# Flight Planning

Every pilot plans his or her flight before getting in his aircraft, checking on wind and weather conditions, areas to avoid, contingency plans, etc. You should do the same.

Once a weather balloon has been released you have no further control of where it goes, when it bursts, or where it lands, making it doubly important that all of these are considered in advance.

Unlike winged aircraft, balloons simply travel with the wind. Where they end up depends on:

* Wind speeds and directions
* Ascent rate
* Burst altitude
* Descent rate

We have some degree of control over all of the above.

## Wind Speeds And Direction

No, we can’t (sadly) control these, but we can choose when to launch. I can’t stress the next statement enough:

*If you cannot ensure a safe flight,* ***do not launch****. Just wait for another day.*

Yes, you may have your heart set on a particular day, but please don’t. Even NASA postpone launches, so take a tip from their book.

## When To Launch

From about 6 days prior to launch, you can start running predictions for your launch site, using your expected ascent rate of 5m/s, expected burst altitude and using 5m/s as a landing speed. Don’t at this stage both with different figures for those. A typical burst altitude is 30km but it depends on your payload weight, balloon size and chosen ascent rate. For now stick with your expected/typical figures and see what the prediction is like for your chosen launch date.

Early predictions are notoriously inaccurate, much like any weather forecast. Generally they settle down and are accurate enough by 3 days from launch for you to have a good idea whether the launch can go ahead or not.

Continue to run predictions each day.

## Ascent Rate and Burst Altitude

Roughly speaking, the balloon ascends at the same vertical speed throughout the flight. The actual situation is quite complex, with factors including the filling gas (helium or hydrogen), air pressure, air temperature, balloon gas temperature (affected by incident heat from the sun), etc. All of the prediction software assumes a constant rate so that’s what we have to use.

The day before launch it is worth looking at different ascent rates to see if you can usefully move the landing area. A “normal” ascent rate is 5m/s but you can try rates from 4.5 to 6.0m/s. Going lower will risk the balloon not bursting (this is bad if you want to get it back!) and above 6m/s needs a lot of gas to make much difference.

As you change the ascent rate in the burst predictor (see your links page) you will see the burst altitude change (because the ascent rate depends on the amount of gas, and more gas means the balloon achieves its burst diameter at a lower altitude). This itself can be a useful tool in modifying the landing position. For example, imagine that at low altitudes the balloon travels due north, but at higher altitudes at travels due west. The ascent rate will affect both of those legs but the burst altitude will only affect the second. If you have a choice of balloons, you can change the burst altitude (a larger balloon bursts higher) thus moving the landing point west only. Conversely, changing the ascent rate will affect both legs (how much of each depends on the wind speeds at different altitudes). Combining the two gives you some control in both east-west and north-south directions, which is ideal.

In summer it’s very common for the lower and upper winds to be in different directions, with lower winds generally going from SW to NE, and higher winds generally travelling west. In the winter the jet stream comes south, reversing the higher lever winds and making them much stronger. The result is that winter flight predictions very often end up in Europe or the North Sea. Combined with stronger ground level winds (on average), and a higher chance of rain/snow, winter launches are much less frequent than summer ones.

## Landing Speed

Landing speed depends on the payload weight and parachute size. There’s a useful calculator (see your links page) for this. The calculation is quite simple and is worthwhile covering as part of a maths lesson.

It is not worthwhile trying to change the landing position by changing the landing speed.

First, much of the descent is very rapid. It’s not uncommon for flights to achieve vertical speeds of well over 100mph initially, and typically descend at 40mph when at 20km altitude. So the time spent in the descent phase, particularly at higher altitudes, is much less than during ascent, meaning that the horizontal track of the balloon is much shorter. We thus have a much shorter track to affect during descent than we did for the ascent.

Second, we don’t want to increase the landing speed by much, because the landing impact energy is a function of the square of the speed. So a small increase in landing speed has a large effect on the impact, which of course we don’t want.

Finally, using a larger parachute means that the balloon remnants have a greater chance of overtaking the parachute and tying itself around it. This then reduces the effectiveness of the parachute, increasing the descent rate which is the opposite to what we wanted.

So for the above reasons, choose a parachute size that will give you a landing speed close to 5m/s.

## Launch Date and Time

The date and time of launch both affect the wind and weather conditions, and it’s often advantageous to opt for a different launch day or even just change the launch time by a couple of hours. Spend time with the predictor to see what is optimal. Also check for ground level winds - anything above 12kph is difficult to launch in.

Of course you still need CAA permission for the launch date and time, so any changes that take you outside your launch window should be agreed first with the CAA. I suggest that 3 days prior to launch, you email the CAA either confirming your initial request, or changing the date/time accordingly. make sure they have at least 3 working days notice of the new launch window.

## Where To Land

Away from airports. Away from cities. Away from large towns.

Those are the essentials; after those you also want to avoid large lakes or forests, either of which make recovery tricky!

We cannot control the landing point exactly, but we should do our best to aim for a nice sparsely populated (by people or trees) area. Remember that the prediction is just that, and the actual landing will be different, because:

* The ascent rate depends on your ability to fill the balloon exactly
* Balloons can burst early or (more often) later than expected
* Your launch time is likely to be later than planned
* Wind predictions aren’t exact
* Balloon models aren’t perfect

So you need a large margin of error around the predicted landing position, especially if the distance travelled is large.