PEAK OF FLIGHT NEWSLETTER

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ALTIMETER VENTING

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PEAK OF FLIGHT

Altimeter Venting

By Bernard Cawley Jr.

It's Really Not That Hard

In June 2017, in issue 445 of Peak of Flight (https://www.apogeerockets.com/education/downloads/Newsletter445.pdf), there was an article by Tim Van Milligan entitled "How to Select an Altimeter". Early in that piece, as Mr. Van Milligan was describing how the sensors used in devices such as rocket altimeters were getting better and better, he said "even the 'size of the vent hole' conversation is not very relevant anymore. I can't tell you how many times people have asked us 'how big of a vent hole you need in the side of the rocket for the altimeter to sample the air?'". Apparently he's still getting that question quite a bit.

In 2019 I did an R&D project for the National Association of Rocketry's Annual Meet (NARAM-61) related to this topic. In that project I did three series of flight tests of a model with multiple payload sections, with varying amounts of venting in these payload sections, each with multiple altimeters of different makes inside. Having seen that project (and knowing that I have been flying lots of altimeters in lots of rockets for over ten years), Mr. Van Milligan asked me to try to answer that "what size vent holes do I need?" question here in Peak of Flight. But first, a quick refresher on barometric altimeters.

Currently available model rocket altimeters, including all those sold by Apogee Components, make use of the well-known and well-documented relationship between altitude and atmospheric pressure and temperature. One depiction of this is shown here: https://www.grc.nasa.gov/WWW/K-12/rocket/atmosmet.html

The software that runs on the processor on board the altimeter takes the pressure and temperature data from the pressure sensor aboard and uses this known relationship to figure out how high above the starting point the model has flown. In some cases it stores enough data that it can also provide a time vs. altitude plot of the entire flight—after you transfer that data to some kind of computer.

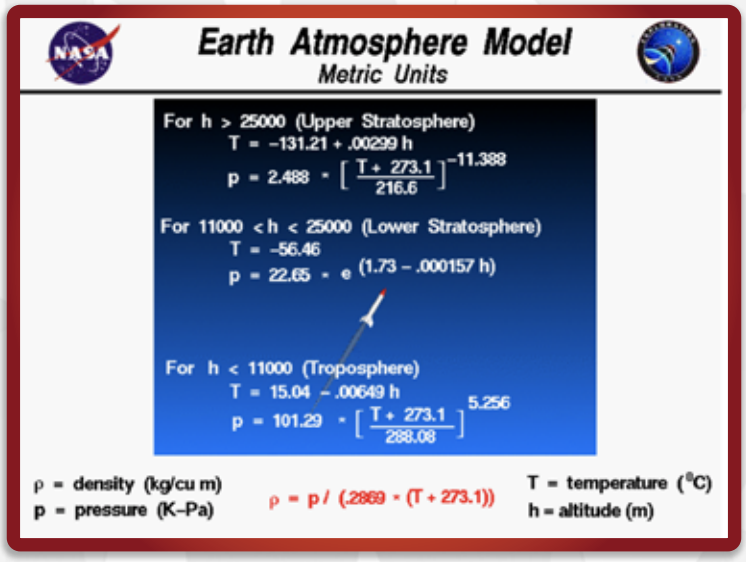

FIGURE 1: NASA EARTH ATMOSPHERE MODEL

Consequently, a key consideration for flying an altimeter in your rocket is providing for a way for the air pressure outside the model to be accurately "seen" by your altimeter with little time lag. This leads us to questions about specifically how to do this, often expressed as "how many holes do I need, how big do they have to be and where should (or shouldn't) they be on my rocket?" And in the back of the mind of the questioner is probably another one: "what happens if I get it wrong?"

Based on the experience from my NAR R&D project and several hundred other model rocket flights carrying one or more altimeters, I can say that for the most part, it's not hard to get "good enough" venting for your altimeter. It's harder (though it's not impossible) to do it so poorly that you don't at least get a good apogee reading from your device.

Let me expand on that a bit. But before I do, let me clarify the scope of this article. As I write this in early 2021

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You can subscribe to receive this e-zine FREE at the Apogee Components website www.ApogeeComponents.com, or by clicking the link here Newsletter Sign-Up

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Altimeter Venting

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I have no experience with electronic recovery deployment, nor do I have any experience with flying anything even close to Mach 1, never mind supersonically. Therefore what follows is aimed at model and mid-power rocket sport flying and model rocket competition flying using barometric electronic altimeters (which may or may not be augmented by accelerometers) to get flight data after the model is recovered. Dealing with Mach effects or deployment computers (or telemetry) are topics for another writer in another edition of Peak of Flight.

First, Do You REALLY Need Venting At All?

In short, yes, you do. As I described above, an altimeter depends on sampling the static air pressure outside your model and using the pressure changes there to calculate its height above its starting point. In flight this sampling is happening at least 10 times per second. If the pressure where the altimeter is riding doesn't follow the static air pressure outside the rocket very closely, then at the very least you will get a reported apogee that is not what was actually reached. In FIGURE 2 below I have overlaid the data from six of nine altimeters that were all on one rocket flight. This flight was one of a series of six flights on one day that I did for that NARAM-61 R&D project. Three of these altimeters (one Altus Metrum MicroPeak, one Adrel ALT-BMP and one PerfectFlite FireFly) were in a 2 1/2 inch long BT-50-sized compartment that I tried to seal against air leakage. The balsa nose block at its base was sealed with two coats of glue, and the joint at the other end of the compartment was taped up before flight. There were no holes in the tube itself. One each of the same three altimeter types were in a compartment that was made exactly the same way except that it had three 1/32 inch diameter holes in it about 120 degrees apart about halfway down its length. A third set of three altimeters was in another compartment where the balsa nose block that formed the base of the compartment was not glue-sealed and the joint between it and the next section (or nose cone) was not taped up, allowing air to leak through the balsa and the upper joint as well. These three compartments were stacked on top of an Estes Nova Payloader and launched for this flight on an Estes C6-5. Then after the flight I downloaded and recorded the data from all nine devices.

As you can see, the altimeters that were riding in the "sealed" compartment (light blue and red lines) both read

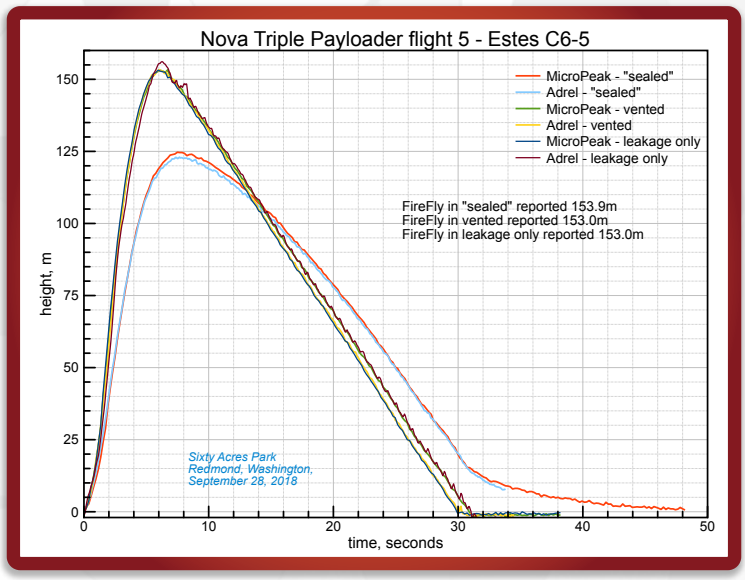

FIGURE 2: NOVA TRIPLE PAYLOADER FLIGHT 5 COMPARISON

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Altimeter Venting

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FIGURE 3: NOVA PAYLOADER WITH THREE PAYLOAD COMPARTMENTS. "SEALED" ON TOP, LEAKAGE ONLY VENTING IN THE MIDDLE, VENTED ON THE BOTTOM

a lower apogee than those that were riding in the vented one (green and yellow lines), or in the one that used only leakage for venting (darker blue and brown lines). The altitude vs. time curves also show that ones in the "sealed" compartment lagged the others by approximately 2.5 seconds. That's certainly long enough to reach apogee and come back down a significant distance.

Interestingly, the actual shapes of the time vs. altitude curves from altimeters riding in the "sealed" compartment look reasonable and if I didn't have the other data to compare them to I wouldn't necessarily have known they were in error. As you can see, the apogees recorded in the "sealed" compartment were almost 30 meters lower. That certainly wouldn't have helped my score if that had been a competition flight!

As an aside, that I got plausible looking curves from the "sealed" compartment on those flights told me that it's harder than I thought it would be to truly seal a compartment

FIGURE 4: TEST COMPARTMENTS. "SEALED" ON TOP, LEAKAGE ONLY IN THE MIDDLE, VENTED ON THE BOTTOM

so well that an altimeter won't detect being launched, at least when using the usual paper/balsa/plastic model rocket materials. But the bottom line is yes, you must provide some way for the pressure near the altimeter to mirror that outside the rocket.

But also notice how closely the traces from the altimeters in the leakage-only compartment (darker blue and brown) follow those from the vented compartment (green and yellow). This suggests that it doesn't take much vent area at all to get acceptable readings, at least when the altimeters are in small compartments such as these. Still, adding vent holes is a reliable and simple way to assure that your altimeter can do its task properly.

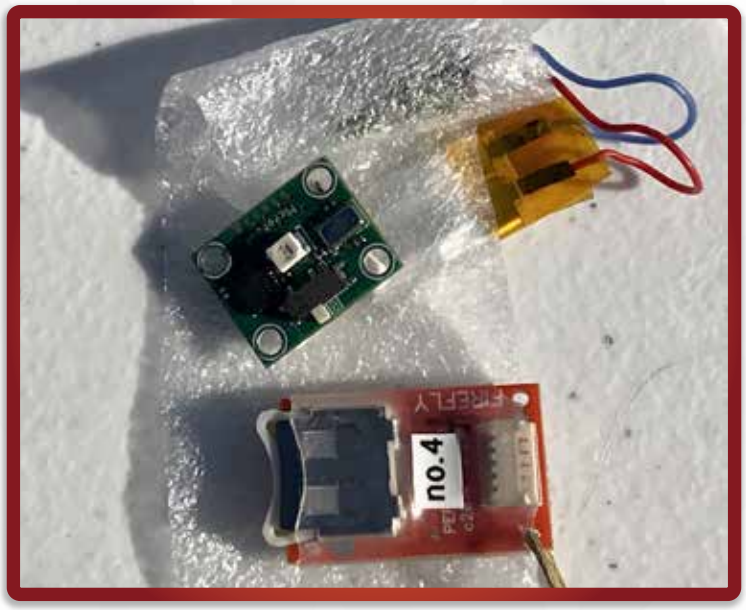

FIGURE 5: ALTIMETERS (AND A LITTLE SHEET FOAM) FOR ONE TEST COMPARTMENT

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Altimeter Venting

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How Large Should the Holes Be and How Many Do I Need?

There is lots of conflicting information on this in various altimeters' manuals and other online sources. Some altimeter manufacturers are very specific in their guidance on this point, others aren't. From an analytical point of view, how much vent area you actually need depends on the volume of the compartment where the altimeter is riding during flight as well as the maximum speed the rocket will be attaining, since the objective is to have the static pressure outside the rocket "read" by the pressure sensor of your altimeter with little time lag. There are some nice tools available or calculating precisely what is needed. But in practice, for most model rockets, it's not as complicated as that sounds. And as I've already suggested, it's also not that fussy.

In that NARAM-61 R&D project I tried to explore the boundaries of this with another series of six flights on which I again flew a stack of three different payload compartments on the Nova Payloader carrier rocket. Two were the same compartments with the 1/32 inch diameter vent holes and the leakage-only venting described above. For this series of flights I replaced the "sealed" compartment with one that had three 3/32 inch diameter holes which therefore had nine times the vent area as the original "vented" compartment. As before I put an ALT-BMP and a MicroPeak in each compartment. I also put a FireFly in one of the compartments on each flight as sort of a cross-check.

Between flights I varied which individual altimeter of each type was in which compartment. I also varied the order in which compartments were stacked on the model. This was done to try to wash out any device-specific peculiarities or variances due to the where, along the overall length of the model, the various venting approaches appeared. All six flights from that series were boosted by Estes C6-5s and all took place on the afternoon of the same late-January day in 2019.

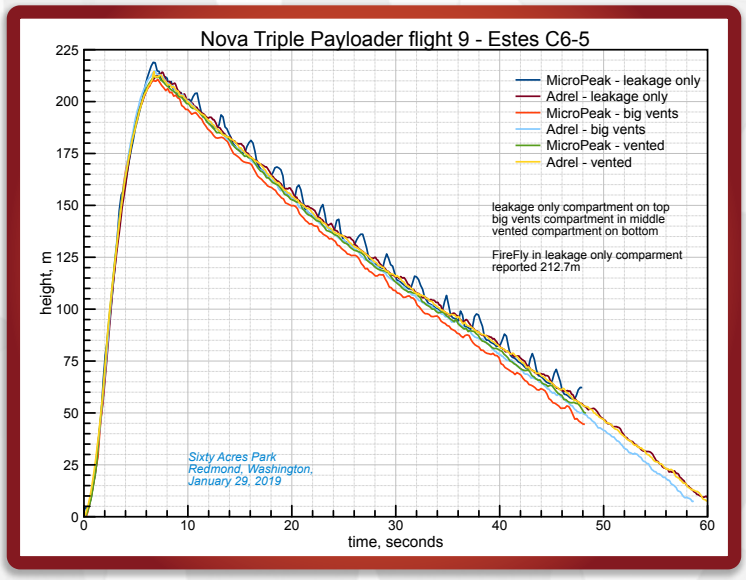

FIGURE 6: NOVA TRIPLE PAYLOADER FLIGHT 9 COMPARISON

After all the data were downloaded and noted I found pretty good consistency between all seven altimeters aboard each of these flights, though the data from the altimeters in the 1/32 inch vents compartment were generally the cleanest. Data from both the larger vent compartment ("big vents" in the graphs) and the one that used leakage only for venting were noisier. This can be seen from ejection through descent. Note that this particular model tends to swing the payload section(s) around under 'chute. This swinging in a circle is the source of the periodic ripples during the descent phase on the graphs. These series of flights pretty well documented what I have been seen from lots of altimeter flying over the last ten years.

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Altimeter Venting

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Based on all of this, here are some suggestions for putting static ports in your model. First, use three or four holes, as suggested by most altimeter makers' instructions. Why three or four? One reason for this is wind gust immunity. With three or four holes, no matter which way your model is oriented on the pad, gusts hitting it are very unlikely to cause significant pressure fluctuations in the compartment where the altimeter is installed and either fool it into recording an incorrect starting point or into thinking it has been launched when it hasn't yet been. I also think having multiple evenly spaced holes help smooth out the pressure changes as the model flies.

Some device instructions and online posts suggest one sufficiently large static port will work and I'm sure that one hole can be used successfully, but I can also see how a gust of wind blowing directly into that one vent hole then subsiding can both lower the starting altitude by momentarily pressurizing the compartment and then cause a false launch trigger as the dynamic pressure from the gust drops as it passes.

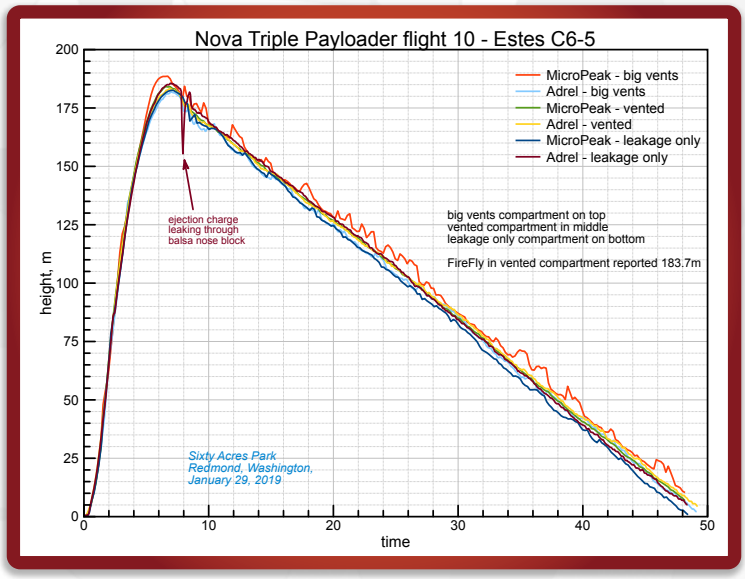

FIGURE 7: NOVA TRIPLE PAYLOADER FLIGHT 10 COMPARISON

I've seen many arguments against using two holes and some altimeter makers' instructions explicitly tell you not to use two. Using three or four has been my practice pretty much from the first time I tried to fly an RC airplane altitude sensor in a rocket as an altimeter. Interestingly, I recently came across the payload section I made for that Eagle Tree Altitude MicroSensor and that one has five small holes arrayed around the base of the payload section. I don't recall why I chose to use five back then.

FIGURE 8: NOVA TRIPLE PAYLOADER WITH LEAKAGE ONLY VENTING ON TOP, BIG VENTS COMPARTMENT IN THE MIDDLE AND VENTED ON THE BOTTOM AS FOR FLIGHT 9

Hole size recommendations:

If you're flying your altimeter in a separate payload section up to a few inches in length, all you really need are pinholes. If you are flying the altimeter in the body of the model with recovery system (well tethered to the recovery system attach point and suitably protected from ejection charge gases, of course!) then the volume from the top centering ring of the motor mount up to the base of the nose cone is what you are venting (and if the nose cone is

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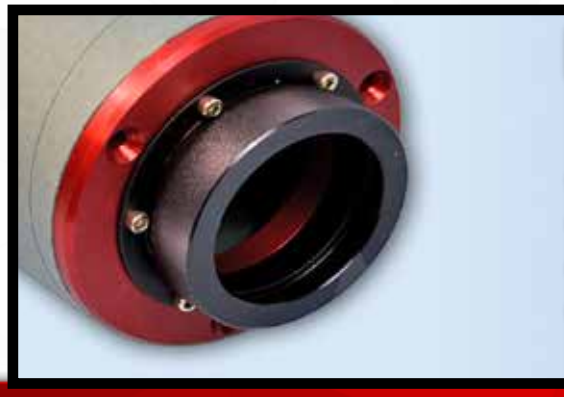

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Altimeter Venting

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hollow and open on the bottom, that volume is added). In this situation I will usually use 3/32 inch holes in models up to 1.6 inches or so in diameter, and 1/8 inch holes for larger ones. For example, I have four 3/32 inch holes in a couple of Estes Big Berthas. There are four 1/8 inch holes in the body of my Estes Super Big Bertha (which is BT-80-based) which are there for the benefit of an altimeter and/or a Jolly Logic Chute Release I sometimes fly in this model.

I suppose it is possible to make static ports too large, and while at least one altimeter manufacturer in recent years strongly cautioned against doing so, I've not seen any issues using the hole sizes I've just described. I don't know where that threshold of "too big" is. Clearly three 3/32 inch holes in a 1 1/4 cubic inch compartment isn't too bad, based on the results discussed and graphed above.

As you can see, there is a pretty wide range that, in my experience, works fine. For most any model-rocket-sized volume flying at a realistic model rocket speed, it doesn't take a large amount of vent area and altimeters are really pretty forgiving about this.

As a check on my practice and recommendations, I used the calculations for port sizing in the Missileworks RRC3 instructions and the instructions supplied with PerfectFlite altimeters (both available online). Using a Big Bertha body as the volume (1.6 inches in diameter, 16 inches of volume to vent), the hole size (for four holes)

FIGURE 9: MY FAVORITE LARGER-THAN-A-PINHOLE STATIC PORT MAKING TOOL—A SHARPENED PIECE OF 3/32 OD BRASS TUBING WITH A SPENT MINI MOTOR CASING FOR A HANDLE

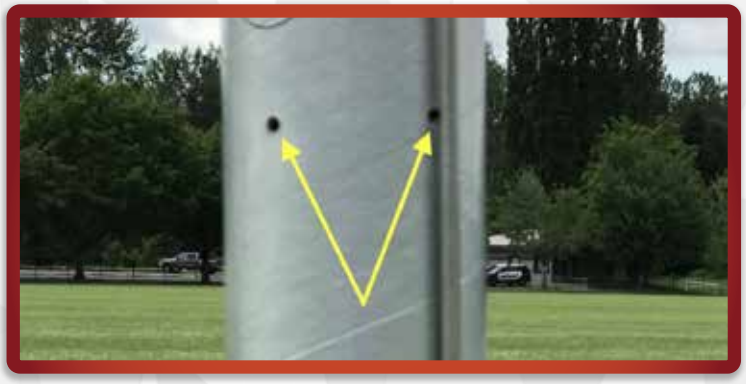

FIGURE 10: TWO OF FOUR STATIC PORTS IN AN ESTES SILVER COMET

that results from doing their calculations is around 1/32 of an inch. Using the spreadsheet created by Tripoli Rocketry Association member Gary Stroick (https://www.offwegorocketry.com/userfiles/file/Calculators/Static%20Port%20Holes.xls), which sensibly also accounts for maximum velocity, yields port sizes up to about 1/16 inch if I assume a really high (approaching Mach 1) maximum velocity. So my suggestion above for four 3/32 inch holes is more than enough. Using those sizes has not caused any issues that I am aware of with respect to getting bad data out of altimeters I've flown.

Where Should My Static Ports Be (And How to Make Them)?

One important consideration for locating the static ports in your model is that if at all possible you want them to be located where the airflow along the model is smooth and parallel to the surface in which the holes are placed. If you look at various recommendations from altimeter makers and others, you will see different constraints suggested to achieve this. And again, as a practical matter, there are just a couple of things to keep in mind. First of all, you don't want your static ports immediately downstream of (below) any sudden changes in the exterior surface of your model. This can be the nose cone to body tube joint (especially if the model is an egg lofter), a rail button, a scale detail, or anything else that's sticking out of the body tube. If the altimeter will be in a separate payload section, I will usually

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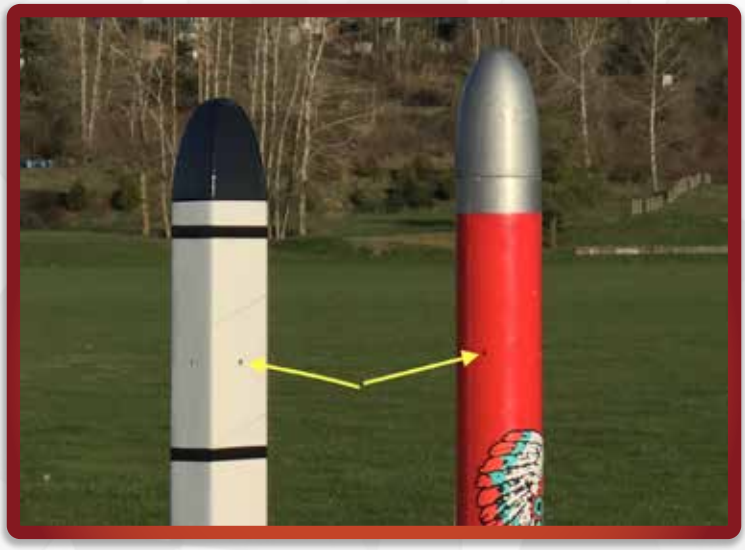

FIGURE 11: ONE OF FOUR STATIC PORTS ON A NEW WAY BIG BESSIE AND AN ESTES BIG BERTHA

put the ports fairly close to the bottom (not in the middle as in those test sections shown in FIGURE 4) to get them as far as practical away from the nose cone/tube joint. When flying the altimeter in with the "laundry" I want to put the ports at least two or three body diameters below the nose cone joint. I generally don't worry about the ports being blocked by the recovery system stuff, as it certainly won't block my typically bigger-than-necessary ports completely.

It is best to make the holes themselves smooth with respect to the outside of the airframe so that they aren't their own sources of turbulence. Pinholes are no problem—the excess tube material is just pushed inside and the outside is pretty smooth. But if you have to use something like a handheld drill (as in a plastic payload section) or a small punch (FIGURE 9) in a paper tube, you want to make sure the edges of the holes are smooth. I usually will flow a little thin CA glue into the edges of the holes, then use some fine sandpaper to smooth the area after it cures.

Also, the holes do not necessarily have to be immediately next to where the altimeter itself is riding, as long as there is a way for air to move inside the model between where the holes are and where the altimeter is. Especially if the altimeter is not in a dedicated compartment, the static ports may well be several inches away from the altimeter.

Having something sticking into the airflow below or beside a static port could also be an issue, but such a thing would have to be pretty close to build up enough turbulence in front of it to affect the static pressure reading. For example, avoiding the launch lug was a driver for where I put the ports in my Estes MAV (FIGURE 12).

FIGURE 12: TWO OF FOUR STATIC PORTS IN AN ESTES MAV

Obviously installing static ports is more easily done while you're building the model than retrofitting after you've done a nice paint job and gotten some flights in. But even if you need to use a tool other than a pin, you can still add them later as long as you support the inside of the tube somehow while making the holes. Supporting the tube for

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Altimeter Venting

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this is easily done by sliding a stage coupler in to where you are going to punch your static ports, then pulling it out (with new dents from your tool in it) after punching the holes.

In building a new model I will often make the top few inches of it into a payload section using a coupler and a ply or fiber disk so that I can fly an altimeter in a separate compartment. It's easier on the altimeter and I get "cleaner" data that way. An example is my two-stage Estes Sterling Silver (FIGURE 13).

FIGURE 13: ONE OF THREE STATIC PORTS IN AN ESTES STERLING SILVER. THIS MODEL HAS THE TOP 2 1/2 INCHES MADE INTO A PAYLOAD SECTION USING AN APOGEE CBD-18 AND COUPLER FOR THE BASE OF THE PAYLOAD SECTION

FIGURE 14 AND 15: STATIC PORTS IN A PAYLOAD ALTITUDE MODEL BASED ON THE APOGEE MIDGE. NOTE THAT THE ALTIMETER FLIES DOWN INSIDE THE TRANSITION, NOT BESIDE THE PINHOLE STATIC PORTS

One more thing before I go: As you can see in the graphs above, the Adrel ALT-BMP and the Altus Metrum MicroPeak track pretty well together when being flown together. It turns out that currently-available altimeters generally give very similar data under similar conditions. This last graph shows the altitude vs. time data for six different altimeters that were flown together in a Semroc Mini-Hustler. Those of you who are NAR Members will see in my article in the 2020-2021 Member Guidebook a figure presenting

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most of these data differently (Figure 7 on page 41 of the Guidebook). Here are the data from those five devices plus an Adrel all overlaid. As you can see, they agree pretty well.

So - if you would like more about how your models perform, get an altimeter or two, and go out and learn something more about your flights. It's not that hard to do and it can be very enlightening as well as lots of fun.

FIGURE 16: ONE OF THREE STATIC PORTS IN AN EGG LOFTER MODEL AND THE PIN USED TO MAKE THEM. HOLES ARE ALSO PUT IN THE BASE OF THE EGG CAPSULE SO THE AIR CAN REACH THE ALTIMETER RIDING THERE

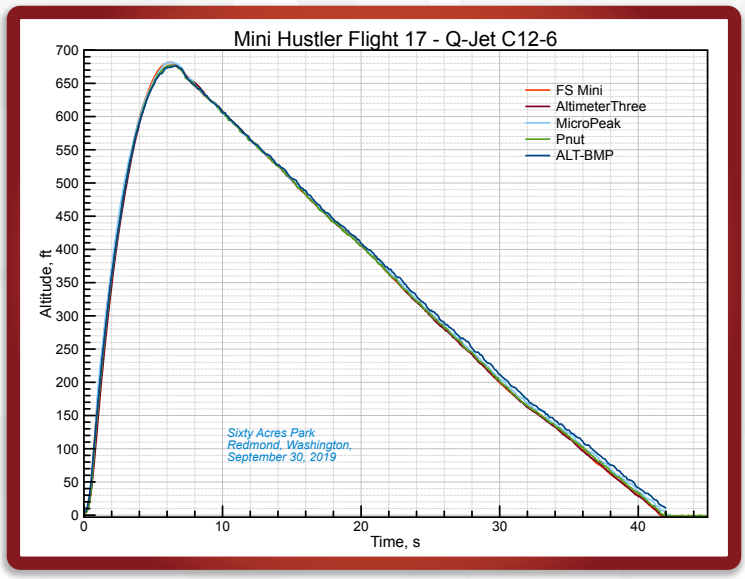

FIGURE 17: SIX ALTIMETERS ON ONE FLIGHT

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About the Author:

Bernard Cawley retired in 2016 after a nearly 38-year long career as a Boeing engineer. He has been an active aeromodeller since grade school, whose focus for many years was electric powered RC airplanes. He enjoys testing and comparing various pieces of equipment for his models and has written a number of in-print and online reviews of speed controls, electric motors, chargers and airplane kits over the years.

He was active in model rocketry while in junior high and high school, including taking a model rocketry-based project all the way to the New Mexico state science fair as a seventh-grader in the spring of 1969. He returned to rocketry in early 2009 after being away since high school and it has pretty much taken over his life, hobby-wise, since.

His interest in testing and comparing with data immediately led him to start flying altimeters in his rockets, beginning by flying devices made for model airplanes as rocket altimeters. Since then he has acquired a ridiculously large collection of rocket altimeters from a number of manufacturers and has done beta testing for several of them. Over the last 11 years has launched hundreds of model rocket flights carrying one or more altimeters, including a series of flights carrying nine of them for a NARAM-61 R&D project comparing static venting approaches.

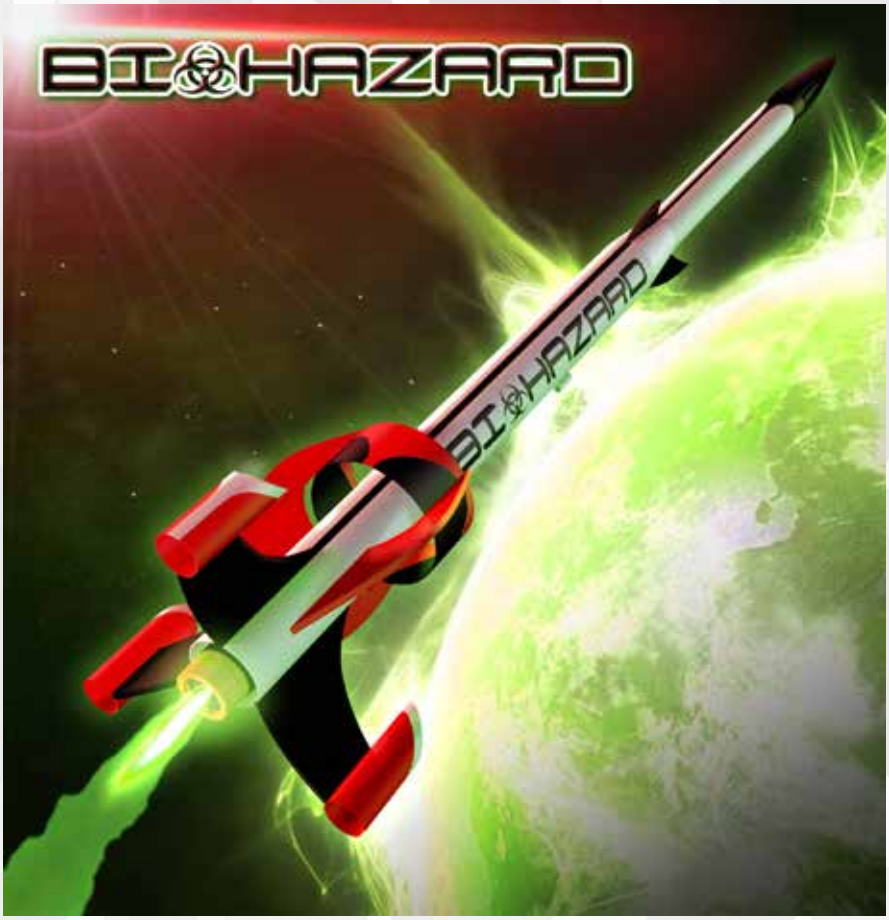
He is an occasional NAR competitor, focusing, not surprisingly, on altitude events. He won B Cluster Altitude at NARAM-56 (his first NARAM), took second in the same event at NARAM-60 and third in E Altitude at NARAM-61.

Biohazard Rocket Plan

Download the ***RockSim*** design file for the Biohazard at:
https://www.apogeerockets.com/Peak-of-Flight-Rocket-Plans

Biohazard Parts List

19999 - (1) PNC-24C Nose Cone
10100 - (1) AT-24 body tube (2-¼" long - 3 pieces)
10100 - (1) AT-24 body tube (12-¾" long)
10131 - (1) 33mm Body Tube (15" long)
10198 - (1) AT-66 Body Tube (BT-80 1-¼" long)
12019 - (1) Motor Mount Kit 24mm/BT-55
12258 - (1) Coupler Bulkhead Disk 33mm (comes with a metal screw eye)
13017 - (1) AC-33 (BT-55) Coupler
44002 - (1) Centering Ring Cardstock (to make customer centering rings from the 24mm tube to fit into the 33mm tube coupler)
30325 - (1) Kevlar Cord 100# X 8 feet
29126 - (1) 18" Plastic Parachute
14095 - (2) 1/8" X 4" X 18" Balsa sheet
(1) Index card paper to make the transition
(1) 3/16" Launch Lug
(1) White decal paper
(1) Clear decal paper



Biohazard *By Neil Weinstock*

About the Design

I had a thread going on The Rocketry Forum where I was exploring designs with rings and tube fins. At one point Chris Mickelson (TRF user "Cabernut") proposed using the Biohazard symbol as design inspiration; I took that and ran with it and this is the result. The process started here: https://www.rocketryforum.com/threads/thinking-about-some-tube-y-and-ring-y-designs.131474/post-1559269. Took me 3 weeks from the original proposal to finished design, much quicker than my usual. This was my second-ever scratch build of a custom design.

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Biohazard Rocket Plan

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Changes from the Original

The design I've submitted here has a few small changes compared to the one I actually built:

Original Build	This submission	Explanation
Balsa transition	Cardstock shroud assembly (template included)	Apogee doesn't sell this transition, or anything similar.
Balsa Nose	Plastic Nose	Changed to a cone sold by Apogee
TTW fins	Surface-mount fins	Too hard to hand-cut, and not necessary. I provided templates for both with and without tabs, just for completeness.
Miter cuts on the pod tubes	Nope, just square	Another extra complication for a design published in this manner, and it can't be represented in Rocksim. As a replacement, I included decal art that is *suggestive* of the miter cut. In my opinion it looks almost as good.
Ring is red with black decals	Ring is solid black	I absolutely could not get the ring texture to display properly in Rocksim (definitely a bug). So I just went with solid black, which also looks good.

Build Notes

- The ring-holder fins are made from two pieces. They might require a bit of sanding to get the ring to fit properly.
- Testing ring fit and getting it inserted straight is a whole lot easier if it is on a piece of BT80 coupler.
- I built mine with 1/8" balsa, so that's what I specified here (in the Rocksim file). Could probably live with 3/32".

Finishing Notes

- Recommended to paint the ring separately (mask off the attachment points) and install it after the rest of the rocket is
  also painted.
- I painted the interior of the pods red, couldn't show that easily in the Rocksim model.
- The curved black parts just below the nose were a pain to do in my build (using masks). Here, I instead included decal art to accomplish the same thing with less effort. Suggested process:
  - Mask and paint the black pinstripes.
  - Apply the curvy decals between them.
- The wraps for the pods should be printed on white decal paper, cut along the indicated lines. I didn't do mine this way but I really wish I had, would have been way easier.

This picture shows a close up of the tail end of mine, showing the slight differences in the pod tubes and the ring décor from the submitted design.

Flight Notes

I believe Rocksim is being overly pessimistic about drag in the biohazard_flight.rkt file. Although I didn't fly it with an altimeter, my uncalibrated eyeballs suggest much higher apogee than Rocksim is predicting, and longer optimal delays. I've successfully flown C11-5 and D12-5. Your mileage may vary.

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Biohazard Rocket Plan

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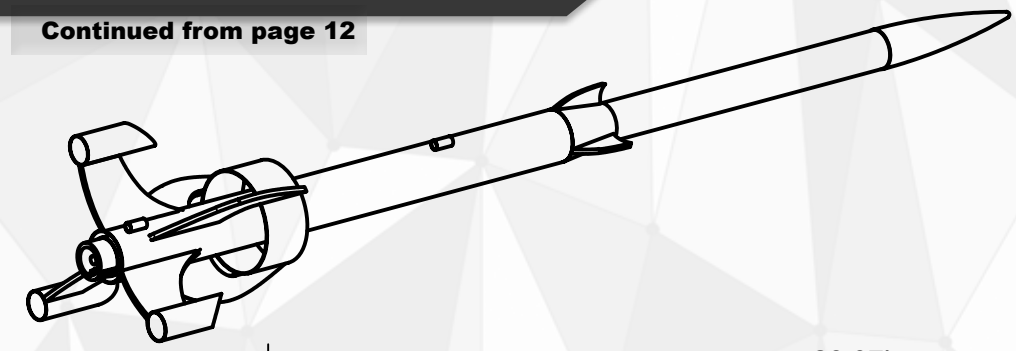

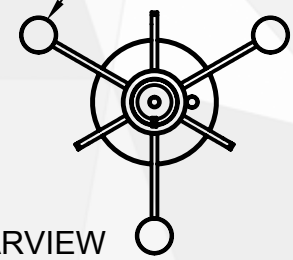

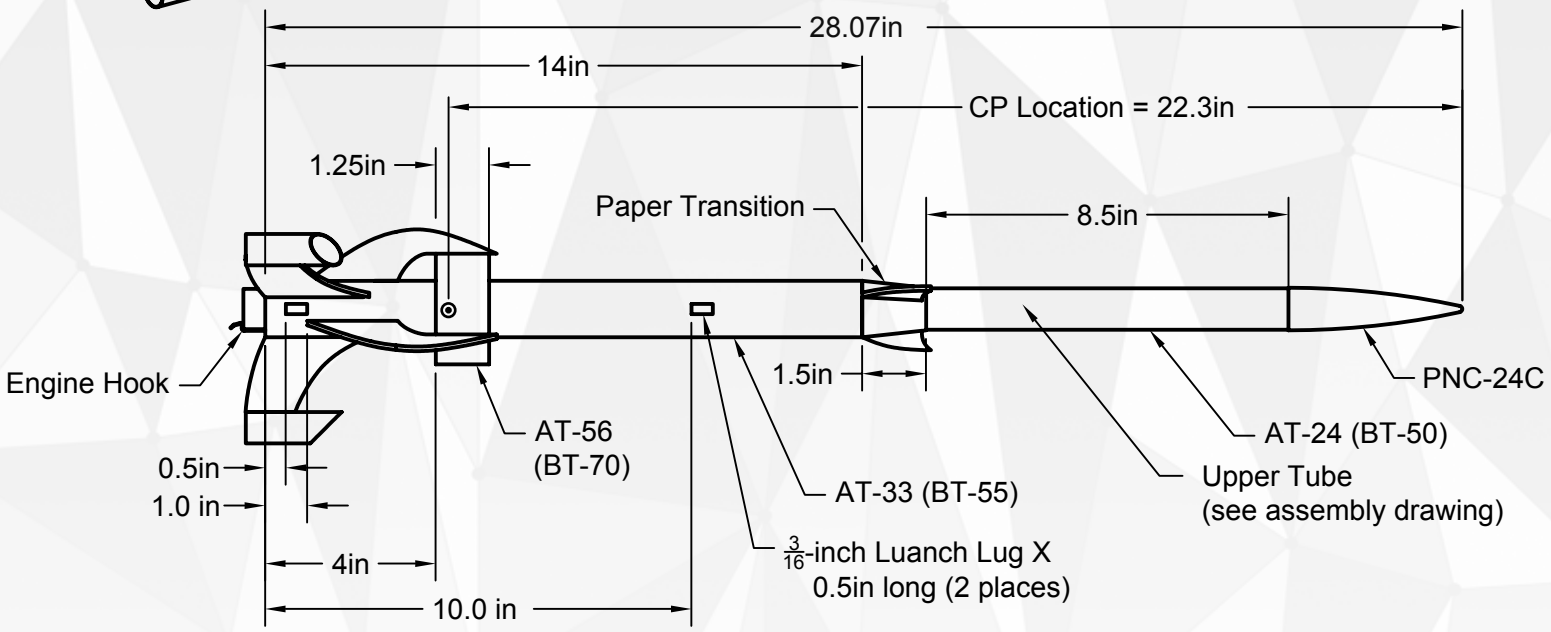

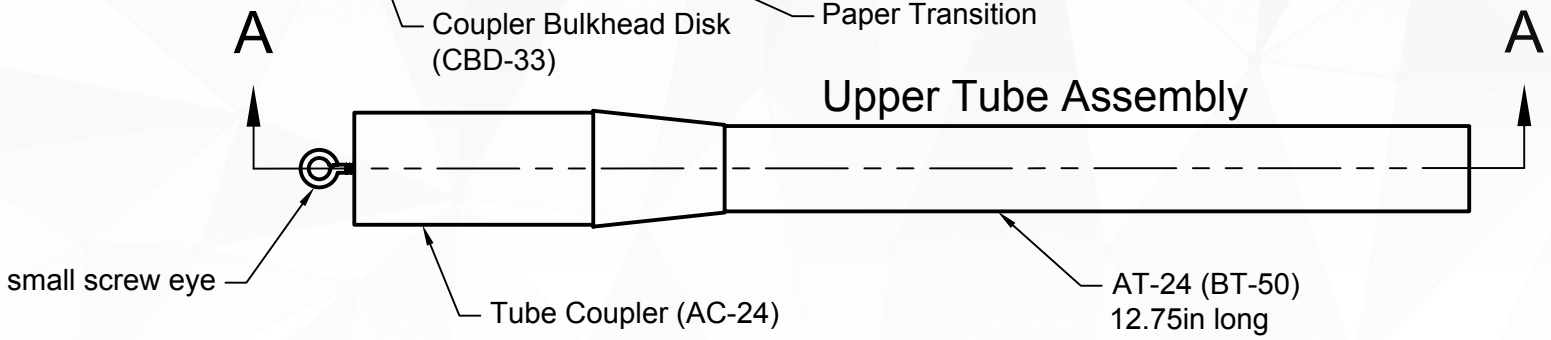

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Biohazard Rocket Plan

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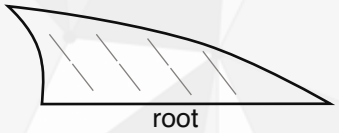
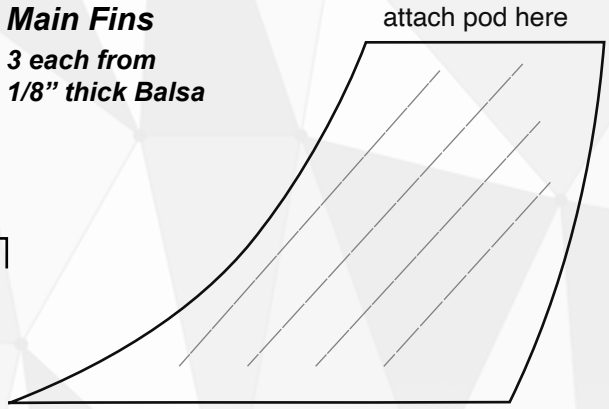
Canard
3 each from
1/8" thick Balsa

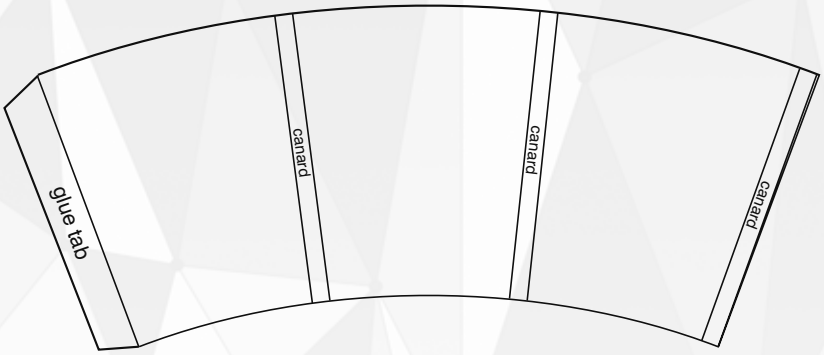


Main Fins
3 each from
1/8" thick Balsa

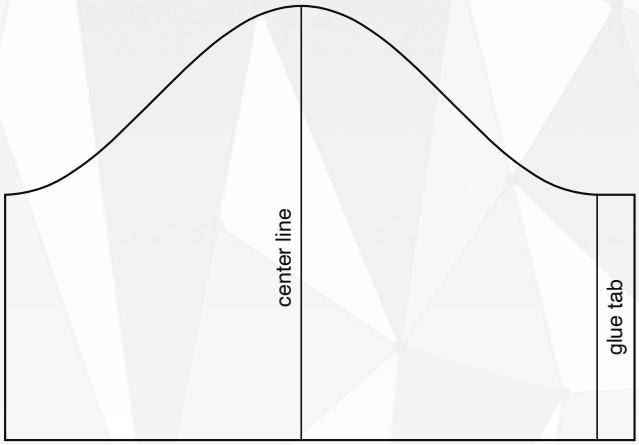


1 INCH

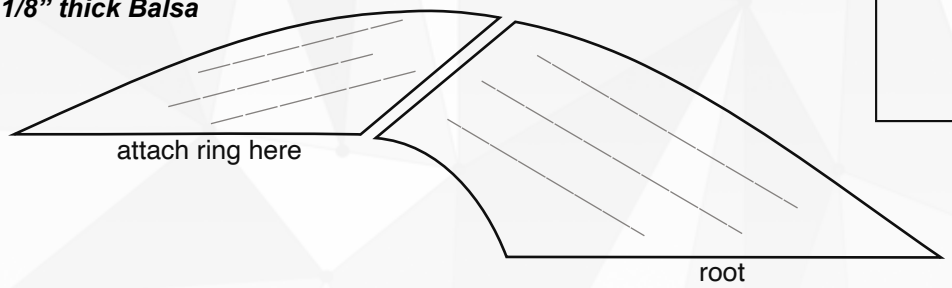
Paper Transition



Angle-Cut Guide



Ring-Holder Fins (2 pieces)
3 each from
1/8" thick Balsa



Continued on page 15

Electronics Hardware Installation Kit

Think of the convenience of getting everything to professionally install your dual-deployment or other electronic payload into a e-bay of your rocket!

Includes: nylon standoffs, screws & nuts, wire, push-switch, drill & tap, ejection charge cannisters, barrier strips, wire ties, and step-by-step DVD instructions.

https://www.apogeerockets.com/Electronics_Payloads/Electronics_Accessories/Electronics_Mounting_Kit

Biohazard Rocket Plan

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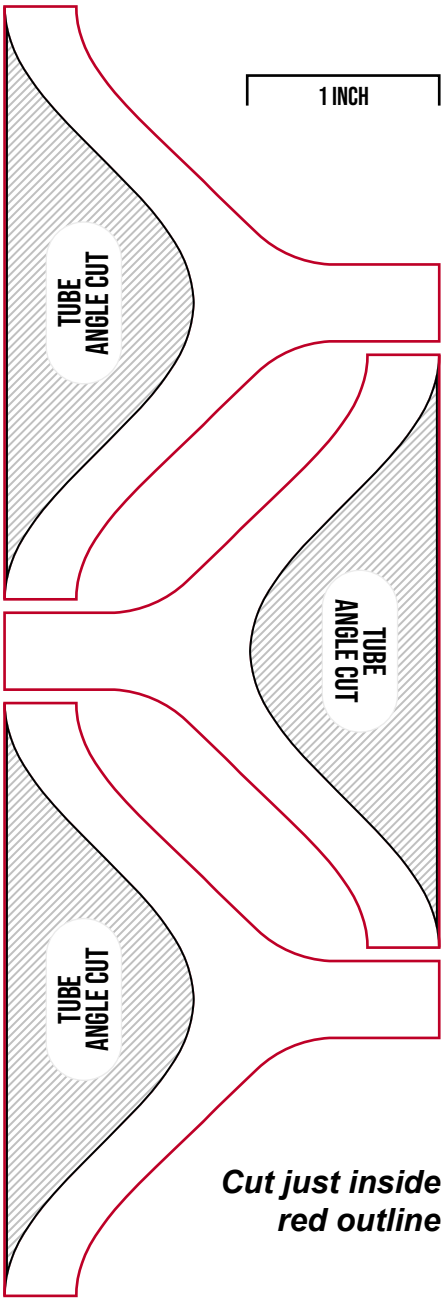
PRINT ON WHITE

Outer Tubes Decals



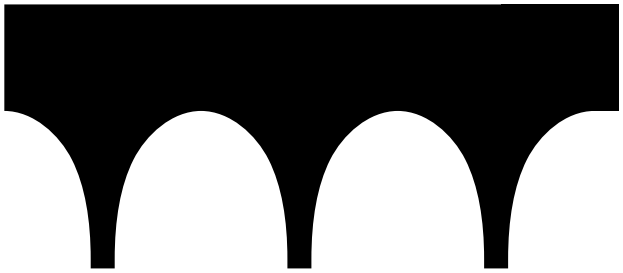
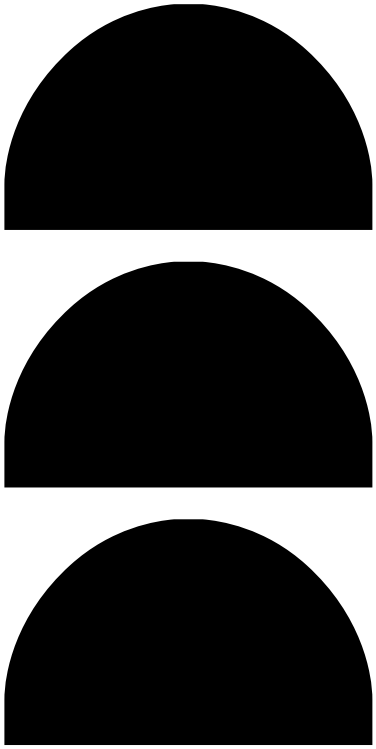
Cut just inside red outline

Biohazard Decal 7.25"x 0.6"

PRINT ON CLEAR

1 INCH

Top Tube Decal 3.2"x 1.375"



Middle Tube Decals