

# MAD-AS Remote Battery Test Report

Version 1.0

## Introduction

MAD-AS is an innovative, small, low-cost automatic sampler for stormwater and wastewater sampling. Recently, the BoSL team built the HC-12 radio module in the MAD-AS device and realised the remote control of the MAD-AS device. With the help of a nearby additional microcontroller equipped with the SIM card, the MAD-AS can be controlled over the webserver to start and stop sampling, and its status can also be viewed nearly real-time.

The introduction of the MAD-AS Remote allows the researchers to have the flexibility to choose and control the sampling period of the samplers according to the changing environment (for example, the researchers want to wait for the wet weather sampling). Previously, the fieldwork crews have to activate a certain sampling program when deploying the samplers in the field, hence the sampling period is largely limited and not flexible at all.

Although the MAD-AS Remote is designed to have extremely low power consumption, it is still very important to understand the capability of two small 3.7V batteries, as the device will be deployed in the field for a significantly longer period in the field for research purposes. This report aims to present the result of the simple battery test in the lab. Please note that this test is based on the current MAD-AS version in use, a new design with the changed battery configuration is in development, and a new battery should be tested with this future version.

## Method

The battery test was done in the air, not in the water where the device is normally deployed in. The MAD-AS Controller (the nearby additional microcontroller with SIM card) and MAD-AS Sampler were set up with the following programs.

MAD-AS Controller:

- Sleeps for 5 minutes 30 seconds each time before checking the web command;
- Once the web command is received, the controller communicates to the MAD-AS Sampler (1s sending and 1s listening) until a response is received from the MAD-AS Sampler;
- Once the response is received, the controller begins listening for the cycle counter, if any message is received, it sends the message to the web before going back to listen again;
- If no radio message is received for 2 hours, the controller sends the last message to the web again before sleeping forever.

MAD-AS Sampler:

- Sampling for 20 spins every 15 mins for 100 days;
- Checks the radio command for 4 seconds, followed by 30-second sleep;

- Before each sampling cycle, checks the radio command for 4 seconds;
- After each sampling cycle, sends the radio command for 4 seconds;

Two tests were performed, the first one was to test the battery life after the sampling program started, and the second was to test the battery life when the sampler was waiting for the command from the web server (both Controller and Sampler keep listening for commands as programmed until batteries are dead).

## Result

Test 1:

- The Sampler ran for 734 intervals within 7.67 days and the Controller's battery was still healthy. MAD-AS Controller Battery Voltage: 3.74V (according to past experience, 40% of the battery is used); MAD-AS Battery Voltage: 3.55V (battery 1) and 2.64V (battery 2). The Sampler died because battery 2 was dead.
- 5 out of 734 cycles were not sent to the web server due to unknown reasons.
- After filtering out the missed cycles, it is found that all other cycles were sent to the web server timely.

Test 2:

- The Sampler listened for commands for around 14 days, and the Controller's battery was nearly dead (according to past experience). MAD-AS Controller Battery Voltage: 3.41V; MAD-AS Battery Voltage: 4.13V (battery 1) and 1.44V (battery 2). The Sampler died because battery 2 was dead.

## Conclusion

If the MAD-AS Sampler's sampling program is activated immediately, the Sampler can last for 7 days (20 spins of water sample every 15 minutes); If the MAD-AS is turned on and keeps listening for the activation command, the Sampler can last for 14 days. The actual battery life for any sampling scenario can be estimated in proportion to the waiting time and sampling time. The field environment may affect the performance of batteries.

The newer version of MAD-AS in development involves the improvement of the battery configuration, as the current version dies because battery 1 is always more consumed and it dies first. Therefore, it is anticipated that the newer version will have a better battery performance. New experiments will be conducted for the new version once it is finished.