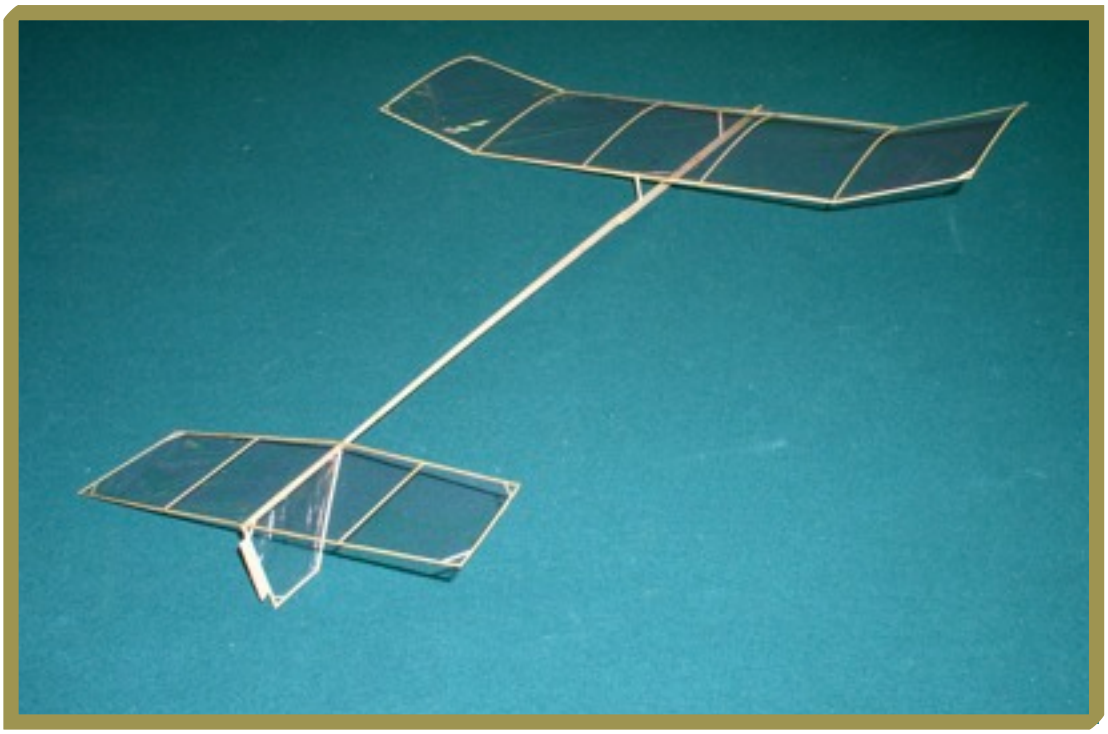
INDOOR TOWLINE GLIDERS

By Chuck Markos



Design, observations and musings

I started playing around with Indoor towline gliders while searching for an alternate aeronautic event for the Science Olympiad competitions. The first attempt was to remove the propeller from a 7-gram Wright Stuff model, adjust the balance for gliding and stick a pin into the fuselage for the tow hook. It actually worked! Flight times were modest, about 20 seconds, but the proof of concept indicated that a towline could replace a helium-filled balloon as a means to attain altitude for glider flying indoors.

At about the same time, the Bong Eagles started sponsoring an Indoor towline glider event at their two annual contests in Racine, WI. The specifications for the event were such that a set of Limited Pennyplane flying surfaces could be used to cobble together an airplane with minimum effort. Since the minimum weight was to be 3 grams, the relatively heavy Wright Stuff parts previously employed were not considered.

Upon completion of a new glider, my first observation was that towing was going to be the major problem in flying it. The airplane must fly in a circular pattern while gliding. A straight flight path would lead to a collision with a wall of the Indoor site, resulting in the premature end of flight. The action of towing seriously magnifies the tendency of the airplane to fly in a circle making it a difficult task to gain respectable altitude before it turns away from a straight tow path and becomes free of the tow line. The first approach to that problem was to design a lightweight latched tow hook so the glider could be towed in circles without the line releasing from the hook when the glider strayed from a straight tow path. Each

circle allowed a slight gain in altitude. When the glider was at maximum altitude (the ceiling) a simple light tug on the line unlatched the hook and the glider was flying free. The best flights were over one minute in duration under the 41-ft ceiling of Memorial Hall in Racine. An excellent drawing of a latched tow hook can be found in the plans for Kurt Krempetz' ToFu Glider on his web site: AMA Glider.

In addition to the latch, the tow hook was displaced off center to the same side as the glider turned in flight. That displacement is a standard method of making an airplane tow straight and free glide in a circle. Some experimentation on the degree of offset displacement will be required to attain the desired results.

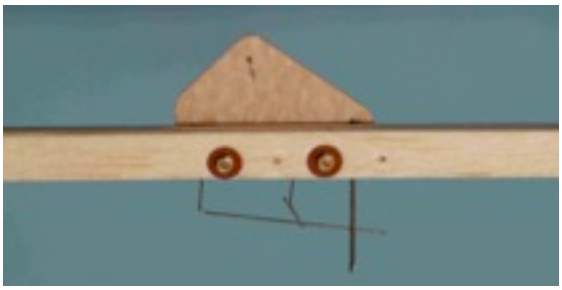
One result of the offset hook is that the glider will yaw excessively to the glide path circle as the towline angle approaches the vertical. That result is due to the change in forces of the towline on glider: At low angles, the force produces a yaw opposite to the side of the offset. At high towline angles, the force is transformed to produce a yaw to the same side as the offset. This can be a good thing as the turning glider on tow can be released at proper attitude and speed for transition into a free flight glide.

In any case, there are at least two variables to consider when using an offset tow hook. One is the degree of offset and the other is placement of the hook in relation to the airplane's center of gravity. Both variables will have an effect on the behavior of the airplane while towing. Generally, the hook is placed about one centimeter ahead of the CG. Placing it too far ahead of the CG will reduce the rate of climb while towing. Placing it too close to the CG will make the glider super sensitive to several aerodynamic effects.

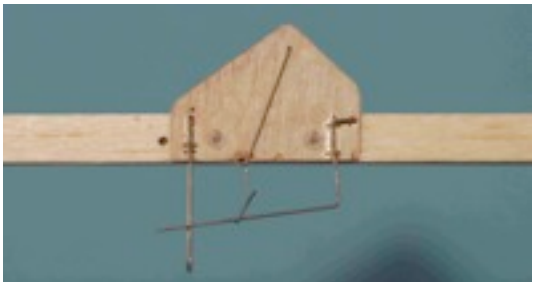
The standard way of controlling the tow behavior of an Outdoor towline glider is to employ a device called an "auto-rudder." That is, when the glider is being towed, the rudder is held in a position that allows it to fly straight. Once the glider is released from the towline, the rudder moves slightly to provide a circular flight path. I have seen one example of an auto-rudder on an Indoor towline glider and it seemed to work well.

Ray Harlan's auto-rudder viewed from the bottom. Adjustment screws are 090. The line attached to the rudder horn goes to the swinging pendulum on the tow hook.

My quest was for simplicity, however. To achieve this goal, the next trials used an impulse release system similar to the ones developed many years ago for Outdoor gliders. The impulse system places the ring on the airplane and the hook on the towline! The hook is fashioned from a



Harlan's tow hook, forward direction is to the left. The "T"-shaped fitting is the pendulum that moves forward

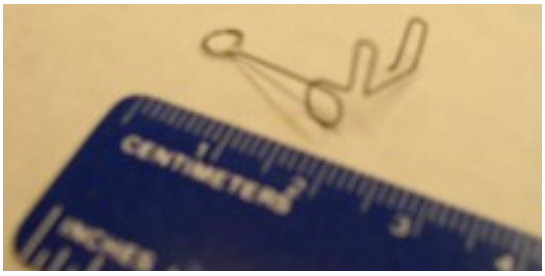


Harlan's hook from the right side of the airplane. The string from the rudder horn is attached to the small loop in the pendulum. Constructed from 0.014" music wire.

spring that can be found in a ball-point pen with a retractable writing point. Tie one end of the spring to your line and open the other end of the spring to form a shallow hook. The ring was fashioned from 0.020" music wire and attached to the fuselage offset to the same side as the airplane turns. To release the hook and line from the ring, simply pluck the line like a guitar string ***while it has some tautness*** and the hook will jump out of the ring.

A further simplification was to form the ring from 0.014" music wire with an extra loop in the wire to provide spring action for the ring. With this ring, no external spring is required on the hook attached to the towline.

Towline with a spring attached, one end forming a hook, for a stationary tow ring on the airplane.



Close-up of the spring action ring, made from 0.014" music wire.

The towline itself is a length of "Spiderwire" braided fishing line. This brand of line resists stretching when under tension….necessary for the impulse system to function. I prefer braided line over monofilament line as I think it resists tangles better. Note that the "Spiderwire" brand is found both on braided and monofilament line. Use the lightest test

line you can find, usually about eight-pound test. The suggested brand of line has two additional advantages that are quite important to attaining success. One is that it is much lighter weight than comparable test line made from other materials and the other is that it is much thinner than others. The mass of the line comes into play when the airplane is flown in very high ceiling sites. The drag of the line is affected by how thin it is. Thinner lines have less drag than thick ones. To overcome excessive drag from the line, the flyer will have to walk faster

Towline and hook used with the spring action tow ring. A "pennant" is attached to the towline so release of the line from the airplane may be discerned by the timer.

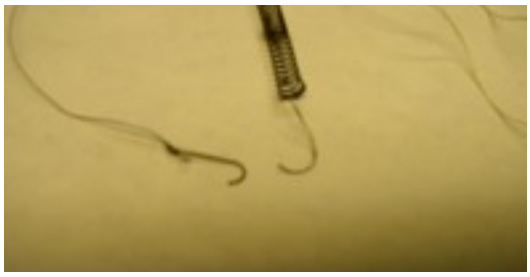
for the airplane to gain altitude than for a low-drag line. Walking faster will increase the stress on the airplane in tow.

The art of circle-towing a glider requires some practice. The initial launch requires a helper to hold the airplane and release it upon your signal. The person towing the glider may use a combination of walking (backwards of course) and hand-over-hand taking in of the line as the airplane gains altitude. When it begins to turn, the towing person must stop walking backwards and taking in line to let the airplane make a circle with the line attached. Most times, the towing person must reverse the towing steps and walk towards the airplane while simultaneously letting out line until the airplane is in a position to start towing it up again. While the glider is circling with the line attached, some loss of altitude will occur, but not so much as to let it hit the ground. Each circle with the line attached should provide a stepwise gain of altitude until the release point is attained. At that point the glider is released into free flight by pulling a little harder on the line for a latched-hook system, or by twanging the line for an impulse system.

To avoid line tangles with your feet and clothing, it is recommended that bare or stocking feet are better than shoes and short pants are better than long pants so you can feel the line if it touches your person. If you have a team mate, tangles can be more easily managed with help.

My findings with circle towing indicate that better altitude gain can be obtained if the towing action (pulling the glider up by walking backwards and/or bringing in line) is started when the glider is just coming past the "back" of the circle. That is, its nose is not pointed directly at the towing person but is pointed to one side. Under no circumstances should you try to pull the glider up when it starts to circle while the line is attached and its nose pointed away from you. The result of such action will be the glider accelerating towards the floor.

With limited access to high-ceiling flying sites, the only opportunities I've had to fly Indoor towline gliders have been both a learning event as well as a competition event. One vexing problem with the impulse release system was that it was the release was not always effective when towing at high-ceiling altitudes although it worked quite well at lower altitudes. The learning and experimentation process led me to two modifications. The first was to reconfigure the hook (on the towline… remember?) to be as shallow as possible. The second was to wait until the glider on tow was well into its turn to twang the line rather than when it was gaining altitude with its nose pointed at me. The reason for difficulty in the release may have to do with some length-induced damping of the "twang" wave in the line, but that is pure conjecture.



Note shallow hook configuration for dependable release of towline from the ring

Towing success is highly dependent on having a straight airplane. Unbalanced warps in the wing or stabilizer will cause any airplane to turn in flight. With the addition of a towline, the tendency to turn is magnified. Often times the warps may seem insignificant and/or difficult to see without careful examination. It the glider is not towing straight enough to gain altitude, the first consideration should be to remove all warps. For Indoor models, this is a simple task. Simply crack the offending part of the structure to correct the warp. Use very thin cyanoacrylate glue at the location of the crack to set that part or the structure to its corrected position.

While flying my glider at the 2009 USIC, it seemed that the structural warps in the airplane were corrected, but still the glider was circling much too tightly while under tow in spite of an extremely wide open glide circle when flying freely. A rudder tab was added to tighten up the glide circle and the stabilizer tilt was removed. With these two changes, the airplane towed better and had a reasonable glide circle diameter for the site. Some of the other gliders towed amazingly well straight up in contrast to mine. I do not know why. It could be a function of CG placement. That is, the well-behaved straight-towing gliders could have had the CG well forward of the 63% position of my glider.

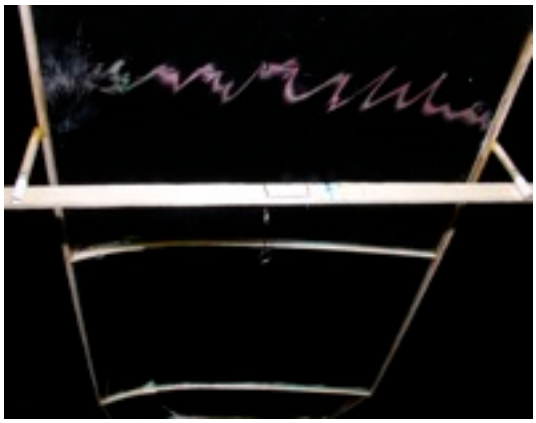
The design of the airplane was dictated by the rules specifications: 3-gram minimum weight, 24-inch maximum overall length and a wing with span less than 18 inches and chord less than 5 inches. Unlike rubber-powered Indoor aircraft, the fuselage need not be very strong. ***The center portions of the wing LE and TE are where the strength belongs. Select the strongest (and heaviest) balsa for these members.*** The ribs were sliced using a template and a razor blade. A notable addition is the lamination added to the forward portion of each wing rib. The laminated part is cut so that the grain of

the wood is tangent to the forward part of its curvature to reinforce the weakest part of the rib. No camber was used for the stabilizer ribs.

At the 2009 US Indoor Championships, my glider was apparently the most efficient airplane once I was able to attain altitude and release near the 114-ft ceiling, although I do not know exactly how near as time was running short and judging height of an airplane directly overhead is not easy. Its best flight was 3:10 to edge out two others that had flights in excess of 3 minutes. The glide may have been enhanced over the competition by using a 5% airfoil with the high point of camber located at 30% of chord as well as a CG set at 63% of the wing chord. Most of the other gliders had much shorter tail moment arms than did mine indicating that they had a more forward CG.

For beginners, construction techniques and a list of materials can be found on line in other articles that I have authored. Look on the web site freeflight.org in the "Beginner's Corner" for balloon launch and a simple Indoor towline glider: the Kisloon and Kisline models. Also, on the Science Olympiad web site, you will find a manual for building and flying Wright Stuff airplanes that contains useful general information for Indoor model construction.

Acknowledgements: Thanks to Ray Harlan for photos of his auto-rudder system and to John T. Warren for drawing the plans of the glider.



The wing is attached to the fuselage by means of sockets (tubes) glued to the fuselage and hard balsa dowels on the wing's LE and TE.

Template for cutting sliced ribs. Make one from compact disc packaging plastic. Each slice produces a new rib.