Eobs' help sheet - Setting up devices

This help file only concerns radio-link (non-solar panel) devices.

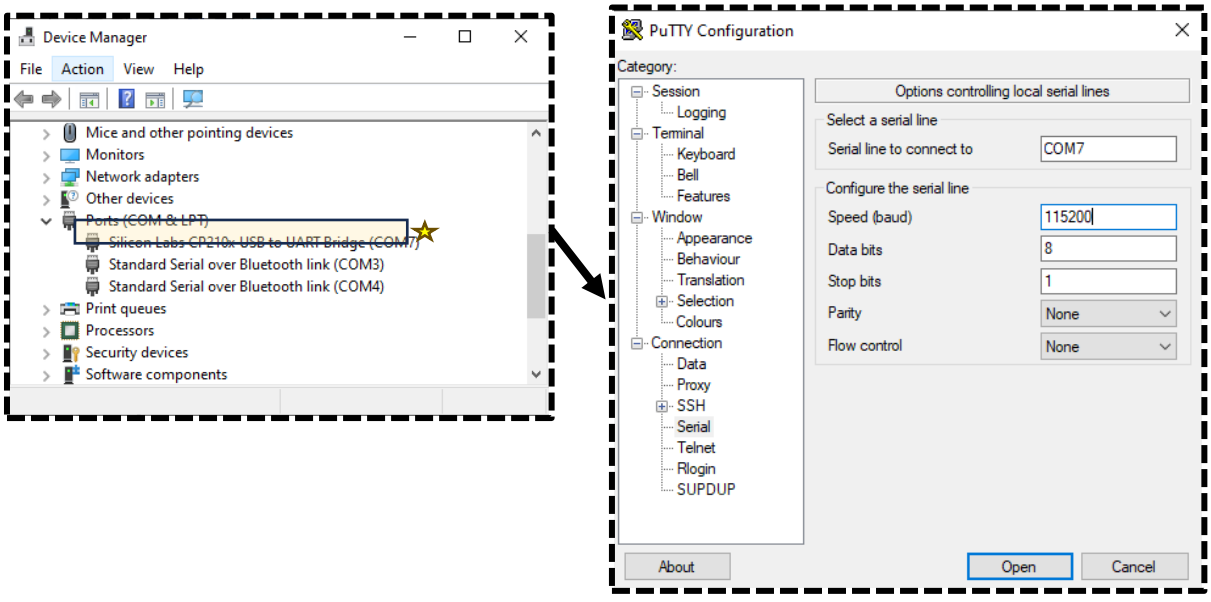
(A) Before setting up collars:

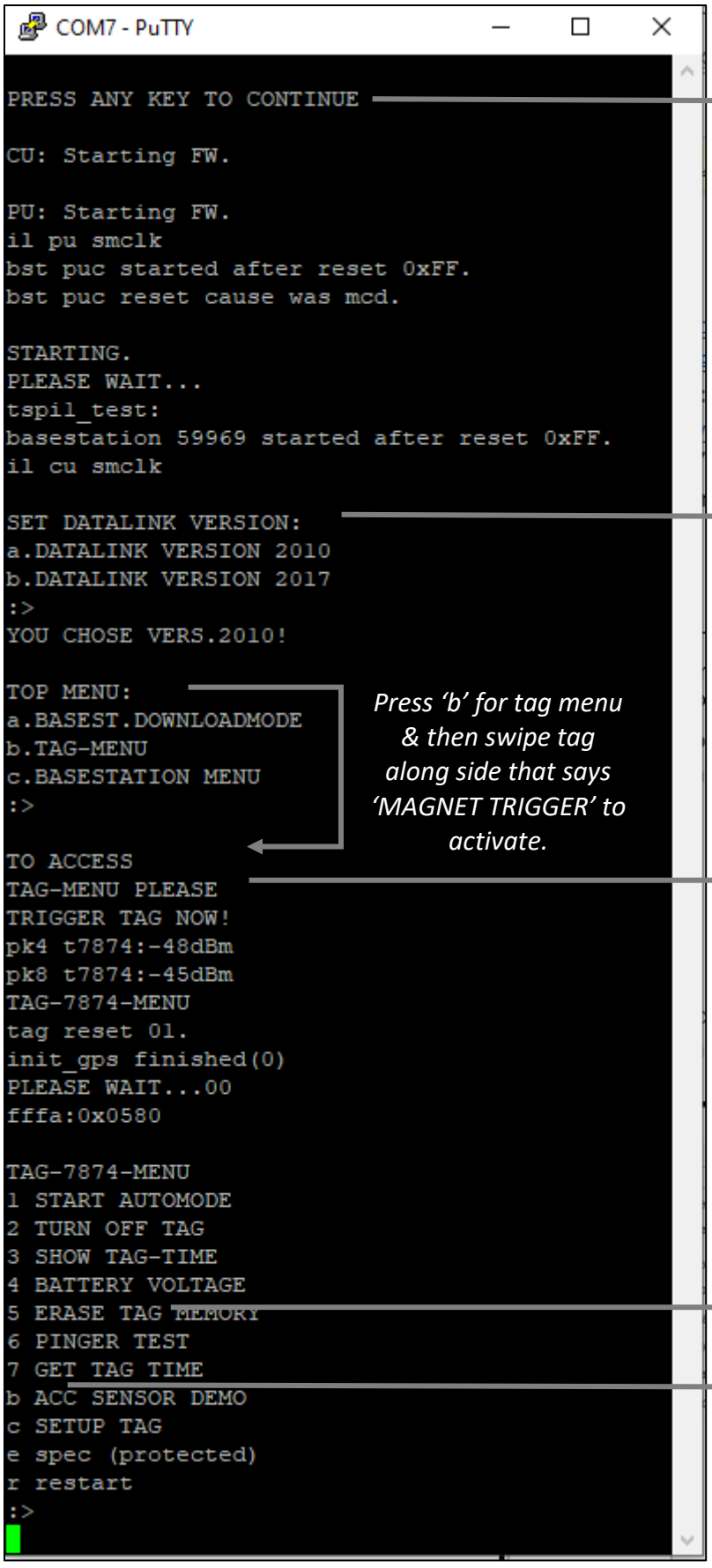
1) Download 'DATA DECODER' from: https://e-obs.de/service.html
2) Set up Movebank account at: https://www.movebank.org/cms/movebank-main
3) Download and install updated 'CP210x' VCP Drivers from: https://www.silabs.com/developers/usb-to-uart-bridge-vcp-drivers?tab=downloads
4) Download and install the HyperTerminal program 'PuTTY' from: https://putty.org/

HyperTerminal displays the BaseStation command window on your screen. It enables the researcher to program e-obs tags.

(B) Connect Base station to HyperTerminal (PuTTY)

i. Connect the inactive (turned off) BaseStation to the PC with USB
ii. Detect which Comport has been assigned. This can be found by opening 'Device Manager' and clicking on 'Ports (COM &LPT)'
iii. When opening a new connection in the PuTTY program, ensure correct COM port number is selected and then go to 'Serial', and ensure that the following parameters are tuned:
   - Bits per second: 115200
   - Data bits: 8
   - Stop bits: 1
   - Parity: None
   - Flow control: None
iv. Confirm settings by clicking the 'OPEN' button and to activate the connection (if screen remains blank please press the space bar)





e.g., Press space bar.

System 2010 vs. System 2017.
The system itself is not changed but signal strength and signal modulation had to be adjusted. Consequently, the 2017 system is a bit slower than the "old" variant with only 60% of its former data transmission speed. However, for old collars and BaseStations, (< 01.10.2016), such as that used here (collar ID 7874 ; BaseStation frequency ~860 MHz), one may need to select Version 2010. For most 'next gen' collars and BaseStations, the option should be DATALINK VERSION 2017 [and usually you are not even asked].

Press 'b' for tag menu & then swipe tag along side that says 'MAGNET TRIGGER' to activate.

If tag if successfully triggered, then the download speed is shown and the tag menu follows…

Press 'c' to SETUP TAG

Always press 'ENTER' after typing each requested parameter.

(C) Setting up the tag within the HyperTerminal program

i. When connected correctly to the HyperTerminal program, you should get the flowing options:

'Top menu:

- a. BASEST.DOWNLOADMODE
- b. TAG-MENU
- c. BASESTATION MENU'

ii. Press 'b.' and then it should say 'TRIGGER TAG NOW!'. Trigger the tag with a magnet. When communication between tag and BaseStation is achieved, the TAG-MENU of the given tag ID will appear as:

'TAG-XXXX-MENU

- 1 START AUTOMODE
- 2 TURN OFF TAG
- 3 SHOW TAG-TIME
- 4 BATTERY VOLTAGE
- 5 ERASE TAG MENU
- 6 PINGER TEST
- 7 GET TAG TIME
- b ACC SENSOR DEMO
- c SETUP TAG
- e spec (protected)
- r restart

iii. Press 'c Setup tag' to program the collar. Note, that depending on device generation, there may be slightly different options / layouts of the above menu, e.g., newer devices will have the option 'f DMP DEMO' and will not have '7 GET TAG TIME'. When it asks, 'SURE TO CHANGE SETUP (y/n)?' → Press 'y', for yes.

'OLD' devices → No IMU. Just 'old' acceleration sensor and GPS

SETUP:

a.EXIT & SAVE SETUP

a. After finalizing tag settings, press 'a' to exit and follow the instructions in HyperTerminal to decide whether to save the changes. (y = yes / n = no)

b.GPS ON FROM 00:00

c.GPS ON UNTIL 23:59

b. Set the start time (in UTC/GMT) for GPS activation.

c. Set the end time (in UTC/GMT) for GPS deactivation.

Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the GPS will remain off. If set to 00:00 and 23:59, respectively, the GPS will remain on (24 h per day).

d.GPS1HZ ON FROM 00:00

e.GPS1HZ ON UNTIL 00:00

d. Set the start time (in UTC/GMT) for 1Hz GPS activation.

e. Set the end time (in UTC/GMT) for 1Hz GPS deactivation.

This setting overrides the regular GPS time settings. For instance, if the times set in 'b-c' overlap with 'd-e', the 1Hz GPS setting will be prioritized.

Note: If both 'd' & 'e' are set to 00:00 (or any other matching times), the 1Hz GPS will remain off.

Some older device models may not support 1Hz GPS. If unavailable, the following options (f-l) will be shifted back by two letters.

f.PING ON FROM 17:00

g.PING ON UNTIL 01:00

f. Set the start time for the pinger activation (UTC/GMT).

g. Set the end time for pinger deactivation (UTC/GMT).

Note: If both 'f' & 'g' are set to 00:00 (or any other matching times), the pinger remains off. If set to 00:00 and 23:59, respectively, the pinger remains on. The pinger does not work during times when the GPS is searching for satellites, recording GPS data, or when the acceleration is recording. This means that the pinger will remain off during 1Hz GPS mode.

h.ACC INTERVAL:30s

h. Define the interval between acceleration bursts, given in seconds. Each burst refers to the time window when the accelerometer records data consecutively.

i.ACC BYTE COUNT:756

i. This parameter establishes the memory capacity for each acceleration burst. Paired with the sample rate, it dictates the burst's time window duration. Practically, onboard memory always utilizes multiples of 64 bytes, with some reserved for 'housekeeping'.

Your setting ACC BYTE COUNT in setup-menu:	Number of available acceleration data bytes	Number of acceleration samples for all ACC-axes together	Onboard memory used in number of bytes
0	0	0	0
1-63	54	36	64
64-126	117	78	128
127-189	180	120	192
190-252	243	162	256
253-315	306	204	320
316-378	369	246	384
379-441	432	288	448
442-504	495	330	512
505-567	558	372	576
568-630	621	414	640
631-693	684	456	704
694-65535 [Up to software version rv4_s1]	747	498	768
694-756 [≥ rv5]	747	498	768
757-819 [≥ rv5]	810	540	832
820-882 [≥ rv5]	873	582	896
883-945 [≥ rv5]	936	624	960
946-1008 [≥ rv5]	999	666	1024
1009-1071 [≥ rv5]	1062	708	1088
1072-1134 [≥ rv5]	1125	750	1152
1135-65535 [≥ rv5]	1188	792	1216

Burst Duration Calculation:

- Duration of one burst = (Available acceleration data bytes) ÷ (1.5 × sampling rate × number of recording axes).
- The sampling rate (in Hz) is derived from the ACC SR DIVISOR. Specifically: 100 ÷ ACC SR DIVISOR. For instance, if ACC SR DIVISOR equals 5, the resultant rate is 20 Hz, translating to 20 acceleration readings/second per recording axis.
- The recording axes can be set to 1, 2, or 3. A tri-axial orthogonal setup, offering three-dimensional measurement, typically requires the axis count to be 3.

Example:

If ACC BYTE COUNT is 756, ACC SR DIVISOR is 5, and the number of recording axes is 3, then the burst's sampling duration = 747 ÷ (1.5 × 20 × 3) = 8.3 seconds.

j.ACC SR DIVISOR:4

j. This value determines the accelerometer sampling rate (in Hz). For a clear understanding, refer to the previous section on burst duration calculation. As an illustration: if ACC SR DIVISOR is set to 4, the resultant rate will be 100 ÷ 4 = 25 Hz.

k.ACC ON FROM: 00:00

l.ACC ON UNTIL: 23:59

k. Specify the start time to activate the accelerometer (UTC/GMT).
l. Specify the end time to deactivate the accelerometer (UTC/GMT).
Note: If both 'k' & 'l' are set to 00:00 (or any other matching times), the accelerometer remains off. If 'k' & 'l' are set to 00:00 and 23:59 respectively, the accelerometer remains on.
1.ACC-AXES: XYZ
1. Define which axes (X, Y, Z) are to be utilized.
X-Axis: Measures LEFT-RIGHT acceleration [sway].
Y-Axis: Measures BACK-FORTH acceleration [surge].
Z-Axis: Measured UP-DOWN accelerations [heave] (orientations are always relative to the tag placement on the animal). If you require all three axes, simply retain the default settings.

2. ADVANCED SETUP 1:

a.EXIT
a. After finalizing settings in ADVANCED SETUP 1, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.ACC LOW SPEED INTERVAL FACTOR:1
b. A factor to extend the ACC INTERVAL when the animal's movement is slow, useful for conserving memory when resting behavior isn't a priority.
The speed threshold is set via "GPS LOW SPEED THRESHOLD" and gauged during a GPS BURST. Default is 1 (no extension). If set to 2, the interval between acceleration bursts is doubled, and so forth.
c.GPS DAY DIVISOR:1
c. Determines how often the GPS records in terms of ‘day skipping’. For example, a divisor of 2 means the GPS activates every second day. Default is 1, implying daily GPS activity.
d.GPS HOURSHIFT:0
d. In combination with the GPS DAY DIVISOR, this allows for a temporal shift in the GPS recording window (e.g., option for hour-, as well as day skipping). Details are not present in the manual. Default is 0, meaning this feature is off.
e.GPS RETRY INTERVAL FACTOR:1
e. Lengthens the GPS interval after an unsuccessful GPS fix attempt. For example, with an interval of 5 minutes and a GPS RETRY INTERVAL FACTOR of 4, the device will wait 20 minutes before the next attempt if the initial fix fails. If the retry is successful, the interval resets to 5 minutes. However, if the retry also fails, the interval remains at 20 minutes. A default value of 1 indicates that this feature is turned off, effectively keeping the attempt interval constant regardless of success or failure. Activating this feature (setting it to a value greater than 1) can conserve energy but will also cancel the set BURST LENGTH immediately following the first unsuccessful fix.
f.GPS LOW SPEED THRESHOLD:50 cm/s
f. GPS operations halt if the calculated speed during a GPS burst (given BURST LENGTH ≥ 3) falls below the threshold, measured in cm/s. The speed from the last GPS fix, in tandem with acceleration variance settings, determines the GPS resolution modes (GPS HIGH RES INTERVAL or LOW RES INTERVAL settings). The default threshold is 50 cm/s. Setting this to zero does not disable this feature but ensures that there will be no switching from GPS HIGH RES INTERVAL to LOW RES INTERVAL settings, regardless of the acceleration variance setting. Refer to the decision algorithm flowchart for clarity.
g.GPS TIMEOUT:150s
g. Duration, given in seconds, that the GPS remains active searching for satellites for a fix. If unsuccessful and the GPS RETRY INTERVAL FACTOR is set above 1, the time before the next attempt will be extended.
h.BURST LENGTH:1s
h. Duration, given in seconds, of each GPS burst, indicating consecutive fixes (1 Hz) post the initial fix after an interval. For example, if the BURST LENGTH is set to 6, the GPS will try to secure 6 consecutive fixes over 6 seconds for every GPS interval. This is specific to HIGH RES GPS sampling; for GPS collected in LOW RES mode, the burst length defaults to one.

i.BURST QPERIOD:1s

i. For 1 Hz GPS recordings, this parameter controls the storage frequency. Default is 1, storing every fix. A setting of 2 means every second fix is stored, and so on.

j.DELAYED TAG START DAY No.:0

j. This setting allows the tag to remain inactive for a specified number of days after being placed on the animal.

Input day number (with Day zero being Sunday, March 4, 2007), followed by hour and minute. Please be aware of potential energy losses due to internal capacity decline, estimated at roughly 10% annually.

k.PINGER INTERVAL:1s

k. This specifies the pinger's pulse rate. Options include 1s (default) or 2s intervals for onsite triangulation. Using 2s intervals is not possible between 868.0 and 868.6 MHz.

l.SECRET KEY (Don't change!):13474

m.ACCESS KEY (Don't change!):12

1.ACC INVERSE LOW SPEED INTERVAL FACTOR: NO

1. When activated (set to YES), the ACC INTERVAL extending factor, governed by the ACC LOW SPEED INTERVAL setting, works in reverse. This means the interval between acceleration bursts lengthens with fast movement (exceeding the GPS LOW SPEED THRESHOLD) rather than with slow movements (below the GPS LOW SPEED THRESHOLD).

2.PING FREQ:869525 kHz

2. Denotes the frequency of the pinger's signal, formatted as XXX.XXX. If deploying multiple tags in a similar region simultaneously, ensure their frequencies differ by a minimum of 10 kHz, ideally 30 kHz or more. It's essential to understand that these frequencies might require fine-tuning. It's advisable to adjust the exact frequency for the clearest ping in your receiver before deployment.

3. ADVANCED SETUP 2:

a.EXIT

a. When you have finished with all settings in ADVANCED SETUP 2, press a. to exit. You do not need to save settings, only when you exit the main SETUP menu, does sit request whether you would like to save all setting changes.

b.GPS HIGH RES INTERVAL:240s

c.GPS LOW RES INTERVAL:240s

b. Dictates the high-resolution GPS recording rate (interval between fix acquisition attempts), which kicks in when the internally calculated speed is greater than the GPS LOW SPEED THRESHOLD.

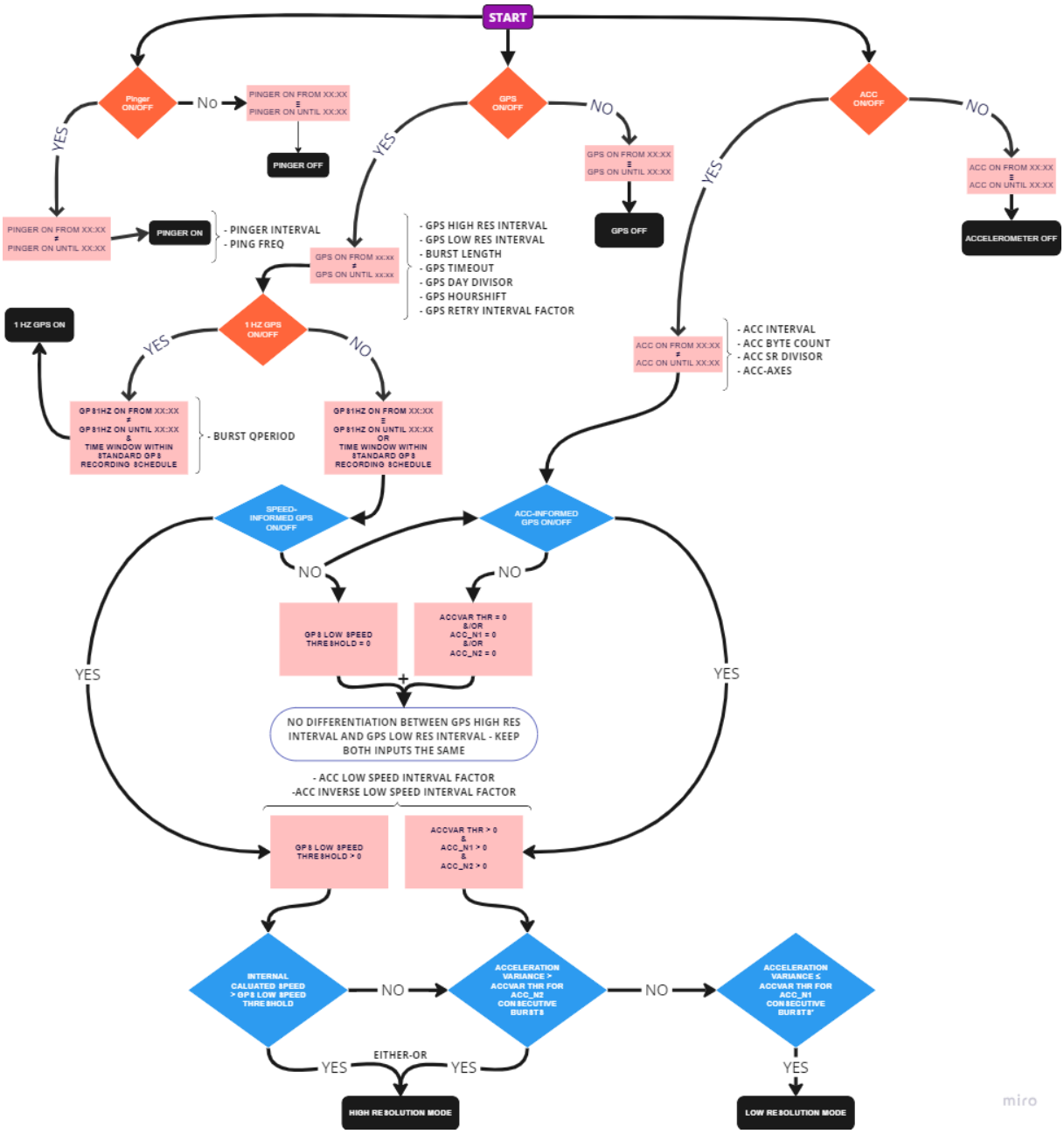
c. Determines the low-resolution GPS recording rate, which is used when the internally computed speed is less than or equal to the GPS LOW SPEED THRESHOLD. Input values in seconds; for instance, 240 signifies a 4-minute interval between GPS fix attempts. Keep in mind that acceleration-informed GPS also helps decide when to switch between HIGH and LOW RES INTERVALS. Refer to the decision algorithm flowchart for clarity.

d.ACCVAR THR:1000

d. This setting controls acceleration-informed GPS. Similar to the GPS LOW SPEED THRESHOLD, it decides which GPS interval (HIGH or LOW RES) is activated. The system calculates the variance of a designated acceleration channel (by default the Z-axis), and if the threshold is surpassed for a specific number of consecutive acceleration bursts (defined by ACC_N2), the GPS switches from LOW to HIGH RES INTERVAL. Conversely, if the variance is under or equal to the threshold for a set number of consecutive bursts (defined by ACC_N1), the GPS switches from HIGH to LOW RES INTERVAL. To disable this feature, set the value to 0. Refer to the decision algorithm flowchart for clarity. When employing ACCVAR THR, ensure the ACC INTERVAL duration is less than the GPS interval. It's crucial to note: if both the GPS speed and acceleration-informed GPS are active, both must meet or fall below their respective thresholds for the GPS to switch to the LOW RES INTERVAL. The preset is 1000, which is unitless and should be determined by users during trial phases.

e.ACC_N1:5
f.ACC_N2:2
e. Details the number of consecutive acceleration bursts required for the variance to be less than or equal to ACCVAR THR to switch to the GPS LOW RES INTERVAL. The default is set to five acceleration bursts.
f. Details the number of consecutive acceleration bursts necessary for the variance to exceed ACCVAR THR to switch to the GPS HIGH RES INTERVAL. The default is set to two acceleration bursts.
1.AXIS FOR VAR:Z
1. Identifies the acceleration axis utilized for determining the variance in ACCVAR THR. The heave (or up-down motion) axis typically offers the most insight regarding movement or its absence.

DECISION ALGORTHM FLOWCHART



Mode Switching Criteria

Switching to High Resolution Mode occurs under any one of the following conditions:

- The device switches to HIGH RESOLUTION MODE when acceleration variance surpasses the ACCVAR THR threshold for ACC_N2 consecutive acceleration bursts.
- The mode also switches if the speed, calculated from the last GPS fix, exceeds the GPS LOW SPEED THRESHOLD.

A transition to High Resolution Mode requires just one of these conditions to be met.

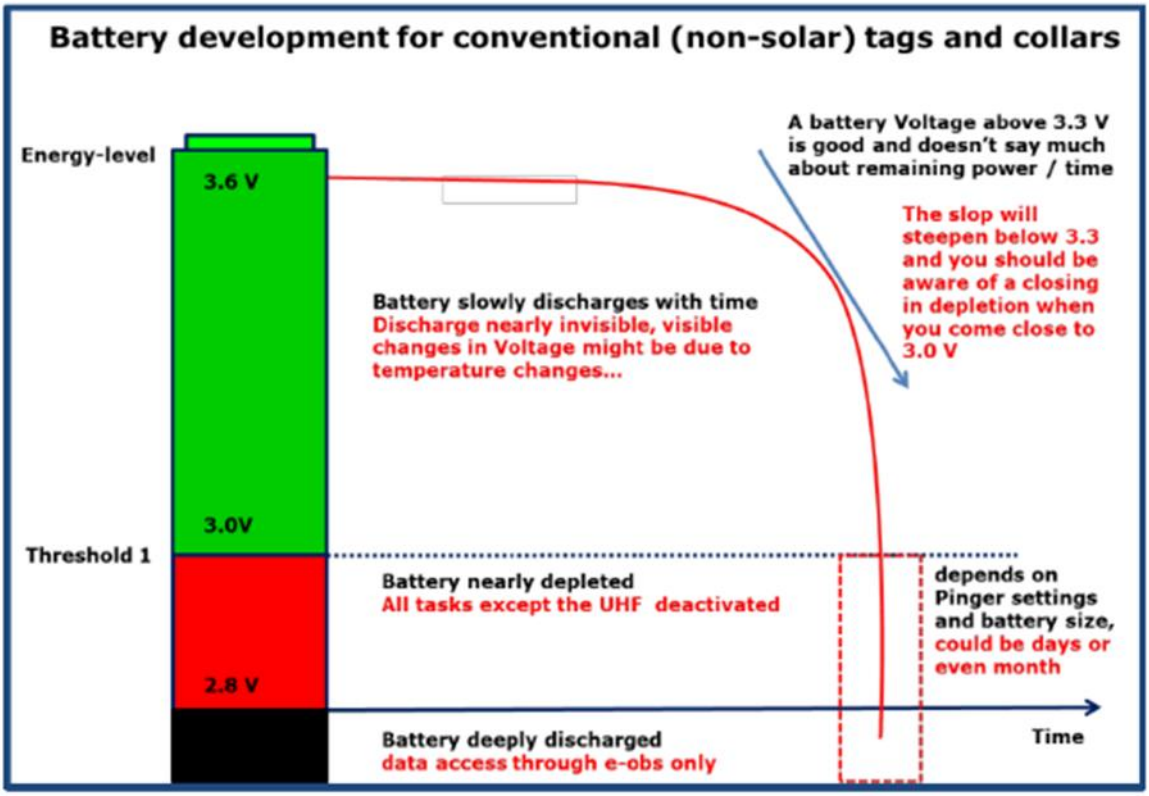
Switching to Low Resolution Mode requires both of the following conditions to be satisfied:

- Acceleration variance must be below or equal to the ACCVAR THR threshold for ACC_N1 consecutive acceleration bursts.
- The speed, determined by the last GPS fix, must be less than or equal to the GPS LOW SPEED THRESHOLD.

The GPS will switch to LOW RES INTERVAL only if both criteria are met or fall below their respective thresholds.

Resolution Mode Implications

- **In HIGH RESOLUTION MODE:** The logger utilizes the GPS HIGH RES INTERVAL for GPS data collection.
- **In LOW RESOLUTION MODE:** The logger adheres to the GPS LOW RES INTERVAL for GPS data collection.
- **GPS Burst Termination:** The GPS burst is prematurely terminated if the calculated speed drops below the GPS LOW SPEED THRESHOLD), and/or if the GPS RETRY INTERVAL FACTOR is activated due to a failed fix attempt.



'NEW' devices → WITH IMU (ID's ≥ 60167, since end of 2022)

SETUP:

a.EXIT & SAVE SETUP

a. After finalizing tag settings, press 'a' to exit and follow the instructions in HyperTerminal to decide whether to save the changes. (y = yes / n = no)

b.ACC ON FROM: 00:00

c.ACC ON UNTIL: 23:59

b. Specify the start time to activate the accelerometer (UTC/GMT).

c. Specify the end time to deactivate the accelerometer (UTC/GMT).

Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the accelerometer remains off. If 'b' & 'c' are set to 00:00 and 23:59 respectively, the accelerometer remains on.

d.IMU ON FROM: 00:00

e.IMU ON UNTIL: 00:00

d. Specify the start time to activate the IMU (UTC/GMT).

e. Specify the end time to deactivate the IMU (UTC/GMT).

Note: If both 'd' & 'e' are set to 00:00 (or any other matching times), the IMU remains off. If 'd' & 'e' are set to 00:00 and 23:59 respectively, the IMU remains on.

f.ACC LRES INTERVAL: 600 s

f. Dictates the low-resolution acceleration recording rate (interval between acceleration bursts). Input values in seconds; for instance, 600 (default value) signifies a 10-minute interval between acceleration bursts.

g.IMU LRES INTERVAL: 0s

g. Dictates the low-resolution IMU recording rate (interval between IMU bursts). Input values in seconds. A 0-second setting (default) deactivates this feature resulting in no IMU data collection during low-resolution mode.

h.ACC HRES INTERVAL: 600s

h. Dictates the high-resolution acceleration recording rate (interval between acceleration bursts). Input values in seconds; for instance, 600 (default value) signifies a 10-minute interval between acceleration bursts. Note, if both the ACC LRES INTERVAL and ACC HRES INTERVAL are the same value, then the recording schedules between these modes do not differ.

i.IMU HRES INTERVAL:0s

i. Dictates the high-resolution IMU recording rate (interval between IMU bursts). Input values in seconds. A 0-second setting (default) deactivates this feature resulting in no IMU data collection during high-resolution mode. Note, if both the IMU LRES INTERVAL and IMU HRES INTERVAL are the same value, then the recording schedules between these modes do not differ.

j.ACC GF LRES INTERVAL: 600s

j. Dictates the low-resolution acceleration recording rate (interval between acceleration bursts) when within the set **GeoFence** parameters (set rectangular area and time-window activated). Input values in seconds; for instance, using 600 seconds (default) translates to a 10-minute interval between acceleration bursts.

k.IMU GF LRES INTERVAL: 0s

k. Dictates the low-resolution IMU recording rate (interval between IMU bursts) when the animal is within the set **GeoFence** parameters. A 0-second setting (default) deactivates this feature resulting in no IMU data collection during low-resolution mode within the set **GeoFence** area and time-window.

l.ACC GF HRES INTERVAL: 600s

l. Dictates the high-resolution acceleration recording rate (interval between acceleration bursts) when within the set **GeoFence** parameters. Input values in seconds; for instance, using 600 seconds (default) translates to a 10-minute interval between acceleration bursts. Note, if both the ACC GF LRES INTERVAL and ACC GF HRES INTERVAL are the same value, then the recording schedules between these modes do not differ within the set **GeoFence** area and time-window.

m.IMU GF HRES INTERVAL: 0s

m. Dictates the high-resolution IMU recording rate (interval between IMU bursts) when the animal is within the set **GeoFence** area and time-window. A 0-second setting (default) deactivates this feature resulting in no IMU data collection during high resolution mode within the set **GeoFence** area and time-window. Note, if both the IMU GF LRES INTERVAL and IMU GF HRES INTERVAL are the same value, then the recording schedules between these modes do not differ within the set GeoFence area and time-window.

n.ACC SR DIVISOR: 10

n. This factor derives the sampling rate in Hz, calculated as 100 ÷ ACC SR DIVISOR. For instance, if ACC SR DIVISOR equals 10 (default value), the resultant rate is 10 Hz, translating to 10 acceleration readings/second per recording axis.

o.ACC BYTE COUNT: 190

o. This parameter establishes the memory capacity for each acceleration burst. Paired with the sample rate, it dictates the burst's time window duration. Practically, onboard memory always utilizes multiples of 64 bytes, with some reserved for 'housekeeping'. See the above table within the 'OLD' devices' settings section for further clarification.

Burst Duration Calculation:

- Duration of one burst = (Available acceleration data bytes) ÷ (1.5 × sampling rate × number of recording axes).
- The sampling rate (in Hz) is derived from the ACC SR DIVISOR:100 ÷ ACC SR DIVISOR.
- The recording axes can be set to 1, 2, or 3. A tri-axial orthogonal setup, offering three-dimensional measurement, typically requires the axis count to be 3.

Example:

If ACC BYTE COUNT is 190 (default value), ACC SR DIVISOR is 10 (default value), and the number of recording axes is 3 (default value), then the burst's sampling duration = 243 ÷ (1.5 × 10 × 3) = 5.4 seconds.

p.ACC LOW SPEED INTERVAL FACTOR: 1

p. A factor to extend the ACC INTERVAL when the animal's movement is slow, useful for conserving memory when resting behavior isn't a priority.

The speed threshold is set via "SPEED THRESHOLD1" and gauged during a GPS BURST. Default is 1 (no extension). If set to 2, the interval between acceleration bursts is doubled, and so forth.

q.IMU START DELAY: 40

q. The IMU system requires a brief warm-up period post-activation before producing accurate data. The "IMU START DELAY" determines the initial period during which the IMU data are presumed to be unreliable and are thus discarded. By default, a 40-event delay equates to ignoring the initial 2 seconds of data, given the IMU's 20 Hz recording rate.

r.IMU ACC CNT: 10

r. This setting is applied when you use the IMU with 20Hz sample rate in standalone mode without parallel GPS. It defines the number of IMU acceleration datasets to be recorded in a single IMU burst. Each dataset comprises 24*3 ACC samples, equivalent to 1.2 seconds or 128 Bytes of data. With a default setting of 10, this results in recording 12 seconds or 1280 bytes of data. Refer to the provided table for further detail. To avoid recording stand-alone IMU acceleration, set this value to zero. Doing so won't affect the 'IMU Switches' settings if they are activated. Note that stand-alone IMU and IMU in parallel with GPS (set within 'IMU Switches') function independently, provided that the desired IMU data acquisition period falls within the specified IMU ON FROM/UNTIL parameters.

s.IMU Q&C CNT: 20

s. When operating the IMU in standalone mode at a 20Hz sampling rate without parallel GPS, this setting determines the number of quaternion & compass datasets to be captured within one IMU burst. Each dataset contains 10 samples, which corresponds to 0.5 seconds or 128 Bytes of data. The default setting is 20, translating to 10 seconds or 2560 bytes of data. Refer to the provided table for further detail. To avoid recording quaternion & compass, set this value to zero. Doing so won't affect the 'IMU Switches' settings if they are activated. Note that stand-alone IMU and IMU in parallel with

GPS (set within 'IMU Switches') function independently, provided that the desired IMU data acquisition period falls within the specified IMU ON FROM/UNTIL parameters.

One IMU ACC dataset consists of 24*3 samples, needs 128 Bytes and is filled in 24/20=1.2 seconds.

IMU ACC DATASET COUNT from setup menu	sampling duration for IMU ACC/seconds	Memory consumption for the whole burst/Bytes
0	0	0
1	1.2	128
2	2.4	256
3	3.6	384
4	4.8	512
5	6	640
10	12	1280
15	18	1920
20	24	2560
25	30	3200
30	36	3840
35	42	4480
40	48	5120
45	54	5760
50	60	6400
55	66	7040
60	72	7680
65	78	8320
70	84	8960
75	90	9600
80	96	10240

One IMU QUAT & COMP dataset consists of 10*(3+3) samples, needs 128 Bytes and is filled in 10/20=0.5 seconds.

IMU ACC DATASET COUNT from setup menu	sampling duration for IMU ACC/seconds	Memory consumption for the whole burst/Bytes
0	0	0
2	1	256
4	2	512
6	3	768
8	4	1024
10	5	1280
12	6	1536
24	12	3072
36	18	4608
48	24	6144
60	30	7680
72	36	9216
84	42	10752
96	48	12288
108	54	13824
120	60	15360
132	66	16896
144	72	18432
156	78	19968
168	84	21504
180	90	23040

1.ACC-AXES: XYZ

1. Define which axes (X, Y, Z) are to be utilized.
X-Axis: Measures LEFT-RIGHT acceleration [sway].
Y-Axis: Measures BACK-FORTH acceleration [surge].
Z-Axis: Measured UP-DOWN accelerations [heave] (orientations are always relative to the tag placement on the animal). If you require all three axes, simply retain the default settings. Note that if this setting is left blank, no acceleration will be recorded, and the GPS-informed acceleration variance settings will also be disabled.

2.ACC INVERSE LOW SPEED INTERVAL FACTOR: NO

2. When activated (set to YES), the ACC INTERVAL extending factor, governed by the ACC LOW SPEED INTERVAL setting, works in reverse. This means the interval between acceleration bursts lengthens with fast movement (exceeding the GPS SPEED THRESHOLD1) rather than with slow movements (below the GPS SPEED THRESHOLD1).

3.GPS SETUP
3. Navigate to this section for GPS recording-related settings.
4. SEL REC SETUP
4. to adjust settings pertinent to selective recording, toggling between high- and low-resolution for ACC, IMU, and GPS mode.
5. COM SETUP
5. Navigate to this section for settings relevant for communication parameters, including UHF pinger timings.

3.GPS SETUP
a.EXIT
a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.GPS ON FROM: 00:00
c.GPS ON UNTIL: 23:59
b. Set the start time (in UTC/GMT) for GPS activation.
c. Set the end time (in UTC/GMT) for GPS deactivation.
Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the GPS will remain off. If set to 00:00 and 23:59, respectively, the GPS will remain on (24 h per day).
d.GPS LRES INTERVAL: 14400s
e.GPS HRES INTERVAL: 300s
d. Dictates the low-resolution GPS recording rate (interval between fix acquisition attempts), activating when the internally assessed speed exceeds SPEED THRESHOLD1.
e. Determines the high-resolution GPS recording rate, which is used when the internally computed speed is at or below SPEED THRESHOLD1. If SPEED THRESHOLD1 is deactivated (set to 0), then ideally, both d. and e should share the same values. Values are in seconds; for instance, 14400 translates to a 4-hour interval between GPS fix attempts. The decision to switch between HIGH and LOW RES INTERVALS can also hinge on acceleration-informed GPS. Refer to the decision algorithm flowchart for clarity.
f.GPS HRES BURSTLEN: 1s
f. Specifies the length of each GPS burst in seconds, reflecting consecutive fixes (1 Hz) after the designated GPS HRES INTERVAL. For instance, a value of 6 for GPS HRES BURSTLEN means the GPS aims for 6 consecutive fixes within 6 seconds during each GPS HRES INTERVAL. Default value is 1 s. Note, by default, in LOW RES mode, GPS burst lengths are always 1 (though see ‘ai ign lres’).
g.GPS GF LRES INTERVAL: 14400s
h.GPS GF HRES INTERVAL: 300s
g. Dictates the low-resolution GPS recording rate (interval between fix acquisition attempts), when the animal is within the set **GeoFence** area and time-window, activating when the internally calculated speed surpasses SPEED THRESHOLD1.
h. Determines the high-resolution GPS recording rate (interval between fix acquisition attempts), relevant when the internally measured speed remains at or below SPEED THRESHOLD1. Values are in seconds; for instance, 14400 translates to a 4-hour interval between GPS fix attempts. Keep in mind that acceleration-informed GPS can influence the choice between GF HIGH and GF LOW RES INTERVALS. See the decision algorithm flowchart for further details.
i.GPS GF HRES BURSTLEN: 1s
i. Specifies the length of each GPS burst in seconds, reflecting consecutive fixes (1 Hz) after the designated GPS GF HRES INTERVAL, when within the designated **GeoFence** area and time window. For example, a value of 6 for GPS GF HRES BURSTLEN indicates an aim for 6 continuous fixes across 6 seconds for every GPS GF HRES INTERVAL. Default value is 1 s. Note, by default, in LOW RES mode, GPS burst lengths are always 1 (though see ‘ai ign lres’).
j.QPERIOD: 1s
j. Governs the storage frequency for 1 Hz GPS recordings. By default, every fix is stored. A value of 2 denotes storage of every alternate fix, and so on. Increasing the value will correspondingly reduce the

frequency of GPS data storage and thus memory consumption. Note, this does not impact the storage of IMU data being concurrently recorded within the GPS data storage structure.

k.GPS RETRY INTERVAL FACTOR: 1
k. Lengthens the GPS interval after an unsuccessful GPS fix attempt. For example, with an interval of 5 minutes and a GPS RETRY INTERVAL FACTOR of 4, the device will wait 20 minutes before the next attempt if the initial fix fails. If the retry is successful, the interval resets to 5 minutes. However, if the retry also fails, the interval remains at 20 minutes. A default value of 1 indicates that this feature is turned off, effectively keeping the attempt interval constant regardless of success or failure. Activating this feature (setting it to a value greater than 1) can conserve energy but will also cancel the set GPS HRES BURSTLEN/GF HRES BURSTLEN immediately following the first unsuccessful fix.
l.SPEED THRESHOLD1: 100 cm/s
m.SPEED THRESHOLD2: 100 cm/s
n.SPEED THRESHOLD3: 100 cm/s
l. SPEED THRESHOLD1 is evaluated after a GPS burst to switch between LOW and HIGH resolution modes.
m. SPEED THRESHOLD2 is assessed during a "Normal Mode" GPS burst to decide if the GPS burst should be terminated prematurely.
n. SPEED THRESHOLD3 is checked during a “SUPER MODE” GPS burst to decide on termination. However, note that “SUPER MODE” is not available for these devices (it's pertinent to solar panel devices), rendering this setting irrelevant.
1.IMU SWITCHES
1. These settings determine whether IMU data (IMU ACC and/or IMU QUAT&COMP) is concurrently sampled alongside GPS data, and whether this sampling occurs at a frequency of 1 Hz or 20 Hz. This setting applies to data collection both within and outside geofenced areas, as well as during the GPS 1Hz mode operation. It specifies how the IMU data (independent of ‘IMU standalone mode’ is integrated into the GPS data storage structure.

[Secret Key: ?uopj3] ← Type this secret key within the **‘3.GPS SETUP’** section to access the options listed below:

For Experts
a.Exit
a. After finalizing settings in the ‘For Experts’ section, press 'a' to exit. This will return to the ‘3.GPS SETUP’ section. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.GPS1Hz ON FROM: 00:00
c.GPS1Hz ON UNTIL: 00:00
b. Set the start time (in UTC/GMT) for 1Hz GPS activation.
c. Set the end time (in UTC/GMT) for 1Hz GPS deactivation.
This setting overrides the regular GPS time settings. Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the 1Hz GPS will remain off. Additionally, the 1Hz GPS mode only activates if the animal is within the set GeoFence and the GeoFence is active (see details later).
d.GPS TIMEOUT: 150s
d. Specifies the time (in seconds) that the GPS remains active searching for satellites for a fix. If unsuccessful and the GPS RETRY INTERVAL FACTOR is set above 1, the time before the next attempt will be extended.
e.radio long delay: 900s
e. Defines the time (in seconds) after a successful data download with the BaseStation during which the tag will not attempt to establish a a new connection
f.bat_threshold2 code: 2458
g.bat_threshold1 code: 2458
h.bat_threshold0 code: 2826

These codes determine the battery levels under which specific functionalities, like GPS & ACC, are turned off. The UHF RadioLink and Pinger will remain operational as long as there's battery. IMPORTANT: Do not modify these settings. These codes do not directly represent battery voltage.
i.maccess voltcode: 2294
i. Lowest possible energy level to sustain basic tag functionality (e.g., memory function). Do not modify this setting.
2.prefer high res: YES
If the variance measure for selective recording is deactivated (VAR INTERVAL: 0) and GPS recording is on (still optionally affected by the GPS-Speed settings), this option ensures continuous High-Resolution acceleration recording when set to 'YES' and Low-Resolution acceleration when set to 'NO'. Note, “3.keep low res” has a higher priority.
3.keep low res: NO
If the variance measure for selective recording is deactivated (VAR INTERVAL: 0) and GPS recording is on (still optionally affected by the GPS-Speed settings), this option ensures that the system always opts for High-Resolution acceleration recording when set to ‘NO’. Note, “3.keep low res” overrules the “2.prefer high res: YES” setting.
4.ai ign lres: NO
4. If enabled (set to YES), the GPS GF HRES BURSTLEN setting will determine the burst length in GPS GF LRES sampling mode, overriding the default burst length of one.
LCFG: a
This is an internal configuration. Do not change.
BAND MHz:c:916
This is an internal configuration. Do not change.

3.GPS SETUP
1.IMU Switches
a.Exit
a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.no GF 1Hz Q&C: NO
b. This setting allows you to toggle the recording of 1Hz Q&C IMU data (Quaternion & Compass) in parallel with the GPS bursts, thus optimizing memory usage by utilizing the GPS data storage structure. This setting comes into play when the device is OUTSIDE the **GeoFence** boundaries or the GeoFence function is turned off. By default, it's set to NO, signifying the absence of 1Hz Q&C during GPS fixes. Note, if this option is enabled, and the GPS burst duration is set to 10 seconds with an IMU START DELAY of 40 (equivalent to 2 seconds), the Q&C data for the initial two fixes in each GPS burst will be omitted. Therefore, only 8 seconds of IMU data would be available for each full burst. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0.
c.no GF 20Hz Q&C: NO
c. This setting allows you to toggle the recording of 20Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is OUTSIDE the **GeoFence** boundaries or the GeoFence function is turned off. By default, it's set to NO, signifying the absence of 20Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0
d.no GF 20Hz ACC & 1Hz Q&C: NO
d. This setting allows you to toggle the recording of 20Hz ACC & 1Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is OUTSIDE the **GeoFence** boundaries or the GeoFence function is turned off. By default, it's set to NO, signifying the absence of 20Hz ACC & 1Hz

Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0.

e.in GF 1Hz Q&C: NO

e. This setting allows you to toggle the recording of 1Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is INSIDE the **GeoFence** boundaries and time window. By default, it's set to NO, signifying the absence of 1Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0

f.in GF 20Hz Q&C: NO

f. This setting allows you to toggle the recording of 20Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is INSIDE the **GeoFence** boundaries and time window. By default, it's set to NO, signifying the absence of 20Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0

g.in GF 20Hz ACC & 1Hz Q&C: NO

g. This setting allows you to toggle the recording of 20Hz ACC & 1Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is INSIDE the GeoFence boundaries and time window. By default, it's set to NO, signifying the absence of 20Hz ACC & 1Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0

h.GPS1Hz 1Hz Q&C: NO

h. Option to activate the 1Hz Q&C IMU recordings when GPS1Hz mode is active. The default setting is NO, which means 1Hz Q&C will not record when GPS1Hz mode is active.

i.GPS1Hz 20Hz Q&C: NO

i. Option to activate the 20 Hz Q&C IMU recordings when GPS1Hz mode is active. The default setting is NO, which means 20Hz Q&C will not record when GPS1Hz mode is active.

j.GPS1Hz 20Hz ACC & 1Hz Q&C: NO

j. Option to activate the 20Hz ACC & 1Hz Q&C IMU recordings when GPS1Hz mode is active. The default setting is NO, which means 20Hz ACC & 1Hz Q&C will not record when GPS1Hz mode is active.

SETUP:

4. SELREC SETUP

a.EXIT

a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.

b.VAR INTERVAL: 60s

b. Defines the interval for ACC VAR calculations to determine if the animal is active or inactive. This is independent from (and can vary from) the ACC LRES INTERVAL and ACC HRES INTERVAL parameters.

c.ACCVAR SR DIVISOR: 5s

c. Defines (together with ACCVAR BYTE COUNT) the length of the acceleration variance measurement (burst). Typical configurations include: 5 for 20 Hz and 10 for 10 Hz. The frequency (Hz) is computed similarly to the ACC SR DIVISOR setting, as 100 ÷ ACCVAR SR DIVISOR.

d.ACCVAR BYTE COUNT: 30

d. Defines (together with ACCVAR SR DIVISOR) the variance measurement (burst) length. See the above table within the 'OLD' devices' settings section for further clarification.

Acceleration Variance Burst Duration Calculation:

- Duration of one burst = (Available acceleration data bytes) ÷ (1.5 × sampling rate × number of recording axes).

NOTE: IF ACC VARIANCE AND ACC ARE RECORDED SYNCHRONOUSLY, HARDLY ANY ADDITIONAL ENERGY IS REQUIRED (ONLY FOR CALCULATING THE VARIANCE FROM THE RAW DATA). THEREFORE, THIS IS RECOMMENDED. HOWEVER, THE AXIS CONSIDERED FOR THE ACC VARIANCE (NORMALLY Z) MUST BE INCLUDED IN THE "REGULAR" ACC AXES (DEFAULT XYZ). ADDITIONALLY, THE SAMPLE RATE MUST BE THE SAME, AND THE ACC BURST MUST BE AT LEAST AS LONG AS THE ACC VARIANCE BURST.

e. ACCVAR THR: 2500

e. This setting controls acceleration-informed GPS. It sets the threshold for the acceleration variance to trigger which GPS interval (Low or High Res) to use. The system calculates the variance of a designated acceleration channel (by default the Z-axis), and if the threshold is surpassed for a specific number of consecutive acceleration bursts (defined by ACC_N2), the GPS switches from LOW to HIGH RES INTERVAL. Conversely, if the variance is under or equal to the threshold for a set number of consecutive bursts (defined by ACC_N1), the GPS switches from HIGH to LOW RES INTERVAL. To disable this feature, set the value to 0. Refer to the decision algorithm flowchart for clarity. When employing ACCVAR THR, ensure the VAR INTERVAL duration is less than the GPS interval. It's crucial to note: if both the GPS speed and acceleration-informed GPS are active (AND the tilt angle – see later for relevance), both must be below or equal to their respective thresholds for the GPS to revert to the LOW RES INTERVAL. It's recommended to input a five-digit value. The preset is 2500, which is unitless and should be determined by users during trial phases.

f.ACC_N2:2

g.ACC_N1:5

f. Details the number of consecutive acceleration bursts required for the variance to be less than or equal to ACCVAR THR to switch to the GPS LOW RES INTERVAL. The default is set to two acceleration bursts.

g. Details the number of consecutive acceleration bursts necessary for the variance to exceed ACCVAR THR to switch to the GPS HIGH RES INTERVAL. The default is set to five acceleration bursts.

h.SPEED_N1: 3

Defines the number of consecutive speed measurements (taken with each GPS Fix burst) that must be either equal to or below, or above the established threshold in order to transition from High to Low Resolution and *vice versa*. The default is set to three consecutive speed measurements.

i.VAR_AXIS: Z

i. Identifies the acceleration axis utilized for determining the variance in ACCVAR THR. The heave (or up-down motion) axis typically offers the most insight regarding movement or its absence.

j.TILT_AXIS2: Y

j. The axis used to measure the tilting of the logger as a trigger feature for ACC informed GPS (used in conjunction with the ACCVAR THR. Most often used the Y-axis (back/forth, or 'surge' dimension of movement since the inclination/declination of this axis determines pitch angle). Note, that if tilt angle is used, then the logger tilt angle must be within this threshold, in addition with the ACCVAR THR and GPS SPEED THRESHOLD1 (if these are also activated) for the GPS to switch to the GPS LOW RES INTERVAL.

k.BRST-LOWSPD-FCNT:5s

k. The number of consecutive GPS fixes during HIGH RES mode with speed counts below the set GPS SPEED THRESHOLD1, needed to mark the animal as NOT MOVING as a trigger for switching from ACC HIGH RES to ACC LOW RES

l.ACCYF: 0

l. In combination with ACCZF, this specifies the 'Tilt limit angle'. See the below table for clarification. Note, this feature is predominantly useful for birds where activity (flying) is typically reflected by a smaller tilt angle (device oriented 'more' horizontally) and resting (perched) is typically reflected by a greater device inclination (tilted backwards). This is typically an irrelevant feature and so should not change.

m.ACCZF: 0

m. In combination with ACCYF, this specifies the 'Tilt limit angle'. See the below table for clarification. Note, this feature is predominantly useful for birds where activity (flying) is typically reflected by a smaller tilt angle and resting (perched) is typically reflected by a greater device inclination. This is typically an irrelevant feature and so should not change.

Tilt limit angle α	ACCYF	ACCZF
0	0	10
5	-1	10
10	-2	10
15	-3	10
20	-4	10
25	-5	10
30	-5	9
35	-6	9
40	-7	8
45	-7	7
50	-8	7
55	-9	6
60	-9	5
65	-10	5
70	-10	4
75	-10	3
80	-10	2
85	-10	1
90	-10	0

n.GPS DAY DIVISOR: 1

n. Determines how often the GPS records in terms of 'day skipping'. For example, a divisor of 2 means the GPS activates every second day. Default is 1, implying daily GPS activity.

o.GPS HOURSHIFT:0

o. In combination with the GPS DAY DIVISOR, this allows for a temporal shift in the GPS recording window (e.g., option for hour-, as well as day skipping). Details are not present in the manual. Default is 0, meaning this feature is off.

p.DELAYED TAG START DAY NO.: 0

p. This setting allows the tag to remain inactive for a specified number of days after being placed on the animal.

Input day number (with Day zero being Sunday, March 4, 2007), followed by hour and minute.

Please be aware of potential energy losses due to internal capacity decline, estimated at roughly 10% annually.

1.NOVAR USE HRES: NO

Decides what to do when the GPS and 1Hz GPS is off (ON FROM ... ON UNTIL; GPS NOT EVERYDAY; GPS interval to 0, Battery < bat_threshold1). Either use H-Res for ACC & IMU (set: YES) or L-Res for ACC & IMU (set: NO).

2.GEOFENCE SETUP

Gets you to the GeoFence setup for further programming.

2.GEOFENCE SETUP

a.EXIT

a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.

b.GF TW FROM: 00:00

c.GF TW UNTIL: 00:00

b. Specify the start time to activate the GeoFence feature (UTC/GMT).

c. Specify the end time to deactivate the GeoFence feature (UTC/GMT).

Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the GeoFence remains off. If 'b' & 'c' are set to 00:00 and 23:59 respectively, the GeoFence feature remains on.

d.GF R1 W LO: 0

d. GeoFence Rectangle1 West Longitude value. Format in units of 1E-7 degree. Whole number without decimal places. Example: 111999190 = 11.1999190 degree.

e.GF R1 E LO: 0

e. GeoFence Rectangle1 East Longitude value. Format in units of 1E-7 degree. Whole number without decimal places.

f.GF R1 N LA: 0

f. GeoFence Rectangle1 North Latitude value. Format in units of 1E-7 degree. Whole number without decimal places.

g.GF R1 S LA: 0

g. GeoFence Rectangle1 South Latitude value. Format in units of 1E-7 degree. Whole number without decimal places.

h.GF R2 W LO: 0

h. GeoFence Rectangle2 West Longitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.

i.GF R2 E LO: 0

i. GeoFence Rectangle2 East Longitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.

j.GF R2 N LA: 0

j. GeoFence Rectangle2 North Latitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.

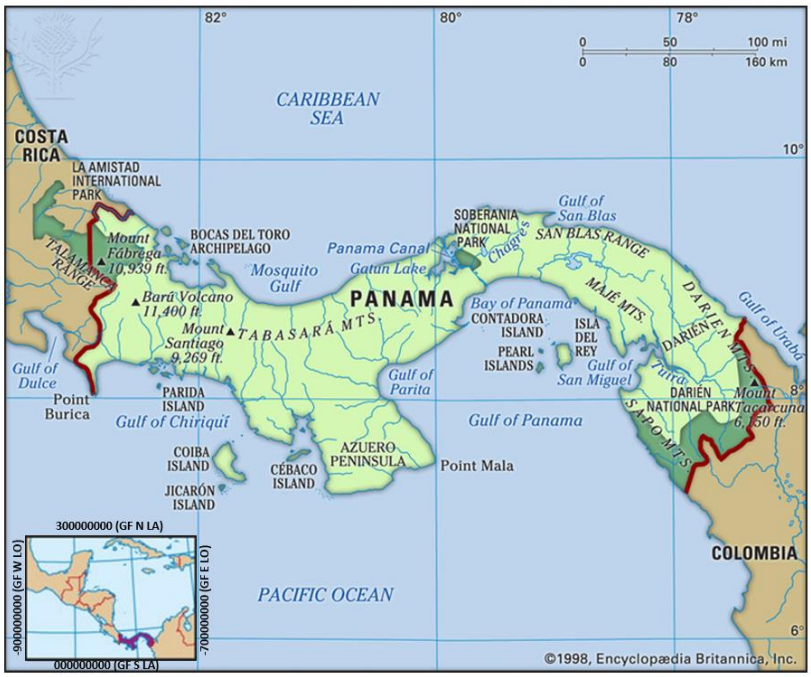
k.GF R2 S LA: 0

k. GeoFence Rectangle2 South Latitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.

l.GF INV: NO

Inverts the application of Geofence settings, from applying within designated areas to applying outside those areas.

Case Study: Explaining the geofence and Optimizing Schedules with Geofence and Time Windows



When the device obtains a GPS fix, it verifies if it's inside the designated area, or outside it, as defined by an inverted geofence (GF INV: NO). Additionally, it verifies if the current time falls within the specified geofence time window, which may differ from the main GPS, ACC, and IMU scheduling windows. Should the animal be within the designated geofence area and during the period when the geofence is set to be active, then the geofence is deemed to be enabled. The device then assesses the animal's activity level based on acceleration variance and internal speed metrics to decide between LOW and HIGH-resolution modes. If the animal is deemed 'active' with the Geofence enabled, it employs the HIGH-resolution geofence parameters (ACC/IMU/GPS GF HRES INTERVAL). If the animal is 'inactive' but the Geofence is still active, LOW-resolution geofence settings (ACC/IMU/GPS GF LRES INTERVAL) are applied.

Without an active Geofence, the device defaults to the standard LOW/HIGH resolution settings (ACC/IMU/GPS LRES INTERVAL vs ACC/IMU/GPS HRES INTERVAL), as applicable. As illustrated in the referenced figure, which showcases a large geofence area (seen in the bottom-left insert), ensuring the animal stays within this zone allows the geofence's active time window alone to determine the ACC/IMU/GPS intervals for LOW and HIGH modes. This functionality is advantageous for implementing an additional GPS schedule based on the time of day, thereby achieving consistency both within and across days.

Case study: Utilizing Geofence Time Windows:
In this example, we have configured the GPS operational window and a geofence window to optimize tracking and conserve battery life. The settings are as follows:

- **GPS Window: 06:00 – 22:00 (16 hours of active tracking)**
- **Geofence Window: 09:00 – 15:00**

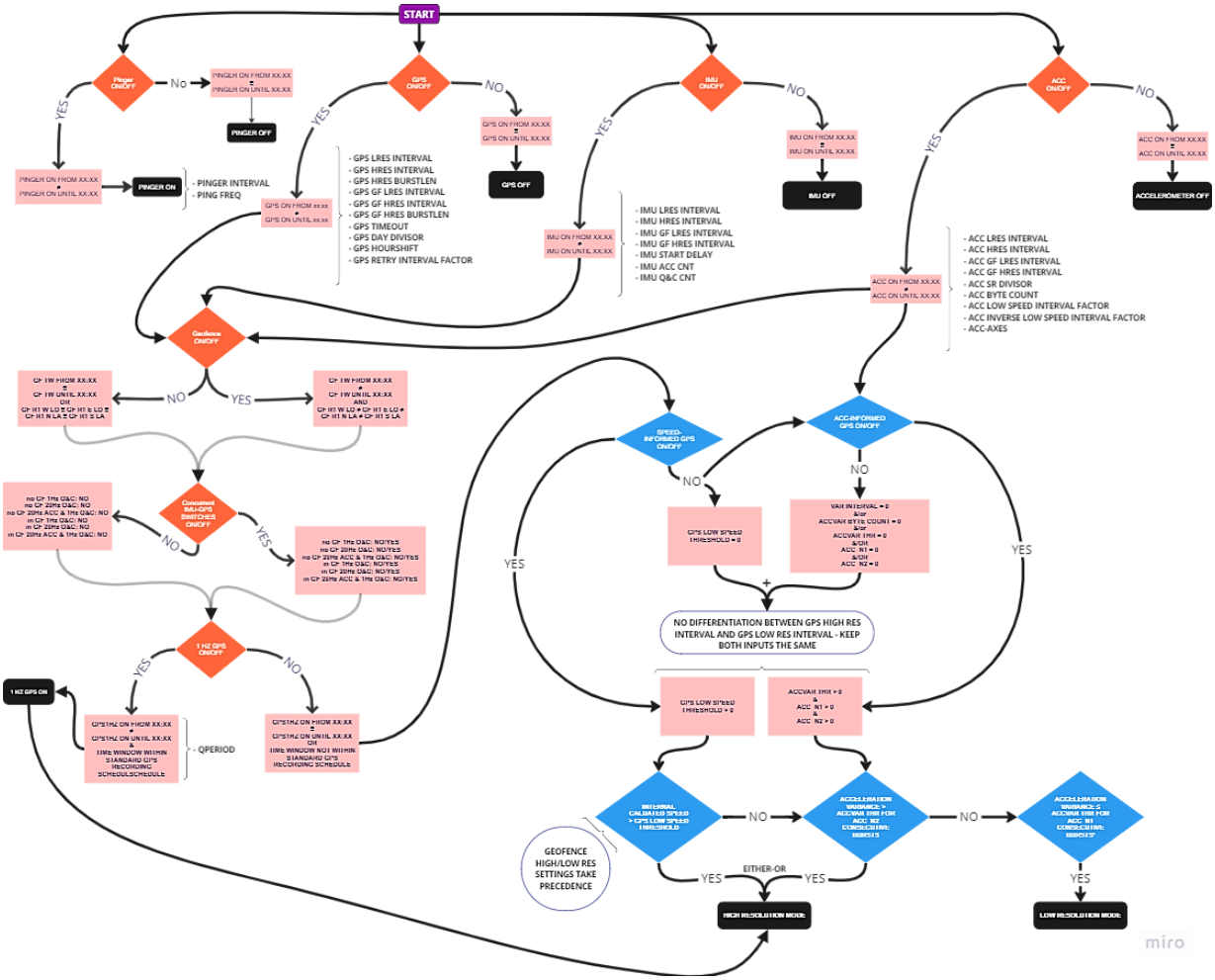
The device operates under the following conditions:

- **00:00 – 06:00: GPS tracking is inactive as the current time is outside the GPS operational window.**
- **06:00 – 09:00: The device operates under "normal" GPS settings (High/Low Res GPS Interval), since it is within the GPS window but outside the geofence window.**
- **09:00 – 15:00: Within this timeframe, the geofence settings (GF High/Low Res GPS Interval) take precedence due to overlap with the geofence window, potentially adjusting the tracking resolution based on the presence within the designated geofence area.**
- **15:00 – 22:00: Post-geofence window, the device reverts to "normal" GPS settings until the end of the GPS window.**
- **22:00 – 24:00: GPS tracking ceases as the timeframe falls outside the GPS operational window.**

SETUP:
4. COM SETUP
a.EXIT
a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.PING ON FROM: 10:00
c.PING ON UNTIL: 10:00
b. Set the start time for the pinger activation (UTC/GMT).
c. Set the end time for pinger deactivation (UTC/GMT).
Note: If both 'b' & 'c' are set to 00:00 00 (or any other matching times), the pinger remains off.
If set to 00:00 and 23:59, respectively, the pinger remains on. The pinger does not work during times when the GPS is searching for satellites, recording GPS data, or when the acceleration/IMU is recording. This means that the pinger will remain off during 1Hz GPS mode.
d.PINGER INTERVAL: 1s
d. This specifies the pinger's pulse rate. Options include 1s (default) or 2s intervals for onsite triangulation. Using 2s intervals is not possible between 868.0 and 868.6 MHz.
e.DC TLIMIT FROM: 08:00
f.DC TLIMIT UNTIL:12:00
e. Set the start time (in UTC/GMT) for DeathCounter (mortality sensor, DC).
f. Set the end time (in UTC/GMT) for DeathCounter (mortality sensor, DC).
Note: If both 'e' & 'f' are set to 00:00 (or any other matching times), the GPS will remain off. If set to 00:00 and 23:59, respectively, the GPS will remain on (24 h per day).
g.DC_VAR_CNT: 0
g. Number of variance measurements after which we decide about the mortality situation (event YES or NO). Its deactivated by default (set to 0). The window depends on your variance interval. For example, if you want the window to be 1 h, and the VAR INTERVAL was set at 120 s, then DC_VAR_CNT should be set to 30 (because 30 × 2 minute intervals = 1 hour worth of variance readings).
h.DC_LOWVAR_CNT_THR: 50
h. Number of “dead” listings in our decision window (VAR_CNT) needed to LOG a mortality event. With a 1h window, a setting of 25 means we need 25 out of 30 measurements (decisions) being “DEAD” (acceleration variance < DC_LOWVAR_THR) to trigger the mortality event.

i.DC_LOWVAR_THR: 100
i. Threshold for variance to decide between listing the animal as dead (i.e., < 100; default value) or alive (> 100; default value) at a given variance measurement point. It doesn't matter if a few are above that level (e.g. animal fed upon), only the majority (DC_LOWVAR_CNT_THR) needs to be met.
j.SECRET KEY (DON'T CHANGE!): 13474
k.ACCESS KEY (DON'T CHANGE!):12
l.PING TW2 FROM: 00:00
m.PING TW2 UNTIL: 23:59
l. Set the start time for a second Pinger window (UTC/GMT) that applies only when GPS fix is within (or without with reverse function) the **GeoFence**.
m. Set the end time for a second Pinger window (UTC/GMT) that applies only when GPS fix is within (or without with reverse function) the **GeoFence**. Deactivated by default.
Note, if 'GF TW FROM' and 'GF TW UNTIL' and/or PING TW2 FROM' and 'PING TW2 UNTIL' have matching times, or no 'GeoFence Rectangle2' is set then this feature is deactivated.

1.PING FREQ: 916000 kHz
1. Denotes the frequency of the pinger's signal, formatted as XXX.XXX. If deploying multiple tags in a similar region simultaneously, ensure their frequencies differ by a minimum of 10 kHz, ideally 30 kHz or more. It's essential to understand that these frequencies might require fine-tuning. It's advisable to adjust the exact frequency for the clearest ping in your receiver before deployment. Even though the format suggests otherwise, input the numbers without a decimal. For instance, entering 916030 will give a frequency of 916.030.
2.GF PING INV: NO
2. Defines if the GF pinger window applies only when the last GPS fix indicates being within the **GeoFence** area and time window (default) or outside of the **GeoFence** area and time window (switch to YES).



Mode Switching Criteria

Switching to High Resolution Mode occurs under any one of the following conditions:

- The device switches to HIGH RESOLUTION MODE when acceleration variance surpasses the ACCVAR THR threshold for ACC_N2 consecutive acceleration bursts.
- The mode also switches immediately if the speed, calculated from the last GPS fix, exceeds the GPS SPEED THRESHOLD1.

  A transition to High Resolution Mode requires just one of these conditions to be met.

Switching to Low Resolution Mode requires both of the following conditions to be satisfied:

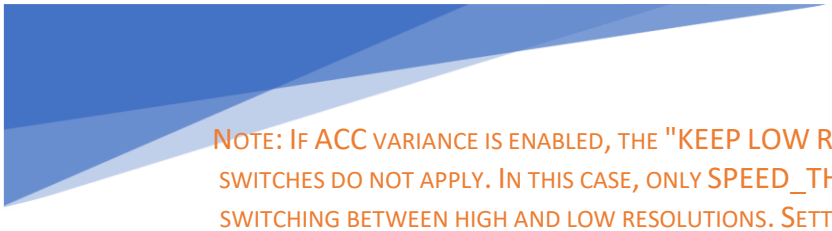
- Acceleration variance must be below or equal to the ACCVAR THR threshold for ACC_N1 consecutive acceleration bursts. This is determined not by the standard ACC schedule but by the VAR INTERVAL, ACCVAR SR DIVISOR, and ACCVAR BYTE COUNT.
- The speed from the last GPS fix must be less than or equal to GPS SPEED THRESHOLD1 for at least SPEED_N1 consecutive measurements. If the acceleration variance feature is turned off and 'Prefer High Res' is set to 'YES', then the schedule for high-resolution acceleration sampling will be given priority.
- *The GPS will switch to LOW RES INTERVAL only if both criteria are met or fall below their respective thresholds.*
- *Specific to ACC LOW RES mode, the BRST-LOWSPD-FCNT indicates the necessary number of consecutive GPS fixes within each GPS burst—where speed counts fall below GPS SPEED THRESHOLD1—to trigger a switch from ACC HIGH RES to ACC LOW RES.*

Note: The values of ACCYF and ACCZF can specify a 'Tilt limit angle,' used alongside ACCVAR THR and GPS SPEED THRESHOLD1 to initiate a switch to GPS LOW RESOLUTION MODE. If this is utilised, then all three thresholds must be surpassed.

Resolution Mode Implications

- **In HIGH RESOLUTION MODE:** The logger utilizes the GPS/ACC/IMU HIGH RES INTERVAL for data collection. If a Geofence is set and active, geofence-specific parameters take precedence.
- **In LOW RESOLUTION MODE:** The logger adheres to the GPS/ACC/IMU LOW RES INTERVAL for data collection. If a Geofence is set and active, geofence-specific parameters take precedence.

GPS Burst Termination: A GPS burst is terminated prematurely if the calculated speed falls below the GPS LOW SPEED THRESHOLD2, for BRST-LOWSPD-FCNT (number of consecutive GPS fixes within each GPS burst), and/or if the GPS RETRY INTERVAL FACTOR is activated due to a failed fix attempt.



NOTE: IF ACC VARIANCE IS ENABLED, THE "KEEP LOW RES" AND "PREFER HIGH RES" SWITCHES DO NOT APPLY. IN THIS CASE, ONLY SPEED_THRESHOLD1 IS IMPORTANT FOR SWITCHING BETWEEN HIGH AND LOW RESOLUTIONS. SETTING SPEED_THRESHOLD1 TO ZERO DOES NOT DISABLE THIS FEATURE. IF YOU WANT TO PREVENT SPEED FROM BEING USED TO TOGGLE BETWEEN LOW/HIGH-RESOLUTION SETTINGS, FOLLOW THESE STEPS:

1. FOR SPEED_THRESHOLD1, CHOOSE A HIGH VALUE SUCH AS 10000 (EQUIVALENT TO 100 M/S OR 360 KM/H). THIS ENSURES THE LOGGER DOESN'T SWITCH TO HIGH RESOLUTION DUE TO SPEED.
2. TO PREVENT THE LOGGER FROM SWITCHING TO LOW RESOLUTION DUE TO SPEED, SET SPEED_N1 TO 250. WHILE THIS DOESN'T ACHIEVE THE GOAL PERFECTLY, IT IS NEARLY PERFECT.

'NEWER NEW' devices → WITH IMU & OPTION FOR TWO GPS/ACC/IMU SCHEDULES (since end of 2023)

***Refer to the section titled :''NEW' devices → WITH IMU (ID's ≥ 60167, since end of 2022)', for relevant supporting figures, tables, and case studies**

SETUP:

a.EXIT & SAVE SETUP

a. After finalizing tag settings, press 'a' to exit and follow the instructions in HyperTerminal to decide whether to save the changes. (y = yes / n = no)

b.ACC ON FROM: 00:00

c.ACC ON UNTIL: 23:59

b. Specify the start time to activate the accelerometer (UTC/GMT).

c. Specify the end time to deactivate the accelerometer (UTC/GMT).

Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the accelerometer remains off. If 'b' & 'c' are set to 00:00 and 23:59 respectively, the accelerometer remains on.

d.ACC ON2 FROM: 00:00

e.ACC ON2 UNTIL: 00:00

d. Specify the start time to activate the accelerometer's independent second schedule (UTC/GMT).

e. Specify the end time to deactivate the accelerometer's independent second schedule (UTC/GMT).

Note: If both 'd' & 'e' are set to 00:00 (or any other matching times), the accelerometer's second schedule remains off.

f.IMU ON FROM: 00:00

g.IMU ON UNTIL: 00:00

f. Specify the start time to activate the IMU (UTC/GMT).

g. Specify the end time to deactivate the IMU (UTC/GMT).

Note: If both 'f' & 'g' are set to 00:00 (or any other matching times), the IMU remains off. If 'f' & 'g' are set to 00:00 and 23:59 respectively, the IMU remains on.

h.IMU ON2 FROM: 00:00

i.IMU ON2 FROM: 00:00

h. Specify the start time to activate the IMU's independent second schedule (UTC/GMT).

i. Specify the end time to deactivate the IMU's independent second schedule (UTC/GMT).

Note: If both 'h' & 'i' are set to 00:00 (or any other matching times), the IMU's second schedule remains off.

j.ACC LRES INTERVAL: 600 s

j. Dictates the low-resolution acceleration recording rate (interval between acceleration bursts). Input values in seconds; for instance, 600 (default value) signifies a 10-minute interval between acceleration bursts.

k.IMU LRES INTERVAL: 0s

k. Dictates the low-resolution IMU recording rate (interval between IMU bursts). Input values in seconds. A 0-second setting (default) deactivates this feature resulting in no IMU data collection during low-resolution mode.

l.ACC HRES INTERVAL: 600s

l. Dictates the high-resolution acceleration recording rate (interval between acceleration bursts). Input values in seconds; for instance, 600 (default value) signifies a 10-minute interval between acceleration bursts. Note, if both the ACC LRES INTERVAL and ACC HRES INTERVAL are the same value, then the recording schedules between these modes do not differ.

m.IMU HRES INTERVAL:0s

m. Dictates the high-resolution IMU recording rate (interval between IMU bursts). Input values in seconds. A 0-second setting (default) deactivates this feature resulting in no IMU data collection

during high-resolution mode. Note, if both the IMU LRES INTERVAL and IMU HRES INTERVAL are the same value, then the recording schedules between these modes do not differ.

n.ACC GF LRES INTERVAL: 600s

j. Dictates the low-resolution acceleration recording rate (interval between acceleration bursts) when within the set **GeoFence** parameters (set rectangular area and time-window activated). Input values in seconds; for instance, using 600 seconds (default) translates to a 10-minute interval between acceleration bursts.

o.IMU GF LRES INTERVAL: 0s

o. Dictates the low-resolution IMU recording rate (interval between IMU bursts) when the animal is within the set **GeoFence** parameters. A 0-second setting (default) deactivates this feature resulting in no IMU data collection during low-resolution mode within the set **GeoFence** area and time-window.

p.ACC GF HRES INTERVAL: 600s

p. Dictates the high-resolution acceleration recording rate (interval between acceleration bursts) when within the set **GeoFence** parameters. Input values in seconds; for instance, using 600 seconds (default) translates to a 10-minute interval between acceleration bursts. Note, if both the ACC GF LRES INTERVAL and ACC GF HRES INTERVAL are the same value, then the recording schedules between these modes do not differ within the set **GeoFence** area and time-window.

q.IMU GF HRES INTERVAL: 0s

m. Dictates the high-resolution IMU recording rate (interval between IMU bursts) when the animal is within the set **GeoFence** area and time-window. A 0-second setting (default) deactivates this feature resulting in no IMU data collection during high resolution mode within the set **GeoFence** area and time-window. Note, if both the IMU GF LRES INTERVAL and IMU GF HRES INTERVAL are the same value, then the recording schedules between these modes do not differ within the set GeoFence area and time-window.

r.ACC SR DIVISOR: 10

r. This factor derives the sampling rate in Hz, calculated as 100 ÷ ACC SR DIVISOR. For instance, if ACC SR DIVISOR equals 10 (default value), the resultant rate is 10 Hz, translating to 10 acceleration readings/second per recording axis.

s.ACC BYTE COUNT: 190

s. This parameter establishes the memory capacity for each acceleration burst. Paired with the sample rate, it dictates the burst's time window duration. Practically, onboard memory always utilizes multiples of 64 bytes, with some reserved for 'housekeeping'. See the above table within the ‘OLD’ devices’ settings section for further clarification.

Burst Duration Calculation:

- Duration of one burst = (Available acceleration data bytes) ÷ (1.5 × sampling rate × number of recording axes).
- The sampling rate (in Hz) is derived from the ACC SR DIVISOR:100 ÷ ACC SR DIVISOR.
- The recording axes can be set to 1, 2, or 3. A tri-axial orthogonal setup, offering three-dimensional measurement, typically requires the axis count to be 3.

Example:

If ACC BYTE COUNT is 190 (default value), ACC SR DIVISOR is 10 (default value), and the number of recording axes is 3 (default value), then the burst's sampling duration = 243 ÷ (1.5 × 10 × 3) = 5.4 seconds.

t.ACC LOW SPEED INTERVAL FACTOR: 1

t. A factor to extend the ACC INTERVAL when the animal's movement is slow, useful for conserving memory when resting behavior isn't a priority.

The speed threshold is set via "SPEED THRESHOLD1" and gauged during a GPS BURST. Default is 1 (no extension). If set to 2, the interval between acceleration bursts is doubled, and so forth.

u.IMU START DELAY: 40

u. The IMU system requires a brief warm-up period post-activation before producing accurate data. The "IMU START DELAY" determines the initial period during which the IMU data are

presumed to be unreliable and are thus discarded. By default, a 40-event delay equates to ignoring the initial 2 seconds of data, given the IMU's 20 Hz recording rate.
v.IMU ACC CNT: 10
v. This setting is applied when you use the IMU with 20Hz sample rate in standalone mode without parallel GPS. It defines the number of IMU acceleration datasets to be recorded in a single IMU burst. Each dataset comprises 24*3 ACC samples, equivalent to 1.2 seconds or 128 Bytes of data. With a default setting of 10, this results in recording 12 seconds or 1280 bytes of data. Refer to the provided table for further detail. To avoid recording stand-alone IMU acceleration, set this value to zero. Doing so won't affect the 'IMU Switches' settings if they are activated. Note that stand-alone IMU and IMU in parallel with GPS (set within 'IMU Switches') function independently, provided that the desired IMU data acquisition period falls within the specified IMU ON FROM/UNTIL parameters.
w.IMU Q&C CNT: 20
w. When operating the IMU in standalone mode at a 20Hz sampling rate without parallel GPS, this setting determines the number of quaternion & compass datasets to be captured within one IMU burst. Each dataset contains 10 samples, which corresponds to 0.5 seconds or 128 Bytes of data. The default setting is 20, translating to 10 seconds or 2560 bytes of data. Refer to the provided table for further detail. To avoid recording quaternion & compass, set this value to zero. Doing so won't affect the 'IMU Switches' settings if they are activated. Note that stand-alone IMU and IMU in parallel with GPS (set within 'IMU Switches') function independently, provided that the desired IMU data acquisition period falls within the specified IMU ON FROM/UNTIL parameters.
1.ACC-AXES: XYZ
1. Define which axes (X, Y, Z) are to be utilized.
X-Axis: Measures LEFT-RIGHT acceleration [sway].
Y-Axis: Measures BACK-FORTH acceleration [surge].
Z-Axis: Measured UP-DOWN accelerations [heave] (orientations are always relative to the tag placement on the animal). If you require all three axes, simply retain the default settings. Note that if this setting is left blank, no acceleration will be recorded, and the GPS-informed acceleration variance settings will also be disabled.
2.ACC INVERSE LOW SPEED INTERVAL FACTOR: NO
2. When activated (set to YES), the ACC INTERVAL extending factor, governed by the ACC LOW SPEED INTERVAL setting, works in reverse. This means the interval between acceleration bursts lengthens with fast movement (exceeding the GPS SPEED THRESHOLD1) rather than with slow movements (below the GPS SPEED THRESHOLD1).
3.GPS SETUP
3. Navigate to this section for GPS recording-related settings.
4. SEL REC SETUP
4. to adjust settings pertinent to selective recording, toggling between high- and low-resolution for ACC, IMU, and GPS mode.
5. COM SETUP
5. Navigate to this section for settings relevant for communication parameters, including UHF pinger timings.

3.GPS SETUP
a.EXIT
a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.GPS ON FROM: 00:00
c.GPS ON UNTIL: 23:59
b. Set the start time (in UTC/GMT) for GPS activation.
c. Set the end time (in UTC/GMT) for GPS deactivation.
Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the GPS will remain off. If set to 00:00 and 23:59, respectively, the GPS will remain on (24 h per day).

d.GPS ON2 FROM: 00:00
e.GPS ON2 UNTIL: 00:00
d. Set the start time (in UTC/GMT) to activate the GPS independent second schedule.
e. Set the end time (in UTC/GMT) to deactivate the GPS independent second schedule.
Note: If both 'd' & 'e' are set to 00:00 (or any other matching times), the GPS will remain off.
f.GPS LRES INTERVAL: 14400s
g.GPS HRES INTERVAL: 300s
f. Dictates the low-resolution GPS recording rate (interval between fix acquisition attempts), activating when the internally assessed speed exceeds SPEED THRESHOLD1.
g. Determines the low-resolution GPS recording rate, which is used when the internally computed speed is at or below SPEED THRESHOLD1. If SPEED THRESHOLD1 is deactivated (set to 0), then ideally, both f and g should share the same values. Values are in seconds; for instance, 14400 translates to a 4-hour interval between GPS fix attempts. The decision to switch between HIGH and LOW RES INTERVALS can also hinge on acceleration-informed GPS. Refer to the decision algorithm flowchart for clarity.
h.GPS HRES BURSTLEN: 1s
h. Specifies the length of each GPS burst in seconds, reflecting consecutive fixes (1 Hz) after the designated GPS HRES INTERVAL. For instance, a value of 6 for GPS HRES BURSTLEN means the GPS aims for 6 consecutive fixes within 6 seconds during each GPS HRES INTERVAL. Default value is 1 s.
Note, by default, in LOW RES mode, GPS burst lengths are always 1 (though see 'ai ign lres').
i.GPS GF LRES INTERVAL: 14400s
j.GPS GF HRES INTERVAL: 300s
i. Dictates the low-resolution GPS recording rate (interval between fix acquisition attempts), when the animal is within the set **GeoFence** area and time-window, activating when the internally calculated speed surpasses SPEED THRESHOLD1.
j. Determines the high-resolution GPS recording rate (interval between fix acquisition attempts), relevant when the internally measured speed remains at or below SPEED THRESHOLD1. If SPEED THRESHOLD1 is turned off (set to 0), both g. and h. should ideally be identical. Values are in seconds; for instance, 14400 translates to a 4-hour interval between GPS fix attempts. Keep in mind that acceleration-informed GPS can influence the choice between GF HIGH and GF LOW RES INTERVALS. See the decision algorithm flowchart for further details.
k.GPS GF HRES BURSTLEN: 1s
k. Specifies the length of each GPS burst in seconds, reflecting consecutive fixes (1 Hz) after the designated GPS GF HRES INTERVAL, when within the designated **GeoFence** area and time window. For example, a value of 6 for GPS GF HRES BURSTLEN indicates an aim for 6 continuous fixes across 6 seconds for every GPS GF HRES INTERVAL. Default value is 1 s.
Note, by default, in LOW RES mode, GPS burst lengths are always 1 (though see 'ai ign lres').
l.QPERIOD: 1s
l. Governs the storage frequency for 1 Hz GPS recordings. By default, every fix is stored. A value of 2 denotes storage of every alternate fix, and so on. Increasing the value will correspondingly reduce the frequency of GPS data storage and thus memory consumption. Note, this does not impact the storage of IMU data being concurrently recorded within the GPS data storage structure.
m.GPS RETRY INTERVAL FACTOR: 1
m. Lengthens the GPS interval after an unsuccessful GPS fix attempt. For example, with an interval of 5 minutes and a GPS RETRY INTERVAL FACTOR of 4, the device will wait 20 minutes before the next attempt if the initial fix fails. If the retry is successful, the interval resets to 5 minutes. However, if the retry also fails, the interval remains at 20 minutes. A default value of 1 indicates that this feature is turned off, effectively keeping the attempt interval constant regardless of success or failure. Activating this feature (setting it to a value greater than 1) can conserve energy but will also cancel the set GPS HRES BURSTLEN/GF HRES BURSTLEN immediately following the first unsuccessful fix.

n.SPEED THRESHOLD1: 100cm/s
o.SPEED THRESHOLD2: 100 cm/s
p.SPEED THRESHOLD3: 100 cm/s
n. SPEED THRESHOLD1 is evaluated after a GPS burst to switch between LOW and HIGH resolution modes.
o. SPEED THRESHOLD2 is assessed during a "Normal Mode" GPS burst to decide if the GPS burst should be terminated prematurely.
p. SPEED THRESHOLD3 is checked during a “SUPER MODE” GPS burst to decide on termination. However, note that “SUPER MODE” is not available for these devices (it's pertinent to solar panel devices), rendering this setting irrelevant.
1.IMU SWITCHES
1. These settings determine whether IMU data (IMU ACC and/or IMU QUAT&COMP) is concurrently sampled alongside GPS data, and whether this sampling occurs at a frequency of 1 Hz or 20 Hz. This setting applies to data collection both within and outside geofenced areas, as well as during the GPS 1Hz mode operation. It specifies how the IMU data (independent of ‘IMU standalone mode’ is integrated into the GPS data storage structure.

[Secret Key: ?uopj3] ← Type this secret key within the **‘3.GPS SETUP’** section to access the options listed below:

For Experts
a.Exit
a. After finalizing settings in the ‘For Experts’ section, press 'a' to exit. This will return to the ‘3.GPS SETUP’ section. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.GPS1Hz ON FROM: 00:00
c.GPS1Hz ON UNTIL: 00:00
b. Set the start time (in UTC/GMT) for 1Hz GPS activation.
c. Set the end time (in UTC/GMT) for 1Hz GPS deactivation.
This setting overrides the regular GPS time settings. Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the 1Hz GPS will remain off. Additionally, the 1Hz GPS mode only activates if the animal is within the set GeoFence and the GeoFence is active.
d.GPS TIMEOUT: 150s
d. Specifies the time (in seconds) that the GPS remains active searching for satellites for a fix. If unsuccessful and the GPS RETRY INTERVAL FACTOR is set above 1, the time before the next attempt will be extended.
e.radio long delay: 900s
e. Defines the time (in seconds) after a successful data download with the BaseStation during which the tag will not attempt to establish a new connection
f.bat_threshold2 code: 2458
g.bat_threshold1 code: 2458
h.bat_threshold0 code: 2826
These codes determine the battery levels under which specific functionalities, like GPS & ACC, are turned off. The UHF RadioLink and Pinger will remain operational as long as there's battery. IMPORTANT: Do not modify these settings. These codes do not directly represent battery voltage.
i.maccess voltcode: 2294
i. Lowest possible energy level to sustain basic tag functionality (e.g., memory function). Do not modify this setting.
2.prefer high res: YES
If the variance measure for selective recording is deactivated (VAR INTERVAL: 0) and GPS recording is on (still optionally affected by the GPS-Speed settings), this option ensures continuous High-Resolution acceleration recording when set to 'YES' and Low-Resolution acceleration when set to 'NO'. Note, “3.keep low res” has a higher priority.

3.keep low res: NO
If the variance measure for selective recording is deactivated (VAR INTERVAL: 0) and GPS recording is on (still optionally affected by the GPS-Speed settings), this option ensures that the system always opts for High-Resolution acceleration recording when set to 'NO'. Note, "3.keep low res" overrules the "2.prefer high res: YES" setting.
4.ai ign lres: NO
4. If enabled (set to YES), the GPS GF HRES BURSTLEN setting will determine the burst length in GPS GF LRES sampling mode, overriding the default burst length of one.
LCFG: a
This is an internal configuration. Do not change.
BAND MHz:c:916
This is an internal configuration. Do not change.

3.GPS SETUP
1.IMU Switches
a.Exit
a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.no GF 1Hz Q&C: NO
b. This setting allows you to toggle the recording of 1Hz Q&C IMU data (Quaternion & Compass) in parallel with the GPS bursts, thus optimizing memory usage by utilizing the GPS data storage structure. This setting comes into play when the device is OUTSIDE the **GeoFence** boundaries or the GeoFence function is turned off. By default, it's set to NO, signifying the absence of 1Hz Q&C during GPS fixes. Note, if this option is enabled, and the GPS burst duration is set to 10 seconds with an IMU START DELAY of 40 (equivalent to 2 seconds), the Q&C data for the initial two fixes in each GPS burst will be omitted. Therefore, only 8 seconds of IMU data would be available for each full burst. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0.
c.no GF 20Hz Q&C: NO
c. This setting allows you to toggle the recording of 20Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is OUTSIDE the **GeoFence** boundaries or the GeoFence function is turned off. By default, it's set to NO, signifying the absence of 20Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0
d.no GF 20Hz ACC & 1Hz Q&C: NO
d. This setting allows you to toggle the recording of 20Hz ACC & 1Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is OUTSIDE the **GeoFence** boundaries or the GeoFence function is turned off. By default, it's set to NO, signifying the absence of 20Hz ACC & 1Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0
e.in GF 1Hz Q&C: NO
e. This setting allows you to toggle the recording of 1Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is INSIDE the **GeoFence** boundaries and time window. By default, it's set to NO, signifying the absence of 1Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START

DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0.

f.in GF 20Hz Q&C: NO

f. This setting allows you to toggle the recording of 20Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is INSIDE the **GeoFence** boundaries and time window. By default, it's set to NO, signifying the absence of 20Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0

g.in GF 20Hz ACC & 1Hz Q&C: NO

g. This setting allows you to toggle the recording of 20Hz ACC & 1Hz Q&C IMU data in parallel with the GPS bursts. This setting comes into play when the device is INSIDE the GeoFence boundaries and time window. By default, it's set to NO, signifying the absence of 20Hz ACC & 1Hz Q&C during GPS fixes. Note, if this option is enabled and the IMU START DELAY was set as 40, the Q&C data for the initial two fixes in each GPS burst will be missing. It's advised that the GPS bursts should exceed the IMU START DELAY by at least one second. Remember, this setting doesn't override the independent IMU data recording (i.e., set up by the IMU ACC/Q&C CNT). Both can operate concurrently if IMU ACC/Q&C CNT is greater than 0

h.GPS1Hz 1Hz Q&C: NO

h. Option to activate the 1Hz Q&C IMU recordings when GPS1Hz mode is active. The default setting is NO, which means 1Hz Q&C will not record when GPS1Hz mode is active.

i.GPS1Hz 20Hz Q&C: NO

i. Option to activate the 20 Hz Q&C IMU recordings when GPS1Hz mode is active. The default setting is NO, which means 20Hz Q&C will not record when GPS1Hz mode is active.

j.GPS1Hz 20Hz ACC & 1Hz Q&C: NO

j. Option to activate the 20Hz ACC & 1Hz Q&C IMU recordings when GPS1Hz mode is active. The default setting is NO, which means 20Hz ACC & 1Hz Q&C will not record when GPS1Hz mode is active.

SETUP:

4. SELREC SETUP

a.EXIT

a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.

b.VAR INTERVAL: 60s

b. Defines the interval for ACC VAR calculations to determine if the animal is active or inactive. This is independent from (and can vary from) the ACC LRES INTERVAL and ACC HRES INTERVAL parameters.

c.ACCVAR SR DIVISOR: 5s

c. Defines (together with ACCVAR BYTE COUNT) the length of the acceleration variance measurement (burst). Typical configurations include: 5 for 20 Hz and 10 for 10 Hz. The frequency (Hz) is computed similarly to the ACC SR DIVISOR setting, as 100 ÷ ACCVAR SR DIVISOR.

d.ACCVAR BYTE COUNT: 30

d. Defines (together with ACCVAR SR DIVISOR) the variance measurement (burst) length. See the above table within the 'OLD' devices' settings section for further clarification.

Acceleration Variance Burst Duration Calculation:

- Duration of one burst = (Available acceleration data bytes) ÷ (1.5 × sampling rate × number of recording axes).

NOTE: IF ACC VARIANCE AND ACC ARE RECORDED SYNCHRONOUSLY, HARDLY ANY ADDITIONAL ENERGY IS REQUIRED (ONLY FOR CALCULATING THE VARIANCE FROM THE RAW DATA). THEREFORE, THIS IS RECOMMENDED. HOWEVER, THE AXIS CONSIDERED FOR THE ACC VARIANCE (NORMALLY Z) MUST BE INCLUDED IN THE "REGULAR" ACC AXES (DEFAULT XYZ). ADDITIONALLY, THE SAMPLE RATE MUST BE THE SAME, AND THE ACC BURST MUST BE AT LEAST AS LONG AS THE ACC VARIANCE BURST.

e. ACCVAR THR: 2500

e. This setting controls acceleration-informed GPS. It sets the threshold for the acceleration variance to trigger which GPS interval (Low or High Res) to use. The system calculates the variance of a designated acceleration channel (by default the Z-axis), and if the threshold is surpassed for a specific number of consecutive acceleration bursts (defined by ACC_N2), the GPS switches from LOW to HIGH RES INTERVAL. Conversely, if the variance is under or equal to the threshold for a set number of consecutive bursts (defined by ACC_N1), the GPS switches from HIGH to LOW RES INTERVAL. To disable this feature, set the value to 0. Refer to the decision algorithm flowchart for clarity. When employing ACCVAR THR, ensure the VAR INTERVAL duration is less than the GPS interval. It's crucial to note: if both the GPS speed and acceleration-informed GPS are active (AND the tilt angle – see later for relevance), both must be below or equal to their respective thresholds for the GPS to revert to the LOW RES INTERVAL. It's recommended to input a five-digit value. The preset is 2500, which is unitless and should be determined by users during trial phases.

f.ACC_N2:2

g.ACC_N1:5

f. Details the number of consecutive acceleration bursts required for the variance to be less than or equal to ACCVAR THR to switch to the GPS LOW RES INTERVAL. The default is set to two acceleration bursts.

g. Details the number of consecutive acceleration bursts necessary for the variance to exceed ACCVAR THR to switch to the GPS HIGH RES INTERVAL. The default is set to five acceleration bursts.

h.SPEED_N1: 3

Defines the number of consecutive speed measurements (taken with each GPS Fix burst) that must be either equal to or below, or above the established threshold in order to transition from High to Low Resolution and *vice versa*. The default is set to three consecutive speed measurements.

i.VAR_AXIS: Z

i. Identifies the acceleration axis utilized for determining the variance in ACCVAR THR. The heave (or up-down motion) axis typically offers the most insight regarding movement or its absence.

j.TILT_AXIS2: Y

j. The axis used to measure the tilting of the logger as a trigger feature for ACC informed GPS (used in conjunction with the ACCVAR THR. Most often used the Y-axis (back/forth, or 'surge' dimension of movement since the inclination/declination of this axis determines pitch angle). Note, that if tilt angle is used, then the logger tilt angle must be within this threshold, in addition with the ACCVAR THR and GPS SPEED THRESHOLD1 (if these are also activated) for the GPS to switch to the GPS LOW RES INTERVAL.

k.BRST-LOWSPD-FCNT:5s

k. The number of consecutive GPS fixes during HIGH RES mode with speed counts below the set GPS SPEED THRESHOLD1, needed to mark the animal as NOT MOVING as a trigger for switching from ACC HIGH RES to ACC LOW RES

l.ACCYF: 0

l. In combination with ACCZF, this specifies the 'Tilt limit angle'. See the below table for clarification. Note, this feature is predominantly useful for birds where activity (flying) is typically reflected by a smaller tilt angle (device oriented 'more' horizontally) and resting (perched) is

typically reflected by a greater device inclination (tilted backwards). This is typically an irrelevant feature and so should not change.
m.ACCZF: 0
m. In combination with ACCYF, this specifies the 'Tilt limit angle'. See the below table for clarification. Note, this feature is predominantly useful for birds where activity (flying) is typically reflected by a smaller tilt angle and resting (perched) is typically reflected by a greater device inclination. This is typically an irrelevant feature and so should not change.
n.GPS DAY DIVISOR: 1
n. Determines how often the GPS records in terms of 'day skipping'. For example, a divisor of 2 means the GPS activates every second day. Default is 1, implying daily GPS activity.
o.GPS HOURSHIFT:0
o. In combination with the GPS DAY DIVISOR, this allows for a temporal shift in the GPS recording window (e.g., option for hour-, as well as day skipping). Details are not present in the manual. Default is 0, meaning this feature is off.
p.DELAYED TAG START DAY NO.: 0
p. This setting allows the tag to remain inactive for a specified number of days after being placed on the animal.
Input day number (with Day zero being Sunday, March 4, 2007), followed by hour and minute. Please be aware of potential energy losses due to internal capacity decline, estimated at roughly 10% annually.
1.NOVAR USE HRES: NO
Decides what to do when the GPS and 1Hz GPS is off (ON FROM ... ON UNTIL; GPS NOT EVERYDAY; GPS interval to 0, Battery < bat_threshold1). Either use H-Res for ACC & IMU (set: YES) or L-Res for ACC & IMU (set: NO).
2.GEOFENCE SETUP
Gets you to the GeoFence setup for further programming.

2.GEOFENCE SETUP
a.EXIT
a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.GF TW FROM: 00:00
c.GF TW UNTIL: 00:00
b. Specify the start time to activate the GeoFence feature (UTC/GMT).
c. Specify the end time to deactivate the GeoFence feature (UTC/GMT).
Note: If both 'b' & 'c' are set to 00:00 (or any other matching times), the GeoFence remains off. If 'b' & 'c' are set to 00:00 and 23:59 respectively, the GeoFence feature remains on.
d.GF R1 W LO: 0
d. GeoFence Rectangle1 West Longitude value. Format in units of 1E-7 degree. Whole number without decimal places. Example: 111999190 = 11.1999190 degree.
e.GF R1 E LO: 0
e. GeoFence Rectangle1 East Longitude value. Format in units of 1E-7 degree. Whole number without decimal places.
f.GF R1 N LA: 0
f. GeoFence Rectangle1 North Latitude value. Format in units of 1E-7 degree. Whole number without decimal places.
g.GF R1 S LA: 0
g. GeoFence Rectangle1 South Latitude value. Format in units of 1E-7 degree. Whole number without decimal places.
h.GF R2 W LO: 0
h. GeoFence Rectangle2 West Longitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.

i.GF R2 E LO: 0
i. GeoFence Rectangle2 East Longitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.
j.GF R2 N LA: 0
j. GeoFence Rectangle2 North Latitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.
k.GF R2 S LA: 0
k. GeoFence Rectangle2 South Latitude value. Format in units of 1E-7 degree. Whole number without decimal places. See 'PING TW2 FROM/UNTIL…' for relevance of this second GeoFence rectangle.
l.GF INV: NO
Inverts the application of Geofence settings, from applying within designated areas to applying outside those areas.

SETUP:
4. COM SETUP
a.EXIT
a. After finalizing settings in GPS SETUP, press 'a' to exit. Saving is not required at this point; saving options will be prompted upon exiting the main SETUP menu.
b.PING ON FROM: 10:00
c.PING ON UNTIL: 10:00
b. Set the start time for the pinger activation (UTC/GMT).
c. Set the end time for pinger deactivation (UTC/GMT).
Note: If both 'b' & 'c' are set to 00:00 00 (or any other matching times), the pinger remains off. If set to 00:00 and 23:59, respectively, the pinger remains on. The pinger does not work during times when the GPS is searching for satellites, recording GPS data, or when the acceleration/IMU is recording. This means that the pinger will remain off during 1Hz GPS mode.
d.PINGER INTERVAL: 1s
d. This specifies the pinger's pulse rate. Options include 1s (default) or 2s intervals for onsite triangulation. Using 2s intervals is not possible between 868.0 and 868.6 MHz.
e.DC TLIMIT FROM: 08:00
f.DC TLIMIT UNTIL:12:00
e. Set the start time (in UTC/GMT) for DeathCounter (mortality sensor, DC).
f. Set the end time (in UTC/GMT) for DeathCounter (mortality sensor, DC).
Note: If both 'e' & 'f' are set to 00:00 (or any other matching times), the GPS will remain off. If set to 00:00 and 23:59, respectively, the GPS will remain on (24 h per day).
g.DC_VAR_CNT: 0
g. Number of variance measurements after which we decide about the mortality situation (event YES or NO). Its deactivated by default (set to 0). The window depends on your variance interval. For example, if you want the window to be 1 h, and the VAR INTERVAL was set at 120 s, then DC_VAR_CNT should be set to 30 (because 30 × 2 minute intervals = 1 hour worth of variance readings).
h.DC_LOWVAR_CNT_THR: 50
h. Number of "dead" listings in our decision window (VAR_CNT) needed to LOG a mortality event. With a 1h window, a setting of 25 means we need 25 out of 30 measurements (decisions) being "DEAD" (acceleration variance < DC_LOWVAR_THR) to trigger the mortality event.
i.DC_LOWVAR_THR: 100
i. Threshold for variance to decide between listing the animal as dead (i.e., < 100; default value) or alive (> 100; default value) at a given variance measurement point. It doesn't matter if a few are

above that level (e.g. animal fed upon), only the majority (DC_LOWVAR_CNT_THR) needs to be met.
j.SECRET KEY (DON'T CHANGE!): 13474
k.ACCESS KEY (DON'T CHANGE!):12
l.PING TW2 FROM: 00:00
m.PING TW2 UNTIL: 23:59
l. Set the start time for a second Pinger window (UTC/GMT) that applies only when GPS fix is within (or without with reverse function) the **GeoFence**.
m. Set the end time for a second Pinger window (UTC/GMT) that applies only when GPS fix is within (or without with reverse function) the **GeoFence**. Deactivated by default.
Note, if 'GF TW FROM' and 'GF TW UNTIL' and/or PING TW2 FROM' and 'PING TW2 UNTIL' have matching times, or no 'GeoFence Rectangle2' is set then this feature is deactivated.
1.PING FREQ: 916000 kHz
1. Denotes the frequency of the pinger's signal, formatted as XXX.XXX. If deploying multiple tags in a similar region simultaneously, ensure their frequencies differ by a minimum of 10 kHz, ideally 30 kHz or more. It's essential to understand that these frequencies might require fine-tuning. It's advisable to adjust the exact frequency for the clearest ping in your receiver before deployment. Even though the format suggests otherwise, input the numbers without a decimal. For instance, entering 916030 will give a frequency of 916.030.
2.GF PING INV: NO
2. Defines if the GF pinger window applies only when the last GPS fix indicates being within the **GeoFence** area and time window (default) or outside of the **GeoFence** area and time window (switch to YES).

(D) Configuring the Tag through HyperTerminal while the Device is on the Animal:

i. When connected correctly to the HyperTerminal program, you should get the flowing options:

'Top menu:
- a. BASEST.DOWNLOADMODE
- b. TAG-MENU
- c. BASESTATION MENU'

i. Press 'c.'
ii. Press 'd.' ADVANCED BASEST.MENU
iii. Press 'd.' MENU ON ANIMAL
iv. You will be prompted to ENTER THE TAG-ID. If you're unable to identify the tag ID, refer to option 'c' to LIST IDS OF RUNNING TAGS WITHIN RANGE for assistance
v. *Enter '2' for SETUP TAG*

[Note: In HyperTerminal, navigate through TOP MENU → c. BASESTATION MENU → ADVANCED BASEST.MENU → d. MENU ON ANIMAL → r. restart to reset the tag/collar. This restart option can be used to reset the tag/collar, effectively reversing any accidental deactivation.]

Battery and memory life:

See: http://xnfyma-richard-gunner.shinyapps.io/appr for R shiny app to help estimate battery life, memory consumption and delayed tag start date.