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APOGEE PEAK OF FLIGHT NEWSLETTER

On the Pad Recovery Using RockSim v4.0

By Bruce S. Levison

Editor's Note: Since this article first appeared in the Apogee E-zine Newsletter, the RockSim software has incorporated spot landing prediction. But this article does have some great information that can be used for other rocketry projects.

How far will my rocket land from the launch pad, and what angle should I launch my rocket at, are two common questions asked by rocketeers at any launch. Until the advent of advanced model rocket flight simulation programs like Apogee's RockSim for use on a personal computer, the answers to these questions have been general rules of thumb which are bad estimates at best. You can use RockSim Version 4.0 along with some easy math to better estimate the distance that a model rocket will actually land from its' launch pad.

If you know the wind speed, and adjust the launch rod angle accordingly you should be able to achieve an "on the pad" or at least a very close to the pad recovery providing all goes well during the flight. RockSim will simulate the distance downrange a given model will travel at a given wind speed for a given launch rod angle and rod length. Program in the ambient wind speed, air temperature and launch guide angle from vertical into the Launch Site data under Application Settings in the Edit Menu. If you know the actual altitude the wind starts at, this could also be entered into the Launch Site menu.

Enter the actual Launch Guide Length into the General Rocket Design Information table under the Rocket menu's Design tab. Under the Components tab in the Rocket Design menu enter the information about the model's parachute recovery device and note the Rocket's rate of descent on the recovery device that RockSim determines.

Install an engine with an appropriate delay into the design and run a simulation with it. Next view the Flight Profile for this configuration under the Simulation menu. Run the flight simulation all the way to the end; the range number at the bottom of the graphic indicates the distance the rocket travels (or weathercocks) away from the launch pad. Also displayed at the bottom of the flight simulation graphic will be the rockets altitude at ejection.

These calculations assume that a model rocket will drift along at the speed of the prevailing winds upon deployment of the recovery parachute, and fall at a constant rate of descent as predicted by RockSim. Air density decreases with an increase in altitude, the air density is about 15 percent less a mile above the pad. The lower air density will increase the rate of descent on the recovery device; this increase in drop rate could also be offset by lift from thermals. The actual thrust output of a model rocket engine can fall within a 20 percent range of its' stated value; causing the same amount of uncertainty in the calculated altitude at ejection and drift up range. The uncertainty in these values allow one to ignore the lesser amount of uncertainty introduced into this procedure from changes in air density.

The estimation also assumes that the model is launched at an angle directly into the wind (parallel with the direction the wind is blowing) to make the three dimensional nature of the actual launch behave more like the two dimensional nature of this simulation. This technique also assumes that wind speed and direction do not vary with altitude. This probably never happens in a real flight, however you would expect the average wind speed and direction to be somewhat constant especially for lower altitude model rocket flights.

Other assumptions made for this technique are that the engine delay occurs exactly when it is supposed to, and that the recovery device deploys instantly upon ejection (or the altitude of ejection equals the altitude for deployment). We all know that engine delays can vary by a second or two either way and that it sometimes takes several seconds for the parachute to deploy and unfurl. The time for deployment and un-

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furling may vary from flight to flight and be dependent on things like the material the parachute is constructed from and how it was folded or even the temperature at deployment. Since there is currently no way to estimate deployment or unfurling times, there was no correction made for them, introducing another source of error in this simulation.

To allow me to use this technique, I purchased a plastic "weather station" for under $8.00 that indicates wind speed and direction. A windsock or streamer could also be used to indicate wind direction near pad level, and you might trust the local weather report for the wind speed. I also incorporated an angle finder into my launch pads design so I know the exact launch guide angle to vertical.

The next three steps allow you to estimate the distance the rocket should land from the launch pad.

1.) Use the simulated altitude at ejection divided by the rate of descent on the parachute to find the length of time it will take the model to descend all the way to the ground. The rate of descent should be set (under Application Settings on the Units tab in the Edit Menu) or converted to feet per second.

2.) Then multiply the wind speed (converted to feet per second, e.g. 1.0 mile per hour equals 1.467 feet per second) by this descent time and calculate the drift distance on the recovery device (in feet).

3.) Subtract this recovery device drift distance from the distance the model flew down range from the pad (from the Flight simulation) and you will have an estimate of how far the model rocket should land from its' launch pad.

Watch the sign on the range value in the Flight Simulation graphic display, the negative sign indicates upwind drift or weathercock that is in the opposite direction of downwind drift on the recovery device!

Thus for the Estes Fat Boy model launched straight up (0 degrees from vertical) in a 10 mile per hour wind the deployment altitude is about 1000 feet and the up wind range is about 240 feet. The time for descent on the parachute is 1000 feet divided by 17.495 feet per second (the descent rate for an 18 inch diameter polyethylene hexagonal parachute) or 57 seconds. Multiply the descent time by the wind speed to calculate the distance the model drifts down wind; 57 seconds times 10 miles per hour times 1.467 feet per second per 1.0 mile per hour which is equal to 836 feet. Therefore expect to recover the model 836 feet minus 240 feet; or 596 feet away from the launch pad.

For the launch rod angle to use for an "on the pad recovery" rerun the flight simulation at various launch rod angles until the range drift is almost equal to the drift downwind on the recovery device, then set your launch rod angle into the wind accordingly.

I have done this calculation for the Estes Fat Boy in a 10mph wind with an 18 inch diameter plastic parachute and an E15-4 motor. If you angle a 3 foot launch rod 19 degrees (-19) into the wind for this situation you should be able to recover this configuration within a few steps (4 feet) of the launch pad! I get an ejection altitude of 806 feet with an up wind drift of 671 feet giving a calculated descent time of 46 seconds and an estimated down wind drift of 675 feet.

With a 12 inch diameter polyethylene parachute as a recovery device, under the same wind and launch site conditions an 11 degree launch rod angle will bring the Fat Boy model to within 5 feet of the launch pad. Ejection altitude 904 feet, up wind range 504 feet, descent time 34 seconds, down wind drift 499 feet. The other settings at the launch site used for these calculations were; Altitude 2800 feet Relative Humidity 15 percent, Temperature 78 degrees F, Latitude 45, wind starts at altitude of 0 feet.

As far as I know, this is the only mathematical method that exists to determine how far a given parachute recovered model rocket will land from its' launch pad. By using trial and error values for the launch rod angle in the flight simulations, one can also determine what angle from vertical to tilt the rod at for an "On the Pad Recovery" for a given rocket and wind speed. This will allow modelers to get an idea of where a flight will end up and allow them to decide if the conditions are too windy for the flying.

You could actually determine if the model rocket will land outside a launch site and calculate what corrections to make to the launch guide for an acceptable recovery. Remember the NAR rules stipulate that the launch rod angle must be kept to less than 30 degrees from vertical for model rockets and 20 degrees from vertical for high power models. If you find yourself exceeding these angles, try using a longer launch rod!

For those who are teachers, this technique provides a nice exercise on how real world events like the flight of a model rocket can be simulated with a mathematical model. This treat-

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ment has not been verified with actual field tests and data; I will leave it up to you and your students to measure the distance the models land from the launch pad and to see how well actual flight data agrees with the calculations. Feel free to contact me vial e-mail at: bsleviso@cc.ysu.edu to share your results and let me know what you think about this simulation and what you learned about its' sources of error.

About the Author:

Bruce S. Levison (NAR #69055, MTMA #606), A.K.A. The Teflon Rocketry Man, is a rocketeer from Ohio, a member of the National Association of Rocketry (NAR), and NAR section #606, the Mantua Township Missile Agency (MTMA). He has published articles on ejection charge proof expanded Teflon recovery systems (hence the nickname), camera tripod mounted launch pads, ablative blast deflectors, a horizontal painting swivel for model rockets, and a method for the simulation of tube fin rocket designs. Bruce holds an advanced degree in chemistry, and is the manager of an instrumentation facility in the Department of Biological Sciences at Youngstown State University.

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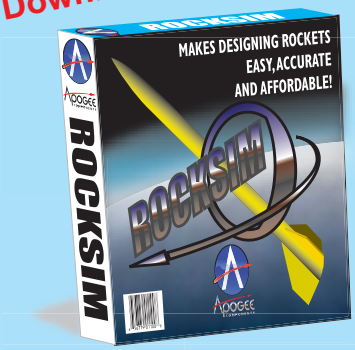

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