Landing 101

by: Dave Davis

One of the highpoints of being a modeler is the perfect flight. Flawless ignition, straight boost, good parachute deployment, and a perfect landing on the field. One of the constants of flying in the Northwest is something we cannot change or control. The wind. Wind creates a special problem for rockets and that's called drift. Drift is the condition of the rocket being blown along by the wind as it descends.

Now for some basic numbers. Descent rates (sink rates) and drift rates are measured in feet per second and we need a basic conversion factor to convert miles per hour to feet per second. How we get this conversion is to divide 5280 feet (feet in 1 mile) by 60 (minutes in an hour) and then divide this number by 60 again (seconds in a minute). This gives us a conversion factor of 1 mile per hour equals 1.47 feet per second.

What we're going to look at now is your basic rocket flight. An Aerotech Initiator powered by an Aerotech G64-10 motor. Here are our givens:

Field Size:	Launching from the center of a square field with 1500 feet on each side.
Vehicle Mass:	1.21 pounds
Vehicle Altitude:	2100 feet
Parachute Sink Rate:	20 feet per second
Wind Speed:	10 miles per hour

With our Initiator at 2100 feet and descending on its parachute at a rate of 20 feet per second, it will take 105 seconds for it to reach the ground. With the wind blowing at our Northwest typical 10 miles per hour, this translates to a drift factor of 14.7 feet per second by using the conversion discussed above. Knowing that the Initiator takes 105 seconds to reach the ground, we multiply the descent time by the wind speed of 14.7 feet per second. The result is that the Initiator will drift 1543 feet downrange. Note that the drift is almost 75% of the altitude and we are over 750 feet outside of our launch site.

Now let's take another look at our givens listed above. We have stated that the wind is a constant at all altitudes. Well, the wind is changing constantly and is moving at different speeds at different altitudes. However, it is known that wind speed is greater at altitude than it is at ground level. Therefore, the wind speed number is on the conservative side and approximate. Sink rate is also shown as a constant and it does not compensate for updrafts (thermals) from the ground or any lift generated by the parachute. The sink rate is then also a conservative approximate number. What this all means is, that our numbers exhibit a "best case" condition and will probably be lower that actual flight conditions. In any case, we will probably be at a minimum 1500 feet downrange. How do we compensate for this??

In order to keep a rocket on the field, several choices can be made. All have their benefits and all have their hazards. The first is to put a smaller motor in the rocket. This means lower altitude and given a constant sink rate, means less descent time, meaning less drift. You also reduce performance which is a bummer.

Another alternative is to reduce parachute size which increases the sink rate. By putting an 18" parachute on the Initiator the sink rate rises to 36 feet per second. This means that your bird will reach the ground in only 58 seconds and only drift 857 feet. Only 100 feet outside of the field boundaries now. Getting better.

However, the downside is, you will hit the ground very hard and severely damage the rocket. Not much of a choice there. Field tests have shown that your basic rocket can take landing shock between 20 and 25 feet per second impact without sustaining serious damage.

Waiting for the wind to die down is another option. However, with our Northwest winds, you may be waiting for a long time. Patience may be a virtue, but is it a viable option?

Bringing the vehicle down in pieces on seperate parachutes is also an option. This way you can use smaller 'chutes which reduce drift and you can retain your sink rate. This option isn't really practical with our Initiator. Because, we only have a booster and a nosecone. Another disadvantage of separate recovery is that you now have to go find two or more pieces and not just one.

In the past, we have chopped out a spill hole in the center of the parachute to let the air out. All this does is reduce the opening shock of the parachute and it is rather difficult to hack a hole in a ripstop nylon parachute. Not much of an option here either.

Another option is to alter the parachutes design to reduce its cross sectional area. Reduce cross sectional area and you reduce drift. By converting your parachute to an X-form shape, you reduce drift by close to 70% regardless of the parachute size. The down side is you have to have a bigger parachute to maintain the sink rate. Our Initiator requires a 30" X-form parachute to keep close to the desired 20 feet per second sink rate. However, due to its design, we still capture the 70% reduction in drift. This means that our drift will now be approximately 463 feet which will place us on the field without damaging the rocket. Reasonable compromise. However we now need to procure a new parachute. There are several X-form parachute manufacturers out there. So, shop around accordingly for the best buy.

It has been shown that we can land that rocket back on the field simply by changing the parachute. Now, what do you do if you don't have any X-form parachutes in your range box? Or you don't like X-forms? What do you do?

The answer is, you fall back on a basic concept of ballistics called Tartaglia's Law. Translated to rocketeese, it states: That a rocket that will go 1000 feet straight up will travel a horizontal distance of 2000 feet and will only ascent to a peak altitude of only

500 feet if launched at an angle of 45 degrees. This means that if we tilt our launch pad into the wind, we reduce the peak altitude, send the rocket uprange and have it drift back to us. Mother Nature will be working for us rather than against us!

Since we are limited by our safety code in the amount of tilt of the launch pad (N.A.R. 30 degrees, Tripoli 20 degrees) a table was generated combining the sink rate process used above with Tartaglia's Law.

Launch Pad Degrees of Tilt	Altitude in Feet	Uprange in Feet	24" Round Drift in Feet	30" X-Form Drift In Feet
0	2100	0	1543	464
10	1867	466	1372	411
20	1633	933	1200	360
30	1400	1400	1029	308

A close look at the table above shows that the Initiator with a 24" round parachute finally hits the field by tilting the launch pad 20 degrees. At 20 degrees tilt, the Initiator flies 933 feet uprange and coasts back 1200 feet landing slightly downrange of the launcher. We finally have the possibility of a successful flight. Due to the reduced altitude however, a change in delays is required to a G64-7.

The optimal setting for the 30" X-Form is a 10 degree tilt. At 10 degrees tilt, the Initiator travels 466 feet uprange and drifts back 411 feet landing less than 50 feet from the launcher. An even better configuration and is robust against wind gusts and changes in direction without changing the ejection delay.

One of the recurring problems we have at several northwest launch sites is keeping birds inside of the field boundaries. A typical example is the Monroe launch site. The Monroe site is rather large. But, due to the weird valley wind vectors, it is difficult to get a predictable recovery with flights over 2000 feet. A quick review of the data that was generated on the Initiator shows why. Even with a 10 mile per hour wind, which is pretty standard for Monroe, it is tough to hit the field on stock parachutes unless you really tilt the launch pad. The above material pertains to one of the universal laws of rocketry and is usable anywhere on any field. By using Tartaglias Law and the Knowledge of Drift, modelers can hope for a higher probability of a successful recovery. With our shorter days and limited launch windows, flight time is at a premium and the less time we spend recovering our models is more time we can spend flying them.

Authors Note: I could not have completed this article without the help of the Dave Fox Paracalc parachute program for his great work on sink rates and parachute sizing and The Handbook of Model Rocketry by Stine on Tartaglia's Law. Thanks for the experience and applied research guys. You make this modelers life easier.

X-Form Parachute Update

One of the major problems that people have when using X-form parachutes is that they tangle and do not deploy properly. When an X-form is tied to the shock cord or eyelet, it cannot center itself to deploy evenly. To solve X-form deployment problems, use a snap swivel on smaller 'chutes or Quick-Link/D-Rings on larger parachutes rather than tying them on. The open mount allows the shroud lines to move freely and not bind eliminating the tangle. The other end of the Quick-Link or swivel can be tied to the recovery system. Another rule of thumb is to have two to three feet of shock cord between the parachute and the nosecone/booster to relieve opening shock. The optimal folding method for X-forms is your basic spike. Formal folding is not necessary and eliminates the parachute from sometimes turning inside out upon deployment.