Hardware Assembly

*Our instructions are intended to be used with our **YouTube videos** that illustrate the different steps. For the hardware assembly watch:* **"How to build the SensorBox – Hardware Assembly"**.

Sensors & Processing Board

We have broken down the assembly of the Sensors & Processing Board into three (3) subsequent steps: **1 Prepare** (solder, ...), **2 Attach** (screws, ...) and **3 Wire** (USB, Qwiic, jumper cables, ...). At each step, go through all components before moving to the next step. Some wiring is done more conveniently during earlier steps, which we identify with the step number, like 2 Wire.

Bottom Plate

1 Prepare: Stick four (4) self-adhesive pads to the underside of the bottom plate.

2 Attach: Insert sixteen (16) M3x4x5 threaded heat inserts with a soldering iron into all the holes on both sides of the bottom plate.

Vision Board

2 Attach: Slide the Vision Board from the side on to the front of the Bottom Plate. If this is difficult, sand the grooves a little bit. Use four (4) M3x6 screws to attach the Vision Board to the Bottom Plate.

FLIR Lepton 3.5 Thermal Camera with GroupGets Pure Thermal 2

1 Prepare: Make sure that the FLIR Lepton 3.5 is pushed well into its socket on the GroupGets Pure Thermal 2.

2 Attach: Insert four (4) M2x4x3.5 threaded heat inserts into the holes of the GroupGets Pure Thermal 2 stands on the Vision Board. Use four (4) M2x4 screws to attach the GroupGets Pure Thermal 2 to its stands on the Vision Board. If the threaded heat inserts do not line up perfectly with the holes, use the soldering iron to adjust them.

3 Wire: Connect the USB cable from the GroupGets Pure Thermal 2 to a USB port on the NVIDIA Jetson Xavier NX Development Board.

MaxBotix HRLV-MaxSonar-EZ4 Ultrasonic Range Finder

1 Prepare: Solder Break Away Headers to all seven (7) pins on the MaxBotix HRLV-MaxSonar-EZ4 Ultrasonic Range Finder. Solder the TTL jumper on the MaxBotix HRLV-MaxSonar-EZ4 Ultrasonic Range Finder to enable TTL on pin 5 (inversion of default provided RS232 signal).

2 Attach: Insert two (2) M2x4x3.5 threaded heat inserts into the holes of the MaxBotix HRLV-MaxSonar-EZ4 Ultrasonic Range Finder stands on the Vision Board. Sand or file away the part of the

stand that interferes with the header. Use two (2) M2x4 screws to attach the MaxBotix HRLV-MaxSonar-EZ4 Ultrasonic Range Finder to its stands on the Vision Board.

3 Wire: Connect the GND (pin 7), V+ (pin 6) and the Serial TTL TX (pin 5) of the MaxBotix HRLV-MaxSonar-EZ4 Ultrasonic Range Finder to the GND (pin GND), V3.3 (pin 3V3) and the UART RX (pin RX/D0) of the SparkFun RedBoard Turbo Development Board using three (3) 20cm male - female jumper wires (black for GND, red for V+ and green for Serial TTL). The UART TX (pin TX/D1) is not and shall not be used.

Intel RealSense D435i RGB-D Camera

2 Attach: Insert four (4) M3x6x4.5 threaded heat inserts into the holes of the Intel RealSense D435i stands on the Vision Board. Use two (2) M3x5 screws to attach the Intel RealSense D435i to the Intel RealSense D435i support. Use four (4) M3x6 screws to attach the Intel RealSense D435i support to its stands on the Vision Board.

3 Wire: Connect the USB cable from the Intel RealSense D435i to a USB port on the NVIDIA Jetson Xavier NX Development Board.

Arducam Sony IMX219 Rolling Shutter RGB Cameras

1 Prepare: Change the FPC 15 pin ribbon cables from the two (2) Arducam Sony IMX219 camera modules against two (2) 30cm long FPC 15 pin ribbon cables. Carefully lift up the plastic tab, that holds the ribbon cable in place. Pull out the ribbon cable and push in the new ribbon cable. Press down on the plastic tab to fix the ribbon cable. Take off the lens protection film.

2 Attach: Insert eight (8) M2x4x3.5 threaded heat inserts into the holes of the two (2) Arducam Sony IMX219 stands on the Vision Board. Use eight (8) M2x4 screws to attach the two (2) Arducam Sony IMX219s to their stands on the Vision Board.

3 Wire: Connect the FPC 15 pin ribbon cables from the two (2) Arducam Sony IMX219 camera modules through the holes in the Processing Board to the MIPI-CSI connectors on the NVIDIA Jetson Xavier NX Development Board. Carefully lift up the plastic tab, that holds the ribbon cable in place. Push in the ribbon cable (blue side outside / contacts inside). Press down on the plastic tab to fix the ribbon cable.

Optional: SparkFun LSM9DS1 IMUs

We are going to connect the two (2) SparkFun LSM9DS1 IMUs using two (2) SparkFun Qwicc Adapters to the SparkFun RedBoard Turbo Development Board. Alternatively, as the Arducam Sony IMX219 are connect to the NVIDIA Jetson Xavier NX Development Board, we can also connect the SparkFun LSM9DS1 IMU to the NVIDIA Jetson Xavier NX Development Board.

1 Prepare: With a soldering iron, solder Break Away Headers to the four (4) I2C pins on the two (2) SparkFun LSM9DS1 IMUs. The header should be pointing up from the board to be later connected to the SparkFun Qwiic Adapters. As we use two (2) SparkFun LSM9DS1 IMUs we need to change the I2C addresses of one of them. Take one of them and use a Carving Craft Knife to cut the trace between

the center and the top pads of the MAG and ACC/GYR jumpers and use solder to short the center and bottom pads to change the address of the magnetometer to 0x1C and the accelerometer and gyroscope to 0x6A.

2 Attach: Insert two (2) M3x6x4.5 threaded heat inserts into the holes of the two (2) SparkFun LSM9DS1 IMUs stands on the Vision Board. Use two (2) M3x6 screws to attach the two (2) SparkFun LSM9DS1 IMUs to their stands on the Vision Board. Place the one with the alternative I2C addresses to the right (seen from the inside).

Optional: SparkFun Qwiic Adapters

1 Prepare: Place the two (2) SparkFun LSM9DS1 IMUs into their locations on the Vision Board. Place the two (2) SparkFun Qwiic Adapters on the Break Away Headers on the SparkFun LSM9DS1 IMUs. Solder the Break Away Headers to the SparkFun Qwiic Adapters.

2 Wire: Connect the two (2) SparkFun Qwiic Adapters to the Qwiic I2C daisy-chain from the SparkFun RedBoard Turbo Development Board. Connect the two (2) SparkFun Qwiic Adapters with a 50mm Qwiic cable and the right SparkFun Qwiic Adapter with a 100mm Qwiic cable to the SparkFun TMP 102 Temperature Sensor.

Battery

2 Attach: Insert sixteen (16) M3x4x5 threaded heat inserts into all the holes on the top (for the Sensor Board) and on the back (for the Processing Board) on the four (4) Battery Stands. Use eight (8) M3x6 screws to attach the Battery Stands to the top of the Bottom Plate. The holes for the Processing Board should face to the right side (looking at the bottom plate from where you can read the text). Insert two (2) 14 inch zip ties into the Battery Stands, from the top left, to top right, to the bottom right, and then back to the bottom left. Insert the tip (only a few mm) into the head and then pull in the head tight to the Battery Stand. Push the USB-C power bank in the Battery Stand through the zip ties so that the front of the USB-C power bank with the connectors faces the back of the Bottom Plate (where the text is). If the USB-C power bank is smaller than the provided space, use double sided tape to make it fit snug. Tighten up the zip ties. You should be able to swing the Bottom Plate with the USB-C power bank around without that the power bank moves. Cut off the ends of the zip ties.

Power Board

2 Attach: Do part of the 2 Attach step of the Sensor Board (next component) first. Use two (2) M3x6 screws to attach the Power Board to the bottom side of the Sensor Board.

SparkFun USB-C Power Delivery Board

1 Prepare: Solder a 2 pin Screw Terminal Block Connector to the VSNK and GND pins on the SparkFun USB-C Power Delivery Board. Take a look at the USB-C Power Delivery part in the software setup section and set up the power delivery of the SparkFun USB-C Power Delivery Board to provide power for the NVIDIA Jetson Xavier NX.

2 Attach: Insert four (4) M3x6x4.5 threaded heat inserts into the holes of the M3x6 stands for the SparkFun USB-C Power Delivery Board on the Power Board. Use four (4) M3x6 screws to attach the SparkFun USB-C Power Delivery Board to its stands on the Power Board.

2 Wire: Connect the USB-C power bank with the USB-C male to male 100W power cable to the SparkFun USB-C Power Delivery Board. Use a multimeter to measure 20V between the VSNK and GND pins (connected to the terminal block) on the SparkFun USB-C Power Delivery Board.

ZIO INA219 Current and Voltage Sensor

2 Attach: Insert four (4) M3x6x4.5 threaded heat inserts into the holes of the ZIO INA219 Current and Voltage Sensor stands on the Power Board. Use four (4) M3x6 screws to attach the ZIO INA219 Current and Voltage Sensor to its stands on the Power Board.

2: Wire: Stripe the ends of an about 30mm long red 22AGW wire with a wire stripper. Connect the + pole of the screw terminal on the SparkFun USB-C Power Delivery board to the – pole of the screw terminal on the ZIO INA219 Current and Voltage Sensor. Connect a 200mm Qwiic cable to the Qwiic connector on the ZIO INA219 Current and Voltage Sensor and slide the other end of the cable through the hole in the Power Board.

DC Barrel Jack Connector

2: Wire: Stripe the ends of a 270mm long red, a 460mm long red and a 230mm black 22AGW wire with a wire stripper. Crimp a male and a female quick disconnect terminal connector with a crimper to the ends of one side of the red wires. These quick connectors will be connected to the quick connectors connected to the push button in the cover when the cover is put on. Using a male and female connector allows to short-cut the wires easily so that the push button is not required to power the SensorBox. Put two (2) red heat shrink tube (just preparation, no heat) over the red wires to join them together, and two (2) black heat shrink tubes over the 270mm long red wire and the black wire. Connect one end of the black wire to the - pole of the screw terminal on the SparkFun USB-C Power Delivery board. Connect the other end of the 270mm long red wire to the – pole of the screw terminal on the ZIO INA Current and Voltage Sensor. Connect the other end of the black wire to the – pole of the DC Barrel Jack connector. Connect the other end of the 460mm long red wire to the + pole of the DC Barrel Jack connector. Position and heat the heat shrink tubes using a heat gun to make them fit. Just for testing, short-cut the wires by connecting the male and female connectors. Use a multimeter to measure 20V between the inside (+ red) and the outside (black) of the DC Barrel Jack connector.

Sensor Board

2 Attach: Before the 2 Attach step of the Power Board (previous component), insert two (2) M3x4x5 threaded heat inserts into the holes for the Power Board on the bottom of the Sensor Board. Use eight (8) M3x6 screws to attach the Sensor Board to the top side of the Battery Stands.

SparkFun RedBoard Turbo Development Board (Arduino Zero)

2 Attach: Insert three (3) M3x6x4.5 threaded heat inserts and one (1) M2x6x3.5 threaded heat insert into the holes of the SparkFun RedBoard Turbo Development Board stands in the back right location

on the Sensor Board. Use three (3) M3x6 screws and one (1) M2x6 screw to attach the SparkFun RedBoard Turbo Development Board to its stands on the Sensor Board. The M2 screw is used for the tiny hole on the SparkFun RedBoard Turbo Development Board close to the USB connector.

2 Wire: The sensors will be connected via a Qwiic I2C daisy-chain to the Qwiic connector on the SparkFun RedBoard Turbo Development Board. We didn't need to, but when daisy-chaining 7x I2C devices on the same bus you may want to disable the I2C pull-up resistors, by cutting the jumpers, on some of the boards.

3 Wire: Connect the SparkFun RedBoard Turbo Development Board from its USB port with a 90° micro USB to USB cable to a USB port on the NVIDIA Jetson Xavier NX Development Board.

SparkFun TMP102 Temperature Sensor

1 Prepare: Solder a Break Away Header to the INT pin on the SparkFun TMP102 Temperature Sensor.

2 Attach: Insert four (4) M3x6x4.5 threaded heat inserts into the holes of the SparkFun TMP102 Temperature Sensor stands in the front right location on the Sensor Board. Use four (4) M3x6 screws to attach the SparkFun TMP102 Temperature Sensor to its stands on the Sensor Board.

2 Wire: Connect the SparkFun TMP102 Temperature Sensor to the Qwiic I2C daisy-chain from the SparkFun RedBoard Turbo Development Board by connecting the SparkFun TMP102 Temperature Sensor with a 50mm Qwiic cable to the SparkFun RedBoard Turbo Development Board.

SparkFun ICM20948 IMU

1 Prepare: Solder Break Away Headers to the INT and FSYNC pins on the SparkFun ICM20948 IMU.

2 Attach: Insert four (4) M3x6x4.5 threaded heat inserts into the holes of the SparkFun ICM20948 IMU stands in the front middle location on the Sensor Board. Use four (4) M3x6 screws to attach the SparkFun ICM20948 IMU to its stands on the Sensor Board.

2 Wire: Connect the SparkFun ICM20948 IMU to the Qwiic I2C daisy-chain from the SparkFun RedBoard Turbo Development Board by connecting the SparkFun ICM20948 IMU with a 100mm Qwiic cable to the left SparkFun Qwiic Adapter on the Vision Board.

SparkFun LPS25HB Pressure Sensor

1 Prepare: Solder a Break Away Header to the INT pin on the SparkFun LPS25HB Pressure Sensor.

2 Attach: Insert four (4) M3x6x4.5 threaded heat inserts into the holes of the SparkFun LPS25HB Pressure Sensor stands in the front left location on the Sensor Board. Use two (2) M3x6 screws to attach the SparkFun LPS25HB Pressure Sensor to its stands on the Sensor Board.

2 Wire: Connect the SparkFun LPS25HB Pressure Sensor to the Qwiic I2C daisy-chain from the SparkFun RedBoard Turbo Development Board by connecting the SparkFun LPS25HB Pressure Sensor with a 50mm Qwiic cable to the SparkFun ICM20948 IMU.

SparkFun NEO-M9N GPS

1 Prepare: Solder Break Away Headers to the PPS, RST, SAFE and INT pins on the SparkFun NEO-M9N GPS.

2 Attach: Insert four (4) M3x6x4.5 threaded heat inserts into the holes of the SparkFun NEO-M9N GPS stands in the back left location on the Sensor Board. Use four (4) M3x6 screws to attach the SparkFun NEO-M9N GPS to its stands on the Sensor Board.

2 Wire: Connect the SparkFun NEO-M9N GPS to the Qwiic I2C daisy-chain from the SparkFun RedBoard Turbo Development Board by connecting the SparkFun NEO-M9N GPS with a 50mm Qwiic cable to the SparkFun LPS25HB Pressure Sensor and the 200mm Qwiic cable from the ZIO INA219 Current and Voltage Sensor.

Processing Board

2 Attach: Use seven (7) M3x6 screws to attach the Processing Board to the right side of the Battery Stands.

NVIDIA Jetson Xavier NX Development Board

1 Prepare: Extract the NVIDIA Jetson Xavier NX Development Board with its antennas of the wifi and bluetooth module from the plastic support of the development kit. Add a NVMe SSD Drive in the M.2 Key M slot to the NVIDIA Jetson Xavier NX board. On the back side of the NVIDIA Jetson Xavier NX Development Board unscrew the retaining screw in the M.2 Key M slot, push in the NVMe SSD Drive into the connector and fix it by screwing the retaining screw back in. Insert a Micro SD Card into the Micro SD slot on the NVIDIA Jetson Xavier NX.

2 Attach: Insert four (4) M2x6x3.5 threaded heat inserts into the holes of the M2x6 stands for the NVIDIA Jetson Xavier NX. Use eight (8) M2x6 screws to attach the NVIDIA Jetson Xavier NX Development Board with its antennas of the WiFi and Bluetooth module to the Processing Board. Place the NVIDIA Jetson Xavier NX Development Board so that the connectors face the back of the Bottom Plate.

3 Wire: Connect the DC Barrel Jack Connector to the DC Jack of the NVIDIA Jetson Xavier NX Development Board. Use double sided tape to fix the DC Barrel Jack Connector to the Processing Board. Use a zip tie to hold the DC Barrel Jack Connector in place.

Cover

Insert two (2) M3x4x5 threaded heat inserts into the two (2) holes on the inside in the front of the Cover, where the Vision Board will be attached.

UCTRONICS 5 Inch Touch Screen Display

Connect a 90° micro USB to USB cable to USB touch port on the UCTRONICS 5 Inch Touch Screen Display (once the display is in the Cover, there is not enough room to get it in). This cable will be

connected to a USB port on the NVIDIA Jetson Xavier NX Development Board when the Cover is put on.

As part of the 3D printing and post-processing, insert already four (4) M3x4 threaded heat inserts into the holes for the UCTRONICS 5 Inch Touch Screen Display in the Display Wall of the Cover. Use four (4) M3x5 screws (smaller than M3x6 screws) to attach the UCTRONICS 5 Inch Touch Screen Display in the Cover.

Power Push Button

Stripe the ends of two (2) about 9cm long red 22AGW wires with a wire stripper. Solder one end of the wires to the Common Ground (C) and Normally Open (NO) connections of the push button. Protect the connections and join the cables together by fitting heat shrink tubes using a heat gun. Crimp a male and a female quick disconnect terminal connector with a crimper to the other end of the wires. Assemble two (2) push buttons this way, so you have a spare push button when using the Sensors & Processing Board without the Cover.

Screw the push button into the little round hole in the back (display) on the right side of the Cover.

Connectors

Push the Keystone jacks from the inside into the Keystone inserts on the left side of the Cover in the following order from the back (display) to the front: USB 3.0, HMDI and USB-C (under the power sign on the Cover).

Air Holes

Cut two (2) pieces out of the PC Computer Air Filter to cover the air holes in the side walls and use some tape to fix them from the inside.

Sensors & Processing Board as a desktop computer

You may want to use the Sensors & Processing Board without the Cover to have full access to the system. We use the Sensors & Processing Board without the Cover for our software setup.

Connect the male and female quick disconnect terminal connectors from the spare push button to the quick disconnect terminal connectors on the wires that come from the Zio INA219 Current and Voltage Sensor and the DC Barrel Jack connector. Put the USB dongle from the Dual USB & Bluetooth Keyboard and Mouse in a USB port of the NVIDIA Jetson Xavier NX. Connect a HDMI monitor directly with a HDMI cable to the HDMI port of the NVIDIA Jetson Xavier NX Development Board.

Connect the USB-C charger directly to the PD 100W IN port of the USB-C power bank.

Push the push button to turn on the Sensorbox. If the SensorBox does not turn on, it might be that the USB-C power bank is not active. To activate the USB-C power bank, either push the button the on USB-C power bank, or (re-)connect the USB-C charger to USB-C power bank. Make sure to shutdown the Sensorbox properly from the operating system (do not just switch off the power).

To set up the SensorBox from a host computer, connect a USB port on the host computer with a Micro USB to USB cable to the Micro USB port on the NVIDIA Jetson Xavier NX Development Board.

Putting on the Cover

Connect a HDMI Male to Female cable to the HDMI port of the NVIDIA Jetson Xavier NX board. Connect a DisplayPort Male to HDMI Female cable to the DisplayPort of the NVIDIA Jetson Xavier NX Development Board. Connect a HDMI Male to Male cable to the DisplayPort Male to HDMI Female cable. Connect a Micro USB to USB cable to the Micro USB port on the NVIDIA Jetson Xavier NX Development Board. Connect a 100W USB-C power cable to the PD 100W IN port of the USB-C power bank.

Slide the Cover over the Sensors & Processing Board until you can still see the USB connectors on the NVIDIA Jetson Xavier NX Development Board. Connect the USB cable from the UCTRONICS 5 Inch Touch Screen Display to a USB port on the NVIDIA Jetson Xavier NX Development Board.

Slide the Cover now 2/3 over the Sensors & Processing Board so you have still enough access to connect all the cables. Connect the HDMI Male to Female Cable from the NVIDIA Jetson Xavier NX Development Board to the HDMI port on the UCTRONICS 5 Inch Touch Screen Display. Connect the male and female quick disconnect terminal connectors from the wires that come from the Zio INA219 Current and Voltage Sensor and the DC Barrel Jack connector to the quick disconnect terminal connectors from the push button in the Cover. Connect the USB-C power cable from the USB-C power bank to the USB-C Keystone Jack in the Cover. Connect the HDMI Male to Male cable from the NVIDIA Jetson Xavier NX Development Board to the HDMI Keystone Jack in the Cover. Connect the Micro USB to USB cable from the NVIDIA Jetson Xavier NX Development Board to the USB 3.0 Keystone Jack in the Cover.

There seems to be a “right” sense on how to connect the USB-C cable from the USB-C charger to the USB-C Keystone Jack so that the USB-C power bank is actually charging. Make sure to test the connection and mark the “right” sense on the USB-C cable prior to putting on the cover all the way.

Slide the cover all the way over the Sensors & Processing Board. Use two (2) M3x6 screws to attach the Vision Board, which is in front of the Sensors & Processing Board, to the Cover.

The total weight of the SensorBox is 2.130kg.

SensorBox as a desktop computer

You can hook up the SensorBox as a Desktop computer with an external monitor, keyboard and mouse.

Connect a HDMI monitor with a HDMI cable to the HDMI Keystone Jack in the Cover. After software setup, the Dual USB & Bluetooth Keyboard and Mouse is connected via Bluetooth directly to the NVIDIA Jetson Xavier NX Development Board.

Connect the USB-C charger with the USB-C cable in the “right” sense to USB-C Keystone Jack in the Cover. Push the push button to turn on the Sensorbox. If the SensorBox does not turn on, it might be

that the USB-C power bank is not active. To activate the USB-C power bank, (re-)connect the USB-C charger to SensorBox. Make sure to shutdown the Sensorbox properly from the operating system (do not just switch off the power).

To set up the SensorBox from a host computer, connect a USB port on the host computer with a USB cable to the USB Keystone Jack in the SensorBox.