## Caveatron Bill of Materials Hardware Revision: C

Date: 2023-02-19

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Main Processor	1	PJRC Electronics	Teensy 4.1	Teensy 4.1	PJRC Store	
		n processor. Availa with or without Eth		e vendors. Versions with	and without the pins pr	re-installed are available (link above is with pins).
Touchscreen	1	BuyDisplay	N/A	LCD 3.5" 320x480	BuyDisplay	73733739377777777

Touchscreen	1	BuyDisplay	N/A	LCD 3.5" 320x480	BuyDisplay	31711100000000000000000
LCD	1	BuyDisplay	IN/A	TFT Display Module, OPTL Touch Screen w/Breakout Board  Options: -Capacitive touch panel -16-bit 8080 40-pin header -3.3V supply -No font chip	виуызріау	Workspace  Social Vibra  Support  State Time Off  Open Address  Staff Time Off  Open Address  St

**Notes:** The display and user interface. Note that this is the capacitive touchscreen version unlike the resistive version used previously.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Laser Rangefinder  OPTION 1	1	JRT Meter Tech., Co, Ltd.	Unknown	40m – 60m Laser Distance Sensor Module	Ebay Ebay Alibaba Alibaba Alibaba Alibaba Alibaba Sites linked above has availability as of the date of this BOM	

**Notes:** *Used for station distance measurements.* There are several variants of this module including those that use ASCII or HEX-based commands both of which are supported by the Caveatron. Based on the datasheets I have reviewed I think any variant of this style should work. This style is the preferred LRF module and the only one for which the Rev C enclosure is designed to accommodate.

Laser Rangefinder	1	JRT Meter Tech., Co, Ltd.	Unknown	100m Laser Distance Sensor Module	Still available from some sources on Ebay or Alibaba but you will	
OPTION 2					have to search	(Kight

**Notes:** *Used for station distance measurements.* This rangefinder module uses the same ASCII protocol and power supply as option 1 above but has a longer range so can be substituted. NOTE: the current enclosure design does not accommodate this LRF so a customized enclosure would be required.

**Notes:** *Used for station distance measurements.* This item is long since discontinued and is almost impossible to find. Do not confuse this with the UT390B+, which is more 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 electronics and code in Rev C still support this LRF although the enclosure does not.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Compass Module  OPTIONAL BUT HIGHLY RECOMMENED	1	Witmotion	RM3100	WitMotion High-Precision RM3100 Military-grade Magnetometer Sensor	Amazon or Witmotion	

**Notes:** *Used to determine the azimuth angle of the Caveatron.* This is the best currently available low-cost magnetometer module option. This magnetometer has proven more accurate, reliable and with less drift than another other tested. It is optional since the Pololu IMU module below also includes a magnetometer but the Pololu magnetometer is much more noisy and less accurate, so it is highly recommended that you use this module.

IMU Module	1	Pololu	MinIMU-9 v5 (#2738) Or AltIMU-10 v5 (#2739)	MinIMU-9 v5 Gyro, Accelerometer, Compass (LSM6DS33, and LIS3MDL Carrier)	<u>Pololu</u>	
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**Notes:** *Used to determine orientation of the Caveatron and measure inclination.* The AltIMU-10 v5 is an equivalent part and can also be used (the altitude sensor is not used). The MinIMU-9 and AltIMU-10 v3 and v4 are still supported by the code and electronics but are no longer available.

Font/Graphics IC	1	Winbond	W25Q128JVSIM	W25Q128 SPI flash memory IC, 128 Mbit, quad 8-SOIC	Digikey and many other source	Part Part

**Notes:** Contains the fonts and graphics used for the GUI. You must use the 128Mbit 8-SOIC package version – other sizes may not work. It is soldered to the pad location on the underside of the Teensy 4.1 that is directly under the micro-SD slot and closest to the edge.

Item	Qty	Manufactu rer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Pack OPTION 1	1	Dantona Industries	L37A52- 2-1-2WX	Li-Ion Battery Pack, 3.7V, 5200 mAh, 18650, wire leads with connector	<u>Digikey</u>	
Notes: Primar	y system	battery. This or	ne is the best of	choice since it is lower cost and	already has a com	nector.
Battery Pack  OPTION 2	1	Tenergy	31001	Tenergy Li-Ion 18650 3.7V 5200mAh Rechargeable Battery PCB module with Bare Leads	Tenergy	
Notes: Primar	y system	battery. Identic	al size and ca	pacity to Option 1, but more ex	pensive and you m	nust add a connector.
Battery Pack OPTION 3	1	Adafruit	354	Lithium Ion Battery Pack - 3.7V 4400mAh	<u>Adafruit</u>	PKCELL  ICR18650 4400mAh 3.70
Notes: Primar	y system	battery. Lower	capacity than	options 1 or 2. Has a connector	r.	

Item	Qty	Manufacture r	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Charger Module	1	Unknown	TP5000	Lithium Ion 3.7V Charger Module	Amazon	102 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	require	d to make it functi				e sure to get the variant with the 4 power pins all on the same side. A arge current above 1 Amp. These are usually on a red PCB but can also be
10k resistor	2	Various	Various	SMD resistor, 10k-ohm, 1%, 1206 package	<u>Digikey</u>	
		tery monitor volta arries no significan		d for IMU power input. Avail	able from numero	ous manufacturers and vendors - the above is only 1 example. <sup>1</sup> / <sub>4</sub> watt or
3.3k resistor	1	Various	Various	SMD resistor, 3.3k-ohm, 1%, 1206 package	<u>Digikey</u>	
Notes: Resistor			ge divider. A	vailable from numerous manu	ifacturers and ver	ndors - the above is only 1 example. 1/4 watt or less is fine since this
0.2-ohm resistor OPTIONAL	1	Various	Various	SMD resistor, 0.2-ohm, 1%, 0.5W, 1206 package	<u>Digikey</u>	
Notes: Resistor	r for bat	tery charger modi	ile. Only need	led if you want to increase the	e charge current o	of the TP5000 from the default 1 Amp to 1.5 Amp.

Notes: Power supply for Teensy.   I	Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
LRF Voltage Regulator  Notes: Power supply for Laser Rangefinder. Output needs to be set to 3.0V.  LIDAR Voltage Regulator  OPTION FOR RPLIDAR Voltage Regulator  Notes: Power supply for RPLIDAR AIM8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  OPTION FOR RPLIDAR AIM8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  RPLIDAR Pololu  2123 Pololu SV Step-Up/Step-Down Voltage Regulator S7V8F5  Pololu  Pololu  Pololu  Pololu  Pololu  Pololu  Regulator U3V70F5  Pololu  Pololu  Pololu  Pololu  Regulator U3V70F5	Regulator –	1	Pololu	2119		<u>Pololu</u>	
Notes: Power supply for Laser Rangefinder. Output needs to be set to 3.0V.  LIDAR AIM8  Notes: Power supply for RPLIDAR AIM8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  OPTION FOR RPLIDAR AIM8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  Notes: Power supply for RPLIDAR AIM8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  OPTION FOR RPLIDAR AIM8. If using the RPLIDAR S2, this cannot source enough current.  Pololu  Pololu  Pololu  Regulator U3V70F5	Notes: Power	supply j	for Teensy.	l			
LIDAR Voltage Regulator  OPTION FOR RPLIDAR A1M8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  Notes: Power supply for RPLIDAR A1M8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  OPTION FOR RPLIDAR A1M8. If using the RPLIDAR S2, this cannot source enough current.  Regulator Voltage Regulator  OPTION FOR RPLIDAR	Voltage	1	Pololu	2118	Up/Step-Down Voltage	<u>Pololu</u>	
Voltage Regulator  OPTION FOR RPLIDAR A1M8  Notes: Power supply for RPLIDAR A1M8. If using the RPLIDAR S2, this cannot source enough current.  LIDAR Voltage Regulator  OPTION FOR RPLIDAR RPLIDAR	Notes: Power	supply J	for Laser Rangefind	der. Output	needs to be set to 3.0V.		
LIDAR Voltage Regulator  OPTION FOR RPLIDAR  Pololu  2891 Pololu 5V Step-Up Voltage Regulator U3V70F5	Voltage Regulator OPTION FOR RPLIDAR	1	Pololu	2123	Down Voltage Regulator	<u>Pololu</u>	
Voltage Regulator  OPTION FOR RPLIDAR	Notes: Power	supply	for RPLIDAR A1M	8. If using t	he RPLIDAR S2, this cannot so	urce enough current.	
	Voltage Regulator OPTION FOR RPLIDAR	1	Pololu	2891		<u>Pololu</u>	

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Power Switch Module	1	Pololu	2808	Mini Pushbutton Power Switch with Reverse Voltage Protection, LV	<u>Pololu</u>	
Notes: Turns	on and oj	t If system power who	en pushbutton j	nower switch is pressed and also con	trols timed auto p	power-off.
RTC Battery Holder	1	MPD and others	BC501SM	Coin Cell Battery Holder - 12mm (for CR1220 batteries)	<u>Digikey</u>	
					<u>Amazon</u>	
						ers are available from many sources with differing part
Piezoelectric	nose I ha	Uxcell	A1406240	all have nearly identical dimensions uxcell A14062400ux0199 5 Pcs		
Buzzer	1	Uxceii	0ux0199	DC 2-28V 80Db Sound Electronic Passive Buzzer Alarm Black, 22 x 4.5 mm	Amazon	

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Power Switch & Charging LED	1	Adafruit	3350	Rugged Metal Pushbutton - 16mm 6V RGB Momentary	Adafruit  Amazon	

**Notes:** On/Off power switch and charge indicating ring LED. This one enables separate colors on the ring LED for indicating charging and charge complete. These can be found at other sources as well but if you buy from another source be sure to get the common anode version.

			•	U		
USB Jack	1	GT Contact	GT114200-10	Mini USB-B C2 size Plastic	USBFirewire.	
			(RR-114200-10)	Panel Mount	<u>com</u>	
						www.USBFireVilre.com
						CO CO
	USB Jack	USB Jack 1	USB Jack 1 GT Contact		USB Jack 1 GT Contact GT114200-10 Mini USB-B C2 size Plastic	USB Jack 1 GT Contact GT114200-10 Mini USB-B C2 size Plastic USBFirewire.

**Notes:** *USB jack for data download, battery charging, and loading of software and calibration parameters.* This is the version with the solder pins on the inside. If you prefer a USB-micro connector, that is available as part number RR-11A200-10 and is an identical fit.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
USB Cap	1	GT Contact	GT1C522122 (RR-1C522122)	Seal Cap	USBFirewire. com	SBFireWire.com

Notes: Waterproof cap for USB jack. This cap works for either the mini or micro USB options.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
MicroSD Card	1	Various	Various	SanDisk 32GB Ultra microSDHC UHS-I Memory Card	Amazon and many other sources	SanDisk Ultra 32 <sub>GB</sub> PS 1 © A1

**Notes:** *Storage for Caveatron data.* Numerous brands and sources available. MicroSD card must be SDHC type not larger than 32 GB (smaller capacities are fine as well). SanDisk brand is preferred as they are generally the most reliable.

**Notes:** For the cable to connect the exterior USB jack to the Teensy. Wires are soldered between this part and the USB jack connector pins. Note that only the D+, D-, and GND are connected on this plug. The USB power (and a second GND wire) goes from the USB jack to a plug on the main PCB.

LCD	1	N/A	N/A	40 pin IDE Male to Female	Ebay or Amazon	
Connector				Extension Cable, 4" (10 cm) or 6"		
Cable				(15 cm)		
						Mo:
						State
						Ch
N	•	Y 60 F 1		1 0 1 1 0 11 1	.1 (1) 11.1	

**Notes:** Cable to connect to LCD Touchscreen from the Caveatron main board. Cables longer than 6" would take up too much space in the enclosure while those shorter than 4" are not long enough. These are available from multiple vendors. Note that some of these connectors do not include one of the middle pins, however those are fine since that pin is not used.

Item	Qty	Manufact urer	Mfr. P/N	Description	Suggested Vendor Link	Photo
JST Connector 5-pin	2 or 3	Various	JST-XH	JST 2.54mm pitch, 5 pin, male connector	Amazon, Ebay and others	
Notes: Conne	ctor for LRF,	power switch, a	nd LIDAR. If yo	u order them prewired as in the	e photo, be sure they are	at least 100 mm in length.
JST Connector 2-pin	3 or 4	Various	JST-XH	JST 2.54mm pitch, 2 pin, male connector	Amazon, Ebay and others	
				zzer, and battery. If you order to bre-connectorized.	hem prewired as in the p	photo, be sure they are at least 100 mm in length. (You
Socket Headers 1	1 (6 pin positions needed)	Prec-Dip or others	310-87- 106-41- 001101	Socket header, 0.1" pitch, 4.2 mm insulation height, single row, 6 pins	Digikey and others	
						d since the RM3100 has tall components. This header size is one side and 2 pins on the other.
Socket Headers 2	3 (54 pin positions needed)	Prec-Dip or others	801-87- 024-10- 001101	Socket header, 0.1" pitch, 7.0 mm insulation height, single row, 24 pins	Digikey and others	One side and 2 pins on the other.
						mm height to avoid interference with the display. Other eensy and 5 pins are needed for the IMU module.

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>	BACK  PACK  PACK
Notes: Protects	ion film	for touchscreen. N	Needs to be co	ut to length. Most any PET scre	een 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.

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

**Notes:** Optical filters for the LRF receiver to only accept readings from the retroreflective card. This filter only has half the optical density required, so must be folded in half when installed. Other neutral density films are fine so long as they are sufficiently dark to prevent the LRF from getting a signal from a non-retroreflective surface but no so dark that they reduce the range from the retroreflective surface.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
LIDAR  OPTION 1	1	Slamtec	RPLIDAR A1M8	LIDAR 360 Degree Laser Range Scanner, 12 m range	RobotShop	

**Notes:** *Scanning LIDAR sensor.* Other models that should also work but have not been tested include RPLIDAR A2M6, A2M7, A2M8, and A3. These LIDARs are triangulation-based. Available from several sources.

LIDAR	1	Slamtec	RPLIDAR	LIDAR 360 Degree Laser	RobotShop	
			S2	Range Scanner, 30 m range		
OPTION 2						
						With Many
						48)

**Notes:** *Scanning LIDAR sensor.* The S2 has 2.5x the range, can collect 4x the number of points per second, has a faster rotation rate, and is smaller, but is more expensive. This LIDAR is a time-of-flight LIDAR. Available from several sources. Watch out since there are several variants out there. A true unit may also be referred to as an S2 R2. Some models which are referred to as S2L are about \$100 cheaper than a true S2, but only have an 18m rated range. There is also an Ethernet version – the S2E but you don't want that version either. Also there may be some defective units out there as the first one I received only reached 14m even through it appears to be a true S2.

Item	Qt y	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Threaded Inserts for Enclosure	10	Initeq		#6-32 Threaded Heat Set Inserts for 3D Printing (Long)	<u>Ebay</u>	
Notes: Heat set	threac	led 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)	<u>Ebay</u>	
Notes: Heat set handle) or mou			3D printed enclos	sure for external mounting. This is	an optional part	if you plan to attach something external to the Caveatron (like a
Threaded Inserts for RPLIDAR A1M8 Standoffs  For RPLIDAR A1M8 only	4	Initeq	INM2504	M2.5-0.4 M2.5 Threaded Heat Set Inserts for 3D Printing (Long)	<u>Ebay</u>	
Notes: Heat set	threac	led inserts used in	3D printed LIDA	R enclosure for RPLIDAR A1M8 st	andoffs. The sta	ndoffs that screw into these are included with the RPLIDAR.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo					
LIDAR Window For RPLIDAR S2 only	1	JMX	N/A	3.1" Acrylic Dome	Amazon						
Notes: Windo	Notes: Window for the RPLIDAR S2. This will only work for a TOF type LIDAR. Curved windows do not work with triangulation LIDARs like the A1 series.										
LIDAR Window For RPLIDAR A1M8 only	1	Small Parts	5302441212	Acrylic Sheet, Transparent Clear, Standard Tolerance, ASTM D788, 0.118" Thickness, 12" Width, 12" Length	Amazon						
seems to be th	e most t	transparent with the	least distortion			PLIDAR A-series windows. Requires cutting to size. Acrylic ch is important for getting good LIDAR and rangefinder readings.					
LRF Window Material	1	Sibe Polymers	5064981212	Clear Acrylic Plexiglass 12" x 12" - 3/32" (.090)	Amazon						
Notes: Transp	arent a	crylic sheet for LRI	 F window on Ma	lin Body.							

Item	Qty	Manufacture r	Mfr. P/N	Description	Suggested Vendor Link	Photo					
Strap Attachment Hardware	1	122317	Hillman Group	D-Ring Hangers	<u>Lowes</u> <u>Amazon</u>						
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	S. I. I.					
Notes: Neck S	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.										
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 Days of the Control of the Contr					

**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:

Caveatron Rec C Printed Circuit Board

CR1220 Battery

Single row male headers, 2.54 mm (0.1") pitch

Double row female headers 2x20 (for 40 pin LCD Connector), 2.54 mm (0.1") pitch

Soldering supplies

6-32 x 1" flat head machine screws (4x)

6-32 x 3/8" flat head machine screws (4x)

6-32 x 3/8" pan head machine screws (4x)

6-32 x 5/8" pan head machine screw (1x)

4-20 x <sup>1</sup>/<sub>4</sub>" thread rolling screws (10x)

M4x0.7 x 6mm (or 5mm) pan head machine screws (4x)

4-20 x ½" thread rolling screws (6x)

2-28 x <sup>1</sup>/<sub>4</sub>" thread rolling screws (11x)

PETG filament for 3D printed parts

O-Ring grease

O-Ring epoxy

Size 114 O-ring (for the LIDAR-Main body interface or make your own from the O-Ring cord above)

Flexible waterproof epoxy sealant

Adhesive-backed foam

Tape (Kapton or cellophane)

**Notes:** For assembly and electrical interconnections between boards.