Technical Note V.1.1

MINTS Sensor Description

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Multi-Scale Integrated Sensing and Simulation
https://mints.utdallas.edu/
https://github.com/mi3nts

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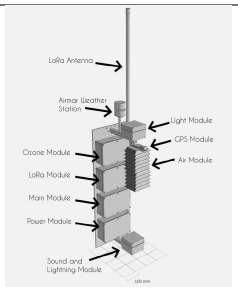
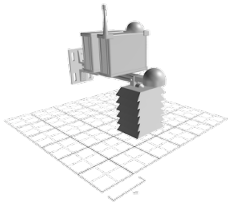
1. Introduction

Sensor Nodes	Central Node	PoLo Node	SoLo Node	Wearable
Sketches			figures/Solo.png	
SBC	Odroid C4	Odroid C4	Odroid C4	Rasberri Pi Zero W
Attached sensors	• IPS7100 • HM3301 • BME280 • BME680 • SCD30 • MGS001 • AS7262 • APDS9002 • GL001 • GUV001 • SI114x • TM3993 • TSL2591 • VEML6075 • SKYCAM • WIMDA	• IPS7100 • BME280 • SCD30 • RG15 • SCD30 • AS7265x • Microphone	• IPS7100 • BME280 • SCD30 • RG15 • SCD30 • AS7265x • Microphone	• IPS7100 • BME280 • SCD30

	• YXXDR • AS3935 • SEN0232 • TB108L • LIBRAD • VK-162 GPS • Microphone			

Note: SBC refers to Single Board Computer

2. Sensors Equipped

2.1 Particle Counters

Particle counters are devices used to measure and monitor the concentration of airborne particles in various environments. They play a crucial role in assessing air quality, especially in industrial settings, laboratories, and indoor spaces. These counters function by detecting and counting particles of different sizes, providing valuable data on particulate matter levels. They help identify potential health hazards, track pollution sources, and evaluate the effectiveness of air filtration systems. With their ability to quickly and accurately quantify particulate matter, particle counters contribute significantly to ensuring a healthier and safer living and working environment for individuals and communities.

2.2 Climate Counters

Climate sensors are vital tools used to monitor and collect data related to various environmental factors that influence climate patterns. These sensors are equipped to measure parameters such as temperature, humidity, atmospheric pressure, wind speed, and direction. They play a crucial role in climate research, weather forecasting, and environmental monitoring. By providing real-time and accurate data, climate sensors help scientists and policymakers better understand climate change, track weather patterns, assess air quality, and make informed decisions to mitigate the impacts of climate-related challenges. Their widespread deployment and continuous data collection contribute significantly to our understanding of the Earth's climate system and the development of sustainable solutions for the future.

2.3 Gas Sensors

Gas sensors are electronic devices designed to detect and measure the presence of specific gases in the surrounding environment. These sensors play a crucial role in various industries and applications, including industrial safety, environmental monitoring, and household safety. Gas sensors work on the principle of chemical reactions between the target gas and a sensing material, generating an electrical signal that indicates the gas concentration. They offer real-time monitoring and early detection of hazardous gases, helping to prevent accidents, ensure air quality, and protect human health. Gas sensors come in various types, each tailored to detect specific gases, making them versatile and indispensable tools in modern-day safety and monitoring systems.

2.4 Light Sensors

Light sensors, also known as photodetectors or photo sensors, are electronic devices designed to detect and measure the intensity of light in their surroundings. These sensors utilize the photoelectric effect, where incident photons interact with the sensor's material, generating a response that can be converted into an electrical signal. Light sensors find wide application in various fields, such as consumer electronics, industrial automation, automotive systems, and environmental monitoring. They play a crucial role in automatic lighting systems, camera technology, and even in modern smartphones, enabling adaptive brightness adjustments and enhancing overall user experience. With their ability to convert light into actionable data, light sensors have become an essential component in the advancement of technology across multiple industries.

2.5 GPS Sensors

GPS sensors, short for Global Positioning System sensors, are electronic devices designed to receive signals from a network of satellites orbiting the Earth. These sensors use the signals to determine the device's precise geographical location, velocity, and time information. They have become widely integrated into various applications, such as navigation systems in vehicles, smartphones, and wearable devices. GPS sensors play a crucial role in providing accurate positioning data, enabling users to navigate, track assets, and access location-based services with ease and efficiency. Their widespread use has revolutionized how we interact with technology, making location-based functionalities an integral part of modern-day living.

2.6 Radiation Sensors

Radiation sensors are essential devices used to detect and measure different types of radiation in various environments. These sensors play a crucial role in ensuring safety and monitoring radiation levels in areas where radioactive materials are present, such as nuclear power plants, medical facilities, and industrial sites. They work by converting radiation energy into an electrical signal that can be analyzed and interpreted by monitoring equipment. These sensors come in various forms, including Geiger-Muller counters, scintillation detectors,

and ionization chambers. Whether in research, healthcare, or nuclear safety applications, radiation sensors are indispensable tools that aid in safeguarding human health and the environment from the potential risks of ionizing radiation.

2.7 Thunder and Lightning Sensors

The Thunder and Lightning Sensor operates by capturing changes in electrical activity within the atmosphere. When lightning strikes, it generates an intense electrical discharge, creating a rapid expansion of air that produces the characteristic sound of thunder. The sensor can accurately detect and differentiate between thunder and lightning occurrences.

2.8 Microphone

Monitoring and analyzing bird calls using a microphone is an innovative approach in the field of ornithology and wildlife research. The process involves deploying a sensitive microphone in a natural habitat or bird-rich area to capture the diverse array of bird vocalizations.

3. Stationary Sensing Systems

3.1 Central Node

The Central Node is a stationary sensor system consisting an array of iot sensors which is an extensible platform in which many newer sensors can be adopted into. The source code for the Central Node as well as most mints projects are open source and is available at https://github.com/mi3nts. The data corresponding to each of the Sensing Units of the Central Node are given below:

3.2 Equipped Sensing Module

3.2.1 Particle Counters

3.2.1.1 IPS7100

dateTime	pc0_1	pc0_3	pc0_5	.....	pm10_0
2023-01-04 00:00:00.059604	64474	18205	11661	.....	5.74317020
2023-01-04 00:00:01.061184	62047	17368	11109	.....	5.57649617
2023-01-04 00:00:02.062446	59468	16571	10640	.....	5.40531891
2023-01-04 00:00:03.063477	56790	15791	10198	.....	5.23171629
2023-01-04 00:00:04.064636	54282	15017	9777	.....	5.06503846
2023-01-04 00:00:05.065186	51981	14281	9377	.....	4.90459504
2023-01-04 00:00:06.066297	49793	13580	9015	.....	4.76209408

The data format of the **IPS7100** *csv* is described on table 26.

Table 1. Data Format used on the **IPS7100** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-02-09 00:00:07.143333	
Particles Counts	pc0_1 to pc10_0	Integer	$\#/Liter$	Particle Counts per *liter* for particle diameters 0.1, 0.3, 0.5, 1.0, 2.5, 5, 10 μm	3272	
Particulate mass fractions	pm0_1 to pm10_0	Float	$\mu g/m^3$	Particle mass fractions for particle diameters 0.1, 0.3, 0.5, 1.0, 2.5, 5, 10 μm	2.56	

3.2.1.2 HM3301

dateTime	pm1	pm2_5	pm10
2023-01-04 00:00:01.230436	1	1	1
2023-01-04 00:00:11.258133	1	1	1
2023-01-04 00:00:21.270849	1	3	1
2023-01-04 00:00:31.283578	4	7	10
2023-01-04 00:00:41.311695	1	1	1
2023-01-04 00:00:51.324609	1	7	10
2023-01-04 00:01:01.337217	1	1	1

The data format of the **HM3301** *csv* is described on table 2.

Table 2. Data format used on **HM3301** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:31.283578	
$PM_{1.0}$	pm1	Integer	$\mu g/m^3$		4	
$PM_{2.5}$	pm2_5	Integer	$\mu g/m^3$		7	
$PM_{10.0}$	pm10	Integer	$\mu g/m^3$		10	

3.2.2 Climate Sensors

3.2.2.1 BME280

dateTime	temperature	pressure	humidity	altitude
2023-01-04 00:00:06.268466	16.81	99540.00	29.00	149.66
2023-01-04 00:00:16.296297	16.81	99542.00	29.00	149.49
2023-01-04 00:00:26.309238	16.80	99537.00	29.00	149.91
2023-01-04 00:00:36.337023	16.80	99538.00	29.00	149.83
2023-01-04 00:00:46.350128	16.80	99539.00	29.00	149.75
2023-01-04 00:00:56.362813	16.79	99539.00	29.00	149.75
2023-01-04 00:01:06.390603	16.79	99539.00	29.00	149.75

The data format of the **BME280** *csv* is described on table 29.

Table 3. Data format used on **BME280** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:06.268466	
Temperature	temperature	Float	$^{\circ}C$		16.81	
Pressure	pressure	Float	$millibars * 100$		99540.00	
Humidity	humidity	Float	%		29.00	
Altitude	altitude	Float	meters		149.66	

3.2.2.2 BME680

dateTime	temperature	pressure	humidity	gas
2023-01-04 00:00:04.568350	16.94	99.50	31.34	12976.91
2023-01-04 00:00:14.725647	16.93	99.50	31.45	12976.91
2023-01-04 00:00:24.882822	16.93	99.50	31.54	12976.91
2023-01-04 00:00:35.024835	16.93	99.50	31.57	12976.91
2023-01-04 00:00:45.182448	16.92	99.50	31.56	12976.91
2023-01-04 00:00:55.339732	16.92	99.50	31.53	12976.91
2023-01-04 00:01:05.496983	16.91	99.50	31.52	12976.91
2023-01-04 00:01:15.654531	16.91	99.50	31.59	12976.91

The data format of the **BME680** *csv* is described on table 30.

Table 4. Data format used on **BME680** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.568350	
Temperature	temperature	Float	$^{\circ}C$		16.94	
Pressure	pressure	Float	hPa		99.50	
Humidity	humidity	Float	%		31.34	
Gas	gas	Float	IAQ		12976.91	

3.2.2.3 RG15

```
dateTime                    accumulation ..............  rainPerInterval
2023-07-26 00:00:07.200348  0.00         ..............  0.00
2023-07-26 00:00:17.201240  0.00         ..............  0.00
2023-07-26 00:00:27.204291  0.00         ..............  0.00
2023-07-26 00:00:37.207039  0.00         ..............  0.00
2023-07-26 00:00:47.209195  0.00         ..............  0.00
2023-07-26 00:00:57.212983  0.00         ..............  0.00
```

The data format of the **RG15** *csv* is described on table 5.

Table 5. Data format used on **RG15** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-07-26 00:00:07.200348	
Accumulation	accumulation	Float			0.00	
Event Accumulation	eventAccumulation	Float			0.00	
Total Accumulation	totalAccumulation	Float			0.00	
Rain Per Interval	rainperInterval	Float			0.00	

3.2.2.4 WIMDA

```
dateTime                    barrometricPressureMercury  ........ checkSum
2023-01-04 00:00:04.499788  29.9021                     ........ 1.0126
2023-01-04 00:00:09.997634  29.9050                     ........ 1.0127
2023-01-04 00:00:15.500336  29.9021                     ........ 1.0126
2023-01-04 00:00:20.998336  29.9021                     ........ 1.0126
2023-01-04 00:00:26.498463  29.9021                     ........ 1.0126
2023-01-04 00:00:31.501278  29.9050                     ........ 1.0127
2023-01-04 00:00:36.999337  29.9050                     ........ 1.0127
```

The data format of the **WIMDA** *csv* is described on table 6.

Table 6. Data format used on **WIMDA** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.499788	
Pressure Measured By Mercury Barometer	barrometric Pressure Mercury	Float	in		29.9021	
Unit of Pressure for Mercury Barometer	BPMUnits	string			I	
Pressure Measured By Mercury Barometer in Bars	barrometric Pressure Bars	Float	Ba		1.0126	
Unit of Pressure for Barometer	BPBUnits	string			B	
Temperature	airTemperature	Float	$^{\circ}C$		22.2	
Unit of Air Temperature	ATUnits	string			C	

Water Temperature	waterTemperature	Float	C°			
Unit of Water Temperature	WTUnits	string			C	
Relative Humidity	relativeHumidity	Float	%		15.5	
Absolute Humidity	absoluteHumidity	Float	%			
Dew Point	dewPoint	Float	C°		-5.2	
Unit of Dew Point	DPUnits	string			C	
True Wind Direction	windDirectionTrue	Float	Degrees		334.1	
True Wind Direction Unit	WDTUnits	string			T	
Magnetic Wind Direction	windDirectionMagnetic	Float	Degrees		329.2	
Magnetic Wind Direction Unit	WDMUnits	string			M	
Wind Speed Knots	windSpeedKnots	Float	m/s		1.4	
Wind Speed Knots Unit	WSKUnits	string			N	
Wind Speed in Meters Per Second	windSpeedMetersPerSecond	Float	m/s		0.7	
Unit for Wind Speed in Meters Per Second	WSMPSUnits	string			M	
check Sum	checkSum	Integer			78	

3.2.3 Gas Sensors

3.2.3.1 SCD30

dateTime	c02	temperature	humidity
2023-01-04 00:00:08.763232	405	19.44	27.58
2023-01-04 00:00:18.775858	406	19.44	27.53
2023-01-04 00:00:28.803976	405	19.42	27.62
2023-01-04 00:00:38.816727	405	19.44	27.64
2023-01-04 00:00:48.829733	405	19.44	27.59
2023-01-04 00:00:58.857351	406	19.44	27.62
2023-01-04 00:01:08.870275	406	19.41	27.59
2023-01-04 00:01:18.883096	406	19.41	27.67
2023-01-04 00:01:28.911038	407	19.42	27.62
2023-01-04 00:01:38.923842	406	19.42	27.70

The data format of the **SCD30** *csv* is described on table 31.

Table 7. Data format used on **SCD30** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.568350	
CO_2	co2	Integer	ppm		405	
Temperature	temperature	Float	$^{\circ}C$		19.44	
Humidity	humidity	Float	%		27.58	

3.2.3.2 TB108L

dateTime	ozone	temperature	pressure	voltage
2023-01-04 00:00:03.772092	71.8	30.3	862.8	0.0188
2023-01-04 00:00:17.731681	57.8	30.2	873.4	0.0188
2023-01-04 00:00:31.724246	66.1	30.2	862.9	0.0188
2023-01-04 00:00:45.716841	93.4	30.2	872.5	0.0188
2023-01-04 00:00:59.681053	104.5	30.2	863.2	0.0188
2023-01-04 00:01:13.673615	105.8	30.2	872.8	0.0188
2023-01-04 00:01:27.661576	95.9	30.2	862.2	0.0188

The data format of the **TB108L** *csv* is described on table 8.

Table 8. Data format used on **TB108L** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:03.772092	
Ozone	ozone	Float			71.8	
Temperature	temperature	Float			30.3	
Pressure	pressure	Float			862.8	
Voltage	voltage	Float			0.0188	

3.2.4 Light Sensors

3.2.4.1 APDS9002

```
dateTime                    luminance   voltage   raw
2023-01-04 00:00:08.974372  1.01        0.00      0
2023-01-04 00:00:20.521757  1.01        0.00      0
2023-01-04 00:00:32.069220  1.01        0.00      0
2023-01-04 00:00:43.616382  1.01        0.00      0
2023-01-04 00:00:55.163985  1.01        0.00      0
2023-01-04 00:01:06.711284  1.01        0.00      0
2023-01-04 00:01:18.273649  1.01        0.00      0
2023-01-04 00:01:29.821167  1.01        0.00      0
2023-01-04 00:01:41.368623  1.01        0.00      0
```

The data format of the **APDS9002** *csv* is described on table 9.

Table 9. Data format used on **APDS9002** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:08.974372	
Luminance	luminance	Float			1.01	
Voltage	voltage	Float	V		0.00	
Raw	raw	Integer	%		0	

3.2.4.2 GL001

```
dateTime                    lightLevel
2023-01-04 00:00:04.784561  23
2023-01-04 00:00:16.331946  22
2023-01-04 00:00:27.879069  21
2023-01-04 00:00:39.441456  19
2023-01-04 00:00:50.989075  20
2023-01-04 00:01:02.536537  18
2023-01-04 00:01:14.083669  17
2023-01-04 00:01:25.631127  15
2023-01-04 00:01:37.178965  15
2023-01-04 00:01:48.741113  15
2023-01-04 00:02:00.288745  15
```

The data format of the **GL001** *csv* is described on table 10.

Table 10. Data format used on **GL001** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.784561	
Light Level	lightLevel	Integer			1.01	

3.2.4.3 GUV001

```
dateTime                    uvLevel
2023-01-04 00:00:07.951263  0
2023-01-04 00:00:19.498775  0
2023-01-04 00:00:31.061110  0
2023-01-04 00:00:42.608385  0
2023-01-04 00:00:54.156001  0
2023-01-04 00:01:05.703240  0
```

The data format of the **GUV001** *csv* is described on table 11.

Table 11. Data format used on **GUV001** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:07.951263	
UV Level	uvLevel	Integer			1.01	

3.2.4.4 SI114x

```
dateTime                    visible  ir   uv    ........  proximity3
2023-01-04 00:00:02.801268  261      255  0.02  ........  0
2023-01-04 00:00:14.364232  261      254  0.02  ........  0
2023-01-04 00:00:25.911306  261      253  0.02  ........  0
2023-01-04 00:00:37.458465  261      254  0.02  ........  0
2023-01-04 00:00:49.006254  262      253  0.03  ........  0
```

The data format of the **SI114x** *csv* is described on table 12.

Table 12. Data format used on **SI114x** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:02.801268	
Visible	visible	Integer			261	
Infra Red	ir	Integer			255	
Ultra Violet	uv	Foat			0.02	
Proximity1	proximity1	Integer			225	
Proximity2	proximity2	Integer			20131	
Proximity3	proximity3	Integer			0	

3.2.4.5 TMG3993

dateTime	infraRed	red	green	.....	proximity
2023-01-04 00:00:01.809116	14.00	4.00	5.00	.....	24
2023-01-04 00:00:13.356797	13.00	4.00	5.00	.....	25
2023-01-04 00:00:24.904051	13.00	4.00	5.00	.....	25
2023-01-04 00:00:36.451265	12.00	4.00	5.00	.....	25
2023-01-04 00:00:47.998818	12.00	4.00	4.00	.....	25
2023-01-04 00:00:59.546473	11.00	3.00	4.00	.....	24
2023-01-04 00:01:11.108258	11.00	3.00	4.00	.....	25
2023-01-04 00:01:22.656208	11.00	3.00	4.00	.....	25
2023-01-04 00:01:34.203607	10.00	3.00	4.00	.....	25
2023-01-04 00:01:45.750780	10.00	3.00	4.00	.....	25
2023-01-04 00:01:57.298541	9.00	3.00	3.00	.....	25
2023-01-04 00:02:08.845794	9.00	3.00	3.00	.....	25
2023-01-04 00:02:20.408250	9.00	3.00	3.00	.....	24
2023-01-04 00:02:31.955576	8.00	2.00	3.00	.....	25
2023-01-04 00:02:43.502923	8.00	2.00	3.00	.....	25

The data format of the **TMG3993** *csv* is described on table 13.

Table 13. Data format used on **TMG3993** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:01.809116	
Infra Red	infrared	Float			14.00	
Red	red	Float			4.00	
Green	green	Float			5.00	
Blue	blue	Integer			7.00	
Proximity	proximity	Integer			24	

3.2.4.6 TSL2591

```
dateTime                    luminosity   ir      full .......    lux
2023-01-04 00:00:11.342016  2687083      41      107  .......    2.214639
2023-01-04 00:00:22.889220  2556007      39      103  .......    2.163324
2023-01-04 00:00:34.436582  2490466      38      98   .......    1.998367
2023-01-04 00:00:45.998925  2359391      36      95   .......    1.993330
2023-01-04 00:00:57.546508  2293851      35      91   .......    1.874708
2023-01-04 00:01:09.093538  2162775      33      87   .......    1.823338
```

The data format of the **TSL2591** *csv* is described on table 34.

Table 14. Data format used on **TSL2591** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:11.342016	
Luminosity	luminosity	Integer			2687083	
Infra Red	ir	Integer			41	
Full	full	Integer			107	
Visible	visible	Integer			66	
Lux	lux	Float			2.214639	

3.2.4.7 VEML6075

```
dateTime                    rawUVA   rawUVB   ..................  index
2023-01-04 00:00:00.801969  0        0        ..................  0.00
2023-01-04 00:00:12.349474  0        0        ..................  0.00
2023-01-04 00:00:23.896498  0        0        ..................  0.00
2023-01-04 00:00:35.444258  0        0        ..................  0.00
2023-01-04 00:00:47.006426  0        0        ..................  0.00
2023-01-04 00:00:58.554261  0        0        ..................  0.00
2023-01-04 00:01:10.101090  0        0        ..................  0.00
```

The data format of the **VEML6075** *csv* is described on table 35.

Table 15. Data format used on **VEML6075** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:00.801969	
Raw Ultra Violet A	rawUVA	Integer			0	
Raw Ultra Violet B	rawUVB	Integer			0	
Visible Compensation	visibleCompensation	Integer			0	
Infra Red Compensation	irCompensation	Integer			0	
Ultra Violet A	uva	Float			0.00	
Ultra Violet B	uvb	Float			0.00	
UV Index	index	Integer			0	

3.2.4.8 SKYCAM003

```
dateTime                    cloudPecentage   allRed ..........  cloudBlue
2023-01-04 00:00:04.353794  100.0            127.5  ..........  127.5
2023-01-04 00:05:04.311989  100.0            127.5  ..........  127.5
2023-01-04 00:10:04.019655  100.0            127.5  ..........  127.5
2023-01-04 00:15:04.216315  100.0            127.5  ..........  127.5
2023-01-04 00:20:03.846723  100.0            127.5  ..........  127.5
2023-01-04 00:25:03.898568  100.0            127.5  ..........  127.5
```

The data format of the **SKYCAM003** *csv* is described on table 36.

Table 16. Data format used on **SKYCAM003** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.353794	
Cloud Percentage	cloudPercentage	Float	%		100.0	
All Red	allRed	Float			127.5	
All Green	allGreen	Float			127.5	
All Blue	allBlue	Float			127.5	
Sky Red	skyRed	Integer			-1	
Sky Green	skyGreen	Integer			-1	
Sky Blue	skyBlue	Integer			-1	
Cloud Red	cloudRed	Float			127.5	
Cloud Green	cloudGreen	Float			127.5	
Cloud Blue	cloudBlue	Float			127.5	

3.2.5 Microphone

3.2.5.1 MBC001

```
dateTime                    label   confidence
2023-07-26 00:28:59.895587  2102    0.9553
2023-07-26 00:36:05.423425  631     0.3048
2023-07-26 00:53:20.633355  2102    0.3403
2023-07-26 00:53:23.633355  2102    0.5494
2023-07-26 00:59:38.500652  1578    0.3418
2023-07-26 01:08:26.517110  408     0.34
2023-07-26 01:18:59.399381  2102    0.3078
```

The data format of the **MBC001** *csv* is described on table 37.

Table 17. Data format used on **MBC001** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-07-26 00:28:59.895587	
Label	label	Integer			2102	
Confidence	confidence	Float			0.9553	

3.2.6 Thunder and Lightning Sensor

3.2.6.1 AS3935

```
dateTime                    source  energy  distance
2023-01-04 00:16:17.044439  2       30      63
2023-01-04 00:21:44.338102  2       0       63
2023-01-04 02:16:17.235212  2       30      63
2023-01-04 03:16:17.390213  2       30      63
2023-01-04 04:16:17.302775  2       30      63
2023-01-04 05:16:16.826721  2       30      63
2023-01-04 06:16:16.929995  2       30      63
2023-01-04 07:51:59.525492  2       0       63
2023-01-04 08:16:16.288806  2       30      63
```

The data format of the **AS3935** *csv* is described on table 38.

Table 18. Data format used on **AS3935** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:16:17.044439	
Source	source	Integer			2	
Energy	energy	Integer			30	
Distance	distance	Integer	km		63	

3.2.6.2 SEN0232

dateTime	rawAnalog	rawVoltage	dB
2023-01-04 00:00:02.040488	17	0.08	4.15
2023-01-04 00:00:04.556777	16	0.08	3.91
2023-01-04 00:00:07.057364	15	0.07	3.66
2023-01-04 00:00:09.558081	13	0.06	3.17
2023-01-04 00:00:12.058904	14	0.07	3.42
2023-01-04 00:00:14.559609	12	0.06	2.93
2023-01-04 00:00:17.060362	15	0.07	3.66
2023-01-04 00:00:19.561099	11	0.05	2.69
2023-01-04 00:00:22.061834	19	0.09	4.64
2023-01-04 00:00:24.578352	13	0.06	3.17
2023-01-04 00:00:27.079106	15	0.07	3.66
2023-01-04 00:00:29.579937	18	0.09	4.39
2023-01-04 00:00:32.080686	15	0.07	3.66

The data format of the **SEN0232** *csv* is described on table 39.

Table 19. Data format used on **SEN0232** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:02.040488	
Raw Analog	rawAnalog	Integer			17	
Raw Voltage	rawVoltage	Float			0.08	
Sound in dB	dB	Float			4.15	

3.2.7 Radiation Sensors

3.2.7.1 LIBRAD

```
dateTime                    countPerMinute   ................ LIBRADCount
2023-01-04 00:00:04.408582  0.0000           ................ 0
2023-01-04 00:00:14.565957  0.0000           ................ 0
2023-01-04 00:00:24.723068  0.0000           ................ 0
2023-01-04 00:00:34.880212  0.0000           ................ 0
2023-01-04 00:00:45.022648  0.0000           ................ 0
2023-01-04 00:00:55.180008  0.0000           ................ 0
```

The data format of the **LIBRAD** *csv* is described on table 40.

Table 20. Data format used on **LIBRAD** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.408582	
count Per Minute	countPer Minute	Float			0.000	
Radiation Value	radiation Value	Float			0.000	
Time Spent	timeSpent	Integer			10000	
Radiation Count	LIBRAD Count	Integer			0	

3.2.7.2 QLMRAD001

dateTime	event
2023-01-04 00:00:00.143675	0063
2023-01-04 00:00:00.146156	0200
2023-01-04 00:00:00.190742	0074
2023-01-04 00:00:00.286839	0056
2023-01-04 00:00:00.293918	0065
2023-01-04 00:00:00.550614	0086
2023-01-04 00:00:00.582952	0050
2023-01-04 00:00:00.636760	0150
2023-01-04 00:00:00.686808	0075
2023-01-04 00:00:00.839238	0229
2023-01-04 00:00:00.903411	0052
2023-01-04 00:00:01.050683	0049
2023-01-04 00:00:01.334357	0738

The data format of the **QLMRAD001** *csv* is described on table 41.

Table 21. Data format used on **QLMRAD001** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:00.143675	
Event	event	Integer			0063	

3.2.8 GPS Sensors

3.2.8.1 GPSGPGGA2

dateTime	timestamp	latitudeCoordinate	...	stationID
2023-01-04 00:00:01.101081	00:00:01	32.715703500000004	...	0
2023-01-04 00:00:04.083579	00:00:04	32.715704833333334	...	0
2023-01-04 00:00:07.086137	00:00:07	32.715700500000004	...	0
2023-01-04 00:00:10.085323	00:00:10	32.71569783333334	...	0
2023-01-04 00:00:13.082585	00:00:13	32.715699666666666	...	0
2023-01-04 00:00:16.081818	00:00:16	32.715701833333334	...	0
2023-01-04 00:00:19.080205	00:00:19	32.71570366666666	...	0

The data format of the **GPSGPGGA2** *csv* is described on table 42.

Table 22. Data format used on **GPSGPGGA2** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC date	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:01.101081	
Time Stamp	timestamp	hh:mm:ss			00:00:01	
Status	status	string			A	
Latitude Coordinate	latitude Coordinate	Float	Degrees		32.7157035	
Longitude Coordinate	longitude Coordinate	Float	Degrees		-96.7480245	
Latitude	latitude	Float	Degrees		3242.94221	
Latitude Direction	latitude Direction	string			N	
Longitude	longitude	Float	Degrees		9644.88147	
Longitude Direction	longitude Direction	string			W	
GPS Quaity	gpsQuality	Integer			2	
Number of Satellites	numberOf Satellites	Integer			10	
Horizontal Dilution	Horizontal Dilution	Float			1.01	
Altitude	altitude	Float	meters		133.4	
Unit of Altitude	altitudeUnits	string			M	
Unit of Altitude	altitudeUnits	string			M	
Undulation	undulation	Float	meters		-25.2	
Unit of Undulation	undulation Units	Float	meters		-25.2	
	age					
Station ID	stationID	string			0	

3.2.8.2 GPSGPRMC2

```
dateTime                    timestamp ..... magVariationDirection
2023-01-04 00:00:01.093170  00:00:01  .....
2023-01-04 00:00:04.076470  00:00:04  .....
2023-01-04 00:00:07.078490  00:00:07  .....
2023-01-04 00:00:10.078148  00:00:10  .....
2023-01-04 00:00:13.075355  00:00:13  .....
2023-01-04 00:00:16.074523  00:00:16  .....
```

The data format of the **GPSGPRMC2** *csv* is described on table 43.

Table 23. Data format used on **GPSGPRMC2** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC date	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:01.093170	
Time Stamp	timestamp	hh:mm:ss			00:00:01	
Latitude Coordinate	latitude Coordinate	Float	Degrees		32.7157035	
Longitude Coordinate	longitude Coordinate	Float	Degrees		-96.7480245	
Latitude	latitude	Float	Degrees		3242.94221	
Latitude Direction	latitude Direction	string			N	
Longitude	longitude	Float	Degrees		9644.88147	
Longitude Direction	longitude Direction	string			W	
Speed of Device over Ground	speedOver Ground	Float			0.082	
True Course	trueCourse					
Magnetic Variation	magnetic Variation					
Magnetic Variation Direction	magnetic Variation Direction					

3.2.8.3 GPGGA

dateTime	UTCTimeStamp	.....	checkSum
2023-01-04 00:00:05.331006	000005	.....	3E
2023-01-04 00:00:10.831074	000010	.....	30
2023-01-04 00:00:15.834106	00001	.....	38
2023-01-04 00:00:21.331956	000021	.....	3A
2023-01-04 00:00:26.834607	000026	.....	3E
2023-01-04 00:00:32.332718	000032	.....	31
2023-01-04 00:00:37.832798	000037	.....	3F
2023-01-04 00:00:42.836016	000042	.....	3E

The data format of the **GPPGA** *csv* is described on table 44.

Table 24. Data format used on **GPGGA** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC date	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:05.331006	
UTC Time Stamp	UTC TimeStamp	Integer			000005	
Latitude	latitude	Float	Degrees		3242.9427	
Latitude Direction	latDirection Direction	string			N	
Longitude	longitude	Float	Degrees		9644.8815	
Longitude Direction	lonDirection	string			W	
GPS Quaity	gpsQuality	Integer			2	
Number of Satellites	numberOf Satellites	Integer			7	
Horizontal Dilution	horizontal Dilution	Float			1.9	
Altitude	altitude	Float	meters		130.2	
Unit of Altitude	AUnits	string			M	

Geoidal Separation	geoidal Separation					
Geoidal Separation Unit	gSUnits					
	ageOf Differential					
Station ID	stationID	string				
checkSum	Check Sum	string			3E	

3.2.8.4 YXXDR

```
dateTime                    angularDisplacement   pitch ..... rollOfvessel
2023-01-04 00:00:00.078385  A                     0.6   ..... ROLL
2023-01-04 00:00:05.576478  A                     0.3   ..... ROLL
2023-01-04 00:00:11.076524  A                     0.5   ..... ROLL
2023-01-04 00:00:16.079577  A                     0.1   ..... ROLL
2023-01-04 00:00:21.577380  A                     0.5   ..... ROLL
2023-01-04 00:00:27.080041  A                     0.5   ..... ROLL
2023-01-04 00:00:32.578080  A                     0.3   ..... ROLL
```

The data format of the **YXXDR** *csv* is described on table 45.

Table 25. Data format used on **YXXDR** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:00.078385	
Angular Dispalcement	angular Displacement	Float	Degree		100.0	
Pitch	pitch	Float	Degree		127.5	
Pitch Unit	degrees	Float			127.5	
Pitch of Vessel	pitchOfVessel	Float			127.5	
Roll	roll	Float	Degree		-0.9	
Roll Unit	degrees2	string			D	
Roll of Vessel	rollofVessel	string			ROLL	

3.3 UTD Node

3.4 Equipped Sensing Module

3.4.1 Particle Counters

3.4.1.1 IPS7100

dateTime	pc0_1	pc0_3	pc0_5	.....	pm10_0
2023-01-04 00:00:00.059604	64474	18205	11661	.....	5.74317020
2023-01-04 00:00:01.061184	62047	17368	11109	.....	5.57649617
2023-01-04 00:00:02.062446	59468	16571	10640	.....	5.40531891
2023-01-04 00:00:03.063477	56790	15791	10198	.....	5.23171629
2023-01-04 00:00:04.064636	54282	15017	9777	.....	5.06503846
2023-01-04 00:00:05.065186	51981	14281	9377	.....	4.90459504
2023-01-04 00:00:06.066297	49793	13580	9015	.....	4.76209408

The data format of the **IPS7100** *csv* is described on table 26.

Table 26. Data Format used on the **IPS7100** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-02-09 00:00:07.143333	
Particles Counts	pc0_1 to pc10_0	Integer	$\#/Liter$	Particle Counts per *liter* for particle diameters 0.1, 0.3, 0.5, 1.0, 2.5, 5, 10 μm	3272	
Particulate mass fractions	pm0_1 to pm10_0	Float	$\mu g/m^3$	Particle mass fractions for particle diameters 0.1, 0.3, 0.5, 1.0, 2.5, 5, 10 μm	2.56	

3.4.1.2 OPCN2 (legacy)

```
dateTime                    valid   binCount0   binCount1 ..... pm10
2021-09-10 00:00:01.610778  1       24          8         ..... 0.54
2021-09-10 00:00:11.656575  1       19          8         ..... 3.43
2021-09-10 00:00:21.702495  1       17          8         ..... 0.19
2021-09-10 00:00:31.748232  1       21          12        ..... 1.75
2021-09-10 00:00:41.809618  1       15          10        ..... 1.75
2021-09-10 00:00:51.840035  1       29          16        ..... 0.5
```

The data format of the **OPCN2** *csv* is described on table 27.

Table 27. Data Format used on the **OPCN2** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2021-09-10 00:00:01.610778	
Valid	valid	Integer			1	
Particulate Counts	binCount0 to binCount23	Integer			4	
Particulate Counts	bin1TimeToCross to bin7TimeToCross	Integer			0	
Sample Flow Rate	sampleFlowRate	Float			3.7	
Temperature or Pressure	temperatureOrPressure	Float			10000	
Sampling Period	sampling Period	Float			10.03	
Check Sum	checksum	Integer			5	
$PM_{1.0}$	pm1	Float			0.59	
$PM_{2.5}$	pm2_5	Float			0.19	
$PM_{10.0}$	pm10	Float			0.54	

3.4.1.3 OPCN3 (legacy)

```
dateTime                    valid   binCount0   binCount1 ..... checkSum
2021-12-10 00:00:02.258444  1       24          8         ..... 24242
2021-12-10 00:00:12.285639  1       19          8         ..... 54075
2021-12-10 00:00:22.328696  1       17          8         ..... 64688
2021-12-10 00:00:32.371679  1       21          12        ..... 49434
2021-12-10 00:00:42.399214  1       15          10        ..... 5776
2021-12-10 00:00:52.426730  1       29          16        ..... 35324
2021-12-10 00:01:02.454126  1       28          6         ..... 35398
```

The data format of the **OPCN3** *csv* is described on table 28.

Table 28. Data Format used on the **OPCN3** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2021-12-10 00:00:02.258444	
Valid	valid	Integer			1	
Particulate Counts	binCount0 to binCount23	Integer			24	
Particulate Counts	bin1TimeToCross to bin7TimeToCross	Integer			37	
Sampling Period	sampling Period	Integer			500	
Sample Flow Rate	sampleFlowRate	Integer			577	
Temperature	temperature	Float			22.18	
Humidity	humidity	Float			28.592	
$PM_{1.0}$	pm1	Float			0.18	
$PM_{2.5}$	pm2_5	Float			0.48	
$PM_{10.0}$	pm10	Float			0.57	

Reject Count Glitch	rejectCount Glitch	Integer			9	
Reject Count Long TOF	rejectCount LongTOF	Integer			3	
Reject Count Ratio	rejectCount Ratio	Integer			208	
Reject Count Out of Range	rejectCount OutOfRange	Integer			2	
Number Of Fan Revolutions	fanRevCount	Integer			0	
Status Of Laser	laserStatus	Integer			644	
Check Sum	checksum	Integer			24242	

3.4.2 Climate Sensors

3.4.2.1 BME280

dateTime	temperature	pressure	humidity	altitude
2023-01-04 00:00:06.268466	16.81	99540.00	29.00	149.66
2023-01-04 00:00:16.296297	16.81	99542.00	29.00	149.49
2023-01-04 00:00:26.309238	16.80	99537.00	29.00	149.91
2023-01-04 00:00:36.337023	16.80	99538.00	29.00	149.83
2023-01-04 00:00:46.350128	16.80	99539.00	29.00	149.75
2023-01-04 00:00:56.362813	16.79	99539.00	29.00	149.75
2023-01-04 00:01:06.390603	16.79	99539.00	29.00	149.75

The data format of the **BME280** *csv* is described on table 29.

Table 29. Data format used on **BME280** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:06.268466	
Temperature	temperature	Float	$^{\circ}C$		16.81	
Pressure	pressure	Float	$millibars * 100$		99540.00	
Humidity	humidity	Float	%		29.00	
Altitude	altitude	Float	meters		149.66	

3.4.2.2 BME680

dateTime	temperature	pressure	humidity	gas
2023-01-04 00:00:04.568350	16.94	99.50	31.34	12976.91
2023-01-04 00:00:14.725647	16.93	99.50	31.45	12976.91
2023-01-04 00:00:24.882822	16.93	99.50	31.54	12976.91
2023-01-04 00:00:35.024835	16.93	99.50	31.57	12976.91
2023-01-04 00:00:45.182448	16.92	99.50	31.56	12976.91
2023-01-04 00:00:55.339732	16.92	99.50	31.53	12976.91
2023-01-04 00:01:05.496983	16.91	99.50	31.52	12976.91
2023-01-04 00:01:15.654531	16.91	99.50	31.59	12976.91

The data format of the **BME680** *csv* is described on table 30.

Table 30. Data format used on **BME680** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.568350	
Temperature	temperature	Float	$^{\circ}C$		16.94	
Pressure	pressure	Float	hPa		99.50	
Humidity	humidity	Float	%		31.34	
Gas	gas	Float	IAQ		12976.91	

3.4.3 Gas Sensors

3.4.3.1 SCD30

dateTime	c02	temperature	humidity
2023-01-04 00:00:08.763232	405	19.44	27.58
2023-01-04 00:00:18.775858	406	19.44	27.53
2023-01-04 00:00:28.803976	405	19.42	27.62
2023-01-04 00:00:38.816727	405	19.44	27.64
2023-01-04 00:00:48.829733	405	19.44	27.59
2023-01-04 00:00:58.857351	406	19.44	27.62
2023-01-04 00:01:08.870275	406	19.41	27.59
2023-01-04 00:01:18.883096	406	19.41	27.67
2023-01-04 00:01:28.911038	407	19.42	27.62
2023-01-04 00:01:38.923842	406	19.42	27.70

The data format of the **SCD30** *csv* is described on table 31.

Table 31. Data format used on **SCD30** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.568350	
CO_2	co2	Integer	ppm		405	
Temperature	temperature	Float	$°C$		19.44	
Humidity	humidity	Float	%		27.58	

3.4.3.2 MGS001

dateTime	nh3	co	.....	c2h5oh
2021-12-10 00:00:09.241742	0.03	0.00	.....	32.64
2021-12-10 00:00:19.269310	0.03	0.00	.....	41.86
2021-12-10 00:00:29.296710	0.03	0.00	.....	55.87
2021-12-10 00:00:39.339705	0.03	0.00	.....	48.08
2021-12-10 00:00:49.367408	0.03	0.00	.....	41.86
2021-12-10 00:00:59.410210	0.04	0.00	.....	23.74
2021-12-10 00:01:09.437861	0.03	0.00	.....	60.52

The data format of the **MGS001** *csv* is described on table 32.

Table 32. Data format used on **MGS001** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.568350	
NH_3	nh3	Float	ppm		0.03	
CO	co	Float	ppm		0.00	
NO_2	no2	Float	ppm		52.85	
C_3H_8	c4h10	Float	ppm		7.89	
C_4H_{10}	c3h8	Float	ppm		22961.39	
CH_4	ch4	Float	ppm		9178.73	
H_2	h2	Float	ppm		6317557.00	
C_2H_5OH	c2h5oh	Float	ppm		32.64	

3.4.4 Light Sensors

3.4.4.1 AS7262

```
dateTime                    temperature   violetPre  ...... redCalibrated
2021-12-10 00:00:06.780209  33            0          ...... 0.00
2021-12-10 00:00:16.808521  33            0          ...... 0.00
2021-12-10 00:00:26.852082  33            0          ...... 0.00
2021-12-10 00:00:36.879697  33            0          ...... 0.00
2021-12-10 00:00:46.923349  33            0          ...... 0.00
2021-12-10 00:00:56.951661  33            0          ...... 0.00
```

The data format of the **AS7262** *csv* is described on table 33.

Table 33. Data format used on **AS7262** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2021-12-10 00:00:06.780209	
Temperature	temperature	Integer			33	
Violet Pre	violetPre	Integer			0	
Blue Pre	bluePre	Integer			0	
Green Pre	greenPre	Integer			0	
Yellow Pre	yellowPre	Integer			0	
Orange Pre	orangePre	Integer			0	
Red Pre	redPre	Integer			0	
Violet Calibrated	violet Calibrated	Float			0.00	
Blue Calibrated	blue Calibrated	Float			0.00	
Green Calibrated	green Calibrated	Float			0.00	
Yellow Calibrated	yellow Calibrated	Float			0.00	
Orange Calibrated	orange Calibrated	Float			0.00	
Red Calibrated	red Calibrated	Float			0.00	

3.4.4.2 TSL2591

```
dateTime                    luminosity   ir     full .......   lux
2023-01-04 00:00:11.342016  2687083      41     107  .......   2.214639
2023-01-04 00:00:22.889220  2556007      39     103  .......   2.163324
2023-01-04 00:00:34.436582  2490466      38     98   .......   1.998367
2023-01-04 00:00:45.998925  2359391      36     95   .......   1.993330
2023-01-04 00:00:57.546508  2293851      35     91   .......   1.874708
2023-01-04 00:01:09.093538  2162775      33     87   .......   1.823338
```

The data format of the **TSL2591** *csv* is described on table 34.

Table 34. Data format used on **TSL2591** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:11.342016	
Luminosity	luminosity	Integer			2687083	
Infra Red	ir	Integer			41	
Full	full	Integer			107	
Visible	visible	Integer			66	
Lux	lux	Float			2.214639	

3.4.4.3 VEML6075

```
dateTime                    rawUVA   rawUVB   ..................  index
2023-01-04 00:00:00.801969  0        0        ..................  0.00
2023-01-04 00:00:12.349474  0        0        ..................  0.00
2023-01-04 00:00:23.896498  0        0        ..................  0.00
2023-01-04 00:00:35.444258  0        0        ..................  0.00
2023-01-04 00:00:47.006426  0        0        ..................  0.00
2023-01-04 00:00:58.554261  0        0        ..................  0.00
2023-01-04 00:01:10.101090  0        0        ..................  0.00
```

The data format of the **VEML6075** *csv* is described on table 35.

Table 35. Data format used on **VEML6075** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:00.801969	
Raw Ultra Violet A	rawUVA	Integer			0	
Raw Ultra Violet B	rawUVB	Integer			0	
Visible Compensation	visibleCompensation	Integer			0	
Infra Red Compensation	irCompensation	Integer			0	
Ultra Violet A	uva	Float			0.00	
Ultra Violet B	uvb	Float			0.00	
UV Index	index	Integer			0	

3.4.4.4 SKYCAM003

```
dateTime                    cloudPecentage   allRed ..........  cloudBlue
2023-01-04 00:00:04.353794  100.0            127.5  ..........  127.5
2023-01-04 00:05:04.311989  100.0            127.5  ..........  127.5
2023-01-04 00:10:04.019655  100.0            127.5  ..........  127.5
2023-01-04 00:15:04.216315  100.0            127.5  ..........  127.5
2023-01-04 00:20:03.846723  100.0            127.5  ..........  127.5
2023-01-04 00:25:03.898568  100.0            127.5  ..........  127.5
```

The data format of the **SKYCAM003** *csv* is described on table 36.

Table 36. Data format used on **SKYCAM003** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.353794	
Cloud Percentage	cloudPercentage	Float	%		100.0	
All Red	allRed	Float			127.5	
All Green	allGreen	Float			127.5	
All Blue	allBlue	Float			127.5	
Sky Red	skyRed	Integer			-1	
Sky Green	skyGreen	Integer			-1	
Sky Blue	skyBlue	Integer			-1	
Cloud Red	cloudRed	Float			127.5	
Cloud Green	cloudGreen	Float			127.5	
Cloud Blue	cloudBlue	Float			127.5	

3.4.5 Microphone

3.4.5.1 MBC001(from Pop voice used for recording bird calls)

dateTime	label	confidence
2023-07-26 00:28:59.895587	2102	0.9553
2023-07-26 00:36:05.423425	631	0.3048
2023-07-26 00:53:20.633355	2102	0.3403
2023-07-26 00:53:23.633355	2102	0.5494
2023-07-26 00:59:38.500652	1578	0.3418
2023-07-26 01:08:26.517110	408	0.34
2023-07-26 01:18:59.399381	2102	0.3078

The data format of the **MBC001** *csv* is described on table 37.

Table 37. Data format used on **MBC001** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-07-26 00:28:59.895587	
Label	label	Integer			2102	
Confidence	confidence	Float			0.9553	

3.4.6 Thunder and Lightning Sensor

3.4.6.1 AS3935

dateTime	source	energy	distance
2023-01-04 00:16:17.044439	2	30	63
2023-01-04 00:21:44.338102	2	0	63
2023-01-04 02:16:17.235212	2	30	63
2023-01-04 03:16:17.390213	2	30	63
2023-01-04 04:16:17.302775	2	30	63
2023-01-04 05:16:16.826721	2	30	63
2023-01-04 06:16:16.929995	2	30	63
2023-01-04 07:51:59.525492	2	0	63
2023-01-04 08:16:16.288806	2	30	63

The data format of the **AS3935** *csv* is described on table 38.

Table 38. Data format used on **AS3935** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:16:17.044439	
Source	source	Integer			2	
Energy	energy	Integer			30	
Distance	distance	Integer	km		63	

3.4.6.2 SEN0232

dateTime	rawAnalog	rawVoltage	dB
2023-01-04 00:00:02.040488	17	0.08	4.15
2023-01-04 00:00:04.556777	16	0.08	3.91
2023-01-04 00:00:07.057364	15	0.07	3.66
2023-01-04 00:00:09.558081	13	0.06	3.17
2023-01-04 00:00:12.058904	14	0.07	3.42
2023-01-04 00:00:14.559609	12	0.06	2.93
2023-01-04 00:00:17.060362	15	0.07	3.66
2023-01-04 00:00:19.561099	11	0.05	2.69
2023-01-04 00:00:22.061834	19	0.09	4.64
2023-01-04 00:00:24.578352	13	0.06	3.17
2023-01-04 00:00:27.079106	15	0.07	3.66
2023-01-04 00:00:29.579937	18	0.09	4.39
2023-01-04 00:00:32.080686	15	0.07	3.66

The data format of the **SEN0232** *csv* is described on table 39.

Table 39. Data format used on **SEN0232** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:02.040488	
Raw Analog	rawAnalog	Integer			17	
Raw Voltage	rawVoltage	Float			0.08	
Sound in dB	dB	Float			4.15	

3.4.7 Radiation Sensors

3.4.7.1 LIBRAD

```
dateTime                    countPerMinute   ................ LIBRADCount
2023-01-04 00:00:04.408582  0.0000           ................ 0
2023-01-04 00:00:14.565957  0.0000           ................ 0
2023-01-04 00:00:24.723068  0.0000           ................ 0
2023-01-04 00:00:34.880212  0.0000           ................ 0
2023-01-04 00:00:45.022648  0.0000           ................ 0
2023-01-04 00:00:55.180008  0.0000           ................ 0
```

The data format of the **LIBRAD** *csv* is described on table 40.

Table 40. Data format used on **LIBRAD** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:04.408582	
count Per Minute	countPer Minute	Float			0.000	
Radiation Value	radiation Value	Float			0.000	
Time Spent	timeSpent	Integer			10000	
Radiation Count	LIBRAD Count	Integer			0	

3.4.7.2 QLMRAD001

dateTime	event
2023-01-04 00:00:00.143675	0063
2023-01-04 00:00:00.146156	0200
2023-01-04 00:00:00.190742	0074
2023-01-04 00:00:00.286839	0056
2023-01-04 00:00:00.293918	0065
2023-01-04 00:00:00.550614	0086
2023-01-04 00:00:00.582952	0050
2023-01-04 00:00:00.636760	0150
2023-01-04 00:00:00.686808	0075
2023-01-04 00:00:00.839238	0229
2023-01-04 00:00:00.903411	0052
2023-01-04 00:00:01.050683	0049
2023-01-04 00:00:01.334357	0738

The data format of the **QLMRAD001** *csv* is described on table 41.

Table 41. Data format used on **QLMRAD001** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:00.143675	
Event	event	Integer			0063	

3.4.8 GPS Sensors

3.4.8.1 GPSGPGGA2

dateTime	timestamp	latitudeCoordinate	...	stationID
2023-01-04 00:00:01.101081	00:00:01	32.715703500000004	...	0
2023-01-04 00:00:04.083579	00:00:04	32.715704833333334	...	0
2023-01-04 00:00:07.086137	00:00:07	32.715700500000004	...	0
2023-01-04 00:00:10.085323	00:00:10	32.71569783333334	...	0
2023-01-04 00:00:13.082585	00:00:13	32.715699666666666	...	0
2023-01-04 00:00:16.081818	00:00:16	32.715701833333334	...	0
2023-01-04 00:00:19.080205	00:00:19	32.71570366666666	...	0

The data format of the **GPSGPGGA2** *csv* is described on table 42.

Table 42. Data format used on **GPSGPGGA2** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC date	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:01.101081	
Time Stamp	timestamp	hh:mm:ss			00:00:01	
Status	status	string			A	
Latitude Coordinate	latitude Coordinate	Float	Degrees		32.7157035	
Longitude Coordinate	longitude Coordinate	Float	Degrees		-96.7480245	
Latitude	latitude	Float	Degrees		3242.94221	
Latitude Direction	latitude Direction	string			N	
Longitude	longitude	Float	Degrees		9644.88147	
Longitude Direction	longitude Direction	string			W	
GPS Quaity	gpsQuality	Integer			2	
Number of Satellites	numberOf Satellites	Integer			10	
Horizontal Dilution	Horizontal Dilution	Float			1.01	
Altitude	altitude	Float	meters		133.4	
Unit of Altitude	altitudeUnits	string			M	
Unit of Altitude	altitudeUnits	string			M	
Undulation	undulation	Float	meters		-25.2	
Unit of Undulation	undulation Units	Float	meters		-25.2	
	age					
Station ID	stationID	string			0	

3.4.8.2 GPSGPRMC2

```
dateTime                    timestamp ..... magVariationDirection
2023-01-04 00:00:01.093170  00:00:01  .....
2023-01-04 00:00:04.076470  00:00:04  .....
2023-01-04 00:00:07.078490  00:00:07  .....
2023-01-04 00:00:10.078148  00:00:10  .....
2023-01-04 00:00:13.075355  00:00:13  .....
2023-01-04 00:00:16.074523  00:00:16  .....
```

The data format of the **GPSGPRMC2** *csv* is described on table 43.

Table 43. Data format used on **GPSGPRMC2** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC date	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:01.093170	
Time Stamp	timestamp	hh:mm:ss			00:00:01	
Latitude Coordinate	latitude Coordinate	Float	Degrees		32.7157035	
Longitude Coordinate	longitude Coordinate	Float	Degrees		-96.7480245	
Latitude	latitude	Float	Degrees		3242.94221	
Latitude Direction	latitude Direction	string			N	
Longitude	longitude	Float	Degrees		9644.88147	
Longitude Direction	longitude Direction	string			W	
Speed of Device over Ground	speedOver Ground	Float			0.082	
True Course	trueCourse					
Magnetic Variation	magnetic Variation					
Magnetic Variation Direction	magnetic Variation Direction					

3.4.8.3 GPGGA (GPS from WIMDA)

dateTime	UTCTimeStamp	.....	checkSum
2023-01-04 00:00:05.331006	000005	.....	3E
2023-01-04 00:00:10.831074	000010	.....	30
2023-01-04 00:00:15.834106	00001	.....	38
2023-01-04 00:00:21.331956	000021	.....	3A
2023-01-04 00:00:26.834607	000026	.....	3E
2023-01-04 00:00:32.332718	000032	.....	31
2023-01-04 00:00:37.832798	000037	.....	3F
2023-01-04 00:00:42.836016	000042	.....	3E

The data format of the **GPPGA** *csv* is described on table 44.

Table 44. Data format used on **GPGGA** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC date	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:05.331006	
UTC Time Stamp	UTC TimeStamp	Integer			000005	
Latitude	latitude	Float	Degrees		3242.9427	
Latitude Direction	latDirection Direction	string			N	
Longitude	longitude	Float	Degrees		9644.8815	
Longitude Direction	lonDirection	string			W	
GPS Quaity	gpsQuality	Integer			2	
Number of Satellites	numberOf Satellites	Integer			7	
Horizontal Dilution	horizontal Dilution	Float			1.9	
Altitude	altitude	Float	meters		130.2	
Unit of Altitude	AUnits	string			M	

Geoidal Separation	geoidal Separation					
Geoidal Separation Unit	gSUnits					
	ageOf Differential					
Station ID	stationID	string				
checkSum	Check Sum	string			3E	

3.4.8.4 YXXDR

```
dateTime                    angularDisplacement   pitch ..... rollOfvessel
2023-01-04 00:00:00.078385  A                     0.6   ..... ROLL
2023-01-04 00:00:05.576478  A                     0.3   ..... ROLL
2023-01-04 00:00:11.076524  A                     0.5   ..... ROLL
2023-01-04 00:00:16.079577  A                     0.1   ..... ROLL
2023-01-04 00:00:21.577380  A                     0.5   ..... ROLL
2023-01-04 00:00:27.080041  A                     0.5   ..... ROLL
2023-01-04 00:00:32.578080  A                     0.3   ..... ROLL
```

The data format of the **YXXDR** *csv* is described on table 45.

Table 45. Data format used on **YXXDR** data *csv*

Parameter	Column Name	Format	Unit	Errors	Example	Comments
UTC Time	dateTime	yyyy-MM-dd hh:mm:ss			2023-01-04 00:00:00.078385	
Angular Dispalcement	angular Displacement	Float	Degree		100.0	
Pitch	pitch	Float	Degree		127.5	
Pitch Unit	degrees	Float			127.5	
Pitch of Vessel	pitchOfVessel	Float			127.5	
Roll	roll	Float	Degree		-0.9	
Roll Unit	degrees2	string			D	
Roll of Vessel	rollofVessel	string			ROLL	

3.5 PoLo Node (Powered LoRa Node)

3.6 SoLo Node (Solar Powered LoRa Node))

3.7 VALo Node (VA Powered LoRa Node))

4. Mobile Sensing Systems

4.1 Wearable Node

5. Central Node Data

Data from each Central Node is initially saved as *csv* files.There are two Single board computers(OdroidC4) that record the data from the sensors.Each of the SBC have unique node id's and a group of sensors connected to each of them. A *csv* file is provided for each sensor within a central node per day and is collected under the respective nodeid. In order to maintain a record of the most recent data read, a unique json file is updated for each individual sensor.Upon connection to the internet both the *csv* and *json* files are transferred via *rsync* [**?**]. Upon transmission the data to the graphical dashboards are updated using an *mqtt* [**?**] pipeline.For each day, each sensor will have a single csv file saved inside the respective node, with the following folder structure @ *\home\teamlary\mintsData*.

```
mintsData
    raw
        001e0636e547
            2023
                01
                    04
                        MINTS_001e0636e547_APDS9002_2023_01_04.csv
                        MINTS_001e0636e547_AS7262_2023_01_04.csv
                        MINTS_001e0636e547_BME280_2023_01_04.csv
                        MINTS_001e0636e547_BME680_2023_01_04.csv
                        MINTS_001e0636e547_APDS9002_2023_01_04.csv
                            .
                            .
                            .
                            .

                        MINTS_001e0636e547_SI114X_2023_01_04.csv
                        MINTS_001e0636e547_TB108L_2023_01_04.csv
                        MINTS_001e0636e547_TMG3993_2023_01_04.csv
                        MINTS_001e0636e547_TSL2591_2023_01_04.csv
                        MINTS_001e0636e547_VEML6075_2023_01_04.csv
mintsData
    raw
```

```
001e06430225
    2023
        01
            04
                MINTS_001e06430225_AS3935_2023_01_04.csv
                MINTS_001e06430225_SEN0232_2023_01_04.csv
                MINTS_001e06430225_SKYCAM003_2023_01_04.csv
                MINTS_001e06430225_WIMDA_2023_01_04.csv
                MINTS_001e06430225_YXXDR_2023_01_04.csv
                snaps
                    MINTS_001e06430225_SKYCAM003_
                    2023_01_04_16_00_43.png
                    .
                    .
                    .
                    MINTS_001e06430225_SKYCAM003_
                    2023_01_04_18_35_03.png
                    MINTS_001e06430225_SKYCAM_binary003_
                    2023_01_04_16_37_44.png
                    .
                    .
                    MINTS_001e06430225_SKYCAM_binary003_
                    2023_01_04_18_35_03.png
```

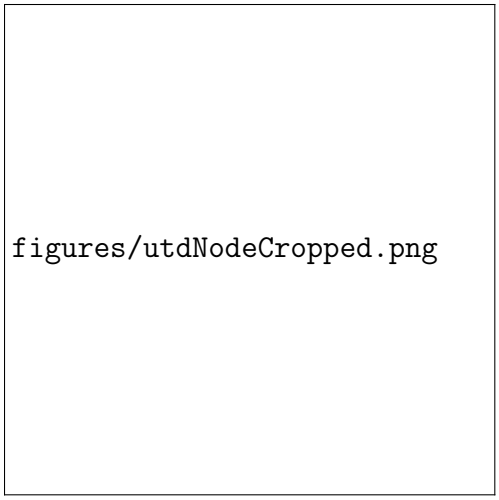
In this example, the sensor ID happens to be *001e0636e547*, *001e06430225* which is the unique ID corresponding to the XU4 and N2+ respectively .

References

Appendix C: Stationary Sensing Systems

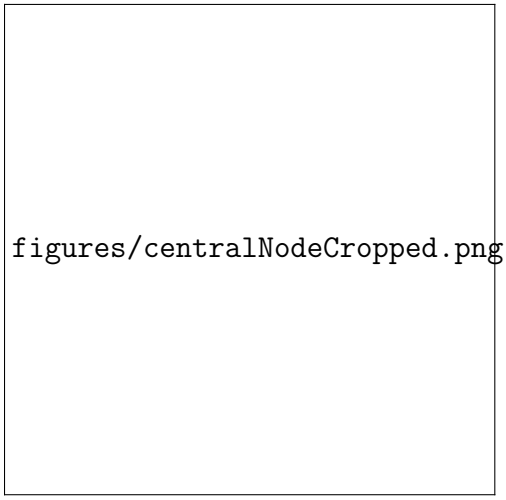
MINTS has been developing multiple sensor systems for a wide range of applications. One subset of such systems is 24/7 Streaming Distributed Sentinels, where the data is provided on a frequent and continuous basis.

1st Generation: UTD Nodes



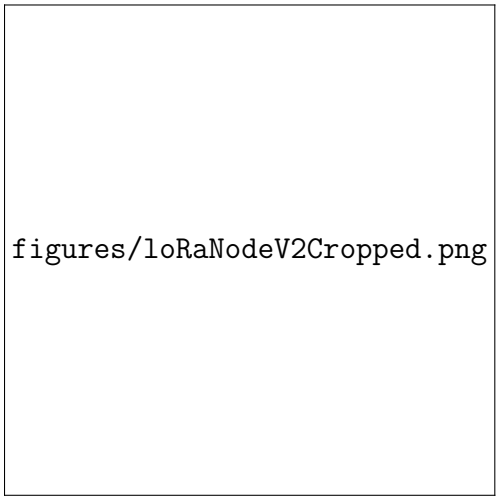
The UTD Node is a stationery sensor system consisting an array of iot sensors which is an extensible platform in which many newer sensors can be adopted into. The UTD Node houses a particulate matter sensor, CO_2 sensor, climate sensor, a set of light sensors as well as an skyward facing camera.

2nd Generation: Central Nodes



Central Nodes are the second generation of UTD Nodes. In addition to providing all the sensors provided by the UTD Node, the Central Node has an expanded light sensing module as well as a radiation sensor, a sound sensor that detects bird calls as well as gunshots, a research grade ozone sensor, a lightning sensor, and remote power management capabilities. Additionally, the Central Node serves as a central gateway for a mesh network of LoRaWAN Nodes described in section 5.

LoRaWAN Nodes



LoRa is an infant communication technology based on ISM (Industrial, Scientific and Medical) bands which are capable of low power and Long Range applications. LoRaWAN is a Wide Area Network protocol that is designed to embed LoRa technology into a network infrastructure . The LoRa Nodes are designed to make use of LoRaWAN technology with each node a part of a mesh network communicating with one Central Node.
The LoRa Nodes are designed to work without the need of direct power nor internet connectivity. This makes it extremely versatile. The main source of power for the LoRa Nodes is sunlight and thus it consists of two solar panels to harness solar energy.
A LoRa Node consists of a particulate matter sensor and a climate sensor.

Appendix D: MINTS GitHub repositories

- Version 1, 3 firmware:
  https://github.com/mi3nts/minWeNodes
- Version 4 firmware:
  https://github.com/mi3nts/minWeZeroNodes
- UTD Node firmware:
  https://github.com/mi3nts/UTDNodes
- Central Nodes firmware:
  https://github.com/mi3nts/centralHub
- LoRaWAN Nodes firmware:
  https://github.com/mi3nts/LoRaWANNodes