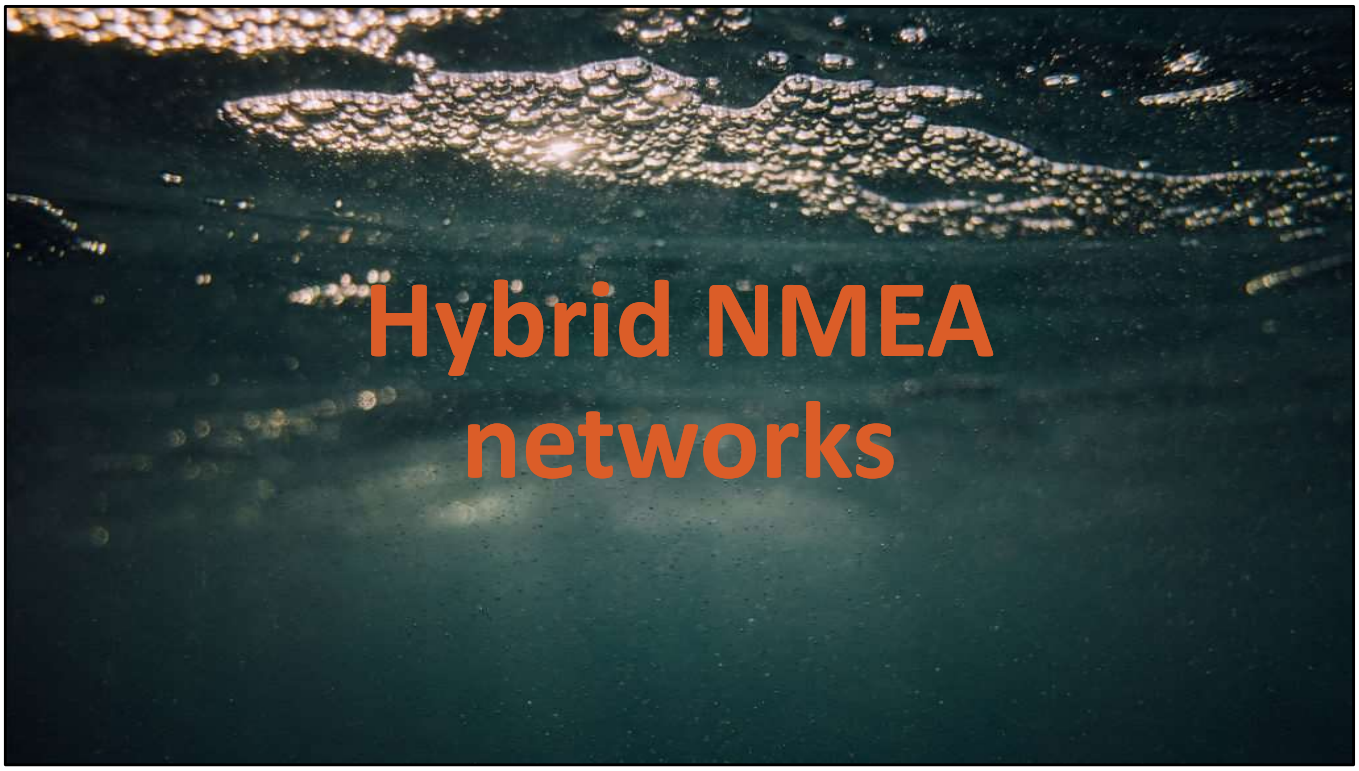
NMEA 2000



- Multiplexers and Buffer not required: the backbone multiplexes the data and isolates all devices whilst sharing data
- Topology creates a true bidirectional data sharing network
- Data bandwidth is typically not an issue that requires management
- CAN Bus network size is limited to 200m without using a Bridge
- Prevalent in Leisure Marine vessels
- Future expandable with NMEA OneNet to solve the physical CAN Bus limitations

NMEA 2000 fundamentals

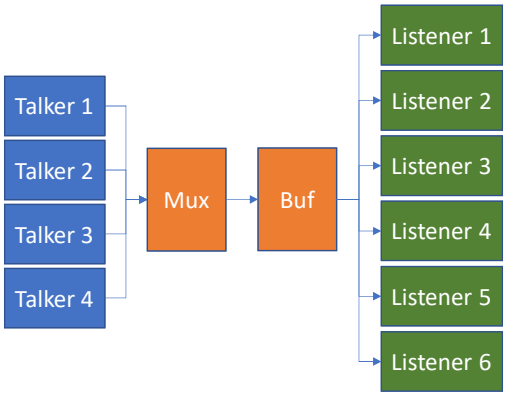
- Multiplexers and Buffer are not required
  – the NMEA 2000 backbone multiplexes the data together and opto-isolates all devices from each other, whilst sharing data
- The topology of an NMEA 2000 network creates a true bidirectional data sharing network
  – CAN Bus is a very impressive physical layer that offers many key abilities that can be easily ignored or unappreciated by its users
- Data bandwidth is typically not an issue that requires management
  – this helps reduce network maintenance needs
- CAN Bus network size is limited to 200 metres without using an NMEA 2000 Bridge
  – this limitation is one of the reasons NMEA 2000 has not seen wide adoption on Commercial Marine vessels
- Prevalent in Leisure Marine vessels
  – wide NMEA 2000 adoption by manufacturers and the subsequent dropping of NMEA 0183 support is driving the need for hybrid NMEA networks
- NMEA 2000 is future expandable with NMEA OneNet that helps to solve the physical CAN Bus limitations
  – this would make a good subject for a future training Webinar



Hybrid NMEA networks

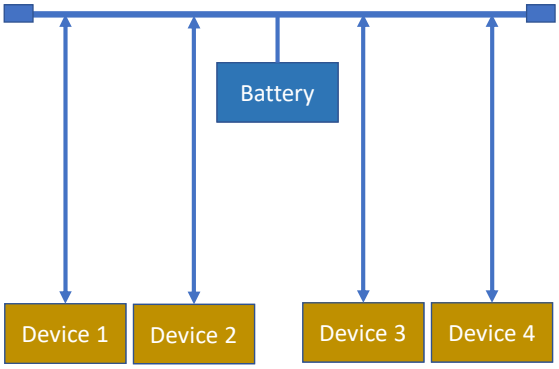
Hybrid Networks

NMEA 0183



RS422

NMEA 2000



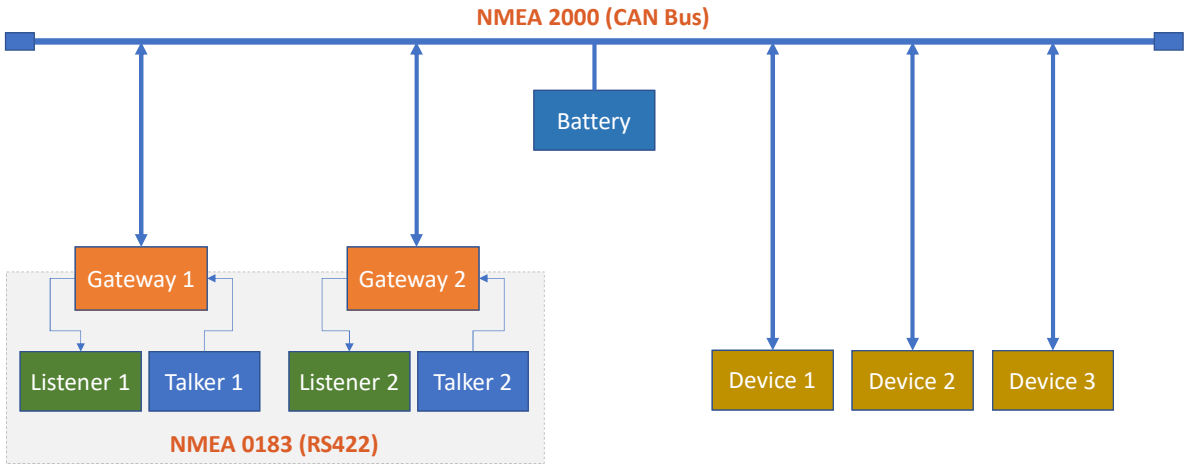
CAN Bus

These two diagrams highlight the very different topologies of NMEA 0183 and NMEA 2000 networks.

It can be argued that the Leisure Marine market's transition to NMEA 2000 has helped create a more integrated data network that has offers the end customer far more capabilities.
However that transition, coupled with many end users desiring to continue using existing "perfectly good" NMEA 0183 devices and the subsequent removal of NMEA 0183 ports from NMEA 2000 devices, has created the need for hybrid NMEA network solutions.

So, how can data be shared between these disparate networks?

Hybrid Networks



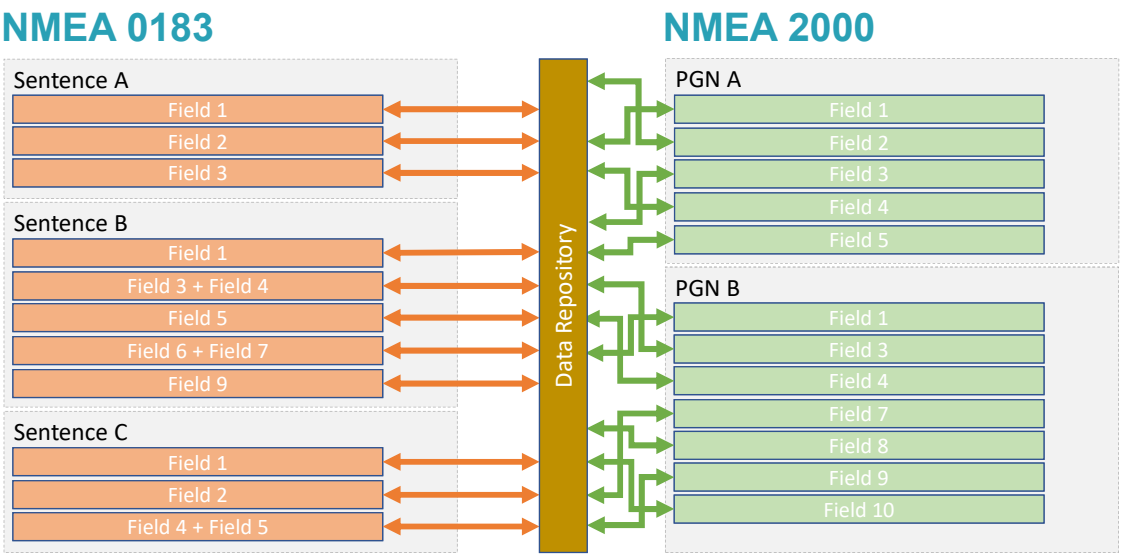
The NMEA 2000 Gateway is the answer and two of them are represented in this Hybrid network diagram by the orange devices.
The NMEA 0183 Listener and Talker functions are shown separately here to highlight the important point that they could be two different devices, if bidirectional data sharing is not required.

Using an individual NMEA 2000 Gateway for each NMEA 0183 Talker or Listener offers many benefits over the alternative idea of using an NMEA 0183 Multiplexer:

- Easy bidirectional sharing of data
- Each NMEA 0183 data source is individually represented on the NMEA 2000 network
- When using an NMEA 2000 Gateway with a floating NMEA 0183 Talker output, isolation of NMEA 0183 devices is easy – improving the reliability of the installation
- Gateway configuration – of what messages to convert and which to ignore – can be easier, with less compromises required
- For 3 or less NMEA 0183 Talkers and Listeners, the cost of network components and installation will be less – that can even be shown to expand to 4 devices, under certain circumstances

Conversions

Conversion Matrix



As the inner workings of NMEA 2000 Gateways vary from manufacturer to manufacturer, this last section will need to focus on how the Actisense NGW-1 and W2K-1 perform their NMEA Conversions.

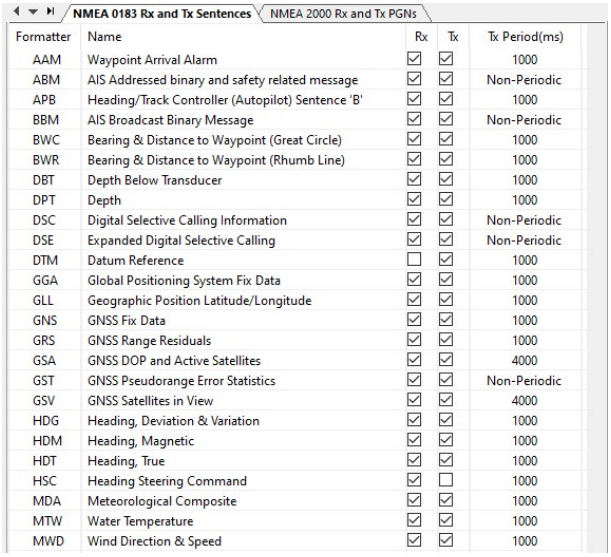
This diagram attempts to break down some of the complexities of the Conversion Matrix.
Three key points to highlight are:
– Sentences and PGN messages are received, their data field values decoded, and the data stored in a Data Repository.
– Some NMEA 0183 data values require combining two adjacent fields to complete the decode – for example, the Latitude numerical field value is combined with the following North or South field before storing the full Latitude value in the Data Repository
– When it's time to output a Sentence or PGN, the Data Repository is checked to see if it contains enough relevant values to build up a new message.

A Data Repository allows the reception on one side and transmission on the other to be completely asynchronous from each other, which in turn allows the NMEA 2000 Gateway to cope with different reception and transmission message rates.

Message Types

Periodic messages

- Update/repeat rate is between 50 milliseconds (20 Hz) and 4000 milliseconds (1/4 Hz)
- Majority of Sentence and PGN messages are periodic



NMEA 0183 Rx and Tx Sentences | NMEA 2000 Rx and Tx PGNs

Formatter	Name	Rx	Tx	Tx Period(ms)
AAM	Waypoint Arrival Alarm	☑	☑	1000
ABM	AIS Addressed binary and safety related message	☑	☑	Non-Periodic
APB	Heading/Track Controller (Autopilot) Sentence 'B'	☑	☑	1000
BBM	AIS Broadcast Binary Message	☑	☑	Non-Periodic
BWC	Bearing & Distance to Waypoint (Great Circle)	☑	☑	1000
BWR	Bearing & Distance to Waypoint (Rhumb Line)	☑	☑	1000
DBT	Depth Below Transducer	☑	☑	1000
DPT	Depth	☑	☑	1000
DSC	Digital Selective Calling Information	☑	☑	Non-Periodic
DSE	Expanded Digital Selective Calling	☑	☑	Non-Periodic
DTM	Datum Reference	☐	☑	1000
GGA	Global Positioning System Fix Data	☑	☑	1000
GLL	Geographic Position Latitude/Longitude	☑	☑	1000
GNS	GNSS Fix Data	☑	☑	1000
GRS	GNSS Range Residuals	☑	☑	1000
GSA	GNSS DOP and Active Satellites	☑	☑	4000
GST	GNSS Pseudorange Error Statistics	☑	☑	Non-Periodic
GSV	GNSS Satellites in View	☑	☑	4000
HDG	Heading, Deviation & Variation	☑	☑	1000
HDM	Heading, Magnetic	☑	☑	1000
HDT	Heading, True	☑	☑	1000
HSC	Heading Steering Command	☑	☐	1000
MDA	Meteorological Composite	☑	☑	1000
MTW	Water Temperature	☑	☑	1000
MWD	Wind Direction & Speed	☑	☑	1000

A critical idea to grasp when you need to configure an advanced NMEA 2000 Gateway, such as the NGW-1, is understanding the difference between Periodic and Non-Periodic messages.

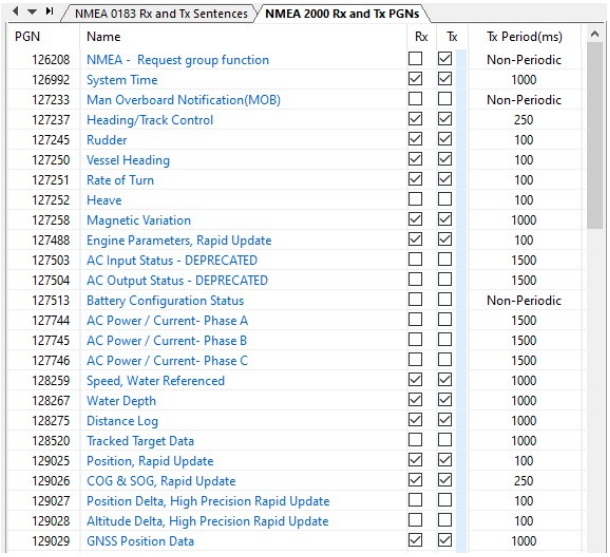
The majority of NMEA 2000 PGNs are periodic in nature, where the data inside those messages updates or refreshes at a specific rate – once, twice or even twenty times per second for example.

The screenshot on the right is taken from the freely available Actisense Toolkit that offers fine tune configuration of which messages are enable and the individual message transmit rates.

Message Types

Non-Periodic messages

- No defined update/repeat rate
- AIS messages
- Alarm messages
- Configuration messages
- DSC messages
- Route messages
- Configuration & Programming operations



NMEA 0183 Rx and Tx Sentences | **NMEA 2000 Rx and Tx PGNs**

PGN	Name	Rx	Tx	Tx Period(ms)
126208	NMEA - Request group function	☐	☑	Non-Periodic
126992	System Time	☑	☑	1000
127233	Man Overboard Notification(MOB)	☐	☐	Non-Periodic
127237	Heading/Track Control	☑	☑	250
127245	Rudder	☑	☑	100
127250	Vessel Heading	☑	☑	100
127251	Rate of Turn	☑	☑	100
127252	Heave	☐	☐	100
127258	Magnetic Variation	☑	☑	1000
127488	Engine Parameters, Rapid Update	☑	☑	100
127503	AC Input Status - DEPRECATED	☐	☐	1500
127504	AC Output Status - DEPRECATED	☐	☐	1500
127513	Battery Configuration Status	☐	☐	Non-Periodic
127744	AC Power / Current- Phase A	☐	☐	1500
127745	AC Power / Current- Phase B	☐	☐	1500
127746	AC Power / Current- Phase C	☐	☐	1500
128259	Speed, Water Referenced	☑	☑	1000
128267	Water Depth	☑	☑	1000
128275	Distance Log	☑	☑	1000
128520	Tracked Target Data	☐	☐	1000
129025	Position, Rapid Update	☑	☑	100
129026	COG & SOG, Rapid Update	☑	☑	250
129027	Position Delta, High Precision Rapid Update	☐	☐	100
129028	Altitude Delta, High Precision Rapid Update	☐	☐	100
129029	GNSS Position Data	☑	☑	1000

In contrast, non-Periodic messages are typically unique in nature, which means that the data inside those messages is unique each time or at least the update or refresh rate is undefined.
This includes AIS, Alarm, Configuration, Digital Selective Calling and Route messages, plus configuration and programming operations.

AIS messages are interesting as they fall into a grey area because it could be argued that they are periodic, however as that period is extremely long, being up to 6 minutes for the Message 5 from a Class A transponder, they are treated as non-periodic.

Conversion examples

NMEA 0183

Message Details

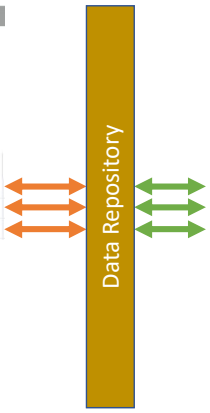
Formatter DPT

Depth

Length = 22

Number of fields = 3

Field	Name	Data	Units
1	Depth	10.0 Metres	
2	Offset	-0.4 Metres	
3	Range	100.0 Metres	



NMEA 2000

Message Details

PGN 128267 / 1F50B

Water Depth

Source Address 2 to 255 (Global), Priority 3, 4 data fields

Field	Name	Data	Units
1	Sequence ID	225	
2	Water Depth, Transducer	10.00	Metre
3	Offset	-0.400	Metre
4	Maximum Depth Range	100	Metre

These screenshots are taken from EBL Reader, our freely available Electronic Binary Log Viewer application.

Water Depth is one of the simplest Conversion Matrix mappings between NMEA 0183 and NMEA 2000 that is direct and logical.

Approximately 40% of the Conversion Matrix contains straightforward mappings like this one.

Conversion examples

NMEA 0183

Message Details

Formatter RMB

Recommended Minimum Navigation Information

Length = 81

Number of fields = 12

Field	Name	Data
1	Positioning System Status	A
2	Cross Track Error	0.24 NM
3	Direction to steer, L/R	Right
4	Origin Waypoint ID	1-121021
5	Destination Waypoint ID	2-121025
6	Destination Waypoint Latitude, N/S	51° 25.000' N
8	Destination Waypoint Longitude, E/W	003° 33.283' E
10	Range to Destination	0.6285 NM
11	Bearing to Destination	230.897° True
12	Destination Closing Velocity	2.657 Knots
13	Arrival Status	V
14	Mode Indicator	A

Data Repository

NMEA 2000

Message Details

PGN 129283 / 1F903

Cross Track Error

Source Address 2 to 255 (Global), Priority 3, 6 data fields

Field	Name	Data	Units	User Data	User Units
1	Sequence ID	239			
2	XTE Mode	0 (Autonomous mode)			
3	NMEA Reserved				
4	Navigation Terminated	3 (Null, Unavailable, Unkn...			
5	XTE	-444.48	Metre		
6	NMEA Reserved				
7	ETA Time	Data not available	Second	Data not avail...	
8	ETA Date	Data not available	Date	Data not avail...	
9	Bearing, Origin To Destination ...	Data not available	Radian	Data not avail...	Degree
10	Bearing, Position To Destination...	4.0302	Radian	230.913	Degree
11	Origin Waypoint Number	Data not available		Data not avail...	
12	Destination Waypoint Number	Data not available		Data not avail...	
13	Destination Wpt Latitude	51° 24.999960' N	Degree	51.4166660°	Degree
14	Destination Wpt Longitude	03° 33.282960' E	Degree	3.5547160°	Degree
15	Waypoint Closing Velocity	1.37	Metre Per Second	2.66	Knots

The remaining 60% of the Conversion Matrix becomes increasingly complex and this is where the vast experience we have amassed over the past 12 years becomes significant. Through customer feedback, help from other manufacturers such as Raymarine and our own investigations, the sometimes very subtle nuances of NMEA Conversions have been tweaked and honed to deliver a reliable output.

This example highlights a few interesting points:

– NMEA 2000 distances are represented in metres and NMEA 0183 distances in Nautical Miles. In the case of Direction to steer in RMB, “Right” becomes a negative distance in PGN 129283. You can see that mapping from field 10 on left to field 2 on right.

– All NMEA 2000 angles are represented in Radians, which are not human friendly, so EBL Reader offers the option to view them in more traditional degrees in the “User Data” column. You can see that mapping from field 12 on left to field 10 on right.

– You will notice the very slight differences between NMEA 0183 and NMEA 2000 data field values, this is due to the different resolutions and conversion between the two. We have focused on keeping this difference negligible.

– The data field values in RMB are stored in the Data Repository and then used to generate two PGNs: 129284 is shown now… and here is PGN 129283.

– This type of one to many mappings, and even many to many mappings are common for these complex message mappings.

Conversion grey areas

NMEA 0183

- Transducer Measurements (XDR) Sentence

NMEA 2000

- Temperature PGN, Pressure PGN and Engine Parameters PGN

Transducer	Type Field	Units Field	ID
Current	I	A = Amperes	NMEA Defined: "Battery#X" "Alternator#X" "Converter#X" "Inverter#X" "SolarCell#X" "WindGen#X"
Displacement (Angular)	A	D = degrees P = percentage of full range	NMEA Defined: "EngineTilt#X" "Trim#X" "Trim" "Heel" "Rudder#X" "Rudder" "Leeway" "Yaw" "Pitch" "Roll"
Displacement (Linear)	D	M = meters P = Percentage of full range	NMEA Defined "Door#X" "Window#X"
Flow Rate	R	I = Liters/second	NMEA Defined: "Fuel#X" "FreshWater#X" "WasteWater#X" "LiveWater#X" "Oil#X" "BlackWater#X" "BrineWater#X"

There are a couple NMEA data conversions that fall into grey areas, that come up from time in Tech Support, and I feel it is helpful to discuss and dispel them here:

The first grey area concerns XDR and the NMEA 2000 PGNs that it could map to, such as the Temperature, Pressure and Engine Parameters PGNs.

XDR is an NMEA 0183 generic Transducer Measurements sentence that was intended to replace several sentences that were subsequently deprecated, such as the Meteorological sentence MDA, but that has never happened. The reason for that is because the contents of an important sentence field were not defined, greatly limiting its real-world use. As it has been easy for NMEA 0183 Listeners to subsequently misunderstand the real meaning of each XDR sentence implemented by different manufacturers, it was deemed too problematic to add that conversion to the NGW-1.

However, to help improve this grey area, in 2016 Actisense proposed to the NMEA 0183 Working Group, the missing definitions for the ID string field that could make XDR useable in practice. Some of those strings are highlighted in orange in this table. That proposal was accepted and I'm happy to say that the new definitions were released with NMEA 0183 v4.11 last year. Now, with the hope of triggering MFD manufacturers into implementing the necessary decode in their products, XDR conversions will be added to the NGW-1 when we next revisit the Conversion Matrix.

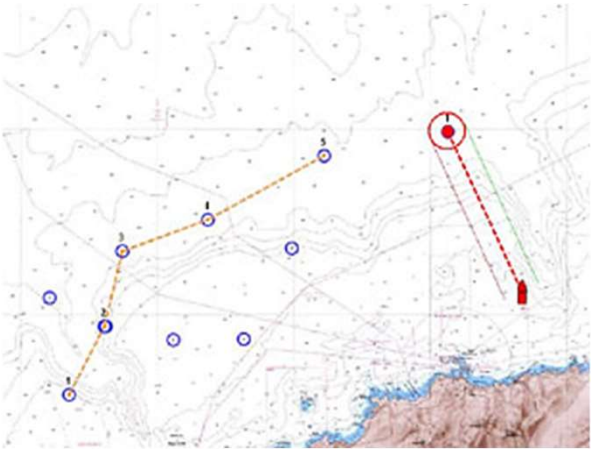
Conversion grey areas

NMEA 0183

- Waypoint to Waypoint Bearing (BWR & BWW)
- Waypoint to Waypoint Distance (WNC)
- Waypoint Location (WPL)
- Routes (RTE)

NMEA 2000

- Route and Waypoint Service PGNs



The second grey area concerns Routes and Waypoints – this is large subject so I can only touch on the high-level details here:

At the base layer, NMEA 2000 waypoint identifiers can only handle pure numeric values – this is an important point to grasp. This can be a barrier when wanting to convert waypoint details between NMEA 0183 and NMEA 2000 as users are used to defining NMEA 0183 waypoints as a text string. The current workaround is to define all NMEA 0183 waypoint names as numeric.

There exists a higher 'Service' layer to NMEA 2000 waypoints that can wrap and expand this base layer, however that is extremely complicated and consists of 11 separate PGNs. In addition, through discussing this subject with engineers on NMEA Working Groups, it quickly became clear that the major marine manufacturers are not using this waypoint 'Service' and have instead designed their own proprietary methods to share waypoint details between their own devices. This is the reason the NGW-1 does not support this waypoint 'Service' layer – simply put because no device is listening, so there is no point.

As a final point, I have a hope that NMEA OneNet will help solve this issue and allow waypoint sharing to become open again.

Feedback and Future Conversions

How can Actisense help you?

The NMEA 2000 Range

NGW-1 NMEA 2000® Gateway

NMEA 2000® Gateway

Hook up to NMEA 2000 whilst keeping currently installed NMEA 0183 devices.

The NGW-1 provides an uncomplicated way to link between a boat's data networks and converts NMEA 0183 data into NMEA 2000 data and vice-versa.

Multiple NGW-1 units can be used to multiplex numerous NMEA 0183 devices onto the NMEA 2000 network, using the network as a means of combining and transferring all data from one place to another.

For those of you not yet familiar with our NMEA 0183 to NMEA 2000 Gateway – The **Actisense NGW-1** is one of the most sophisticated on the market with a large and mature library of useful bi-directional conversions.
That same conversion library is used inside our NMEA 2000 Wi-Fi Gateway, the **Actisense W2K-1**, to allow sharing of NMEA data over Wi-Fi networks.

Just a quick reminder that our recently launched Knowledge Base on the Actisense website is the best place to find answers to regularly asked questions on these and any our products.

Does anyone have a new conversion or feature they would like us to add to the NGW-1 or W2K-1?

Thank you for joining us today…

ANY QUESTIONS?

Please write any questions you may have in to the “Q & A” area of the webinar interface and we will try to answer them

Thank you for reading/listening and I hope you found it interesting.
Please send any technical questions you may have using this Support link
https://www.actisense.com/support/contact-us/
and we will try to answer them…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Webinar #1
Demystifying
NMEA Data Conversions