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NEWSLETTER

In This Issue

Exploring Rocketry Through the Use of Research Wind Tunnels

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Apogee Components, Inc. — Your Source For Rocket Supplies That Will Take You To The “Peak-of-Flight”
3355 Fillmore Ridge Heights
Colorado Springs, Colorado 80907-9024 USA
www.ApogeeRockets.com e-mail: orders@apogeerockets.com
Phone: 719-535-9335 Fax: 719-534-9050

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Exploring Rocketry Through The Use of Research Wind Tunnels

By Tim Van Milligan

A dream came true for me this summer. I've always wanted to put some model rockets in a real high-quality wind tunnel, and it finally happened when my two daughters got permission to use one of the low-speed wind tunnels at the United States Air Force Academy in Colorado.

Even though computers and computational fluid dynamics programs have come a long way, they still leave a lot of room for doubt. Wind tunnels are not going away anytime soon, because they are used to verify the data is accurate.

Typically, other theoreticians will argue the quality of your data, because home-brew tunnels often suffer from a lot of internal turbulence. This turbulence can interfere with making accurate measurements. That is why I wanted to use a good one, like the ones at the Air Force Academy. To use research-quality wind tunnel is special, because you can prove the accuracy of the data.

How Do You Get To Use A Research Wind Tunnel?

Your first question, and the one that I pondered on for a long time before this project, was how do you go about getting permission to use a university research tunnel? After all, good wind tunnels are in high demand, and rarely is there free-time available when they aren't beings used. And when they aren't, they are usually undergoing maintenance, where they are being upgraded or fixed. They are expensive to operate. For example, when you get tunnel time, you also get a dedicated professional that knows how to operate the knobs and switches. And they also know how best to set up a experiment. Because if you set up your project wrong, you'll get back garbage data. These people don't come cheap.

Photo 1: The family portrait taken in one of the laboratories at the Air Force Academy. To the left is the low-speed 'student' wind tunnel, and to the right in the far distance is large subsonic tunnel.

Someone has to pay for the wind tunnel time, and I doubt that a rocketeer's budget is big enough. So you need an angle...

The strategy I'll lay out for you is what you'd use, no matter what your goal is. Whether it is getting time in the wind tunnel, borrowing a computer projector or even athletic equipment for your kid's sports team.

The best angle to use is to come up with a project that the university is interested in seeing the results for themselves. It would have to be some sort of Holy Grail quest that mankind has been working on since the dawn of time. For example, if you discovered a way to solve the world's energy problems by coming up with a unique windmill blade shape, then you might be able to get a grant to use the laboratory. Unfortunately, I can't think of a Holy Grail type experiment that involves model rockets.

What I did, and what you can do too, is to become a part of the "team" at the university. This is very doable.

Universities are constantly looking for outside experts to help them with student projects. In this case, YOU do have expertise in rocketry. And the student project would be something like the Student Launch Initiative (SLI).

That is exactly what I used to become part of the team at the educational institution. I knew they were forming a rocket club to participate in the SLI competition, because

Continued on page 3

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Newsletter Staff

Writer: Tim Van Milligan
Layout / Cover Artist: Tim Van Milligan
Proofreader: Michelle Mason

Continued from page 2

Exploring Rocketry Through Wind Tunnels

Photo 2: From the ceiling hang hundreds of plastic model airplanes. They use them to show students how various areonautic issues are solved, and the aircraft shape that results.

the Academy cadets (students) were coming to Apogee to buy stuff. So I volunteered my time to work with them to build and fly their rockets.

You have to be tuned to the things that are happening around you, particularly in your club. If you get university students contacting your club to find a launch site, that is a screaming siren of their intentions. They are doing something, and this is your opportunity to volunteer.

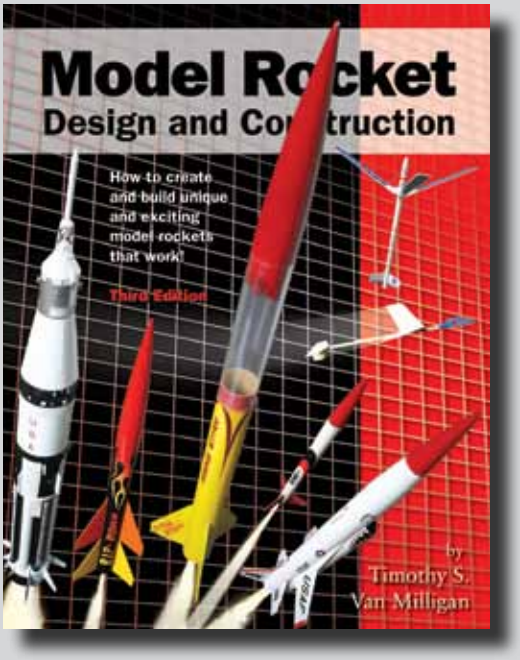
Now I've worked with the students in the past, and it

Photo 3: USAFA students are just like any others. They are eager to learn and to experience the fun and excitement of rocketry. Whoever they might be, someone needs to guide students; how about you?

has been a lot of fun. In those past volunteer opportunities, I didn't even think about my dream of doing wind tunnel testing. But this time, because my daughters were looking for projects for their NARAM Research and Development competition, it hit me that a wind tunnel would be ideal. Here in Colorado, we often have fire-bans because of dry grass conditions, so their projects had to be of the "indoors" variety.

The next step is to "ask." I guarantee to you that they will not offer out of the clear blue sky. They know it will be

Continued on page 4



Model Rocket Design and Construction

By Timothy S. Van Milligan

The Expanded 3rd Edition

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For more information, and to order this hefty book, visit the Apogee web site at: www.ApogeeRockets.com

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telephone: 719-535-9335
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Continued from page 3

Exploring Rocketry Through Wind Tunnels

extra work for them, and nobody is going to volunteer that extra effort and the money it will cost them. So until you start making inquiries, they will assume that you're satisfied with your current role.

Your chief ally in getting permission is the instructor that is in charge of the students. They will know you the best, and will vouch for your character. That is what this will come down to; how good your integrity is. Can they trust you, and are you performing well in your advisor role with the students?

The instructor will know the ins-and-outs of the school system. They will know who to ask for permission, and how to get the process approved. There is a lot of horse-trading inside organizations. And you can be sure that the instructor is calling in a lot of favors, so never abuse the privilege of using their equipment. If they feel like they got burned, they'll never trust you, and it will make it harder for the next rocketeer to get the use of the wind tunnel.

Finally, and this is just as important as the initial volunteering you did, is the follow-up after the project is over. Not only do you need to thank them profusely for their graciousness in allowing you to use the equipment and personnel, but you also need to do it publicly.

No matter who the person is, what they crave most of

Photo 4: Various wind tunnel test models are displayed everywhere in the lab. For a rocketeer, it is like being in heaven.

all is recognition for the value they bring to the world. We all want to feel that our lives on the earth accounted for something good. Therefore, you need make sure to let their colleagues know how much value they created by allowing your project to be successful. In other words, the cost of using the wind tunnel is that they get all the credit. You take none. And in reality, they deserve it since they are putting their reputation on the line for your project.

In my case, the follow-up I'm doing is to write sev-

Continued on page 5

Continued from page 4

Exploring Rocketry Through Wind Tunnels

eral articles for the local newspaper in Colorado telling about the successful project, and how the instructors at the USAFA made it all happen. They get the credit, and my daughters got good data plus an experience that they'll remember for years.

The Air Force Academy Aeronautics Laboratory

At this point, I want to brag on the Aeronautics Laboratory at the USAFA. It is a state of the art facility that serves a dual purpose. Not only are they educating the students and turning them into junior officers for the Air Force, they are also a research center for the US Air Force. The testing they are doing there is expanding the capability of both civilian and military aviation.

Photo 5: The large subsonic wind tunnel. It is so big that only half of the tunnel fits inside the building.

The first thing we did when we got permission to use a wind tunnel, was to request a tour of the laboratory so that we could figure out how to set up the model rockets to be tested. We thought that this tour was going to be of the

Photo 6: The Supersonic wind tunnel runs at speeds from Mach 1.5 to Mach 2.5.

Continued on page 6

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Continued from page 5

Exploring Rocketry Through Wind Tunnels

one wind tunnel that we were going to use. As it turned out, it was a complete room-by-room tour, showing us all the facilities.

In addition to having three operational jet engines, and a rocket engine test cell, we counted at least eight research tunnels in the department.

It is hard to say which one they are most proud of, but the one getting most of the attention might be the large closed-circuit subsonic tunnel with a 3-foot by 3-foot test section capable of speeds up to Mach 0.6. While we were there, there was a model of an A-10 Warthog in it.

They also have a Trisonic (Mach 0.4 to 4.38) Blow-down Wind Tunnel with a 1-in by 1-inch test section. This tunnel is the oldest at the Academy, and the laboratory was designed in 1949 around all the pressure tanks that in needs to operate.

Photo 7: We nicknamed these tunnels the "twin sisters," since they were identical and that sat together. They are low speed tunnels, but have large test sections.

Photo 8: The Cascade wind tunnel is used to test objects that rotate in the air, like jet turbine blades. The test model is mounted in the corner where the air is forced to make a direction change.

There are the two big "twin sisters," as we called them. They are 'open return' tunnels. That means air comes in one end, and is blown out the other. So there is fresh air in the tunnel, as opposed to the closed-circuit tunnel mentioned above. The "twin sisters" also have 3-foot by 3-foot test sections, but the wind speed is a lot lower. The maximum speed is around 90 feet per second through the test section.

The facilities handbook that we got lists a Supersonic wind tunnel with a 1" X 1" test section, and speeds from Mach 1.5 to 2.5. But I didn't remember seeing it. There was so much to take in, that I could have easily overlooked it.

One type of wind tunnel that I never heard of before, which they also have, is an Aero-Thermo-Dynamic Cascade wind tunnel. What is a "cascade tunnel" you ask? It

Continued on page 7

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Continued from page 6

Exploring Rocketry Through Wind Tunnels

allows the simulation of real running turbine or compressor blades in jet engines. Since it is difficult to study a rotating and moving machine, its better to fix the blade and let the air circulate over them, then study all the parameters of the blades.

Another type of tunnel they operate that I had never seen before, was a "water tunnel." Instead of using air to flow over the object, it uses a stream of water. The advantage of this is that the quality of data is even better because of the density of water compared to air. The disadvantage is that you can't put a cardboard rocket into the tunnel, as it would get soaked and fall apart.

Photo 9: The water tunnel gives very high fidelity data at low flow rates (0.3 to 1.3 feet/sec).

The newest wind tunnel, which is still undergoing trials, is the hypersonic wind tunnel. Like the other high-speed wind tunnels, it has a very small test section. I could be wrong, but I recall it being 1" x 1". It was capable of speeds over Mach 5. Essentially, they make an explosion at one end, and the shock wave rips past the object in the test section. The whole experiment lasts for just a fraction of a second. That means the test is done even before your body has a chance to flinch from the boom at the far end of the room.

Photo 10: The hypersonic tunnel tests models at speeds exceeding Mach 5. It is so new that it is in a temporary structure in a parking garage.

The wind tunnel that we got to use was the one that was shown to us on the final leg of the tour. It was the "student" tunnel. While not nearly as impressive as the other tunnels, I'd gladly accept it for my own use if they ever decided to get rid of it. They list having three of these tunnels in their inventory, but we only saw the one that was used for our projects.

The student tunnels are "Open Circuit, Eiffel Type." It looks like a long tube with a big funnel at one end that

Continued on page 8

Continued from page 7

Exploring Rocketry Through Wind Tunnels

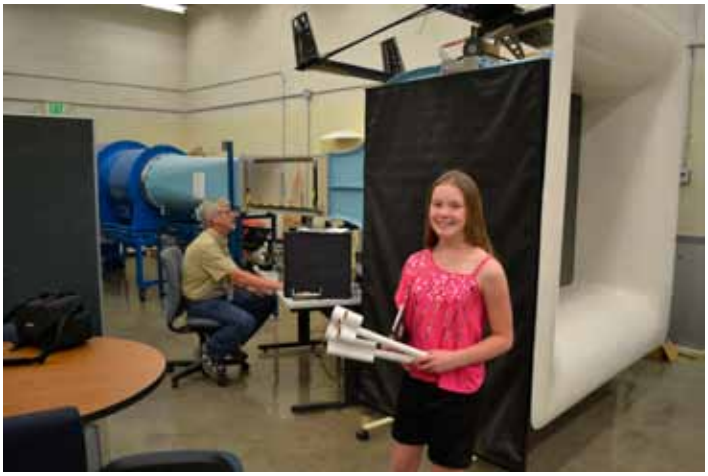


Photo 11: The student wind tunnel. It has a 1' X 1' X 2' test section. Just the perfect size for small model rockets. The dark-blue fan at the far left sucks air in from the giant white intake on the right. The test section is clear plexiglass so you can see your model from all sides.

sucks in the air. The test section was 12" x 12", and about two feet long. It was clear Plexiglas, so you could see through it from all sides. Wind speed was capable of 20 to 150 feet/sec. Our tests were run about 57 feet/sec (about 39mph), which was about half-speed.

Why not run at full speed? The reason was that the fan was sucking air through the tunnel, so the model was upstream of the blades. They were worried that something might break off our model and go through the fan. This is a justifiable concern, as the models were made by grade-school kids.

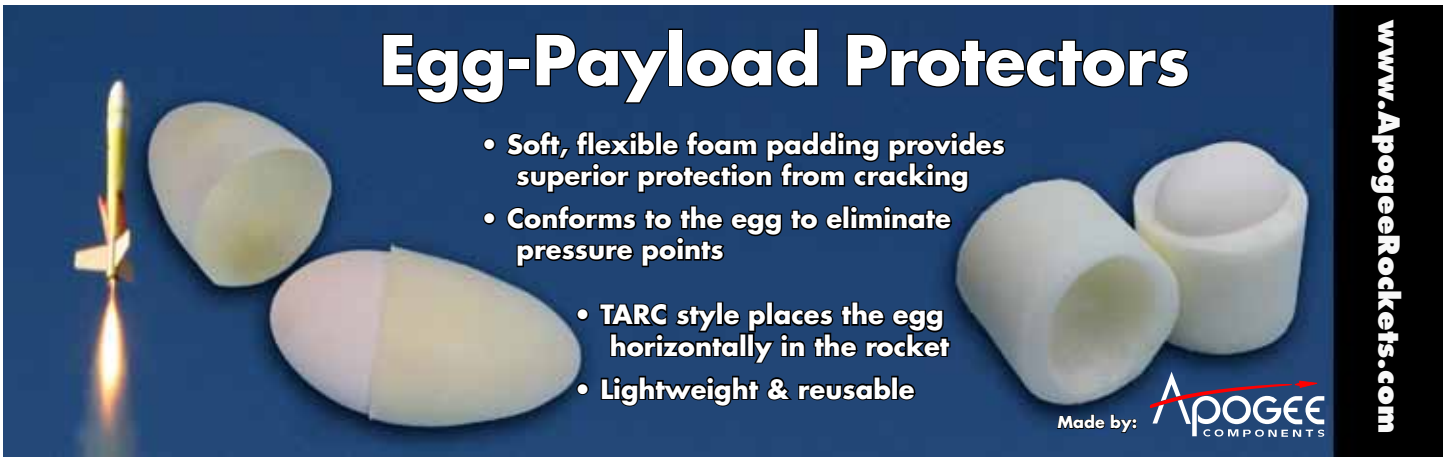
Conclusion

This was a very unique experience of testing rockets in a wind tunnel, and I hope that more people are able to do this. Heck... I'd love to see your data when you're done. And in a future issue, we'll talk about our projects in detail, and what information we collected.

But my real purpose in this article was to document the process of getting to use a research-quality wind tunnel, and what types of equipment that you might come across at a university near you.

If you'd like to build your own simple wind tunnel, be sure to read *Peak-of-Flight Newsletter 252* - www.ApogeeRockets.com/Education/Downloads/Newsletter252.pdf "Build Your Own Inexpensive Wind Tunnel." It is useful if you need to accurately measure the location of the Center-of-Pressure on a Rocket.

And if you'd like to learn my secrets of getting publicity for your project, see Issue number 019 at www.ApogeeRockets.com/Education/Downloads/Newsletter19.pdf .

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. 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 a 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 the curator of the rocketry education web site: http://www.ApogeeRockets.com/education/. He is also the author of the books: *"Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics"* and publisher of a FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site.