



## 1. INTRODUCTION

This document is a specification for the Digital Matter Yabby Edge LoRaWAN device. Contact [info@digitalmatter.com](mailto:info@digitalmatter.com) for more information.

### 1.1. Revision History

Date	Version	Changes
2021-06-10	1.0	Initial release
2021-09-17	1.2	Added Location Engine message summary Added NAV message format
2021-09-28	1.3	Added inactivity heartbeat in downlink 16
2022-06-07	1.4	Added GNSS Effort in downlink 11 Corrected offsets in downlink 15 Added new NAV message format

## 2. DEVICE BEHAVIOUR

The Yabby Edge's behaviour can be configured by setting a variety of parameters using a USB programming adapter, or by sending a subset of those parameters during a downlink message. The details of these parameters can be found on the [product support website](#).

### 2.1. Uplink

#### 2.1.1. Location Messages

The Yabby Edge uses an accelerometer to detect movement, allowing it to decide when an asset is in-trip, and when it is stationary. This allows it to schedule the transmissions as infrequently as possible, to maximize battery life. Each time a status update is scheduled the Yabby Edge will attempt a GPS capture, then transmit the results. You can configure the Yabby Edge to transmit a status update:

- Periodically (ie. 24-hour heartbeat)
- At configured times of the day
- At the start of a regular or after-hours trip
- During the trip
- At the end of the trip
- When the 'Inactivity Indicator' status changes

#### 2.1.2. Device Statistics

The Yabby Edge transmits a device statistics message once every 4 days, to allow monitoring of device activity and associated battery usage. The device statistic messages can be disabled to prevent tracking disruption in regions where the transmit duty cycle restrictions are a bottleneck (868 MHz regions can limit transmissions to 1 every 3 minutes).

#### 2.1.3. Aiding Requests

The Yabby Edge must download time, position, and almanac aiding data for optimal GNSS performance. The position aiding requests are built into every location uplink, but the time and almanac requests are handled separately. They may add up to several extra uplinks per day, but under ideal conditions could average less than 15 uplinks per month. Aiding requests can be disabled, at the expense of GNSS performance.

#### 2.1.4. Uplink Fragmentation

When a location message destined for port 5 is too large to send, it can optionally be fragmented and sent as multiple uplinks on ports 101-116. Most regions allow 51 byte uplinks, which can support a 7 access point WiFi scan, without fragmentation. However, for typical GNSS scans, and in regions with 11 byte uplink limits, fragmentation is required.

### 2.2. Downlink

#### 2.2.1. Parameter Update Downlinks

LoRaWAN potentially allows for a downlink with every regular data uplink, but most networks will only allow a few per day. When a parameter update is sent down to the Yabby Edge, it responds with an application layer acknowledgement uplink as soon as possible. In some regions, this could take several minutes. If the next uplink received is not the expected acknowledgement, the downlink should be resent.

#### 2.2.2. Aiding Responses

In addition to parameter update downlinks, aiding data must be downlinked to the Yabby Edge for optimal GNSS performance. Some of these downlinks are sent in request / response pairs, and some are streamed down to the device as a background process. In a region supporting 51 byte downlinks, there will typically be 20-30 aiding downlinks per month.

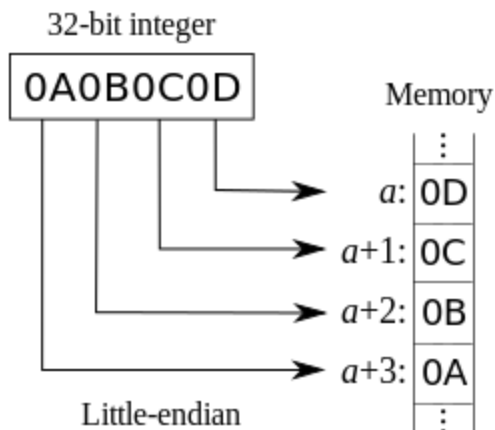
## 3. REGULAR MESSAGES ---

### 3.1. Number Formats

#### 3.1.1. Little Endian

Except where noted, all data in the payloads is LITTLE ENDIAN. Be aware of this when converting data fields that consist of more than one byte from the data payload.

<https://en.wikipedia.org/wiki/Endianness#Little>



### 3.1.2. Signed (Negative) Numbers

When a field is specified as *signed*, it is represented in 'two's complement' form. Be aware of this when converting signed fields from the data payload. Where unspecified, assume that fields are unsigned.

[https://en.wikipedia.org/wiki/Two's\\_complement](https://en.wikipedia.org/wiki/Two's_complement)

## 3.2. Uplink

LoRaWAN uplink payloads can be as small as 11 bytes in some regions (for the longest-range transmissions). The packet headers already include the device serial number, and a 'port number' from 1 to 223, which we will use as a message type.

### 3.2.1. Uplink Port 1: Hello Message

Offset	Description
0	Firmware major version
1	Firmware minor version
2	Product Id (86)
3	Hardware revision
4.0	Power on reset
4.1	Watchdog reset
4.2	External reset
4.3	Software reset
4.4 - 3.7	Reserved
5 – 6	Watchdog reset code
7	Battery voltage, LSb = 7 mV, 2 V offset
8	LR1110 hardware revision
9	LR1110 firmware major version
10	LR1110 firmware minor version

Please note that when the device resets to apply new parameters after a downlink, the watchdog reset flag will be set and the watchdog reset code will be 1. This indicates a normal reboot under software control.

Example: 010A56010203017A220305

- 010A
  - Version 1.10
- 5601
  - Product Id 86, hardware revision 1
- 02
  - 00000010 in binary
  - 1 indicates watchdog reset
- 0301
  - 0x0103 in hex
  - Watchdog reset reason 259
- 7A
  - 122 in decimal
  - $2000 + 7 \times 122 = 2854$  mV
- 220305
  - LR1110 hardware revision 0x22
  - LR1110 firmware 3.5

### 3.2.2. Uplink Port 2: Downlink Ack

Offset	Description
0.0 - 0.6	Sequence number (identifies downlink to server)
0.7	0: Downlink rejected, 1: Downlink accepted
1	Firmware major version
2	Firmware minor version
3	Product Id (86)
4	Hardware revision
5	Downlink port number
6	LR1110 hardware revision
7	LR1110 firmware major version
8	LR1110 firmware minor version

Example: D30102560107220305

- D3
  - 11010011 in binary
  - 1010011 - acknowledging downlink sequence number 83
  - 1 - downlink accepted
- 0102
  - Firmware 1.2
- 5601

- Product Id 86, hardware revision 1
- 07
  - Acknowledging downlink on port 7
- 220305
  - LR1110 hardware revision 0x22
  - LR1110 firmware 3.5

### 3.2.3. Uplink Port 3: Stats Message

Offset	Description
0	Initial battery voltage, LSb = 7 mV, 2 V offset
1	Current battery voltage, LSb = 7 mV, 2 V offset
2	Wakeups per trip
3.0 - 4.5	Trip count, LSb = 32 trips
4.6 - 5.7	Uptime, in weeks
6.0 - 7.1	Battery used, LSb = 2 mAh
7.2 - 7.7	Percentage used on LoRaWAN, LSb = 1.5625%
8.0 - 8.5	Percentage used on GNSS, LSb = 1.5625%
8.6 - 9.3	Percentage used on WiFi, LSb = 1.5625%
9.4 - 10.1	Percentage used sleeping, LSb = 1.5625%
10.2 - 10.7	Percentage used on battery self-discharge, LSb = 1.5625%

The *Percentage used* values are the percentage of the *Battery used* value attributed to each activity. The sum of the values may not add up to 100%. The *Percentage used on wakeups* is calculated as 100 minus the sum of the transmitted percentages.

### 3.2.4. Uplink Port 4: Reserved

Originally an alternate location message format, this port number is no longer in use.

### 3.2.5. Uplink Port 5: Location Message

Offset	Description
0.0 - 0.4	Number of WiFi access points N (0-31)
0.5	In-trip
0.6	Inactivity indicator
0.7 - 1.1	Reserved
1.2	Timestamp in NAV message, if present, is valid
1.3 - 1.7	Position assistance sequence number
2	Access point 1, RSSI, in dBm (signed)
3	Access point 1, MAC address
9	Access point 2, RSSI, in dBm (signed)

10	Access point 2, MAC address
16	Further access points
7N + 2	Semtech format GNSS NAV message (optional)

Example 1: 22E09DAC86749221DB0A48C09342A0CA01961B2230217E03

- 22E0
  - E022 in little endian
  - 11100000000100010 in binary
  - 00010 - N = 2 WiFi access points
  - 1 - trip in progress
  - 0 - inactivity threshold not reached
  - 0 - no timestamp in NAV message
  - 11100 - position sequence 28
- 9DAC86749221DB
  - 9D - Access Point 1 RSSI is -99 dBm
  - AC86749221DB - Access Point 1 MAC Address
- 0A48C09342A0CA
  - 0A - Access Point 1 RSSI is 10 dBm
  - 48C09342A0CA - Access Point 2 MAC Address
- 01961B2230217E03
  - Semtech NAV Message

Example 2: 00F401961B2230217E03

- 00F4
  - F400 in little endian
  - 11110100000000000 in binary
  - 00000 - N = 0 WiFi access points
  - 0 - no trip in progress
  - 0 - inactivity threshold not reached
  - 1 - timestamp in NAV message is valid
  - 11110 - no position assistance available
- 01961B2230217E03
  - Semtech NAV Message

Example 3: 01FC9DAC86749221DB

- 01FC
  - FC01 in little endian
  - 11111100000000001 in binary
  - 00001 - N = 1 WiFi access points
  - 0 - no trip in progress
  - 0 - inactivity threshold not reached
  - 1 - timestamp in NAV message is valid
  - 11111 - position aiding disabled
- 9DAC86749221DB

- 9D - Access Point 1 RSSI is -99 dBm
- AC86749221DB - Access Point 1 MAC Address

### 3.3. Downlink

LoRaWAN downlink payloads can be as small as 11 bytes in some regions (for the longest-range transmissions). The packet headers already include a 'port number' from 1 to 223, which we will use as a message type. The Yabby Edge sends an explicit acknowledgement uplink (port 2) on reception of a parameter configuration downlink. It sends the acknowledgement only once, on its next uplink attempt. The uplink includes a sequence number to help identify the specific downlink being acknowledged, despite any queuing / buffering in the network. 'Confirmed' and 'unconfirmed' downlinks are handled in the same way.

#### 3.3.1. Downlink Port 1: Set Trip Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Enable higher precision thresholds, and thresholds below 0.078 G
1 (BYTE)	Max time between fix attempts out of trip ('heartbeat'), 1-127: 1-127 mins, 129-255: 1-127 hours, default 24 hours
2 (BYTE)	Trip end timeout, LSB = 10s without accelerometer detecting movement, 0 disables trip tracking entirely (heartbeats only), default 5 mins
3 (BYTE)	Time between fix attempts in-trip during work hours, 1-127: 1-127 seconds, 129-255: 1-127 minutes, 0 or 128 disables, default 10 mins
4 (BYTE)	Time between fix attempts in-trip after hours, 1-127: 1-127 seconds, 129-255: 1-127 minutes, 0 or 128 disables, default 10 mins
5.0	Fix on start of trips during work hours, default true
5.1	Fix on end of trips during work hours, default true
5.2	Fix on start of trips after hours, default true
5.3	Fix on end of trips after hours, default true
5.4 - 5.7	Accelerometer sampling rate (Hz), 0-4: {1, 10, 25, 50, 100}, default 1 (10 Hz)
6 (BYTE)	Accelerometer wakeup threshold, 2-32: 32-512 mG, default 94 mG
7 (BYTE)	Accelerometer wakeup count, 1-100: 10-1000 ms, default 100 ms
8 (BYTE)	Random Tx delay, 0: disabled, 1-127: 1-127 seconds, 129-255: 1-127 minutes, default 8 seconds
9.0	Disable wakeup filtering during work hours, 1: only apply accelerometer wakeup threshold and count, 0: apply threshold, count, and filter, default 0
9.1	Disable wakeup filtering after hours, 1: only apply accelerometer wakeup threshold and count, 0: apply threshold, count, and filter, default 0
9.2 - 9.7	Reserved

#### 3.3.2. Downlink Port 2: Set After-Hours 1

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1 (BYTE)	Start of after-hours period on Monday, LSb = 7m30s since 00:00 local time, setting to end time indicates no after-hours period, default 0
2 (BYTE)	End of after-hours period on Monday, LSb = 7m30s since 00:00 local time, setting to start time + 1 indicates a 7m30s after-hours period, set start time to 00:00 and end time to 24:00 to indicate the whole day is after-hours, default 0
3 (BYTE)	Start of after-hours period on Tuesday, see above
4 (BYTE)	End of after-hours period on Tuesday, see above
5 (BYTE)	Start of after-hours period on Wednesday, see above
6 (BYTE)	End of after-hours period on Wednesday, see above
7 (BYTE)	Start of after-hours period on Thursday, see above
8 (BYTE)	End of after-hours period on Thursday, see above

### 3.3.3. Downlink Port 3: Set After-Hours 2

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1 (BYTE)	Start of after-hours period on Friday, LSb = 7m30s since 00:00 local time, setting to end time indicates no after-hours period, default 0
2 (BYTE)	End of after-hours period on Friday, LSb = 7m30s since 00:00 local time, setting to start time + 1 indicates a 7m30s after-hours period, set start time to 00:00 and end time to 24:00 to indicate the whole day is after-hours, default 0
3 (BYTE)	Start of after-hours period on Saturday, see above
4 (BYTE)	End of after-hours period on Saturday, see above
5 (BYTE)	Start of after-hours period on Sunday, see above
6 (BYTE)	End of after-hours period on Sunday, see above

### 3.3.4. Downlink Port 4: Set Time Zone

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7 - 1.1	Reserved, set to zero
1.2 - 2.1	Offset of normal time zone from UTC, LSb = 15 minutes, <b>signed</b> , default 0
2.2 - 2.5	Daylight saving time shift, LSb = 15 minutes, 0 disables, default 0



2.6 - 3.0	Start of DST Nth day of month, 1: First day, ..., 5: Fifth day, 6: Last day, 0: Use absolute date instead of relative '2 <sup>nd</sup> Sunday of October' style
3.1 - 3.5	1-7: Monday-Sunday, or 1-31: Day of month (absolute date), local time
3.6 - 4.1	1-12: January-December
4.2 - 5.2	Offset from 00:00 local time, LSb = 15 mins, <b>signed</b> , can select hours in previous days like '02:00 on Friday before last Sunday of October local time' would need Offset = (2hr - 48hr) * 4 = -184
5.3 - 5.5	End of DST Nth day of month, 1: First day, ..., 5: Fifth day, 6: Last day, 0: Use absolute date instead of relative '2 <sup>nd</sup> Sunday of October' style
5.6 - 6.2	1-7: Monday-Sunday, or 1-31: Day of month (absolute date), local time
6.3 - 6.6	1-12: January-December
6.7 - 7.7	Offset from 00:00 local DST, LSb = 15 mins, <b>signed</b> , can select hours in previous days like '02:00 on Friday before last Sunday of April local DST' would need Offset = (2hr - 48hr) * 4 = -184

### 3.3.5. Downlink Port 5: Set Scheduled Upload Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	0: Single fix attempt, 1: Retry fix attempts if network not ready (i.e. join failed - uplinks are still unconfirmed), default 0
1 (BYTE)	Local time* of scheduled upload time 1, 1-192: 00:07:30-24:00:00 (7.5 min intervals), +- 5 minutes randomization, default 0 (disabled)
2 (BYTE)	Local time* of scheduled upload time 2, see above
3 (BYTE)	Local time* of scheduled upload time 3, see above
4 (BYTE)	Local time* of scheduled upload time 4, see above
5 (BYTE)	Local time* of scheduled upload time 5, see above
6 (BYTE)	Local time* of scheduled upload time 6, see above
7 (BYTE)	Local time* of scheduled upload time 7, see above
8 (BYTE)	Local time* of scheduled upload time 8, see above
9 (BYTE)	Local time* of scheduled upload time 9, see above
10 (BYTE)	Local time* of scheduled upload time 10, see above

\*Local time takes time zone and daylight savings offset into account (configurable in Downlink 4).

The scheduled upload feature allows for heartbeats to be scheduled, rather than setting an upload interval. Each upload will occur within a 5 minute offset (i.e. scheduled upload at 13:00 could occur anywhere between 12:55 and 13:05). Up to 12 upload times may be configured per day. The first 10 upload times are configured with this downlink.

### 3.3.6. Downlink Port 6: Set Scheduled Upload Parameters (continued)

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1 (BYTE)	Local time* of scheduled upload time 11, 1-192: 00:07:30-24:00:00 (7.5 min intervals), +- 5 minutes randomization, default 0 (disabled)
2 (BYTE)	Local time* of scheduled upload time 12, see above

\*Local time takes time-zone and daylight savings offset into account (configurable in Downlink 4).

The scheduled upload feature allows for heartbeats to be scheduled, rather than setting an upload interval. Each upload will occur within a 5 minute offset (i.e. scheduled upload at 13:00 could occur anywhere between 12:55 and 13:05). Up to 12 upload times may be configured per day. The 11<sup>th</sup> and 12<sup>th</sup> upload times are configured with this downlink.

### 3.3.7. Downlink Port 7: Set LoRaWAN Channels

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1.0 - 1.3	Minimum data rate to use when ADR is disabled, default is 0 (DR0)
1.4 - 1.7	Maximum data rate to use when ADR is disabled, default is 2 (DR2)
2 - 10	Uplink channel mask, set bits are enabled channels, LSb of the 1 <sup>st</sup> byte is channel 0, MSb of the 9 <sup>th</sup> byte is channel 71, set all zeros (default) for the region-specific defaults

The Yabby Edge will spread its transmissions out over the allowed data rates in such a way as to equalize the time spent on-air at each data rate. For the default setting of DR0-DR2, this gives a 16 / 30 / 54% split between the three data rates and maximizes the gateway's capacity. However, the relative range of the three data rates are 100, 75, and 50% respectively. When ADR is enabled, the network server controls the data rate instead.

The uplink channel mask should be left 0 (default) in regions where the network join channels are fixed. In these regions, the gateway will tell the Yabby Edge which channels to use, during the Join procedure.

In regions where the join channels are not specified (US902-928, AU915-928), you should set the channel mask to avoid continued transmission on unused channels. In these regions the gateway will usually not tell the Yabby Edge which channels to use, resulting in significant packet loss if the mask hasn't been programmed.

### 3.3.8. Downlink Port 8: Set LoRaWAN Join / App EUI

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Set JoinEUI, 0: Use default JoinEUI, 1: Use supplied JoinEUI, default 0

1 - 8	JoinEUI, non-zero, <b>big endian</b> , i.e. default JoinEUI 70-B3-D5-70-50-00-00-04 is encoded with first byte as 0x70 and the second byte 0xB3
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The acknowledgement will be transmitted **once** on the existing JoinEUI, and then the Yabby Edge will switch to the new JoinEUI. It continues to use the already provisioned NwkKey and AppKey, which cannot be programmed over the air.

Note that:

- In LoRaWAN 1.0, the JoinEUI is known as the AppEUI
- In LoRaWAN 1.1, changing the JoinEUI resets three cryptographic counters:
  - RJCount1
  - DevNonce
  - JoinNonce
- So after changing the JoinEUI in 1.1, you must reset the counters on the join server

### 3.3.9. Downlink Port 9: Set Advanced LoRaWAN Options

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1 (BYTE)	Days between network joins, 0 disables, default 7
2.0 - 2.1	ADR support, 0: Never, 1: When out-of-trip, 2: Always, default never
2.2 - 2.3	Reserved, set to zero
2.4 - 2.7	Initial frame repetitions (NbTrans/Reps), 1-15, default 1
3.0 - 3.3	Initial MaxCount0, sets uplinks between Rejoin0 attempts in LoRaWAN 1.1 OTAA, uplink interval equals $2^{(4+MaxCount0)}$ , default 15
3.4 - 3.7	Initial MaxTime0, sets approx. time between Rejoin0 attempts in LoRaWAN 1.1 OTAA, uplink period equals $2^{(10+MaxTime0)}$ s, default 15
4.0 - 4.3	Initial ADRAckLimitExp, sets uplinks between ADR confirmation requests, uplink interval equals $2^{ADRAckLimitExp}$ , default 6 (limit is 64)
4.4 - 4.7	Initial ADRAckDelayExp, sets uplinks between ADR backoff steps, uplink interval equals $2^{ADRAckDelayExp}$ , default 5 (delay is 32)
5 (INT8)	Maximum Tx power limit, <b>signed</b> , -128-127: -128 to 127 dBm EIRP, default 127 (no limit)

For a detailed description of these parameters, please see the *Configuration and Usage Guide* on the support website.

### 3.3.10. Downlink Port 10: Reset ABP Session Counters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reset FCnts every power cycle when using ABP on LoRaWAN 1.0, default 0 (don't reset)

## 3.3.11. Downlink Port 11: Set Position Scanning Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1.0	Do not require timestamp for autonomous GPS, default false (required)
1.1	Disable uplink fragmentation, disabling simplifies uplink decoding but limits how much scan data can be transmitted, default false
1.2 - 2.2	Maximum number of bytes to send in position update payload, 9 - 282, default 282
2.3 - 2.7	Minimum number of WiFi access points to send when transmitting WiFi scan data, 1-31, default 2
3.0 - 3.4	Maximum number of WiFi access points to send when transmitting WiFi scan data, 1-31, default 7
3.5 - 3.7	Send order of scanned position data, 0-2 = {GNSS then WiFi, WiFi then GNSS, Best signal only}, default GNSS then WiFi (0)
4.0 - 4.2	Scan order for acquiring position data, 0-4 = {GNSS then WiFi, GNSS only, GNSS with WiFi fallback, WiFi only, WiFi with GNSS fallback}, default WiFi with GNSS fallback (4)
4.3 - 4.7	GNSS (satellites) / WiFi (AP count) margin to trigger fallback position scan, 0-32, default 3
5.0 - 5.5	Maximum number of scanned satellites to save, 6-32, default 12
5.6 - 6.3	Maximum number of WiFi access points to save, 1-32, default 21
6.4 - 7.6	WiFi channel scan timeout, 105-2047 ms, recommend 105-315, default 210
7.7	Do not use GNSS aiding data even if available, default false (use aiding)
8.0	Filter out short lived WiFi MAC addresses from scan, default false
8.1	Filter out non-global WiFi MAC addresses from scan, default true
8.2	Filter out WiFi MAC addresses that may be guest access points from scan, default true
8.3	GNSS scan effort, 0: Best effort, 1: Low Power, default Best effort
8.4 - 8.7	Reserved

## 3.3.12. Downlink Port 12: Set Uplink Fragmentation Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved
1 (BYTE)	Minimum number of frames to send per encapsulated uplink, 1-128, default 1

2 (BYTE)	Minimum percentage of packet loss to tolerate when fragmenting, 0-75 %, default 20 %
3 (BYTE)	Maximum number of bytes to transmit in a single position uplink frame, 11-255, default 222

### 3.3.13. Downlink Port 13: Set Downlink MTU Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved
1 (BYTE)	Percentage to reduce maximum downlink size, 0-200: 0-100 %, default 0
2 (BYTE)	Bytes to further reduce maximum downlink size, if possible, 0-255, default 0
3 (BYTE)	Maximum downlink size, applied after reductions, 11-255, 0 disables, default 0

### 3.3.14. Downlink Port 14: Set Almanac Management Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved
1 (BYTE)	Minimum almanac age before new download begins, 3-87 days, default 21
2 (UINT16)	Maximum random delay to add after almanac expiry, 12 - 1440 hours, default 336 (14 days)
4 (UINT16)	Nominal time between almanac requests, 5-65535 minutes, default 720 (12 hours)
6 (BYTE)	Base time between almanac request retries, 5-255 minutes, default 60
7 (BYTE)	Maximum number of downlink opportunities between almanac request retries, 1-255, default 3
8 (BYTE)	Time between failsafe connection checks, 1-255, 0 disables, default 28
9.0 - 9.3	Base time between aiding requests, $0 \leq x \leq 15$ where time = $128 \ll x$ seconds, default 12 (6 days)
9.4 - 9.7	Time request back-off when out of coverage, 0-15, default 3

### 3.3.15. Downlink Port 15: Set Battery Statistics Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Battery type is alkaline, default false
1 (UINT16)	Time between statistics uplinks, 0 - 65535 hours +-12% variance, 0 disables, default 96 (4 days)

3 (UINT16)	Battery capacity used by network server (DevStatusReq) and self-discharge calculations, 1-65535 mAh, 0 disables, default 1100
5 (BYTE)	Battery percentage discharge per year, 0-255: 0-25.5 %, default 3 %

### 3.3.16. Downlink Port 16: Set Inactivity Indicator Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved
1.0 - 1.1	Fix on set, 0: no fix, 1: single fix attempt, 2: retry fix attempts if network not ready (i.e. join failed - uplinks are still unconfirmed), default 0
1.2 - 1.3	Fix on clear, see above
1.4 - 1.7	Reserved
2 (BYTE)	Inactivity timeout, 1-127: 10-1270 minutes, 129-255: 12-1524 hours, others disable, default 60 minutes
3 (BYTE)	Inactivity beacon period ('heartbeat') when Inactivity timeout has elapsed, function overrides default 'heartbeat' if enabled, 1-127: 1-127 mins, 129-255: 1-127 hours, default 0 (disabled). Optional, supported from firmware v1.5 onwards

## 4. LOCATION ENGINE MESSAGES

To achieve optimal GNSS performance, the Yabby Edge needs position, time, and almanac aiding data. The almanac is particularly large (600-900 bytes per month, compressed), and the GNSS location uplink messages usually require fragmentation. Doing this robustly and efficiently requires a protocol much more complex than the broadcast and command / response protocol in the previous section. Since the integration effort required to implement this protocol is unreasonably high, it is handled transparently by Digital Matter's Location Engine cloud service, which also offloads the WiFi and GNSS solver lookups.

### 4.1. Message Summary

This section is intended to help you understand what messages will be sent, and how often. Since the portions of the protocol handled by the Location Engine are not specific to the Yabby Edge, the full details will be published in a separate document.

#### 4.1.1. Port 89: Connection Management

A pair of small messages are exchanged on port 89 to establish a connection between the device and the aiding data server. This typically happens only once, when the device joins the network, but can happen again if the aiding data server is reprovisioned.

#### 4.1.2. Port 90: MTU Advice

A pair of small messages are exchange on port 90, to tell the aiding data server what size downlinks are acceptable. This typically happens only once, but can be repeated if the network server reconfigures the device with a MAC command. The MTU sizes are calculated according to the LoRaWAN standard, and adapt to the current uplink spreading factor

without further negotiation. If you run into compatibility issues with your network server, you can lower the MTU sizes using device parameters.

#### 4.1.3. Port 91-99: Almanac Aiding

An Almanac is downloaded once a month, at a randomized time. The device queries for a new almanac version on port 91, then requests a download on port 92. The download is then streamed down on ports 92 to 99. The downlinks will be made as large as possible, which typically means 51 bytes and 14 downlinks. At the lowest spreading factors, the download could complete in only 4 downlinks, but the worst case is on the order of 70-90 smaller downlinks. The device will send a new request on port 92 if the stream stops before the download completes. Any gaps in the data are filled in using a forward error correction technique, and the almanac is delta compressed for maximum efficiency.

New requests are throttled to roughly two per day by default, but can be more frequent if the device sees downlink traffic from the server. Additionally, it will retry more aggressively on the first day after battery insertion (retry period backs off linearly from 2 to 30 minutes).

#### 4.1.4. Port 100: Position Aiding

A small position aiding message is downlinked on port 100, every time the server notices the device has moved 50 km from its last aided position.

#### 4.1.5. Port 101-116: Uplink Fragmentation

Location Message uplinks on port 5 are frequently too large to send in a single 51 byte uplink, so provision is made to fragment them. The fragmentation protocol can split a message destined for any uplink port into several messages for ports 101-116. The destination port and the original timestamp are captured and sent with the fragments. Additionally, a configurable number of forward error correction uplinks can be added to the fragment set, to prevent packet loss from becoming a problem.

The fragmentation protocol allows typical GNSS scan to be sent in two 51 byte uplinks, plus one optional forward error correction uplink. It also allows operation in regions restricted to 11 byte uplinks - but this results in a factor 5 more uplinks, which is not always practical.

#### 4.1.6. Port 202: Time Aiding

A pair of small messages are exchanged on port 202, by default once every 6 days. The messages follow the LoRaWAN Application Layer Clock Synchronization protocol, v1.0.0. If there is no reply from the server, the request will be repeated with backoff. It may repeat up to 14 times in 6 days by default. Additionally, it will retry more aggressively on the first day after battery insertion (retry period backs off linearly from 1 to 30 minutes).

### 4.2. Standalone Operation

If you need to operate a Yabby Edge LoRaWAN without a Location Engine integration, you can disable the cloud features to achieve standalone operation by:

- Disabling GNSS aiding
  - *Scanning->GNSS Aiding Mode = Autonomous no Time* in Provisioning Tool
  - Or bits 1.0 and 7.7 in downlink 11
- Disabling uplink fragmentation
  - *Scanning->Uplink Fragmentation = Disabled* in Provisioning Tool



- Or bit 1.1 in downlink 11
- Ensuring your uplink data rate can carry large messages
  - *Advanced LoRaWAN->Min Data Rate* in Provisioning Tool
  - Or field 1.0 in downlink 7
- Leaving all *Scheduled Uploads* and *After Hours* definitions empty
  - Set them to empty (default) in Provisioning Tool
  - Or clear them with downlinks 2, 3, 5, and 6 (all fields set zero)

When configured this way, the Yabby Edge LoRaWAN will deliver only simple position and battery statistic uplinks, at the expense of greatly reduced GNSS performance. Because GNSS messages use more than 51 bytes, implying a higher data rate, the maximum range for GNSS operation is also reduced. The position uplinks will contain the scanned WiFi MAC addresses and raw GNSS timing information, which can then be resolved with a lookup service from Google, Semtech, or any other provider.

## 5. SEMTECH NAV MESSAGE FORMAT

When the LR1110 module scans for GNSS satellites, it outputs a NAV message containing the satellite timing information. This message is in a format appropriate for the Semtech cloud solver. For completeness, the known components of the message format are documented here. However, in practise it is not necessary to parse the NAV messages.

The NAV message is bit-packed in little endian format. The number and presence of the fields can vary, so the offsets of the fields aren't constant.

### 5.1. NAV Message Version 1

Bits			Description
4			Message type, always '1'
4			Reserved
16			GPS Time in seconds, divided by 4, and truncated to 16 bits
1			Aiding presence / absence flag. If set, the next 24 bits are approximate latitude and longitude (+/-150 km), otherwise they aren't sent at all.
	[12]		Latitude, signed, LSb = $90 / 2^{11}$ degrees. Aiding data, not position fix!
	[12]		Longitude, signed, LSb = $180 / 2^{11}$ degrees. Aiding data, not position fix!
4			Constellation, 1: GPS, 2: Beidou
4			Satellite Count, number of satellites encoded for this constellation
	7		Satellite Id, 0-31: GPS, 32-50: SBAS, 64-124: Beidou
	2		Satellite C/No, 0: >44 dB, 1: 41-44 dB, 2: 37-40 dB, 4: <37 dB
	1		<i>Unknown</i> 8-bit field encoded below (not used by Yabby Edge)
	1		<i>Bit Change</i> 8-bit field encoded below (not used by Yabby Edge)
	1		'Doppler frequency inconsistent with aiding data' indicator
	1		<i>Doppler frequency</i> 15-bit field encoded below (usually present)
	1		<i>Unknown</i> 19-bit field encoded below (not used by Yabby Edge)



	1		<i>Pseudorange</i> 19-bit field encoded below (always present)
		19	Pseudorange, unsigned, LSb = 3 ns
		[15]	Doppler, signed, LSb = 1 Hz (not necessarily sent for every satellite)
	7		Satellite Id
	...		...
4			Constellation, 1 = GPS, 2 = Beidou. This second constellation is optional. When present, its data is sampled precisely 4 seconds after the first set.
...			...
-			Any trailing bits in the last byte are zero filled

## 5.2. NAV Message Version 2

Bits		Description
4		Message type, always '2'
1		'Doppler frequency inconsistent with aiding data' indicator
1		<i>Doppler Count</i> fields are present
1		<i>Bit Change</i> field present after first Scan Type field (only)
1		Aiding fields present after GPS Time field
16		GPS Time in seconds, divided by 4, and truncated to 16 bits
	[11]	Latitude, signed, LSb = $90 / 2^{10}$ degrees. Aiding data, not position fix!
	[11]	Longitude, signed, LSb = $180 / 2^{10}$ degrees. Aiding data, not position fix!
2		First Scan Type, 0: GPS, 1 or 2: Beidou
[25]		Bit Change information, present in first scan type only
4		Satellite Count, number of satellites encoded for this Scan Type
1		Using 5-Bit Ids, 1: Following Id fields are 5 bit, 0: Id fields are 6 bit
[3]		Doppler Count, $\leq$ Satellite count
	5/6	Satellite Id, 0-63: G1-G64, or B1-B64, depending on Scan Type
	2	Satellite C/No, 0: >44 dB, 1: 41-44 dB, 2: 37-40 dB, 4: <37 dB
	0	Pseudorange is implied zero for first satellite in Scan Type
	[11]	Doppler Frequency, signed, LSb = 16 Hz, present in first <i>Doppler Count</i> satellites in the Scan Type
	5/6	Satellite Id, 0-63: G1-G64, or B1-B64, depending on Scan Type
	2	Satellite C/No, 0: >44 dB, 1: 41-44 dB, 2: 37-40 dB, 4: <37 dB
	18	Pseudorange, LSb = 4 ns
	[11]	Doppler Frequency, signed, LSb = 16 Hz, present in first <i>Doppler Count</i> satellites in the Scan Type

	...	...
2		Second Scan Type, 0: GPS, 1 or 2: Beidou, entire second scan is optional
4		Satellite Count, number of satellites encoded for this Scan Type
1		Using 5-Bit Ids, 1: Following Id fields are 5 bit, 0: Id fields are 6 bit
[3]		Doppler Count, <= Satellite count
6		Gap between scans, in seconds?
	5/6	Satellite Id, 0-63: G1-G64, or B1-B64, depending on Scan Type
	2	Satellite C/No, 0: >44 dB, 1: 41-44 dB, 2: 37-40 dB, 4: <37 dB
	0	Pseudorange is implied zero for first satellite in Scan Type
	[11]	Doppler Frequency, signed, LSb = 16 Hz, present in first <i>Doppler Count</i> satellites in the Scan Type
	5/6	Satellite Id, 0-63: G1-G64, or B1-B64, depending on Scan Type
	2	Satellite C/No, 0: >44 dB, 1: 41-44 dB, 2: 37-40 dB, 4: <37 dB
	18	Pseudorange, LSb = 4 ns
	[11]	Doppler Frequency, signed, LSb = 16 Hz, present in first <i>Doppler Count</i> satellites in the Scan Type
	...	...
-		Any trailing bits in the last byte are zero filled

## 6. CONTACT INFORMATION

For the latest version of this document plus other product information please visit our website at [www.digitalmatter.com/support](http://www.digitalmatter.com/support), or contact DM at [info@digitalmatter.com](mailto:info@digitalmatter.com).