# PEAK OF FLIGHT NEWSLETTER

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APOGEE COMPONENTS

PEAK OF FLIGHT

# RockSim Pro vs RockSim

## By Tim Van Milligan

On July 16, 2021 Apogee Components released RockSim-Pro v3.0 (we call it RS-PRO). This was our first update to RS-PRO since 2009. In this article, I wanted to go over what RS-PRO is, and who it is designed for. We don't think it is for everyone, and our attempt here is to give you enough information to decide if it is right for your project.

RS-PRO is an off-shoot of RockSim. Basically, they both do the same thing -- they are both model rocket design and simulation programs. That means they do two things… design rockets and simulate the flight of rockets.

They are identical in the "design" portion. Which means that RS-PRO does NOT have any extra features that will help you to design rockets, nor any type of additional import/export features. "Identical" means they are exactly the same in this regard. This seems to be the biggest confusion for people, since they think that it would be better in every regard over the regular version of RockSim because it is a pro-version.

But when it comes to simulation, they are different.

The difference is how the rocket is constrained during flight by the equations of motion. RockSim constrains the rocket to three degrees of motion. Technically, it is called 3 Degrees of Freedom (3-DOF). Those three degrees are 1) Up/downward, 2) With the wind direction, and 3) Pitch rotation into the wind.

You see this when you look at the 2D flight profile of the rocket after you've run a simulation. The rocket can go up in the air, and come back down. It can drift with the wind, or weathercock into the wind. And finally, it can pitch (rotate about its CG) into the wind, or with the wind.

For most flights, this is totally acceptable. In fact, the reason people use RockSim over other programs is because the 2D flight profile really adds a lot of value to the process of simulating rockets.

*FIGURE 1: ROCKSIM'S 2D FLIGHT PROFILE*

I don't know how many times people have sent me rocket designs to troubleshoot. They are freaked out because they run a simulation and their rocket doesn't go as high as they expected it to. They want to know why.

The first thing that I always ask them is: "have you looked at the rocket in the 2D flight profile viewer of RockSim?"

Could it be that the rocket didn't go as high as you expected it, because it weathercocked into the wind severely? Or maybe the rocket went unstable? In a majority of times, this is exactly what happened.

That is why the 2D flight profile is so invaluable. It gives you information about your rocket that is hard to determine by simply looking at a summary table of values about the flight like speed, altitude, and distance. Even though I'm an engineer and could probably figure out what happened in a rocket's flight by looking at the summary table and then digging into the graphs of the flights, it is just a million times easier to figure out what is going on by watching an animation of the flight.

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Where RS-PRO is different from RockSim is that it uses 6 Degrees-of-Freedom in its simulations, instead of just three. So it has the same basic three directions of motion as Rocksim: 1) Up/downward, 2) With the wind motion, 3) Pitch rotation into the wind, and then allows motion in the 4) Cross-wind direction, 5) Yaw rotation, and 6) Roll about the centerline of the rocket. See Peak-of-Flight Newsletter issue 186 (https://www.apogeerockets.com/education/downloads/Newsletter186.pdf) for more information about the 6 Degrees.

This is exactly how a rocket would behave in real life - since it is unconstrained in all six degrees of motion.

So RS-PRO first became available around 2006 when we bought out a program called SPLASH from David Hall. It had all the 6DOF equations in it, so it was relatively easy to incorporate those into RockSim and create the PRO version.

The Splash software could be described as: "a wind-weighted 6 degree-of-freedom (6DOF) rocket simulation with statistics-based impact analysis capability. Splash is intended not just for the nominal trajectory analysis that most simulations are, but also for splash pattern generation consistent FAA/OST requirements. This means that Splash can provide the data used to determine not just a nominal impact point but an impact zone complete with statistics to back up the likelihood of a vehicle impact in any given region. No other simulation package available at a reasonable price offers this capability."

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The features this added were:

- Earth modeled as a rotating oblate spheroid.
- Gravitational effects that vary with altitude and latitude.
- An altitude model that extends to 632 km above sea level (ASL).
- Uncertainty analysis for 18 different vehicle/scenario parameters.

However, Splash was only a simulation program… it didn't allow you to design rockets. So marrying it to RockSim seemed like a no-brainer decision. And it was.

But there were a couple of big issues we had with RS-PRO that prevented me from promoting it for everyday use by most modelers. First and most importantly, we were told that it may be a program that is ITAR regulated. This is a government designation that makes it illegal to distribute it to non-USA citizens, because it could be used in weapon systems by people hostile to America.

In 2020, I actually went through the expensive process of getting the correct classification of the program by the US Government. Fortunately, it didn't come back as being ITAR regulated, but EAR-99. That is a lower classification that does allow it to be exported, but not to certain countries like North Korea or Iran. With this situation resolved, we started work on updating the other issues that limit the versatility of RS-PRO.

The big one, which I mentioned previously, is that in order for any simulation to be useful, you need to see an animation of the rocket's flight. Where RockSim at least had a 2D flight profile, the original RS-PRo didn't have any real-time animation of the rocket's flight.

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The best it had was a 3D plot of the trajectory after the flight was over. We could display what the finished trajectory of the rocket looked like after it had completed the mission. But that only showed motion in three directions, not six. It only displayed translation in the directions: Up/Down, with the wind, and cross wind. It did not show pitch, yaw, or roll of the rocket.

That data was generated by RS-PRO, but we had no way to visualize it. To actually get it, you'd have to go to the graphs, or export the data into a spreadsheet and try to decipher things like pitch rates, yaw rates, and roll rates. There are about one out of every 1000 modelers that would even care what this meant, or even what it was good for.

So I actually had to wait for computer technology and peripheral software to catch up to what is needed to actually make some sort of 3D animation even possible.

At the beginning of 2020, right before COVID hit, I contracted with an outside developer to create what we call the "Launch Visualizer" that is now the heart of RS-PRO. It is only now that we have it available!

The "Launch Visualizer" is the 3D environment that I had envisioned nearly 20 years ago when we incorporated the Splash software into RS-PRO. Not only does it show the motion of the rocket in all 6 degrees of freedom, but the environment it does it in is actually the earth. So you'll see the rocket on YOUR launch field.

This makes a huge difference, because on your launch field, there are places where you don't want the rocket to land. You may have a creek or lake nearby, or maybe you have a series of rocket-eating trees to one direction of the launch field.

*FIGURE 2: THE 3D LAUNCH VISUALIZER IN RS-PRO*

Being able to see the trajectory of the rocket in its native environment will blow your socks off.

The 3D environment should be very familiar to you if you've ever used a product like Google Earth. It is not static. You can move around in the environment, rotating the camera and zooming in on different areas that you wish to see. So you can look at the rocket from any angle you want.

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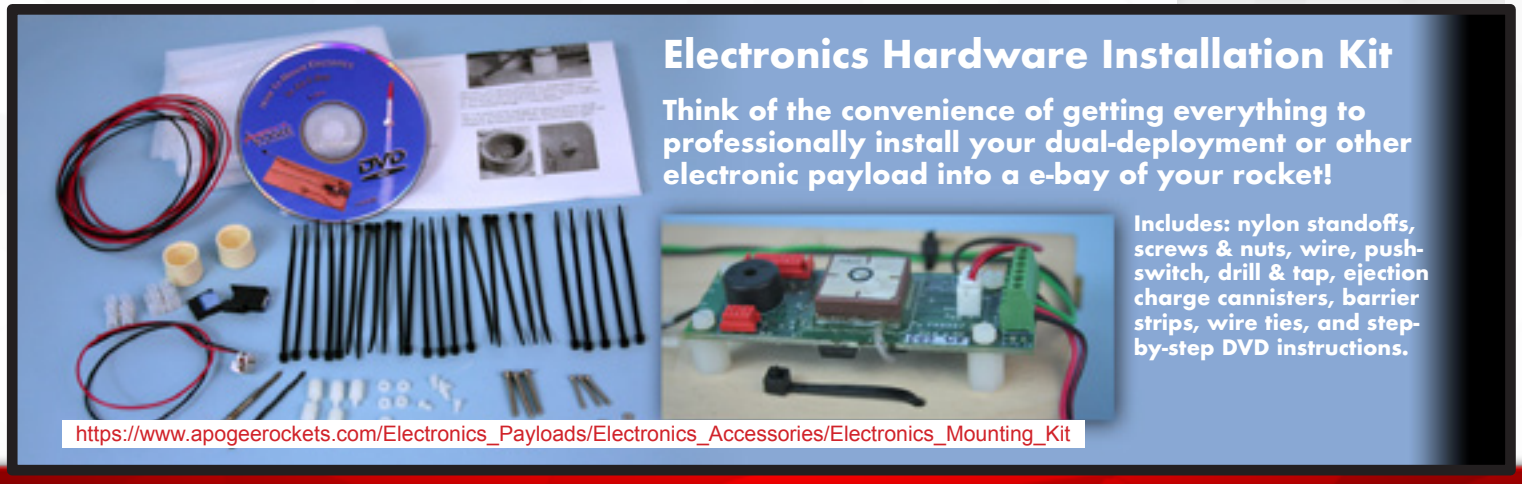

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I can't tell you how valuable it will be to you to see the rocket's movement through the environment. You can really get a perspective on the speed of the rocket as it whizzes past objects on the ground. If you didn't see objects on the ground, you really have nothing to reference against for distance comparisons. This is what really made an impression on me when I first saw my first animation of a flight in the Launch Visualizer. I just had no idea how fast 500 mph was when the rocket took off. It is really really fast.

At the same time, when the rocket begins to weathercock into the wind, you start to notice things on the ground over which the rocket is flying. It hit me, and I thought to myself, "do I really want a stray rocket to fly over that house, or into those woods?" I would have never got that thought had it not been from looking at the flight from a different perspective.

To give modelers even more perspective, we added the weathercocking cone, just like we did in RockSim version 10.0. The weathercocking cone is an imaginary 30° cone that projects upward from the launch pad into the sky. The purpose of the cone is to give you an indication of how much arc the trajectory can tolerate and still be considered safe. To use it, you want to see the apogee point (the highest point of the flight), to stay within the cone. If it arcs over and the apogee point is outside the cone, you could say that the rocket is going more horizontal than it is vertical.

We even color-coded the apogee point in the Launch Visualizer. If the apogee point is a green dot, then the point is within the weathercocking cone. If the dot is red colored, then the apogee point is outside of the cone, and the trajectory should be considered unsafe for a model rocket flight.

*FIGURE 3: THE RED COLOR APOGEE POINT IN THE IMAGE TELLS YOU THE ROCKET WEATHERCOCKED TOO MUCH*

*FIGURE 4: A THREE STAGE FLIGHT SHOWN IN THE LUANCH VISUALIZER. YOU CAN SEE THAT IT ALSO WEATHERCOCKS TOO MUCH.*

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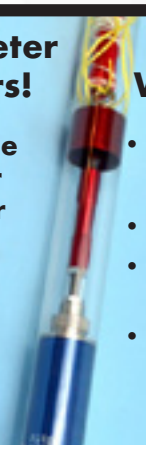

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With this new tool, I started experimenting with multi-stage rockets. I have always known that anything more than three stages is prohibited by the NAR safety code. And if you look at most multi-stage rockets in the Launch Visualizer with the weathercocking cone, you see that they really like to arc over and go outside the cone at their apogee point. The longer the thrust duration of the motor burn, the more susceptible to weathercocking the rockets are.

Another feature we added to the Launch Visualizer is different camera views. The default view of the scene is to keep the rocket centered in the exact middle of the window. So the rocket will stay in place, while the earth moves in the background. This is the easiest view for modelers, because you always know exactly where the rocket is. But if the rocket flies really high, you lose perspective on how far it travelled, because the launch point may have moved out of the viewport on your computer.

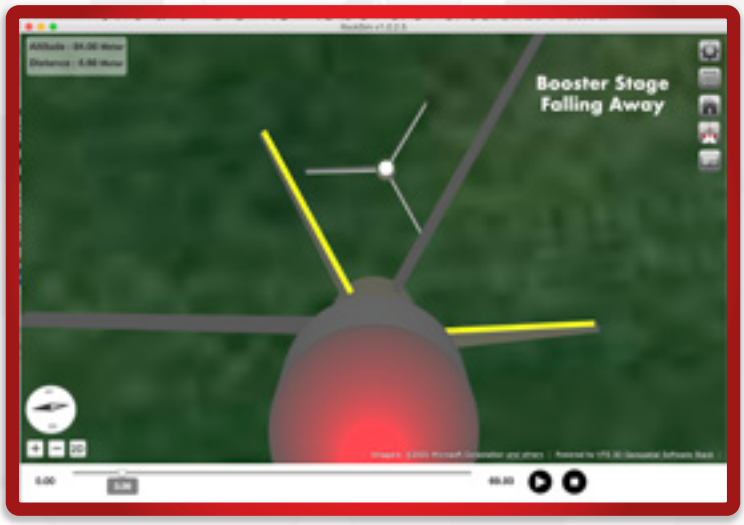


*FIGURE 5: ONBOARD CAMERA VIEW*

So we added a fixed camera view. Imagine the camera being at a fixed view angle, like it was sitting on a quad-copter drone. The camera is looking at a spot in the sky, and the rocket can fly past the lens. That might not be very useful. But if you move the location of the camera - backing it up far enough away, then you can see the entire trajectory of the flight from lift-off to touch down. Now that would be really useful. You could better see how far it traveled in a given amount of time, so you could gauge the speed at which it was travelling.

But when you're so far away from the rocket, the one thing you will miss is the movements of pitch, yaw, and roll of the rocket as it ascends upward. So what we did was to add a mini-viewport in the scene that gives you a close-up view of the rocket so that you can see those movements. It is like a picture-in-a-picture that you'd see when you were watching a sporting event on television. Seeing the same event, but from different view angles simultaneously is priceless.

I added two other default camera views to the Launch Visualizer that are a little less useful, but a lot of fun in their own right. The third view is the onboard camera view. It is like you attached a video camera to the side of your rocket, and had it looking down to the ground while the rocket takes off.

The final default view is what we call the "ground observer" view. This mimics what an observer on the ground, holding the launch controller would see as the rocket takes off. Like in real life, the rocket zooms skyward, and after the smoke dissipates, all you see is a tiny speck in the sky.

To make the Launch Visualizer as realistic as possible, we also added smoke and fire to the animation. And what is really cool is that you can adjust the color of each of them.

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*FIGURE 6: CHANGE THE FLAME COLOR TO ENHANCE THE VISUAL SCENE OF THE ROCKET'S FLIGHT*

So say you wanted to mimic the flight of a redline propellant -- you'd go into the preferences of the Launch Visualizer and change the flame color to bright red. Do you want a Green flame? Yep, you can switch it over to green too.

You also have control over the smoke color too. In this feature, the Launch Visualizer is better than actual life. You can make the thrust smoke a different color than the delay (tracking) smoke. Say you wanted black smoke for the rocket as long as the motor is burning and making thrust. And then you wanted it to be bright blue when it was coasting upwards. You can't do that in real life, but you can do it in the visualizer.

And why would you want to have different colored smoke in the visualizer? So you could tell just by looking at the trajectory where the motor burned out -- like you wanted to know quickly how high up in the sky it was when the propellant was consumed. This is really useful information, especially if you were explaining rocketry to a newbie that didn't know how quickly a rocket really consumed the propellant in the motor.

The Launch Visualizer also has "augmented reality" features too. Augmented reality is the placement in the scene of additional markers that help you make sense of the situation. In the case of the RS-PRO Launch Visualizer, we added not only the weathercocking cone, but a trajectory line coming out of the rocket as it ascended in the sky. Plus there is a ground track line that shows you what the rocket is travelling over as it takes off. We've also connected the trajectory line and the ground track line with a curtain, so you can maintain your perspective as you adjust the scenery by changing the camera position that looks at the rocket.

And like in RockSim, we've added the ability to display the thrust and drag forces acting on the rocket. This is really useful if you're teaching students about the four forces of flight.

There is a whole lot more that you can use the Launch Visualizer to see too. When you get into dual-deployment, multi-staging, clusters, air-starting motors, and strap-on booster pods, you'll want to see how they affect the flight too. And the 6DOF simulator of RS-PRO and the Launch

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Visualizer make it possible to see the effects on the trajectory of the model.

Imagine seeing the booster stages drop away and tumble back to the ground. Or seeing the parachutes and streamers pop out of the model as it descends to the ground, and where they are likely to land on your field. How valuable would that be to you?

We don't know exactly how many parts the visualizer can track at once. The most we've tested is nine parts raining down from the sky.

Another benefit of the visualizer is that the rocket you see in the scene is the rocket that you've designed. It is our hope, that maybe, just maybe... people will start to color their rockets and make them some other color than the default blue color.

RS-PRO has some advanced features too. Since it was based on the Splash software, it has a lot of high-end inputs and versatility to make it more realistic in the simulations. Like in RockSim, you can adjust the Cd and the CP of the rocket and override the estimations by default. But unfortunately, they are much more complex to enter into this software, and therefore the RS-PRO software is overkill for what most modelers need.

So unless you're an extreme flyer, RS-PRO will be a bit too complex for the average modeler. We don't recommend it for everyone.

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### *The ONLINE Launch Visualizer*

While RS-PRO is not for everyone, we do think the Launch Visualizer should be used by everyone. It is extremely useful, and downright addicting to use.

*FIGURE 7: THE ONLINE LAUNCH VISUALIZER (COMING FALL OF 2021)*

Our other project is to separate the Launch Visualizer out from RS-PRO and put it on the Internet (in the cloud) so that everyone has access to it. By putting it in the cloud, where you can get to it through a web browser, it bypasses one of the other issues that we've been fighting over many years. You will no longer have problems running it on your computer, because there will be no software to install. Just open up a browser and you can see your simulation in the online Launch Visualizer.

The online Launch Visualizer is planned for release in late fall of 2021. In a number of ways, it is even better than RS-PRO. We've streamlined the set-up process, so it

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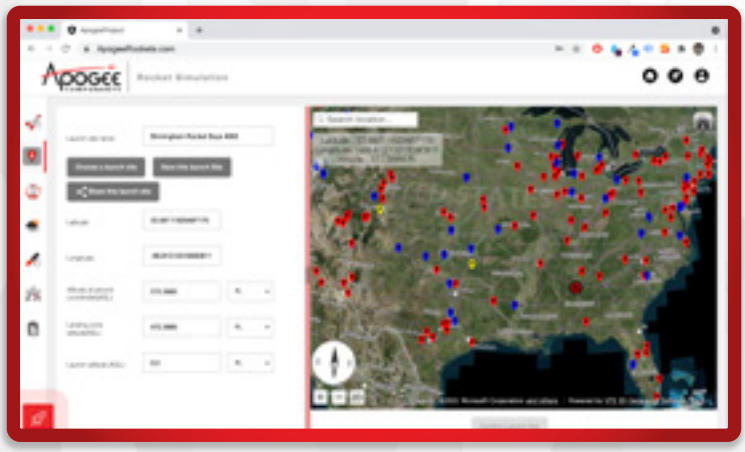

FIGURE 8: SELECTING A LAUNCH SITE IN THE ONLINE LAUNCH VISUALIZER

is very user friendly to modelers that are familiar with the regular version of RockSim. But it is even more intuitive to use, because of its 3D graphical interface.

The process of simulating a flight starts by opening a RockSim file. These can either be selected from the online database, or uploaded by individual users like you. Once you open it, you immediately see your rocket sitting on the launch pad.

Next you choose your launch site. Why? Because where you launch from on the planet is very important. To pick your launch site, you'll navigate around the globe (like you do in your favorite map software), and put a red dot in the exact location you want to place the launch pad. Don't put it too close to a tree… right? That's what you'd do in real life, and what you'll do in Launch Visualizer. Because you'll see the trees as they surround your launch field.

FIGURE 9: ORIENT THE ROCKET ON THE LAUNCH PAD IN THE ONLINE LAUNCH VISUALIZER

After picking your launch site, you'll adjust the launch pad orientation. Here is where it gets really cool. You'll have slider and dial controls that move the 3D image of the rocket in real-time. So when you angle the launch rod, you'll see it immediately move in the rocket image. Then swing it around in a compass direction, so you can aim it away from those rocket-eating trees. Just like you'd do in real life. You can also rotate your rocket around on the pad, like you would with a glider to orient it so that the wings are perpendicular to the wind hitting the model on the pad.

Once the rocket is on the pad, you'll then load the motors and set the weather conditions. When everything is set, you can give your countdown and launch the rocket! At this point, the scene changes to the rocket in the 3D Launch Visualizer environment, just like we described in the RS-PRO software. You'll have all the same controls and the features of looking at the rocket from any view angle.

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But since it is online, you also have the option of sharing your cool simulations with your rocketry friends. You'll be so impressed, that you just have to share the excitement with other modelers. If they can see what you see, they will hopefully get addicted to rocketry too. In this way, we'll all grow the hobby together. We'll add a share-button feature so that you can easily send messages to your rocketry friends, and they'll see the same simulation that you just ran yourself.

The one downside of the online Launch Visualizer is that you can't design rockets in it. Unlike RockSim or RS-PRO, you can only perform simulations. Why? Because we didn't have the time or money to get the programmers to put all the design portion of RockSim into the online version. Eventually, that will be our goal. But we're not there yet, and don't anticipate getting there for many years.

So right now, our recommendation for most modelers is to get the regular version of RockSim v10, and then wait until this fall (2021) to subscribe to the online Launch Visualizer. This way you'll have the best of RockSim, where you're able to design really cool models, and then with the Launch Visualizer, you'll be able to see them in a 3D earth environment.

If you are a high end modeler, where you want to perform splashdown patterns on the ground, and you're able to understand and input important parameters like Cd, Cb, CNa, CP locations, then we'd recommend RS-PRO. It is not for everyone, and we won't be hurt if you wait until the online Launch Visualizer comes out later this year.

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### *Conclusion*

I'm sure you have a lot of questions about RS-PRO and the launch visualizer. We put up an extensive FAQ on our website that answers them, and we'd recommend you read through them first before you contact us via email.

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For regular RockSim info, visit: https://www.apogeerockets.com/RockSim/RockSim_Information

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