VEET 2.1 Data Interpretation Guide

Introduction

This guide provides keys and examples to help researchers understand the values of the lines of data in the Visual Environment Evaluation Tool (VEET) sensor file.

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Note on Data Firmware Versions

The format of the VEET data file (sensor_data.csv) was updated with Firmware Version FW2.1.3. This latest version includes changes to the Information (INF), Spectral Sensor (PHO) and Ambient Light Sensor (ALS) data lines. Please see Appendix: Changes in VEET Firmware for keys and examples of the VEET data lines in this older format.

You can find your data's Firmware version in the Information (INF) line, as shown in **bold** below:

```
1743796406,INF,VEET,24110244,FW2.1.8 Apr  1 2025 16:26:00
```

If there is an already existing sensor_data.csv file on the VEET, the existing data file won't be updated or deleted when you update the device to FW2.1.3 or later. However, all new data is logged in the updated data format. To avoid logging mixed-format data, delete the old sensor_data.csv file from the device after the update.

File example: Sensor_Data.csv

When you onboard your VEET sensor data file (without splitting it by sensor type) it looks like this following example:


```
1743796406,INF,VEET,24110244,FW2.1.8 Apr  1 2025 16:26:00
,abc123,abc123,-8,2000,2000,2000,2000,L
1743796413,PHO,100,512,11,35,48,62,63,63,109,54,38,0,0,0
1743796413,IMU,0.118513,3.716998,8.576031,-1.953125,-8.789062,-6.286621,41.0000
00
1743796413,TOF,255,255,255,255,0,0,0,0,0,0,255,0,255,255,0,0,0,0,0,255,255,255,
0,0,0,0,255,255,255,255,0,224,0,0,0,255,255,255,0,191,0,0,0,255,255,188,0,0,0,0
,0,0,255,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,32,32,32,32,0,0,0,0,0,0,39,0,93,97,0,0,0,0,0,74,90,91,0,0,0,0,84,86,96,98,0,94
,0,0,0,102,100,99,0,139,0,0,0,108,121,92,0,0,0,0,0,0,129,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
1743796414,ALS,100,4096,1024,4096,837,608299,169182,7,63.67
1743796417,IMU,-0.116119,3.873818,8.927979,-44.677734,-29.174805,-67.749023,40.
000000
1743796417,PHO,100,512,319,727,1010,1252,1372,1419,1986,1095,778,0,0,0
1743796417,TOF,23,20,39,65,73,69,62,42,16,11,33,91,160,192,165,75,16,21,97,232,
255,255,255,255,14,15,15,99,255,255,255,255,26,19,21,23,23,150,255,176,23,15,13
,10,0,9,15,19,39,25,25,25,17,13,22,34,27,26,25,24,17,16,16,26,0,12,16,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,18,0,0,0,0,0,0,0,0,19,26,41,0,0,0,0,0,11,23,43,27,14,0,0,0,0
,0,0,9,10,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,371,362,383,379,394,382,371,360,378
,401,425,418,414,397,389,381,369,378,399,386,384,372,357,347,378,392,411,412,40
6,395,377,368,368,372,354,360,378,368,357,349,391,395,382,374,0,404,384,385,377
,368,357,358,379,378,370,354,388,394,384,382,397,384,385,389,0,633,585,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,729,0,0,0,0,0,0,0,0,904,839,784,0,0,0,0,0,933,833,785,760,7
31,0,0,0,0,0,0,892,785,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
1743796418,ALS,100,4096,256,2048,3224,560755,348242,7,226.7
```


Observations on the structure of the Sensor_Data.csv file:

- The time sequence may not be in perfect linear order. The processor records the time when the sensor was called to make a reading, which can be prior to the local time or the last datapoint recorded from another sensor.
- Time is recorded in whole seconds only, while device internal clock time is kept in milliseconds. As a result, sensing epochs may report drift by up to a second if the internal clock rolls over the next second before writing to the disk.
- For various clock and saturation event reasons, the total number of sensed events may differ from expected by up to 2%. This behavior is normal.

Information (INF)

An information (INF) line reports the device's state at the time data is logged. The VEET generates an information line every time the system restarts or switches states, such as when the device is in the following states:

- Connected to a computer
- Waking from Deep Sleep
- Manually restarted, such as for a configuration update
- Undergoes a firmware update

Organization of Data in an Information Line

```
[time_stamp],INF,[product_name],[serial_number],[fw_version],[Researcher_ID],[P
articipant_ID],[Time_Zone_offset],[IMU_interval],[PHO_interval],[TOF_interval],
[ALS_interval],[Temple_config]
```

Key for Information Line

Item	Detail
`time_stamp`	The Unix time since 1970-01-01 00:00:00 UTC in seconds. Possible values: `1325376002` to `1893484800+` Data type: `uint32`
`INF`	The current line is information data. Only value: `INF` Data type: `string`
`product_name`	The hardware version of the temple arm of the VEET device. Possible values: `HW2.x.x,` Data type: `string`
`serial_number`	The unique identifier of the temple arm of the VEET device. Data type: `string`
`fw_version`	The build version of the firmware of the temple arm of the VEET device. Possible values: `FW2.x.x` Data type: `string`
`Researcher_ID`	The identifier of the researcher.
`Participant_ID`	The identifier of the research participant.
`Time_Zone_offset`	The time zone from UTC of the temple arm of the VEET device.
`IMU_interval`	The time between sensor reads in milliseconds.
`PHO_interval`	The time between sensor reads in milliseconds.
`TOF_interval`	The time between sensor reads in milliseconds.
`ALS_interval`	The time between sensor reads in milliseconds.
`Temple_Config`	Indicates the temple arm is left or right.

Spectral Sensor (PHO)

The Spectral Sensor or `PHO` line reports the data from the Spectral sensor.

Observations on Spectral Sensor data:

- All counts provided by this sensor are reported in calibrated raw counts.
- These counts must be further processed to provide useful spectral information.
- A Spectral Power Reconstruction guide will be available on https://projectveet.com around May 2025. Contact veetsupport@meta.com for more information.

Organization of Data in a Spectral Sensor Line

```
[time_stamp],PHO,[Integration],[Gain],[415_nm],[445_nm],[480_nm],[515_nm],[555_
nm],[590_nm],[630_nm],[680_nm],[IR],[Dark],[Clear]
```

Note: *The last 11 columns are the raw sensor values.*

Key for Spectral Sensor Line

Item	Detail
`time_stamp`	The Unix time since 1970-01-01 00:00:00 UTC in seconds. Possible values: `1325376002` to `1893484800+` Data type: `uint32`
`PHO`	The current line is spectral sensor data. Only value: `PHO` Data type: `string`
`Integration`	The length of time for the measurement by the sensor in milliseconds, currently fixed. Only value: `100` Data type: `uint16`
`Gain`	The index of the gain used by the sensor at time of reading. References to a gain table.
`415_nm`	The response* in raw counts, centered on nominal wavelength of 415nm and bandwidth of 26nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`445_nm`	The response in raw counts, centered on nominal wavelength of 445nm and bandwidth of 30nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`480_nm`	The response in raw counts, centered on nominal wavelength of 480nm and bandwidth of 36nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`515_nm`	The response in raw counts, centered on nominal wavelength of 515nm and bandwidth of 39nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`555_nm`	The response in raw counts, centered on nominal wavelength of 555nm and bandwidth of 39nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`590_nm`	The response in raw counts, centered on nominal wavelength of 590nm and bandwidth of 40nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`630_nm`	The response in raw counts, centered on nominal wavelength of 630nm and bandwidth of 50nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`680_nm`	The response in raw counts, centered on nominal wavelength of 680nm and bandwidth of 52nm FWHM. Value Range: `0` to `65535`, Data type: `uint16`
`IR`	The response centered on nominal wavelength of 910nm and bandwidth of 104nm FWHM in raw counts. Value Range: `0` to `65535`, Data type: `uint16`

Item	Detail
Dark	The response on the masked channel in raw counts. Used to measure noise level. Value Range: 0 to 65535, Data type: uint16
Clear	The response at full spectrum in raw counts. Value Range: 0 to 65535, Data type: uint16

Inertial Measurement Unit (IMU)

An inertial measurement unit or IMU line reports the data from the IMU sensor.

Observations on Inertial Measurement Unit data:

- The IMU is not calibrated:
    - Resting acceleration magnitude won't exactly match local gravity and may differ by up to +/-.2m/s^2 per manufacturer's datasheet.
    - Resting gyroscope may show noise up to +/- 0.5 degrees per second in addition to an offset of 2.5 dps.
- The IMU is housed along the temple arm, thus the acceleration data can be post processed to estimate head tilt.
- Both Acceleration and Gyroscopic data can be used to determine if the device is being worn.
- When the glasses frames are oriented upright and resting on a flat, level surface, the acceleration axis is vertical (Y axis) with an approximate value of -9.8m/s^2.
- The temperature reading included in the IMU data line is not calibrated and measures the internal temperature of the device. This temperature lags behind environmental temperature changes. This time delay has not been characterized.

Organization of Data in an Information Line

```
[time_stamp],IMU,[ax],[ay],[az],[gx],[gy],[gz],[temp]
```

Key for Inertial Measurement Unit Line

Item	Detail
time_stamp	The Unix time since 1970-01-01 00:00:00 UTC in seconds. Possible values: 1325376002 to 1893484800+ Data type: uint32
IMU	The current line is inertial measurement unit sensor data. Only value: IMU Data type: string
ax	The position of the X-axis accelerometer in meters per second-squared. Possible values: -39.24 to +39.24 (-4g to +4g), Data type: float
ay	The position of the Y-axis accelerometer in meters per second-squared. Possible values: -39.24 to +39.24 (-4g to +4g) Data type: float

Item	Detail
az	The position of the Z-axis accelerometer in meters per second-squared. Possible values: -39.24 to +39.24 (-4g to +4g) Data type: float
gx	The angle of the X-axis gyroscope in degrees per second. Possible values: 0 to 2000 Data type: float
gy	The angle of the Y-axis gyroscope in degrees per second. Possible values: 0 to 2000 Data type: float
gz	The angle of the Z-axis gyroscope in degrees per second. Possible values: 0 to 2000 Data type: float
temp	The temperature captured by the IMU sensor in degrees Celsius. Possible values: -41 to +87 Data type: int_16

Orientation of IMU axis

Time of Flight Sensor (ToF)

A time of flight or TOF line reports the data from the Time of Flight (ToF) sensor.

Observations on Time of Flight Sensor data:

- The Time of Flight sensor has been validated to not require device-specific calibration.
- When the VEET is fully occluded, the Time of Flight Sensor reads approximately 11mm: the distance from the sensor to the surface of the glass.

Organization of Data in a Time of Flight Sensor line

```
[time_stamp],[TOF],conf1[0:63],conf2[0:63],dist1[0:63],dist2[0:63]
```

From the point of view of the research participant looking out, the Time of Flight (TOF) data is

organized as an 8x8 row-major array with the top left being (0,0), the next data value being (0,1) (same row, next column). As such, (1,0) is the second row, first column. The lower right corner is (7,7).

Key for Time of Flight Sensor Line

Item	Detail
`time_stamp`	The Unix time since 1970-01-01 00:00:00 UTC in seconds. Possible values: `1325376002` to `1893484800+` Data type: `uint32`
`TOF`	The current line is time of flight sensor data. Only value: `TOF` Data type: `string`
`conf1[0:63]`	Object 1 confidence: the signal-to-noise ratio for the 1st object in the zone. Possible values: `0` to `255` Data type: `uint8`
`conf2[0:63]`	Object 2 confidence: the signal-to-noise ratio for the 2nd object in the zone. Possible values: `0` to `255` Data type: `uint8`
`dist1[0:63]`	The distance to Object 1 in the zone in millimeters. Possible values: `0` to `5000` Data type: `uint16`
`dist2[0:63]`	The distance to Object 2 in the zone in millimeters. Possible values: `0` to `5000` Data type: `uint16`

The `Data[0:63]` values are organized as a raster scan with `[row, column] [0,0]` in the upper left. The orientation is facing away from the sensor (`0,0`: upper left; `7,7`: lower right).

Orientation of Time of Flight Sensor

	Column 0	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
Row 0	0	1	2	3	4	5	6	7
Row 1	8	9	10	11	12	13	14	15
Row 2	16	17	18	19	20	21	22	23
Row 3	24	25	26	27	28	29	30	31
Row 4	32	33	34	35	36	37	38	39
Row 5	40	41	42	43	44	45	46	47
Row 6	48	49	50	51	52	53	54	55
Row 7	56	57	58	59	60	61	62	63

Ambient Light Sensor (ALS)

The light meter or `ALS` line reports the data from the Ambient Light Sensor.

Observations on Ambient Light Sensor data:

- All counts provided by this sensor are reported in calibrated raw counts.
- Lux values report from 0.001 to 100000+ with no hard upper limit.

- 0 Lux is reported as 0.001 to aid in logarithmic plotting of the data.
- In the event of sensor saturation, which may happen when the sensor is searching for the right gain value, the event is not reported in the Sensor_data.csv file but logged in the log.csv file. It is typical for this sensor to saturate when transitioning from very dark to very bright conditions.
- The device reports flicker up to 7kHz. If the sensor cannot determine a flicker, it reports NAN.

Organization of Data in an Ambient Light Sensor Line

```
[time_stamp],ALS,[Integration],[uvGain],[visGAin],[irGain],[uvValue],[visValue]
,[irValue],[Flicker],[Lux]
```

Key for Ambient Light Sensor Line

Item	Detail
`time_stamp`	The Unix time since 1970-01-01 00:00:00 UTC in seconds. Possible values: `1325376002` to `1893484800+` Data type: `uint32`
`ALS`	The current line is light meter sensor data. Only value: `ALS` Data type: `string`
`Integration`	The length of time for the measurement by the sensor in milliseconds. Analogous to shutter speed. Only value: `100` Data type: `uint16`
`uvGain`	The index of the gain used by the UV channel at time of reading. References to a gain table.
`visGain`	The index of the gain used by the visible channel at time of reading. References to a gain table.
`irGain`	The index of the gain used by the near IR channel at time of reading. References to a gain table.
`uvValue`	The response* in raw counts of the UV channel. Possible values: `0` to `1048575` Data type: `float`
`visValue`	The response* in raw counts of the visible channel. Possible values: `0` to `1048575` Data type: `float`
`irValue`	The response* in raw counts of the near IR channel. Possible values: `0` to `1048575` Data type: `float`
`Flicker`	The predominant flicker rate of light during sensor read in hertz. Possible values: `0` to `7000 otherwise NAN`
`Lux`	The estimated function of visible and IR channels in lux.

Appendix: Changes in VEET Firmware

Firmware version 2.1.3 made several changes to the data format. These changes were implemented for the following reasons:

Changes in Information (INF) Line

- Reduced legacy data and information that is no longer utilized.

Organization of Data in an Information Line (FW2.1.2 and previous)

```
1709249589,INF,VEET_1.5,3G7Z178FCD0011,FW1.49h Feb 13 2024
17:24:57,abc123,abc123,-8,2000,2000,2000,2000,R,250,1.00,1.00,1.00,1.00,s,mV,ms
,m/s^2,deg/s,count,#,mm,count,#,Hz
```

Organization of Data in an Information Line (FW2.1.3 and above)

```
1741824121,INF,VEET,24110244,FW2.1.3 Mar 11 2025
15:41:35,abc123,abc123,-8,2000,2000,2000,2000,L
```

Changes in Spectral Sensor (PHO) Line

- Clear channel reporting changed from ClearL and ClearR to a single aggregated value: Clear. The change simplifies post processing.

Organization of Data in a Spectral Sensor (PHO) Line (FW2.1.2 and previous)

1709249595,PHO,50,512,48,135,137,221,239,282,389,262,459,0,901,**910**

Organization of Data in a Spectral Sensor (PHO) Line (FW2.1.3 and above)

1741824129,PHO,100,512,10,22,30,44,55,75,92,64,39,0,198

Changes in Ambient Light Sensor (ALS) Line

- The way flicker is reported when the sensor is saturated changed to NAN for easier data analysis.

Organization of Data in an Ambient Light Sensor Line (FW2.1.2 and previous)

1706922030,ALS,100,4096,1024,2048,0,0,0,**65534**,0.0000

Organization of Data in an Ambient Light Sensor Line (FW2.1.3 and above)

1741824153,ALS,100,4096,4096,4096,153,33,638,**NAN**,0.0000