Caveatron Bill of Materials

Hardware Revision: B Date: 2020-10-26

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	PJRC Electronics	Teensy 3.6	Teensy 3.6	PJRC Store	MXGGFXIMAVMOTA ANGORAL ANGOR

Notes: The main system processor. Available from multiple vendors. Versions with and without the pins pre-installed are available (link above is with pins).

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Touchscreen LCD	1	BuyDisplay	N/A	LCD 3.5" 320x480 TFT Display Module,OPTL Touch Screen w/Breakout Board	BuyDisplay
OPTION 1				Options:	
				- Resistive touch panel - 16-bit 8080 40-pin header	
				- 3.3V supply - No font chip	



Notes: The display and user interface. This is the new and currently preferred choice for the display. At present the Caveatron PCB and enclosure designs have not been updated for this display.

Touchscreen LCD OPTION 2	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: Alternate display. This display was previously the preferred choice but is likely no longer going to be available. At present the Caveatron PCB and enclosure are only designed to use this display.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Touchscreen LCD OPTION 3	1	Coldtears Electronics	N/A	4.0" inch TFT LCD module w/Font IC 480x320 ILI arduino DUE MEGA 3.2 2.5 STM32	<u>Ebay</u>	

Notes: Alternate display. Same resolution as the 3.5" but in a larger size. The angle viewing contrast is not as good as the 3.5" display. This display is likely no longer going to be available.

Graphics Module (SPI	1	Multiple (Winbond IC)	W25Q64 or similar	W25Q64 64Mbit 8MByte Flash Memory Module	<u>Amazon</u>	
Flash Memory)				Data Flash SPI Interface		loo.
						DI WZ50XX

Notes: Storage for fonts and graphics used in the GUI. SPI Flash memory must be Winbond W25Q32, W25Q64, or W25Q128 (memory size should be 32Mbit or higher.) Winbond W25Q16 (16 Mbit) could be used, but will only hold the fonts and not support the graphics.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Laser Rangefinder OPTION 1	1	Uni-T	UT390B	Laser Distance Meter	Ebay. Availability very limited and changes frequently.	UNI-T U7308 2055 = 2957 = 295

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 wider availability, 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 changes	
OPTION 2					frequently.	The state of the s

Notes: *Used for station distance measurements.* This rangefinder module is similar in size to Option 1 above and is easier to find. 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.

Laser Rangefinder OPTION 3	1	JRT Meter Tech., Co, Ltd.	Unknown	40m – 60m Laser Distance Sensor Module	Ebay Availability changes frequently.	

Notes: *Used for station distance measurements.* This rangefinder module has not been tested but it appears to operate with an identical protocol to the Option 2 rangefinder, so would be compatible. However, it also likely has the same performance considerations. It is significantly smaller than the others.

Pololu AltIMU-10	AltIMU-10 v3 Gyro,		
v3 (#2469) Or	Accelerometer, Compass, and Altimeter (L3GD20H, LSM303D, and LPS331AP	<u>Pololu</u>	
	Carrier)		
	Or AltIMU-10 v4 (#2470)	Or LSM303D, and LPS331AP Carrier) AltIMU-10	Or LSM303D, and LPS331AP Carrier) AltIMU-10

Notes: Used to determine orientation of the Caveatron and measure azimuth and inclination. The AltIMU-10 v4 is an equivalent part and can also be used. The older v3 and v4 versions of the modules are preferred over the newest AltIMU-10 v5 or the MinIMU-9 v5 since the magnetometer in this module (LSM303D) has a lower noise output than the LIS3MDL used in the newest versions. However, if the older modules becomes unavailable, the Caveatron code will be updated to support the v5 modules.

Compass Module	1	Pololu	LSM303D (#2127)	LSM303D 3D Compass and Accelerometer Carrier with Voltage Regulator	<u>Pololu</u>	
OPTION 2				with voltage negulator		

Notes: *Used to measure azimuth and inclination.* As an alternative to the single AltIMU, separate compass and gyroscope modules are supported, but must be co-aligned with each other. This module uses the same accelerometer and magnetometer IC as the AltIMU-10 v3 and v4.

Gyroscope Module	1	Pololu	L3GD20H (#2129)	L3GD20H 3-Axis Gyro Carrier with Voltage Regulator	<u>Pololu</u>	
OPTION 2			Or L3GD20 (#2125)	Negalator		

Notes: Used to supplement compass module to improve orientation measurement. As an alternative to the single AltIMU, separate compass and gyroscope modules are supported, but must be co-aligned with each other. This module uses the same gyroscope as the AltIMU-10 v3 and v4. The older L3GD20 module can also be used.

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.*

OPTION 2	1 Tenergy	5200mAh Battery PC	Rechargeable B module with e Leads Walmart Tenergy	The state of the s
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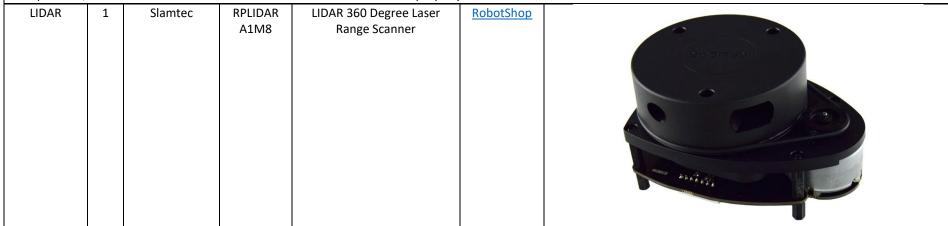
Notes: *Primary system battery.* Higher capacity battery with identical dimensions and voltage to Option 1. Does not include connector unlike Option 1.

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

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 a 1.5 k Ω resistor (see assembly instruction.)

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



Notes: Scanning LIDAR sensor. Other models that may also work but have not been tested include RPLIDAR A2M6 and A2M8. Available from several sources.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Voltage Regulator – 5V	1	Pololu	2119	5V Step-Up/Step-Down Voltage Regulator S7V7F5	<u>Pololu</u>	

Notes: Power supply for Teensy.

Notes: Power supply for LIDAR. A Pololu 2118 (see below) could also be used if set to 5.0 V. Voltage Regulator – Adjustable Adjustable Adjustable Regulator S7V8A Pololu Pololu Pololu Pololu Pololu Pololu Pololu Pololu Pololu Regulator S7V8A	Voltage Regulator – 5V	1	Pololu	2123	Pololu 5V Step-Up/Step- Down Voltage Regulator S7V8F5	<u>Pololu</u>	
	Voltage Regulator –				Pololu Adjustable Step- Up/Step-Down Voltage	1	

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested	Photo
					Vendor Link	

Power Switch Module	1	Pololu	2808	Mini Pushbutton Power Switch with Reverse Voltage Protection, LV	<u>Pololu</u>	
Notes: Turns o	on and	off system power	when pushbu	tton power switch is presses an	d also controls t	timed auto power-off.
Piezoelectri c Buzzer	1	Uxcell	a140624 00ux017 3	Uxcell 5 Pcs DC 1-30V 90Db Sound Passive Electronic Buzzer Alarm Black, 30 x 6 mm	<u>Amazon</u>	
Notes: Indicat	or buzz	zer.	I			
Power Switch & Charging LED	1	Adafruit	3350	Rugged Metal Pushbutton - 16mm 6V RGB Momentary	Adafruit Amazon	
momentary p	ushbut		Adafruit are	available with a single color LEI		ne ring LED for indicating charging and charge complete. Other 16mm are longer in length, so may not fit well in the enclosure. If you buy from
Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested	Photo

Vendor Link

USB Jack	1	GT Contact	GT114200 -50	Waterproof USB Connector - Mini-B Female to Mini-B Female	<u>USBFirewire</u> <u>.com</u>	www.usefirewing.com www.v.usefire.com
	-	-	-			parameters. The connector on the back plugs into the Teensy micro-USB to be used if you use a micro-USB that terminates in bare leads.
USB Cap	1	GT Contact	GT1C5221 22	Seal Cap	USBFirewire .com	BFireWire.com
Notes: Water	proof c	ap for USB jack.				
Teensy USB interface cable	1	StarTech or Seismic Audio	UMUSBO TG8IN or SA- USBM8i	Micro USB Male to Mini USB Male Adapter Cable	Amazon or Amazon	
Notes: Connec	cts the	micro-USB connec	ctor on the Te	ensy to the external waterproo	f mini-USB jack s	shown above.
RTC Battery Holder	1	Unknown	PRT- 00783	Coin Cell Battery Holder - 20mm (PTH)	<u>Sparkfun</u>	

Notes: Holds a CR2032 battery to provide power to maintain the Real-time clock on the Teensy 3.6. Similar holders are available from many sources. So long as they can hold a CR2032 and the pins have a 20 mm spacing, it should work.

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, 4" (10 cm) or 6" (15 cm)	Ebay or Amazon	The state of the s
39 pins with o		sing near the cent	er. Cables lon	ger than 6" would take up too	much space in t	onnector you order has all 40 pins! Some IDE connector cables only have the enclosure. These are available from multiple vendors.
JST Connector for LIDAR Motor	1	Various	N/A	JST 1.25mm pitch, 3 pir connector	n, male <u>Ar</u>	<u>nazon</u>
Notes: Connec	ctor for	LIDAR Motor.				
JST Connector for LIDAR Sensor		Various	N/A	JST 1.25mm pitch, 4 pii connector	n, male <u>Ar</u>	mazon
otes: Connec	tor for	· LIDAR Sensor				

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
JST Connector 5- pin	3	Various	JST-XH	JST 2.54mm pitch, 5 pin, male connector	Amazon, Ebay and others	
Notes: Connect	or for l	LRF, LIDAR, and po	wer switch. If you	u order them prewired as in the ph	oto, be sure the	y are at least 150 mm in length.
JST Connector 2- pin	2	Various	JST-XH	JST 2.54mm pitch, 2 pin, male connector	Amazon, Ebay and others	
Notes: Connect	or use	d for battery and ρ	niezo buzzer. If yo	u order them prewired as in the ph	oto, be sure the	ey are at least 150 mm in length.
MicroSD Card	1	Various	Various	SanDisk 16GB Ultra microSDHC UHS-I Memory Card	<u>Amazon</u>	SanDisk Ultra 16 GB MSS © A1

Notes: Storage for Caveatron data. Numerous brands and sources available. MicroSD card must be SDHC type not larger than 32 GB. SanDisk brand is preferred as they are

generally the most reliable.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Threaded Inserts for LIDAR Standoffs	4	Initeq	INM2504	M2.5-0.4 M2.5 Threaded Heat Set Inserts for 3D Printing (Long)	<u>Amazon</u>	
Notes: Heat se	t threac	ded inserts used in	3D printed LIDAR	enclosure for LIDAR standoffs. The	e standoffs that	screw into these are included with the RPLIDAR.
Threaded Inserts for Enclosure	10	Initeq		#6-32 Threaded Heat Set Inserts for 3D Printing (Long)	<u>Amazon</u>	
Notes: Heat se	t threac	ded inserts used in	3D printed enclos	sure.		
Threaded Inserts for external mounting (Optional)	1	Initeq		#1/4-20 1/4" Threaded Heat Set Inserts for 3D Printing (Short)	Amazon	

Notes: Heat set threaded inserts used in 3D printed enclosure for external mounting. This is an optional part if you plan to attach something external to the Caveatron (like a handle) or mount it to a tripod.

Item	Qty	Manufacture r	Mfr. P/N	Description	Suggested Vendor Link	Photo
2-28 Thread Rolling Screws	14	Small Parts		410 Stainless Steel Thread Rolling Screw for Plastic, Passivated Finish, Pan Head, Phillips Drive, #2-28 Thread Size, 1/4" Length	<u>Amazon</u>	
Notes: Screws	for thi	reading directly ir	nto 3D printed hole	es		
4-20 Thread Rolling Screws	10	Small Parts		410 Stainless Steel Thread Rolling Screw for Plastic, Passivated Finish, Pan Head, Phillips Drive, #4-20 Thread Size, 1/4" Length	Amazon	
Notes: Screws	for thi	reading directly ir	nto 3D printed hole	25	1	
LIDAR Window Material	1	Small Parts	5302441212	Acrylic Sheet, Transparent Clear, Standard Tolerance, ASTM D788, 0.118" Thickness, 12" Width, 12" Length	Amazon	
•				•		windows. Requires cutting to size. Acrylic seems to be the for getting good LIDAR and rangefinder readings.
LRF Window Material	1	Sibe Polymers	5064981212	Clear Acrylic Plexiglass 12" x 12" - 3/32" (.090)	Amazon	

don't want to order this 0.090" thick sheet. Requires cutting to size.

Laser Rangefinder Optical Filter	1	Rosco	299	Roscolux 1.2 Neutral Density Filter, 20x24"	<u>Adorama</u>		
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Notes: Filters rangefinder receiver to only accept readings from the retroreflective card.

Item	Qty	Manufacture r	Mfr. P/N	Description	Suggested Vendor Link	Photo
Screen Protector	1	Supershieldz	N/A	iPhone SE and iPhone 5 Screen Protector	Amazon	PACK 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 Attachment Hardware	1	122317	Hillman Group	D-Ring Hangers	Lowes	

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	Amazon	
Notes: Neck S	trap. T	his neck strap wo	rks well, but other	options are available. Recommen	d a nylon camera	strap of 52-60" in length and about 3/8" wide in the ends.
O-Ring Seals	4 ft	The O-Ring Store	N50.103/10	0.103" (2.62mm) Buna-N 50 O-Ring Cord Stock, 10' Piece, Black	O-Ring Store	The O

Notes: O-Ring material for seals in main enclosure and LIDAR module. This 50 durometer material is preferred over more readily available 70 durometer since it is softer and can make a tighter seal. Must cut to length and glue ends (this vendor also sells O-ring glue in small quantities.) Other vendors sell similar material.

Other Required Items:

PETG Filament for 3D Printing

Caveatron Printed Circuit Board

CR2032 Battery

Single row male headers

Single row female headers

Double row female headers 2x20 (for 40 pin LCD Connector)

1.5 kΩ resistor

6-32 x 1/2" Flat Head Screws (8x)

6-32 x 3/8" Pan Head Screws (4x)

6-32 x 9/16" Pan Head Screw (1x)

6-32 Nut (3x)

Adhesive-backed foam

Epoxy, sealant, and grease

Tape (Kapton or electrical)

Soldering supplies

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

Retroreflective Card Date: 2019-11-07

ltem	Qty	Manufacture r	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. A 6" (150 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	B00E8S5686F	Kydex T Sheet, P3 Velour	<u>Amazon</u>		
Substrate			or 12x24"	Matte, 0.028" thickness			
			sheet – other				
			sizes have				
			different part				
			numbers				

Notes: Substrate material for retroreflective station cards. Need to be cut to about 6.25"x7.5" (160x190 mm). Kydex was chosen since it is durable, thin and flexible, comes in a variety of easy to see colors, 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 it needs to be flexible. The 6x6" retroreflective sheet goes toward one edge of the card leaving about 1.5" to one side for the grommet and a handhold location.

3/8" Brass Grommets	1	Various	N/A	Various vendors	
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Notes: Provide attachment point to retroreflective card. Place it near one corner on the side without the retroreflective sheet.