Caveatron Bill of Materials – Main Body
Hardware Revision: A
Date: 2017-09-10

Red = No longer available – replaced in Hardware Rev. B   Yellow = Limited availability (no longer manufactured). Replaced in Hardware Rev. B

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

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: https://forum.arduino.cc/index.php?topic=256771.0

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Touchscreen LCD	1	Coldtears Electronics	N/A	3.5 inch TFT LCD module w/Font IC 480x320 full angle Arduino DUE MEGA 3.2 4.3	N/A	

Notes: *The display and user interface.* The component used in Hardware revision A is no longer available. A revised component was released by the manufacturer with a new font IC and different display driver that requires revised code Caveatron firmware that is currently under development. The 4 inch 480x320 module produced by this manufacturer appears to use the previous font IC and driver so may work with original firmware, but has not been tested.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
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	
Notes: *Providea electrical interface from Arduino to the Touchscreen LCD.*						
Laser Rangefinder	1	Uni-T	UT390B	Laser Distance Meter	Ebay, Amazon, or other sources. Availability changes frequently.	
Notes: *Used for station distance measurements.* This item appears to be discontinued but can still be found online from various 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 Caveatron hardware rev. B uses a new rangefinder that has assembly advantages, but operational disadvantages over this model.						

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.*						
Real-Time Clock and	1	N/A	N/A	DS3231 AT24C32 Real time clock module memory module	Ebay or other sources. Ebay sellers change frequently	
Notes: *Provides date/time and used to store calibration and system parameters.* This board contains a Maxim DS3231 real-time clock and an Atmel AT24C32 EEPROM memory IC. Requires a CR2032 battery to keep clock active. Available from many vendors and Ebay sellers						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Pack	1	Adafruit	354	Lithium Ion Battery Pack - 3.7V 4400mAh	Adafruit	
Notes: *Primary system battery.*						
Battery Charging Module	1	Adafruit	259	USB LiIon/LiPoly charger - v1.2	Adafruit	
Notes: *Controls the charging of the LI-Ion battery pack and provides charge indication to power switch LED.* Default charge current is 500 mA, but can be increased to 1000 mA by adding resistor (see product page at vendor link.) This part has been replaced in Caveatron hardware rev. B with a combined battery charger and fuel gauge module.						
Battery Gauge Module	1	Sparkfun	TOL-10617	LiPo Fuel Gauge	Sparkfun	
Notes: *Monitors battery level.* Contains a MAX17043 battery fuel gauge IC. These are also available at other, cheaper sources such as Ebay and Amazon, but sometimes use a counterfeit Maxim IC that does not function properly. This part has been replaced in Caveatron hardware rev. B with a combined battery charger and fuel gauge module.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Voltage Regulator – 9V	1	Pololu	2116	9V Step-Up Voltage Regulator U3V12F9	Pololu	
Notes: *Power supply for Arduino Due.*						
Voltage Regulator – 5V	1	Pololu	2123	Pololu 5V Step-Up/Step-Down Voltage Regulator S7V8F5	Pololu	
Notes: *Power supply for LIDAR Module.*						
Voltage Regulator – Adjustable	1	Pololu	2118	Pololu Adjustable Step-Up/Step-Down Voltage Regulator S7V8A	Pololu	
Notes: *Power supply for Laser Rangefinder.* Output is set to 3.0V.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Piezoelectric Buzzer	1	Pololu	1260	30mm Piezo Buzzer: 1-30V	Pololu	
Notes: *Indicator buzzer.* Item has been discontinued. A new part needs to be identified for hardware rev. B.						
Power Switch & Charging LED	1	Adafruit	916	Rugged Metal On/Off Switch with Red LED Ring - 16mm Red On/Off	Adafruit	
Notes: *On/Off power switch and charge indicating ring LED.* Several colors of the LED are available.						
USB Jack	1	GT Contact	GT114200 -10	Mini USB-B C2 size Plastic Panel Mount	USBFirewire .com	
Notes: *Mini-USB jack for data download, battery charging, and loading of software and calibration parameters.*						
USB Cap	1	GT Contact	GT1C5221 22	Seal Cap	USBFirewire .com	
Notes: *Waterproof cap for USB jack.*						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
LIDAR Interface Jack	1	Conxall/ Switchcraft	17982-6SG-300	Micro-Con-X 6 Position Circular Connector Receptacle, Female Sockets Solder Cup Gold	Digikey	

Notes: *Jack for LIDAR interface cable.* Available from multiple vendors.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
LIDAR Interface Cap	1	Conxall/ Switchcraft	16295	Micro-Con-X Receptacle Dust Cap	Digikey	

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 Connector Cable, 6"	Ebay or Amazon	

Notes: *Cable to interface Due LCD Interface Shield and LCD Touchscreen.* 6" is the preferred length. Longer would take up too much space in the enclosure. 4" can work as well, but is a bit of a stretch. Available from multiple vendors.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Main Body 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 Mounting Rail	1	Weaver	TO-9M	Tip-Off Aluminum Base	Amazon	
Notes: *Rail for mounting LIDAR module.* Weaver TO-9 rail is identical but with a shiny finish. Available from multiple vendors						
Plastic Base Material	1	Small Parts	STPVC-0093-F	PVC Sheet, Opaque Gray, 0.093" Thickness, 12" Width, 24" Length	Amazon	
Notes: *Plastic sheet for mounting internal components in Main Body Enclosure and LIDAR Enclosure.* Requires cutting to size and drilling mounting holes.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Window Material	1	Small Parts	5064981212	Acrylic Sheet, Transparent Clear, 0.06" Thickness, 12" Width, 12" Length	Amazon	
Notes: *Transparent acrylic sheet for Rangefinder window on Main Body and LIDAR windows on LIDAR Module.* 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"	Adorama	
Notes: *Filters rangefinder receiver to only accept readings from the retroreflective card.*						
Screen Protector	1	iCarez	N/A	iPhone 5 Ultra Clear Screen Protector 6-pack	Amazon	
Notes: *Protection film for touchscreen.* Also comes in a 3 pack. Needs to be cut to length. Most any 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. Available from multiple vendors.						

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Strap Attachment Hardware	1	122317	Hillman Group	D-Ring Hangers	Lowes	
Notes: *Small D-rings for attaching neck strap.* Available from multiple						
Neck Strap	1	N/A	N/A	N/A	N/A	
Notes: *Neck Strap.* Recommend a nylon camera strap of 52-60" in length about 1.5" wide and about 3/8" wide in the ends. Original source no longer available.						
Assorted Fastener Hardware: Screws, Washers, and Nuts						
Notes: *For assembly.* Several sizes of standard hardware required. To be detailed in assembly instructions.						
Assorted Electrical Hardware: Wire, Header Connectors, and JST Connectors.						
Notes: *For electrical interconnections between boards.* To be detailed in assembly instructions.						

New Components for Hardware Revision: B
Date: 2017-09-10

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Touchscreen LCD	1	Coldtears Electronics	N/A	3.5 inch TFT LCD module w/Font IC 480x320 full angle Arduino DUE MEGA 3.2 4.3	Ebay	

Notes: *The display and user interface.* This replaces the Touchscreen LCD for hardware Rev A. This component uses a different Font IC so requires a different interface library and changes to the Caveatron GUI library. The display driver also appears to be slightly different and requires a small change to the display library code to work properly.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Laser Rangefinder	1	Unknown	Unknown	100m Laser Distance Sensor Module	Ebay Availability changes frequently.	

Notes: *Used for station distance measurements*. This new rangefinder module is very similar in size to the one in hardware rev. A, is easier to mount due to the presence of mounting holes, is easier to attach wiring, has a simpler command and data structure, and has similar sensitivity. However, it's method of operation is less well suited to the Caveatron since it can take up to 3 sec to timeout with failed readings vs 1 sec on the old one, which does not work as well in Passage mode.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Battery Charger and Gauge	1	Sparkfun	PRT-13777	Battery Babysitter - LiPo Battery Manager	Sparkfun	

Notes: *Battery charge controller and fuel gauge.* This replaces both the separate charger and fuel gauge modules in hardware rev. A. It is more capable with a more reliable method for monitoring battery charge level and can be adjusted to charge at up to 1500mA. The only downside is that connecting wiring to the external charge indicator LED on the power switch is more difficult.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Piezoelectric Buzzer	1	Unknown	Unknown	Unknown	Unknown	

Notes: *Indicator buzzer.* A couple of parts have been tested but have not been found to be a suitable replacement. It appears that a buzzer 16mm or larger is requires as smaller ones do not produce sufficient sound at lower frequencies. Many options remain available to test.

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.	

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.

Item	Qty	Manufacturer	Mfr. P/N	Description	Suggested Vendor Link	Photo
Station Card Substrate	1	Small Parts	B00E8S5686 For 12x24" sheet – other sizes have different part numbers	Kydex T Sheet, P3 Velour Matte, 0.028" thickness	Amazon	

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.