My name is Louie Turek and I am the coordinator of the Glider Competition for the SECME event at UCF. I am unfortunately unable to attend the Train the Trainer workshop this year and hence have written up this document to go along with the slide show that I use to convey various concepts about gliders. There is a list of a few key topics, followed by a description of the information on each slide. For anyone who attended the workshop last year, the guidelines for the gliders and the slide show are the same.

Just for your information, the organization that I represent is the Orlando Youth Aviation Center, which is a group dedicated to teaching kids about aviation. I have been involved in their aviation classes for over a decade and have also taught various aviation events at local schools. As a hobby I am a pilot and through a national program to take kids flying, I have flown over 430 kids. I have also been running the glider competition at SECME since 2009.

If anyone has any questions, please do not hesitate to ask me via the e-mail address in the presentation.

Key Terms and Concepts (the most important things for the students to understand)

- What constitutes a properly balanced glider
- The importance of a wing with the right type of shape
- Having a tail that is long enough and tail surfaces big enough to stabilize the glider

Slide 3

This slide shows a cross section of a wing, and the shape that the wing has is called an airfoil. This type of shape is what makes a wing work well at producing lift to keep the glider in the air while not producing too much drag (excessive drag will inhibit the ability of the glider to glide very far). The main thing that I always emphasize about airfoils is that the shape is thicker and rounded at the front (the leading edge) and then tapers off towards the back (the trailing edge). This is the shape that makes a good airfoil. The distance between the leading and trailing edges is called the chord. I recommend for the gliders that the students build that the chord be at least a couple of inches as very short chord lengths will not make for a good wing, to make a long aerodynamic story short.

Slide 4

This slide is intended to illustrate the kinds of things that make a good glider. The aircraft shown is a sail plane, which is designed to glide as efficiently as possible. There is also a sail plane on the front page of the design guidelines for the competition since I am trying to subtly nudge the students towards that kind of design. The things that characterize a sail plane are:

- A wide wing span
- Relatively thin and slender wings (although as stated on the previous slide, the chord length for the students’ gliders should not be much less than a few inches)
- A sleek, slender body
- A smooth, rounded airfoil shape for the wing

Slide 5

The purpose of this slide is to illustrate that wings, like any other structure, will bend when subjected to a force. In this case, it is the force of the lift pushing upwards on the wing. A long and thin wing will work well aerodynamically but it will also bend more easily, and if it is not strong enough can potentially break. The force of lift will be equal to the weight of the glider. For the glider competition, the rules state that the
total weight of the glider cannot exceed 10 ounces. This means that the force of lift on the wing will be no more than 10 ounces and this is actually not too much of a structural challenge. The biggest structural challenge for the wing usually comes from the fact that the glider may hit a wing on the ground or a wall, and the wing has to be strong enough to take such punishment without breaking or being damaged much.

**Slide 6-**

With the idea in mind that the wing needs to have a strong but lightweight structure, this slide review a few ways that hobby type aircraft are made. The image in the upper left consists of foam that has been carved to an airfoil shape and the lower right image shows a balsa wood skeleton. Both of these are a lot more elaborate than what is necessary for the glider competition but are included just to illustrate the concepts.

**Slide 7-**

This slide illustrates a more practical means of achieving an airfoil shape without a huge amount of effort. A balsa wood beam is placed in between two pieces of foam (glued together at the ends) and since the wood beam is moved towards the front of the wing, the wing takes on that airfoil shape with the thickest part of the wing being towards the front and the back end tapering off. The wood beam is a structural element referred to as a wing spar, and most airplanes use a spar running along the wings for strength. The leading and trailing edges of the foam wing can then be sanded with fine sand paper to round off the edges.

**Slide 8-**

When it comes to airplanes, one common thought that a lot of people have (including me when I was a kid) was that if a particular design feature works well for a particular airplane, it must be a good idea for all airplanes. This is absolutely not true. This aircraft on this slide is an F-15 and while it is a truly awesome fighter, it is a bad glider. Its swept back wing design is perfect for supersonic flight, but it does not glide well. The long and straight wing shape of a sail plane is a much better choice. Bottom line: just because something looks cool does not mean that it is a good idea.

**Slide 9-**

This slide is intended to illustrate a wing shape concept called dihedral. This is a slight upward canting of the wings. This tends to help improve the stability of the airplane in flight, and in particular it helps prevent the airplane from drifting back and forth side to side. However, I should note that dihedral is not required for stable flight, it is just a nice little extra to have but is not essential. Also, notice in the picture that the upward cant of the wing is slight, not extreme. If the upward cant were extreme, a good portion of the lift of the wing would be pointed sideways and therefore the glider would not glide very far since the effective lift that it would have would be significantly reduced.

**Slide 10-**

The previous slide illustrated a simple dihedral, whereas this slide illustrates compound dihedral. It is two different ways of achieving the same thing. The advantage to the compound dihedral in this image is that the center portion of the wing is one solid piece. The center of the wing is the point of greatest stress due to the bending of the wing from lift. Hence, it is nice to be able to have this center portion be solid rather than two halves coming together like in the previous slide (which might be a little weaker, depending on how the wing is built). Again though, dihedral is a nice thing to have but is not essential for stable flight.
Slide 12-

If there is any portion of homemade gliders that gets overlooked, it is the tail. Whenever I am talking about the tail of an airplane, I like to point out to people that without a tail, an airplane has no idea that it is supposed to keep the nose pointed forward. We as human beings know that it should, but an airplane does not know this without a tail. The tail stabilizes the airplane both in the up and down as well as the side to side direction.

Slide 13-

Even if people put a tail on a glider, there is much more to it than that. The tail surfaces have to be big enough to do their job. This airplane is of course the Spirit of St. Louis, made famous by Charles Lindbergh flying solo across the Atlantic in it. Lindbergh participated in the design of this airplane and purposely made the tail surfaces too small. To help students learn about the proper sizing of tail surfaces, I like to ask them what is the result of the tail surfaces on this plane being too small? Pretty soon they get the answer in that the airplane will have trouble keeping its nose pointed forward. I ask why Lindbergh would want an airplane that had trouble keeping the nose pointed forward. Again, pretty soon somebody figures out that he did that to help him stay awake on the flight across the Atlantic, which he knew would take about a day and a half.

I then tell the students that the moral of this story is that the tail surfaces have to be big enough to do their job. I find that stories like this are very effective at illustrating such concepts. I then give what I call the Rule of Fingers for the tail surfaces. The vertical surface of the tail should be 10 times smaller than the surface of the wing (or bigger, if in doubt). The horizontal surface of the tail should be 5 times smaller than the wing (again, go bigger if in doubt). The 10 and 5 numbers are why I call it the Rule of Fingers, which is a name that I find makes it easier for students to remember the numbers.

Note: The 10 and 5 numbers stated above are not precise requirements, just guidelines that the students probably should not go below to ensure that the tail can do its job. If in doubt, the tail surfaces should be a bit bigger (such as 8 times and 4 times smaller, for example).

Slide 14-

This slide shows the concept of a canard, which puts the horizontal tail surface at the nose of the airplane. To make a long story short, this works very efficiently aerodynamically but it can be very difficult to get it stable. In other words, if it is not balanced just right, it will tumble out of control when the students toss the glider into the air (much more on balancing a glider later). I am not telling anyone that they cannot built a canard type glider, just warning them that getting it to fly well might take a lot of effort.

Slide 15-

This image is of the B-2, which is a flying wing design. This design is even more efficient than the canard design but it is also more unstable. A flying wing is efficient because there is no drag or weight from the body or the tail since there is no body or tail. It is just a wing. However, as I said a few slides ago, without a tail the airplane has no idea that it is supposed to keep the nose pointed forward. The B-2 is able to fly since it has millions of dollars’ worth of computers on board maintaining stable flight. The gliders that the students build will not, and hence a flying wing design will be virtually impossible to make stable. As with the canard, I am not telling them that they are not allowed to do this, but I feel sorry for anyone trying to get a hand tossed flying wing design to be stable.

Slide 16-
This slide shows the 4 forces that act on an airplane in flight, namely lift, weight, drag, and thrust. There may be multiple sources of each for any given airplane, but nevertheless the key point is that any force that acts on an airplane will always fall into one of these four categories.

The other key point of this slide is that the location of the lift force (which is due to the location of the wing) is a little bit behind the force of the weight. This is essential for stable flight and is expanded upon a lot in slide 18.

**Slide 17**

Having discussed with students the four forces that act on an airplane, I like to then quiz them about gliders. A glider obviously has lift (if it did not it would just fall straight to the ground). It definitely has weight since it is made out of solid material, and it also has drag since any object moving through the air will experience drag. But, the question that I then pose to the students is if a glider has a source of thrust (and for their hand tossed gliders, I am not talking about their hand tossing it), and ask them to raise their hands for yes and no. The correct answer is yes, even though a glider may not have an engine, it will have a source of thrust.

To show them what I mean, I ask them to think about what would happen if they were riding a bicycle and they took their feet off of the pedals. The answer of course is that they would come to a stop. But, I then ask them to think about doing the same thing but with the bicycle going downhill. The answer then of course is that they would not lose speed and the reason is that gravity is propelling them downhill. I like to point out that a glider is like a bicycle without any pedals. Gravity is its only source of propulsion but as long as it can keep going down, it can keep going.

**Slide 18**

This slide literally might be the most important slide in the whole presentation. It illustrates the basics of balancing a glider, and it is literally impossible to get a glider to fly if it is not properly balanced. I often joke that if I could engrave into people’s minds one word for all of aviation, that word would be balance.

The first thing is to discuss the concept of the balance point. This is commonly called the center of gravity, but I like to refer to it as the balance point since that conveys the idea that if you hold the glider on your finger tip underneath the balance point, the glider will balance. It is vital that the balance point be about one quarter to one half way back along the wing. If it is much farther forward than this, the glider will nose dive into the ground. If it is much farther back, the glider will tumble end over end to the ground. As was shown in slide 16, it is a good thing if the balance point (the weight) is just a bit forward of the middle of the wing since this will tend to help the glider glide down at a shallow and smooth angle.

Also, the wing (and the balance point) should be no more than about ¼ of the way back along the body of the glider, and the length of the body of the glider should be about the same as the wingspan of the glider. Following these guidelines will help ensure that the tail is long enough to stabilize the glider well. I talked about how big the tail surfaces should be in slide 13, and ensuring that the tail is long enough is the other half of making sure that the tail will stabilize the glider well.

Probably the number one thing that I have seen be a problem for gliders over the years is that the balance point is in a different location than one quarter to one half way back along the wing (usually too far back due to the tail being too heavy and bulky). The tail being too small and not long enough is another very common problem and so when I am teaching about this I really try to drive these points home.
Slide 19-

This slide is just intended to remind everyone that these are the three key points that going into a good glider.

Slide 20-

For the first bullet on this slide, I discuss how you can check if a glider is at least close to properly balanced by placing your finger underneath the middle of the wing and checking to see if the glider balances or close to it. If it does, then and only then is it worth trying a flight to see how it flies.

For the second bullet, I mention that ballast is a term for dead weight that can be moved around the glider to adjust its balance point. The marbles that the glider must carry as per the design rules work well for this, but the students should keep in mind that the marbles are required to be all kept together and hence they cannot put some marbles in one part of the glider and some in another.

Lastly, I always remind students that a good glider is nothing if their throwing technique is lacking. A nice smooth and steady throw is better than a wild attempt to throw the glider as hard as they can. I often tell students to imagine that they are moving their hand along a clothesline and that helps ensure a steadier and straighter throw.

Slide 21-

This is just a review of some of the more significant design rules. The minimum 24 inch wing span, the fact that the body of the glider cannot be anything more than 4 inches by 4 inches, and the 6-10 ounce weight limit range (including the marbles) are the major ones. The last bullet states that if any piece of the glider breaks off upon landing, that flight is reduced in score by 25%.

Note that I put the rule about the body of the glider not being allowed to be any more than 4 inches by 4 inches to help ensure that the students do not make the body of the glider any bigger than it needs to be. It only needs to carry the marbles, and the bulk that results from making it much bigger than it needs to be will only add unnecessary weight and drag.

Slide 22-

This slide is a wrap up convey a few key thoughts and suggestions based on questions that I have gotten over the years. The first few bullets are simply stating that balsa wood is an excellent choice for making a number of parts of the glider and that it is readily available in hobby and craft stores. The marbles that the gliders must carry are also available in craft stores. I typically buy them from Hobby Lobby or Michael’s. They are ordinary glass marbles, and if you cannot find an exact match to their description in the rules, that is ok. The marbles will weigh about 2 ounces and hence if you buy marbles, you can just weigh out 2 ounces of them and use them for practice in the glider. 2 ounces is 2 ounces. As stated in the rules, we will provide the marbles for the gliders the day of the competition.

I also suggest trying to get a hold of small balsa gliders that you can buy in hobby stores which are quite small and cheap and are excellent tools for letting the students practice getting a glider to balance properly. If the glider is pitching up or down or tending to drift to either side, they can get practice using ballast (such as a paper clip) to get the glider to fly properly. For example, if the glider is pitching downward, they can shift weight further back, or if it is pitching upwards then they can shift weight forwards. If the glider were drifting to the left, they could add a paperclip to the right wing. Alternatively, they could shift the position of the wing a little bit rather than adding weight.
Lastly, a few things to not do. I have seen some students add features to gliders just because they look cool (like a small spot for a little pilot or a little flag with their school colors on it). If any such things will not help the glider fly well, by all means forget about them. Also, the small balsa gliders I mentioned above have slots cut into them so that they can be assembled without glue or tape. This is fine for those gliders but trying to cut slots into the gliders that the students will be making for this event will be a nightmare of time and effort. Plus, it is also unnecessary. Wings, tail surfaces, and other parts can be attached with tape, glue, or rubber bands a lot easier than by cutting slots for everything.

One last thought that I often tell people but that is not in the presentation is that I recommend that they test fly the glider a number of times before the day of the competition. I would be doubtful of any glider’s ability to fly well without a few test flights, no matter how well designed it is. Showing up for the competition with a glider that has never flown is not something that I recommend.

Once again, if anyone has any questions, please do not hesitate to e-mail me.

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