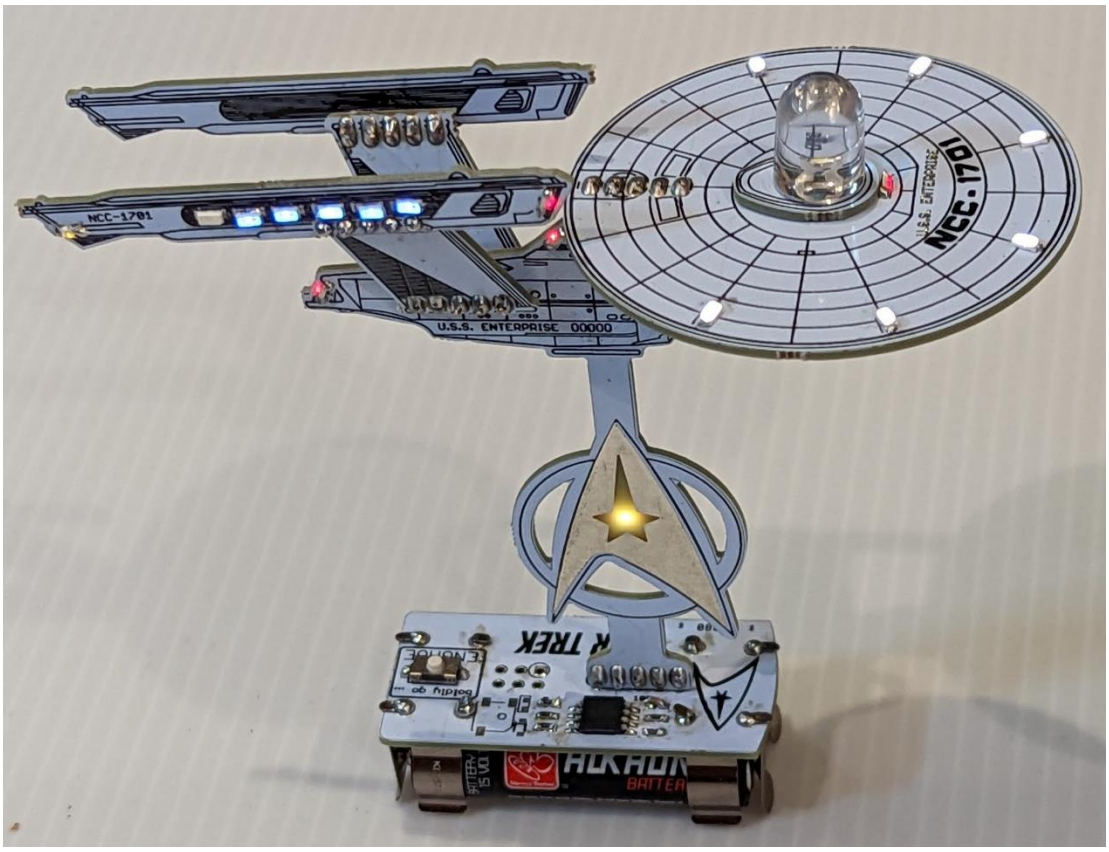
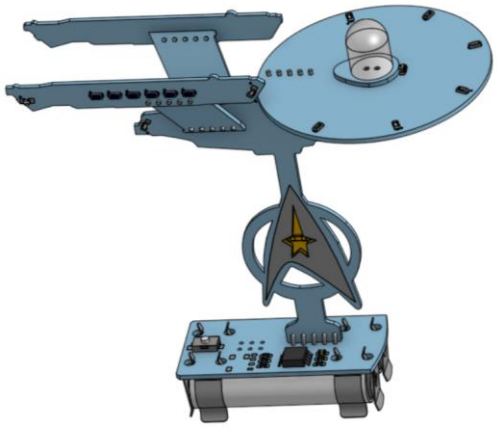
3D Star Trek Enterprise



Congratulations! You get to boldly go about building a 3D Animated Star Trek Enterprise using surface mount components. It comes from https://hackaday.io/project/162654-pcb-3d-startrek-enterprise and we have given you lots of instructions and hints on how to build the kit. You can also find an online Onshape model to help you visualize the build at:

https://cad.onshape.com/documents/565c0cbf5eeea3c30d27d792/w/7b3cc5df3d4af13422d8813f/e/97d0ae98d388b07cf3120b6e?renderMode=0&uiState=6394d9f163195064948017d5



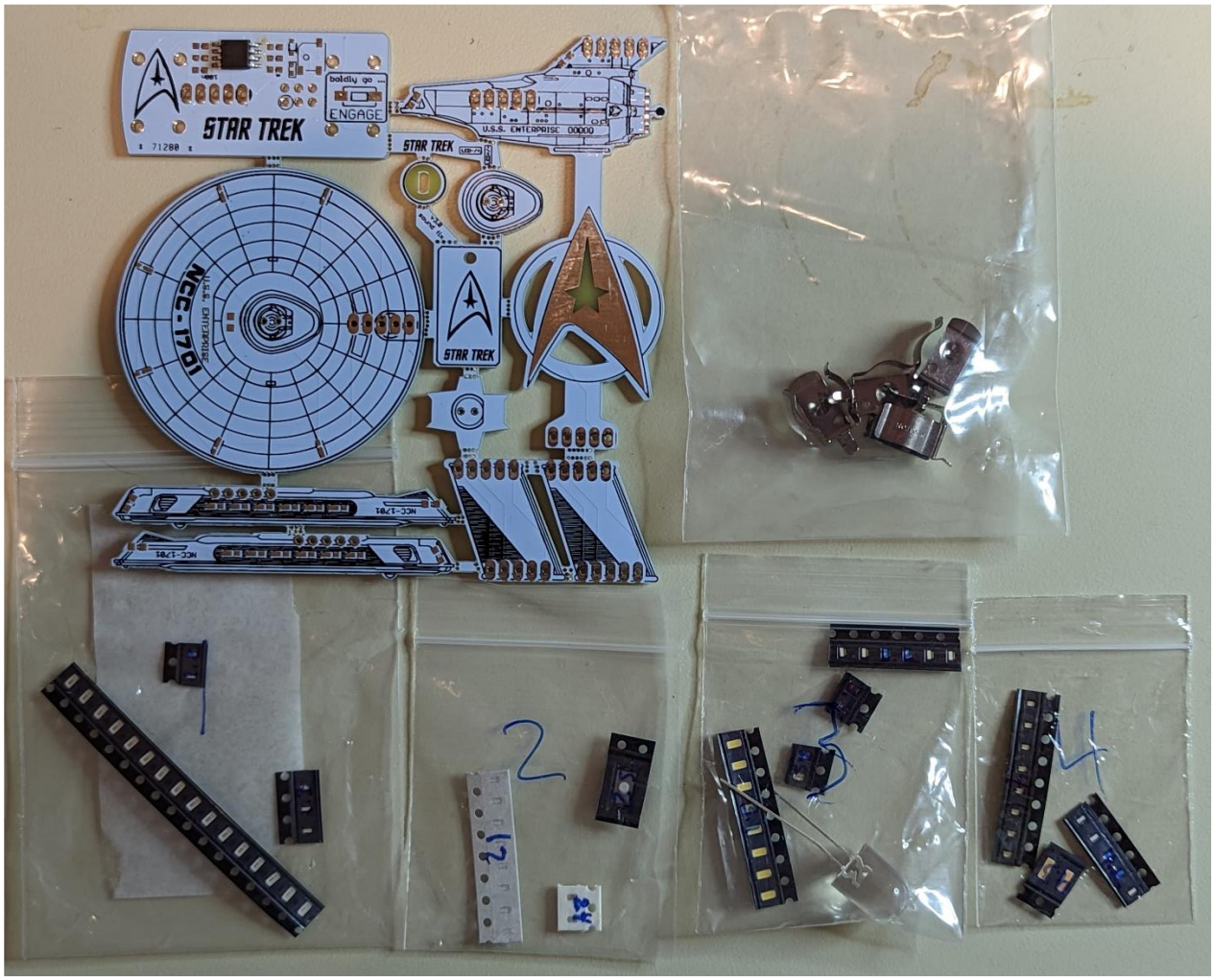
What's in the kit?

All the parts have been sorted into individual bags based on the section of the design to make it easier to keep them together.

- Bag 1 – Nacelles
- Bag 2 - Main Board
- Bag 3 – Saucer top and bottom
- Bag 4 – Body stand – Both sides

Inside each bag, the parts has been labeled to make them easy to identify. As it turns out, there is a different quantity of each part in bags (with the exception of 3.4 and 3.5, but 3.4 is obviously red) to also make it easier to distinguish between them.

There are also a few extra of each part to allow for the inevitable "oops, I dropped it on the floor and can't find it" or "applied too much heat and let out the magic smoke" so don't be worried about something left over when you are done.



Parts List

Item	Needed	Kit	Part number	Name	Description
1				**Nacelles**	
1.1	12	16	QBLP674-IB	[ENGINE-SIDES] LED BLUE 2PLCC SMD	2PLCC Blue LED
1.2	2	2	LTST-S270KSKT	[ENGINE-TAIL] LED YELLOW CLEAR CHIP SMD R/A	Yellow LED
1.3	2	3	LTST-S270KRKT	[ENGINE-INTAKE, BODY-MARKER, UNDER-DISK] LED RED CLEAR CHIP SMD R/A	Red Clear LED
2				**Main Board**	
2.1	5	8	RK73B1JTTD470J	RES 47 OHM 5% 1/8W 0603	0603 47 Ohm Resistor
2.2	4	4	36-82-ND	BATT CONT CLIP MULT 1 CEL PC PIN	Battery Clip
2.3	2		AAA	AAA Battery	AAA Battery
2.4	1	2	C0603C104M4RAC7867	CAP CER 0.1UF 16V X7R 0603	0603 .1uf Capacitor
2.5	1	1	434113025826	SWITCH TACTILE SPST-NO 0.05A 12V	Switch
3				**Saucer**	
3.1	6	8	QBLP674-IWM-CW	[DISH-TOP] LED COOL WHITE DIFF 2PLCC SMD	2PLCC Cool White LED
3.2	4	6	QBLP617-IW	[UNDER-DISK] LED WHITE CLEAR 0602 SMD R/A	0602 White LED
3.3	1	1	VAOL-10GWY4	[BRIDGE] LED WHITE CLEAR T/H	White LED Through Hole
3.4	1	2	CMD17-21VRD/TR8	[DISH-TOP-MARKER] LED RED DIFFUSED 0805 SMD	0805 Red Diffused LED
3.5	1	2	150080VS75000	[LASER] LED GREEN CLEAR 0805 SMD	0805 Green LED
4				**Stand**	
4.1	6	8	150060BS75000	[DEFLECTOR-DISH] LED BLUE CLEAR 0603 SMD	0603 Blue LED
4.2	4	5	LTST-S270KRKT	[ENGINE-INTAKE, BODY-MARKER, UNDER-DISK] LED RED CLEAR CHIP SMD R/A	Red Clear LED
4.3	1	2	KW DPLS32.EC-6H6J-4R8T-1-120-R18	[Under Star] LED SYNIOS E4014 3000K 2SMD	4014 White LED

Tools you will need

First off you will need a soldering iron with a very small tip because the parts you will be assembling are far smaller than a grain of rice.

It is also useful to have a nice flat surface, preferably bright color so that you can see the tiny parts when you invariably drop them. A white surface is less than ideal because most of the tiny parts are white and small enough that even shining a light across the surface looking for their shadow doesn't really work.

A magnifying glass is quite useful – particularly so you can check the orientation of the LEDs. A lighted one is even better.

A fine pair of tweezers to hold onto the parts.

A nice pair of wire cutters for trimming the wires.

A small pair of pliers to form the wires. A beading pliers is very useful if you have one.

(Optional) a 3-volt power supply so that you can test connections along the way.

Some general Assembly Tips

Soldering surface mount parts takes a steady hand and a bit of patience. However, if you want to cheat, you could carefully glue all the parts which are face up into position and then heat the board in a toaster oven to melt the solder. However, this only gets about half of the parts, so it probably isn't worth it.

Remember that these parts are TINY. A grain of rice is huge compared to many of them. When picking them up with a tweezers, don't squeeze too hard or it might just jump out of the tweezers and hid in that black hole where socks from the dryer seem to go.

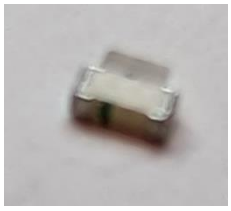
You will want to keep the boards all together until you have finished soldering. It is tough enough to handle the small surface mount parts, and worse when trying to keep the small circuit boards in place.

Occasionally I find it is useful to use a piece of painters' tape to hold a part down so that it doesn't move.

LED Orientation

The most important thing to track is which way the LED needs to face. Unfortunately there are a variety of ways that the LEDs are marked. The ones you will encounter in this kit:

- A larger pad on the back indicates the cathode/negative side.
- A triangle on the back with the tip pointing to the cathode/negative side.
- A simple stripe on the back closer to the cathode/negative side.



- A sideways T on the back with the bottom “pointing” at the cathode/negative side.

- Two small squares in the corner on the front indicating the cathode/negative side
- The shorter lead on the through hole LED indicating the cathode/negative side.

On the assembly drawings, there is an indication of the markings to look for on the particular LEDs used in the step, so you don’t have to guess.

LED Placement

There are three ways that the LEDs need to be placed on the board as indicated in the drawings.

- **Normal** – this is basically where the LED is flat against the board. This turns out to be the most challenging, but if you first orient the LED properly, put a blob of solder on the larger pad, heat it up and then carefully plop the led onto the pad ENSURING that there is room to access the other pad. Then you can apply a little solder to the other pad and have it wick under the part.
- **Side** – the drawing will have [Side] next to the description. These are probably the easiest to do. After aligning the LED and holding it carefully with a tweezers, put a blob of solder onto one pad and push the LED into that spot making sure you have room on the other pad. Then solder the other pad and come back and touch up the first pad. It is useful to hold onto it with the tweezers so that it points exactly how you want it.
- **Upside Down** – There is one LED behind the star on the main vertical board. This one is tricky. You could cheat and do it as a side LED using the lower pad so that the LED shines up, but for the best effect, you need to lay it UPSIDE down on the pads. To do this, first take a couple of strands of wire and tin them. Then carefully solder them to the pads on the bottom of the LED. Next you place the LED upside down on the pads (if you are gutsy, you could superglue it in place) and solder on of the strands to the pad and then the other strand to the other pad. It is useful to then glob a little more solder on top of the strands (making sure that they don’t come loose) to ensure it stays in place.

Testing Along the way

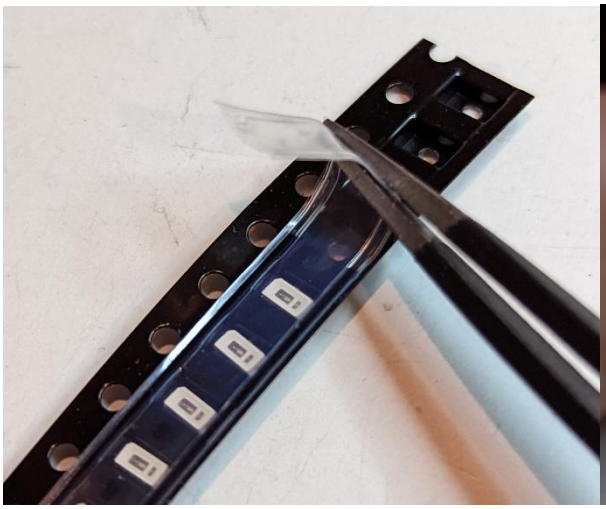
Because all of the LEDs are lit via a matrix with all 5 points of the matrix replicated with the 5 connections to each board, it is really easy to test that each LED is in place and working after you solder it. To do this you will need a 2.2 and 3 volt power supply (or a 3 volt power supply and a resistor for the 2.2 volts). The drawings indicate which of the pins will light the corresponding LED.

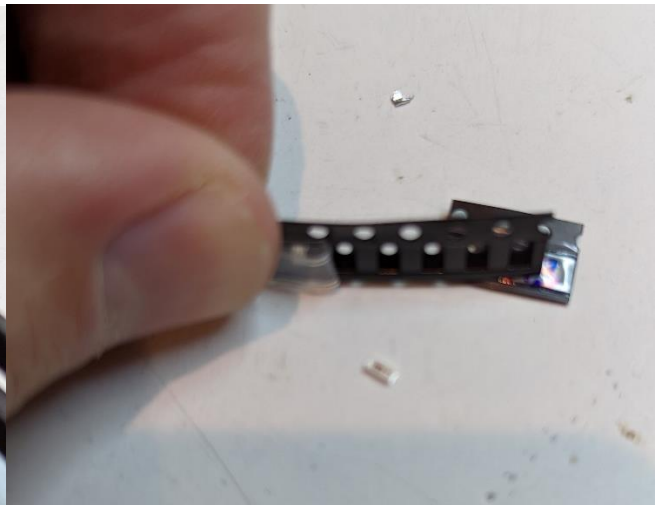
Once you have finished a board, it is also worth confirming that all the LEDs still work. Sometimes when you are soldering an LED you might bump one near it and it is no longer connected. It is much easier to debug and resolder when all the boards are laying flat on the work surface.

Getting Parts Ready

To keep from getting parts mixed up, you should only pull out a single part at a time. Only open the bag for the step you are working on. Pull out the package with the part you need (they should all be labeled) and then carefully use the tweezers to peel off the plastic to release a single part onto your work surface and then let the plastic go back to cover so that another part doesn't just fall out.

Then you can grab the part with the tweezers to determine the correct orientation. Technically they are all in the same orientation in the package, but when you drop it out, it certainly won't keep that orientation.



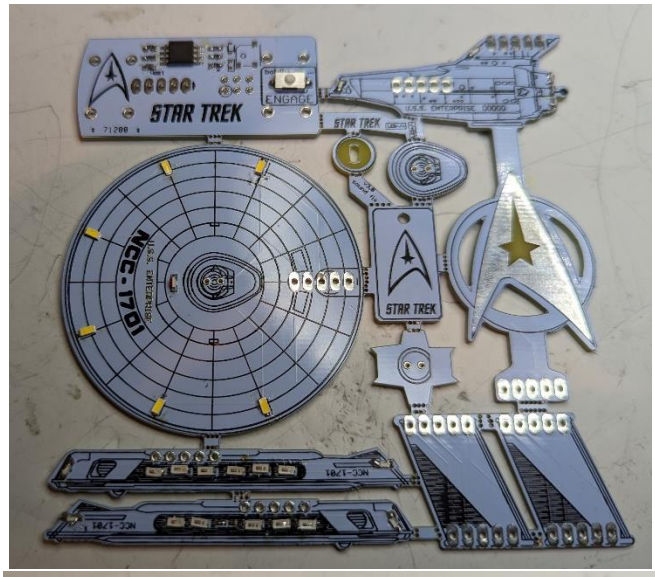


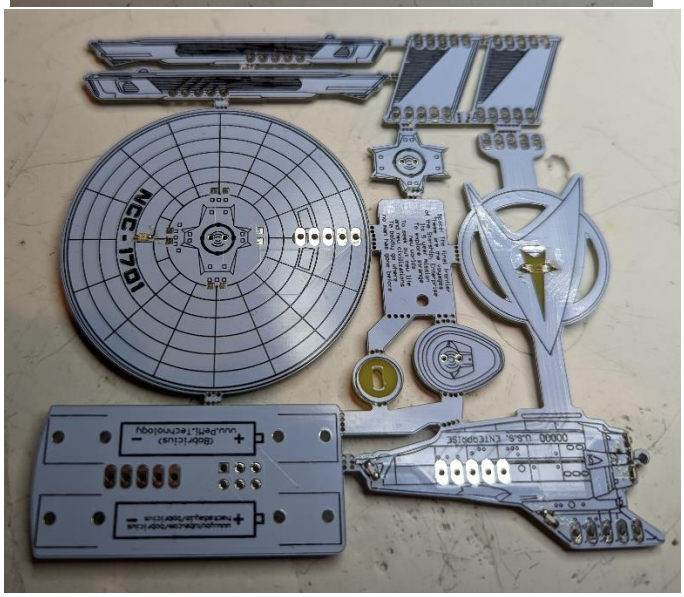
Part Soldering Order

The simplest order for putting the parts on the board is how they are organized in the bags:

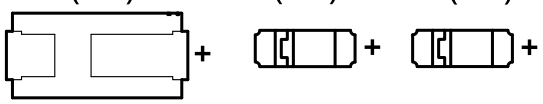
1. Nacelles
2. Main Board (except for the battery clips)
3. Saucer top and bottom except for the big through hole led
4. Body Stand (both sides) – Save the upside-down star LED for last

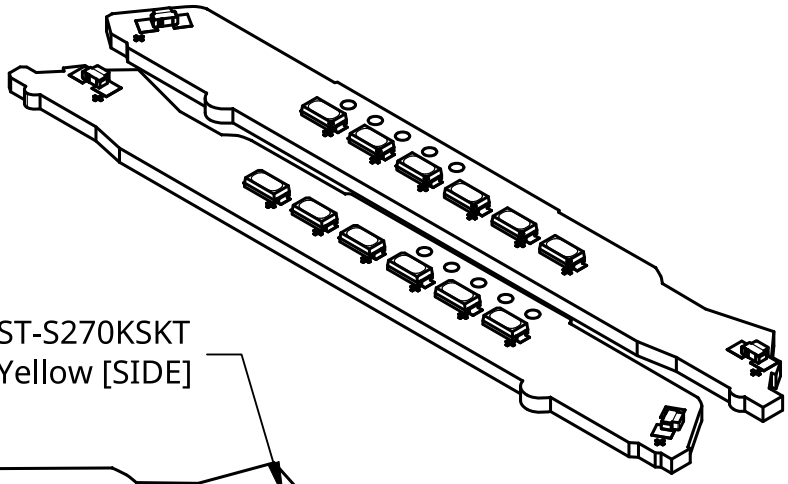
The assembly diagrams for the first four sections are next. When you are done with step 4, it should look like this.

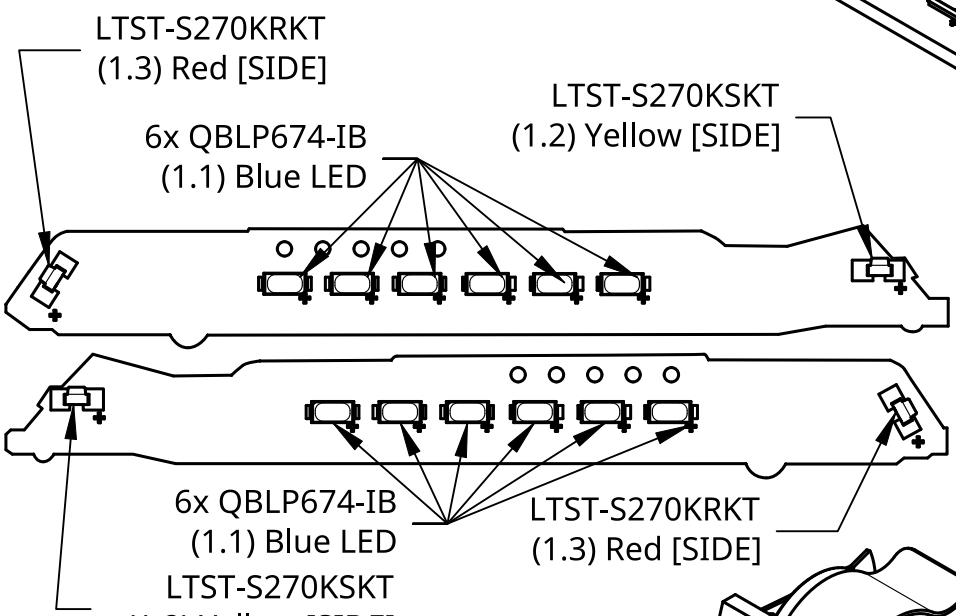


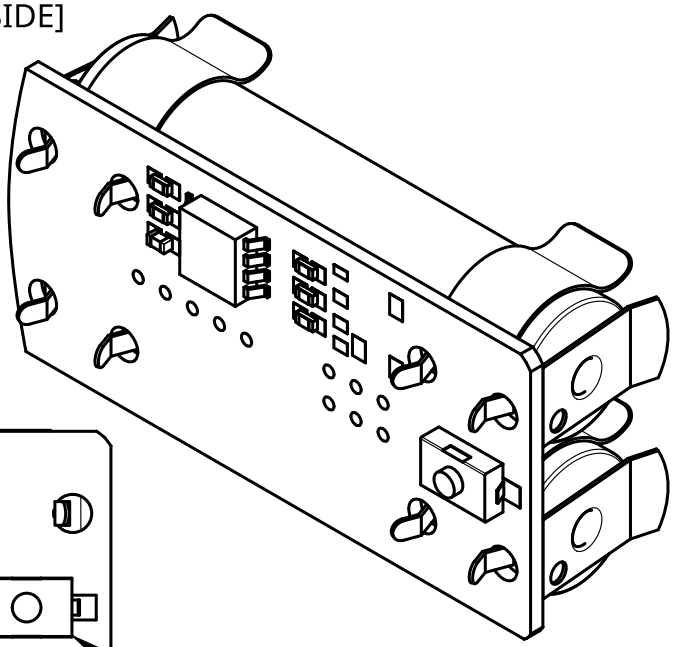


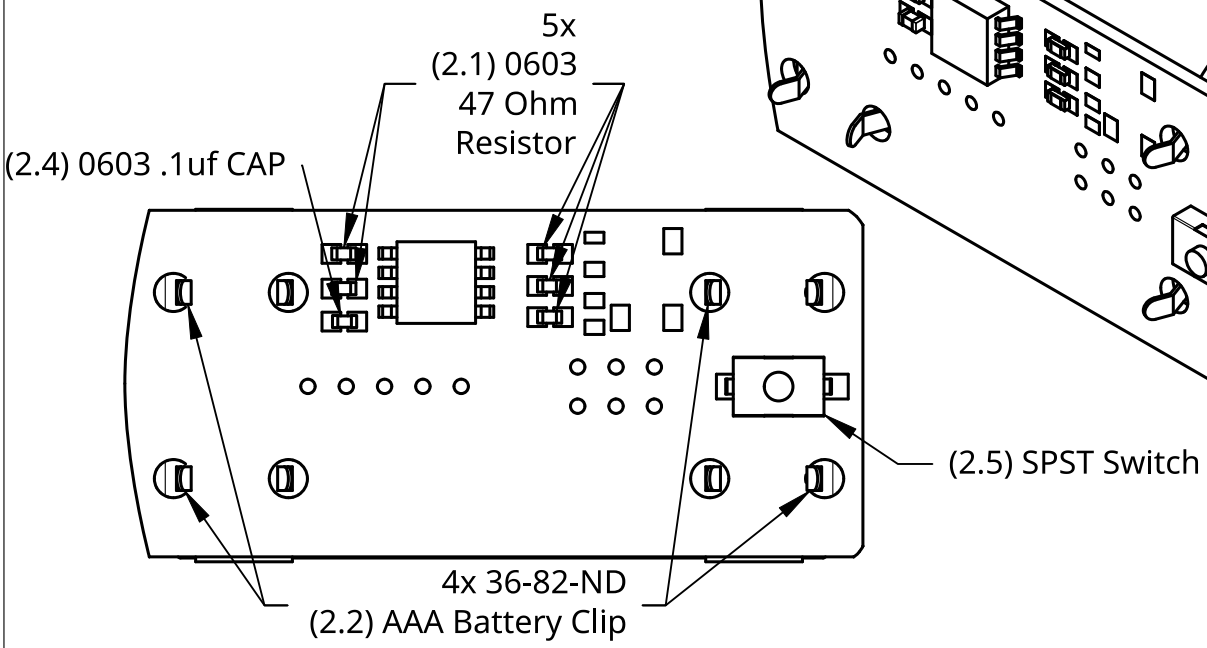
LED Orientation Detail











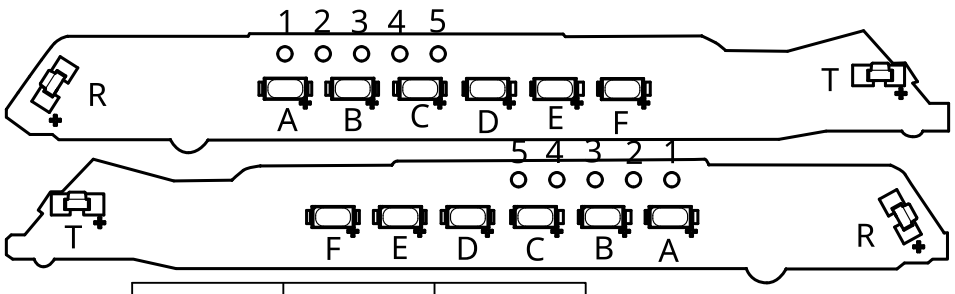
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES .XX = ±.0- .XXX = ±.00- .XXXX = ±.000- ANGULAR = ± ° FRACTIONAL = ± SURFACE FINISH		NAME	DATE
	DRAWN	JOHN TOEBES	12/05/2022
	CHECKED		
	APPROVED		
DO NOT SCALE DRAWING			
BREAK ALL SHARP EDGES AND REMOVE BURRS			
THIRD ANGLE PROJECTION	MATERIAL	FINISH	

TITLE: Enterprise

https://hackaday.io/project/162654-pcb-3d-startrek-enterprise

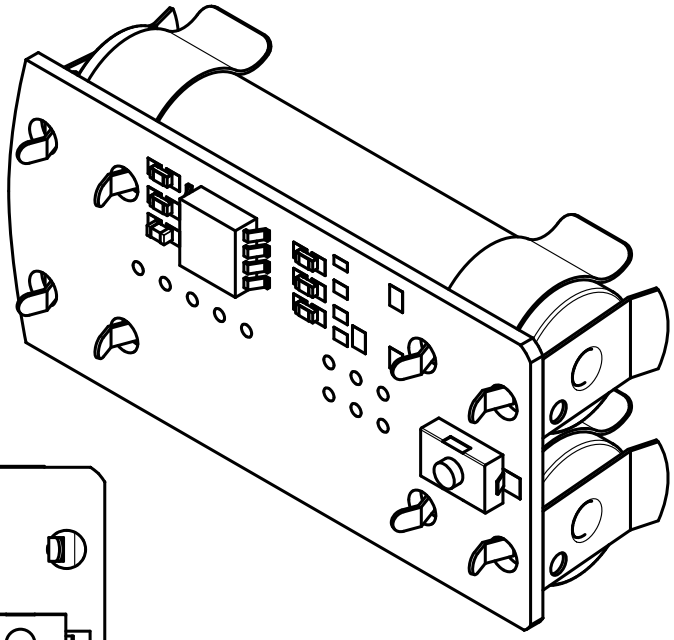
SIZE	DWG NO.	REV.
A		

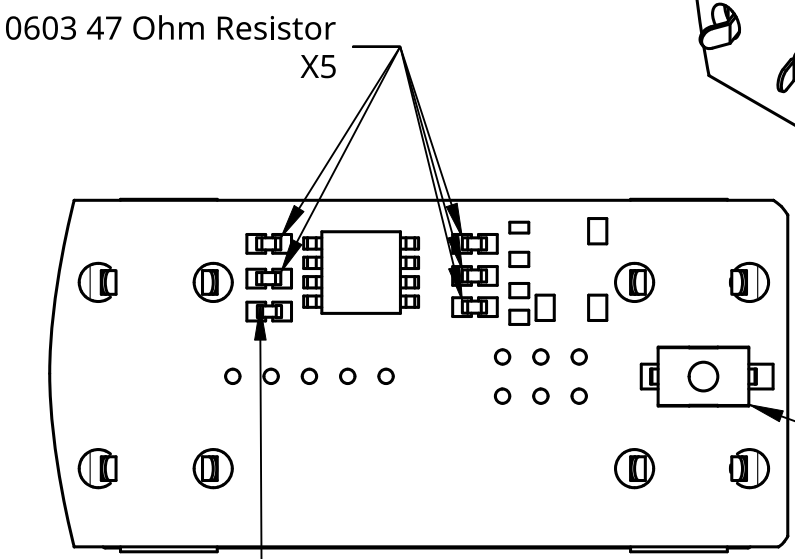
SCALE	WEIGHT	SHEET
2:1		1 of 7



LED	+2	Gnd
R	5	4
T	5	3

LED	+3	Gnd
A	4	1
B	4	2
C	4	3
D	4	5
E	5	1
F	5	2





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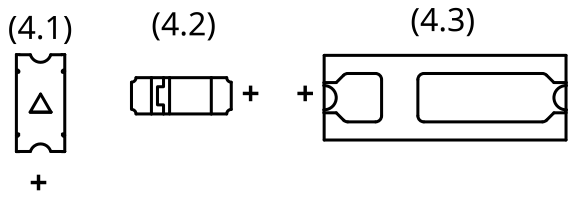
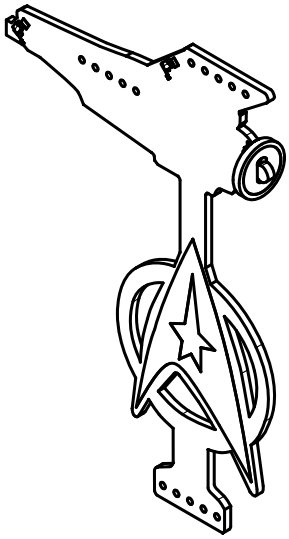
SIZE	DWG NO.	REV.
A		

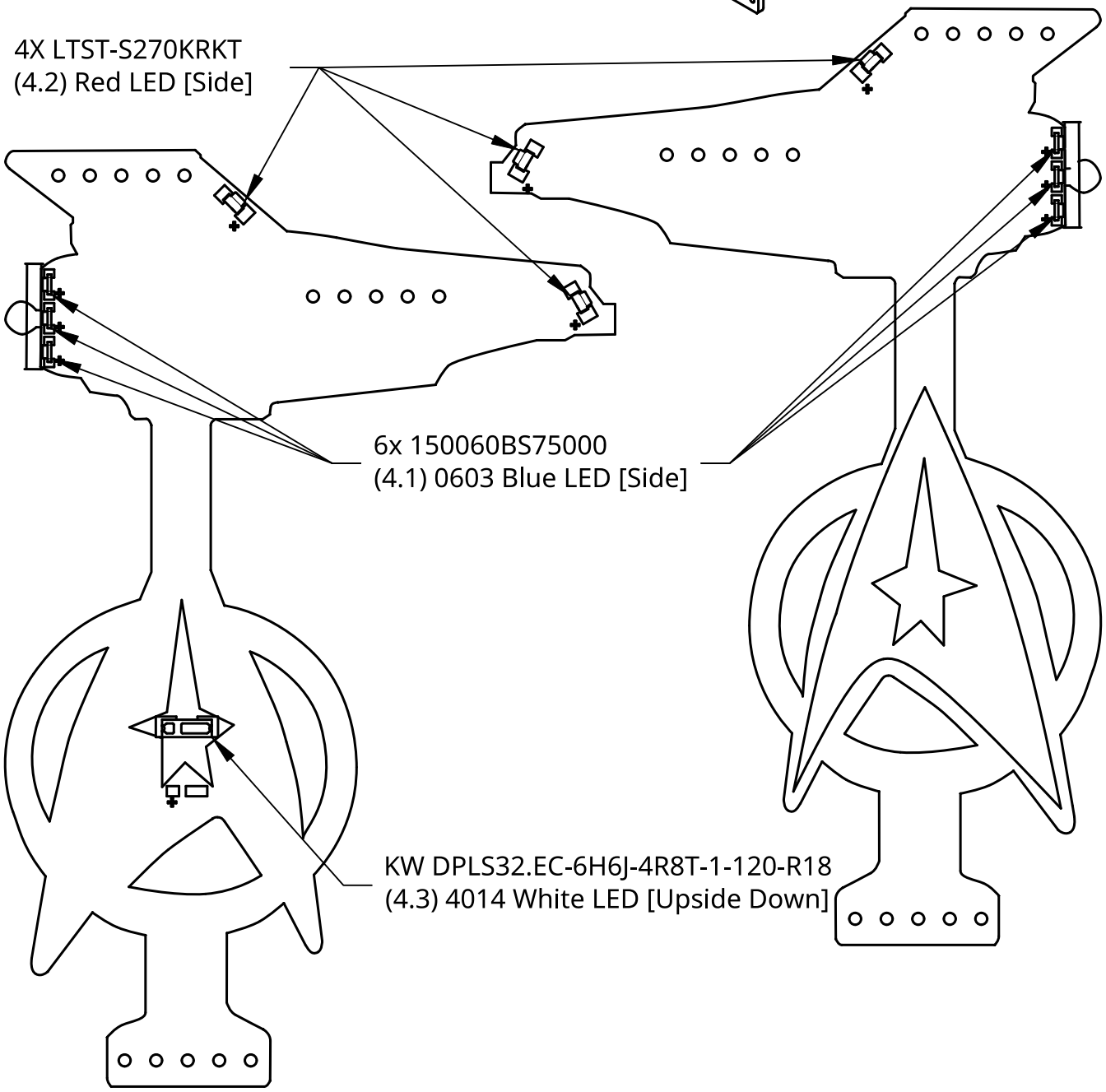
SCALE	WEIGHT	SHEET
2:1		2 of 7

LED Orientation Detail





SCALE 1:1



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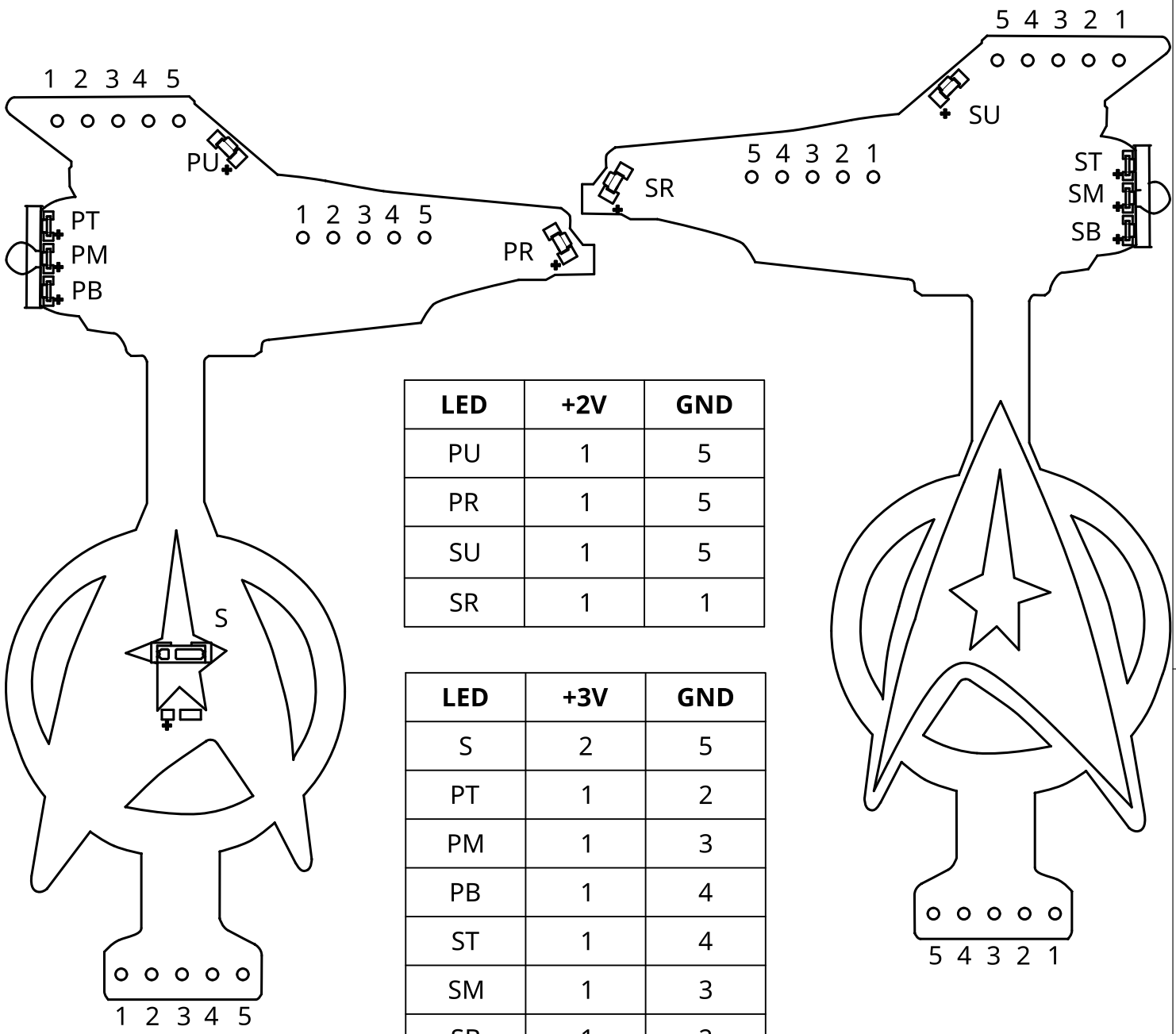
	A	2:1	3 of 7	

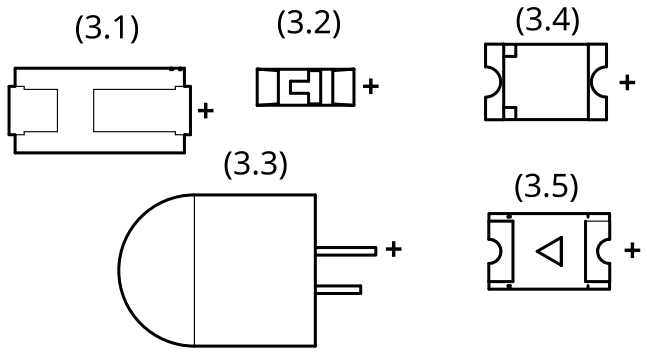


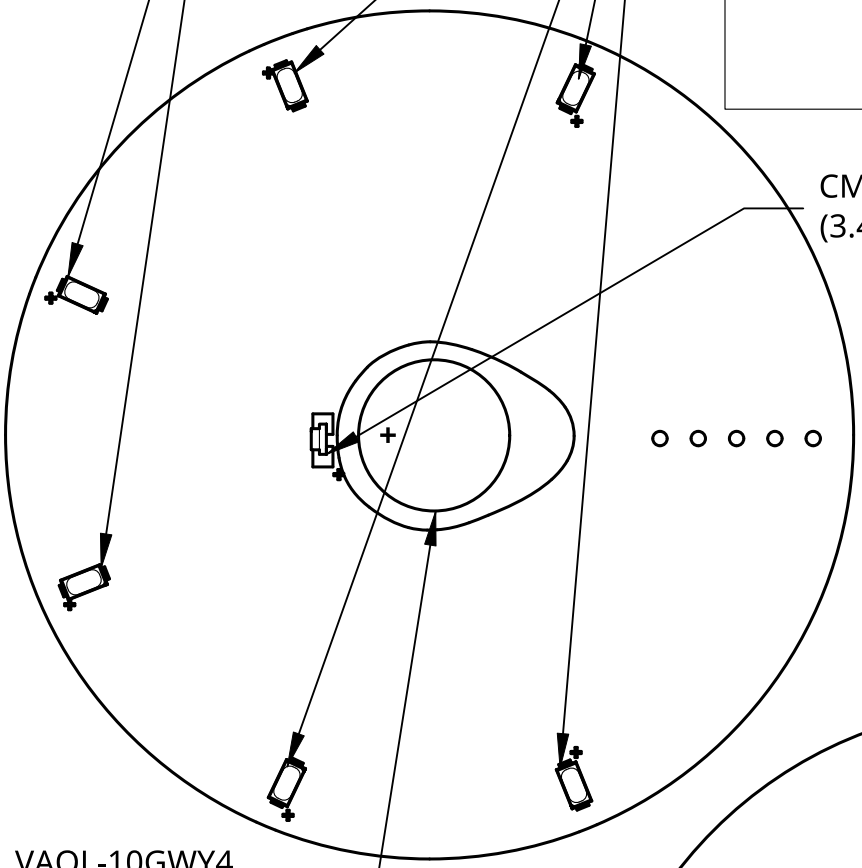
LED	+2V	GND
PU	1	5
PR	1	5
SU	1	5
SR	1	1

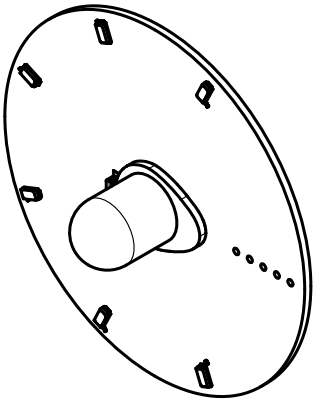
LED	+3V	GND
S	2	5
PT	1	2
PM	1	3
PB	1	4
ST	1	4
SM	1	3
SB	1	2

DWG NO.	SIZE	SCALE	SHEET	REV.
	A	2:1	4 of 7	

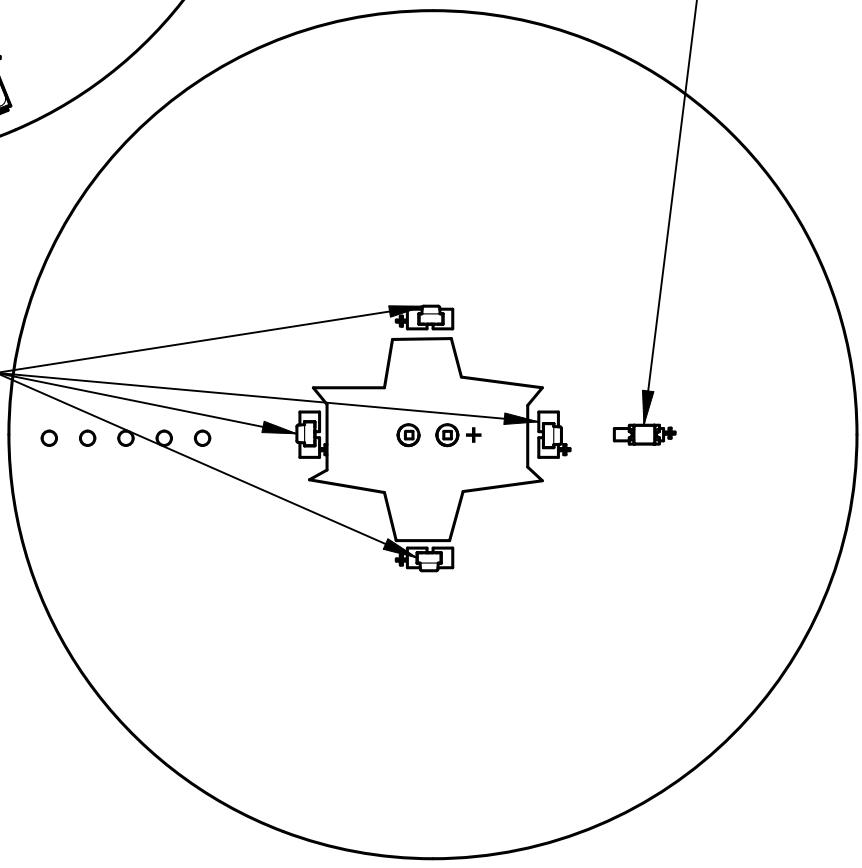
LED Orientation Detail

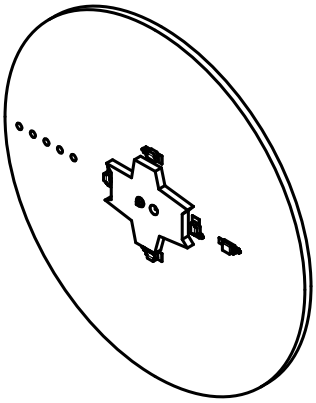






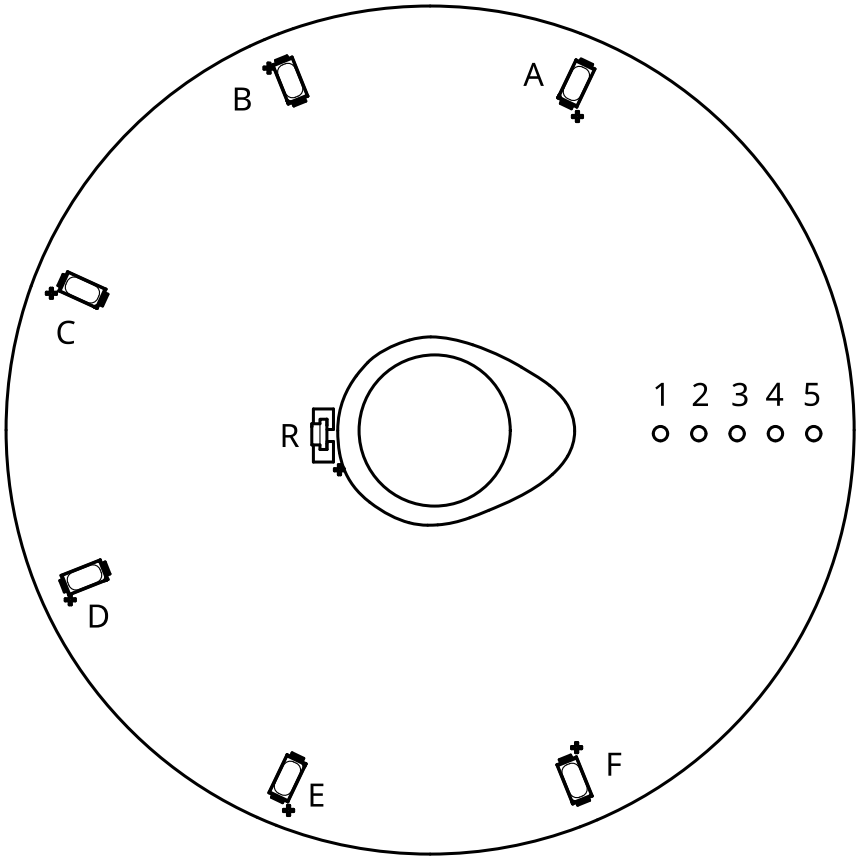
SCALE 1:1





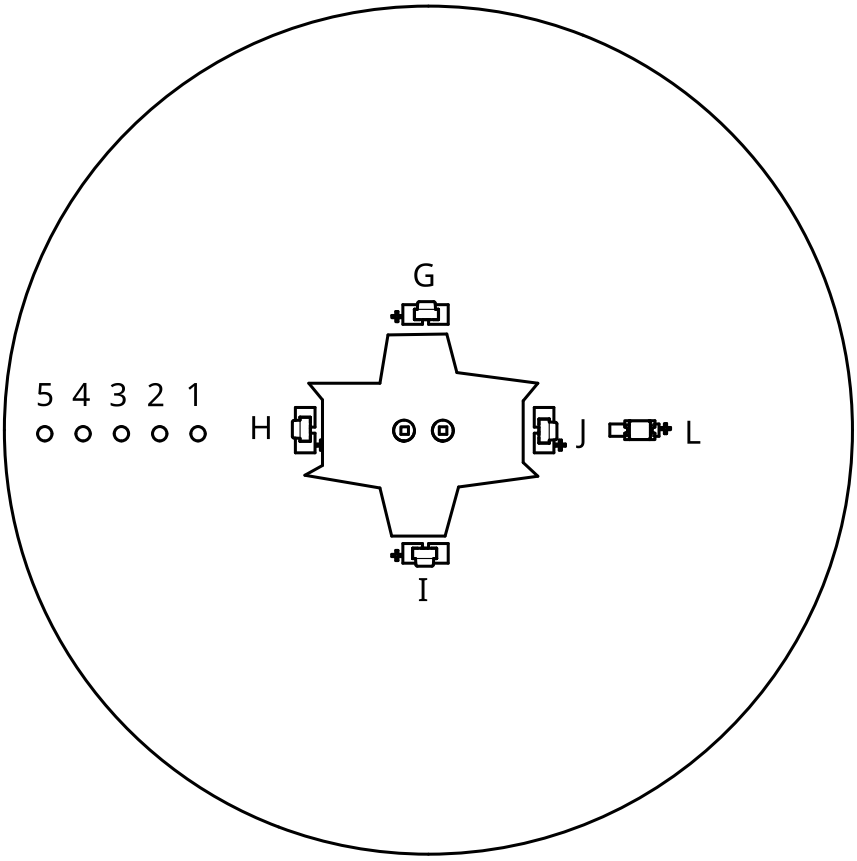
SCALE 1:1

DWG NO.	SIZE	SCALE	SHEET	REV.
	A	2:1	5 of 7	



LED	+3	Gnd
A	2	3
B	3	5
C	3	4
D	3	2
E	3	1
F	2	1
R	2	4
Bridge	2	4

LED	+3	Gnd
G	2	4
H	2	4
I	2	4
J	2	?
L	5	2



DWG NO.	SIZE	SCALE	SHEET	REV.
	A	2:1	6 of 7	

Ship Assembly

Once you have all the boards assembled and tested (you did confirm that they all work, right?) you will want to cut all the boards apart. You can break them apart or carefully cut with an X-Acto knife, being careful not to knock any parts off the board (not that you can see them 😊). You may also want to carefully sand the edge of the boards so that you a nice appearance.

Next you want to assemble the saucer section. Do this by taking the large LED (3.2) and place it through the small board for the top of the saucer section paying attention to the orientation so that the longer lead is toward the back of the ship (the elongated portion of the small board). Then place the LED leads through the main saucer section, again making sure that the longer lead is toward the back of the ship. Solder both these leads to the bottom of the main saucer board making sure that the LED is tight to the top forming the bridge. TEST to make sure that it works (you should see the lights below the saucer light up along with the bridge) and then put on the small star board and once again solder the leads of the LED to keep the board in place. Once you are happy with it, trim the LED leads.

Now that you have done all of the surface mount parts, it might be time to exchange the tiny tip on the soldering iron for a larger one, although it will work but may take a bit longer to solder some of the remaining parts.

Insert the four battery clips into the bottom of the main board (the opposite side from the processor and the switch) and solder both tabs on each clip. When soldering the clip near the processor, be careful not to unsolder the resistors.

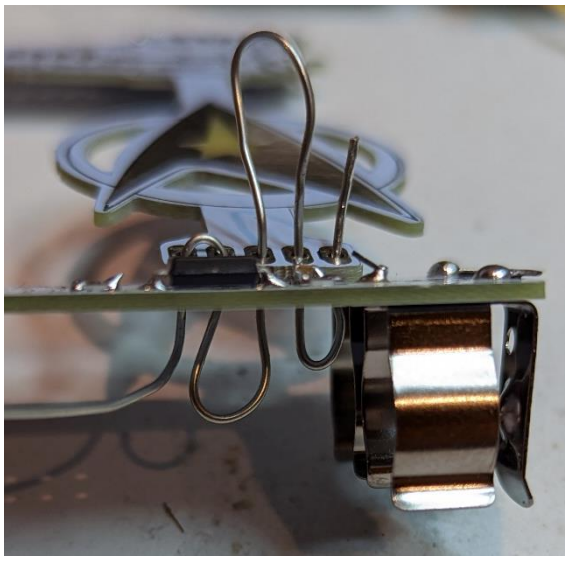
Connecting the boards

The last step is to connect the boards using wires to jumper the 5 connections to each board.

This will be done by first connecting the body stand to the main board. When that is done, you can pop in a pair of batteries and it should light up the star led, deflector dish and the hull lights.

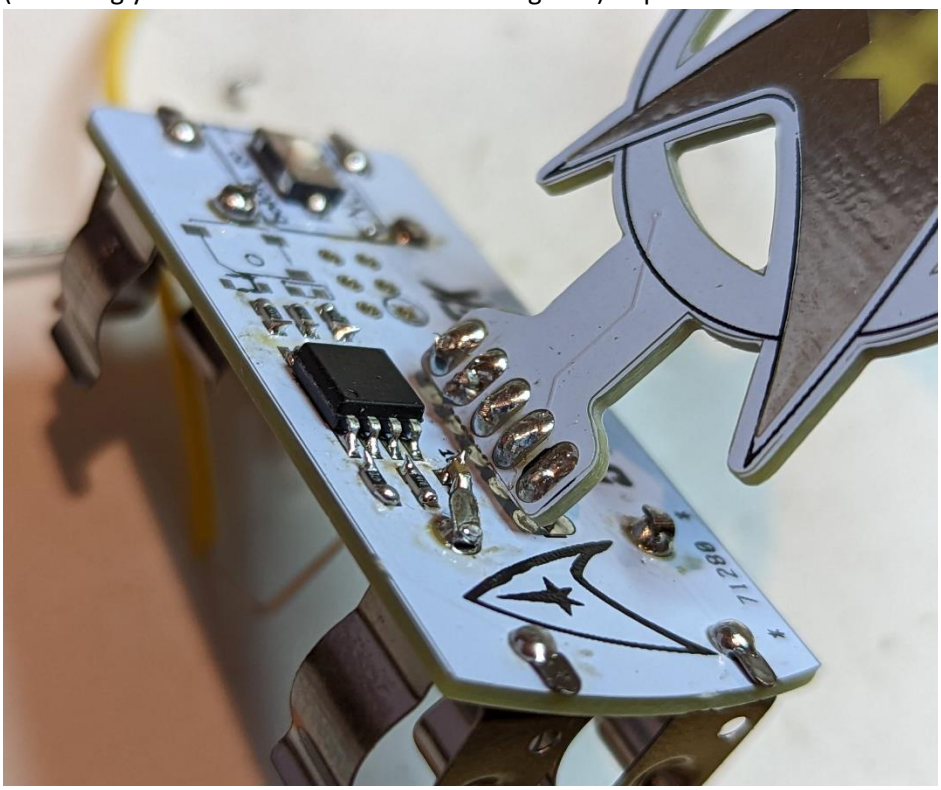
Next the saucer gets attached to the body stand.

This is followed by the pylons holding up the nacelles and then lastly the nacelles themselves.



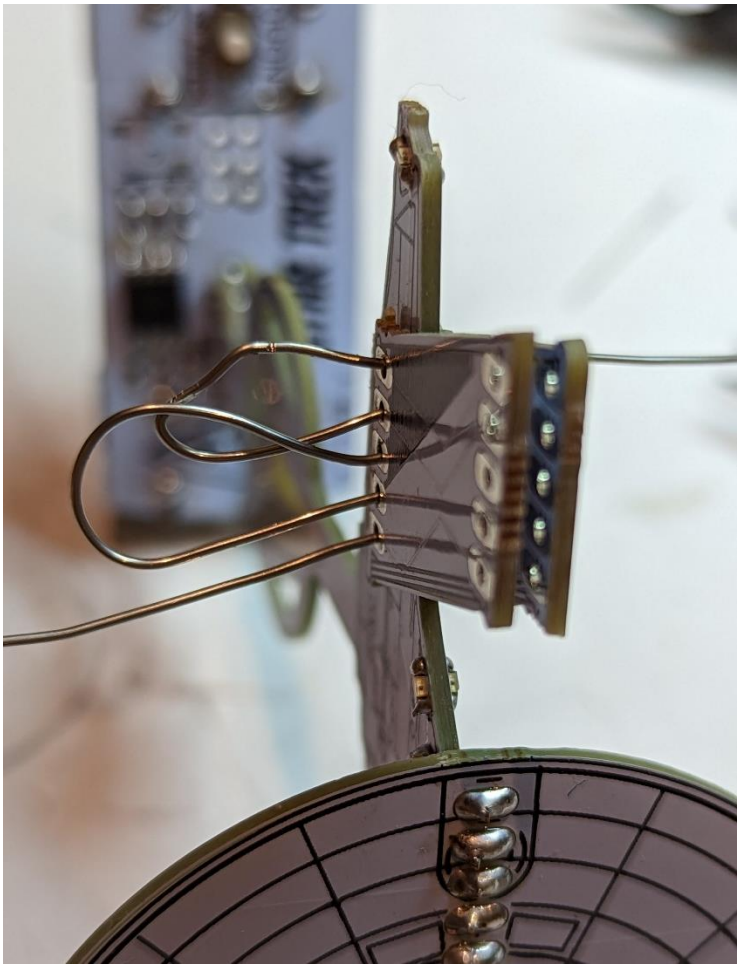
To do the connection, the easiest way is to take a piece of solid core wire and thread it through the holes with some slack on each side. This will hold the boards together in the right place and you can easily solder the wire to one of the boards. Then trim off the wires on the soldered side and slide the other board into place. Tack one of the wires and then carefully adjust the board to the final place (this is where those beading pliers are useful). Once you are happy with it, solder the other end of the connections and trim the ends.

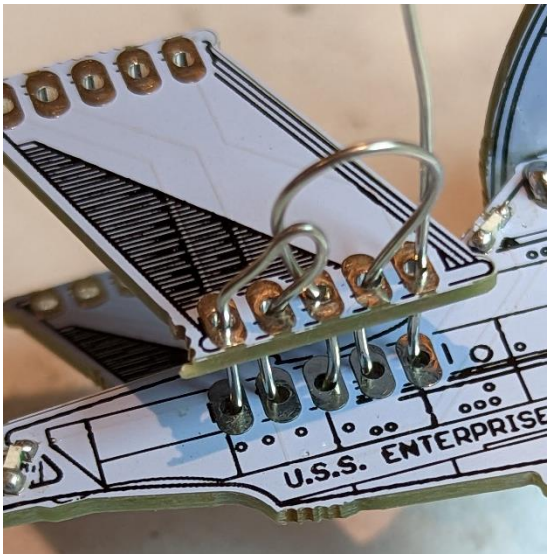
With it in place, it is also useful to solder the inner side of the board where the wires are connecting (assuming you can reach it with the soldering iron) to provide a bit more stability for the connection.



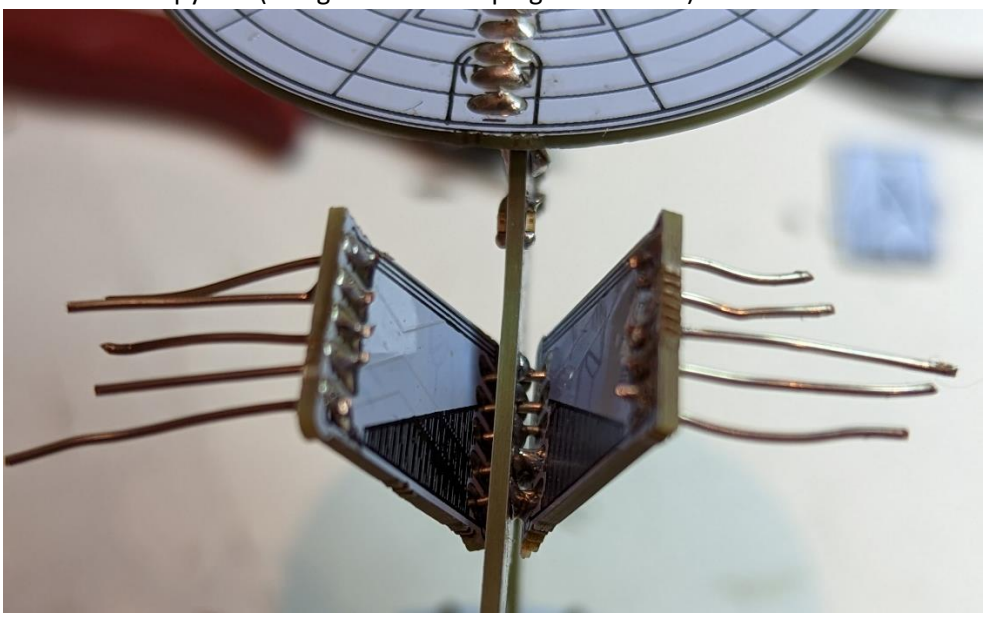
With it in place, now's the opportunity to test with the batteries. If the LEDs in the star or deflector dish don't light up, you can first make sure that batteries are oriented correctly. If they appear to be right and pressing the button doesn't change anything it is time to do a little debugging. First make sure that the LEDs light up by following the same test you did when the board was first built. If that still works, by can advance down to checking the sides of the resistors coming out of the processor. Essentially 5 of the 8 pins from the processor are directly connected throught the resistors to the 5 wires. You can test from both sides of the resistors to make sure that they are connecting to the 5 wires.

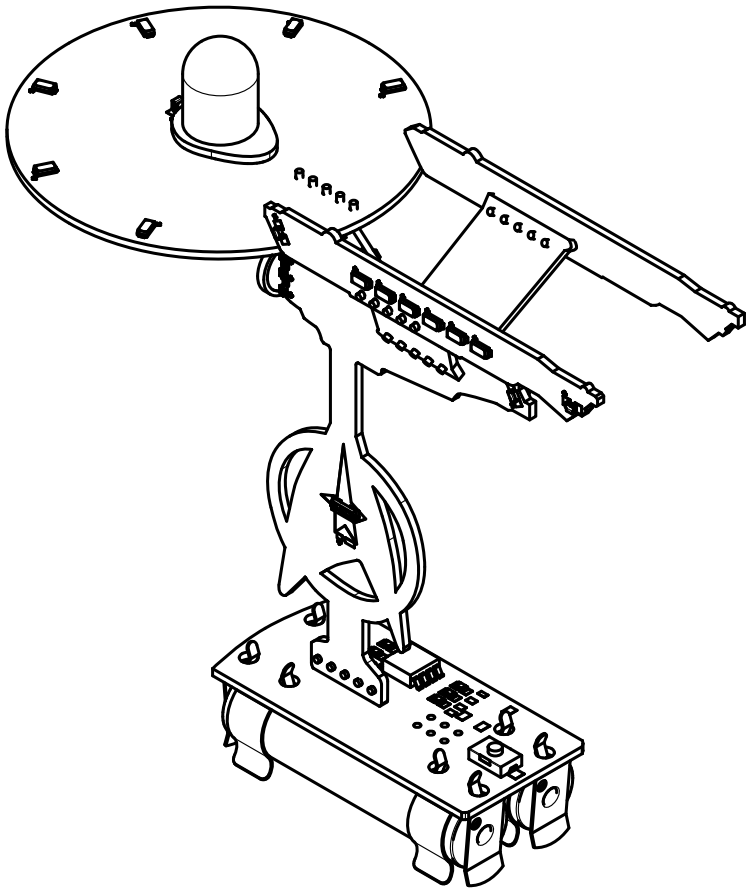
When doing the pylons, you want to put on both pylons at once. Just loop the wire through the pylons on the outside with the body stand in the middle. Tack down the wires to one pylon and trim it. Then push the other pylon close to but not completely touching the center. You are trying to make it close enough so that you can angle the pylons. Tack one of the wires and then spread out the pylons to their final position. One edge of the pylon should be touching the center board. Once you are happy, solder all the connections and trim.

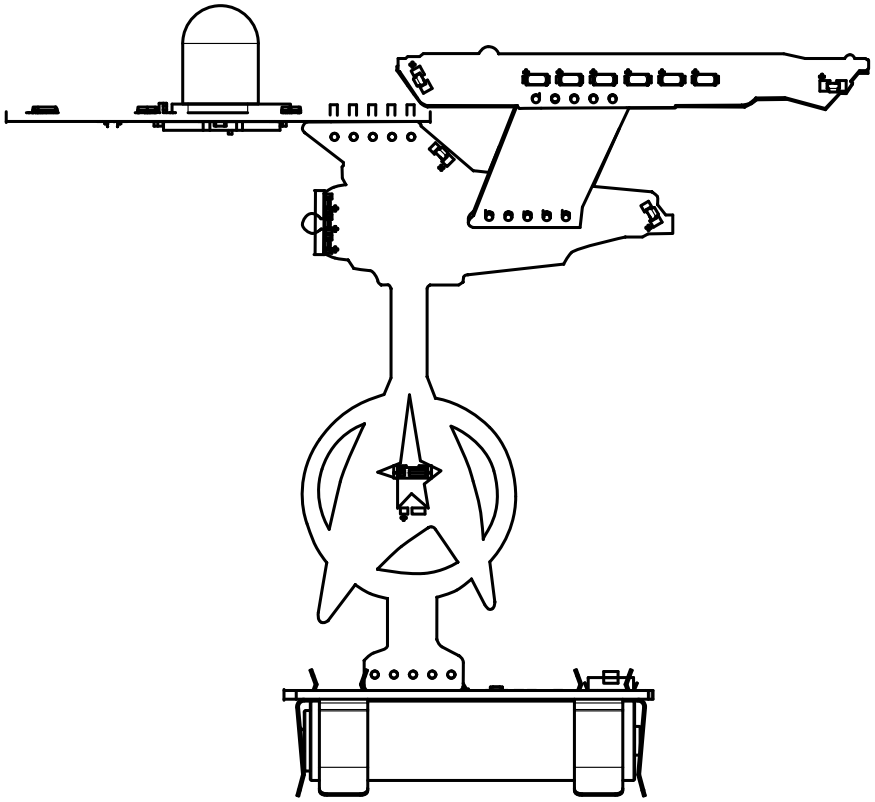


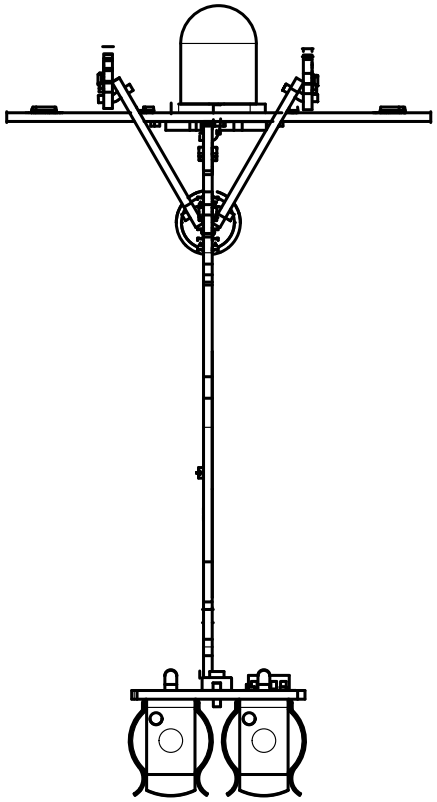


For the nacelles, it is a little easier to just put the wires into the pylons (using the same looping mechanism) and then solder and trim the one end.









DWG NO.	SIZE	SCALE	SHEET	REV.
	A	1:1	7 of 7	

Once you have the wires in place, put on the nacelles (remember to orient them correctly) so that the LEDs are facing out and tack one wire. Then adjust them so that they are vertical and then solder the other wires. Once you are happy, trim the wires and give them one more soldering to smooth out the edges which are visible.

LED Matrix for Testing

When you have the entire ship assembled, you can test any of the LEDs when the batteries are out by connecting to the bus wires as below. All 20 combinations of positive/negative will light up something on the ship.

		Positive				
		1	2	3	4	5
Ground	1		Saucer Top Port Back	Saucer Top Port Middle	Nacelle Side LED 1/6	Nacelle Side LED 5/6
	2	Deflector LEDs UR/LL		Saucer Top Port Front	Nacelle Side LED 2/6	Nacelle Side LED 6/6 Green Laser
	3	Deflector LEDS Middle	Saucer Top Starboard Back		Nacelle Side LED 3/6	Nacelle Tail LED
	4	Deflector LEDs UL/LR	Bridge/ Under Saucer	Saucer Top Starboard Front		Nacelle Front LED
	5	Hull LEDs	Star Backlight	Saucer Top Starboard Middle	Nacelle Side LED 4/6	

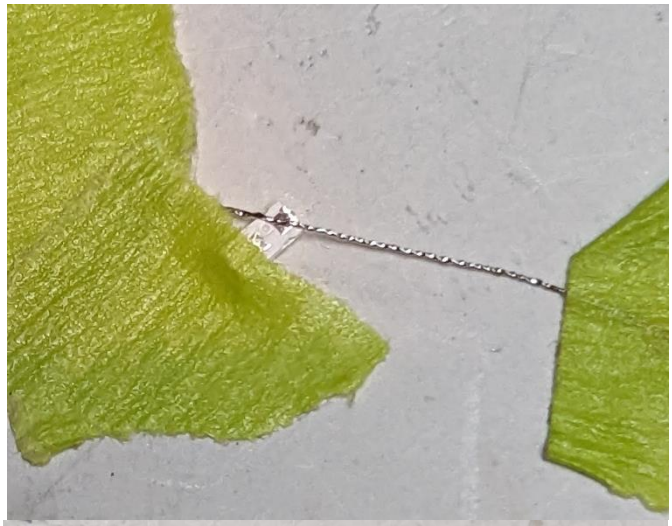
Congratulations!

If you have gotten to here, it should be working and putting in the batteries will give you an opportunity to try out the different patterns with the button on the base.

Extreme Repairs

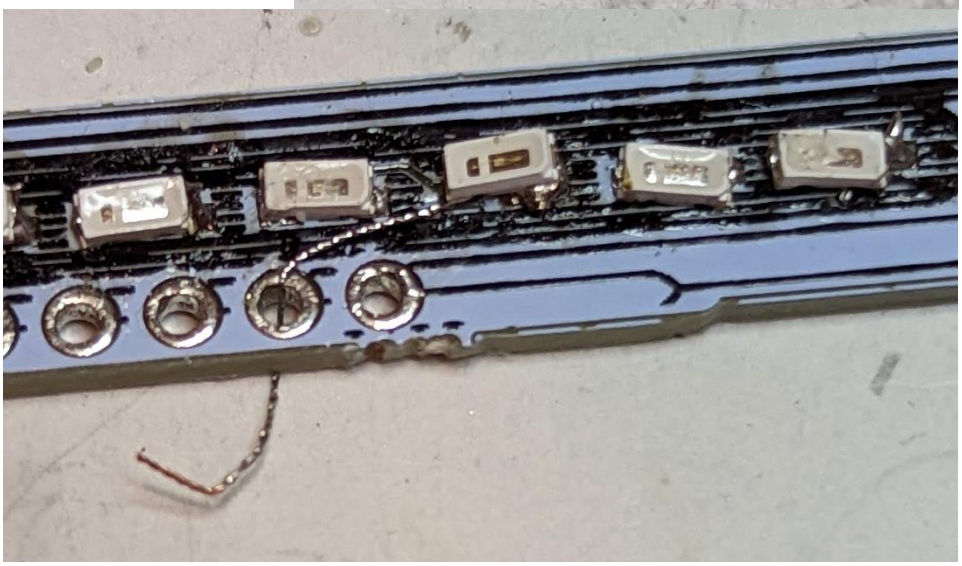
Occasionally you might make a mistake and accidentally pull a trace off the board when trying to reposition an LED. Although i is tedious, here's one technique to recover the project.

Take a couple of small strands of wire and twist them together. Tin the wires and then tape them down to your work surface with some painters tape. Using the tweezers, slip the LED upside down (lead side up) under the wire and slide it so that the wire is makign contact with the positive (usually smaller) side. Carefully tack the wire to the LED. It shouldn't take much.



Then you can untape it and the wire should be stuck to the LED. Trm off the side of the wire that you don't need and then solder down the LED to the board in the correct location/orientation being careful to make sure that the wire stays attached.

You can then route the wire to the correct location paying attention to the fact that it is a bare wire and you don't want it touching anything it shouldn't. In this case, it was just being routed to one of the 5 bus wires so it was an easy fix.



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