## Caveatron Bill of Materials – Base Unit

Hardware Revision: A Date: 2019-11-06

All the parts in this list have been tested with the Caveatron and integrated into the code. For some parts, alternate options are available.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Main Processor	1	Arduino	Due	Arduino Due	<u>Amazon</u>	1000   1000

**Notes:** The main system processor. Available from many vendors. Third party clones are available at lower cost but may require modification of the reset circuit by adding a capacitor and/or resistor as per this link: <a href="https://forum.arduino.cc/index.php?topic=256771.0">https://forum.arduino.cc/index.php?topic=256771.0</a>

Touchscreen LCD  OPTION 1	1	Coldtears Electronics	N/A	3.5 inch TFT LCD module w/Font IC 480x320 full angle Arduino DUE MEGA 3.2 4.3	<u>Ebay</u>	

**Notes:** The display and user interface. This component uses a Font IC with a proprietary font/graphic library (UTFT\_GHL) that is not provided with the Caveatron code. This library can be downloaded from a link provided when purchasing the LCD module. This replaces a similar touchscreen LCD used previously (and that uses a different library – UTFT\_CTE) but is no longer available. The UTFT\_CTE library is still included since it supports a 4-inch 480x320 module still being produced (OPTION 2 below).

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Touchscreen LCD	1	Coldtears Electronics	N/A	4.0" inch TFT LCD module w/Font IC 480x320 ILI arduino DUE MEGA 3.2 2.5	<u>Ebay</u>	
OPTION 2				STM32		

**Notes:** Alternate display and user interface. This component uses a Font IC with the older UTFT\_CTE library.

Due LCD Interface Shield	1	Coldtears Electronics	N/A	TFT/SD Shield for Arduino DUE TFT LCD Module SD Card Adapter 2.8 3.2 inch Mega	Ebay	
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**Notes:** Provides electrical interface from Arduino to the Touchscreen LCD. Works with either touchscreen option above. Be careful about which one you get. I think sometimes they send an incompatible shield. Coldtears own link on their product page sends you to a different Ebay store product page: <a href="https://www.ebay.com/c/893425946">https://www.ebay.com/c/893425946</a>

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Laser Rangefinder <b>OPTION 1</b>	1	Uni-T	UT390B	Laser Distance Meter	Ebay, Amazon, or other sources. Availability changes frequently.	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1

**Notes:** Used for station distance measurements. This item is long since discontinued but can still be found online from a few sources. Do not confuse this with the UT390B+, which is widely available but does not have an accessible serial port, so is not useable. The UT390B+ has a bubble level in the upper left which the UT390B does not. The UT390B must be disassembled and the LCD removed to access the electronics board. The JRT rangefinder (OPTION 2) has has wider availability and is easier to assemble into the enclosure, but has operational disadvantages. The UT390B remains the preferred rangefinder if you can find one.

Laser Rangefinder	1	JRT Meter Tech., Co, Ltd.	Unknown	100m Laser Distance Sensor Module	Ebay Availability	
OPTION 2					changes frequently.	CONTRACTOR OF THE PROPERTY OF

**Notes:** Used for station distance measurements. This rangefinder module is very similar in size to Option 1 above, is easier to mount due to the presence of mounting holes, however, it's method of operation is less well suited to the Caveatron since it has a variable measurement time (rather than the UT390B's fixed 1 sec measurement time) and can take up to 3 sec to acquire a reading or timeout. This means that when scanning in Passage mode, you can end up with fewer reference points and a less accurate scan.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Compass Module	1	Pololu	LSM303D (#2127)	LSM303D 3D Compass and Accelerometer Carrier with Voltage Regulator	Pololu	

**Notes:** Used to measure azimuth and inclination. The orientation of this component is important and needs to be mounted with the side pictured facing up and the x-axis toward the front of the unit.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Pack  OPTION 1	1	Adafruit	354	Lithium Ion Battery Pack - 3.7V 4400mAh	<u>Adafruit</u>	PKCELL ICR18650 4400mAh 3.7U

**Notes:** Primary system battery.

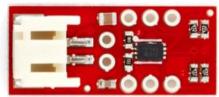
Battery Pack	1	Tenergy	354	Tenergy Li-lon 18650 3.7V 5200mAh Rechargeable	<u>Walmart</u>	
OPTION 2				Battery PCB module with Bare Leads	<u>Tenergy</u>	THE PROPERTY OF THE PROPERTY O

Notes: Primary system battery. Higher capacity battery with identical dimensions and voltage to Option 1. Does not include connector unlike Option 1.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Charging Module OPTION 1	1	Adafruit	259	USB Lilon/LiPoly charger - v1.2	<u>Adafruit</u>	O O O O O O O O O O O O O O O O O O O

**Notes:** Controls the charging of the LI-lon battery pack and provides charge indication to power switch LED. Default charge current is 500 mA, but can be increased to 1200 mA by adding appropriate resistor (see assembly instruction.) An alternate part is available with a combined battery charger and fuel gauge module, but is more problematic in several ways, so this part is still the preferred option.

Battery	1	Sparkfun	TOL-	LiPo Fuel Gauge	<u>Sparkfun</u>	
Gauge			10617			
Module						
OPTION 1						



**Notes:** *Monitors battery level.* Contains a MAX17043 battery fuel gauge IC. It is highly recommended to purchase this directly from Sparkfun. These can be found at other, cheaper sites, but often use a counterfeit Maxim IC that does not function properly. An alternate part is available with a combined battery charger and fuel gauge module, but is more problematic in several ways, so this part is still the preferred option.

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**Notes:** Battery charge controller and fuel gauge. This is an alternative to both the separate charger and fuel gauge modules listed above. It is capable of 1.5A charging current and provides a more accurate method for monitoring battery charge level. However, it is more challenging to mount inside the enclosure, it causes a 5-10 sec delay when booting the Caveatron, draws a small amount of power even when turned off, and does not provide an easy way to connect the charging LED on the power switch, so you never know when charging is completed.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Voltage Regulator – 9V	1	Pololu	2116	9V Step-Up Voltage Regulator U3V12F9	<u>Pololu</u>	
Notes: Power	supply	for Arduino Due.				
Voltage Regulator – 5V	1	Pololu	2123	Pololu 5V Step-Up/Step- Down Voltage Regulator S7V8F5	<u>Pololu</u>	
Notes: Power	supply	for LIDAR Module	. A Pololu 211	L8 (see below) could also be us	sed if set to 5.0 V.	
Voltage Regulator – Adjustable	1	Pololu	2118	Pololu Adjustable Step- Up/Step-Down Voltage Regulator S7V8A	Pololu	

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Real-Time Clock and EEPROM Module	1	Various		DS3231 AT24C32 RTC Clock Module Memory Board	<u>Amazon</u>	SCL SOW SCL SOA O
		mory module for st	toring calibrat	ion parameters and real-time o	lock. This part is	s available from numerous vendors on Amazon and Ebay. Requires a
Piezoelectric Buzzer	1	Uxcell	a140624 00ux017 3	Uxcell 5 Pcs DC 1-30V 90Db Sound Passive Electronic Buzzer Alarm Black, 30 x 6 mm	Amazon	
Notes: Indicat	or buz	zer.				
Power Switch & Charging LED	1	Adafruit	916	Rugged Metal On/Off Switch with Red LED Ring - 16mm Red On/Off	<u>Adafruit</u>	
Notes: On/Off	power	r switch and charg	e indicating r	ing LED. Several other colors of	the LED are ava	nilable.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
USB Jack	1	GT Contact	GT114200	Mini USB-B C2 size Plastic	<u>USBFirewire</u>	
			-10	Panel Mount	<u>.com</u>	WAVV.USBFireWinom
Notes: Mini-U	ISB jack	for data downlo	ad, battery ch	arging, and loading of software	and calibration	parameters.
USB Cap	1	GT Contact	GT1C5221	Seal Cap	<u>USBFirewire</u>	
			22		<u>.com</u>	SBFireWire.com
Notes: Water	proof c	ap for USB jack.				
LIDAR Interface Jack	1	Conxall/ Switchcraft	17982- 6SG-300	Micro-Con-X 6 Position Circular Connector Receptacle, Female Sockets Solder Cup Gold	<u>Digikey</u>	

LIDAR Interface Cap	1	Conxall/ Switchcraft	16295	Micro-Con-X Receptacle Dust Cap	<u>Digikey</u>	
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**Notes:** Cap for LIDAR interface jack. Available from multiple vendors.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
LCD Connector Cable	1	N/A	N/A	40 pin IDE Male to Female Extension Cable, 6" (15 cm) or 4" (10 cm)	Ebay or Amazon	Wigich Constitution of the

**Notes:** Cable to interface Due LCD Interface Shield and LCD Touchscreen. Be certain that the connector you order has all 40 pins! Some IDE connector cables only have 39 pins with one missing near the center. The preferred length is 6" (15 cm). Longer cables would take up too much space in the enclosure. A 4" (10 cm) cable can work as well, but is a bit of a stretch to get it to reach. These are available from multiple vendors.

Base Unit Enclosure	1	Bud Industries	PN-1324- DG	NEMA ABS NEMA 4x Enclosure, Dark Gray	Amazon	

**Notes:** *Enclosure box for main body.* Requires machining of base to add cutouts for USB jack and front window and machining of the cover to add screw holes for the LIDAR Mounting Rail, LCD Touchscreen, Strap Attachment Hardware, and cutouts for the Touchscreen LCD, and LIDAR Interface Jack. Available from many vendors.

LIDAR	1	Weaver	TO-9M	Tip-Off Aluminum Base	<u>Amazon</u>	
Mounting Rail						• • • • •

Notes: Rail for mounting LIDAR module. Weaver TO-9 rail is identical but with a shiny finish. Available from multiple vendors

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Plastic Base Material	1	Small Parts	STPVC- 0093-F	PVC Sheet, Opaque Gray, 0.093" Thickness, 12" Width, 24" Length	<u>Amazon</u>	

**Notes:** *Plastic sheet for mounting internal components in Main Body Enclosure and 4m LIDAR Enclosure.* Requires cutting to size and drilling mounting holes. Other thicknesses and materials could be used as well.

Window Material	1	Small Parts	50649812 12	Acrylic Sheet, Transparent Clear, 0.06" Thickness, 12" Width, 12" Length	<u>Amazon</u>	

**Notes:** *Transparent acrylic sheet for Rangefinder window on Main Body.* The 0.118" transparent acrylic sheets used for the 12m RP LIDAR module windows could be used as well if you don't want to order this thinner sheet. Requires cutting to size. Acrylic seems to be the most transparent with the least distortion and defects of the various clear plastics tested, which is important for not interfering with the LIDAR and rangefinder readings.

Laser Rangefinder Optical Filter	1	Rosco	299	Roscolux 1.2 Neutral Density Filter, 20x24"	<u>Adorama</u>		
				l: 6 11 1 61 1:			

**Notes:** Filters rangefinder receiver to only accept readings from the retroreflective card.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Screen Protector	1	Supershieldz	N/A	iPhone SE and iPhone 5 Screen Protector	<u>Amazon</u>	PACK  PACK  PACK  Screen Protector  Screen Protector

**Notes:** *Protection film for touchscreen.* Needs to be cut to length. Most any PET screen protector film for iPhone 4, 4S, 5, 5s, or SE should work as they have the same screen width as the 3.5" LCD. Multiple vendors produce a similar product.

Strap	1	122317	Hillman	D-Ring Hangers	Lowes	
Attachment Hardware			Group			
Haraware						

**Notes:** Small D-rings for attaching neck strap. Available from multiple sources and similar parts likely available from other vendors.

Neck Strap	1	DOROM	N/A	DOROM Universal Adjustable Slim Shoulder Sling Neck Strap for All Camera DSLR SLR	<u>Amazon</u>	S. I. I.
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**Notes:** Neck Strap. This neck strap works well, but other options are available. Recommend a nylon camera strap of 52-60" in length and about 3/8" wide in the ends.

## Other Required Items:

CR2032 Battery for RTC Module

Screws

Washers

Nuts

**Hookup Wire** 

JST Connectors

**Header Connectors** 

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Tape

**Notes:** For assembly and electrical interconnections between boards. Several sizes of standard hardware required. More information in assembly instructions.

## Retroreflective Card Date: 2017-09-11

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo	
Retro- reflective Sheet	1	3M	580 or 680	Scotchlite Reflective Film	B.C.I Imaging Supplies for 8" wide or larger sheet OR Seton for half width 4" rolls.	3M	

**Notes:** Retroreflective film for station card. Required to obtain positive return signal from laser rangefinder for all measurements and scans. 3M 680 film is used currently. 580 film is more readily available and is identical except for being more permanent when applied. An 8" (200 mm) wide roll is ideal but is expensive unless you are making many cards. A much cheaper half-width roll could be used as two side by side strips. Many other reflective tapes are available and may work fine but have not been tested. I would suggest a uniform material like the 3M Scotchlite as I am not sure how well the prismatic style reflective tapes would work since they might provide too strong a reflection or a non-uniform reflection that depends on where on the card you hit. But they may work fine too.

Station Card	1	Small Parts	B00E8S5686	Kydex T Sheet, P3 Velour	<u>Amazon</u>		
Substrate			For 12x24" sheet –	Matte, 0.028" thickness			
			other sizes				
			have different				
			part				
			numbers				
						The state of the s	

**Notes:** Substrate material for retroreflective station cards. Need to be cut to about 8"x8" (200x200 mm). Kydex was chosen since it is durable, thin and flexible, comes in a variety or bright colors easy to see in the cave, and is easy to cut. The material needs to be flexible since it will need to bend to accommodate some survey station locations. Other colors and sheet sizes available from this source – recommend getting a sheet big enough for at least two cards to have a spare. Many other plastics will work but I would not recommend using anything thicker as it may not be flexible enough.