August 17, 2017
Test Report: 17D0410-1

# TEST REPORT

**CLIENT:** Union Cycliste Internationale
Ch. De la Mêlée 12
Aigle, Suisse CH1860

**OBJECTIVE:** To determine the efficacy of a scanner intended to detect the presence of hidden electric motors in carbon bicycles.

**BACKGROUND:**

Microbac Laboratories is a third party, independent testing laboratory, based in Boulder, Colorado, in the United States. Microbac serves a variety of industries, including aerospace, pharmaceutical, medical, underground plastic pipe, industrial machinery, and the bicycle industry, among others. Microbac has existed in continuous operation since 1961, formerly Hauser Laboratories, before being acquired by Microbac in 2002. Microbac's bicycle testing began in 2006, in chain tensile testing. Today, Microbac serves a broad range of bicycle industry clients and products, with testing services offered for ISO, ASTM, and client custom research and development methods. Staff members of Microbac have served on ASTM and ISO bicycle standards development committees since 2009.

In January, 2016, the first confirmed case of the use of an electric motor intended to provide assistance to a racer was discovered (referred to commonly as "technological fraud" or "mechanical doping"). The UCI developed a scanning device and proprietary software for use by race officials to aid in the detection of motors at race venues.

Microbac was contracted by the client to independently validate motor detection equipment. The equipment to be tested was a scanner and tablet used to detect the presence of hidden electric motors inside the frames of carbon bicycles. The scanner operates by establishing a reference ambient magnetic field, and identifying disturbances in the established field during the scanning of a bicycle. Metal components of sufficient size within the bicycle frame interrupt this magnetic field, which registers on the tablet, which is an Apple iPad. The magnitude of the magnetic field interruption is quantified by the proprietary UCI software, and registers a value from 1-10 on the tablet, with 10 being the strongest disruption. The general concept of the scanning device is to detect magnetic field disruptions around the entirety of the bicycle frame and associated components, which then, in turn, triggers additional inspection by race officials.

Because of the inherent magnetic field signature produced by the components of electric motors, the principle upon which the detection method was developed is based in sound physics.

The author of this test report attended a training course delivered to USA Cycling race officials on February 10, 2017, which was conducted by UCI Technical Manager, Mark Barfield. The training included instruction on the proper use of the scanning device and associated software, and was the instruction used in performing all testing at Microbac.

**SAMPLES:** Two (2) UCI iPads, equipped with a custom electric motor detection sensor and applicable software, arrived at Microbac Laboratories on February 9, 2017. The iPads are referred henceforth as the UCI Scanners, and are shown in Figures 1 and 2. The sensor on each Scanner, as previously described herein, is designed to detect the presence of and disturbances in a magnetic field, created by electric motors.

Four (4) bicycles of carbon fiber construction arrived at Microbac Laboratories for testing on various dates in March 2017. Two of the bicycles were provided by employees of SRAM, and two were provided by employees of Shimano, neither of whom had knowledge of the testing to be performed. The client requested that the bikes exhibit a mix of the most common types of racing bicycles and their accompanying drivetrains. This includes both mechanical and electronic drivetrains from major manufacturers Shimano and SRAM. The different drivetrain types were selected to investigate any interference between the electronic drivetrains and the UCI Scanner. The bikes are listed below, and shown in Figures 3 through 6.

- Focus Cayo carbon, size small, SRAM Rival mechanical drivetrain
- Cannondale Supersix Evo carbon, 48cm, SRAM Red Etap electronic drivetrain
- Cannondale Supersix Evo carbon, 56cm, Shimano Dura-ace mechanical drivetrain
- Trek Emonda SL carbon, 50cm, Shimano Ultegra Di2 electronic drivetrain

One (1) additional bicycle frame, fork, and drivetrain was provided by the client for testing. This frameset was a Wilier Cento1 Cross carbon cyclocross frame and fork, and is shown in Figure 7. This frameset had a known bicycle-specific motor installed into the seat-tube.

Microbac attempted to acquire motors designed for drive assistance at the crank spindle and intended to be placed in the seat tube, but was unsuccessful. A motor of comparable physical size was selected for validation of the scanning equipment. Physical size was prioritized so the motor could be hidden in a frame, and a blind test be executed by Microbac staff, without knowledge of the motor's location. The motor selected for testing was a Micromo series M3138U DC micromotor with 6V windings and output power of 19.65 watts. It should be noted that typical crank-spindle mounted assistance motors can reportedly produce 250 or more watts of power, and therefore the Micromo motor would theoretically be more difficult for the Scanner to detect because of its lower power output and fewer windings. The motor used in testing herein is shown in Figure 8.

**TESTING:** For the testing of hidden motors inside bicycles using the UCI Scanner, Microbac employees were instructed to hold the Scanner horizontal to the ground, and perpendicular to the centerline of the bicycle on the non-drive side, per the proper use instructions of the scanner. They were instructed to scan the entire bicycle including frame, fork, and wheels. They were instructed to move the scanner in an arbitrarily slow manner along the surfaces of the bicycle at specified distances, defined by the test procedure.

A "blind test" was developed by Microbac to determine the efficacy of the UCI Scanner. A motor was placed in the downtube of one of the four test bikes, chosen at random. The motor came to rest at or near the bottom bracket, and the bicycle was fully reassembled to leave no indication as to which bicycle contained the hidden motor.

Employees of Microbac were given instruction in the proper use of the Scanner. These employees, who had no knowledge of within which bicycle the motor resided, were then instructed to scan each of the four bikes, including the entirety of the frameset and both front and rear wheels, and report the highest observed Scanner reading. The test incorporated 4 replicates of testing, and each replicate incorporated 5 varying distances between the scanner and bicycle frame, in 10 mm increments. The purpose of the distance variable was to understand at which point the motor signal dissipated to the point of non-detection.

The testing also included the fifth carbon fiber bicycle frame, the Wilier Cento1 Cross frame, which contained a known motor, and was used as a control in the study. This frame was not tested in replicate, but did also incorporate the stepped 10mm Scanner distance increments. The operator did know a motor was present in this frame, and was not a part of the blind testing.

**RESULTS:** Results for the hidden motor tests, using the UCI Scanner, were recorded and are shown in Table 1 below. The numbers correspond to the highest number observed from each scan, and are on a scale from 1-10, with 10 being the strongest signal that could be measured.

The columns of the table below indicate each replicate of testing. Each set of rows indicates a different specified distance the Scanner was held from the bicycle. The yellow boxes in the table indicate which bicycle contained the motor in each instance.

| | Bike w/ motor | Replicate | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Operator | 1 | Operator | 2 | Operator | 3 | Operator | 4 |
| | | Time of run | | Time of run | | Time of run | | Time of run | |
| Scan performed 50mm from frame | Focus | 15:12 | 2 | 10:06 | 0 | 13:17 | 6 | 10:25 | 0 |
| | Cannondale Supersix large | 15:22 | 0 | 10:10 | 0 | 13:16 | 6 | 10:25 | 0 |
| | Cannondale Supersix small | 15:23 | 0 | 10:08 | 2 | 13:15 | 0 | 10:25 | 0 |
| | Trek Emonda | 15:21 | 1 | 10:04 | 1 | 13:15 | 1 | 10:25 | 1 |
| Scan performed 40mm from frame | Focus | 15:26 | 4 | 10:15 | 1 | 13:20 | 10 | 10:33 | 0 |
| | Cannondale Supersix large | 15:25 | 1 | 10:14 | 1 | 13:19 | 10 | 10:31 | 0 |
| | Cannondale Supersix small | 15:28 | 0 | 10:13 | 2 | 13:19 | 1 | 10:31 | 1 |
| | Trek Emonda | 15:24 | 1 | 10:12 | 3 | 13:18 | 2 | 10:30 | 2 |
| Scan performed 30mm from frame | Focus | 15:31 | 6 | 10:20 | 0 | 13:23 | 10 | 10:38 | 1 |
| | Cannondale Supersix large | 15:30 | 2 | 10:19 | 5 | 13:22 | 10 | 10:37 | 0 |
| | Cannondale Supersix small | 15:32 | 0 | 10:18 | 3 | 13:22 | 0 | 10:36 | 2 |
| | Trek Emonda | 15:29 | 0 | 10:17 | 10 | 13:21 | 1 | 10:35 | 3 |
| Scan performed 20mm from frame | Focus | 15:35 | 10 | 10:26 | 0 | 13:25 | 10 | 10:43 | 1 |
| | Cannondale Supersix large | 15:34 | 2 | 10:28 | 0 | 13:25 | 10 | 10:42 | 0 |
| | Cannondale Supersix small | 15:36 | 1 | 10:25 | 7 | 13:24 | 0 | 10:42 | 2 |
| | Trek Emonda | 15:33 | 0 | 10:23 | 10 | 13:23 | 1 | 10:40 | 10 |
| Scan performed 10mm from frame | Focus | 15:39 | 10 | 10:32 | 0 | | 10 | 10:48 | 0 |
| | Cannondale Supersix large | 15:38 | 2 | 10:33 | 10 | 13:27 | 10 | 10:48 | 0 |
| | Cannondale Supersix small | 15:40 | 1 | 10:32 | 10 | 13:27 | 0 | 10:48 | 0 |
| | Trek Emonda | 15:37 | 1 | 10:31 | 10 | 13:26 | 3 | 10:46 | 10 |
| Scan performed 0mm from frame | Focus | 8:37 | 10 | 10:38 | 1 | 13:29 | 10 | 10:54 | 1 |
| | Cannondale Supersix large | 8:38 | 10 | 10:38 | 0 | 13:29 | 10 | 10:52 | 10 |
| | Cannondale Supersix small | 8:37 | 10 | 10:37 | 10 | 13:28 | 0 | 10:52 | 6 |
| | Trek Emonda | 8:35 | 10 | 10:37 | 10 | 13:28 | 7 | 10:51 | 10 |

| Wilier Frame with Motor (control) | |
|---|---|
| Operator | RLT |
| Distance (mm) | Reading |
| 40 | 1 |
| 30 | 4 |
| 20 | 2 |
| 10 | 10 |

**Table 1: Hidden motor testing matrix. Boxes highlighted yellow indicate the bicycle with the hidden motor installed.**

August 17, 2017
Test Report: 17D0410-1

**CONCLUSION:** The UCI Scanner detected the hidden motor in 100% of the scans executed by trained staff when the Scanner was positioned 10mm or less from the bicycle. The successful function of the Scanner was validated independent of operator, bicycle brand, bicycle size, or drivetrain, and was successful in identifying both the test motor, and the known bicycle-specific motor installed in the Wilier Cento1 Cross frame.

No false negatives were observed (i.e. a low or zero reading when scanning an area with a motor installed).

Several false positives were observed, where the Scanner produced high readings on a bicycle without a motor installed. These false positives were noted exclusively in areas with high metallic concentrations, such as bearings or bottom bracket shells. False positives should not be considered a failure of the system; additional training may improve recognition of a false positive due to metallic components, or a false positive may trigger further inspection.

Proper distance of the Scanner was observed to be of critical importance. Successful detection of the motor was observed in 100% of cases at 0 and 10mm, 75% in distances at 20mm, and efficacy further declined at 30mm and beyond.

**REPORT WRITTEN BY:**

Russell Willacker
Forensics Department Manager

**DATA REVIEWED AND REPORT REVIEWED BY:**

Larry Drake
Managing Director,
Microbac Laboratories, Boulder Division

**Figure 1: UCI Scanners**


**Figure 2: UCI Scanners**


**Figure 3: Focus Cayo carbon, small size, SRAM Rival mechanical drivetrain.**

**Figure 4: Cannondale Supersix Evo carbon, 48cm, SRAM Red Etap electronic drivetrain.**


**Figure 5: Cannondale Supersix Evo carbon, 56cm, Shimano Dura-ace mechanical drivetrain.**


**Figure 6: Trek Emonda SL carbon, 50cm, Shimano Ultegra Di2 electronic drivetrain.**


**Figure 7: Wilier Cento1 Cross carbon cyclocross frame and fork, with known, bicycle specific motor contained in the seat-tube.**


**Figure 8: Micromo series M3138U DC micromotor with 6V windings and output power of 19.65 watts.**