GROUND Communications Protocol Specification
Version 1.2.1

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Overview

The GROUND (GAIA Radio OUtput Network Delivery) protocol is designed for transmitting data from the Cansat to the ground station. All data is serialized in little-endian format, meaning the least significant byte is sent first. For example, the number `0x1234` would be transmitted as `0x34 0x12`.

Packet Structure

A packet comprises the following fields:

#	Field Name	Size
1	`magic_number`	4 bytes
2	`content_type`	2 bytes
3	`content_size`	2 bytes
4	`content`	`content_size` bytes

Field Descriptions

`magic_number`: A constant value `0x47414941` (ASCII for `GAIA`) that marks the start of a packet.

`content_type`: Specifies the type and structure of the data. Its two bytes are interpreted as follows:

- **First byte**:
  - High nibble (`0xF0`): Indicates which CRC checksum is included (`0x0` = none, `0x1` = CRC-8, `0x2` = CRC-16-IBM, `0x3` = CRC-32-ISO-HDLC. See Checksums).
  - Low nibble (`0x0F`): Specifies the data category (see Data Types). May never be `0x0`.
- **Second byte**:
  - High nibble (`0xF0`): Indicates whether the data is a single value (`0x0`) or an array (`0x1`).
  - Low nibble (`0x0F`): Specifies the data's primitive type (see Data Types).

`content_size`: The number of bytes in the `content` field.

`content`: The actual data payload. Its interpretation depends on `content_type`.

Handling `magic_number` in Content

If the `magic_number` sequence `0x47414941` appears in the `content`, it must be escaped by appending a `0x00` byte immediately after. For example:

47 41 49 41 → 47 41 49 41 00

The escape byte contributes to `content_size` but is excluded from array length calculations. It should be removed during packet parsing.

Data Types

Raw Data Types

Value	Type	Description
0x00	u8	Unsigned 8-bit integer
0x01	u16	Unsigned 16-bit integer
0x02	u32	Unsigned 32-bit integer
0x03	u64	Unsigned 64-bit integer
0x04	s8	Signed 8-bit integer
0x05	s16	Signed 16-bit integer
0x06	s32	Signed 32-bit integer
0x07	s64	Signed 64-bit integer
0x08	float	32-bit floating point number
0x09	double	64-bit floating point number
0x0A	bool	Boolean
0x0B	char	ASCII character

Categorical Data Types

Value	Type	Description
0x01	GPS	GPS coordinates
0x02	G-force	G-force measurement
0x03	Angle	Angle measurement
0x04	Time	GPS Time
0x05	Age	Time in ms since last gps fix
0x06	HDOP	Horizontal Dilution of Precision
0x07	Satellites	Number of satellites in view
0x08	GPS Fail %	Percentage of GPS cheksums failed
0x09	CO2*	CO_2 concentration in ppb
0x0A	Temperature	Temperature in °C
0x0B	Pressure	Pressure in Pa
0x0C	Dust*	Dust concentration in idk what
0x0D	UV*	UV radiation in idk what
0x0E	Packet	Packet number

* These sensors may not be present on the final Cansat.

Checksums

The checksum nibble can take on the following values:

Value	Checksum Type
0x0	None
0x1	CRC-8
0x2	CRC-16-IBM
0x3	CRC-32-ISO-HDLC

CRC-8

The following fields are used for calculating the CRC-8 checksum:

- Polynomial: 0x07

- Initial value: 0x00

- Final XOR value: `0x00`

- Reverse input: `false`

- Reverse output: `false`

CRC-16-IBM

The following fields are used for calculating the CRC-16-IBM checksum:

- Polynomial: `0x8005`

- Initial value: `0x0000`

- Final XOR value: `0x0000`

- Reverse input: `true`

- Reverse output: `true`

CRC-32-ISO-HDLC

The following fields are used for calculating the CRC-32-ISO-HDLC checksum:

- Polynomial: `0x04C11DB7`

- Initial value: `0xFFFFFFFF`

- Final XOR value: `0xFFFFFFFF`

- Reverse input: `true`

- Reverse output: `true`

Examples

Single Value

Packet encoding a single unsigned 16-bit integer with value `4660`:

```
47 41 49 41 21 01 02 00 34 12
```

Breakdown:

```
47 41 49 41 // Magic number
21          // Content type: Unsigned 16-bit integer
02 00       // Content size: 2 bytes
34 12       // Content: 4660
```

Array

Packet encoding GPS coordinates (latitude, longitude) as two 64-bit doubles:

```
47 41 49 41 11 19 11 00 8C 01 E2 36 9D B4 49 40 1B F1 90 7B 96 F4 15 40 6D
```

Breakdown:

```
47 41 49 41             // Magic number
11                      // Content category: GPS coordinates with CRC-8
19                      // Content type: Array of 64-bit doubles
10 00                   // Content size: 17 bytes
1F 8B 8C 0C F4 B6 49 40 // Latitude: 51.411047802309525
77 05 98 4A 64 D4 15 40 // Longitude: 5.488855295869395
6D                      // CRC-8 checksum
```

Escaped Magic Number

GPS coordinates with a `magic_number` sequence in the content:

```
47 41 49 41 21 19 13 00 47 41 49 41 00 F8 B6 49 40 10 61 4A 8F 35 D4 15 40 82 E8
```

Breakdown:

```
47 41 49 41              // Magic number
21                       // Content category: GPS coordinates with CRC-16
19                       // Content type: Array of 64-bit doubles
13 00                    // Content size: 17 bytes
47 41 49 41 00 F8 B6 49 40 // Latitude: 51.429451142090834 (with escaped magic number)
10 61 4A 8F 35 D4 15 40   // Longitude: 5.457235564150565
82 E8                    // CRC-16-IBM checksum
```