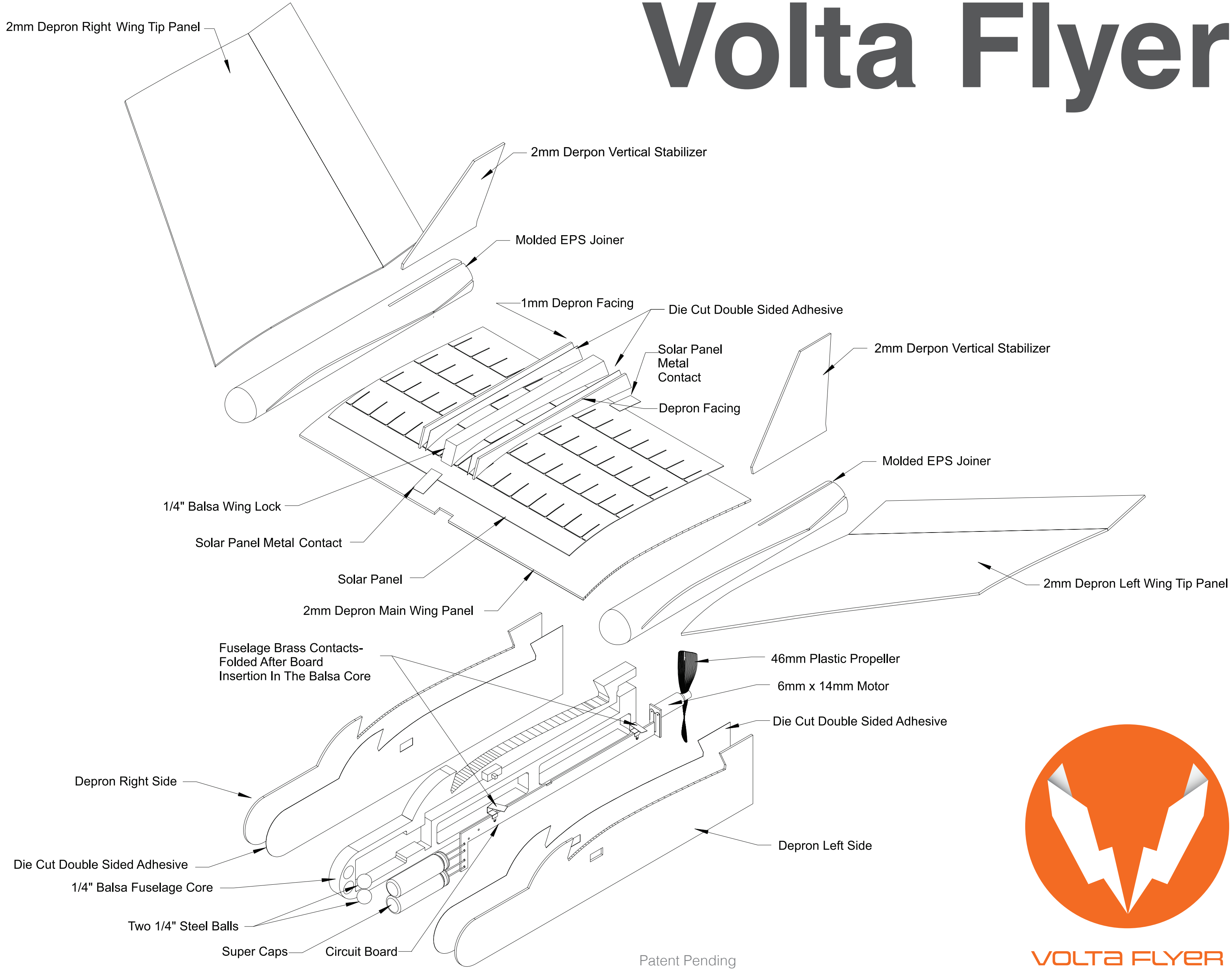
ToyLabs

Volta Flyer



Patent Pending

VOLTA FLYER

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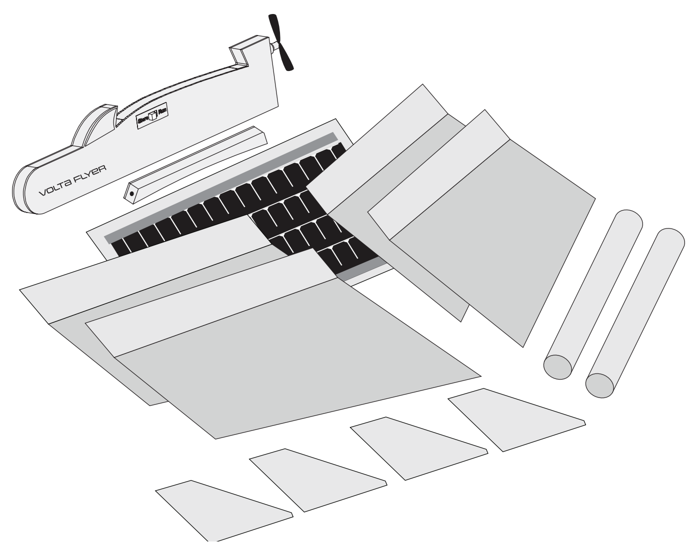


Volta Flyer Parts and Components

What's in the Box

You'll find all the prefabricated parts and components required to build your Volta Flyer itemized below.

Solar Panel Thin Film Amorphous Silicon, using proprietary roll-to-roll manufacturing. *Made in Ames, IA.*	1 each
Fuselage Laser cut balsa wood and depron using the Epilog Legend EXT laser cutter. *Cut in Cedar Crest, NM.*	1 each
Wing Lock Laser cut balsa wood and depron using the Epilog Legend EXT laser cutter. *Cut in Cedar Crest, NM.*	1 each
Main Wing Laser cut depron using the Epilog Legend EXT laser cutter. *Cut in Cedar Crest, NM*	2 each
Outer Wings Laser cut depron, using the Epilog Legend EXT laser cutter. *Cut in Cedar Crest, NM.*	4 each two sets
Vertical Stabilizers Laser cut depron using the Epilog Legend EXT laser cutter. *Cut in Ceder Crest, NM.*	4 each two sets
Wing Joiners EPS molded, using injection molding systems. *Made in Visalia, CA.*	2 each one set
Stickers and Logos *Made in Pasadena, CA.*	1 set
Assembly Instructions and Learning Tutorials Before proceeding to the assembly instructions on page 9, we encourage you to read all tutorials before assembling the Volta Flyer.	1 set

VOLTA FLYER

Important Notes Before Getting Started

The Volta Flyer requires a large open flying space away from streets, roads, traffic, buildings or power lines. Find a suitable space like a park, a sporting field, an open space, or a large school yard.

Never chase your Volta Flyer on unstable grounds, dangerous terrain or near traffic of any kind.

Get familiar with the way your Volta Flyer flies before you fully charge it and fly it. Start by simply gliding it without charging it, and then incrementally increase the charge times as you get a better feeling for how it behaves in flight.

Don't fly the Volta Flyer when wind speeds are greater than 5 MPH (8 km/h).

When building or handling the Volta Flyer **please handle with special care** because it is hand-made out of super lightweight materials to achieve optimal performance.

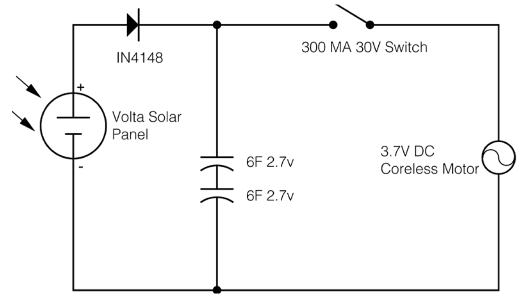
When not in use, store the Volta Flyer with the power switched off and away from sunlight.

Kids under 12 years of age should be assisted by an adult through the assembly process.

Kids under 12 years of age should be supervised by an adult when flying the Volta Flyer.

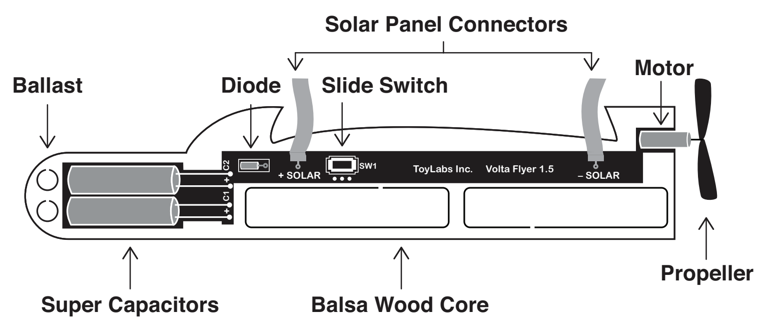
About the Volta Flyer's Basic Circuit Design

The Volta Flyer uses a simple basic circuit design that allows the onboard solar panel to capture the Sun's energy and store it in the onboard super capacitors (energy storage system). With the flip of the power switch—the super capacitors move the stored energy to the rear motor to drive the propeller. We use a diode to prevent the super capacitors from leaking their stored energy back to the Solar Panel.



Volta Flyer Circuit Board Components

Switch	Slide SPDT 300 MA 30V ROHS Certified
Capacitors	6F 2.7V T/H ROHS Certified
Diode	GEN PURP 50V 1A D041 ROHS Certified
Motor	6mm x 14mm 3.7V coreless electric motor (30,000 RPM)
Propeller	46mm Nylon Plastic
Brass Tabs	Hand cut from bulk sheets
Ballast	¼ diameter steel balls



Inside View of the Volta Flyer Motor

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About the Solar Panel

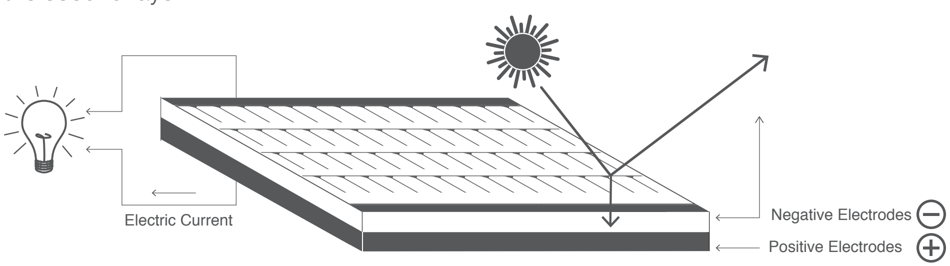
Built on a super thin polymer substrate, the Volta Solar Panel is durable and flexible. The substrate is as thin as 1 mil (0.025MM). Amorphous silicon is the absorber layer in the solar panel. The panel has a strong environmental profile and is cadmium free.

Operating Voltage	4.8
Wattage	.48
Current	100
Typ Voc	6.4V
Typ Isc	130mA
Typ Output @ AM 1.5	110mA @ 4.8V
Width	5.75 in, 146 mm
Length	3.7 in, 94 mm
Weight	.1 oz, 3.9 g

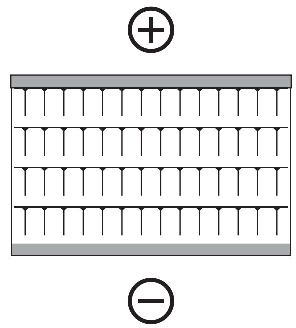
How Solar Panels Work

A solar panel turns the sun's light into electricity. For example, when you turn on a lamp, electrons move through the power cord and light up the bulb. That flow of electrons is called electricity.

A solar panel is made up of many solar cells. Each of these cells uses light to make electrons move. The cell is made up of two different layers that are stuck together. The first layer is loaded with electrons, so the electrons are ready to jump from this layer to the second layer.



That second layer has had some electrons taken away, so it is ready to take in more electrons. When the sun hits an electron in the first layer, the electron jumps to the second layer. That electron makes another electron move, which makes another electron move, and so on. It was the sunlight that started the flow of electrons, or electricity.



Why We Designed the Volta Flyer to Look Like It Does

There are a variety of reasons the Volta Flyer has its shape. To help you understand the factors that were considered when designing the Volta Flyer, the major components are broken down here.

Fuselage

Let's begin with the body. The proper name for the body is the **fuselage**. That name comes from the French and has been used as the word for the body of airplanes since the very early days of aviation. We use super lightweight balsa wood for the core, which houses the electronics, and thin depron siding (skins) to seal the balsa wood core and electronics. We cut 10 fuselages from a single 1/4" x 4" x 36" balsa sheet, each sheet weighs approximately 37 grams.

Motor and Propeller

The **motor and propeller** are located at the rear of the fuselage. With this design the propeller pushes the Volta Flyer through the air. Most propeller-driven airplanes have the motor and propeller at the front of the fuselage. When configured that way, the propeller pulls the airplane through the air. We use a 6 x 14mm 3.7 Volt coreless electric motor rated at 30,000 RPM and a 46mm nylon plastic propeller.

We positioned the motor and propeller on the back of the Volta Flyer - to protect the propeller from impacts. The bottom of the fuselage and the top edges of the Vertical Stabilizers protect the propeller from impact when the Volta Flyer lands or impacts the ground or an object during flight.

Wing

You'll notice that the Volta Flyer has only one wing (flying wing design). Flying wing designs are aerodynamically efficient (low drag). Our design eliminates the tail section which is commonplace in most airplanes. We did this to reduce the number of parts that can be broken when the Flyer strikes an object or encounters a hard landing.

Our wing design includes three sections, 1) **Main** Center of the Wing which carries the Solar Panel and connects to the Fuselage, 2) **Outer Left** Left side Portion, 3) **Outer Right** Right side Portion.

We use the Wing Joiners to connect all three parts of the Wing and to hold the Vertical Stabilizers in place. The Wing Joiners are designed to not only hold these parts in place, but they also allow these parts to safely separate when they impact objects. We currently use 2mm laser cut depron material for the Wings and Vertical Stabilizers.

To enable flying wing airplanes to fly properly, the wing has a special shape. When you look at the Volta Flyer from the side you'll see flaps at the trailing edge of each wing that are bent up. The flaps are called elevators. When they are bent up, they act like the horizontal stabilizers on an airplane with a large main wing and a smaller rear wing. You can 'gently' attenuate the flaps to slightly alter the turn of the Volta Flyer, *please don't over attenuate*.

Wing Curve—Strength

As you look at the wing from the side you'll notice that it has a curve that runs from the front (leading edge) of the wing to the back (trailing edge). That curve has two functions - Strength and Lift. To maintain proper flight, the wing needs to stay straight and the curve helps the wing maintain its rigidity which helps it stay straight during flight.

Wing Curve—Lift

The curve in the wing has another purpose as well. The reason for a wing on an airplane is to create lift when the wing moves through the air. As air moves across a surface, like a wing, it changes direction. At the trailing edge of the wing the air moves down. When that happens, the wing is pushed up slightly. The larger the wing, the stronger the upward push. The goal of any airplane wing design is to make it just large enough to create enough upward push to balance the weight of the airplane. If the wing is too large you add more weight than is necessary. If the wing is too small the airplane has to fly faster to stay in the air.

A flat wing will produce the upward push also known as **lift.** You can demonstrate this by holding your hand out flat on a windy day. Tilt your hand up slightly and notice how it will want to lift up. That push upward is what is happening to a wing moving through the air. You may also notice that your hand feels like it's getting pushed back. The more you tilt your hand the more you'll feel these forces. That backward push is called **drag**. Airplane wings also have drag.

When a person designs an airplane wing they want to create enough lift to overcome the weight of the airplane, but they also want to make the drag of the wing as small as possible. Drag uses up some of the power available from the motor. That means that some of the fuel is used up by drag. The fuel needed to overcome drag reduces how far an airplane can fly on a given tank of fuel. The same is true for the Volta Flyer. Some of the stored solar energy is used up by overcoming drag which reduces the amount of time the Volta Flyer can stay in the air.

When a wing is curved slightly, it is easier for the air to make the downward turn. That means it can create the needed lift with less drag. So the wing of the Volta Flyer has the curve along its length to make it stiffer, and to reduce drag while creating lift.

The actual shape of the wing when you look down from the top of the Volta Flyer can take many forms. Since the Volta Flyer carries a solar panel, the center part of the wing is in the shape of a simple rectangle (the shape of the solar panel). The tips of the wing—the parts that are bent upward—have a tapered shape. This helps reduce the drag of the wing slightly. The tips are angled back a bit to help balance the Volta Flyer.

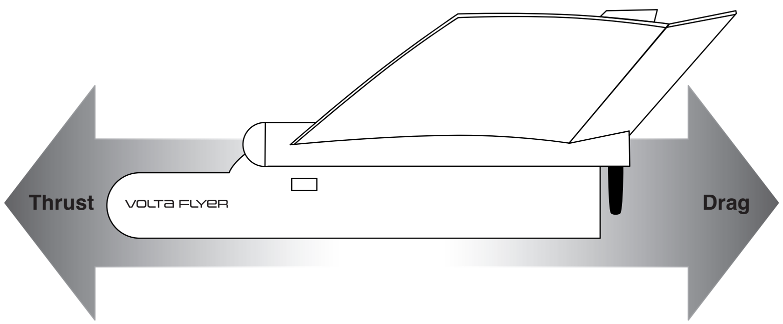
Vertical Stabilizers

Finally, we have the two surfaces that rise up vertically from the Wing Joiners, which join the outer wing to the main wing panel. These are called **vertical stabilizers**. The vertical stabilizers' job is to provide stability for the aircraft, to keep it flying straight. The vertical stabilizers keep the nose of the plane from swinging from side to side, which is called **yaw**. The **horizontal stabilizers** prevent an up-and-down motion of the nose, which is called **pitch**. If you were to remove them and attempt to fly the Volta Flyer, it would fly very erratic and crash to the ground. The size of the stabilizers are set to provide enough control force to keep it flying in a consistent manner.

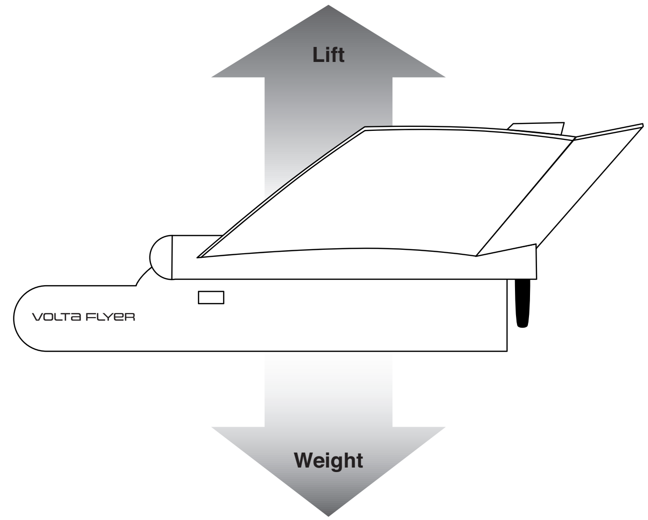
VOLTA FLYER

Tutorial on How Aerodynamics Help the Volta Flyer and All Airplanes Fly

Like anything that moves through air, airplanes are affected by aerodynamics. Aerodynamics is the science of how solid objects move through air or how air moves around objects. The Volta Flyer and other flying objects (like birds, kites, or drones) have to overcome forces of gravity (that pulls them downwards), and drag (that reduces forward motion). By studying the forces and motion of air around an object (aerodynamics), we can design and engineer objects to have enough forces of upward lift and forward thrust to achieve flight.



Forces that produce **forward** and **backward** motion



Forces that produce **upward** and **downward** motion

Air and Air Pressure

Before discussing how flight works, let's understand the air that the Volta Flyer flies through. **Air** is a physical substance which has **mass** and **weight**. Air molecules in the Earth's atmosphere act like a fluid that is constantly moving. When the moving air molecules contact an object, it puts a force on the object. The force is called **air pressure**, and it has the power to lift, push, and pull on objects.

The Four Aerodynamic Forces of Flight

The Volta Flyer needs four forces for flight. They are **thrust, drag, lift**, and **weight**. They work in pairs to balance with one another to hold the Volta Flyer in the air: thrust and drag; lift and weight. The amount of each force compared to its opposite force determines how the Volta Flyer moves through the air.

Horizontal Force Pair: Thrust and Drag

Thrust is a force that moves the Volta Flyer forward. Drag is the resistance of the air as the Volta Flyer passes through. It is the opposite force to thrust. When thrust is greater than drag, the Volta Flyer can move forward. When thrust and drag are equal, the Volta Flyer flies at a constant rate of speed. To produce thrust, the Volta Flyer uses a propeller (a large passenger airplane uses jet engines).

Vertical Force Pair: Lift and Weight

Lift is a force that pushes the Volta Flyer upwards while weight is a gravitational force that pulls the Volta Flyer downwards. The Volta Flyer moves upwards if there is more lift force than weight. When lift and weight are equal, the Volta Flyer flies level. Weight, the opposing force of lift, keeps the Volta Flyer from rising any higher than the desired altitude. The amount of fuel, solar charge, in the Volta Flyer's case, the airplane's mass, and the payload—passenger and/or cargo—all contribute to the airplane's weight.

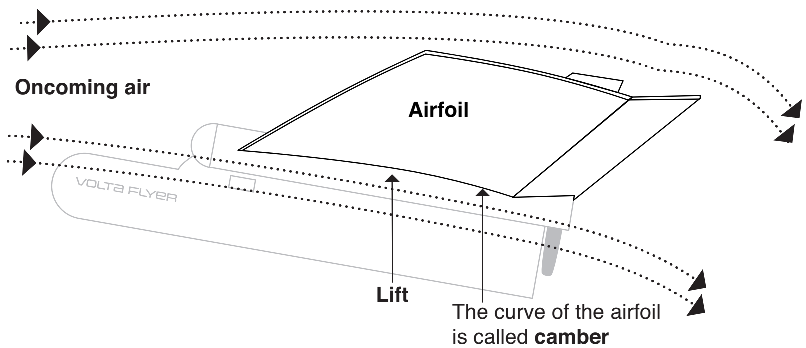
How The Volta Flyer Flies

When the Volta Flyer is grounded and not moving (without wind), there is not enough air flowing around it to lift it up in the air. So another force, thrust, is needed to move the Volta Flyer forward through the air to create the surrounding airflow. This thrust is generated by the Volta Flyer's motor (or a jet engine on a large passenger plane). As the motor and propeller propel the Volta Flyer forward, air flows over and under the wing creating enough lift for it to overcome the downward force of its weight to become airborne.

We talked a lot about how the Volta Flyer's wing is specially designed for flight in the "Why We Designed the Volta Flyer to Look Like It Does" section. In the following section we'll discuss how basic aerodynamics affect flight.

Airfoil

Just like the Volta Flyer, the curved shape of an airplane's wings is what makes it possible for the airplane to fly. This shaped wing, called an airfoil, is narrower in length with a curved upper surface and a flatter lower surface. Two important effects result from the airfoil shape: it reduces the amount of drag and creates lift.



Airfoil Reduces Drag

The shape of an object affects the amount of drag: round surfaces usually have less drag than flat surfaces and narrow surfaces usually have less drag than wide surfaces. When an airplane flies through air, air molecules hit the surface of the airplane and 'pushes back' making it harder to move through. The more air that hits the surface, the more the drag the air produces. The narrow shape of the airfoil reduces the amount of surface area that the moving air molecules encounter while the curved front allows air molecules to speed up and flow around and down reducing drag, or air resistance.

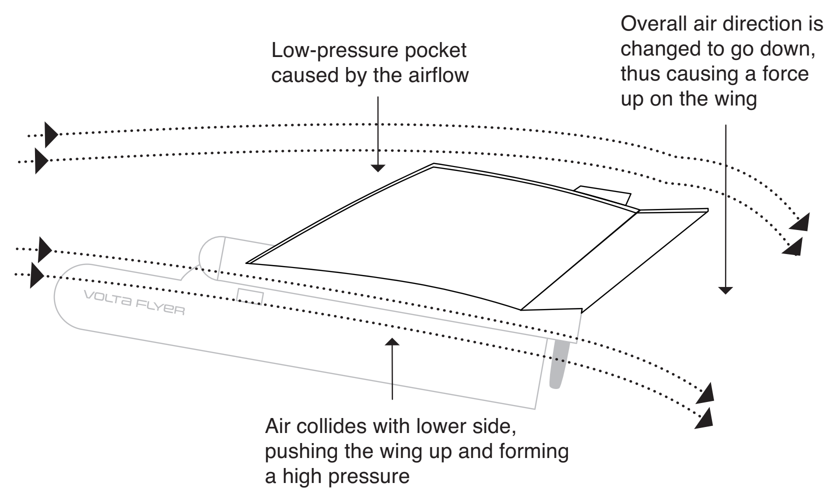
Airfoil Lifts the Plane

Airfoils create lift due to a combination of pressure differences and Newton's Third Law of Motion, "for every action there is an equal and opposite reaction."
Airplane wings, or airfoils, are shaped to cause air to flow faster on top than on bottom. Air naturally wants to move in a straight line, but because of the curve and back tilt of the airfoil, oncoming air speeds up over the upper surface and pulls air molecules downward along the airfoil's length. As the air molecules move faster, the pressure of the air decreases around the upper surface as less air molecules are contacting the airfoil. This creates a low pressure air pocket following **Bernoulli's Principle**, "an increase in the speed of a fluid produces a decrease in pressure."

As the airplane moves forward, the faster-moving air on the upper airfoil places less pressure on the airfoil than the slower-moving air on the lower airfoil. This creates a difference in air pressure, or an unbalance of forces exerted on the airfoil. The stronger force under the airfoil pushes the airfoil upwards creating lift.

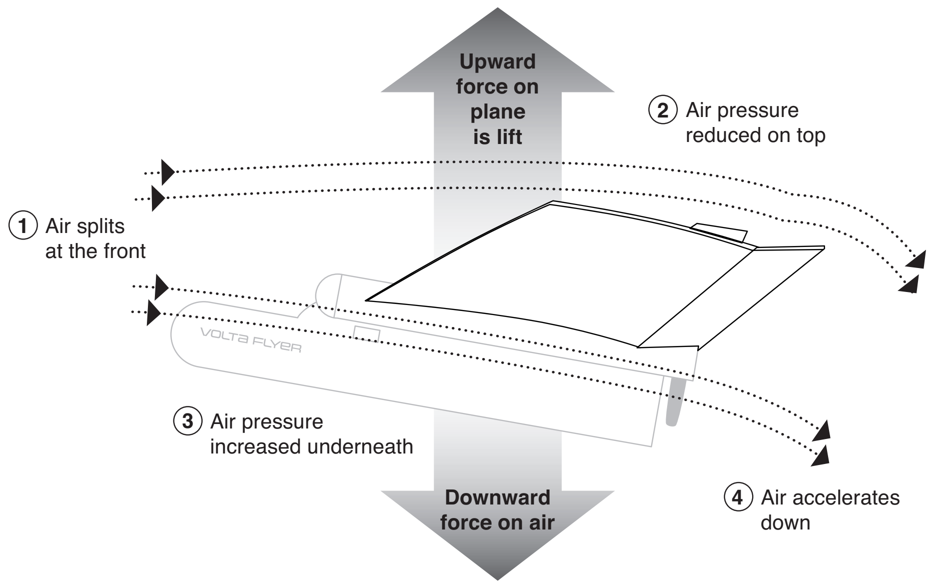
Additionally, the airfoil's tilted angle changes the direction of the horizontal incoming air to leave the back edge of the airfoil slightly downwards. By Newton's law, since there was a force which caused the air to be deflected downwards, an equal force in the opposite direction causes the airfoil to go upwards.

To remain aloft, the lower half of the airfoil must have a greater pressure force than the upper half of the airfoil. Dents, mud, and ice can spoil the built-in shape of the airfoil and interfere with the airplane's performance.



Summary

An airplane, such as the Volta Flyer, uses its wings for lift and its engines or propellers for thrust. For flight, its lift must balance its weight, and its thrust must exceed its drag. The shape of the wings is crucial for flight. The airfoil design allows the wing to experience lift while reducing drag. Drag is reduced by the plane's smooth, narrow shape, and the weight is controlled by the materials it is made of and the amount of fuel and payload it carries.



Key Words

Air
A fluid, invisible physical substance made up of nitrogen, oxygen, and minute amounts of other gases that surrounds the earth and forms its atmosphere.

Airfoil
Any surface, such as a wing, aileron, or stabilizer, designed to aid in lifting or controlling an aircraft by making use of the air currents through which it moves.

Air Pressure
The force exerted onto a surface by the weight of the air.

Bernoulli's Principle
The pressure in a stream of fluid is reduced as the speed of the flow is increased.

Camber
The curve designed into an airfoil to increase the maximum lift coefficient.

Drag
The force on an object that resists its motion through a fluid.

Fins (or Stabilizers)
Small wings on an airplane to help it move in a controlled path.

Flying Wing Airplane
A one-wing airplane.

Force
The power or energy exerted against a material body in a given direction.

Fuselage
The body of an airplane.

Gravity
The force that attracts a body toward the center of the earth, or toward any other physical body having mass.

Lift
An upward-acting force on an aircraft wing or airfoil.

Motor and Propeller
The motor is a mechanical device that provides the power to move the propeller, a revolving shaft with two or more broad angled blades that pushes or pulls the airplane forward.

Newton's Third Law of Motion
For every force there is a reaction force that is equal in size, but opposite in direction.

Pitch, Yaw, Roll
Three aircraft in flight rotations.

Pitch. Nose up or down about an axis running from wing to wing.

Yaw. Nose left or right about an axis running up and down.

Roll. Rotation about an axis running from nose to tail.

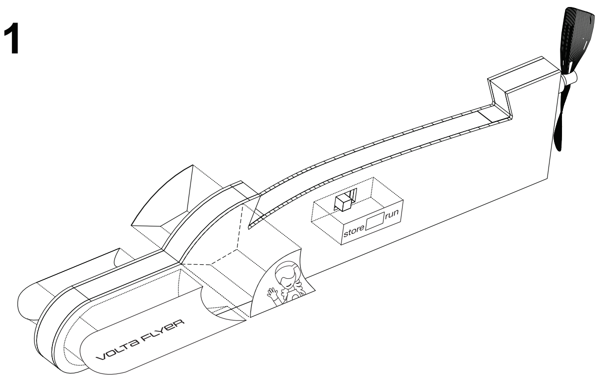
Stabilizers—Horizontal and Vertical
Small wings on an airplane to help it move in a controlled path.

Thrust
A force that is exerted on an object by the expulsion or acceleration of mass in one direction.

Weight
The force created by earth's gravitational pull on an object, weight = mass x gravity.

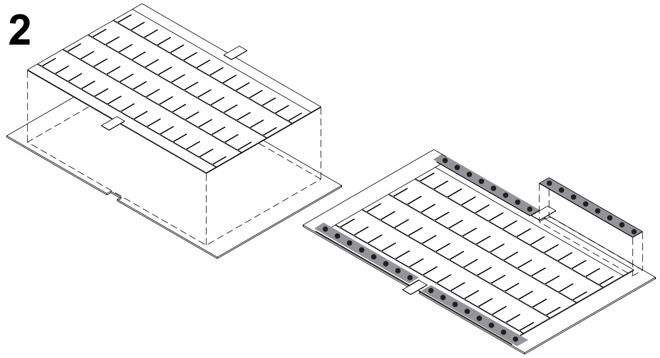
Assembly & Flying Instructions

1



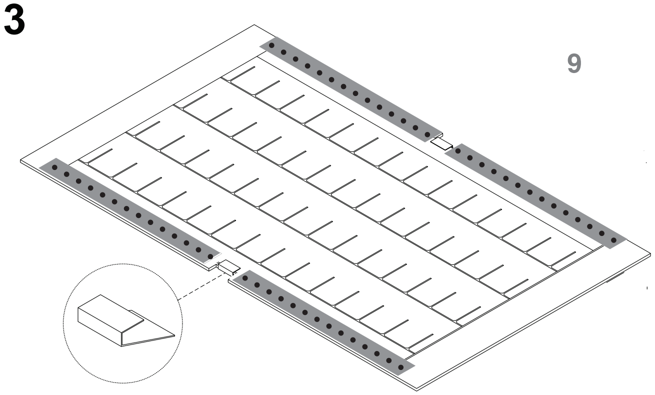
Begin assembly by applying the body stickers as shown. A pair of tweezers will help with the removal and placement of the stickers.

2



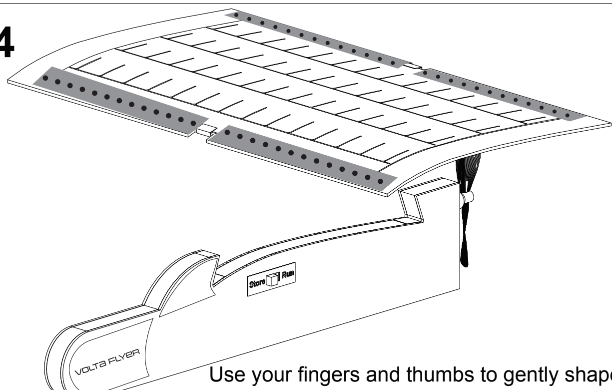
Now attach the Solar Panel to the top of the Main Wing panel. Center the Solar Panel over the Main Wing panel as shown. Use the four gray stickers with simulated rivets to attach the Solar panel to the Main Wing. The stickers should extend beyond the ends of the Solar Panel by about 1/8 of an inch.

3



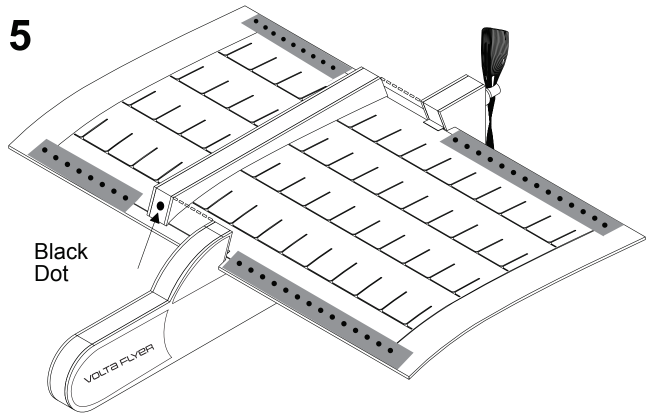
Fold the metal tabs at the center of the Solar Panel down around and under the Main Wing panel as shown. The metal tabs will come in contact with the brass tabs on the Fuselage.

4



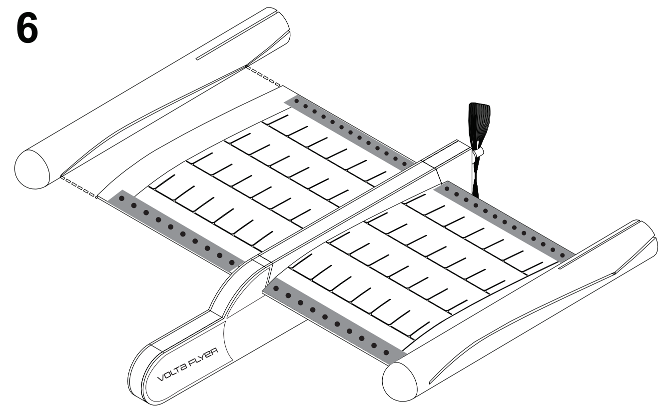
Use your fingers and thumbs to gently shape the Main Wing and Solar Panel into a slight curve. Then gently insert the Main Wing and Solar Panel assembly into the fuselage. Start by placing the rear slot of the Main Wing assembly into the rear crease of the Fuselage and then carefully curve it to slot in the front portion of the wing into the front crease of the Fuselage.

5



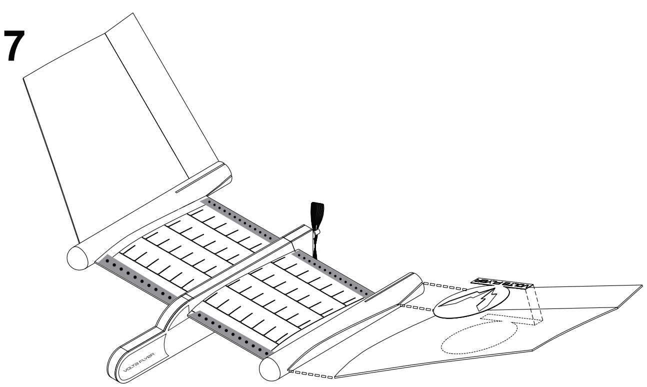
Carefully slide the Wing Lock into position by gently working it (back and forth) into place. Note that the black dot on the one end of the Wing Lock faces forward.

6



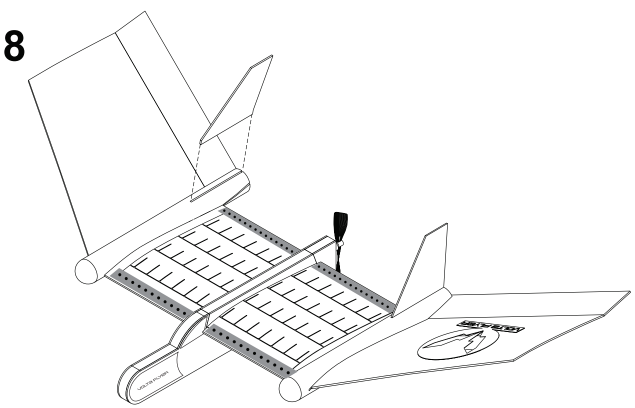
Gently slide the outer edges of the Main Wing into the slots (following the slot curves) of the Wing Joiners. The rounded ends of the Wing Joiners point forward as shown.

7



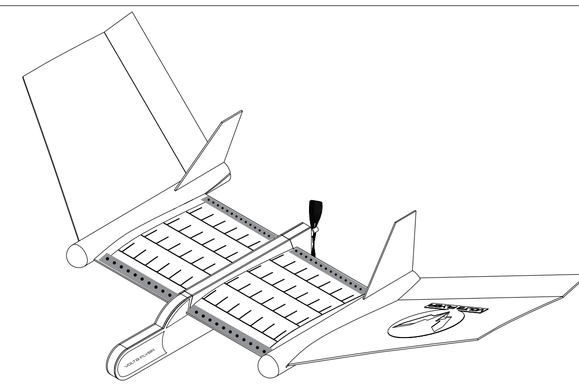
Now insert the inside edges of the Outer Wings into the outer slots of the Wing Joiners (following the slots curve). Then place the Volta Flyer logo on the left wing which will help the Volta Flyer turn during flight. The wings will angle upwards as shown.

8



Insert each Vertical Stabilizer into the slots on top of the Wing Joiners. The Vertical Stabilizers will tilt in slightly towards the center of the Volta Flyer.

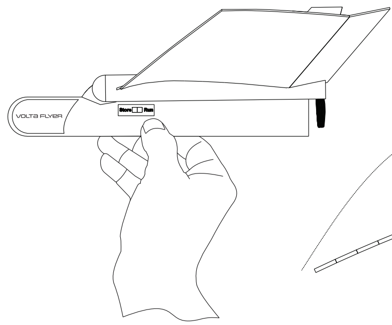
9

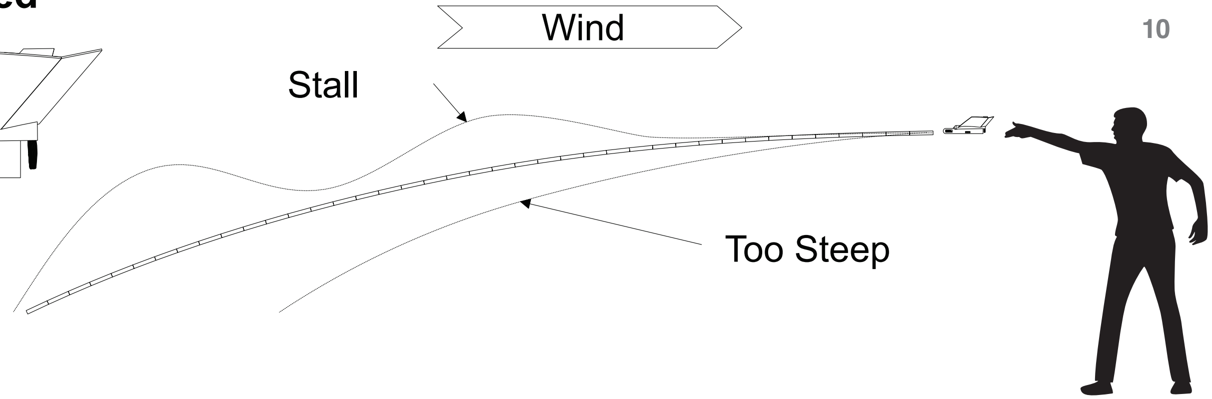


The Volta Flyer is now complete. Make sure the power switch on the side of the fuselage is switched to the Store position. Go outside on a sunny day and point the top of the Solar Panel towards the Sun to charge the Volta Flyer. Please read the Flying Instructions before you get started.

Assembly & Flying Instructions continued

Before flying your Volta Flyer under power, it is a good idea to give it a few hand glides. Your Volta Flyer will want to turn. It it best to perform the hand glides in calm wind conditions. This helps make sure your observations are related to the way your Volta Flyer wants to fly and not a function of wind gusts.

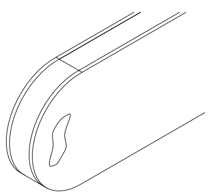




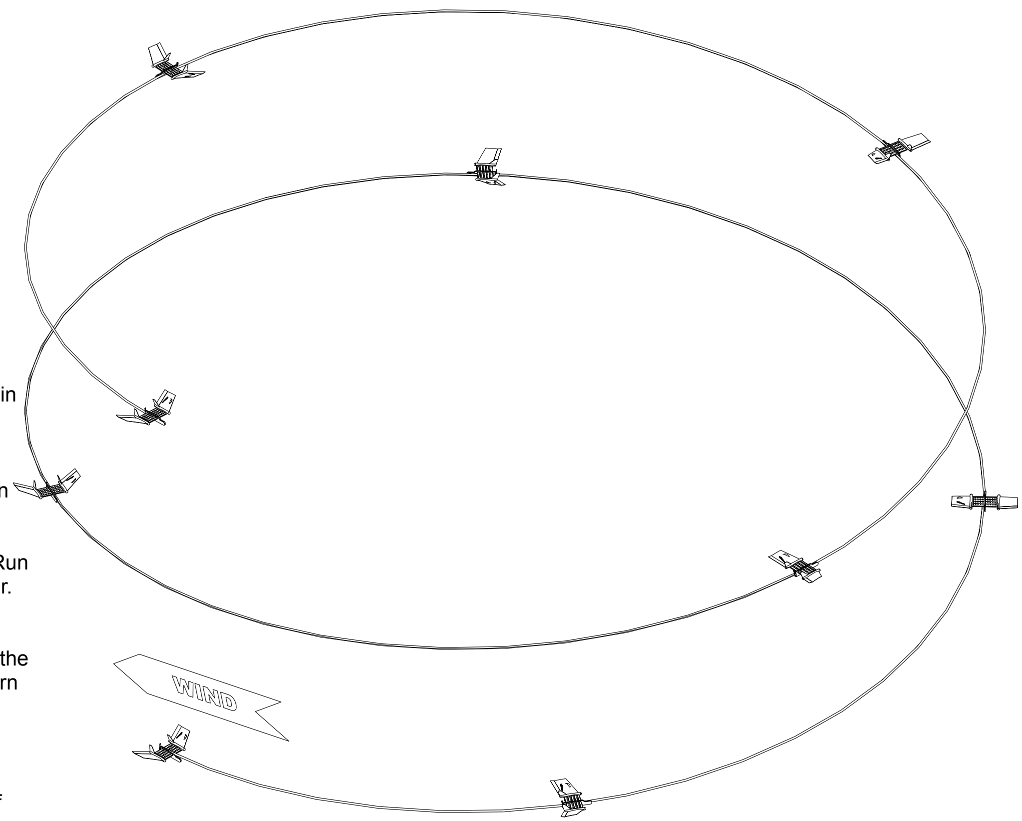
When hand gliding the Volta Flyer, always use gentle arm movements. Don't throw it like a baseball. Grip the Volta Flyer under the body in the middle. Move your arm forward like you are throwing a dart. Point the nose down very slightly. Release the Volta Flyer when your arm is just about all the way forward.

Observe the flight path. The Volta Flyer should turn on its own. Some turn is important to keep the Volta Flyer from flying to far away when power is applied. It may be necessary to bend the rear of the right wing tip up to get the Volta Flyer to turn right when gliding. Note if the Volta Flyer does not fly with a gradual decent path as shown by the heavier line in the above diagram.

If the Volta Flyer's glide path has dips as shown at the top of the diagram, it is stalling. If the Volta Flyer is stalling, add a small amount of modeling clay to the nose.



If the Volta Flyer's glide path is too steep, bend the rear of each wing tip panel up a slight amount near the tip. It does not take much of a bend to affect the glide path.



When satisfied with the results of your hand glides, you are ready for powered flight.

For your first powered flights it is suggested you select a day with fairly calm winds. Once you confirm the Volta Flyer is flying with the correct flight path, it can be flown with some wind blowing. Avoid flying it in winds above 5 mph. In strong winds it can travel some distance and may land in a place that would make it difficult to retrieve.

In bright sun the Volta Flyer will take several minutes to fill the Energy Storage System. With the switch in the Store position, hold the Volta Flyer so the solar panel is facing the sun.

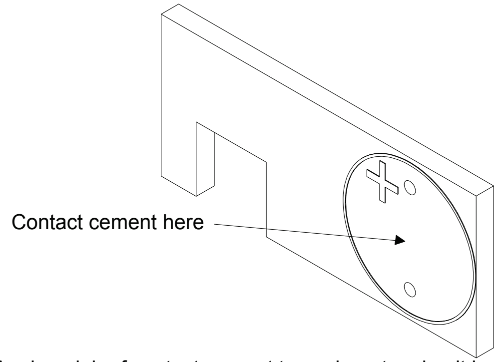
After about 3 minutes hold the Volta Flyer so you are facing any prevailing wind. Slide the switch to the Run position. Using the same launching technique as when performing the hand glides, launch the Volta Flyer. This time the nose should be level. Do not launch the Volta Flyer with the nose pointed up.

The Volta Flyer should climb out of your hand turning to the left or right. As the stored energy is used up the motor will slow down and the Volta Flyer will start turning to the right while descending. If the initial left turn is too much, bend the rear edge of the right wing tip up a small amount. Try the Volta Flyer again. If the initial turn is still too tight, bend rear edge of the right wing tip up some more. Repeat that step until the Volta Flyer's initial left turn is fairly open and the Volta Flyer is climbing under power.

The motor will continue to run after the Volta Flyer lands. Move the switch to the Store position to turn off the motor. This will also start storing energy for your next flight.

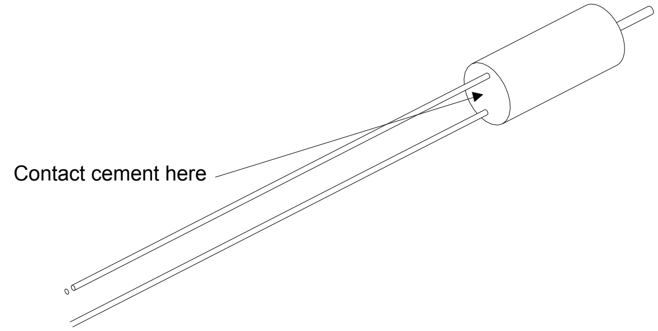
How We Assembled the Volta Flyer Circuit Board

1



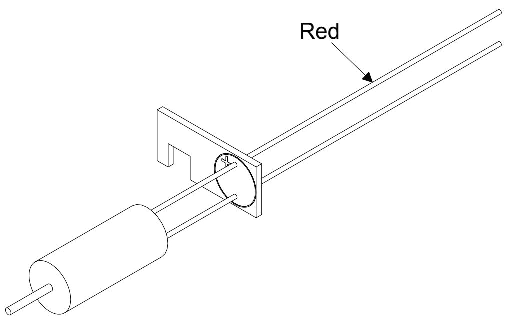
Apply a dab of contact cement to each motor circuit board inside the printed circle on the component side of the board. Do this in batches of 20 boards.

2



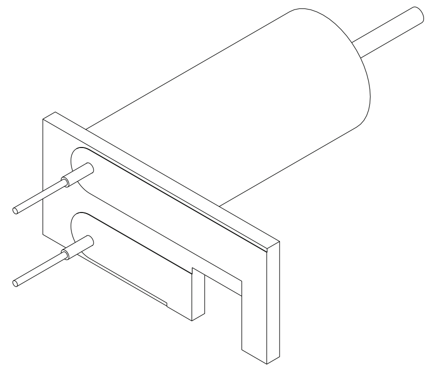
Apply a dab of contact cement to back of each motor. Do this in batches of 20 boards.

3



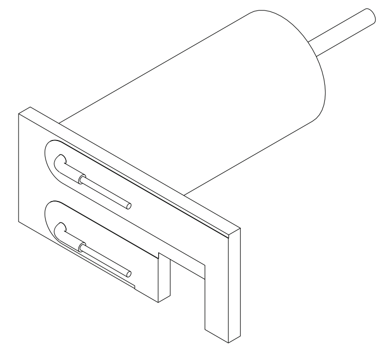
Start with the first motor and board of the batch that received contact cement. Mount a motor to each motor circuit board. Slide the motor leads through the two holes in the board. The red lead goes in the hole with the "+" sign. Using light pressure, pull the motor into position inside the printed circle. Press the board to the back of the motor. Repeat steps 3, 4, and 5 until all motors/boards needed for the production run have been completed.

4



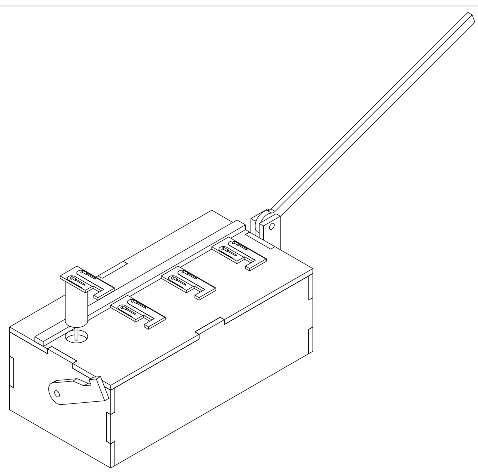
Using a cutting/stripping tool, trim the motor leads near the circuit board on the trace side. About 1/8" of stripped wire should show for each motor lead. Do this for all motors in the production set.

5



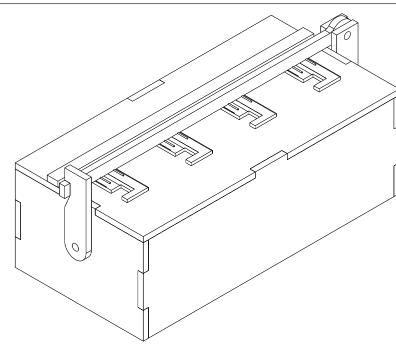
Bend each motor lead down so the stripped end is in contact with the respective circuit board trace. Do this for all motors in the production set.

6



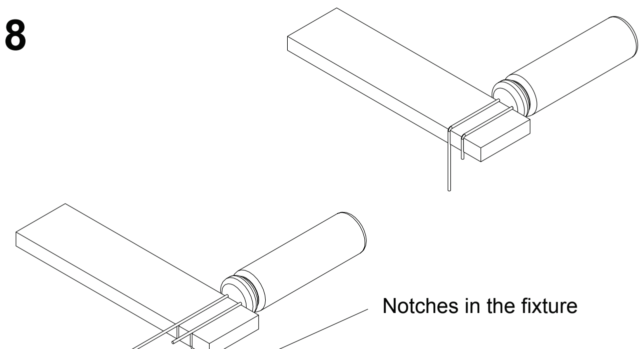
Place four motor/board sets in the soldering fixture as shown.

7



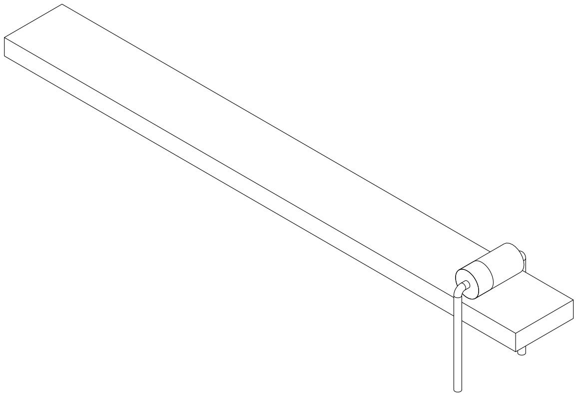
Clamp the motor leads as shown. Solder each lead to its respective circuit board trace. Remove each motor/board assembly from the fixture. Repeat the process for all of the motor assemblies needed for a production run.

8



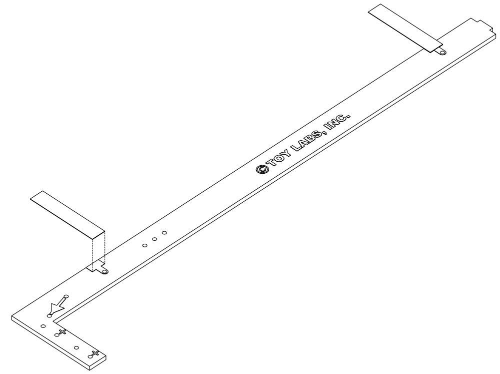
Two capacitors are used for each Flyer. The leads are bent to a 90 degree angle 1/2" from the base using the bend fixture shown. The short lead should be in the orientation shown. Bend all of the capacitors in one batch.

9



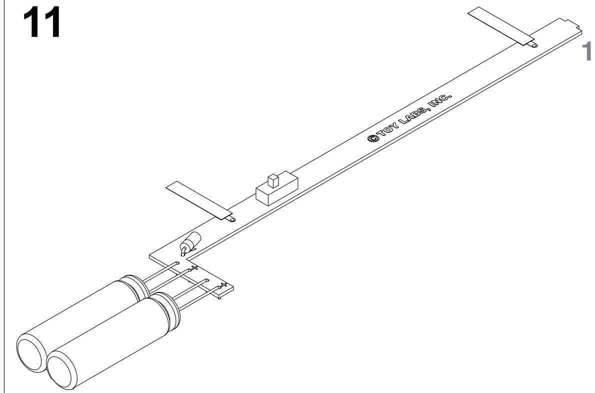
All of the IN4148 diodes need to have their leads bent to fit the circuit board holes. A bending fixture is used to maintain consistent bend locations.

10



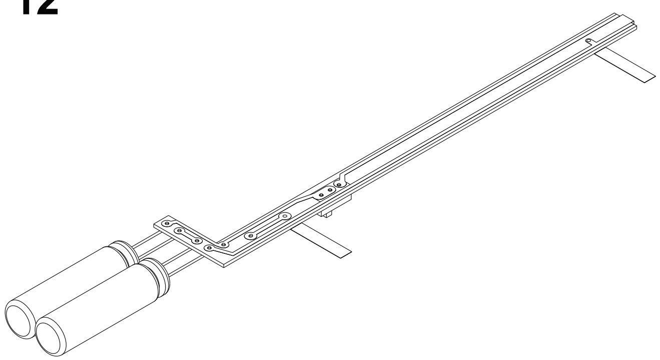
Solder the solar panel brass contacts to the main circuit board. The contacts are made from .0025 brass shim stock and are 1/8" x 9/16". Do this for all of the boards in the production run.

11



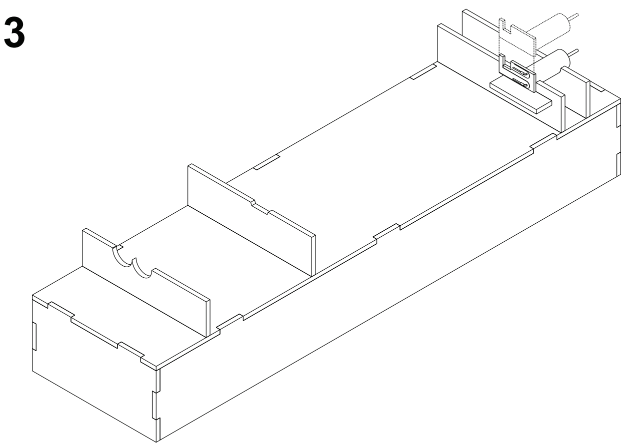
Insert the capacitors, diode, and switch into the main circuit board. Flip the board over and bend the leads so the components are retained in the board. Do this for all of the boards in the production run.

12



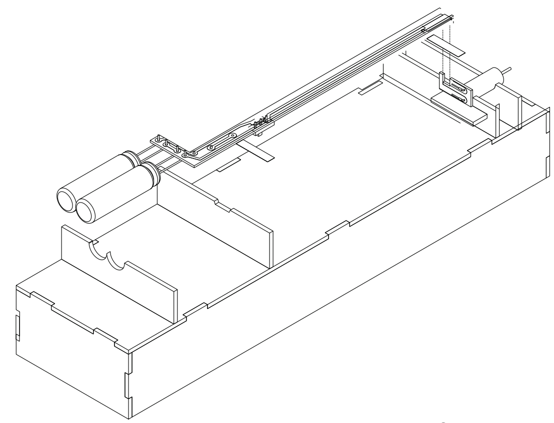
Solder the component leads to the main circuit board. Trim off the excess lead lengths. Do this for all of the boards in the production run.

13



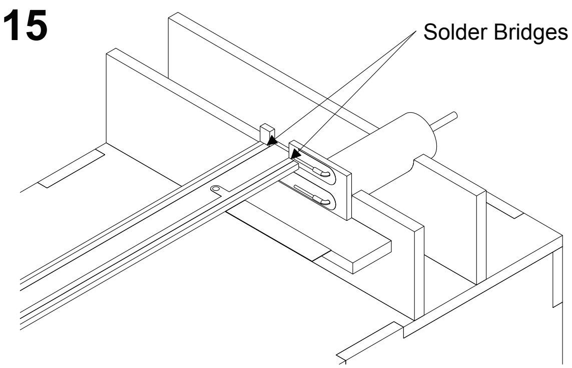
Place a motor/circuit board on the assembly fixture as shown.

14



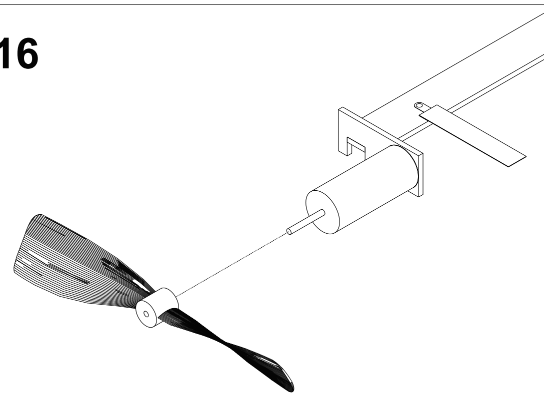
Place a main circuit board assembly on the assembly fixture as shown. Apply a small dab of glue to the circuit board tab before inserting it into the motor circuit board slot.

15



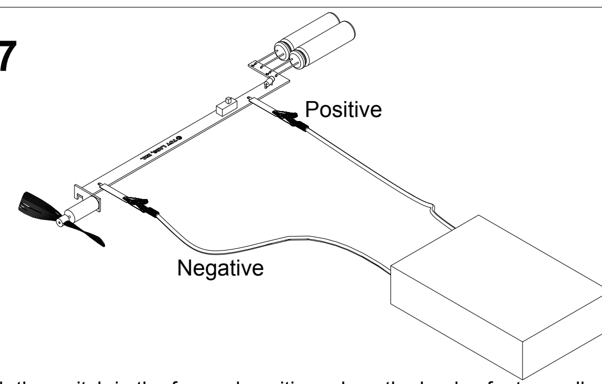
Solder the motor circuit board to the main board. Form a solder bridge between the two boards on the respective traces. Do this for all of the electronics modules of the production run.

16



Each motor needs to have a propeller pushed on to the output shaft. The orientation of the propeller is very important. The cup of the blades must face away from the motor. Hold the motor, not the circuit board when pushing the prop onto the motor shaft.

17



With the switch in the forward position, place the leads of a two cell battery pack (3v) on the solar panel connectors as shown. Charge the capacitors for about 10 seconds and then remove the battery leads. Move the switch to the rear position and confirm that the motor runs. Check all modules in the production run.