Bit definitions for Fontus acoustic messages
Version 1.0

This document describes the format of Fontus acoustic messages. These messages are 64 bits long, which includes a 12-bit cyclic redundancy check (CRC) at the end of the message (i.e., messages have 52 data bits and 12 CRC bits) (Table 1). Not all messages require 52 data bits; in such cases, all remaining bits are reserved for future use. There are 10 message types in version 1.0 of the Fontus standard that are described below. Note that these messages mostly correspond to those in the original version 1.0 Fontus standard description document, but some messages in that document are not described here because they are no longer needed. Specifically, the enforcement-specific messages are not needed if owner passkeys are stored in the cloud upon deployment; enforcement can access passkeys in the cloud and use Release Requests in the same manner as the gear owner to retrieve gear.

Vendor messages have been added to the standard to allow additional vendor-specific data to be passed between ships and devices. The ship-to-device vendor payload is 22 bits and the device-to-ship vendor payload is 34 bits. If these payloads are too small, a vendor can implement a system of custom cargo packets that follow the Vendor Request/Report to carry additional data.

A 12-bit cyclic redundancy check (CRC) on the data messages is included in the standard. Devices should do the following upon receiving a message: calculate a CRC over the 52-bit data portion of the message and check if this calculated CRC matches the transmitted CRC. If there is a match, this is a legitimate Fontus message, but it is *not* a Release, Status or Vendor Request message. If it does not match, append the device's 16-bit passkey on the 52-bit data message, calculate a CRC over the resulting 68-bit payload and check if this calculated CRC matches the transmitted CRC. If there is a match, this is a legitimate Release, Status or Vendor Request.

The only sensor that is required by the Fontus standard to be integrated into the acoustic device is a calibrated pressure sensor capable of measuring the depth of the device (this is used for the cloud-based localization procedure). However, the standard provides the ability to report measurements from other potentially useful sensors if they are present, including battery voltage/usage, device orientation and water temperature. The message formats described below provide specific values to indicate when these sensors are either not installed or not working properly.

The reader may note that there are no messages specifically designed to release gear in the case of an accident where a person is dragged overboard by gear that is actively being deployed. We envision this functionality being implemented with the Release Request message below in the following manner. If there are 2 or more fishers aboard the vessel, then the screen on the ship's central command unit (CCU) will display a large red emergency button during the deployment sequence. If one of the fishers is dragged overboard, the other will press the emergency button to trigger the transmission of a Release Request message to the devices that were most recently deployed. With automatic identification of deployed gear (described in the

Fontus standards document and implemented with RFID technology), the CCU will be aware of what devices have been recently deployed and can therefore send the appropriate Release Request message(s). If there is only one fisher on board, then the CCU's screen will display a large green button that the fisher must press within 1 minute after fishing gear is deployed to verify that the fisher is safely aboard (audio alarms can be used to remind the fisher to press the button in time). If the button is not pressed, the CCU automatically sends a Release Request message to the most recently deployed gear.

Message Types

Localization Request

When directed by the cloud, a ship will transmit the Localization Request message with a specific device ID to verify the general location of the device and to collect localization information, including the depth of the device, the 1-way travel time between the ship and the device, and optionally the bearing to the device (if the ship is equipped with a USBL or similar bearing-resolving technology). The date/time is transmitted in this message to allow all devices that detect the transmission to determine if they are lost or not (devices that have not been addressed by a Localization Request in the past 72 hours will consider themselves lost and will respond to the Localization Request with a Lost Device Report; see below).

Localization Report

In response to a received Localization Request that contains the correct device ID, a device will respond with a Localization Report that includes a response ID, response delay, device depth, and optional sensor information. The CCU on the ship estimates the 1-way travel time by measuring the elapsed time between transmission of the Localization Request and receipt of the Localization Report, subtracting the response delay, and dividing by 2. This 1-way travel time, the depth, optional bearing, and optional sensor data are then reported to the cloud.

Release Request

The Release Request is initiated by the owner, owner-authorized third party or enforcement to activate the release mechanism associated with the device addressed in the device ID field. Each device has a 16-bit passkey that is stored on the device, the owner's CCU and in the cloud. This passkey is used to authenticate the release request, and enforcement will have access to the passkey via the cloud. Authentication is carried out as follows: the device-specific 16-bit passkey is appended to the 52-bit data message, and the 12-bit CRC is computed by the CCU on the resulting 68-bit payload. This CRC is transmitted with the 52-bit data message. For devices receiving the release request, the 16-bit device-specific passkey will be appended to the 52-bit data message and a CRC computed. If this CRC matches the CRC sent in the transmission, then the message is both verified as transmitting correctly and it is authenticated. Note that while device IDs are transmitted acoustically and are therefore public, the passkey is never transmitted acoustically, and is therefore private.

Release Report

In response to a received and authenticated Release Request that contains the correct device ID, the device will activate the release, and then report on the status of that activation to the requesting ship. An activation status value of 0 indicates the release activated normally.

Lost Device Request

When directed by the cloud, a ship will transmit a Lost Device Request to locate fishing gear that was recently lost nearby. The date and time encoded in this message are used by any devices that receive this request to determine if they are lost.

Lost Device Report

In response to either a Lost Device Request or a Localization Request addressed to another device, a device that considers itself lost (i.e., no ship has addressed a Localization Request to it) will transmit a Lost Device Report with its full device ID. In the latter case (i.e., response to a Localization Request addressed to a nearby device), the transmission of this message should be delayed by a randomly selected time between 3 and 6 seconds after the receipt of the Localization Request to allow the addressed device time to respond.

Status Request

The Status Request message is initiated by the fisher or enforcement to check on the status of the device and its attached release mechanism. This message is authenticated in the same manner as the Release Request so that only the gear owner, owner-authorized third parties, or enforcement can query the status of the device.

Status Report

In response to a Status Request, the Status Report will include a response ID, the status of the attached release and optional sensor information, including battery voltage/usage, device orientation and temperature. If additional vendor-specific status information is desired, it can be shared with Vendor Request/Report messages.

Vendor Request

A fisher can request additional information from a specific device by sending a Vendor Request. Manufacturers are free to include whatever information they wish in the 22-bit vendor downlink payload in whatever format they wish. The Vendor Request message is authenticated in the same manner as the Release Request so that only the gear owner, owner-authorized third parties, or enforcement can successfully send this message.

Vendor Report

In response to a Vendor Request, the Vendor Report will include a response ID and a 34-bit vendor uplink payload. This payload can contain whatever information a vendor wishes in whatever format they wish. If additional data transmission from the device to the ship is desired, the payloads of the Vendor Request and Vendor Report messages can arrange for the transmission of additional cargo packets.

Message Fields

Message type (6 bits)

A number specifying the type of message being sent, which in turn specifies how the binary message is formatted. New versions of messages should be assigned a unique message type (e.g., version 2 of the Localization Request should be assigned a number different from 0). Values in version 1.0 include the following:

0: Localization Request
1: Localization Report
2: Release Request
3: Release Report
4: Lost Device Request
5: Lost Device Report
6: Status Request
7: Status Report
8: Vendor Request
9: Vendor Report

Device ID (24 bits)

The unique identification number of an acoustic device. The size of this field will accommodate over 16.5 million unique IDs.

Date/time (9 bits)

Date and time are only used by devices to measure elapsed time since deployment for the purposes of determining if they are lost (note that if no ship has addressed a device with a Localization Request in the past 72 hours, the device considers itself lost). Date and time are represented as the number of quarter days since January 1, 2020 00:00 UTC modulo 512, which provides a number between 0 and 511 that changes from 511 to 0 every 128 days. Date/time values are provided for the following example dates:

January 1, 2020 01:00 UTC modulo 512 = 0
January 1, 2020 06:00 UTC modulo 512 = 1
January 2, 2020 00:00 UTC modulo 512 = 4
March 1, 2020 00:00 UTC modulo 512 = 240
May 8, 2020 00:00 UTC modulo 512 = 0
January 1, 2025 00:00 UTC modulo 512 = 140

Response ID (12 bits)

When a device responds to a request from a ship, it will include a response ID in the message so that the ship can confirm that the received message is a response to its request. The response ID is simply the 12 least significant bits of the device's ID.

Response delay (2 bits)

This field specifies the elapsed time between the receipt of a message by a device and the transmission of a response. It is used in the calculation of 1-way travel time by the CCU on the ship. To support a variety of different vendor implementations, values include the following:

0: 500 ms
1: 750 ms
2: 1000 ms
3: 2000 ms

Device depth (9 bits)

This is the water depth of the device in meters as measured by a calibrated pressure sensor. The depth is calculated from the transmitted 9-bit integer as follows:

Depth = minimum depth + (digital value – minimum digital value) / (maximum digital value – minimum digital value + 1) / (maximum depth – minimum depth)

where the minimum/maximum digital value and the minimum/maximum depth are derived from the piecewise linear scales in Table 2. A digital value of 511 indicates that the pressure sensor is not working.

Table 2. Scaling terms to convert a 9-bit integer to depth.

Group	Minimum digital value	Minimum digital value	Minimum depth (m)	Maximum depth (m)	Range (m)	Resolution (m)
1	0	127	0	25	25	0.195
2	128	255	25	125	100	0.781
3	256	383	125	525	400	3.125
4	384	511	525	2125	1600	12.5

Battery (8 bits)

Battery status is represented as a 1-bit indicator followed by a 7-bit digital value. If the indicator bit is 0, the 7-bit digital value represents the battery voltage, which is calculated as follows: battery voltage = digital value / 126 * 32 (range of 0-32 V, resolution of 0.25 V). If the indicator bit is 1, the 7-bit digital value represents the percentage of battery capacity remaining, which is calculated as follows: percent remaining = digital value / 126 * 100. Regardless of the indicator bit, a digital value of 127 indicates that the battery is not reported (i.e., either the sensor is not working or not present)

Temperature (10 bits)

Temperature is represented as a 10-bit integer that is linearly scaled between -5 and 40 °C with a resolution of 0.044°C (temperature in units of °C = -5 + digital value / 1023 * 45). A

digital value of 1024 indicates that either temperature is not measured (no temperature sensor is installed) or the sensor is not working correctly.

Orientation (4 bits)

The orientation of the device is represented as a 4-bit integer that is linearly scaled between 0 and 180° (digital value in units of degrees = digital value / 14 * 180). The desired orientation is 0° (digital value = 0) and the most undesired orientation is 180° (digital value 14). A digital value of 15 indicates that either orientation is not measured (no orientation sensor is installed) or the sensor is not working correctly.

Release status (6 bits)

The status of the release when queried with a Status Request is reported as a 6-bit number with the following values:

0: Release mechanism is working
1: Release mechanism not responding
2: Release mechanism unable to activate
3: Release mechanism battery low
4: Release mechanism battery depleted
5: Insufficient pressure to fill lift bag

These values are commonly agreed upon statuses that any release mechanism will report as part of the standard. More detailed vendor-specific status information should be reported in a Vendor Report.

Activation status (6 bits)

The status of the release activation process when activated with a Release Request is reported as a 6-bit number with the following values:

0: Release has successfully activated
1: Release mechanism is not responding
2: Release mechanism unable to activate because of mechanical failure
3: Release mechanism unable to activate because of low/depleted battery

These values are commonly agreed upon statuses that any release mechanism will report upon activation as part of the standard. More detailed vendor-specific status information should be reported in a Vendor Report.

Table 1. Fontus message types and formats.

Message type	*Field*	*size (bits)*	*Units/value*
Localization Request	Type	6	Value = 0
Ship to device	Device ID	24	None
	Date/time	9	quarter days since January 1, 2020 mod 512
	Reserved bits	13	None
	CRC	12	None
	Total	**64**	
Localization Report	Type	6	Value = 1
Device to ship	Response ID	12	12 LSBs of Device ID
	Response delay	2	0 = 500 ms, 1 = 750 ms, 2 =1000 ms, 3 = 2000 ms
	Reserved bits	5	None
	Device depth	9	meters
	Battery	8	V/%
	Temperature	10	degrees Celsius
	CRC	12	None
	Total	**64**	
Release Request	Type	6	Value = 2
Ship to device	Device ID	24	None
	Reserved bits	22	None
	CRC	12	None
	Total	**64**	
Release Report	Type	6	Value = 3
Device to ship	Response ID	12	12 LSBs of Device ID
	Activation status	6	None
	Reserved bits	28	None
	CRC	12	None
	Total	**64**	

Table 1. Fontus message types and formats (continued).

Message type	*Field*	*size (bits)*	*Units/value*
Lost Device Request	Type	6	Value = 4
Ship to device	Date/time	9	quarter days since January 1, 2020 mod 512
	Reserved bits	37	None
	CRC	12	None
	Total	**64**	
Lost Device Report	Type	6	Value = 5
Device to ship	Device ID	24	None
	Response delay	2	0 = 500 ms, 1 = 750 ms, 2 =1000 ms, 3 = 2000 ms
	Reserved bits	3	None
	Device depth	9	meters
	Battery	8	V/%
	CRC	12	None
	Total	**64**	
Status request	Type	6	Value = 6
Ship to device	Device ID	24	None
	Reserved bits	22	None
	CRC	12	None
	Total	**64**	
Status Report	Type	6	Value = 7
Device to ship	Response ID	12	12 LSBs of Device ID
	Reserved	6	None
	Release status	6	None
	Battery	8	V/%
	Orientation	4	degrees
	Temperature	10	degrees Celsius
	CRC	12	None
	Total	**64**	

Table 1. Fontus message types and formats (continued).

Message type	*Field*	*size (bits)*	*Units/value*
Vendor Request	Type	6	Value = 8
Ship to device	Device ID	24	None
	Vendor downlink payload	22	None
	CRC	12	None
	Total	**64**	
Vendor Report	Type	6	Value = 9
Device to ship	Response ID	12	12 LSBs of Device ID
	Vendor uplink payload	34	None
	CRC	12	None
	Total	**64**	