

# The PABLO Box

August 2017

Michael Benjamin, mikerb@mit.edu  
Department of Mechanical Engineering, CSAIL  
MIT, Cambridge MA 02139

---

<b>1</b>	<b>The PABLO Hardware (Bill of Materials)</b>	<b>2</b>
<b>2</b>	<b>PABLO Housing and Waterproof Connectors</b>	<b>2</b>
2.1	Enclosure . . . . .	3
2.2	Waterproof Cable Gland . . . . .	3
2.3	Waterproof USB Connector (x 2) . . . . .	3
2.4	Waterproof Ethernet Connector . . . . .	4
2.5	Waterproof Connector Cap . . . . .	4
<b>3</b>	<b>PABLO Computer and Related Hardware</b>	<b>5</b>
3.1	Computer . . . . .	5
3.2	MicroSDHC Card . . . . .	5
<b>4</b>	<b>PABLO Cables and Wiring</b>	<b>5</b>
4.1	Waterproof Power Connector . . . . .	6
4.2	MicroUSB Cable for Raspi Power . . . . .	6
4.3	6" Ethernet Cable . . . . .	7
4.4	Butt Splice . . . . .	7
4.5	Shore Power Supply . . . . .	7
<b>5</b>	<b>PABLO Internal Mounting Components</b>	<b>8</b>
5.1	Mounting Plate . . . . .	8
5.2	Raspi Mounting Screws . . . . .	8
5.3	Raspi Mounting Screw Spacers . . . . .	9
5.4	Raspi Mounting Screw Spacers . . . . .	9
5.5	Plate Mounting Screws . . . . .	9
<b>6</b>	<b>PABLO Power</b>	<b>10</b>
6.1	Field DC-DC Power Supply . . . . .	10
6.2	PABLO Battery . . . . .	10
<b>7</b>	<b>PABLO Cable to M200 Payload Port</b>	<b>11</b>
7.1	Waterproof Ethernet Connector . . . . .	11
7.2	Ethernet Cable Tip Crimp Tool . . . . .	11
7.3	Spare Ethernet Cable Tips . . . . .	11
<b>8</b>	<b>PABLO Parts No Longer Used</b>	<b>12</b>
8.1	TFT Display . . . . .	12
8.2	Raspi Mounting Screws . . . . .	12
8.3	Raspi Mounting Hex Nuts . . . . .	12
8.4	Raspi Elevating Spacers . . . . .	12

---

# 1 The PABLO Hardware (Bill of Materials)

Materials for the PABLO reference design were selected to minimize customization. Parts on this list can be purchased from multiple vendors and substitutions of similar items can be used in most cases. Listed vendors are for price comparison only and are not intended as an endorsement. Holes in the enclosure and the mounting plate can be accomplished easily with typical machine shop tools and a laser cutter or with some difficulty by a mechanical novice.

Below is a listing of parts required to assemble a single Pablo unit. Web links and prices given are accurate as of March, 2016.

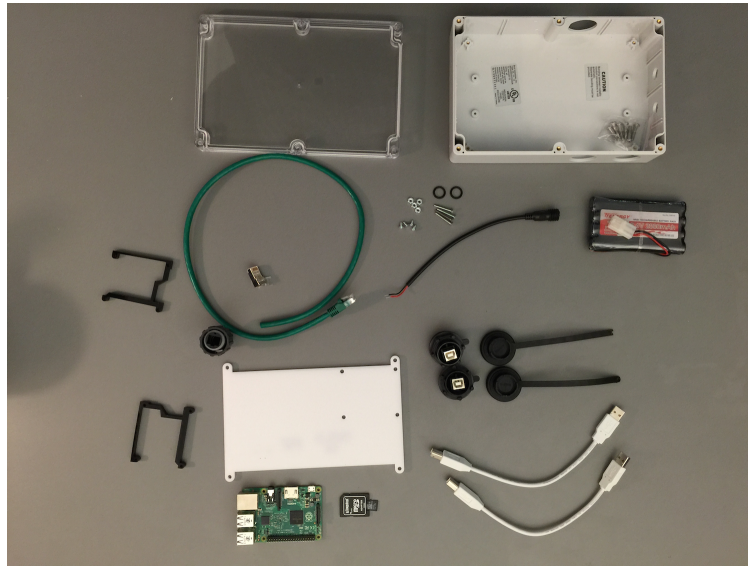


Figure 1: The parts of an unassembled PABLO unit.

## 2 PABLO Housing and Waterproof Connectors

The Pablo unit housing is a polycarbonate box with a clear lid. This particular box was selected to fit inside the M200 payload bay while still having tall enough sides to support pass-through holes. The box is breached in four places with waterproof fittings:

1. 2 x USB connectors
2. 1 x Ethernet connector
3. 1 x PG7 Gland (for 5v power input)

## 2.1 Enclosure



- *Model ID:* Bud Industries P1325-C
- *Description:* Polycarbonate enclosure with clear lid
- *Purpose:* Provides housing and IP66 level of water protection
- *Purchase:* 1 x \$33 ea
- *Notes:* Pricing is for standard uncut enclosure only. For additional costs, the box can be custom-ordered from Newark with precut holes in minimum quantity of 10.
- <http://www.newark.com/bud-industries/pn-1325-c/enclosure-junction-box-polycarbonate/dp/95F6390>

## 2.2 Waterproof Cable Gland



- *Model ID:* JACOB 50.007 PA-F
- *Description:* PG7 Cable Gland, 3 mm to 6.5 mm
- *Purpose:* Enables power cable to pass through the enclosure.
- *Purchase:* 1 x \$1 ea
- *Notes:* Any cable gland sized for PG7 and 3mm to 6.5mm diameter cable can be used.
- <http://www.newark.com/jacob/50-007-pa-f/cable-clamp-gland-dome-top-nylon/dp/26M7389>

## 2.3 Waterproof USB Connector (x 2)



- *Model ID:* Bulgin Buccaneer PX0842/A
- *Description:* IP68 USB-A Connector
- *Purpose:* Waterproof USB connectors on the enclosure that allow external devices to connect to the computer.
- *Purchase:* 2 x \$16 ea
- *Notes:* The PX0842/A provides a USB-A receptacle on the outside. The PX0842/B can be used instead to provide a USB-B receptacle on the outside but requires a USB A-A cable to connect internally to the computer.
- <http://www.newark.com/bulgin/px0842-a/adaptor-usb-a-usb-b/dp/86H3159>

## 2.4 Waterproof Ethernet Connector



- *Model ID:* Bulgin Buccaneer PX0833
- *Description:* IP68 RJ45 Ethernet Connector
- *Purpose:* Waterproof Ethernet connector on the enclosure that connects the internal computer to the local network.
- *Purchase:* 1 x \$26ea
- <http://www.mcmelectronics.com/product/831-2945>

## 2.5 Waterproof Connector Cap



- *Model ID:* Bulgin Buccaneer PX0733
- *Description:* Sealing Cap for Buccaneer USB/Ethernet
- *Purpose:* Ensure waterproofing on USB and ethernet ports when no USB cable is connected.
- *Purchase:* 3 x \$2ea
- <http://www.newark.com/bulgin/px0733/sealing-cap-polyamide/dp/48F2467>

## 3 PABLO Computer and Related Hardware

The Raspberry Pi 3 Model B was selected as a low-power, small-footprint computer that supports a GNU/Linux type of operating system. The computer uses a MicroSDHC card as a storage drive. An optional TFT display can attach inside the housing.

### 3.1 Computer



- *Model ID:* Raspberry Pi 3 Model B
- *Purpose:* Primary PABLO computer
- *Purchase:* 1 x \$35 ea
- *Notes:* Older Raspi versions can be used but are not supported by Pablo documentation.
- <http://www.mcmelectronics.com/product/83-17300>

### 3.2 MicroSDHC Card



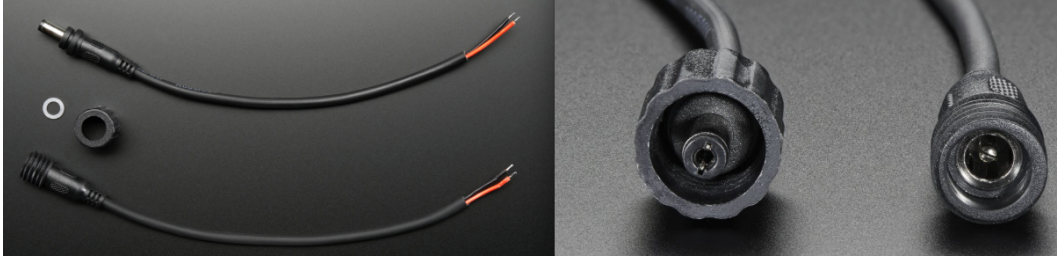
- *Model ID:* Kingston 16gb (SDC4/16GBET)
- *Description:* 16gb Class 4 microSDHC
- *Purpose:* Data storage for the Raspberry PI
- *Purchase:* 1 x \$5 ea
- *Notes:* Any 16gig microSDHC card can be used. Beware of counterfeit microSD cards.
- <http://www.amazon.com/dp/B00DYQYLQQ>

## 4 PABLO Cables and Wiring

Manufactured cables are used to connect the computer to the enclosure-mounted waterproof USB and Ethernet connectors. Unfortunately, no existing cables meet the needs for powering the computer,

with a waterproof barrel connector outside the box and a micro-USB within. Therefore, these are purchased separately and custom-joined during Pablo assembly.

#### 4.1 Waterproof Power Connector



- *Model ID:* Adafruit Industries 743
- *Description:* Waterproof DC Power Cable Set, 5.5/2.1mm
- *Purpose:* Connect to an external regulated 5V power source.
- *Purchase:* 1 x \$3 ea
- *Notes:* Can be purchased as a 10-pack for lower per-unit cost.
- [https://www.adafruit.com/products/743?gclid=CjwKEAju\\_LG8BRDb1JTxm8uP\\_UwSJADu\\_8pWwcVIcvts4PvYkEisCA2u0CgV-nf9aue6t-gyB95PwRoCrHvw\\_wcB](https://www.adafruit.com/products/743?gclid=CjwKEAju_LG8BRDb1JTxm8uP_UwSJADu_8pWwcVIcvts4PvYkEisCA2u0CgV-nf9aue6t-gyB95PwRoCrHvw_wcB)

#### 4.2 MicroUSB Cable for Raspi Power



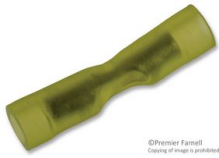
- *Model ID:* Stellar Labs HK-MUS11
- *Description:* 3' USB A Male to Micro B Male Cable
- *Purpose:* Connect power to the internal computer.
- *Purchase:* 1 x \$1 ea
- *Notes:* The USB-A end of the cable will be cut off during installation.
- <http://www.mcmelectronics.com/product/83-16412>

### 4.3 6” Ethernet Cable



- *Model ID:* TE Connectivity 1487586-2
- *Description:* USB A to B cable, 0.25M
- *Purpose:* Connect the Raspi to the external waterproof USB connectors.
- *Purchase:* 1 x \$13 ea
- *Notes:* This item is a 10-pack of 6” ethernet cables.
- <http://www.amazon.com/dp/B000QQQLCK>

### 4.4 Butt Splice



- *Model ID:* TE CONNECTIVITY / AMP 321026
- *Description:* TERMINAL, BUTT SPLICE, 26-22AWG, YELLOW
- *Purpose:* Connect the input power and microUSB cables.
- *Purchase:* 2 x \$0.18 ea
- *Notes:* Butt splices can be replaced by proper soldering with adequate heat shrink.
- <http://www.newark.com/te-connectivity-amp/321026/terminal-butt-splice-26-22awg/dp/24Y9956>

### 4.5 Shore Power Supply



- *Model ID:* TRIAD MAGNETICS WSU050-3000
- *Description:* AC/DC Power Supply, Switch Mode, 100-240V, 5V, 3A
- *Purpose:* 5V power source when AC is available or working away from the field vehicle.
- *Purchase:* 1 x \$13 ea
- *Notes:* Any converter with a barrel plug of 5.5 x 2.1mm can be used that supplies regulated 5V at a minimum of 2.5A. This particular unit was selected as the least expensive unit from a reputable manufacturer with a published datasheet.
- <http://www.newark.com/triad-magnetics/wsu050-3000/ac-dc-converter-external-plug/dp/83T4304>

## 5 PABLO Internal Mounting Components

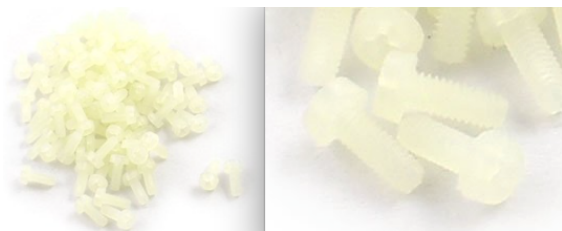
The computer installed on a mounting plate, which is then affixed to the inside bottom of the enclosure. The enclosure has bosses for M3 screws. Holes in the Raspi accept up to 2.5mm diameter screws.

### 5.1 Mounting Plate



- *Model ID:* MIT Pablo Raspberry Pi Mounting Plate
- *Purpose:* Attaches the Raspi inside the enclosure.
- *Purchase:* 1 x \$25 ea
- *Ordering URL:* <http://www.ponoko.com/showroom/MITPablo>
- *Notes:* The file is a free download from Ponoko and can be cut on any laser cutter or customized and uploaded back to Ponoko to be created. More than one plate can be cut from the same P2-sized sheet of acrylic.

### 5.2 Raspi Mounting Screws





- *Description:* M2.5 x 6mm Thread Rod Insulation Nylon Cross Head Screws Bolts
- *Purpose:* Affixes the Raspi to the mounting plate.
- *Purchase:* 1 x \$7.46 ea (100 screws in package, 4 used in PABLO unit)
- <https://www.amazon.com/gp/product/B00UJ9BYY8/>

### 5.3 Raspi Mounting Screw Spacers



- *Description:* Nylon Hex Standoff Spacer M2.5 Female to Male 12mm+6mm
- *Purpose:* Affixes the Raspi to the mounting plate.
- *Purchase:* 1 x \$10.40 ea (100 screws in package, 4 used in PABLO unit)
- <https://www.amazon.com/gp/product/B00NQBDHOG/>

### 5.4 Raspi Mounting Screw Spacers



- *Description:* M2.5 Thread Nylon Hex Nut Threaded Spacer Support for PCB Board
- *Purpose:* Nuts for the nylon bolts holding the RasPi bard the PABLO mounting plate.
- *Purchase:* 1 x \$6.84 ea (50 nuts in package, 4 used in PABLO unit)
- <https://www.amazon.com/gp/product/B00UBUBJL8/>

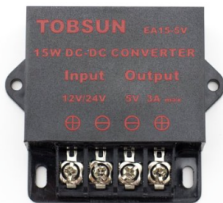
### 5.5 Plate Mounting Screws



- *Description:* Steel Machine Screw, Zinc Plated Finish, Flat Head, Phillips Drive, 6mm Length, M3-0.5 Metric Coarse Threads
- *Purpose:* Affixes the mounting plate and Raspi.
- *Purchase:* 1 x \$2.40 ea (100 screws in package)
- <https://www.amazon.com/gp/product/B000NHVQTO>

## 6 PABLO Power

### 6.1 Field DC-DC Power Supply



- *Model ID:* SINOLLC DC 12V 24V to 5V 3A Converter Step Down Regulator
- *Purpose:* 5v power source on the field vehicle or from other DC source.
- *Purchase:* 1 x \$8ea
- *Notes:* One DC-DC power supply is required for each vehicle.
- <https://www.amazon.com/Converter-Regulator-Regulated-Supplies-Transformer/dp/B00J3MHRNO>

### 6.2 PABLO Battery



- *Model ID:* Tenenergy 9.6V 2000mAh NiMH High Capacity Battery Pack
- *Purpose:* Battery for PABLO on the vehicle
- *Purchase:* 1 x \$14.99
- *Notes:* One battery is required for each vehicle, spares are good.
- <https://www.amazon.com/gp/product/B001BA292A/>

## 7 PABLO Cable to M200 Payload Port

### 7.1 Waterproof Ethernet Connector



- *Model ID:* Conec 17-10001 RJ45 waterproof
- *Purpose:* Connect to the waterproof Ethernet receptacle on the Kingfisher M200.
- *Purchase:* 1 x \$7ea
- <http://www.mouser.com/ProductDetail/CONEC/17-10001/?qs=sGAEpiMZZMuG%2fXKM6MUafUhtttQiSa>

### 7.2 Ethernet Cable Tip Crimp Tool



- *Model ID:* Klein Tools VDV226-011-SEN Ratcheting Modular Crimper/Stripper/Cutter
- *Purpose:* Crimp connector onto end of Ethernet cable.
- *Purchase:* 1 x \$33ea
- <http://www.amazon.com/dp/B002D3B97U>

### 7.3 Spare Ethernet Cable Tips



- *Model ID:* C&E Cat6, Cat5e crimp connectors

- *Purpose:* Spare Ethernet connector to replace those damaged during installation or use.
- *Purchase:* 1 x \$9ea
- *Notes:* Contains 50 connectors in the bag for this price.
- <http://www.amazon.com/dp/B00BS92DCA>

## 8 PABLO Parts No Longer Used

### 8.1 TFT Display

- *Model ID:* Adafruit Model 1601 (or 1601B)
- *Description:* PiTFT 320x240 2.8 inch with touchscreen
- *Purpose:* User interface display to simplify terminal access to the Raspi and to assist with system troubleshooting.
- *Purchase:* 1 x \$34 ea
- *Notes:* An internal display is optional but highly recommended. Alternatives include installing a waterproof HDMI port and pigtail; opening the lid of the enclosure to connect an HDMI cable.
- <http://www.newark.com/adafruit-industries/1601/pitft-lcd-screen-touchscreen/dp/42X0914>

### 8.2 Raspi Mounting Screws

- *Model ID:* Small Parts B00F33LFTE
- *Description:* Slotted Nylon Machine Screw, 6/6 M2.5-0.45 x 25mm
- *Purpose:* Affixes the Raspi to the mounting plate.
- *Purchase:* 1 x \$4 ea (100 screws in package, 4 used in PABLO unit)
- <http://www.amazon.com/dp/B00F33LFTE>

### 8.3 Raspi Mounting Hex Nuts

- *Model ID:* Small Parts B00DGB9SWG
- *Description:* Nylon 6/6 M2.5-0.45 hex nut, 5mm driver
- *Purpose:* Affixes the Raspi to the mounting plate.
- *Purchase:* 1 x \$5 ea (100 screws in package, 4 used in PABLO unit)
- <http://www.amazon.com/dp/B009EFSCN4>

### 8.4 Raspi Elevating Spacers

- *Model ID:* Small Parts B00DIHVJD4
- *Description:* Round Nylon, 8mm Screw Size, 8mm OD, 3.2mm ID, 5mm
- *Purpose:* Spacers to elevate the Raspi mounting.
- *Purchase:* 1 x \$7 ea (100 spacers in package)
- [www.amazon.com/dp/B00137U7I4](http://www.amazon.com/dp/B00137U7I4)