PEAK OF FLIGHT NEWSLETTER

Issue 609 / September 26th 2023

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Development of the Draco BG Boost Glider

By Martin Jay McKee

With the release of the Draco BG and my having been in the position of product designer here at Apogee for roughly a year, we thought that an article reviewing the development process of the Draco BG might be an interesting exploration. For myself, it is interesting because the development process of this particular kit has taken a majority of the time I have been at Apogee – the idea having its genesis only shortly after I started. Also, because the Draco BG is a complicated product in many ways, the story of its development is more interesting than it might be for many of our other products. The Draco BG must fly as both a glider and a rocket – there are two different flight modes that it needs to excel in. Moreover, since it's always important for us to capitalize on our investments, the Draco was developed to take advantage of our soon to be released (at the time of development) BT-60 nose cone (https://www.apogeerockets.com/Building-Supplies/Nose-Cones/Low-Mid-Power-Nose-Cones/PNC-41-6-BT-60-and-BT-60-to-BT-55-Transition) and transition. The use of this particular part constrained our design choices and since the Draco was based on a scale prototype, it was important to keep as much of the "feel" of the motivating design as possible.

Throughout this article I explore the many steps (and missteps) in the development of the kit and hopefully give a bit of a view into the sorts of challenges and processes that we use to create the products that make Apogee so unique. We're not afraid to attempt a difficult design if we think it's going to be good for our customers, but no matter how many times we may stumble getting it to work, the final goal is to create a product that makes it possible for our customers to be successful without all the missteps we made.

Idea and Conceptual Design

The Draco BG came about as the result of a customer recommendation. In the fall of 2022, it was suggested that we should build a model of the GLSDB (Ground-Launched Small-Diameter Bomb). This is a precision ordnance that combines the winged GBU-39 Small Diameter Bomb (developed by Boeing) with an M26 rocket booster. The appeal of the design, so far as a kit was concerned, was the wings that unfold for

This image of the GLSDB in glide configuration shows both the unique wing configuration as well as giving a good idea of the actual size of the ordinance. (Tom Gannam/AP)

controlled gliding flight. There was little question that this could make a cool model. Cool though it may be, however, it was unclear if such a design were even feasible. And so, the first goal was to check just that.

The first prototype of the design which became the Draco BG was a "chuck glider" with balsa wings, a standard tube, and a 3D printed nose cone (because even our prototype PNC-41.6 nose cones had not arrived yet). The glider had a 24mm motor mount installed because the initial idea had been to create a rocket glider from the general GLSDB arrangement. The whole point of the glider was to see if it was possible to achieve a reasonable glide at the wing load the glider would have to fly at. Tossing in a spent motor casing and clay in the nose for balance, a smooth – surprisingly gentle – glide was easily achieved. That's all that was required to demonstrate that the wing area was going to be sufficient for usable glide performance so long as the weight of the chuck glider could be maintained. Of course, it was also important to note that the weight of the completed glider (125 g, 4.4 oz) was comfortably within the weight range that 24mm Estes motors could lift. The next problem was making the wings fold.

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The original glider built to test the feasibility of the kit returning as a glider was nearly the exact same weight as later versions of the design but was unpainted and had smaller wings. As a result, the final version very easily glides as well despite the wing deployment mechanism.

Once it was clear that making a glider was at least feasible, an additional feasibility study was completed for the wing folding mechanism. Much more design work was required for the folding study than for the first chuck glider as it was necessary to accurately design the entire mechanism. The chuck glider had been designed around the basic outline of the wings and had been completed with scratch building using TLAR (that-looks-about-right) design practices. For the feasibility test of the folding mechanism, a full 3D model was constructed in Fusion 360.

We build the designs in CAD for several reasons. First, it simplifies later creation of laser cut files. Given the general usefulness of laser cutting to so many of the things that we do here at Apogee, that alone would be a sufficient reason to build a 3D model. There are more advantages however. Rather than hand drawing all of the illustrations in our instructions, we can use a model to render the images that are more detailed and accurate in a shorter amount of time – saving money and making it possible to release more kits faster. Finally, building a model using a parametric 3D modeling application such as Fusion 360 makes it much easier to change the design later (as proved to be very useful with the Draco BG!). Parametric 3D modeling is a little like programming (is my computer science training coming out?) as it makes it possible to define variables (such as length, or thickness) and use those variables to define dimensions either directly or as part of formulas. Then, simply changing the value of a single variable can completely change the design of a whole mechanism.

In the rush to release a dozen rockets in 2023 however, the folding study did not follow immediately after the initial glider study. There were a number of other projects that were being developed in the interim including the Quick Draw (https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/Quick-Draw) and the Antares Explorer (https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-3-Model-Rocket-Kits/Antares-Explorer). The time for the design to stew in my subconscious was helpful (as is often the case with unclear solutions) and led to the first major design change (even before a flying prototype had been completed) from a rocket glider with the engine remaining on the glider to a boost glider that had a booster which recovered separately. While the resultant weight reduction of the glider would be advantageous, the primary reason for the change was that it greatly simplified the wing lock mechanism. So, when the mechanism was initially created for the folding study, the wings were already sporting the tip locking tubes that made it to the final version. Indeed, the feasibility study is very near to the final version in basic layout. The frame, however, was built almost entirely out of 1/8" plywood as that was one of the least expensive options with the correct material properties. The folding action was lovely… almost perfect, really. And the wing frame weighed as much as a brick. Or,

Built almost entirely of 1/8" plywood, the initial model of the wing folding mechanism was kinematically almost identical to the final version but weighs over twice as much.

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at least, it felt like it did. Just the frame was 60g, 2.1 oz. For comparison, that is a full half of the original chuck glider's weight, and it would have increased the weight almost by that full amount as the chuck glider simply used a rough shape out of balsa wood for the frame. As a result, the first round of weight reduction began – even as the first prototype was being created.

Version 1 Flying Model

The first prototype followed shortly after the folding study because there was very little that needed to be done except for some basic weight reduction and finalizing of the booster design and the shape of the vertical and horizontal stabilizers on the glider. The first prototype used 1/16" plywood and balsa in place of much of the 1/8" ply frame of the study model, resulting in a frame of approximately half the weight (35g, 1.2 oz). All the flying surfaces (booster fins, glider wings and glider stabilizers) were of 1/8" balsa and the interstage system consisted of the piston and three alignment pins (two of which are the wing locking pins). The paint scheme of the first flying model was just a quick test of colors that we had lying around in the shop. It's actually surprisingly similar to the final design, though that is mostly because we were focused on keeping the design language somewhat militaristic as an homage to the GLSDB the rocket was based on.

After what was a fairly rushed week of building, we launched the first version of the Draco BG at a club launch (SCORE, in Pueblo, Colorado, which is where we test most of our products in development). The boost was solid but had a bit more weathercocking than would have been ideal. Nevertheless, after the delay charge, the booster and glider separated, the wings extended, and the glider did a slow arching half-loop (a Split S in aerobatics nomenclature) to get into an upright solid glide. It took its time and for the entire transition – everyone was concerned – but the glider pulled out into a flat (but rather fast!) glide. The booster had simultaneously deployed its parachute and was floating down to a safe recovery while the glider headed back

The first model was fully painted to ensure that flight testing was done at the final weight. This model looks surprisingly similar to the final – released – version.

toward the launch area and straight toward the crowd! No one got hurt – though there were some who had to jump out of the way – but the glider "landed" by flying directly into the railcar that acts as storage at the Hudson Ranch launch site. Needless to say, there was some damage. Two of the wings broke (both the main wing and stay wing on the right side) and the left horizontal stabilizer was broken off. But none of the damage was the result of a failure in flight. The flight was a total success.

Given the success of the first flight of the first prototype, one might wonder why there were three further versions during development. As we'll see, there are a number of reasons for this. While it won't be particularly discussed further, one of the reasons is that a single successful flight of such a complicated design is simply not enough for me to feel a design has been completely tested. Certainly for a standard 3FNC rocket, loading it up with a motor that will make it the least stable and most stressed and letting

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it rip could be considered sufficient testing. The fact is, the design of such basic rockets has been so thoroughly scrutinized over the past sixty years that the combination of personal experience and an accurate RockSim simulation is generally enough to trust a design. Some of our recent designs are different. The TTV (https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/TTV) was a design that had some interesting stability challenges due to its unusual weight distribution. Similarly, due to its unusual arrangement of aerodynamic surfaces, simulation of the Draco BG was anything but simple and personal experience was no help whatsoever. As such, the flight program was initially expected to extend to several flights simply to cover for the many unknowns that are inherent in any non-standard design.

The first test flight did highlight one important change however, and that is weight reduction. The fact that the Draco turned back toward the crowd has nothing to do with any issues in the design. The very high glide speed, however, certainly was a result of the design. Specifically, it comes down to the relationship between the wing area and total weight. Prior to flying a prototype, it was somewhat unclear where the structure might be under or over designed. Having built and flown the design though, it was much easier to make decisions as to what areas could be reduced in size to save weight. It's obvious that a light rocket can fly on a smaller motor and will (typically) go higher with the same motor. So it is valuable for any rocket to be light. It's much more important for a plane to be light, however. And the reason all comes down to a single equation – the lift equation: $L = W = ½\ \rho v^2 S C_l$. As much fun as digging into the theory of aircraft design might be, there are really only a few things about the equation that concern this story. First, in an established stable glide, the lift (L) is equal to the weight (W) of the plane. Second, there are two important relationships that the equation informs us of. The equation tells us that the speed of the glide (V) is proportional to the weight (a heavier glider will fly faster, given the same wing) and that the speed is inversely proportional to the wing area (a larger wing will fly slower, given the same weight). The ratio between weight and wing area (W/S) is called wing loading. Taking the two relationships together, a plane with a lower wing loading will fly more slowly than one with a

The version 1 rocket complete with booster and wings locked back, ready for launch."

high wing loading. And, given the rapidity with which people had to exit the glider's flight path at the conclusion of its first flight, it made sense to decrease its glide speed as much as possible. This could be done a number of ways, but the simplest are either to reduce the weight of the glider or increase the total wing area.

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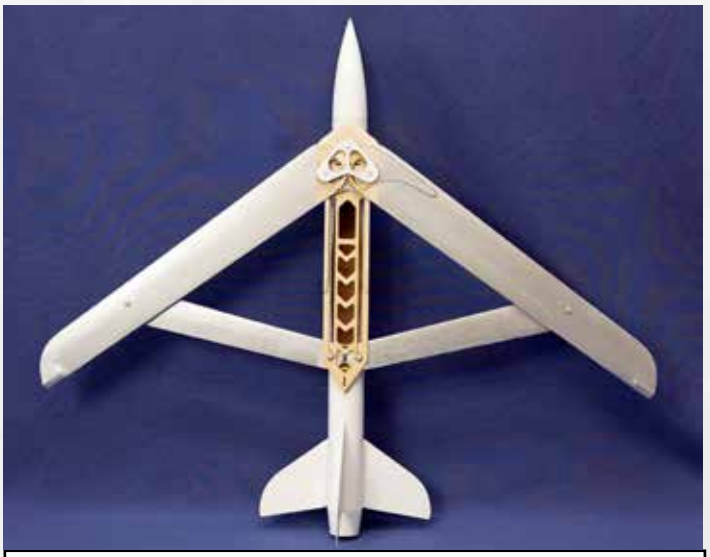
Version 2 Flying Model

To achieve a more docile flight, the goal was made to reduce the weight of the glider by 15% – a substantial decrease given that many of the heaviest components including the tube, nose cone, and paint could not be made significantly lighter. Between judicious use of thinner wood in some parts combined with decreasing the actual size of parts and adding lightening holes, it was possible to decrease the predicted weight by almost 12%. At the same time, the wing layout was slightly tweaked to decrease the need for nose weight (when trimming the glider) and the wing area was increased by about 6%. As a result, the wing loading decreased by a larger percentage than it would have from simply the targeted weight reduction. An ace in the pocket option was to suggest leaving the glider unpainted which would save around 20 g, 0.7 oz. (a further 13%) from the glider.



While both a painted and unpainted example of the version 2 design were built, only the painted model flew under rocket power as it demonstrated excellent glide characteristics. The unpainted model was used for comparison as a chuck glider and for determining the weight difference that paint made.

One thing that is interesting about the changes for the version 2 model is that it really requires careful observation of the designs to identify the changes. These were not large changes to the design. It was the addition of lightening holes in many places and reducing the width of the wing frame. The wings were changed in a number of ways (sweep, span, and cord measurements all changed), but from a distance they look identical.

At the same time that these changes were made, a number of changes were made to improve the experience of assembling the glider by making assembly simpler and more accurate. Small features such as tabs and slots were added to ensure alignment during assembly. And the fit of parts was adjusted to make more sense. In fact, the entire assembly procedure for the wing frame was rethought with the addition of small alignment frames to ensure that the model could be built accurately with ease.

As mentioned above, another concern that we had after the first test flight was excessive weathercocking. Any amount of non-vertical flight can cause issues, but there are three particular problems that are especially troubling with a glider. First, a non-vertical flight can lead to wing deployment at high speeds if it happens when the rocket is already traveling generally horizontal. The two vastly different regimes of flight – boost and glide – put substantially different stresses on the craft and given the necessity for weight reduction described before, it simply isn't reasonable to design a glider with wings that are strong enough to handle the full force of boost while chasing the absolutely lightest design. The second issue that a non-vertical flight can lead to is insufficient time for the glider to enter a stable glide. There is a period of transition between the boost phase and glide where the glider is not actually flying. At best it is traveling ballistically through the air like any other rocket during the coast phase of flight. If the glider is too close to the ground when the wings open, the result will be a crash. Finally, a non-vertical flight path can increase the possibility of a fly-away of the glider

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as it will enter the glide already more distant from the launch site. As such, two flight models of the Version 2 booster were built. One version included spin tabs and the other was without spin tabs. This was done to test the effect of spin stabilizing the rocket during boost on weathercocking. Similarly, two flight models of the glider were built – painted and unpainted – to test the effects of weight on the glide.

The first flight test of Version 2 took place at the 2023 NSL West (National Sport Launch West) in Alamosa, Colorado. The Draco flew on the second day as the first day had been so windy as to halt the launch and any level of wind can be difficult for gliders. Generally, I would prefer to not to do too many test flights at a major launch as it is generally a stressful situation to begin with, but NSL saw testing of not only the Draco prototypes but a prototype of the TTV as well. We flew the Draco only once (as the wind came back about mid-morning the second day) and flew the painted version with the spin-stabilized booster. The launch triggered oohs and aahs from the crowd as the combination of the spin tabs with the asymmetrical glider caused a tight spiral rather than a simple spin around the rocket's axis. The Draco looked rather like an over-caffeinated Tasmanian Devil as it climbed – arrow straight – toward apogee. While the spin stabilization had avoided weathercocking, it seemed clear that the angle of the tabs – at least – was too large.

Just as the rocket approached apogee, the ejection charge blew and the rocket separated and deployed the wings, perfectly. Less perfect, however, was my trimming of the glide, and the rocket ended up in a slightly too tight right turn. The glider inspired substantial adulation too as it soared overhead. As it neared the ground however, it became clear that damage was likely. The Draco glider hit the ground in a fairly steep bank and tumbled as it hit. The result looked very similar to the first flight with the previous version with the two wings on the starboard side broken. Despite the damage however, the flight had been quite successful and given that the SLVROC (NAR #774) launch site that NSL took place at is at 7600' above sea level, the weight reduction had certainly been effective in slowing the glide. Even up at that altitude (about 1800' higher than SCORE) the glide was much nicer. The Draco still glided at a high speed compared to many boost gliders, but it was slow enough that were it correctly trimmed, the glider would have easily been recovered with no damage.

It makes sense to pause for a moment to consider how the glider had been flown with the trim less than ideal. As a child, I was interested in flying aircraft before I ever became interested in rockets. I have been trimming airplanes for more years than I care to remember. I know how to do it. So how did I manage to fly a simple glider without managing to trim it properly? Simple. I was rushed. Just as happened with the Version 1 prototype, the Version 2 prototypes were completed the days just before the launch at NSL. The same was the TTV prototype that flew there as well. This happens often as there are only a couple of launches a month that are easy to travel to. As a result, I make an effort to force all the development testing into those biweekly windows. Sometimes – as was the case with the TTV development – we were running out of time to hit our target and that was going to push the Draco development later. So I pushed to get both of them done for NSL, since I was going to be there anyway. Between poor weather in Colorado Springs during the days before the launch, the rush of getting there, and the threat of major winds, I simply wasn't able to spend the time that was necessary to trim the glider as it should have been.

Nevertheless, the improper glide could be seen as a blessing in disguise. Indeed, the fact that the glider broke in the same manner despite two very different collisions demonstrated an intrinsic weakness in the design that was worth fixing in a subsequent version. So, that ensured a version 3. All that would need to be done with the V3 design was to increase strength at the root of the main wings and of the stay wings, and clean up any remaining design features that made building the rocket more difficult.

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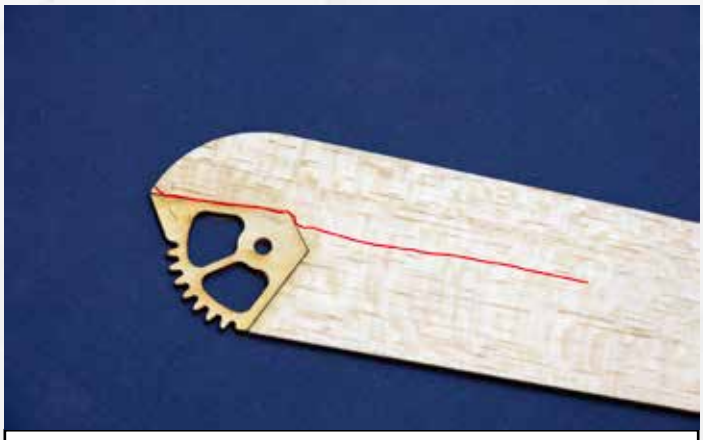
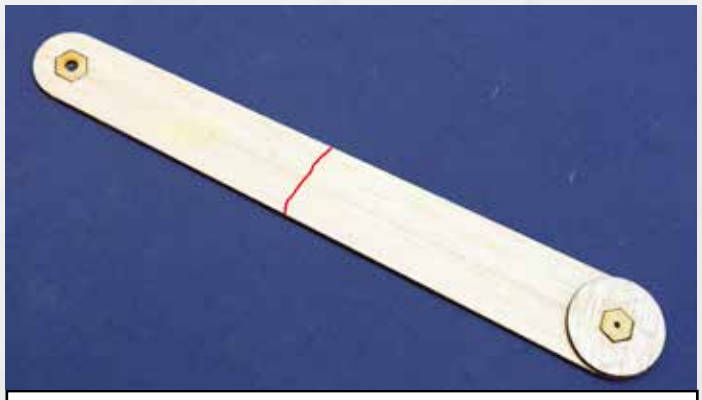
Version 3 Flying Model

With the changes required to make the glider more robust, the weight was guaranteed to increase again, but it was deemed more important to ensure reliable flights than to maximize glide performance in what was already not a competition glider. As mentioned above, the damage to both versions of the glider was almost identical. The main wing split beginning at the joint between the root pivot and the balsa wing, then continued down the grain of the balsa. As it did so, the wing applied pressure to the stay wing which promptly broke clean across the whole wing. As the changes were being made to improve strength, we also wanted to take another pass and make building even easier, so there were many tiny changes (as small as adding engraved markings) to the parts that happened in version 3.



Damage to the main wing consistently proceeded from the root joint (at left in this image), along the joint, and then down the grain of the balsa wood.



The stay wings broke perpendicular to the grain by being compressed when the main wing impacted an object during flight. As a result, a stronger material was needed to reduce the probability of damage.

After tossing around several ideas for reinforcing the stay wings, the decision was made to ensure the stay wings were no longer a weak point and simply add a plywood spar along the length of the wing, using the inner end of the spar as the root pivot point. This was the first change that felt like possible engineering overkill in the Draco development as the added weight of the plywood spar was substantial and the added strength was only useful in the event of a crash. Nevertheless, after making the change, the spar wings have never broken again, so the goal of removing them as a weak link was achieved.

The plywood spar covers the entire length of the stay wing and provides a much more durable core to the wing without adding significant extra weight.

The damage on the main wing was always a result of a fracture that started at the glue joint between the plywood pivot and the balsa wing itself. As a result, the solution was to strengthen the joint itself. The simplest way to do that was to add a 1/16” plywood piece that was glued across the joint. Once again, this led to a greater increase in weight than I would have liked, but it has proven to be an extremely robust solution and has completely solved the earlier weakness of the system. In addition to increased weight, the added stiffener piece resulted in an increase in the wing thickness which necessitated the use of taller nylon spacers for the wing pivots. Luckily, the design already used the longer spacers on the sliding mechanism, so the change did not require the addition of yet another part. Rather it just changed the quantities of different parts that were required.

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The main wing stiffener bridges the joint between the plywood pivot and the balsa main wing, reducing the possibility of a split happening at the glue joint.

The weight increase from the changes were less than feared but far from inconsequential. It was necessary to do another couple of test flights just to check that the glide was not negatively affected. The first of these flights was absolutely beautiful. The boost was straight up, deployment of the wings was swift and there was a smooth transition into a flat glide with a gentle right-hand turn. The glider landed a bit further away than would have been ideal (it was a bit of a walk!) but there was no damage and the overall flight was just as we would have hoped. It seemed that we were narrowing in on a final version. Of course, narrative foreshadowing being what it is, we were in for a surprise.

Since we also wanted to back out the Cd (coefficient of drag) of the Draco BG rocket we planned to conduct another test flight at SCORE with the addition of an altimeter. The plan was to fly the rocket and using its known weight and engine, to use the method outlined in an article in Peak of Flight #303 (https://www.apogeerockets.com/education/downloads/Newsletter303.pdf) to determine the coefficient of drag. Things did not go to plan. Not even remotely. I know I'm supposed to look forward to learning opportunities… but I still hate those days. After many successful flight tests it is easy to become complacent about potential failures and I had only been concerned about the continuous moderate winds blowing the glider into the large number of people that the launch had provided. Instead, the rocket cleared the launch rod, arched back slightly toward the crowd and promptly went unstable. In analyzing the videos and launch photos of the flight, it became clear what had happened. The interstage solution that I had settled on was just a bit too flexible. But, that was not all. After a complete reanalysis of the design's

Shown is the final version of the glider (version 4). The only visible difference from version 3, however, is the vanes on the boat tail. The number of changes in the final version of the glider were minimal.

stability it became clear that even with the already large boost fins, the rocket was only marginally stable if wind hit it within about 10 degrees of square to the plane of the wings. Further off than that, it was fine. But, of course, the wind at the launch was hitting the rocket almost perfectly broadside with the wings. This marginal stability combined with the flexibility in the interstage caused the glider (and thus the wings) to tilt slightly away from vertical, generate lift, and cause result in an arching path up to the point where a gust of wind changed the angle of attack for the rocket enough for it to become unstable. So, a version 4 was in order to both increase stability and reduce the flexibility in the interstage.

Version 4 Flying Model

Rather than the more general modifications that needed to be made on earlier versions – either to improve the building experience or to cut weight, the revisions for the fourth flying version of the Draco were very specifically targeted to avoid the potential for instability under a worst case scenario. The video analysis had identified two main causes of instability and the goal was to fix both of those in the redesign. The first was the fact that the interstage coupling was slightly flexible and the second was that the booster fins were slightly too small. The simplest problem to solve was certainly the booster fin size. Rather than a uniform upscale of the fins, however, I decided to switch from a booster layout with three fins to one with four and to have two different sets of fins that were separately designed to be large enough for the side and top profiles of the rocket. This not only took care of the stability issues in the plane of the wings but also avoided extreme weathercocking with other wind directions.

Stiffening the interstage was a more difficult problem as the glider needed to slide smoothly out of the booster at apogee to deploy the wings and glide back safely. Simply making the interstage tighter could easily risk the glider getting stuck, resulting in a crash of the whole rocket. Also, it is always important for us to design our rockets so that a minimum of "special knowledge" is required to make them fly successfully. Getting the "correct" fit can be difficult when it is a question of how tight two parts fit together. Certainly, it is possible to describe how easily two parts should slide apart, but such descriptions will often be open to interpretation. The ideal solution would be one that – even if built looser than the prototype – would work effectively. As such, the design needed to be changed in a fairly fundamental way as the inner and outer surface of the boat tail had – to this point – been used to provide alignment. The problem with this came mostly from the inner diameter of the boat tail being variable as a result of both the thickness variations inherent in the blow-molding process as well as the variations that result from cutting the shoulder off by hand. One option was to use the external diameter of the boat tail as the reference both

A ring was added as an initial attempt to improve the alignment ability of the piston and is visible in the piston on the right. While this resulted in an easy design to build, it suffered from lack of flexibility and difficulty with adjustability.

fore and aft. This was tested first as it would mean a minimal change to the design. The booster piston was modified with a ring that worked to center the aft end of the boat tail while the forward end of the piston continued to center the forward end of the boat tail. This solution worked to stiffen the coupling, but it was difficult to prep and surprisingly difficult to build. Just a single coat of paint changed the fit enough that it could be considered too tight, and at that point it would be difficult to change the piston assembly to get a correct fit. As such a different solution would be needed.

The solution that materialized was actually very similar to my original vision of the interstage and it used four vanes glued onto the boat tail to provide a flat sliding surface against the inside of the piston tube. Unlike my original design, I extended the vanes back through the piston disk to provide a longer parallel surface. This had two advantages. First, the longer vanes allow for a looser fit while still constraining the bending of the interstage. Secondly, the extremely small triangular-shaped vanes I was originally envisioning were physically difficult to work with. They were too small to hold in position without gluing oneself to the model. By extending the vanes beyond the aft end of the boat tail, assembly became much easier simply because the parts were easier to hold.

Once a new version 4 booster was built and the version 3 glider had been modified with

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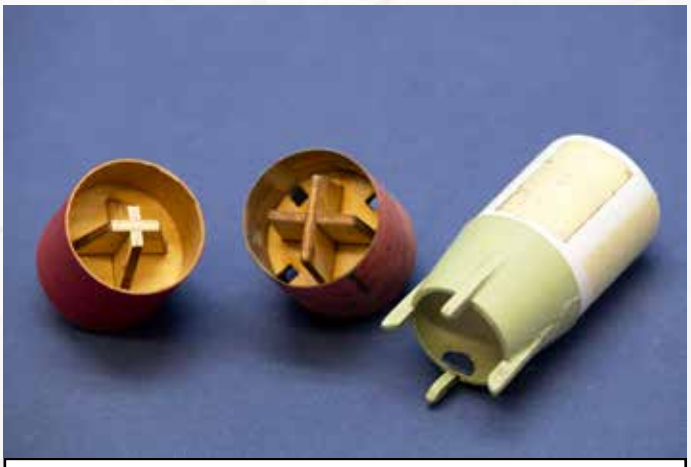

The final solution for interstage rigidity was to add plywood vanes to the boat tail (seen far right), that slide on the interior of the piston tube. The resulting piston is shown in the middle compared with an early version.

the changes (including the addition of a launch lug), we were ready to test fly once again. The initial flights were completed with an Adrel altimeter (https://www.apogeerockets.com/Electronics-Payloads/Altimeters/Adrel-Altimeter) onboard so that we could back out the coefficient of drag from the flights. This new version flew twice with the altimeter onboard and despite not being perfectly trimmed (following the addition of the altimeter), it flew well and survived the day, despite moderate winds. On subsequent flights both alone and with the addition of cameras, the version 4 glider and booster have flown reliably and successfully. After four major versions (and many smaller revisions) we finally achieved a finished product. But the development process was far from complete.

The Naming Saga

Throughout the course of this article, I have been referring to the product as the Draco, or Draco BG (the full name). The naming of this rocket, however, was a challenge in itself. Through most of the development, we referred to the project as either the GLSDB (as an initialism) or simply "the glider". Over the course of development, we spoke many times in meetings about the need for a name, and we ended up leaving – time and time again – empty handed. I'm not sure what was so difficult about coming up with a name for this particular rocket, but it certainly left us scratching our heads.

On the one hand, we wanted to reference the original product by using GLSDB in the name, but

The final version of the Draco BG, fully decorated and stacked in launch configuration.

we wished to avoid the use of the word "bomb" (for possibly obvious reasons), and it was clear that – as an acronym – GLSDB left quite a bit to be desired in terms of being pronounceable. It was also easy, and quite typical, for all of us to mis-remember the exact initialism. So that particular approach to finding a name never seemed fruitful.

Another thought, as we began to see a Ukrainian connection, was to use a Ukrainian word as the name. We did have fun searching out different names and found a few that we liked, but the fact was that they ran into similar issues of being difficult to pronounce, read (if we had

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used Cyrillic), and understand. No matter how exciting the meaning of a name may be, if it doesn't roll off the tongue and mean something to a customer, it's not much of a name. So Ukrainian names failed to make the cut as well.

Finally it was decided to reach out to the – eponymous – "internet" (or rather to "social media") and run a naming contest. The result was a couple of weeks of our highest engagement across social media platforms. There were hundreds of name suggestions (with dozens of duplicates), and it was quite a challenge first organizing those suggestions and finally coming to a decision about the winner. In the end, the winning entry was only slightly massaged into the final "Draco BG".

Product Release

Having a functional product and a name, the work of producing and releasing the kit could be completed. Some of the steps are fairly straightforward. For instance, we need pictures for the web page, and those had been collected over the course of the test flights. Other steps, by contrast, require substantial additional investment – such as the instructions. Indeed, it took close to two months from the time that we had successfully tested the final flying version before the Draco could be released.

The first, and largest, project required for release was to create the instruction booklet. Between the complexity of the build and the importance of trimming the glider for flight, the instructions for the Draco BG were anything but negligible. While we always try to make our instructions of industry-leading quality, it was obvious that we needed to ensure that the instructions were as complete and understandable as possible. Looking at the instructions from a purely numeric perspective, we generated over 170 individual renders of the construction process, which were combined into nearly 100 steps spread out over 24 pages with around 8000 words of text. Each render, image, and description needed to be both created and checked (by multiple people), to ensure that it was as clear as we could make it. Understandably, this process took some time – many weeks, in fact.

In addition to the instructions, it is important for us to generate production files that allow us to manufacture our kits efficiently and consistently. Having the ability to laser cut inhouse provides the ability to do rapid prototyping of ideas as well as to quickly replenish stock of items. However, inefficient laser cutting files can cause our production efforts to grind to a halt. The Draco BG, requiring a substantial number of complicated laser cut parts, had the potential to have a major negative impact on our ability to produce other kits and components, so a full week was devoted to optimizing the production files both to minimize the potential for waste and maximize the rate that parts could be produced.

Finally, like all our other kits, it was important to build a web page that provides our customers with complete information about the features, benefits, components, and struggles of the kit. Given the unique nature of the Draco BG both within the population of standard model rocket kits and given some fairly atypical construction features, the web page was quite a project in itself. Between photographing all the many parts, producing animations, producing videos, and writing up the copy, there is likely a full week's worth in the web page alone.

Retrospective of the Process

Spanning very nearly a full year, the development of the Draco BG has been an eye opening process for me. It is a particularly complex and involved kit, and it presented several interesting challenges throughout the process. It is my hope that this article has given the reader an interesting glimpse in our development process here at Apogee. The path from the suggestion of a customer to the release of a highly refined kit was a circuitous though far from surprising route. Indeed, in some ways what is most surprising to me – in hindsight – is how few major upsets there were along the way. This general consistency can easily be seen with all the flight models together as it takes a careful eye to identify the specific changes in structure as development

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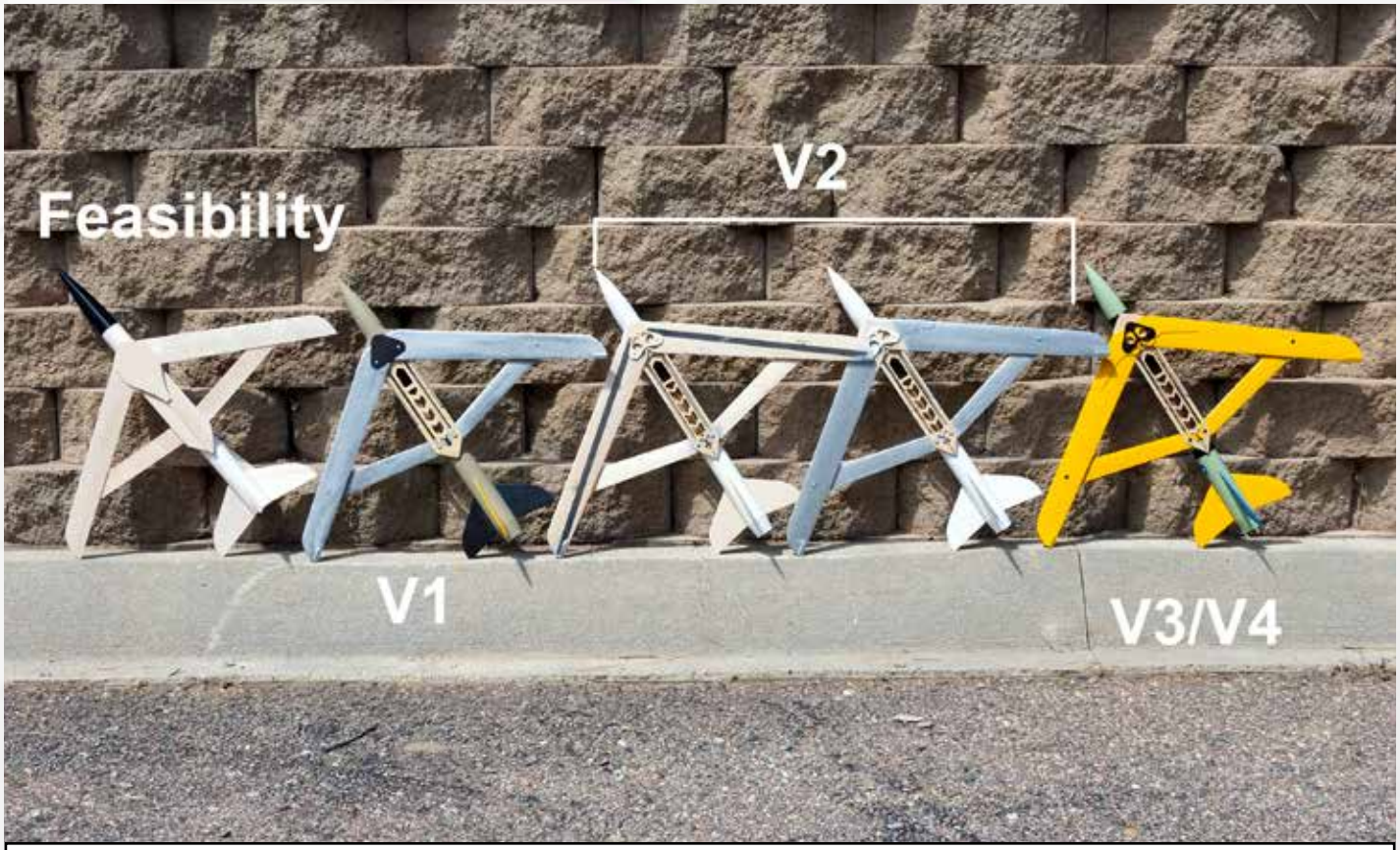

Possibly more striking than anything is the similarity of the different versions of the Draco glider beginning with the feasibility model on the left and continuing to the final – released – version (version 4) on the right. Very careful inspection shows changes in the wing dimensions, frame dimensions, and components, but from a distance, it is clear how much of the original design remained through all the different versions.

progressed. The general layout of the initial feasibility study glider is strikingly similar to the layout of the final production version of the rocket. Similarly, the first study for the mechanical system established the layout of the wing folding mechanism in such a way that no major modifications proved to be necessary during development. Rather, the development proceeded as a series of slight revisions – reducing the weight a couple of grams here or there, making a single assembly step easier, or improving the strength of one component.

Far from each version being revolutionary, the changes in each step were actually boring and uninspiring. However, there is no doubt that the final flight version is immeasurably improved over the first flight version. In every metric that matters – flight, reliability, buildability, and even appearance – the final version is a massive improvement. And, in the end, that's what the development process here at Apogee so often is. A first version may work. But it's not enough for a product to simply work. We want a product to be a joy to build and fly. We want it to fit together precisely and take all the drudgery out of building while still providing the modeler with a unique challenge. And that, it seems to me, we absolutely achieved with the Draco BG.

About the Author:

Martin has been designing and building rockets for as long as he can remember. After originally toying with the idea of pursuing a career in Aerospace Engineering, he did a double major in Computer Science and Fine Art then spent a decade working in K-12 math and science education. Only recently did he land at Apogee Components as the Product Designer.

Tim's Messy Desk - October 2023

What Is Going On at Apogee Components?

Summertime is when we have a little extra time to take on new projects because school is out of session. This summer we're doing a lot of training for our new team members. We did have a bit more turn-over of staff this year than normal, which I wasn't prepared for. While we're going to miss those that have left Apogee, we've already brought on a number of fresh faces. The exciting thing is the new people bring fresh energy and ideas to the company.

With new people in the house, my goal is to do things a bit different in the future. I want to try to get the company to run more autonomously. As the company grows, my time becomes stretched, and I find that I can't do "everything" anymore. Soon, I'll be searching for a general manager that can run the day-to-day operations of Apogee and take a lot of the daily decisions off my plate. So if you know of anyone that I should talk to, please let me know.

On a different subject, one of the odd things that we've noticed this year is that the rest of the rocketry industry has been relatively quiet. Where are all the cool new rocketry products from other manufacturers? It just seems that we're not hearing about new stuff. Maybe everyone is worried about the economy, or maybe they're holding back to release new items in the future. I'm just speculating, because I don't know. We're always looking for new products to sell, and not having a lot to pick from has me a little uneasy.

Here at Apogee, we're still hard at work coming out with our own new items. Our latest release is the Draco Boost Glider model (https://www.apogeerockets.com/Model-Rocket-Kits/Skill-Level-5-Model-Rocket-Kits/Draco-BG) that we've been working on since last spring. You can read about the development process in this issue's main article by Martin Jay McKee.

We also just released a brand new 3-inch diameter nose cone (https://www.apogeerockets.com/Building-Supplies/Nose-Cones/Low-Mid-Power-Nose-Cones/PNC-74A-For-3-0in-Thin-Wall-Tubes) in July. We purchased our own tooling for the blow-mold, so we could control the shape. This one is an ogive shape with a ratio of 5-to-1 (length to diameter). That makes it another long nose cone

3" diameter nose cone

for our catalog. Now that it is available, I'm sure you can guess what our next project will be. Yes, that's right, a new 3-inch diameter rocket kit to use the new nose cone.

We think that a 3-inch diameter will make a very versatile rocket. That size diameter can easily be flown with either 29mm, or 38mm diameter motors. From listening to customers, it seems that modelers seem to want a rocket that is a cross-over between mid-power and high-power. In other words, something that can be flown with a lot of different F and G size motors, and then occasionally with an H motor. So that is what our next rocket kit will feature.

Personally, I will always recommend the 4-inch diameter Zephyr rocket (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-3-Model-Rocket-Kits/Zephyr) for the actual certification flight over a 3-inch diameter model. The reason is that the Zephyr was designed with thick-wall tubes and will always be more durable. And being bigger in diameter, it won't fly as high, which is actually very important when you're going for a Level-1 certification, because if you don't get the rocket back, you won't accomplish the certification. The Zephyr rocket has proved itself in probably over 200 certification flights so far, that it is a perfect choice for a "beginner" high power rocket. And it is more than just a beginner… you can always

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The Zephyr rocket

put those really high thrust "I" and "J" motors into it without fear. It is an amazing rocket that I love watching whenever it takes to the skies.

Something that we've tried different this year is to do our tool-of-the-month offer. We hope to raise the quality of construction in the hobby by offering a low price (or free) tool with a purchase of other Apogee merchandise. So far we've done 9 tools this year through the month of September. It seems to be finally catching on with customers, because in September we actually ran out of the tool (which was a set of micro drills). We didn't expect that to happen based on the previous month's offers.

Tool of the Month

Why are we doing the tool of the month? Because if you're building better looking and higher flying rockets, it motivates you to continue to do more rocketry projects in the future. It is a win-win for everyone. And it even helps the hobby in general, because better flying models are safer. My plan is to continue it through the end of December, which would make for 12 new construction tools for our customers.

We're already planning on the next round of products for next year. This year our goal was to get a new rocket kit out the door every month. And for the most part, we're pretty close to meeting that goal. And that includes some pretty complex projects like the TTV and the Draco BG rockets that came out in the last couple of months. We don't just want to release "me-too" type rockets; our goal is to put out rockets that are exciting and that will motivate customers by providing innovative products that motivate and challenge your skills. We want them to be classics that modelers will want to get a hold of in 20 years.

The future of Apogee and of the rocketry hobby is very bright indeed, and we're happy and thankful to have been a part of your rocketry experience.

On a personal note, both my daughters are out of the house. My youngest, Ashley, is a freshman at the University of North Texas, where she is majoring in Biomedical Engineering. She is also a competitive diver on the swim & dive team. Because of that, I'll be traveling to Texas throughout the school year to watch some of her competitions. The first ones will be in just a few weeks. So if you see me in Texas, be sure to say hello.

May the winds be light,

May the skies be blue…

And may all your rockets fly straight and true.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward an M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and also the author of the books: Model Rocket Design and Construction, 69 Simple Science Fair Projects with Model Rockets: Aeronautics and publisher of the "Peak-of-Flight" newsletter, a FREE e-zine newsletter about model rockets. You can email him by using the contact form at https://www.apogeerockets.com/Contact.