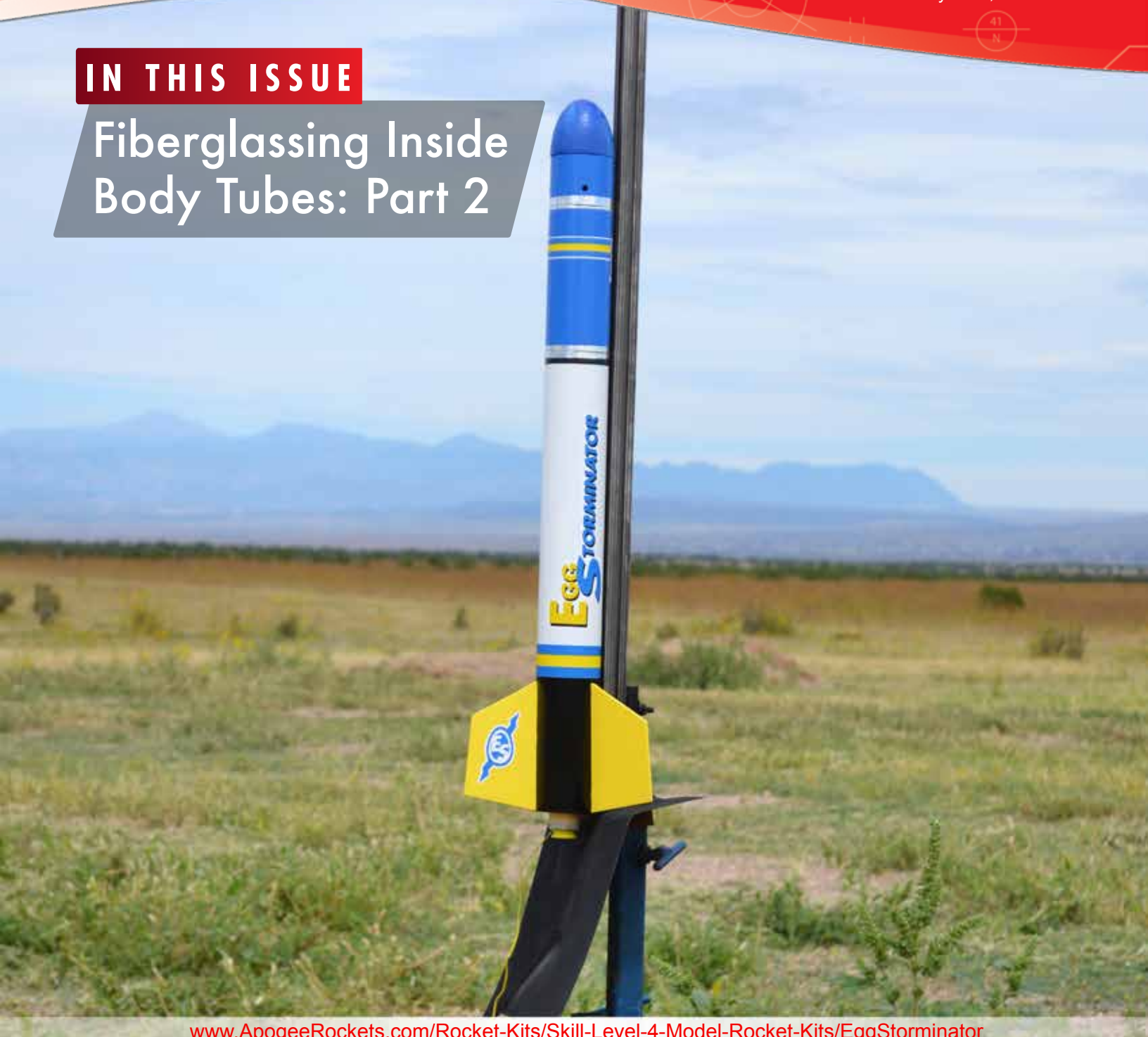
Peak Of Flight Newsletter

ISSUE 469 | May 15th, 2018

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Fiberglassing Inside Body Tubes: Part 2

By Dave Juliano

In the first part of this series, I gave you some instructions on how to improve the strength of your tube fins in a high power rocket (it's probably not worth it in a lower power bird, because it adds weight to the aft end, and unless you're bringing in a weighty vehicle, the naked tube is likely strong enough!). Now that you've got those nicely glassed interior surfaces, what's next?

One of the great things about tube fins in my book is the opportunity to really dress it up. Adding contrasting colors to the now-glass-smooth inner surface sets your build apart! Masking that has got to be quite a chore, right? Not so bad if you leverage some of the previous tips! The first step is always the hardest- finding the right color combo... you're on your own there, as I struggle with this all the time! Once you settle, fix your tube fins to a painting stick in such a way that you get full, unobstructed access to the interior. I had some scrap pieces I ripped off a 1x4, that give me straight sticks 3/4" wide, and about 3/8" thick. Using some heavy rubber bands, I secured my 6 tubes to two boards (**Figure 1**).



Figure: 1 tube on stick (other 5 not shown)

With light coats, shoot your interior color. Sanding the inside is tough, so go light, and build up to a nice finish. As you'll see, I should've heeded my own advice a bit more and also could have used a bit of spot-putty filling some voids I had, but for my first try, I'm not too disappointed. Continue laying down thin coats until you've reached your goal-level of smoothness, and don't fret too much about overspray on the outside of the tube. Allow to dry fully (**Figure 2**).



Figure 2: Painted tubes

Now, for optimal bonding, and since we're pre-finishing the tubes, we need to do a little bit of masking, to keep paint from our areas where we will epoxy the fins to the airframe, and to each other. The steps shown here will depend on the number of fins, but the concept should be clear if you do a dry-fit. In my 6-finned rocket's case, I need to mark the fins as if they're going to themselves receive 3 fins- they touch each other at 120° intervals. The airframe joint will be 180° from the "outside" fin, that doesn't actually exist. Here's a crude sketch (**Figure 3**)- imagine the top tube fin is an airframe that will get three fins- the area where the launch lug would go (opposite the outboard fin) is where the airframe will bond to the fin.

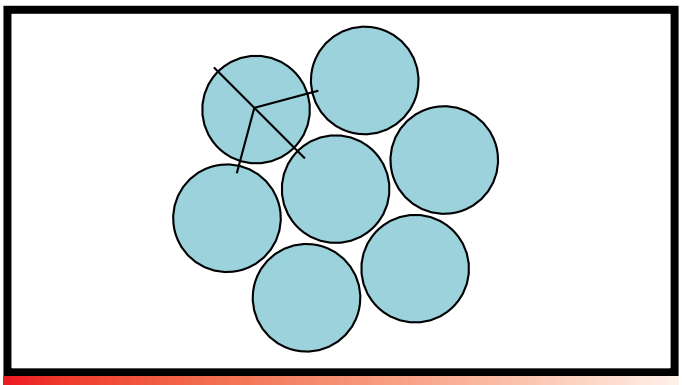


Figure 3: Representation of masking angles

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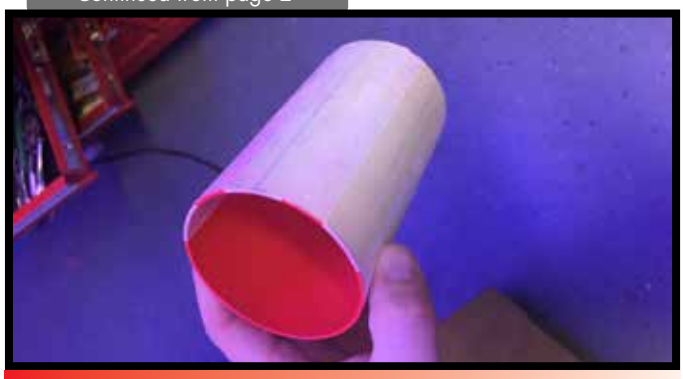


Figure 4: Marked tubes

Use RocSim or your favorite tool to print fin alignment templates for the right diameter (in my case 3") rocket with 3 fins, and add a launch lug line, as if you're building a short 3FNC rocket. I marked the lug line, and the two fin lines adjacent to it (**Figure 4**), but since the "third fin" isn't actually anything I care about, I left that off.

This leaves you with your tubes with 3 lines: two that will join the neighboring fins, and one that will bond to the airframe. Grab some masking tape (3/4" width was good for fins my size) and lay down a strip on each line (**Figure 5**). Now, when we do the exterior color we can peel off the masking tape and have bare cardboard that will give us a better structural bond.



Figure 5: Taped tubes



Figure 6: Taped airframe

Take this one step further to save yourself a headache later: create another alignment template with your favorite program using your airframe diameter and the number of tube fins. Nothing unusual here: I've got a 3" tube, with 6 "Fins", so I set that up, printed it out, and marked my locations. I taped these off just like those on the fins (**Figure 6**). This way I can paint the airframe with the same paint since painting between or near the fins is going to be a huge hassle once the fins are mounted.

The next steps will depend on your level of desire for a smooth finish. I'm pretty interested in hiding every vestige of the seams, so I did some filler and several coats of high-build sandable primer. A common technique employed with high-power rockets is to fiberglass the outside of the tube (remember that from the first part?), doing that here adds unnecessary weight, since we've already reinforced the tube fins, and fiberglassing the airframe at the base will not add strength that matters, since it won't contact the ground hard. Additionally, it will increase your outside diameter, which will throw off your fin spacing. So don't bother doing it... just use some thinned wood filler, or however you prefer to fill spirals.

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Figure 7: Filled spirals on air frame

Now, before you do any painting of any kind (finish coat if you're good with tube spirals, or primer if you're like me), grab your extra balloons, and inflate one into each tube, just like you did when laminating the interior of the fin. This will go much easier since you're not trying to work with wet, sticky fiberglass and goopy epoxy, but still, pay attention to placement. Ensure that the balloon ends "balloon" out on each end. This is how you mask your interior color.



Figure 8: Balloons in tubes

If you're going for primer layers first, go ahead and shoot to your heart's content, sanding as you wish between coats to get whatever level of finish you're willing to suffer for. Sanding may pop the balloons, or it may be easier to sand without the balloons, so be sure to have a stash. Also, prime the aft-end of your airframe, treating it like you would any other rocket. This one just has tape lines where the fins will go (**Figure 9**).



Figure 9: Primed, with balloons in place

Now it's time for the flash! Get your main color paint, ensuring that it's compatible with your choice of primer by testing it on scrap first, ensuring all layers are well-cured. Paint like you have on all your other builds. Light coats are always best, then set aside all parts to dry. This might be tough with balloons in place but don't be tempted to remove them early or you might get interior runs. I happen to have a stash of hemostats that I clamped to the knot of the balloon and then slid onto a dowel so the tubes hang freely (**Figure 10, Page 5**), but clever rocketeers like you who haven't got so many hemostats will find a way! Clothespins and string also work.

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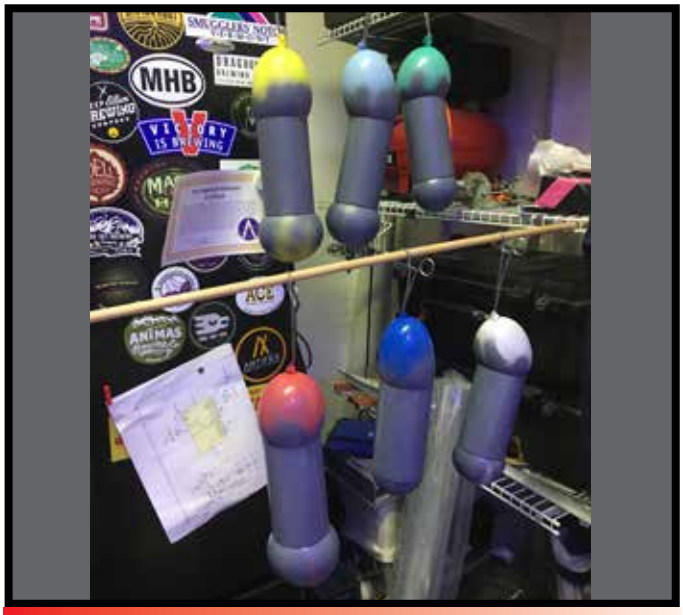


Figure 10: drying rack (these are wearing just primer)

Continue laying coats until you're satisfied and let everything dry overnight. Now comes the fun part: popping the balloons. Hopefully, you'll see that you've got a striking finish Two colors on each tube with no bleed! If you get bleed don't despair as with any masking job some touch up may be required.

Peel off all the tape and mix up a quantity of your favorite structural epoxy. Working with two fins at a time and on top of a well-covered surface, you are now going to pick one of the "outside" lines on the tube fins lay a coating of epoxy down and join the fin pairs together clamping once the ends are aligned. Allow to cure (**Figure 11**).

You've now got beautiful pairs of fins and need to turn this into a rocket... but since you've worked this hard on it why not do it right? You can choose to do this now or later but eventually, you're going to need some nice fillets between the tubes both for strength and appearance. We can do some math here to make this process less wasteful but if you hate math you can bypass the next step and just mix up "enough" finishing epoxy with filler. I'm budget-conscious so I used some math.



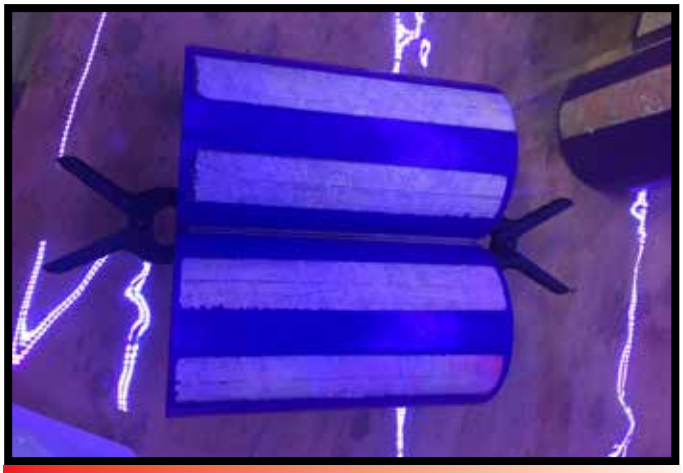


Figure 11: Clamped pairs of fins.

It would be ideal to know the density of your epoxy resin and hardener but I just assumed they were the same as water and found that it worked well enough for my purposes. I needed to know how much epoxy to mix up to make nice fillets so I grabbed a ruler and did some calculations. Nicely scaled fillets on this bird are about 8mm deep, 4mm across, and run the length of the inter-fin intersection. This is an area roughly shaped like a triangular prism (it's not exactly accurate, but this isn't absolutely necessary and this gets the job done!). The formula for the volume of a triangular prism is every math-phobe's nightmare:

The variables themselves are pretty easy to understand:

$$V = \frac{1}{4}h\sqrt{-a^4+2(ab)^2+2(ac)^2-b^4+2(bc)^2-c^4}$$



Figure 12: Volume of a triangular prism formula/drawing

Looks just like a cross-section of a fillet!

I happened to get this wonderful formula and drawing (**Figure 12**) showing variables from Google by typing in "Volume of a triangular prism" which also gives you a wonderful calculator! Math-phobes unite! Do like I did and just type in the details and save some epoxy for future builds!

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Make sure your units are consistent. I used cm so any mm measurement was decimal (8mm = 0.8cm). The nice thing about this is that the end result is in cm^2 i.e. grams if you assume that the epoxy density is the same as water. It's likely close enough unless you're using highly technical aerospace epoxy, but if you are you should have the density in the spec sheet. I'm using US Composites 4:1 635-formulation.

My result is ~2.17g of epoxy per fillet. Rounding to 2 is fine for this purpose. I'm also using 4:1 epoxy so 5 parts total. I know I need to use 0.4g of hardener to 1.6g of resin (1 part to 4 parts). Adding filler will increase volume and density an inconsequential amount but stop! You're doing multiple fillets here. Since you've got sets of nicely flat fins normally you'd have to wait to do so many fillets at one time! So multiply those figures by the number of fin pairs you have and then before mixing grab that masking tape once again and make some dams at the end of each fin pair so the epoxy doesn't flow out the open ends (**Figure 13**).



Figure 13: Dammed fins

Now you can mix up your chosen epoxy, adding your filler of choice. Sandable fillers are best in this application. Flow a bit of epoxy into each pair ensuring with whatever disposable tool you prefer that the filler material fills in smoothly without air bubbles (**Figure 14**). Continue flowing in the filled-epoxy until you reach your desired profile. You should find if your math and measurements are correct that you have little-to-no waste!

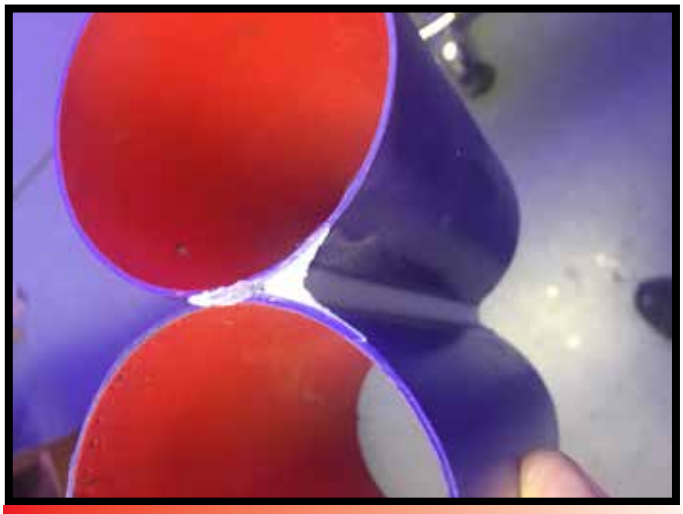


Figure 14: Filleted fins

Once the epoxy is set, remove the dams, and sand the fillets as you are inclined (**Figure 15**). You will scratch the finish on the fins, but fear not, we've got more painting ahead of us! You've come this far, though, so onward ho!



Figure 15: Sanded fillets

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Now we can actually bond these fancy pairs of pre-finished fins to the airframe. Set up your airframe tube in your preferred rocket-building stand, mix up some more structural epoxy, and lay down two beads of epoxy on two adjacent lines on the airframe. Position a pair of fins so that the bare-cardboard lines are over those areas. Remember taping earlier? This is why! Epoxying painted surfaces yield a very weak bond. Clamp or secure the pair to the frame until the cure is complete.

Now on to the next step: mix up just a bit more epoxy than you needed the first time. Now we rotate the tube to the next set and we also have to bond the pair of fins to the previous pair. Wet out the three lines (the two on the airframe and the one on the adjacent fin tube) and again clamp or otherwise secure the new pair to the airframe as well as to the previously secured set.

Repeat that step with the last pair. If you have more continue on as needed.



Figure 16: All on

Now you've got something that looks like a rocket! (**Figure 16**) Upon closer inspection, you'll find that you've only got half your fillets completed and there are no half-measures in rocketry! Do that triangular prism calculation again, now only mixing up one portion worth. Install your tape dams and flow the filled epoxy into the valleys between pairs of fins where fillets are needed but missing. This will be the slow part since like most traditional builds you can only do one fillet, maybe two on a normal finned rocket, at a time.



Figure 17: Dammed valley

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Figure 18: Epoxy in

Keep on keepin' on until you've laid down all the needed fillets (**Figure 18**).

Awesome, you've got a very robust rocket but also some very naked fillets and likely some scratches in the finish on the tube fins... what to do now? More ballons! Once more, inflate a balloon into each fin again, shielding the interior paint from overspray (**Figure 19**). Recoat the fins, the fillets, and any scratches in the tube fin exterior with your main paint color. Let it dry, then pop the balloons and you'll have a product that will leave the flight line wondering just how the heck you did that masking job! (**Figure 20**)



Figure 19: Final coat shielding

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Figure 20: Finished fin can

About the Author:

Dave Juliano is a Born Again Rocketeer who got back into the hobby with his own kids after attending a local club launch a few years ago. He's currently a Level 2 certified flier and enjoys the build process the most. His first and still favorite rocket is Estes Big Bertha, and now proudly flies three sizes, with a High Power upscale planned. He and his family live near Tucson, AZ, and fly with the Southern Arizona Rocketry Association (SARA), but not as often as they would like.

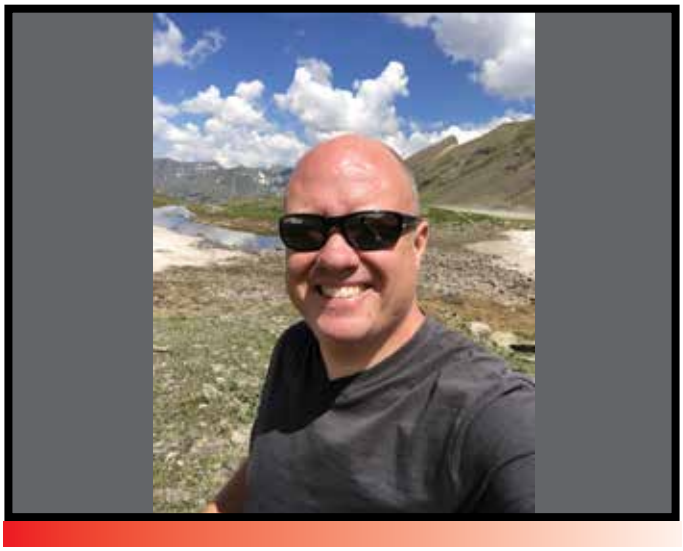


Figure 21: Author Dave Juliano