1 Overall Packet Structure

The structure of the packet (and the data sub-packet) relies on byte positions and known values, rather than delimiters.

Field	Value	Byte Position	Length
Start	0xAA	0	1
Protocol version	0x00	1	1
Length of data (not whole packet)		2	1
Data		3	194
CRC of data (not whole packet)		197	1
End	0x55	198	1

Table 1: Overall packet structure

Important: If the *length of data* is 0, the packet immediately ends, meaning the *data, CRC,* and *end* fields do not exist.

2 Data Sub-Packet

The data sub-packet consists of 32 "chunks" (30 sensors and 2 MAC addresses). Each "chunk" follows one of seven formats.

2.1 Data Formats

Format	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
1	(1 « 7) | 7-bit int	(neg « 7) | 7-bit frac.	-	-	-	-
2	7 MSb	LSB	-	-	-	-
3	Addr5	Addr4	Addr3	Addr2	Addr1	Addr0
4	(1 « 7) | (neg « 6) | (4-bit int « 2) | 2 MSb of frac.	8 LSb of frac.	-	-	-	-
5	(neg « 6) | 6 MSb	8 LSb	-	-	-	-
6	(1 « 7) | (neg « 6) | 6 MSb	Middle 8 bits	8 LSb	-	-	-
7	First 8 "chunks"	8 "chunks"	8 "chunks"	Last 8 "chunks"	-	-

Table 2: Data formats

This version of the Waggle protocol does not use standard representations for floating point numbers. Instead, the location of the decimal point is pre-determined (between the integer and fractional components, if applicable).

The most significant bit in byte 0 of formats 1, 4, and 6 means the data is already converted. Formats 2 and 5 contain raw data.

Formats 1, 4, 5, and 6 contain a "negative" bit. If this bit is 1, the value is negative.

2.2 Data "Chunks"

The *length* in each data "chunk" represents the number of bytes of sensor data. The total "chunk" length is *length* + 2.

Field	ID	Validity | Length	Data
Main MAC address	0x00	(1 « 7) | 0x06	Table 4
TMP112	0x01	(0/1 « 7) | 0x02	Table 5
HTU21D	0x02	(0/1 « 7) | 0x04	Table 6
GP2Y1010AU0F	0x03	(0/1 « 7) | 0x02	Table 7
BMP180	0x04	(0/1 « 7) | 0x05	Table 8
PR103J2	0x05	(0/1 « 7) | 0x02	Table 9
TSL250RD	0x06	(0/1 « 7) | 0x02	Table 9
MMA8452Q	0x07	(0/1 « 7) | 0x08	Table 10
SPV1840LR5H-B	0x08	(0/1 « 7) | 0x02	Table 11
TSYS01	0x09	(0/1 « 7) | 0x02	Table 12
HMC5883L	0x0A	(0/1 « 7) | 0x06	Table 13
HIH6130	0x0B	(0/1 « 7) | 0x04	Table 6
APDS-9006-020	0x0C	(0/1 « 7) | 0x02	Table 9
TSL260RD	0x0D	(0/1 « 7) | 0x02	Table 9
TSL250RD	0x0E	(0/1 « 7) | 0x02	Table 9
MLX75305	0x0F	(0/1 « 7) | 0x02	Table 9
ML8511	0x10	(0/1 « 7) | 0x02	Table 9
D6T	0x11	(0/1 « 7) | 0x22	Table 14
MLX90614	0x12	(0/1 « 7) | 0x02	Table 5
TMP421	0x13	(0/1 « 7) | 0x02	Table 5
SPV1840LR5H-B	0x14	(0/1 « 7) | 0x02	Table 11
Total reducing gases	0x15	(0/1 « 7) | 0x02	Table 15
Ethanol	0x16	(0/1 « 7) | 0x02	Table 15
Nitrogen dioxide	0x17	(0/1 « 7) | 0x02	Table 15
Ozone	0x18	(0/1 « 7) | 0x02	Table 15
Hydrogen sulphide	0x19	(0/1 « 7) | 0x02	Table 15
Total oxidizing gases	0x1A	(0/1 « 7) | 0x02	Table 15
Carbon monoxide	0x1B	(0/1 « 7) | 0x02	Table 15
Sulfur dioxide	0x1C	(0/1 « 7) | 0x02	Table 15
Sensirion	0x1D	(0/1 « 7) | 0x04	Table 6
Bosh	0x1E	(0/1 « 7) | 0x03	Table 16
Intel MAC address	0x1F	(1 « 7) | 0x06	Table 4
Sensor status (health)	0xFE	(1 « 7) | 0x04	Table 17

Table 3: Data sub-packet structure (each row is a "chunk")

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**
Address 5	Address 4	Address 3	Address 2	Address 1	Address 0
Format 3					

Table 4: MAC address

Byte 0	**Byte 1**
Temperature	
Format 1	

Table 5: Sensor data

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**
Temperature		Humidity	
Format 1		Format 1	

Table 6: Sensor data

Byte 0	**Byte 1**
Dust	
Format 2	

Table 7: Sensor data

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**
Temperature		Atmospheric pressure		
Format 1		Format 6		

Table 8: Sensor data

Byte 0	**Byte 1**
Light	
Format 2	

Table 9: Sensor data

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
Acceleration X		Acceleration Y		Acceleration Z		RMS	
Format 1		Format 1		Format 1		Format 1	

Table 10: Sensor data

Byte 0	Byte 1
Sound pressure	
Format 2	

Table 11: Sensor data

Byte 0	Byte 1
Temperature	
Format 2	

Table 12: Sensor data

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Magnetic X		Magnetic Y		Magnetic Z	
Format 4		Format 4		Format 4	

Table 13: Sensor data

Byte 0	Byte 1	...	Byte 32	Byte 33
Temperature		Temperature	Temperature	
Format 1		Format 1	Format 1	

Table 14: Sensor data

Byte 0	Byte 1
Gas concentration	
Format 2	

Table 15: Sensor data

Byte 0	Byte 1	Byte 2
Atmospheric pressure		
Format 6		

Table 16: Sensor data

Byte 0	Byte 1	Byte 2	Byte 3
Health status (1 bit per "chunk")			
Format 7			

Table 17: Sensor status (health)

3 Sensor Data Units : Raw and Processed

Sensor/Parameter	Raw Units	Processed Units	Comments
Main MAC address	No Units	No Units	6 Octets in hex notation separated by ':'
TMP112	°C	°C	
HTU21D	°C, RH %	°C, RH %	
GP2Y1010AU0F	integer	ppm	
BMP180	°C, hPa	°C, hPa	
PR103J2	integer	°C	
TSL250RD	integer	w/m^2	**finalize after discussion with EVS**
MMA8452Q	g,g,g,g	g,g,g,g	
SPV1840LR5H-B	integer	dB	
TSYS01	°C	°C	
HMC5883L	µT,µT,µT	µT,µT,µT	
HIH6130	°C, RH %	°C, RH %	
APDS-9006-020	integer	w/m^2	**finalize after discussion with EVS**
TSL260RD	integer	w/m^2	**finalize after discussion with EVS**
TSL250RD	integer	w/m^2	**finalize after discussion with EVS**
MLX75305	integer	w/m^2	**finalize after discussion with EVS**
ML8511	integer	w/m^2	**finalize after discussion with EVS**
D6T	*Seventeen* °C values	*Seventeen* °C values	
MLX90614	°F	°C	
TMP421	°C	°C	
SPV1840LR5H-B	integer	dB	
Total reducing gases	integer	concentration	**finalize after discussion with EVS**
Ethanol	integer	ppm	Quadratic equation with calibrated weights
Nitrogen dioxide	integer	ppm	Quadratic equation with calibrated weights
Ozone	integer	ppm	Quadratic equation with calibrated weights
Hydrogen sulphide	integer	ppm	Quadratic equation with calibrated weights
Total oxidizing gases	integer	concentration	**finalize after discussion with EVS**
Carbon monoxide	integer	ppm	Quadratic equation with calibrated weights
Sulfur dioxide	integer	ppm	Quadratic equation with calibrated weights
Sensirion	°C, RH %	°C, RH %	
Bosh	hPa	hPa	
Intel MAC address	No Units	No Units	6 Octets in hex notation separated by ':'
Sensor status (health)	No Units	No Units	4 bytes of sensor health data

Table 18: Sensor and Parameter units both in raw and processed format.

4 Example

In the example below, the spaces and brackets are used to clearly show the different fields within the packet. The actual packet, or any component of it, does not have spaces or brackets. This example is in hex format.

4.1 Whole Packet

{AA} {0} {C2} {[0 86 6 5 4 3 2 1] [1 82 F1 49] [2 4 C8 2C CE 8] [3 2 55 8C] [4 5 B3 83 D1 98 54] [5 82 2D 5] [6 2 75 6B] [7 8 88 A3 92 8C E2 A1 8D CF] [8 82 30 D1] [9 2 6D 61] [A 6 CC C2 84 99 82 9C] [B 4 B4 9E AA C2] [C 2 69 C5] [D 82 30 C4] [E 82 A E5] [F 82 4D 39] [10 2 77 E8] [11 A2 85 F ED 81 F3 5 DB 62 C3 5 A0 42 E1 26 ED E1 B4 25 99 61 D0 88 81 CB BA AA C0 C D5 5E AB C4 B2 6] [12 2 B5 52] [13 82 DD 5F] [14 82 3D CE] [15 82 72 61] [16 2 E 78] [17 82 17 E] [18 2 62 7] [19 82 5E 47] [1A 82 58 29] [1B 2 5B A2] [1C 82 62 46] [1D 4 9C 2C C7 1A] [1E 3 B3 12 64] [1F 86 C B A 9 8 7] [FE 84 FF DF FF FF]} {29} {55}

To avoid any confusion, this is what the packet actually looks like:

AA0C2086654321182F14924C82CCE832558C45B383D198545822D562756B7888A3928CE2A18DCF88230D1926D61A6CCC28499829CB4B49EAAC2C269C5D8230C4E82AE5F824D3910277E811A285FED81F35DB62C35A042E126EDE1B4259961D08881CBBAAAC0CD55EABC4B26122B5521382DD5F14823DCE15827261162E78178217E18262719825E471A8258291B25BA21C8262461D49C2CC71A1E3B312641F86CBA987FE84FFDFFFFF2955

Field	Value	Explanation
Start	0xAA	Start-of-packet indicator
Protocol version	0x00	Version of Waggle sensor protocol being used
Length of data	0xC2	Byte length of data sub-packet
Data		Data sub-packet
CRC	0x29	CRC-8 of data sub-packet
End	0x55	End-of-packet indicator

Table 19: Example of whole packet

4.2 Data Sub-Packet

Value	Explanation
0x00	ID
0x86	0b***1***0000000 (valid) OR'd with 0x06 (length)
0x06	Address byte 0
0x05	Address byte 1
0x04	Address byte 2
0x03	Address byte 3
0x02	Address byte 4
0x01	Address byte 5

Table 20: Example of MAC address

Value	Explanation
0x01	ID
0x82	0b***1***0000000 (valid) OR'd with 0x02 (length)
0xF1	0b***1***0000000 (data converted) OR'd with 0x71 (integer)
0x49	0b***0***0000000 (positive) OR'd with 0x49 (fractional)
113.73	Temperature in decimal

Table 21: Example of TMP112

Value	Explanation
0x1E	ID
0x03	0b***0***0000000 (not valid) OR'd with 0x03 (length)
0xB3	0b***1***0000000 (data converted) OR'd with 0b0***0***000000 (positive) OR'd with 0b00***110011*** (6 MSb of data)
0x12	Middle byte of data
0x64	LSB of data
5118100	Pressure in decimal (pascals)

Table 22: Example of Bosh

Value	Explanation
0x0FE	ID
0x84	0b***1***0000000 (valid) OR'd with 0x04 (length)
0xFF	Sensors (including MAC addresses) 31-24 are healthy (operating correctly)
0xDF	Sensor 21 (total reducing gases) not healthy. Sensors 23, 22, 20-16 are healthy
0xFF	Sensors 15-8 are healthy
0xFF	Sensors 7-0 are healthy

Table 23: Example of sensor status (health)