THOUGHTS ON JET CATAPULTS

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Any number of articles have been written about what works in scale jet catapult. This article instead highlights some pitfalls to avoid in chasing the elusive successful flight of these trick), beasts. As someone who has yet to actually win the event, I have lots of experience in what doesn't work.

Configuration

I thought that scale jet catapults would be easy. I had lots of experience building hand-launch gliders and non-scale catapult gliders. But the optimized configurations of standard AMA competition gliders and tricks like stabilizer tilt to induce a turn are not available for Scale Jet Cats. FAC general competition rules explicitly forbid stabilizer tilt on FAC models to include jet cats - bummer.

Compared to non-scale gliders the configurations of most scale jets feature a nose that is too long and a tail moment that is too short. Frequently there is excessive side area compared to the wing area. I haven't explored all types of shapes, but I've explored some excursions and learned some lessons about configurations. My go to shape is an airplane with a wingspan and length about the same (currently I'm flying a McDonnell Banshee and a Martin B-57A).

I got excited by the prospects of a high aspect ratio wing and built a Martin RB-57D. This is a high altitude version of the B-57 with a big wing. It did not work as well as imagined. A lot of the weight is concentrated in the long wing compared to the really short tail and rear fuselage. This resulted in an airplane that had a high moment of inertia along an axis perpendicular to the wing and low moment contribution fore to aft from the fuselage. In a similar way to inertia from mass there was an imbalance of forces from air resistance to raise a wingtip compared to the force to raise the tail. The glider was very touchy in pitch going from loopy flying from too much incidence to not enough incidence with tiny changes. The long wing resisted most efforts for a bit of rotation in the transition that could position the glider for a clean roll-out. The glide was OK, but not enough to compensate for the difficult launch. I tried to correct the out of balance moments by cutting window panes in the wing, removing balsa, and covering with tissue. This didn't change the flight much, gave me a wing that easily warped, and one that screamed it's defiance to the wind with every launch. This model will end its days with the kids of Bonnie's cousins (previous models given to these kids lasted all of an hour - they enjoyed them even more as parts started to break off with every launch).

Back in the Max Fax of 1/97 I had a design for a ?" B-2 flying wing. It flew great in the hanger at Pax River back in the day. With this success I thought that a bigger B-2 would work out. Despite trying many similar flying wings (B-2s, Gotha, and a Douglas X-4) I've not been able to reproduce this success. All of these flying wings have a relatively short fuselage and long wing. They are very touchy

to tiny changes in c.g. and amount of bent-in trailing edge reflex. While great fun to sail across an auditorium they are outrageously difficult to launch with any consistency at higher power. Many flights ended with spectacular aerobatics that would please any child. A good jet cat performance - not so much.

Strength

The strength required for these gliders is high to best utilize the full potential of a loop of 1/4" rubber. Building a glider as light as possible and yet strong enough is a balancing act. Many plans show a bent wire glued in a hole in the fuselage. For me this has not proven to be good enough. One of these hooks pulled out at full stretch, launching the wire across the flying field. This is something I only wanted to do once. My hooks are a piece of plywood firmly glued in a sandwich with the strong backbone of the fuselage and nose weight elements.

Other strength elements come into play both at full extension prior to launch and immediately upon release. I was surprised just how much pull comes from the rubber band. I've had the glider pulled out from my fingers before I was ready. In trying to lighten the rear of the glider I have had some places where the balsa chosen was too light. This resulted in the fuselage coming apart between the hook and my grip. I now use a strong fuselage backbone to which the hook, grip, wing, and tail all connect. I still cringe if I hear any creaking sounds at full pull. After launch I've had a wing break off under the loads. Sometimes the horizontal tail will break letting the wing get into trouble. For this reason I use spruce or basswood leading edges on all surfaces. The heavy wood near the leading edge on an otherwise light balsa surface helps to keep flutter at bay (a common source of the scream that some gliders make upon launch).

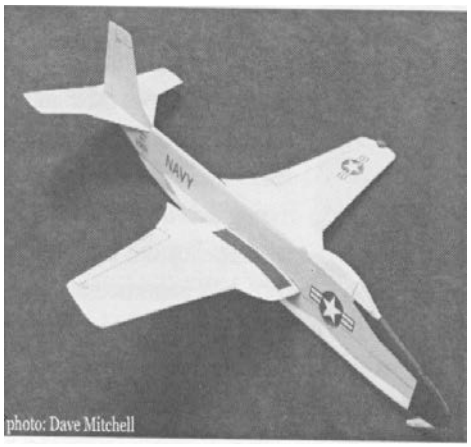
Airfoil

Many scale catapults pay little attention to the airfoil used. One of my early jet cats had a thin 1/16" rounded leading edge airfoil. While this resulted in a light wing, the airplane was very touchy. If launched perfectly the flight was great. It was hard to not fly through some part of the launch, transition, or glide where the airflow did not meet the wing at too large an angle of attack (separated flow on the top) or too Iowan angle with separation on the bottom. This airplane would stall and spin both right side up or upside down. Adding another piece of wood to thicken the wing improved the flight consistency. The airfoil that I now try to emulate is the BE5017VN catapult airfoil described in the 2010 NFFS Symposium (see insert next column--ed.) Developed using the XFOIL computer modeling program it features low drag at zero lift and decent LID in the glide. It is a 5% thick section with a vortex nose (flat section just behind the leading edge) to help transition the boundary layer on these small gliders. A thicker wing would be stronger and produce more lift but have higher drag. I've tried to carve the wing using a template for this shape but what a pain in the neck.

Some Aspects of Trimming and Launching

OK, so by now you have built a light strong glider, with good structural integrity, and a good layout. There are still many ways to screw up the launch. It was a middle schooler competing in the Science Olympiad elastic-launch glider event who taught me a thing or two about launch discipline. Randy Kleinert and I both noticed that this girl first pulled the glider back to the desired tension, then in a separate motion set the bank angle, and finally she elevated to tile vertical angle for launch. She had been clearly coached to think about each of these elements and decide what worked.

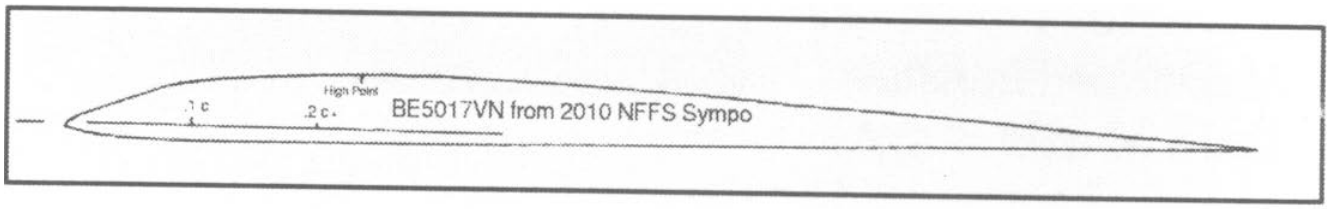
My wife, Bonnie, has been trying for some years to get a good photograph of a jet cat in flight shortly after launch. Careful examination of these photos revealed two problems with my launch technique. In an effort to get more pull on the rubber loop I had taken to gripping model not at the back of the



fuselage but at a point not that far from the catapult hook. I found in some of the photos that the axis of my grip and the catapult hook were at an angle from the intended direction of flight. This would lead to a waggle of the fuselage from side-to-side upon launch. You couldn't see the model move in this side-to-side way but I had noticed that some flights just didn't go as high as others. This was particularly noticeable with a P-80 glider that had enough side area to cause big side forces if launched poorly. Since the model is off to the side of your head it is hard to see this misalignment. Being aware of the problem made it easy to correct. Secondly, I was also, on occasion, holding the launcher at a different tilt angle from the tilt of the glider. This twisted angle would impart some rotation during launch.

I have adapted the practice of the AMA gliders with a hook near the nose. This means that the first motion of the glider has the wing at a low angle of attack. It is only as the glider slows that the decalage drives the wings towards a lifting condition. Thus while going fast the wing wing lift and hence drag are low. I launch this glider more vertically than I would if I relied upon the wing to take it skyward. As you position the catapult hook back towards the wing the wing generates more lift during launch. If you find yourself losing sight of the glider behind you head immediately after launch it is often from a rearward hook location. Image a line made by the rubber band to the hook and think where the center of gravity is on the model (both along the horizontal length and vertically). The rubber band will orient the wing in the air upon launch.

Transitions from launch to glide are sensitive to the location of the center of gravity. I prefer a center of gravity as far back as the glider ,,;11 tolerate. This gives a model that has a low margin of stability in pitch running with a low angle between the bottom of the wing and the horizontal stabilizer. It is risky because a small change in incidence can result in a lawn dart from not enough incidence. When it works the glider will flop over at the top of a steep launch rotating easily about the c.g. The glider is bouncy and more sensitive to the air around it.



An airplane that is very stable requires a lot of incidence to successfully glide well. This can be made to work with a lot of bank angle in the launch to force a glider that would otherwise loop into an upward spiral. The size of the loop is directly related to the relative incidence between the wing and horiz. stab. The extra stability help in flying in wild windy days and makes the glider fly in a predictable path. The glider is flown through the transition to glide as it will not readily flip at the top of the launch. This is done by having the upward spiral end a bit downwind so as not to stall at the top. With practice you can get the glider to smoothly fly from the spiral up into the glide. I can't launch a more stable model as high as one with a more rearward c.g. Finally, you can definitely overpower these airplanes. Some airplanes with their many breathed-in settings fly better if not launched at the maximum power allowed. If there are crazy things happening at launch it might be worth trying to slow down the action and sorting out things at a lower power.

My next glider Since your next airplane project always flies much better than your current airplanes , I have some ideas for my next jet cat. I want to go to a glider that is a bit larger than my current -11" designs. I thought that I could drive a small glider further above ground turbulence getting to smooth air. This hasn't worked well for me because the higher speeds made tiny adjustments overly effective. I had trouble understanding what was going on in some of the flights and getting the desired consistency. The next airplane will be larger, more in line with the 15-18" size commonly used in AMA non-scale gliders.

I want to go to a slightly thicker 6% airfoil. The wing will have taper in thickness on the other 1/3 of the wing to lighten wingtips for effective roll. This thicker wing trade-offs launch altitude for greater lift in -the glide. I hope that this also will improve consistency in flight. Finally, I'm not convinced that adding engine pods or tip tanks for the bonus points are worth the added drag and pain when they break.

With all of these words you are more than ready to try the crazy world of jet catapults. Bonnie loves the fact that I get lots of exercise walking back and forth chasing the beasts. A lot of excitement in just a few seconds.