debug innovations 0101001101

Mataki Quick Start Guide

Version 1

This document provides a brief guide to the basics required to get started with Mataki tags including how to set up trackers and base stations. It also covers the most common procedures and common questions such as battery and antenna choices.

Version History

Version	Date	Changes
1	28 Feb 2018	First Release

Related Documents

Mataki-Lite User Guide
Mataki-Classic User Guide
Mataki Support Board User Guide
Mataki-Classic Programming Guide
Mataki-Lite Programming Guide
PuTTY Installation and Configuration

Contents

1. Hardware Overview

The Mataki system is designed to track birds and other animals using GPS. A 'tag' device with a unique ID number is attached to each animal and the tracking information collected by the tags is sent to a base station over a radio link. The base station data can then be uploaded to a PC and logs for each tag separated out. The radio link means there is no need to re-capture the animals to recover the data.

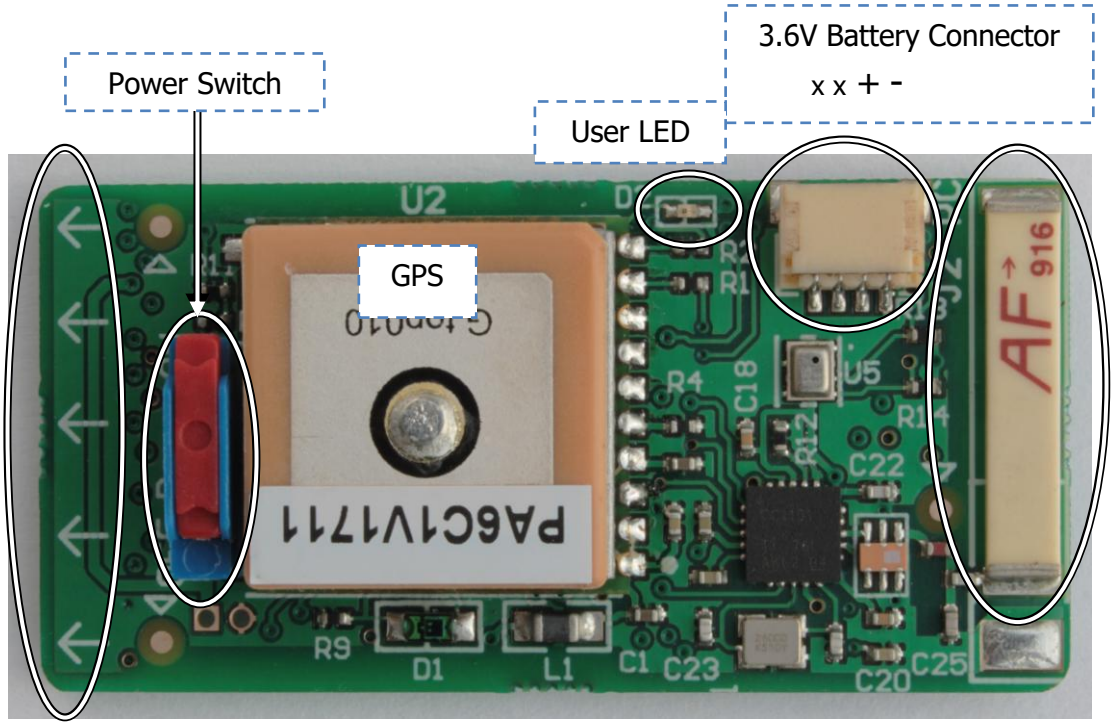
Two types of tag are available from Debug Innovations. Both types use the same radio system and can be deployed at the same time using the same base station. The radio frequencies can be changed for use in Europe or the USA.

1.1. Mataki-Classic

Shown below is a Mataki-Classic tag with basic features labelled. Mataki-Classic tags can be used as trackers (attached to animals) or base stations. They are supplied pre-loaded with tracker software. For base station use, they need to be re-programmed with the base station software. There are two battery options and three antenna options for flexibility with the different roles.

In addition to GPS position, Mataki-Classic tags can also log air temperature / pressure and accelerometer sensor data. The tag weighs around 10g excluding the battery.

See Mataki-Classic User Guide for more information.



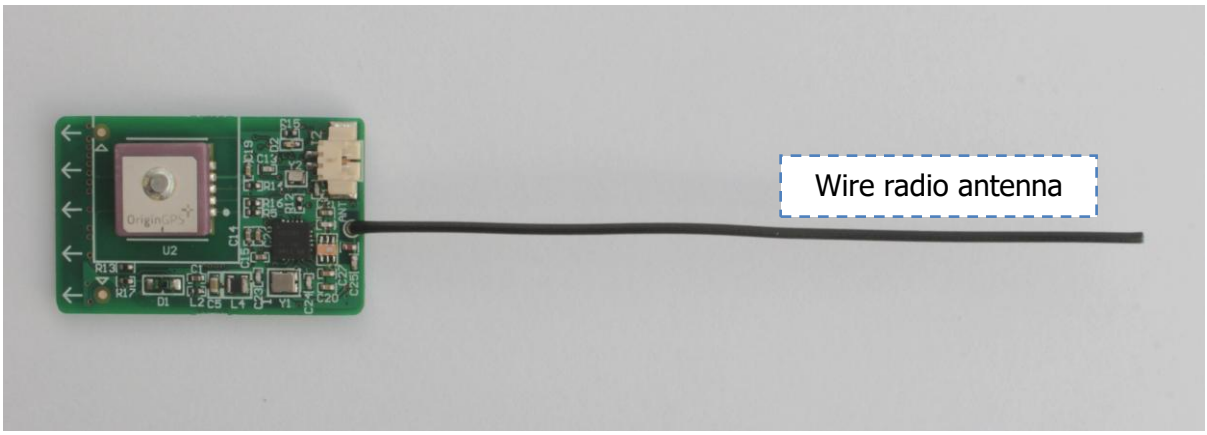
Mataki-Classic V5.4

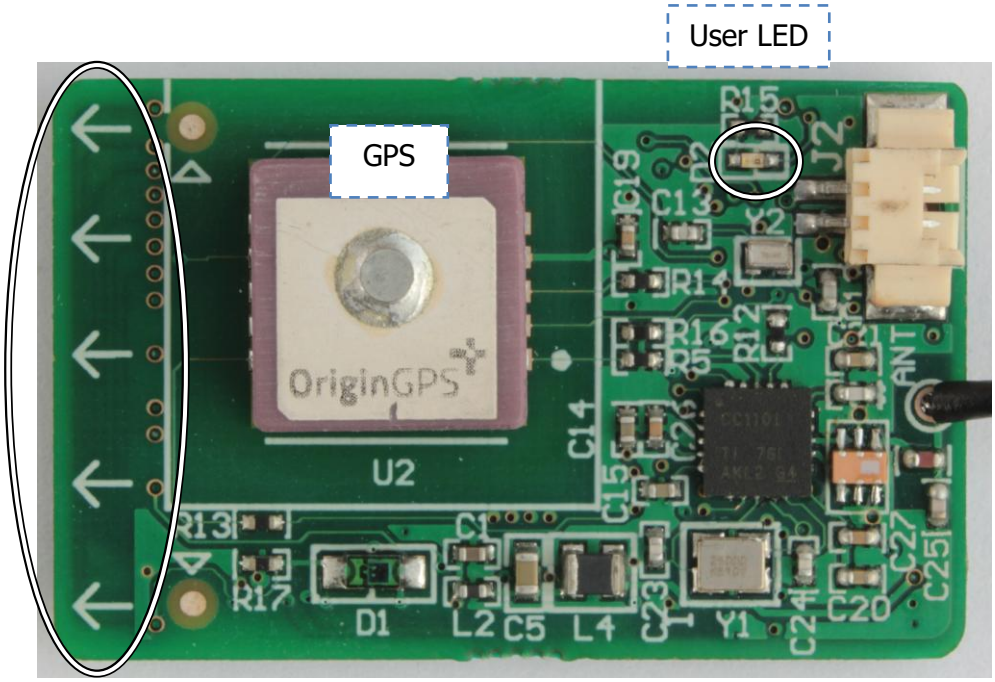
1.2. Mataki-Lite

Shown below is a Mataki-Lite tag with basic features labelled. Unlike Mataki-Classic, this is a tracker only device. It uploads its data to a Mataki-Classic base station. The tag weighs just 3.5g excluding the battery which means it can be used with smaller animals.

The tracking and logging behaviour of Mataki-Lite tags is entirely controlled by a user-supplied script giving much more control over the logging process and allowing species-specific behaviour.

See Mataki-Lite User Guide for more information.

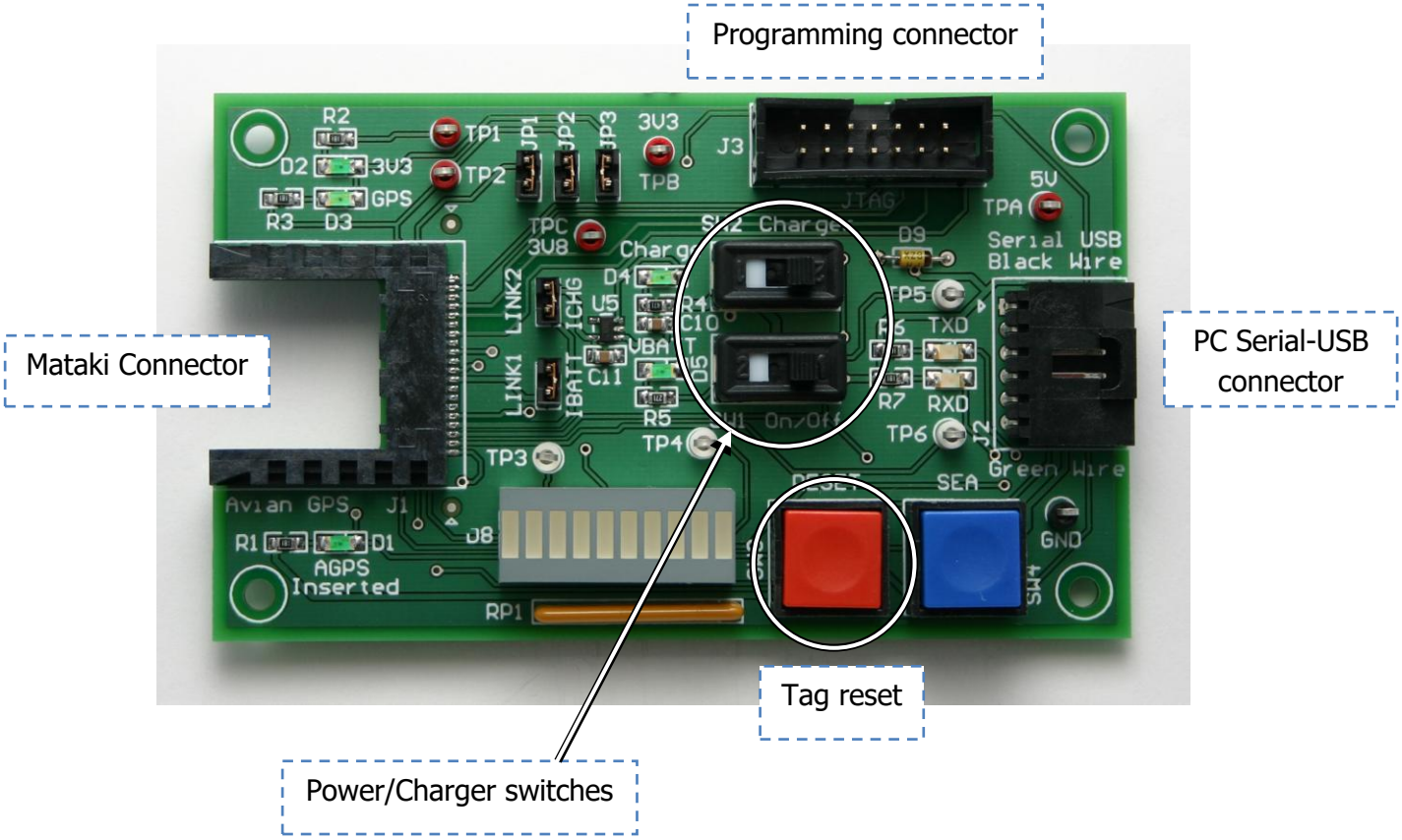




Mataki-Lite V1.2

1.3. Mataki Support Board

For tag setup, reading logs, loading scripts and firmware programming a support board is required. Both tag types are compatible with the same support board. Shown below is a support board with basic features labelled.



The support board comes with a serial USB cable and is powered from your PC via the USB port. All operations are controlled using a PuTTY terminal. See PuTTY Installation Guide if you do not have this installed.

The tag is inserted into the Mataki Connector on the left of the picture. Be careful not to pull up the tag when inserting it as the connector is quite delicate and only pressed home at the board entry end. The LED marked 'AGPS Inserted' will light when the tag is inserted. If you have any difficulty communicating with the tag, try re-inserting the tag as the contacts tarnish over time.

The two large switches control power to the tag. SW1 (On/Off) provides 3.8V as a 'battery substitute' and SW2 (Charger) turns on a battery charger that will charge batteries connected to the tag.

Mataki-Classic and Mataki-Lite tags get their power in different ways (see the relevant guide for more information). However, it is safe just to turn both switches on and off together for either tag.

See Mataki Support Board User Guide for more information.

1.4. Electrical Safety / Handling

All our products are supplied as bare PCBs. They operate at a low voltage and are safe to handle with the power on. However, they can be damaged if they come into contact with conductive objects, even if just briefly. Take special care when handling tags not to put them down on metal surfaces, connectors, tools, wires and other tags and be careful with metal watch straps, spectacles and jewellery.

The electronic components can be sensitive to static electricity. Please take ESD precautions when handling boards e.g. use an anti-static mat and wrist strap. Also be careful not to generate static by wearing appropriate clothing and earthing yourself before touching the boards.

When tags are deployed, it may be necessary to protect the electronics from the animal and the environment by shrink wrapping or boxing tags as appropriate.

1.5. Tag Logs and Settings

Tags have flash memory which is used to store log entries such as GPS position fixes. The logs are preserved when the power is off so logs can be recovered from tags even if the battery goes flat. Mataki-Classic tags have a large log capacity to enable their use as a base station where it may contain logs from many other tags. Mataki-Lite tags have a much smaller log capacity.

Tags also have settings which are stored in the flash memory so they survive a power on/off cycle. Examples are the tag's ID, the radio frequencies to use, tracker settings on Mataki-Classic and the tracker script on Mataki-Lite.

1.6. Programming Tag Firmware

The tag firmware can be programmed through the support board's programming connector. This is necessary to upgrade the firmware or, for Mataki-Classic, to switch between tracker and base station firmware. The required programming tools are different for Mataki-Classic and Mataki-Lite. Mataki-Lite also needs an adaptor. See Mataki-Lite and Mataki-Classic programming guides for more information.

2. Common Operations

Many of these operations require a PuTTY terminal. See PuTTY Installation Guide if you do not have this installed.

2.1. Establishing Connection with a Tag

Connecting a tag and getting messages through a PuTTY terminal can be achieved by:

- Opening a PuTTY terminal for the COM port of the support board
- Inserting the tag into the support board
- Powering on or resetting the tag if it is already on
- The tag should display start up messages then be ready to accept commands. On Mataki-Lite the script may be set to run on startup. This can be cancelled by following the instructions on screen.
- Type 'help' to get a list of supported commands. More information can be found in the relevant guides.

2.2. Charging Batteries

To charge a battery, the easiest method is to attach the battery to a tag and plug it into a support board. Then use switch SW2 to start charging the attached battery. Note: this will turn on a Mataki-Lite, so if an auto-run script is loaded it will be started if not cancelled.

2.3. Deploying Tags (Starting a New Study)

To start a new tag deployment, you need to:

- **Choose a radio frequency to use.** We recommend 868MHz in Europe and 916MHz in the USA. All tags and the base station need to be set to the same frequency. The default frequency is 868MHz.
    - On Mataki-Classic, the frequency is set using the 'fbase' command e.g. fbase 916
    - On Mataki-Lite, the frequency is set using the _FREQBASE setting e.g. _FREQBASE = 916
    - Frequency settings require a tag reset to take effect
    - The user is responsible for complying with the radio frequency regulations in the country of use
- **Make sure all the batteries are charged**
- **Set up a base station** (see section 3 below)
    - Turn it on before setting up tracker tags (they may contact the base station)

- Make sure the base station time is set to UTC time
- Clear the log using the command:

```
f_reset
```

- Only one base station should be used at any given time. Multiple base stations will interfere with each other as they share the radio channels.

- **Set up each Mataki-Classic tag in turn**

1. Set the radio frequency to use if not already set, using the 'fbase' command, for example:

```
fbase 916
```

2. Assign the tag a unique ID
   - Do not use ID 0, it is reserved
   - ID 1 is the default setting, so it shouldn't be used in order to avoid clashing with new tags
   - The maximum ID value is 255
   - Tag IDs ≥ 250 are usually used for base stations
   - Use the command (where n is the ID number):

```
id n
```

3. Set the tracker and other sensor logging settings
   - See Mataki-Classic User Guide
4. Clear the log using the command:

```
f_reset
```

- **Set up each Mataki-Lite tag in turn**

1. Set the radio frequency to use if not already set, using the _FREQBASE variable, for example

```
_FREQBASE = 916
```

2. Assign the tag a unique ID
   - Do not use ID 0, it is reserved
   - ID 1 is the default setting, so it shouldn't be used in order to avoid clashing with new tags
   - The maximum ID value is 255
   - Tag IDs ≥ 250 are usually used for base stations
   - Use the _ID variable (where n is the ID number):


```
_ID = n
```

3. Load a new EMBASIC script if required
   - See section 2.4 below
   - Make sure Auto-Run is enabled or the script won't run after a reset

4. Set supplementary data
   - On Mataki-Lite, supplementary data can be set on the tags to give more information about the tag when contacting the base station. Supplementary data is stored in the flash memory and will be remembered between power cycles.
   - Currently, owner and study information can be set with EMBASIC statements like the examples below:

```
_OWNER$ = "Monty Python"
_STUDY$ = "Norwegian Parrot Study 1"
```

5. Clear the log
   - Use the EMBASIC statement:

```
_LOGCLEAR = 1
```

2.4. Mataki-Lite Scripts

On Mataki-Lite, an EMBASIC script must be loaded on to the tag to describe its behaviour. There are two ways to do this:

1. Using the script loader utility:
   - This is the normal way to load scripts
   - Write a script in a text editor on the PC and save with the extension '.bas'
   - Connect the tag with a support board and then use the tool from a PC command prompt to load the script. For example (-r enables auto-run):

```
C:\> load_script -r example/script/test.bas
```

2. Writing the script on the tag
   - Only use this for development, as auto-run can only be changed with the loader utility
   - Edit the script and execute EMBASIC statements through the PuTTY terminal
   - `new` will clear the current script
   - The example below saves the script to the flash memory so it can be recalled after the device is reset:

```
save "test_script"
```

2.5. Collecting Logs

To get the data collected by a Mataki-Classic base station follow these steps:

- Ensure PuTTY has log output enabled
- Insert the base station tag into the support board and reset it
- Enter `abort` when prompted to stop the tag behaving as a base station so other tags can't interrupt the reading process
- Enter the `read` command into terminal (this could take some time to finish depending on how many logs are on the tag)
- Check PuTTY log file contains the data displayed

WARNING

Once a base has been formatted to remove the logs the data is non-recoverable. Only format the base when you are sure the data has all been extracted.

2.6. Converting Log Data

Once the data has been extracted from the base station tag, the raw data needs to be converted to more suitable files. A Python command line utility called `ConvertMatakiLogs.py` has been provided to automate this. Use it like the example below to output the converted data to a `.zip` file in the same directory:

```
C:\> ConvertMatakiLogs.py example/data.log
```

3. Setting Up a Mataki-Classic Base Station

In order to start collecting data with a Mataki-Classic base station, it must be configured and started correctly. There are two methods possible to provide power to a base station, connected to a support board and connected to a battery, each having a different series of steps before starting to collect data. The steps for each type are listed below:

- **Connected to a support board**

    1. Ensure the tag has been loaded with the Base application firmware
    2. Set the battery switch (red switch on the tag) to the OFF position
    3. Set the configuration (ID, Base frequency etc.)
    4. Set the time by typing, for example

        ```
        time 14:30:00 13.02.2018
        ```

    5. Perform an `f_reset` to clear the log (this may take a few minutes)
    6. After reset the tag gives you 30 seconds to type 'abort' then starts acting like a base station

- **Running on battery (not connected to a support board)**

    1. Ensure the tag has been loaded with the Base application firmware
    2. Set the battery switch (red switch on the tag) to the OFF position
    3. Connect a battery to the tag
    4. Temporarily insert the tag into a support board
    5. Set SW2 (charger) switch to the ON position
    6. Set the battery switch (red switch on the tag) to the ON position
    7. Set the configuration (ID, Base frequency etc.)
    8. Set the time by typing, for example

        ```
        time 14:30:00 13.02.2018
        ```

    9. Perform an `f_reset` to clear the log (this may take a few minutes)
    10. Carefully pull the tag from the support board. If the User LED (red LED on the tag) flashes during or briefly after removal, then the base has reset and must then be reconfigured. Go back to step 2 and repeat the steps. Otherwise, the tag is now running as a base station.

4. Batteries

4.1. Overview

Both Mataki-Classic and Mataki-Lite use a 3.6V battery. A capacity of around 100mAh is typical for Mataki-Lite as it is designed to be as small as possible. Mataki-Classic is often run with batteries up to 1000mAh and, for base stations, even larger batteries can be used. The battery type (chemistry) is not important providing the voltage is around 3.5-4.2V but typically this means a Lithium-Ion or Lithium-Polymer battery. These types of batteries have shipping restrictions so please check there are no flight restrictions before flying with them.

On Mataki-Classic the battery is connected by a JST SM04B-SRSS-TB connector (Farnell part number 183-0839) with the battery connected on pin 1 (negative) and pin 2 (positive). It is recommended that pre-made cables are bought for this, such as: https://www.digikey.com/short/qjd0n9, as the tools for crimping are very expensive. There is also a small pair of holes next to the battery switch, where a battery can be directly soldered (positive and negative are marked on the bottom of the board). See Mataki-Classic User Guide for more details.

On Mataki-Lite the battery is connected instead by a Molex Picoblade (Farnell part number 112-5373) with negative on pin 1 and positive on pin 2. It is recommended that pre-made cables with connectors are bought for this, such as https://www.digikey.com/short/qjd0nz. Batteries with the right connector can be bought, but these often have the polarity of the pins incorrect. These can still be used if the pins are swapped over using a small screwdriver to release the plastic latches holding the crimps in place. See Mataki-Lite User Guide for more details.

WARNING

Check the polarity of the battery very carefully before inserting as inserting it the wrong way round is likely to cause permanent damage to the tag

4.2. Battery Life Estimation

For Mataki-Lite: An approximation for the battery life can be calculated using the 100mAh table below. The line in bold is the default 10 minute GPS fixes used by the example tracker script. For a different battery size, multiply the values accordingly e.g. for a 200mAh battery with 10m GPS intervals, battery life would be double 8.9 days at 17.8 days.

This table is available from Debug Innovations on request in an Excel spreadsheet form where the values are calculated automatically.

Battery life is notoriously difficult to estimate and many assumptions are build into this table. The key to good battery life is to minimise the GPS 'on time' because the GPS takes about 35mA whereas the tag in a sleep state only take about 40uA, roughly 1/1000th of the current.

Note: At about 3000 logs, the log will be full. Change battery size and GPS interval to keep under this limit.

Mataki-Lite using **100mAh** battery and 20s radio every hour				
GPS interval (seconds)	**Average current (mA)**	**Battery life (hours)**	**Battery life (days)**	**Logs used (entries)**
10	16.20	6.2	0.3	2222
60	2.87	34.9	1.5	2094
120	1.53	65.3	2.7	1958
300	0.73	136.6	5.7	1639
600	**0.47**	**214.8**	**8.9**	**1289**
1200	0.33	301.0	12.5	903
1800	0.29	347.5	14.5	695
3600	0.24	411.0	17.1	411

For Mataki-Classic in base mode: The radio is always on taking an average current of approximately 20mA. So:

- A 1000mAh battery would last for 50 hours
- Each day requires 480mAh

Using a car battery (12V) or a phone charger pack (USB 5V) with a suitable voltage regulator can also work for base stations.

5. Radio Range and Antennas

5.1. What is the radio range?

A common question is "What is the radio range?". Unfortunately it isn't an easy question to answer because it depends on so many factors:

- Type of antenna
- Height of antenna
- Tuning of the antenna (antennas are de-tuned by their proximity to conductive objects and people/animals). They work best in the open as far away from objects and the ground as possible.
- Proximity of other radio users
- Hills, objects and buildings between or near the radios
- The weather

To minimise power consumption and to comply with regulations, the transmission power is limited and the receiver sensitivity depends on how much other radio 'noise' there is around. In a city with high rise buildings and thousands of mobile phones and other radio sources, if you use small antennas, the radio range may be limited to a few hundred metres. On the other hand, if you have a base station on a high hill connected to a 'white stick' or Yagi antenna on an isolated island surrounded by the sea, you may get 10km or more range if the weather is good (eventually the horizon becomes the limit, which depends on the height of the base station antenna and the height of the tag, which could be very high on a bird).

A different way to answer the question is "Under typical conditions, the range is around 1-2km". Those conditions are:

- Good antenna on the base station
- Wire antenna on the tags
- Not in a city
- No obstructions
- Fine weather

But there are no guarantees. For example near the Debug Innovations site, there is a base station for Tetra radios (police, ambulance etc.). It has such a strong signal that we have to use a radio filter on our antennas when we want a

long range. Every site is different and reliable long range communications requires tuning the setup with expensive equipment.

5.2. How close can I put the base stations?

Another common question is "How close can I put the base stations?". The simple answer is twice the maximum radio range for guaranteed non-interference (a tag exactly half way between base stations can only contact one of them at most).

Unfortunately a consequence of the massive variability in radio range means that for a bird which flies high, the range might be 25km, which means the base stations would have to be 50km apart to be sure they wouldn't interfere. The conclusion is it is simpler not to use more than one base station.

5.3. Antenna Choices

Mataki-Lite tags use a wire antenna. It is cut to a length of 85mm for 868MHz and 80mm for 916MHz operation. It operates best when straight and vertical but in reality it is often bent round - it will still work but not as well.

Mataki-Classic tags have a choice of antenna:

- A ceramic component as shown in the photo in section 1.1
- A wire can be soldered to the lower pin of the ceramic antenna patch
- On PCB V5.4 and above, an SMA patch is provided

The SMA connector should be used for the base station if possible and an external antenna for the selected frequency attached.

- Be careful about regulations if you use directional antennas such as a Yagi since the power in the right direction can exceed the regulations in your country
- You can add RF filters in the cable to remove local interference sources
- Don't put any amplifiers in the cable. This is a transmitter as well as a receiver.