Amtiri

REFERENCE MANUAL

# NMEA

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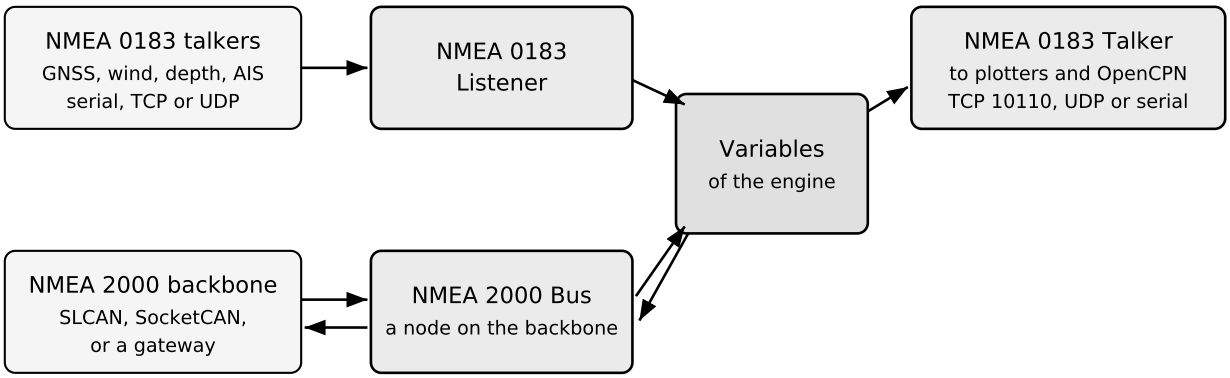


NMEA is how a boat's instruments talk: a GNSS receiver's position, a wind instrument, a depth sounder, an AIS receiver, an engine. Three modules speak it. Two speak **NMEA 0183**, the line-of-text protocol where one talker drives a wire and anyone listens; one speaks **NMEA 2000**, the CAN backbone newer instruments share.

| Module | What it does | Typical use |
|---|---|---|
| `NMEA-0183-Listener` (NMEA 0183 Listener) | Takes the fields of the sentences a talker sends into variables | A GNSS receiver's fix, a wind instrument, AIS targets, a multiplexer's feed |
| `NMEA-0183-Talker` (NMEA 0183 Talker) | Builds sentences from variables and serves them; takes what a client sends back into variables | Feeding a chart plotter or OpenCPN with values the instance holds |
| `NMEA-2000` (NMEA 2000 Bus) | Takes parameter groups off a backbone into variables, and sends variables onto it as a node | Reading a vessel's position, depth, wind and engines without a gateway converting them |

**Enable**, **Name** and the **Status and messages** tab work the same way in every module. They are described in Settings every module shares.

> **Important**
>
> **Data Orchester reads and writes NMEA 2000 parameter groups; it is not NMEA 2000 certified.** Its definitions of the groups are canboat's, reverse-engineered from public sources and published under the Apache License 2.0, because the official database is for members only. The engine claims an address and answers what other devices ask a node, but holds no NMEA certification and no NMEA manufacturer code. Where a tender asks for certified equipment, put a certified gateway between the backbone and the engine.

## Addresses

Every row of the three modules names a variable and an **address**: which value of which sentence or group it is.

**NMEA 0183** addresses are `[talker]SENTENCE[selectors]:field`.

- `GGA:latitude` is the latitude of any talker's GGA sentence; `GPGGA:latitude` only that of the talker `GP`.
- A field's name is marineapi's, which the editor lists for each sentence: `GGA:satelliteCount`, `RMC:speed`, `MWV:angle`. A position is two fields, `latitude` and `longitude`; a time and a date are ISO 8601 text.
- AIS messages are addressed under `AIS`, whichever type they are and whether VDM or VDO carried them: `AIS[MMSI=257123456]:speedOverGround` is that vessel's speed from whichever position report last gave it.

**NMEA 2000** addresses are `PGN[selectors]:field`.

- `128267:depth` is the depth of any sounder; `129025[src=12]:latitude` only the position from the device at source address 12, when two receivers are on the backbone.
- A field's name is canboat's, which the editor lists for each group with its unit. A field of a repeating set takes its position after a dot: `129540:snr.3` is the third satellite's.

A **selector** is a field that must hold a value for the sentence or group to count: `MWV[true=false]:angle` is the apparent wind angle and not the true one, which MWV sends under the same name, and `127488[instance=1]:speed` is the starboard engine's speed. In an NMEA 2000 address `src` is the sender and `dst` the destination; a lookup field may be selected by its name or its number. In a forwarder a selector is a field **sent** as a constant: `GPRMC[status=ACTIVE]:latitude` sends RMC marked valid. Names are matched whatever their case.

**Units.** NMEA 0183 values are in the sentence's own units - knots, degrees, metres - as the talker sent them. NMEA 2000 values are in SI units, as canboat defines each field: radians, metres per second, kelvin, pascal. A lookup field, such as a wind reference, holds its name as text (`Apparent`); a value the sender marks as not available is not written at all.

## NMEA 0183 Listener

The `NMEA-0183-Listener` module listens to one talker, or to a multiplexer that combines several. **Collectors** take fields of its sentences into variables. NMEA 0183 is simplex: nobody answers a talker, so this module only listens.

### Settings

| Key | Setting | Type | Default | Meaning |
|---|---|---|---|---|
| `transport` | Transport | text | `serial` | `serial` reads a serial port, `tcp` connects to a multiplexer's feed, `udp` listens for broadcast sentences |
| `serialPort` | Serial port | text | (empty) | `serial`: the device, such as `/dev/ttyUSB0` or `COM3`. The editor offers the ports it finds on the server |
| `bauds` | Bauds | int | `4800` | `serial`: the line speed. NMEA 0183 runs at 4800; AIS receivers and fast multiplexers at 38400 |
| `host` | Host | text | (empty) | `tcp`: the multiplexer's address |
| `port` | Port | int | `10110` | `tcp`: the port to connect to. `udp`: the port to listen on |
| `collectors` | Collector | list of rows | empty | The fields taken into variables |

## Collectors

| Key | Column | Type | Default | Meaning |
|---|---|---|---|---|
| `field` | Variable | variable code | (none) | The variable the field is written to |
| `address` | Address | text | (empty) | The field, as Addresses says |
| `minIntervalMs` | Minimum interval [ms] | int | (empty) | The least time between two writes of the variable. Empty or 0: every change |

The **Type / problem** column is not stored: it shows the variable type the field yields, or what is wrong with the address. The picker above the table lists every sentence the library reads and the fields of the one chosen, with their types; **Add as collector** adds a row for them.

## Behaviour

- **Opening.** The transport, and every row's address, are checked first: an address that does not parse, or names a sentence or field the library does not have, stops the module opening, with a message naming the row.
- **The source.** On `serial` and `tcp` the module keeps the port or the connection open, and opens it again every 2 seconds when it goes. On `udp` it listens on the port, on every network interface.
- **Only what is mapped is read.** A sentence no collector names is passed over without being parsed.
- **Checksums.** A sentence that carries a checksum must match it; one that does not is dropped. A sentence with no checksum is taken as it is. Anything before the `$` or `!` - a tag block, a gateway's timestamp - is ignored.
- **Lost sentences.** A sentence with a bad checksum, or one the library cannot read, is dropped and counted. While sentences keep being lost the module warns, with the count; the warning ends once a minute has passed without one. A bad sentence costs that sentence and nothing else.
- **AIS.** A message split over several VDM sentences is put back together before it is read. A message type the library does not decode is passed over.
- **Values.** A field the talker left empty writes nothing: an empty field is the talker saying it does not know. A value lands only when it differs from the last one written, and no sooner than `minIntervalMs` after it; the last value is never lost, it waits for the interval to end. Values are written through the engine's event queue.

## Messages

All texts are in English; the full list is in Module messages. "then `ERROR`" follows `errorAfterSeconds` in Settings every module shares. `{server}` and `{bus}` name the source as `NMEA 0183 on /dev/ttyUSB0` or `NMEA 0183 at host:port`; `{mapping}` is the variable's code.

| When | Level | Text |
|---|---|---|
| Opening: a transport that is not one of the three | `ERROR` | `'{transport}' is not serial, tcp or udp` |
| Opening: `serial` with no port, or `tcp` with no host | `ERROR` | `No serial port` or `No host` |
| Opening: an address that does not parse | `ERROR` | `{mapping}: {reason}` |
| Opening: a sentence the library does not read | `ERROR` | `{mapping}: {sentence} is not a sentence this module reads` |
| Opening: a field the sentence does not have | `ERROR` | `{mapping}: {sentence} has no field '{field}'` |
| Opening, `udp`: the port cannot be bound | `ERROR` | `Cannot listen on port {port}: {reason}` |
| `udp`: listening | `INFO` | `Listening on port {port}` |
| The port or connection is open | `INFO` | `Connected to {server}` |
| The port or connection could not be opened, or was lost | `WARNING`, then `ERROR` | `Disconnected from {server}`, then `Bus {bus} unavailable: {reason}` |
| Sentences with a bad checksum | `WARNING` | `Bad checksum on {n} sentence(s)` |
| Sentences the library could not read | `WARNING` | `{n} unreadable sentence(s) discarded: {reason}` |
| A value its variable's declared type refuses | `WARNING` | `Output {output} refused {value}: {reason}` |
| The engine's event queue is full | `WARNING` | `Event queue full: {count} events pending, {dropped} dropped` |

> **Tip**
>
> On Linux, the account the service runs as needs access to the serial device, usually through the group that owns it (`dialout` on Debian and Ubuntu). Without it the module reports the port as unavailable.

## Example

A GNSS receiver on a USB serial adapter, and the AIS position of one vessel from the same multiplexed line:

```
Transport      serial
Serial port    /dev/ttyUSB0
Bauds          38400

Collector    GNSS_LAT      GGA:latitude
Collector    GNSS_LON      GGA:longitude
Collector    GNSS_SATS     GGA:satelliteCount
Collector    COG           RMC:course                                1000
Collector    TUG_SOG       AIS[MMSI=257123456]:speedOverGround       5000
```

The position follows every GGA. The course is written at most once a second, and the tug's speed at most every five seconds, whatever rate the talker sends at.

# NMEA 0183 Talker

The `NMEA-0183-Talker` module builds NMEA 0183 sentences from variables and sends them. Served on TCP it is a server, as the Modbus TCP slave is: chart plotters, OpenCPN and other engines connect to its port, port 10110 by convention, and each is served the same sentences. It can also broadcast on UDP, or be the talker on a serial line.

**Forwarders** build the sentences. **Collectors** take the sentences a client sends back on its connection, or the serial port receives - an autopilot's heading, a route - into variables, exactly as the listener's do.

## Settings

| Key | Setting | Type | Default | Meaning |
|---|---|---|---|---|
| `transport` | Transport | text | `tcp-server` | `tcp-server` serves clients, `udp` broadcasts, `serial` drives a serial port |
| `port` | Port | int | `10110` | `tcp-server`: the port to listen on, on every network interface. `udp`: the port sent to |
| `maxClients` | Maximum clients | int | `8` | `tcp-server`: how many clients are served at once. One more is refused |
| `host` | Host | text | `255.255.255.255` | `udp`: where to send. The default is the local network's broadcast address |
| `serialPort` | Serial port | text | (empty) | `serial`: the device |
| `bauds` | Bauds | int | `4800` | `serial`: the line speed |
| `talkerId` | Talker identifier | text | `II` | The talker of a sentence whose address names none. `II` is integrated instrumentation |
| `forewarders` | Forwarder | list of rows | empty | The fields sent from variables. The stored key is spelled `forewarders` |
| `collectors` | Collector | list of rows | empty | The fields taken from what clients send back |

## Forwarders and collectors

A forwarder row uses `field`, `address` and `intervalMs`. A collector row uses `field`, `address` and `minIntervalMs`.

| Key | Column | Type | Default | Meaning |
|---|---|---|---|---|
| `field` | Variable | variable code | (none) | Forwarder: the variable a field is built from. Collector: the variable written |
| `address` | Address | text | (empty) | The field, as Addresses says |
| `intervalMs` | Interval [ms] | int | (empty) | Forwarders: also send the sentence on this clock, whether or not anything changed. Empty or 0: on change only |
| `minIntervalMs` | Minimum interval [ms] | int | (empty) | Collectors: the least time between two writes of the variable |

**Rows of one sentence make one sentence.** Every forwarder whose address names the same talker, sentence and selectors fills the same sentence: `GPRMC:latitude`, `GPRMC:longitude` and `GPRMC:speed` are one RMC line. It is sent when any of their variables changes, with the current value of each, and on the shortest interval any of them asks for. The picker is the sentence builder: it lists the sentences the library can write and, for the one chosen, the fields it can fill.

## Behaviour

- **Opening.** Every forwarder is checked: its sentence and field must be ones the library can write, a position needs both `latitude` and `longitude` in the same sentence, AIS is refused because it is received and never sent, and the talker must be a known one. Collectors are checked as the listener's are. `tcp-server` binds its port here, so a port another program holds is the module's status at Start.
- **Building.** marineapi encodes the sentence and its checksum. A variable that holds nothing yet leaves its field empty, which is what NMEA 0183 means by unknown. A selector is a field sent as a constant.
- **Clients.** Each client is served from a queue of its own, of 256 sentences. A client that stops reading is dropped when its queue fills, so it never slows the others; one that disconnects takes nothing with it.
- **What clients send back.** Each client's lines are read as the listener reads a talker's, checksums and counting included, and land in the collectors' variables.
- **Plotters.** A chart plotter plots RMC only when it is marked valid: send it as `RMC[status=ACTIVE]:…`.

## Messages

All texts are in English; the full list is in Module messages. `{message}` is the sentence, as `GPRMC[status=ACTIVE]`.

| When | Level | Text |
|---|---|---|
| Opening: a transport that is not one of the three | `ERROR` | `'{transport}' is not tcp-server, udp or serial` |
| Opening: `serial` with no port, or `udp` with no host | `ERROR` | `No serial port` or `No host` |
| Opening, `udp`: the host cannot be resolved | `ERROR` | `Cannot send to {host}: {reason}` |
| Opening: an address that does not parse, or names nothing | `ERROR` | `{mapping}: {reason}`, `{mapping}: {sentence} is not a sentence this module reads` or `{mapping}: {sentence} has no field '{field}'` |
| Opening: AIS in a forwarder | `ERROR` | `{mapping}: AIS is received, not sent` |
| Opening: a field the library cannot write | `ERROR` | `{mapping}: {field} cannot be written into {sentence}` |
| Opening: half a position | `ERROR` | `{mapping}: a position needs both latitude and longitude` |
| Opening: an unknown talker | `ERROR` | `{mapping}: '{talker}' is not a talker identifier` |
| Opening, `tcp-server`: the port cannot be bound | `ERROR` | `Cannot listen on port {port}: {reason}` |
| `tcp-server`: listening | `INFO` | `Listening on port {port}` |
| A client connected | `INFO` | `Client {address} connected` |
| A client disconnected | `WARNING` | `Client {address} disconnected`, cleared when it connects again |
| One client more than `maxClients` | `WARNING` | `Invalid request discarded: {address} would be client {n} of {max}` |
| A client dropped for not reading | `WARNING` | `Client {address} dropped: it did not keep up` |
| `serial`: the port opened, or was lost | `INFO`, or `WARNING` then `ERROR` | `Connected to {server}`, or `Disconnected from {server}` then `Bus {bus} unavailable: {reason}` |
| A sentence could not be built or sent | `WARNING` | `Transmitting {message} failed: {reason}` |
| Sentences from clients with a bad checksum, or unreadable | `WARNING` | `Bad checksum on {n} sentence(s)` or `{n} unreadable sentence(s) discarded: {reason}` |
| A value its variable's declared type refuses, or the event queue is full | `WARNING` | `Output {output} refused {value}: {reason}` or `Event queue full: {count} events pending, {dropped} dropped` |

## Example

The bridge feed: a position and speed every second, apparent wind every half second, and the heading an autopilot sends back:

```
Transport           tcp-server
Port                10110
Maximum clients     8
Talker identifier   GP

Forwarder    GNSS_LAT        RMC[status=ACTIVE]:latitude     1000
Forwarder    GNSS_LON        RMC[status=ACTIVE]:longitude
Forwarder    SOG             RMC[status=ACTIVE]:speed
Forwarder    WIND_ANGLE      WIMWV[true=false]:angle          500
Forwarder    WIND_SPEED      WIMWV[true=false]:speed
Collector    AUTOPILOT_HDG   HDG:heading
```

OpenCPN connected to port 10110 plots the position from `GNSS_LAT` and `GNSS_LON`, and a client that writes an HDG sentence back on its connection sets `AUTOPILOT_HDG`.

## NMEA 2000 Bus

The `NMEA-2000` module joins an NMEA 2000 backbone. **Collectors** take fields of the parameter groups other devices send into variables. **Forwarders** send variables onto the backbone, as parameter groups the module sends as a node.

NMEA 2000 is J1939 over CAN at 250 kbit/s, so the module reaches the backbone the way the CAN modules reach a bus, and shares their transport layer. A long group travels as a fast packet, or through the J1939 transport protocol; the module puts both back together and splits what it sends.

### Settings

| Key | Setting | Type | Default | Meaning |
|---|---|---|---|---|
| `transport` | Transport | text | `slcan` | `slcan`, `socketcan`, `yd-serial`, `yd-tcp`, `actisense` or `loopback`, as Reaching the backbone says |
| `serialPort` | Serial port | text | (empty) | `slcan`, `yd-serial`, `actisense`: the device |
| `bauds` | Bauds | int | `115200` | The serial speed of the adapter or gateway |
| `interface` | Interface | text | `can0` | `socketcan`: the Linux interface. `loopback`: the loopback's name |
| `host` | Host | text | (empty) | `yd-tcp`: the gateway's address |
| `port` | Port | int | `1457` | `yd-tcp`: the port the gateway serves its RAW stream on |
| `sourceAddress` | Source address | int | `100` | The address the module claims first, 0 to 253. Taken, it claims the next free one |
| `deviceInstance` | Device instance | int | `0` | The device instance in the module's NAME, lower three bits and upper five |
| `systemInstance` | System instance | int | `0` | The system instance in its NAME, 0 to 15 |
| `collectors` | Collector | list of rows | empty | The fields taken into variables |
| `forewarders` | Forwarder | list of rows | empty | The fields sent from variables. The stored key is spelled `forewarders` |

### Collectors and forwarders

A collector row uses `field`, `address` and `minIntervalMs`. A forwarder row uses `field`, `address` and `intervalMs`.

| Key | Column | Type | Default | Meaning |
|---|---|---|---|---|
| `field` | Variable | variable code | (none) | Collector: the variable written. Forwarder: the variable a field is sent from |
| `address` | Address | text | (empty) | The field, as Addresses says |
| `minIntervalMs` | Minimum interval [ms] | int | (empty) | Collectors: the least time between two writes of the variable |
| `intervalMs` | Interval [ms] | int | (empty) | Forwarders: also send the group on this clock. Empty or 0: on change only |

Every forwarder whose address names the same group, selectors and destination fills the same group, which is sent when any of their variables changes and on the shortest interval any of them asks for. A field the forwarders do not give is sent as not available. Only the fields before a repeating set can be sent. The picker above the tables lists every group canboat defines and the fields of the one chosen, with their units.

### Reaching the backbone

| Transport | Reaches the backbone through | The module is |
|---|---|---|
| `slcan` | An SLCAN USB adapter (CANable, USBtin) on a serial port, set to 250 kbit/s by the module | A node: it claims an address |
| `socketcan` | A Linux SocketCAN interface, whose bit rate the system sets. Linux only | A node |
| `yd-serial`, `yd-tcp` | A Yacht Devices gateway in RAW mode, over its USB port or its network port | A node |
| `actisense` | An Actisense NGT-1, which hands over whole groups | Not a node: the gateway is, and sends for it |
| `loopback` | A bus inside the engine, for tests and demonstrations | A node |

### Joining as a node

A device may not send on an NMEA 2000 backbone before it has **claimed an address**. Through every transport but `actisense`, the module claims `sourceAddress` when the bus comes up, waits 250 ms for another device to contest it, and moves to the next free address if one with a better NAME does. A module that finds no free address says so and sends nothing; it reclaims whenever the bus comes back. Two modules, or two engines, never claim with the same NAME: its unique number comes from the installation and the module's name.

Its NAME says what it is: a PC gateway among internetwork devices, in the marine industry group. It carries no manufacturer code, because Amtiri holds none.

A node must also answer what other devices ask it, or a plotter may not list it:

| Request | Answer |
|---|---|
| ISO Request (59904) for the address claim (60928) | The module's claim |
| ISO Request for product information (126996) | Model `DataOrchester`, the engine's version, the canboat release, the installation's identifier. Certification level is left unknown |
| ISO Request for the PGN lists (126464) | The groups it sends - its forwarders' and the administration groups - and the groups it receives |
| ISO Request for a group one of its forwarders sends | That group, now |
| ISO Request addressed to it for anything else | An ISO Acknowledgement (59392), NAK |
| Group function (126208), Request | As an ISO Request, acknowledged with "PGN not supported" when the module does not have it |
| Group function, Command to the address claim | Fields 3 and 4 set the device instance and field 8 the system instance; the module acknowledges and claims again with its new NAME. Any other command is acknowledged with "PGN not supported" |

Instances set from the backbone last until the engine restarts; the ones in the module's settings are the lasting ones. Behind an Actisense gateway, the gateway is the node: it claims its own address, answers for itself, and the module's forwarders are sent through it.

## Behaviour

- **Opening.** The transport, the source address and every row are checked first: an address that does not parse, a group canboat does not define, a field the group does not have, a repeated field without its position, a repeated field in a forwarder, or `src` in a forwarder stop the module opening, with a message naming the row. A missing adapter does not: the module opens, says the bus is unavailable, and picks the adapter up when it appears.
- **Receiving.** Fast packets and J1939 transport messages are put back together; a message whose frames stop arriving is dropped after 750 ms. Only the groups a collector names are decoded. A group with several definitions in canboat - a manufacturer's proprietary group - is read by the one whose match fields it carries.
- **Values.** A field the sender marks as not available writes nothing. A value lands only when it differs from the last one written, and no sooner than `minIntervalMs` after it, through the engine's event queue.
- **Sending.** A group goes out only while the module holds an address. Behind `actisense`, the gateway sends it.

## Messages

All texts are in English; the full list is in Module messages. `{bus}` and `{server}` name the transport, as `SLCAN on /dev/ttyACM0` or `Yacht Devices gateway at host:port`; `{message}` is the group, as `127488[instance=0]`.

| When | Level | Text |
|---|---|---|
| Opening: a setting that cannot work | `ERROR` | `Configuration invalid: {reason}` : `'{transport}' is not an NMEA 2000 transport` , `No serial port` , `No interface` , `No host` , `A source address is 0 to 253, not {n}` , `SocketCAN is available on Linux only, not on {os}` , or `{bus} is already open at {bitrate} bit/s` |
| Opening: an address that does not parse | `ERROR` | `{mapping}: {reason}` |
| Opening: a group canboat does not define | `ERROR` | `{mapping}: {pgn} is not a parameter group the catalogue defines` |
| Opening: a field the group does not have | `ERROR` | `{mapping}: {pgn} ({name}) has no field '{field}'` |
| Opening: a repeated field without its position | `ERROR` | `{mapping}: {field} repeats, so it needs its position, {field}.1` |
| Opening: a repeated field in a forwarder | `ERROR` | `{mapping}: {field} repeats, and only the fields before a repeating set are sent` |
| Opening: `src` in a forwarder | `ERROR` | `{mapping}: src selects a sender, and this module sends as itself` |
| The bus is up | `INFO` | `Connected to {server}` |
| The address is claimed | `INFO` | `Address {address} claimed` |
| The adapter or gateway could not be opened, or was lost | `WARNING` , then `ERROR` | `Disconnected from {server}` , then `Bus {bus} unavailable: {reason}` |
| The controller is error passive | `WARNING` | `{bus} is error passive` |
| The controller is bus-off | `ERROR` | `{bus} is bus-off` |
| Every address is taken | `ERROR` | `No address could be claimed, so nothing is transmitted` |
| A group could not be built or sent | `WARNING` | `Transmitting {message} failed: {reason}` |
| A value its variable's declared type refuses, or the event queue is full | `WARNING` | `Output {output} refused {value}: {reason}` or `Event queue full: {count} events pending, {dropped} dropped` |

## Example

A backbone reached through an SLCAN adapter: the position, the depth, the apparent wind and both engines, and a generator's speed sent to the backbone every 100 ms:

```
Transport        slcan
Serial port      /dev/ttyACM0
Source address   100

Collector    LAT          129025:latitude
Collector    LON          129025:longitude
Collector    DEPTH        128267:depth                              1000
Collector    AWA          130306[reference=Apparent]:windAngle
Collector    RPM_PORT     127488[instance=0]:speed                  500
Collector    RPM_STBD     127488[instance=1]:speed                  500
Forwarder    GEN_RPM      127488[instance=2]:speed                  100
```

`AWA` is in radians and `DEPTH` in metres. `GEN_RPM` goes out as engine instance 2 once the module has claimed its address, every 100 ms and whenever it changes.

## Next steps

- CAN
- Module catalogue
- Settings every module shares
- Module messages
- Connectivity

This page describes Data Orchester engine 6.20.0.