Electrical instructions

1. Electrical assembly platform

**Timing:** 1h

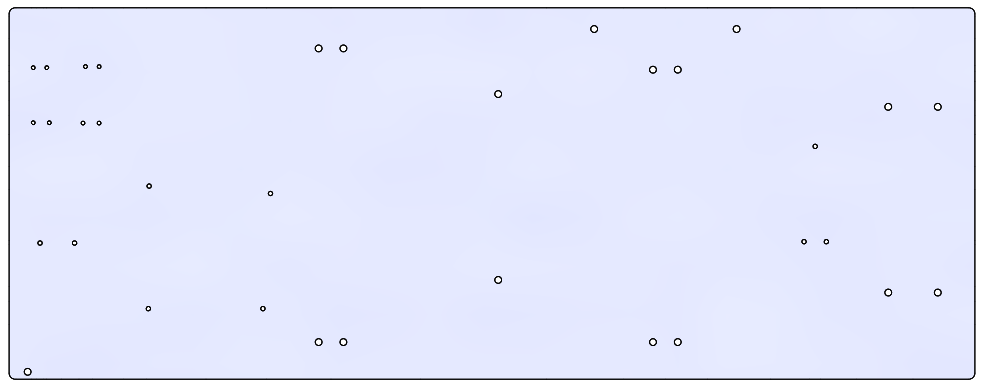
**Materials:** Aluminium plate, electrical components (power supplies, controller boards, din rail components, cable carrier).

**Equipment:** Screws, nuts and spacers (M3, M4 and M5), M3 male nylon spacers and nuts, Allen keys.

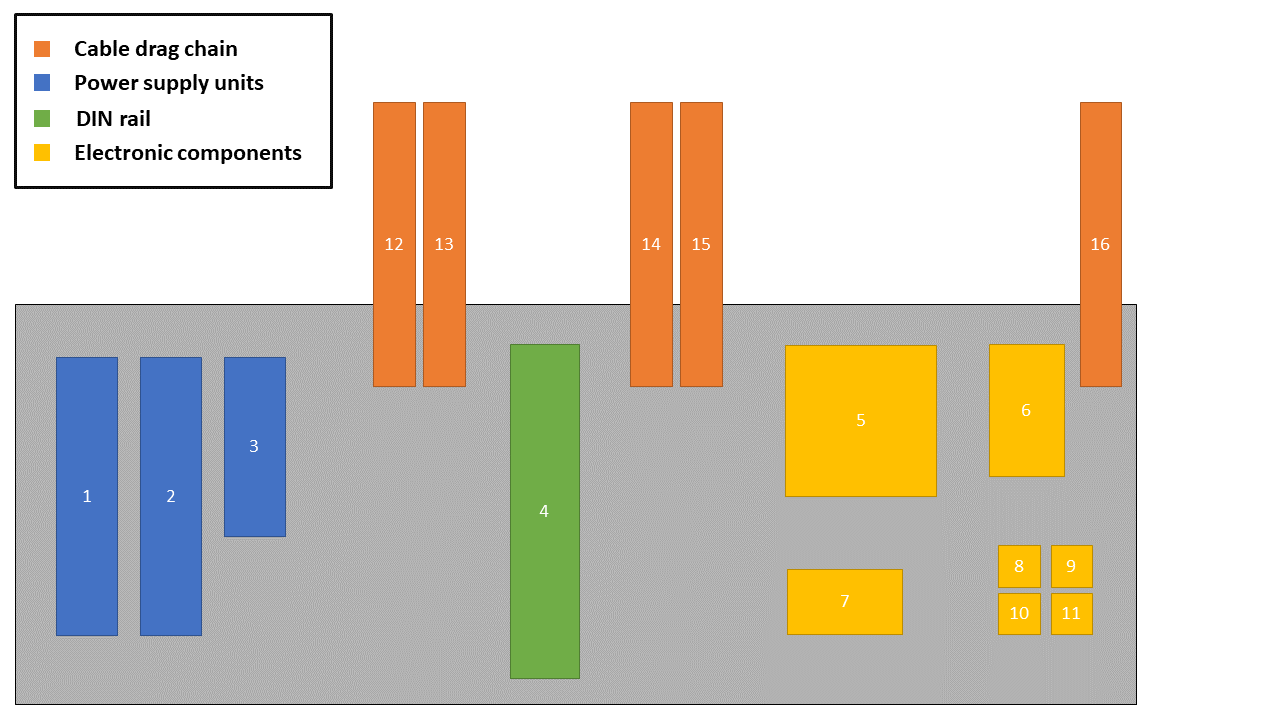
**Critical:** Make sure that mechanical components are not in contact with any electrical circuits (especially when assembling small electronic devices).

The aluminium plate of dimensions 770x290x3mm (**Figure 1**) was used as a base to assemble most of the electrical components of the MEW platform. **Figure 2** shows the location of the electrical components on the Aluminium plate. each device was numbered to simplify the assembly.

1. Use M3 screws to mount 12VDC PSU (1), 48VDC PSU (2) and 24/5 VDC PSU (3).
2. Use M4 screws to mount din rail (4).
3. Use M3 Nylon spacers to mount Smoothieboard (5) and create a gap between the device and the asluminium plate.
4. Use M3 screws to mount Arduino Due (6) using a provided plastic base plate.
5. Attach mini breadboard (7) using adhesive.
6. Mount two thermocouple amplifiers (8, 9) and two digital-analog converters (10, 11).
7. Prepare attachment point for five cable carriers (12-16).



**Figure 1**. Aluminium assembly plate ensures quick and straightforward placement of electrical components.



**Figure 2**. Distribution of electrical components across the aluminium assembly plate. There are 3 power supplies (blue), 1 din rail (green), 7 electronic components (yellow) and five cable carriers (orange).

1. Cable carriers

**Timing:** 0.5h

**Materials:** As listed in the kit documentation.

**Equipment:** M4, M5 Allen key.

**Critical:** Test whether the length of each cable carrier is sufficient to allow the drawer to slide out.

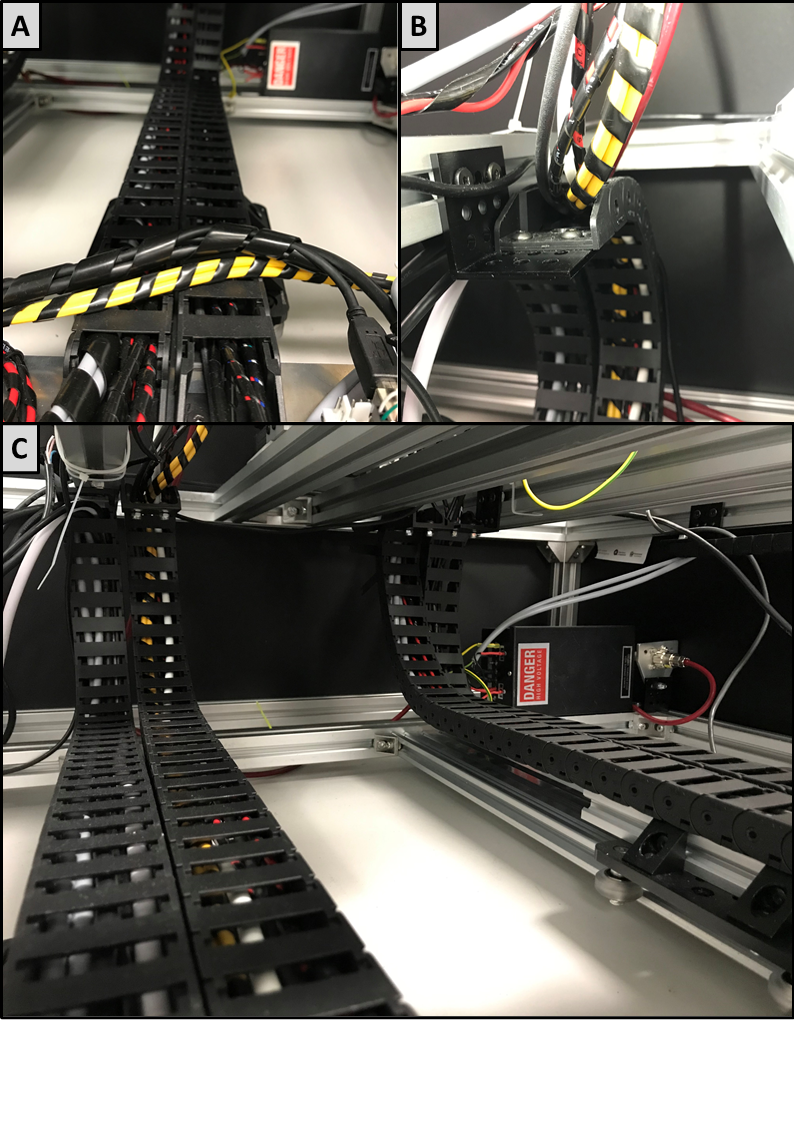
A cable carrier was used to provide a neat and convenient way of guiding electrical connections to sensors and actuators. Since the electrical components were mounted on a withdrawable aluminium plate, a cable carrier provided a great solution to maintain a secure and safe connection for moving electrical connections.

The instructions of cable carrier assembly are available online 1,2

The bottom end of each cable carrier is attached to the aluminium base plate (**Figure 3A**) while the top end is attached to the aluminium profile (**Figure 3B**) using L-shaped brackets. **Figure 3C** shows a final cable carrier assembly.

1<https://www.youtube.com/watch?t=1618&ref=0dnte9dlczx&v=6LY1KcPJ4s4&feature=youtu.be&ab_channel=OpenBuilds>

2<http://makerhardware.net/wiki/doku.php?id=add_on_packs:cable_drag_chain_mounting_pack>



**Figure 3**. Cable carrier assembly. **A)** Bottom end of the cable carrier was assembled staring onto the Aluminium plate. **B)** Top end of the cable carrier was mounted to an aluminium profile using an L-shaped bracket. **C)** Assembled cable carriers.

1. Smoothieboard

**Timing:** 1h

**Materials:** 1mm2 power cables, 0.5mm2 4-core cable, thermocouple, thermocouple extension cable, thermocouple female connector, thermocouple amplifier, XT60 connectors, stepper motors, phoenix connectors (supplied with Smoothieboard), USB type A (male) to USB type B (male) cable.

**Equipment:** Wire strippers, wire crimping tool.

**Critical:** Make sure all connections are correctly wired before turning the power on.

The Smoothieboard connection diagram is shown in **Figure 4**. Refer to this figure during the wiring process.

1. Connect x-axis stepper motor to Smoothieboard. Connect ENA+, DIR+ and PUL+ motor pins to EN1, DIR2, ST1 on Smoothieboard. GND is connected to ENA-, DIR- and PUL-
2. Repeat step 1) for the y-axis and z-axis stepper motors using EN2, DIR2, ST2, EN3, DIR3, ST3. For detailed motor documentation refer to the stepper motor datasheet3.
3. Use dip switches and a lookup table printed each stepper motor to select microstepping to 6400.
4. Connect thermocouple amplifiers4.
5. Use a thermocouple extension cable and female a thermocouple connector to connect both syringe and ring thermocouples to the corresponding amplifiers.
6. Connect ring and syringe heaters using XT60 and phoenix connectors.
7. Connect 12VDC PSU.
8. Connect USB-TTL cable via a panel-mount USB connector.
9. Connect Smoothieboard to the PC via a panel-mount USB connector.

3 <https://www.omc-stepperonline.com/download/ISS23-10.pdf>

4 <https://www.adafruit.com/product/1778>



**Figure 4**. Simplified Smoothieboard circuit diagram. Three stepper motors, thermocouples, thermocouple amplifiers, nozzle and syringe heaters are connected to Smoothieboard. The computing unit is connected to via USB while the 12VDC power supply provides power to the microcontroller board.

1. Arduino

**Timing:** 2h

**Materials:** Jumper cables, USB A to USB micro cable, 1mm2 power cables, 0.5mm2 4-core cable, pressure regulator with a connecting cable, pressure sensor with a connecting cable, solder, resistors, operational amplifiers, capacitors, pin headers.

**Equipment:** Wire strippers, wire crimping tool, soldering iron, tweezers.

**Critical:** Make sure the connections are made according to the provided circuit diagram. Make sure the VCC and GND connections are properly wired before testing the circuit.

A custom Arduino PCB shield has been designed to allow several sensors and actuators to exchange data. PCB layout and circuit schematic are available in attached documentation5. **Figure 5** shows a simplified circuit diagram.

Note: The PCB design includes components that are not used in the presented version of the MEW platform and can be considered as a future improvement.



**Figure 5**. Simplified Arduino Due and PCB shield circuit diagram. Pressure sensor, pressure regulator, high voltage unit, digital-analog converters are connected to Arduino Due via PCB shield.

*5*[*https://github.com/Lasonic/automated\_mew\_platform/tree/master/Electrical%20diagrams/Arduino\_shield\_PCB*](https://github.com/Lasonic/automated_mew_platform/tree/master/Electrical%20diagrams/Arduino_shield_PCB)

*PCB*

1. Solder components (R1-3, U1-6, C1-7) as described in the circuit schematic.
2. Solder header pins to POWER, AD\_L, DIGITAL, COMMS, PWM\_L as shown in.
3. Connect PCB shield to Arduino Due.

*Digital-analog converter*

Refer to Figure 5 and online tutorial6 for wiring instructions of the MCP4725 digital-analog converter.

*Pressure sensor*

Using provided Schmalz connection cable, connect:

1. Pin 1(Brown) to 24VDC via din terminal.
2. Pin 3(Blue) to GND via din terminal.
3. Pin 4(Black) to P3 on PCB.

Next:

1. Connect P2 to AD0 on PCB.

For more details refer to the pressure sensor datasheet7.

*Pressure regulator*

Using provided SMC connection cable, connect:

1. Pin 1(Brown) to 24VDC.
2. Pin 2(White) to Pin 21 on PCB.
3. Pin 3(Blue) to GND.

Next:

1. Connect P19 to pin VOUT on DAC #1

For more details refer to the pressure regulator datasheet8.

*High voltage*

Using 4-core and earth cable, connect:

1. Pin 1 (earth) to the chassis of the platform.
2. Pin 3 to Pin 11 on PCB.
3. Pin 4 to GND on din terminal.
4. Pin 5 to 24VDC.
5. Pin VM (voltage monitor) to pin AD1.
6. Pin CM (current monitor) to pin AD2.

For more details refer to the High voltage datasheet9.

*USB connection*

1. Connect Arduino to the PC via a panel-mount USB connector.
2. Connect USB-TTL cable via a panel-mount USB connector.

6 <https://learn.adafruit.com/mcp4725-12-bit-dac-tutorial/wiring>

7<https://github.com/Lasonic/automated_mew_platform/blob/master/Datasheets/schmalz_pressure_sensor_datasheet.pdf>

8<https://github.com/Lasonic/automated_mew_platform/blob/master/Datasheets/SMC_ITV_datasheet.PDF>

9<https://github.com/Lasonic/automated_mew_platform/blob/master/Datasheets/Gamma_high_voltage_datasheet.pdf>

1. Din terminals

**Timing:** 1h

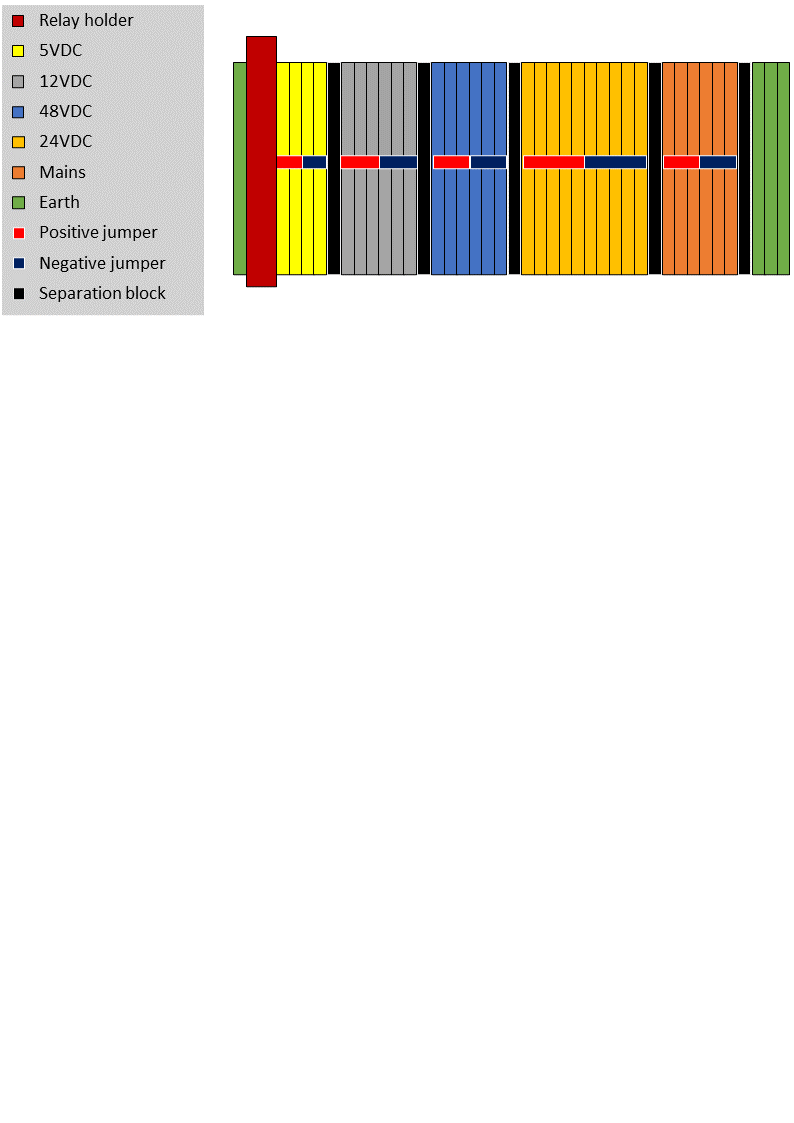
**Materials:** Aluminium din guide rail, din terminals, relay holder, relay.

**Equipment:** M5 Allen key, flat head screwdriver.

**Critical:** Make sure din screw terminals are not shorted with each other (one side of a din screw terminal is exposed and the other one is not).

**Figure 6** shows an assembly diagram of DIN screw terminals.

1. Mount Aluminium din rail.
2. Mount grey din terminals (optional: use separator plate between different voltage levels).
3. Use jumpers to distribute the power between terminal blocks.
4. Mount earth terminals and lock them in.
5. Mount a relay holder.
6. Place a relay inside a relay holder.



**Figure 6**. DIN rail screw terminal assembly diagram. Aluminium din rail and screw terminals are used to supply 5VDC, 12VDC, 24VDC, 48VDC, mains and earth connections of the system. A relay holder provides housing for a 24VDC relay, positive and negative jumpers are used to connect neighbouring terminals, while separation blocks help to keep the design clear and tidy by separating different voltage levels.

1. Power

**Timing:** 1h

**Materials:** Power supply units, IEC wall mount connector, mains cable, 1mm2 power cables, fork and female spade crimp terminals, earth cable, ring crimp terminal, M5 hammer nut, M5 low profile screw.

**Equipment:** Crimping tool

**Critical:** The power system was designed according to Australian standards. Please check and adjust accordingly for other countries.

The power system consists of 3 power supplies: 320W 48VDC, 350W 12VDC, 68W dual output 5 VDC and 24VDC. IEC panel mount connector with a 10A fuse and illuminated switch is used to provide mains power to the platform. Additional earthing connections within the platform were made to ensure safe operation with the HV unit.

**IMPORTANT:** The power system must be checked by a certified electrician. It is **NOT** recommended to perform wiring of mains power, earthing as well as any of the power devices by an unauthorised person.

Once the mains power is connected, make sure the power is switched OFF.

1. Connect the positive and negative output of 48VDC.
2. Use terminal jumpers to distribute accordingly.
3. Connect the positive and negative output of 24VDC.
4. Use terminal jumpers to distribute accordingly.
5. Connect the positive and negative output of 12VDC.
6. Use terminal jumpers to distribute accordingly.

Follow ‘Power distribution diagram.pdf’ in supporting documents10 to connect input power to other electrical devices.

1. Connect 12VDC to Smoothieboard.
2. Connect 24VDC to the pressure regulator.
3. Connect 24VDC to the pressure sensor.
4. Connect 48VDC to the linear actuators.

10<https://github.com/Lasonic/automated_mew_platform/blob/master/Electrical%20diagrams/Power%20distribution%20diagram.pdf>

1. Safety

**Timing:** 1h

**Materials:** Non-contact magnetic switch, earth

**Equipment:** wire strippers

**Critical:** Make sure magnetic switches correctly toggle the electromagnetic relay on and off before connecting high voltage unit.

Non-contact magnetic switches are used along with the relays to make sure the high voltage is disconnected when any doors of the platform are open. This minimises the risk of a user getting shocked by the high voltage. For more details refer to the installation guide “non-contact magnetic switch manual.pdf” available in supporting material11.

1. Connect magnetic **switch#1** Pin 1(Brown) to 24VDC.
2. Connect magnetic **switch#1** Pin 3(Blue) to GND.
3. Connect magnetic **switch#1** Pin 7(Gray) to 24VDC.
4. Connect magnetic **switch#1** Pin 4(Black) to magnetic **switch#2** Pin 7(Gray).
5. Connect magnetic **switch#2** Pin 4(Black) to relay input.
6. Connect relay output to GND.
7. Connect a diode1N4004 between magnetic **switch#1** Pin 1(Brown) and Pin 4(Black)
8. Connect a diode1N4004 between magnetic **switch#2** Pin 1(Brown) and Pin 4(Black)

11<https://github.com/Lasonic/automated_mew_platform/blob/master/Electrical%20diagrams/non-contac%20magnetic%20switch%20manual.pdf>

1. Monitoring and illumination

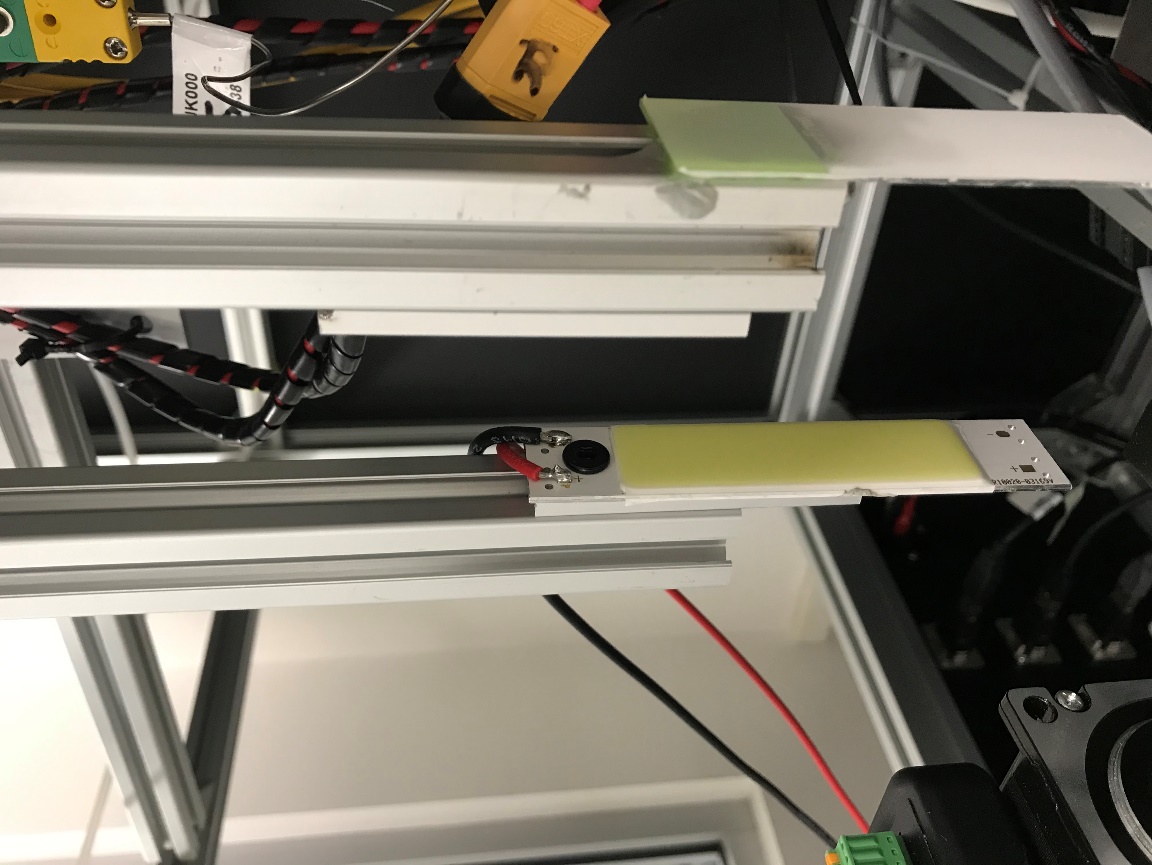
**Timing:** 1h

**Materials:** USB3 cable, lens, camera, LED panel, 12VDC power supply, solder, 0.5mm2 black and red cable, M5 screws and hammer nuts

**Equipment:** Soldering iron, M5 Allen key

**Critical**: Consider heat radiating from the LED at high current operation.

Basler Ace camera is connected with a computing PC via a USB3 cable.

A 20x40mm LED panel was mounted on a 20x20 profile and powered with an external power source as shown in **Figure 7**.

**Figure 7**. LED panel was placed along the axis of the camera to create backlight illumination and obtain a silhouette of the fibre jet.