
# Earth Networks
# Total Lightning Data Feed
# Version 4
# Interface Control Document

October 2022

# Table of Contents

# 1 Overview

This document describes how to connect to the v4 Earth Networks Lightning data feed using WebSockets.

# 2 Connection Instructions

To connect to the ENTLN service, you must have a Lightning Feed partner ID and the services host name. The partner id and host name are provided by your Earth Networks account manager or customercare@earthnetworks.com

- Using your partner ID and the host name provided, open a WebSocket connection using the URL structure below.
- The WebSocket URL is of the following form and the URL parameters are defined in the table below:
  - `ws://INSERT_HOST_NAME/ws/?p=INSERT_PARTNER_ID&f=INSERT_FORMAT&t=INSERT_TYPE&l=INSERT_LIGHTNING_TYPE`
- Failure to provide valid values for the WebSocket URL parameters will either terminate the connection or prevent the ENTLN server from sending data. Refer to the table below and section 8 for troubleshooting instructions.
- The Earth Networks environment is redundant and highly available. Connections to the host name in the connection URL are routed to a server instance based on load and availability. So, establishing a single connection to the data feed and implementing logic to re-establish the connection if the connection drops will achieve high availability. Refer to section 8 for troubleshooting instructions.
- Some example URL parameter value combinations:
  - JSON, Pulse, InterCloud and CloudToGround
    - `ws://INSERT_HOST_NAME/ws/?p=INSERT_PARTNER_ID&f=json&t=pulse&l=all`
  - Binary, Combo, CloudToGround
    - `ws://INSERT_HOST_NAME/ws/?p=INSERT_PARTNER_ID&f=binary&t=combo&l=cg`
  - CSV, Flash, CloudToGround
    - `ws://INSERT_HOST_NAME/ws/?p=INSERT_PARTNER_ID&f=csv&t=flash&l=cg`
  - UALF, Pulse, InterCloud
    - `ws://INSERT_HOST_NAME/ws/?p=INSERT_PARTNER_ID&f=ualf&t=pulse&l=ic`
  - JSON, Pulse, InterCloud and CloudToGround, Start data feed from 300 seconds ago
    - `ws://INSERT_HOST_NAME/ws/?p=INSERT_PARTNER_ID&f=json&t=pulse&l=all&h=300`

**Table 1 - WebSocket URL Parameters**

| URL Parameter | Description |
|---|---|
| “p”: <Partner ID> | Mandatory. The <Partner ID> is provided by Earth Networks. Each feed should have its own Partner ID.<br><br>Providing an invalid value for partner ID will result in the following response: |

| | |
|---|---|
| | `Invalid partner Id : PARTNERID-WILL-BE-DISPLAYED-HERE` |
| "f":<format> | Mandatory. Defines the response data structure format. Allows the following values:<br>• json<br>• csv<br>• binary<br>• ualf<br>Providing an invalid value for format will result in the following:<br>`Invalid request : Incorrect Format Type` |
| "t":<type> | Mandatory. Defines the content of the response data structures. Allows the following values:<br>• combo - Combination of flash and pulse (only available for json and binary formats)<br>• flash<br>• pulse<br>Providing an invalid value for type will result in the following response:<br>`Invalid request : Incorrect Feed Type`<br>Providing an invalid combination of format and type will result in the following response:<br>`Invalid request : Feed Type cannot be combo for csv/UALF format` |
| "l": <lightning_type> | Mandatory. Defines the type of pulses and/or flashes that will be included in the response data stream. Allows the following values:<br>• cg – Cloud to Ground<br>• ic – Intra Cloud<br>• all – cg and ic<br>Providing an invalid value for lightning type will result in the following response:<br>`Invalid request : Incorrect Lightning Type` |
| "k": <keep alive msgs> | Optional. Instructs the system whether to send "keep-alive" (aka "heartbeat") messages to the consuming client at a fixed interval. This optional feature can help consuming clients be certain that the data feed connection is live during times of no lightning activity. Times of no lightning activity can occur if the partner ID is configured with a geographic bounding box and no lightning has occurred within that geographic area. This option is not necessary to keep the connection open, it is designed to simply give a consuming client additional assurance that the connection is still active during spans of no lightning activity. Allows the following values:<br>• on – send "keep-alive" messages<br>• off – the default value, do not send keep alive messages<br>If this parameter is set to "on" a "keep-alive" message will be sent to the consuming client for any 30 second time span of no pulse or flash activity. Refer to the Binary, JSON, CSV, and UALF sections of the document for the definition and examples of the "keep-alive" message structure for each supported data format.<br>Providing an invalid value for this parameter will result in the following response:<br>`Invalid request : Incorrect value for 'k' parameter. Valid values are 'on' or 'off'.` |
| "h": <history seconds> | Optional. The number of seconds back in time, from which the data stream should start. The maximum allowed value is 500 (seconds). The system will approximate the lightning time (not system clock time) associated with the provided value for this parameter and start the data stream with the pulses and or flashes whose time of occurrence is roughly that old. The data |

| | |
|---|---|
| | stream will catch up to current lighting time and continue from there as a normal near-real-time data stream.<br>Providing a value larger than the maximum will result in the following response:<br>`Invalid request: Incorrect value for History Seconds` |

Once the WebSocket connection is established you should start to see data streaming to your WebSocket client within a few seconds.

# 3 Data Element Descriptions

The following data elements are available in a lightning feed.

- Time in Universal Time Coordinated (UTC). Note that the "time" for a flash is recorded as the time of the *major pulse* of the flash. We define "major pulse" as follows:
  - If the flash is an In-Cloud (IC) flash, then the major pulse is the IC pulse with the *largest absolute amplitude value.*
  - If the flash is a Cloud-to-Ground (CG) flash, then the major pulse is the CG pulse with the *largest absolute amplitude value.*
- Latitude in decimal degrees
- Longitude in decimal degrees
- Flash Type (aka Classification): Possible values are 0 or 1 (or 40). If a flash contains one or more CG (cloud-to-ground, 0) pulse(s) then the flash will be classified as a CG. Otherwise, it will be classified as IC (intra-cloud, 1). If the customer's partner ID is subscribed to GLN, the datafeed might also generate flashes whose type is 40, but only if the "showSource" connection URL parameter is set to "true". 40 means the flash is from the WWLLN lightning detection network and should be regarded as a CG. Refer to section 8 of this document for more on the "showSource" parameter. (Flash Type can also have a value of 9 for "keep-alive" messages when using the "k" URL parameter. Refer to section 2 for more details).
- Pulse Type (aka Classification): Possible values are 0 or 1 (or 40). By definition, a pulse detected by EN sensors is classified as "CG" (cloud to ground, type=0) when it contains a return stroke. Any pulse that does not contain a return stroke is classified as "IC" (in-cloud, type=1). If the customer's partner ID is subscribed to GLN, the datafeed might also generate pulses whose type is 40, but only if the "showSource" connection URL parameter is set to "true". 40 means the pulse is from the WWLLN lightning detection network and should be regarded as a CG. Refer to section 8 of this document for more on the "showSource" parameter.
- Peak Current: Peak Current for CG or peak radiated field normalized to 30 km for IC lightning. Please note that the amplitude of a given flash is defined as the amplitude of the major pulse in the flash. For any pulses that do not contain peak current data, the value will be zero.
- Number of Sensors: Number of sensors used in locating a lightning flash/pulse.
- Multiplicity: A flash can consist of many pulses. Therefore, these values represent the number of IC pulses and CG pulses in each flash.

- Height: Applies to IC only. This parameter estimates the height of the IC lightning in meters. This value can be as high as 20,000 meters and it should be noted that it will be most accurate in locations with a high sensor density.
- Error Ellipse: Applies to pulses only. The true location of the lightning having a chance of being inside the ellipse. The error ellipse is constructed using the length of the major and minor axis, and bearing. Please note that the bearing is the angle in degrees east of north of the major axis of the ellipse where north = 0, east = 90, south = 180, and west = 270.
- Metadata: Applies to flashes only. The duration of the flash strike and the area the flash is located. The "start time" is recorded as the occurrence of the *first pulse* within a flash; this will differ from the "time" parameter which is the time of the *major pulse* of the flash, as mentioned above. The "duration" is the time range of the flash in nanoseconds that is constructed using the start time and the time of the last pulse in the flash. The area of the flash is calculated using all pulses in a flash. The four latitude & longitude coordinates represent the "upper left" (ul) and "lower right" (lr) corners of the minimum bounding box that contains all of the pulses associated with a given flash; most likely, there will not be pulses at the corners of the bounding box.

Here are a couple of screen captures below that illustrate the composition of a flash and how to identify the strongest pulses in a given flash:

chksum=243

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| class=1 | time=20150614T111538.195 | lat=29.1419468 | lon=-97.6947447 | amp=7583 | err=0 | ht=12578 | sensors=34 | mult=19 | chksum=87 |
| class=1 | time=20150614T111538.008 | lat=29.1424696 | lon=-97.7016576 | amp=-1345 | err=0 | ht=18657 | sensors=10 | mult=19 | chksum=241 |
| class=1 | time=20150614T111538.021 | lat=29.1472161 | lon=-97.6926531 | amp=-2119 | err=0 | ht=18185 | | | chksum=129 |
| class=1 | time=20150614T111538.034 | lat=29.1086524 | lon=-97.6764246 | amp=1433 | err=0 | ht=1 | | | ksum=29 |
| class=1 | time=20150614T111538.048 | lat=29.1269047 | lon=-97.6769749 | amp=1776 | err=0 | ht=1 | | | ksum=203 |
| class=1 | time=20150614T111538.179 | lat=29.1444374 | lon=-97.7000508 | amp=-1529 | err=0 | ht=1 | | | ksum=113 |
| class=1 | time=20150614T111538.182 | lat=29.1110265 | lon=-97.6877118 | amp=1467 | err=0 | ht= | | | ksum=104 |
| class=1 | time=20150614T111538.195 | lat=29.1419468 | lon=-97.6947447 | amp=7583 | err=0 | ht=12578 | sensors=19 | mult=19 | chksum=102 |
| class=1 | time=20150614T111538.201 | lat=29.1231875 | lon=-97.6620923 | amp=1389 | err=0 | ht=19576 | sensors=9 | mult=19 | chksum=112 |
| class=1 | time=20150614T111538.206 | lat=29.1311535 | lon=-97.7150852 | amp=754 | err=0 | ht=13215 | sensors=11 | mult=19 | chksum=155 |
| class=1 | time=20150614T111538.208 | lat=29.1210278 | lon=-97.6879073 | amp=1432 | err=0 | ht=18604 | sensors=11 | mult=19 | chksum=22 |
| class=1 | time=20150614T111538.225 | lat=29.1047935 | lon=-97.6850682 | amp=2353 | err=0 | ht=18385 | sensors=20 | mult=19 | chksum=137 |
| class=1 | time=20150614T111538.227 | lat=29.1229201 | lon=-97.6887218 | amp=1588 | err=0 | ht=14302 | sensors=13 | mult=19 | chksum=0 |
| class=1 | time=20150614T111538.236 | lat=29.126456 | lon=-97.6620689 | amp=815 | err=0 | ht=16146 | sensors=10 | mult=19 | chksum=230 |
| class=1 | time=20150614T111538.248 | lat=29.1056183 | lon=-97.6823744 | amp=-1630 | err=0 | ht=15598 | sensors=18 | mult=19 | chksum=7 |
| class=1 | time=20150614T111538.279 | lat=29.1318633 | lon=-97.7099008 | amp=-690 | err=0 | ht=17061 | sensors=7 | mult=19 | chksum=197 |
| class=1 | time=20150614T111538.339 | lat=29.1434619 | lon=-97.6502192 | amp=1579 | err=0 | ht=12645 | sensors=18 | mult=19 | chksum=155 |
| class=1 | time=20150614T111538.403 | lat=29.1519084 | lon=-97.6461314 | amp=795 | err=0 | ht=13769 | sensors=6 | mult=19 | chksum=135 |
| class=1 | time=20150614T111538.412 | lat=29.1514502 | lon=-97.6480469 | amp=3265 | err=0 | ht=19019 | sensors=20 | mult=19 | chksum=63 |
| class=1 | time=20150614T111538.417 | lat=29.1487433 | lon=-97.6431176 | amp=1296 | err=0 | ht=18725 | sensors=12 | mult=19 | chksum=252 |

chksum=201

Strongest pulse in this IC flash

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| chksum=66 | | | | | | | | | |
| class=0 | time=20150614T111536.539 | lat=27.3573606 | lon=-101.7837128 | amp=-67018 | err=0 | ht=0 | sensors=56 | mult=16 | chksum=69 |
| class=1 | time=20150614T111536.239 | lat=27.3640183 | lon=-101.7876318 | amp=-9720 | err=0 | ht=13960 | sensors=19 | mult=16 | chksum=192 |
| class=1 | time=20150614T111536.240 | lat=27.3352878 | lon=-101.794994 | amp=-8423 | err=0 | ht=13727 | [illegible] | mult=16 | chksum=253 |
| class=0 | time=20150614T111536.268 | lat=27.3714902 | lon=-101.7929665 | amp=-13230 | err=0 | ht=0 | [illegible] | mult=16 | chksum=86 |
| class=0 | time=20150614T111536.316 | lat=27.3557165 | lon=-101.7802941 | amp=-27194 | err=0 | ht=0 | [illegible] | mult=16 | chksum=134 |
| class=0 | time=20150614T111536.354 | lat=27.3541653 | lon=-101.7836207 | amp=-23295 | err=0 | ht=0 | [illegible] | [illegible] | [illegible] |
| class=0 | time=20150614T111536.386 | lat=27.3710256 | lon=-101.7700755 | amp=-12586 | err=0 | ht=0 | [illegible] | [illegible] | [illegible] |
| class=1 | time=20150614T111536.499 | lat=27.4111564 | lon=-101.6932729 | amp=-4230 | err=0 | ht=1713 | [illegible] | [illegible] | [illegible] |
| class=1 | time=20150614T111536.506 | lat=27.4343329 | lon=-101.7768446 | amp=4837 | err=0 | ht=18174 | sensors=20 | mult=16 | chksum=158 |
| class=1 | time=20150614T111536.513 | lat=27.4291865 | lon=-101.726947 | amp=13166 | err=0 | ht=15990 | sensors=12 | mult=16 | chksum=146 |
| class=0 | time=20150614T111536.539 | lat=27.3573606 | lon=-101.7837128 | amp=-67018 | err=0 | ht=0 | sensors=20 | mult=16 | chksum=105 |
| class=1 | time=20150614T111536.546 | lat=27.3617809 | lon=-101.7708122 | amp=-15219 | err=0 | [illegible] | sensors=19 | mult=16 | chksum=55 |
| class=1 | time=20150614T111536.591 | lat=27.354996 | lon=-101.7856475 | amp=-19146 | err=0 | [illegible] | [illegible] | [illegible] | [illegible] |
| class=1 | time=20150614T111536.636 | lat=27.353414 | lon=-101.7806531 | amp=-16817 | err=0 | [illegible] | [illegible] | [illegible] | [illegible] |
| class=0 | time=20150614T111536.677 | lat=27.358924 | lon=-101.7830998 | amp=-15417 | err=0 | [illegible] | [illegible] | [illegible] | [illegible] |
| class=0 | time=20150614T111536.682 | lat=27.2998578 | lon=-101.7292548 | amp=-4509 | err=0 | ht=0 | sensors=9 | mult=16 | chksum=43 |
| class=0 | time=20150614T111536.972 | lat=27.3592274 | lon=-101.7785606 | amp=-23622 | err=0 | ht=0 | sensors=20 | mult=16 | chksum=73 |

There are IC pulses part of this CG flash.

Strongest stroke in this CG flash.

# 4 JSON Format

Assuming you provided “json” as the value for the “f” (format) URL parameter, your WebSocket connection will receive a stream of JSON data structures. Depending on your selections for the “t” (type) and “l” (lightning_type) URL parameters, and the configuration of your partnerID, the JSON data structures in your data feed will contain both flashes and pulses (combo), or just flashes, or just pulses. This section illustrates the JSON data structure for these 3 cases.

## 4.1 Combo Feed

The illustration below contains the data structure that will be streamed from the data feed when the “t” (type) URL parameter is set to “combo”. The data stream is a continuous stream of these JSON flash data structures, each of which contains the pulses that underlie the flash.

In the JSON format peakCurrent is in amperes, and icHeight, eeMajor, and eeMinor are all in meters.

**Table 2 - Combo Feed JSON Data Structure**

```
{
"type":0,
"time":"2021-04-13T20:24:33.094300187Z",
"latitude":-8.623366,
"longitude":26.324089,
"peakCurrent":19678.0,
"numSensors":5,
"icHeight":0.0,
"icMultiplicity":1,
"cgMultiplicity":1,
"startTime":"2021-04-13T20:24:33.094300187Z",
```

```
"endTime":"2021-04-13T20:24:33.116637089Z",
"duration":22336902,
"ulLatitude":-8.585775,
"ulLongitude":26.327941,
"lrLatitude":-8.623366,
"lrLongitude":26.324089,
"Pulses":
[
        {
             "type":1,
             "time":"2021-04-13T20:24:33.116637089Z",
             "latitude":-8.585775,
             "longitude":26.327941,
             "peakCurrent":11167.0,
             "numSensors":7,
             "icHeight":11669.0,
             "eeMajor":214.0,
             "eeMinor":70.0,
             "eeBearing":103.0,
        },
        {
             "type":0,
             "time":"2021-04-13T20:24:33.094300187Z",
             "latitude":-8.623366,
             "longitude":26.324089,
             "peakCurrent":19678.0,
             "numSensors":5,
             "icHeight":0.0,
             "eeMajor":293.0,
             "eeMinor":53.0,
             "eeBearing":99.0,
        }
]
}
```


A Combo “keep-alive” message is a combo data structure with 9 as the value for “type”. All other values in this ‘keep-alive” message are meaningless. An example is in the table below. Refer to section 2 for more information about the optional “k” URL parameter and the resulting “keep-alive” messages.


```
{
"type":9,
"time":"2022-08-09T20:16:21.896606500Z",
"latitude":0.0,
"longitude":0.0,
"peakCurrent":0.0,
"numSensors":1,
"icHeight":0.0,
"icMultiplicity":0,
"cgMultiplicity":0,
"startTime":"2022-08-09T20:16:21.896606500Z",
```

```
"endTime":"2022-08-09T20:16:21.896606500Z",
"duration":0,
"ulLatitude":0.0,
"ulLongitude":0.0,
"lrLatitude":0.0,
"lrLongitude":0.0,
"Pulses":
[
       {
         "type":9,
         "time":"2022-08-09T20:16:21.896606500Z",
         "latitude":0.0,
         "longitude":0.0,
         "peakCurrent":0.0,
         "numSensors":1,
         "icHeight":0.0,
         "eeMajor":0,
         "eeMinor":0,
         "eeBearing":0
       }
]
}
```


## 4.2 Pulse Feed

The illustration below contains the data structure that will be streamed from the data feed when the “t” (type) URL parameter is set to “pulse”. The data stream is a continuous stream of these JSON pulse data structures.

**Table 3 - Pulse Feed JSON Data Structure**


```
{
       "type":0,
       "time":"2021-04-13T20:56:25.154003149Z",
       "latitude":29.122692,
       "longitude":-89.794134,
       "peakCurrent":15537.0,
       "numSensors":12,
       "icHeight":0.0,
       "eeMajor":345.0,
       "eeMinor":41.0,
       "eeBearing":165.0,
}
```


A Pulse “keep-alive” message is a pulse data structure with 9 as the value for “type”. All other values in this ‘keep-alive” message are meaningless. An example is in the table below. Refer to section 2 for more information about the optional “k” URL parameter and the resulting “keep-alive” messages.

```
{
	"type":9,
	"time":"2022-08-09T20:16:21.916693800Z",
	"latitude":0.0,
	"longitude":0.0,
	"peakCurrent":0.0,
	"numSensors":1,
	"icHeight":0.0,
	"eeMajor":0,
	"eeMinor":0,
	"eeBearing":0
}
```


## 4.3 Flash Feed

The illustration below contains the data structure that will be streamed from the data feed when the “t” (type) URL parameter is set to “flash”. The data stream is a continuous stream of these JSON flash data structures.

**Table 4 - Flash Feed JSON Data Structure**


```
{
	"type":0,
	"time":"2021-04-13T20:59:01.947149630Z",
	"latitude":9.151455,
	"longitude":-5.246916,
	"peakCurrent":15488.0,
	"numSensors":6,
	"icHeight":0.0,
	"icMultiplicity":0,
	"cgMultiplicity":1,
	"startTime":"2021-04-13T20:59:01.947149630Z",
	"endTime":"2021-04-13T20:59:01.947149630Z",
	"duration":0,
	"ulLatitude":9.151455,
	"ulLongitude":-5.246916,
	"lrLatitude":9.151455,
	"lrLongitude":-5.246916
}
```


A Flash “keep-alive” message is a flash data structure with 9 as the value for “type”. All other values in this ‘keep-alive” message are meaningless. An example is in the table below. Refer to section 2 for more information about the optional “k” URL parameter and the resulting “keep-alive” messages.


```
{
	"type":9,
	"time":"2022-08-09T20:16:21.896599700Z",
	"latitude":0.0,
```

```
        "longitude":0.0,
        "peakCurrent":0.0,
        "numSensors":1,
        "icHeight":0.0,
        "icMultiplicity":0,
        "cgMultiplicity":0,
        "startTime":"2022-08-09T20:16:21.896599700Z",
        "endTime":"2022-08-09T20:16:21.896599700Z",
        "duration":0,
        "ulLatitude":0.0,
        "ulLongitude":0.0,
        "lrLatitude":0.0,
        "lrLongitude":0.0
}
```


# 5 Binary Format

Assuming you provided “binary” as the value for the “f” (format) URL parameter, your WebSocket connection will receive a stream of binary data structures. Depending on your selections for the “t” (type) and “l” (lightning_type) URL parameters, and the configuration of your partnerID, the binary data structures in your data feed will contain both flashes and pulses (combo), or just flashes, or just pulses. This section defines the binary data structure for these 3 cases.

## 5.1 Pulse Feed

The illustration below contains the data structure that will be streamed from the data feed when the “t” (type) URL parameter is set to “pulse”. The data stream is a continuous stream of these binary pulse data structures, each containing 32 bytes of data.

Table 5 - Pulse Feed Binary Data Structure

| Byte | Content |
|---|---|
| 0 | The number of bytes for packet |
| 1 | pulse Type |
| 2 | “Time” byte 1, MSB |
| 3 | “Time” byte 2, LSB+2 |
| 4 | “Time” byte 3, LSB+1 |
| 5 | “Time” byte 4, LSB |
| 6 | Nanosecond byte 1, MSB |
| 7 | Nanosecond byte 2, LSB+2 |
| 8 | Nanosecond byte 3, LSB+1 |
| 9 | Nanosecond byte 4, LSB |

| Byte | Content |
|---|---|
| 10 | “Latitude” byte 1, MSB |
| 11 | “Latitude” byte 2, LSB+2 |
| 12 | “Latitude” byte 3, LSB+1 |
| 13 | “Latitude” byte 4, LSB |
| 14 | “Longitude” byte 1, MSB |
| 15 | “Longitude” byte 2, LSB+2 |
| 16 | “Longitude” byte 3, LSB+1 |
| 17 | “Longitude” byte 4, LSB |
| 18 | Peak Current byte 1, MSB |
| 19 | Peak Current byte 2, LSB+2 |
| 20 | Peak Current byte 3, LSB+1 |
| 21 | Peak Current byte 4, LSB |
| 22 | “IC Height” byte 1, MSB |
| 23 | “IC Height” byte 2, LSB |
| 24 | “Number of Sensors” |
| 25 | “Major Axis Byte 1 MSB” |
| 26 | “Major Axis Byte 2 LSB” |
| 27 | “Minor Axis Byte 1 MSB” |
| 28 | “Minor Axis Byte 2 LSB” |
| 29 | “Bearing Byte 1 MSB” |
| 30 | “Bearing Byte 2 LSB” |
| 31 | “CheckSum” |

## Byte Description

**Byte 0** contains the length of a packet and the value should be 32.

**Byte 1** is pulse type, where "0" signifies a return stroke, "1" signifies any other kind of pulse and “9” signifies a keep-alive packet with no lightning data.

**Bytes 2, 3, 4, and 5** represent pulse or flash time (depending on feed) and are combined to form an unsigned 32 bit binary integer that represents the number of non-leap seconds since January 1, 1970 00:00:00.

**Bytes 6, 7, 8, 9** represent pulse or flash (depending on feed) time and are combined to form an unsigned 32-bit binary integer that represents nanoseconds.

- To determine the exact lightning time, combine the total non-leap seconds from Bytes 2, 3, 4 and 5 with the nanoseconds value from Bytes 6 and 9.

**Bytes 10, 11, 12 and 13** are combined to make a signed, 32-bit binary number that represents the latitude position in which negative numbers are represented by the two’s complement (Table 6). This is a signed number where a positive value represents North latitude, and a negative number represents South latitude:

- The latitude is WGS84. To extract the latitude from the binary number, convert the number to the signed decimal value and divide by 10,000,000 (10 power 7). The following table shows calculation examples of latitude.

Table 6 – Binary Latitude Calculation

| Latitude | 10000000*Latitude | Byte 10 | Byte 11 | Byte 12 | Byte 13 |
|---|---|---|---|---|---|
| 37.8256 | 378256000 | 22 | 139 | 186 | 128 |
| -37.8223 | -378223000 | 233 | 116 | 198 | 104 |
| 44.9872 | 449872000 | 26 | 208 | 128 | 128 |
| -17.7376 | -177376000 | 245 | 109 | 117 | 0 |
| 12.3456 | 123456000 | 7 | 91 | 202 | 0 |
| -65.4321 | -654321000 | 216 | 255 | 218 | 152 |

**Bytes 14, 15, 16 and 17** are combined to make a signed, 32-bit binary number that represents the longitude position in which negative numbers are represented by the two's complement (Table 7). This is a signed number where a positive value represents East longitude, and a negative number represents West longitude:

- The longitude is WGS84. To extract the longitude from the binary number, convert the number to the signed decimal value and divide by 10,000,000 (10 power 7). Review the table below for example calculations of longitude.

Table 7 – Binary Longitude Calculation

| Longitude | 10000000*Longitude | Byte 12 | Byte 13 | Byte 14 | Byte 15 |
|---|---|---|---|---|---|
| 12.8734 | 128734000 | 7 | 172 | 83 | 48 |
| 92.3412 | 923412000 | 55 | 10 | 38 | 32 |
| 10.44121 | 104412100 | 22 | 139 | 186 | 128 |
| -17.83214 | -178321400 | 245 | 95 | 8 | 8 |
| -38.9123 | -389123000 | 232 | 206 | 116 | 72 |
| -18.6125 | -186125000 | 244 | 231 | 245 | 56 |

**Bytes 18, 19, 20 and 21** are combined to make a signed, 32-bit binary number of amperes of peak current (Table 8).

Table 8 – Binary Peak Current

| Peak Current | Byte 16 | Byte 17 | Byte 18 | Byte 19 |
|---|---|---|---|---|
| 72300 | 0 | 1 | 26 | 108 |
| -43900 | 255 | 255 | 84 | 132 |

**Bytes 22 and 23** are combined to make an unsigned 16-bit binary number of IC Height (Table 9).

Table 9 – Binary IC Height

| IC Height | Byte 21 | Byte 22 |
|---|---|---|
| 6764 | 26 | 108 |
| 108 | 0 | 108 |

**Byte 24** is a signed 8-bit binary number of Number of Sensors.

**Byte 25, 26** are combined to show an unsigned 16-bit binary number (meters) the major axis of error ellipse.

**Byte 27, 28** are combined to show an unsigned 16-bit binary number (meters) the minor axis of error ellipse.

**Byte 29, 30** are combined to show an unsigned 16-bit binary number (degree) the bearing of error ellipse.

**Byte 31** contains the packet checksum. The value of this byte is calculated by adding all other bytes to a byte variable and subtracting the result from 256.

## 5.2 Flash Feed

The illustration below contains the data structure that will be streamed from the data feed when the "t" (type) URL parameter is set to "flash". The data stream is a continuous stream of these binary flash data structures, each of which containing 56 bytes of data.

Table 10 - Flash Feed Binary Data Structure

| Byte | Content |
|---|---|
| 0 | The number of bytes for packet |
| 1 | flash Type |
| 2 | "Time" byte 1, MSB |
| 3 | "Time" byte 2, LSB+2 |
| 4 | "Time" byte 3, LSB+1 |
| 5 | "Time" byte 4, LSB |
| 6 | Nanosecond byte 1, MSB |

| Byte | Content |
|---|---|
| 7 | Nanosecond byte 2, LSB+2 |
| 8 | Nanosecond byte 3, LSB+1 |
| 9 | Nanosecond byte 4, LSB |
| 10 | “Latitude” byte 1, MSB |
| 11 | “Latitude” byte 2, LSB+2 |
| 12 | “Latitude” byte 3, LSB+1 |
| 13 | “Latitude” byte 4, LSB |
| 14 | “Longitude” byte 1, MSB |
| 15 | “Longitude” byte 2, LSB+2 |
| 16 | “Longitude” byte 3, LSB+1 |
| 17 | “Longitude” byte 4, LSB |
| 18 | Peak Current byte 1, MSB |
| 19 | Peak Current byte 2, LSB+2 |
| 20 | Peak Current byte 3, LSB+1 |
| 21 | Peak Current byte 4, LSB |
| 22 | “IC Height” byte 1, MSB |
| 23 | “IC Height” byte 2, LSB |
| 24 | “Number of Sensors” |
| 25 | “IC Multiplicity” |
| 26 | “CG Multiplicity” |
| 27 | “Start Time” byte 1, MSB |
| 28 | “Start Time” byte 2, LSB+2 |
| 29 | “Start Time” byte 3, LSB+1 |
| 30 | “Start Time” byte 4, LSB |
| 31 | Start Time Nanosecond byte 1, MSB |
| 32 | Start time Nanosecond byte 2, LSB+2 |
| 33 | Start Time Nanosecond byte 3, LSB+1 |
| 34 | Start Time Nanosecond byte 4, LSB |
| 35 | Duration in Nanosecond byte 1 MSB |
| 36 | Duration in Nanosecond byte 2 LSB + 2 |
| 37 | Duration in Nanosecond byte 3 LSB + 1 |
| 38 | Duration in Nanosecond byte 4 LSB |
| 39 | “UL[1] Latitude” byte 1, MSB |

[1] UL=upper left

| Byte | Content |
|---|---|
| 40 | “UL Latitude” byte 2, LSB+2 |
| 41 | “UL Latitude” byte 3, LSB+1 |
| 42 | “UL Latitude” byte 4, LSB |
| 43 | “UL Longitude” byte 1, MSB |
| 44 | “UL Longitude” byte 2, LSB+2 |
| 45 | “UL Longitude” byte 3, LSB+1 |
| 46 | “UL Longitude” byte 4, LSB |
| 47 | “LR[2] Latitude” byte 1, MSB |
| 48 | “LR Latitude” byte 2, LSB+2 |
| 49 | “LR Latitude” byte 3, LSB+1 |
| 50 | “LR Latitude” byte 4, LSB |
| 51 | “LR Longitude” byte 1, MSB |
| 52 | “LR Longitude” byte 2, LSB+2 |
| 53 | “LR Longitude” byte 3, LSB+1 |
| 54 | “LR Longitude” byte 4, LSB |
| 55 | CheckSum |

## Byte Description

**Byte 1** is flash, where "0" signifies a CG flash, "1" signifies an IC flash, and “9” signifies a keep-alive packet with no lightning data. Any flash containing at least one pulse of type 0 is a CG flash; flashes containing only pulses of type 1 are IC flashes.

***Please refer to Byte Description under Table 2 in the pulse Feed section for details of contents for bytes 2 - 24.***

**Byte 25** is a signed 8-bit binary number of IC Multiplicity.

**Byte 26** is a signed 8-bit binary number of CG Multiplicity. For IC flash data, this value will always be 0.

**Bytes 27, 28, 29, and 30** represent first pulse time of the flash and are combined to form an unsigned 32-bit binary integer that represents the number of non-leap seconds since January 1, 1970 00:00:00 Universal Coordinated Time (UTC).

**Bytes 31, 32, 33, and 34** represent first pulse time of the flash and are combined to form an unsigned 32-bit binary integer that represents nanoseconds.

- To determine the complete lightning time, combine the total non-leap seconds from Bytes 27, 28, 29 and 30 with the nanoseconds value from Bytes 31 to 34.

[2] Lr=lower right

**Byte 35, 36, 37, 38** are combined to show unsigned 32-bit binary number (nanoseconds) representing the duration of the flash. If the flash only has one pulse (indicated by a total multiplicity of 1), the value for this attribute will be 0.

**Bytes 39, 40, 41 and 42** are combined to make a signed, 32-bit binary number that represents the upper left latitude position in which negative numbers are represented by the two's complement (Table 6). This is a signed number where a positive value represents North latitude, and a negative number represents South latitude.

**Bytes 43, 44, 45 and 46** are combined to make a signed, 32-bit binary number that represents the upper left longitude position in which negative numbers are represented by the two's complement (Table 7). This is a signed number where a positive value represents East longitude, and a negative number represents West longitude:

**Bytes 47, 48, 49 and 50** are combined to make a signed, 32-bit binary number that represents the lower right latitude position in which negative numbers are represented by the two's complement (Table 6). This is a signed number where a positive value represents North latitude, and a negative number represents South latitude.

**Bytes 51, 52, 53 and 54** are combined to make a signed, 32-bit binary number that represents the lower right longitude position in which negative numbers are represented by the two's complement (Table 7). This is a signed number where a positive value represents East longitude, and a negative number represents West longitude:

**Byte 55** contains the packet checksum. The value of this byte is calculated by adding all other bytes to a byte variable and subtracting the result from 256.

## 5.3 Combo Feed

The table below contains the data structure that will be streamed from the data feed when the "t" (type) URL parameter is set to "combo". The data stream is a continuous stream of these binary flash and pulse data structures, each of which contains 156 bytes of data.

Table 11 - Combo Feed Binary Data Structure

| Byte | Content |
|---|---|
| 0 | MSB of the number of bytes for the packet |
| 1 | LSB of the number of bytes for the packet |

| Byte | Content |
|---|---|
| 2-57 | flash sub-Packet |
| 58-89 | pulse 1 sub-packet |
| 90-121 | pulse 2 sub-packet |
| … | … |
| Last byte | Checksum |

Bytes 0-1 in the combination packet contain the expected packet size.
Bytes 2-57 in the Combination Packet contain the flash sub-packet content. ***Please refer to Byte Description under Table 10 in the flash Feed section for full details of contents for bytes 2-57.***

Bytes 58-89 in the Combination Packet contain the first pulse sub-packet content. The content will repeat, following the same pattern, for all subsequent pulses. For instance, the next pulse will be bytes 90-121. Byte 1 of each of the pulse sub-packet will indicate the flash type; where "0" signifies a CG flash, "1" signifies an IC flash, and "9" signifies a keep-alive packet with no lightning data. Any flash containing at least one pulse of type 0 is a CG flash; flashes containing only pulses of type 1 are IC flashes. ***Please refer to Byte Description under Table 5 in the pulse feed section for full details of contents for all other bytes.***
Last byte contains the packet checksum. The value of this byte is calculated by adding all other bytes of the combination packet to a byte variable and subtracting the result from 256.

# 6 CSV Format

Assuming you provided "csv" as the value for the "f" (format) URL parameter, your WebSocket connection will receive a stream of CSV data records. And depending on your selections for the "t" (type) and "l" (lightning_type) URL parameters, and the configuration of your partnerID, the CSV data records in your data feed will contain flashes or pulses. A combo feed is not supported for CSV. This section defines the CSV data structure for these 2 cases. The fields are separated by a comma, and with the exception of field 1, are fixed width.

## 6.1 Pulse Feed

Table 12 - Pulse Feed CSV Data Structure

| Field | Content | |
|---|---|---|
| 1 | Pulse Type: | 0 = CG, 1 = IC, 40 = WWLLN CG |
| 2 | Pulse Time: | YYYYMMDDThhmmss.sss in UTC (ISO 8601) |
| 3 | Latitude: | + or – nn.nnnnnnn |
| 4 | Longitude: | + or – nnn.nnnnnnn |
| 5 | Peak Current: | + or – xxxxxxxxx |

| Field | Content | |
|---|---|---|
| 6 | Reserved: | Always 000 |
| 7 | IC Height: | xxxxx |
| 8 | Number of Sensors: | xxx |
| 9 | Multiplicity: | xxx (this value is not meaningful for pulses) |

## 6.2 Flash Feed

Table 13 - Flash Feed CSV Data Structure

| Field | Content | |
|---|---|---|
| 1 | Flash Type: | 0 = CG, 1 = IC, 40 = WWLLN CG |
| 2 | Flash Time: | YYYYMMDDThhmmss.sss in UTC (ISO 8601) |
| 3 | Latitude: | + or – nn.nnnnnnn |
| 4 | Longitude: | + or – nnn.nnnnnnn |
| 5 | Peak Current: | + or – xxxxxxxxx (amperes) |
| 6 | Reserved: | Always 000 |
| 7 | IC Height: | xxxxx (meters) |
| 8 | Number of Sensors: | xxx |
| 9 | Multiplicity: | xxx |

## 6.3 Example CSV Feed

This is an example of 8 CSV pulse records streamed over the WebSocket connection.

```
1,20210510T195819.911,+25.1087160,+090.1000420,-000011203,000,03424,017,001
1,20210510T195819.349,+25.0162700,+090.0803870,+000003770,000,03874,008,001
0,20210510T195819.263,+26.8569760,+108.6501040,-000017110,000,00000,008,001
0,20210510T195819.885,+26.4474860,+109.3470040,-000011010,000,00000,008,001
1,20210510T195819.468,+08.9638750,-078.6788490,+000002795,000,16887,006,001
1,20210510T195819.426,+08.9553430,-078.5730800,-000005281,000,04113,012,001
0,20210510T195819.430,+08.9630880,-078.5806380,-000004512,000,00000,010,001
1,20210510T195819.375,+08.9519280,-078.5740450,-000003036,000,07027,007,001
```

This is an example of 8 CSV flash records streamed over the WebSocket connection.

```
0,20210510T195515.460,+32.3503080,-075.8755510,-000011232,000,00000,043,025
1,20210510T195515.426,+08.4264930,-074.3035900,+000002954,000,19878,005,001
1,20210510T195515.890,+08.9654230,-078.4404890,+000003938,000,16053,007,001
0,20210510T195515.935,+09.0896770,-078.5472550,-000002994,000,00000,006,001
1,20210510T195515.436,+04.8144210,-075.7165030,-000006344,000,05276,008,003
1,20210510T195515.660,+06.9294080,-077.3215610,+000004240,000,16180,007,001
1,20210510T195515.092,+29.2733850,+122.9450230,+000006786,000,03049,005,001
1,20210510T195515.013,+28.9949060,+122.7638680,+000011649,000,07574,007,007
```

This is an example CSV pulse “keep-alive” record. A Pulse “keep-alive” message is a pulse data structure with 9 as the value for “type”. All other values in this “keep-alive” message are meaningless. Refer to section 2 for more information about the optional “k” URL parameter and the resulting “keep-alive” messages.

```
9,20220809T201754.164,+00.0000000,+000.0000000,+000000000,000,00000,001,001
```

This is an example CSV flash “keep-alive” record. A flash “keep-alive” message is a flash data structure with 9 as the value for “type”. All other values in this “keep-alive” message are meaningless. Refer to section 2 for more information about the optional “k” URL parameter and the resulting “keep-alive” messages.

```
9,20220809T201723.167,+00.0000000,+000.0000000,+000000000,000,00000,001,001
```

# 7 UALF Format

Assuming you provided “ualf” as the value for the “f” (format) URL parameter, your WebSocket connection will receive a stream of UALF data records. And depending on your selections for the “t” (type) and “l” (lightning_type) URL parameters, and the configuration of your partnerID, the UALF data records in your data feed will contain flashes or pulses. A combo feed is not supported for UALF. This section defines the UALF data structure for these 2 cases. The fields are separated by a space. For further information about the UALF specification refer to the following web site: https://api.met.no/images/UALF_format.png

## 7.1 Pulse and Flash Feed Data Structure

The following data structure is used for UALF pulses and flashes.

Table 14 - Pulse and Flash Feed UALF Data Structure

| Field | Content | |
|---|---|---|
| 1 | Version: | Always zero/0 |
| 2 | Year: | YYYY (UTC) |
| 3 | Month: | MM (UTC) |
| 4 | Day of Month: | DD (UTC) |
| 5 | Hour: | HH (UTC) |
| 6 | Minute: | MM (UTC) |
| 7 | Second: | SS (UTC) |
| 8 | Nanosecond: | xxxxxxxxx (UTC) |
| 9 | Latitude: if positive) | xx.xxxxxxx (leading minus sign if negative, no plus sign |

| Field | Content | |
|---|---|---|
| 10 | Longitude: | xxx.xxxxxxx (leading minus sign if negative, no plus sign if positive) |
| 11 | Peak Current: | kiloamperes, -9999 thru +9999, with leading minus sign if negative, leading plus sign if positive |
| 12 | Multiplicity: | 0 for pulse, 1-500 for flash |
| 13 | Number of Sensors: | 5 thru 99 |
| 14 | Degrees of Freedom: | 0 thru 99 |
| 15 | Ellipse Angle: | 0 thru 180 |
| 16 | Major Axis Length: | xx.xx (kilometers) |
| 17 | Minor Axis Length: | xx.xx (kilometers) |
| 18 | Chi-Square: | 0 for flash, 0 thru 500.00 for pulse |
| 19 | Rise Time: | Always zero/0 |
| 20 | Peak-to-Zero Time: | Always zero/0 |
| 21 | Max Rate-of-Rise: | Always zero/0 |
| 22 | Cloud Indicator: | 0 = Cloud to Ground, 1 = Intra Cloud |
| 23 | Angle Indicator: | Always zero/0 |
| 24 | Signal Indicator: | Always zero/0 |
| 25 | Timing Indicator: | Always one/1 |

## 7.2 Example UALF Feed

This is an example of 8 pulse UALF records streamed over the WebSocket connection.

```
0 2021 05 10 19 46 49 847545609 36.4554570 -72.2441560 +4 0 25 21 129 0.04 0.02 0.06 0 0 0 1 0 0 1
0 2021 05 10 19 46 49 758427920 36.4439800 -72.2431370 +5 0 27 23 133 0.06 0.03 0.13 0 0 0 1 0 0 1
0 2021 05 10 19 46 49 154902268 31.4284830 121.2299530 +18 0 9 5 114 0.22 0.13 0.95 0 0 0 1 0 0 1
0 2021 05 10 19 46 49 745640728 28.8750930 109.0472610 +24 0 12 8 130 0.29 0.15 1.63 0 0 0 0 0 0 1
0 2021 05 10 19 46 49 74813980 10.4751830 55.2057480 -22 0 12 8 156 1.10 0.57 24.26 0 0 0 1 0 0 1
0 2021 05 10 19 46 49 1999614 9.1904340 -79.2613850 -4 0 7 3 144 0.55 0.21 2.24 0 0 0 1 0 0 1
0 2021 05 10 19 46 48 489779172 9.1808300 -79.3401210 +5 0 7 3 153 0.43 0.08 0.39 0 0 0 1 0 0 1
0 2021 05 10 19 46 49 383828874 9.1960650 -79.2764530 +6 0 9 5 147 0.47 0.18 2.14 0 0 0 1 0 0 1
```

This is an example of 8 flash UALF records streamed over the WebSocket connection.

```
0 2021 05 10 19 52 53 165398486 2.6258910 -77.6824700 +5 6 7 3 0 0 0 0 0 0 0 1 0 0 1
0 2021 05 10 19 52 53 570683364 4.8405720 -75.6941620 -1 1 5 1 0 0 0 0 0 0 0 1 0 0 1
0 2021 05 10 19 52 53 805979378 32.7219650 129.8348040 +8 1 7 3 0 0 0 0 0 0 0 1 0 0 1
0 2021 05 10 19 52 53 869753742 28.5551200 121.7128360 -46 11 10 6 0 0 0 0 0 0 0 0 0 0 1
0 2021 05 10 19 52 53 69824530 32.8818810 -93.9852800 -2 32 13 9 0 0 0 0 0 0 0 0 0 0 1
0 2021 05 10 19 52 53 305549230 18.8866310 -103.0909340 +11 2 30 26 0 0 0 0 0 0 0 1 0 0 1
0 2021 05 10 19 52 53 175645755 28.9297590 -101.8505350 +2 1 9 5 0 0 0 0 0 0 0 1 0 0 1
0 2021 05 10 19 52 53 146902095 26.4252970 -100.3645290 -4 2 12 8 0 0 0 0 0 0 0 1 0 0 1
```

This is an example UALF pulse “keep-alive” record. A Pulse “keep-alive” message is a pulse data structure with 9 as the value for “type”. All other values in this “keep-alive” message are meaningless. Refer to section 2 for more information about the optional “k” URL parameter and the resulting “keep-alive” messages.

```
0 2022 08 09 20 17 51 167997900 0.0000000 0.0000000 +0 0 1 0 0 0.00 0.00 0 0 0 0 9 0 0 1
```

This is an example UALF flash “keep-alive” record. A flash “keep-alive” message is a flash data structure with 9 as the value for “type”. All other values in this “keep-alive” message are meaningless. Refer to section 2 for more information about the optional “k” URL parameter and the resulting “keep-alive” messages.

```
0 2022 08 09 20 17 54 164432900 0.0000000 0.0000000 +0 0 1 0 0 0.00 0.00 0 0 0 0 9 0 0 1
```

# 8 Lightning Source

If you subscribed to a GLN feed, you will be able to identify the source of a pulse or flash using the value of pulse/flash type. If the pulse or flash type is 40, then the source of the flash is the WWLLN lightning network (and it is a CG). If type=0 or 1 then the source is Earth Networks.

If you do not want to have the source identified then append showSource:false as an additional URL parameter in your connection URL. As a result, all pulses and flashes will have type values of 1 or 0 (WWLLN flashes or pulses are CGs and so will be type 0s). For example, this is what the URL will look like this:

- `ws://INSERT_HOST_NAME/ws/?p=INSERT_PARTNER_ID&f=json&t=pulse&l=all&showSource=false`

# 9 Troubleshooting

| Symptom | Possible Reason / Solution |
|---|---|
| **No data is coming through after the initial connection.** | The initial data stream may take up to 10 seconds to begin. But if the data stream has not started to arrive after that time-period then please ensure the following.<br>1) The URL host name is correct.<br>2) The PartnerID is correct.<br>3) The connection URL format and URL parameters are correct.<br><br>If that does not resolve the issue, consult with Earth Networks Support – customercare@earthnetworks.com |
| **Error ellipse data is not available for all pulse data set** | Only pulses that are generated by a dense lightning network will contain the error ellipse data. Some CG data that is generated by a lower density lightning network will not have the error ellipse data. |

| | |
|---|---|
| **The data stream from the WebSocket stops after some time interval.** | Internet connections are not 100% reliable over periods of time. If the inbound data stream stops arriving for more than 1 or 2 minutes, then close the WebSocket connection and re-establish it. If the problem was a dropped connection, then the data stream should resume. Your client implementation should be implemented to close and then reconnect automatically under these circumstances. |