

# **EXIT SEPARATION**

Instructor A Thesis

By Steven Geens

## **Foreword**

The reason I chose this subject for my Instructor A Thesis is that there are still a lot of skydivers who should know a little more about this topic. How many times have you heard the question “How much time between exits?” and someone answers “5 seconds is fine”, not knowing what the groundspeed of the aircraft is or what kind of skydive that person is doing.

Another thing that some skydivers do is rely on vertical separation. This is a bad habit and shouldn't be recommended. Imagine slow openings, premature openings and malfunctions, and gone is our separation. So when I consider separation in this thesis I mean horizontal separation.

We also have a constant stream of new people coming into the sport, and they should be given more information about this subject fairly soon in their skydiving career.

I hope that after reading this thesis people will have greater understanding of how they can achieve a safe separation between different freefall groups.



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## **Introduction**

In recent years exit spacing (how much time/distance between exits) and exit order (which group/discipline exits when) has become a lot more complicated than say ten years ago. There are several reasons for this:

- Different freefall speeds (freely or formation skydiving)
- Disciplines that cover large horizontal distances (tracking, flocking, atmonauti)
- More dropzones using bigger turbine aircraft (more altitude, more exits)
- Faster canopies (require more distance between one another on opening)
- Different opening altitudes (students, tandems, canopy exercises)

In this thesis I will try to show that how and when we leave a plane is very important in connection with all the above factors, and that in fact it can make the difference between fun and tragedy.



I'll start very theoretically by calculating the distance/time needed between two groups flying the same discipline on a nil wind day. Then I will show how different freefall speeds, freefall drift and wind speeds can influence the required distance/time between the exits. The last section will discuss disciplines that use a lot of horizontal space or have higher opening altitudes.

## Jumprun

How long can we make a jumprun so that every jumper has a fair chance to land on the DZ? Canopies these days have an average airspeed of 13 m/s and average descent rate of 6.5 m/s<sup>1</sup>. We usually have open parachutes by around 2500 ft, so the useful height we have left to fly to the DZ will be around 2000 ft. (You lose a bit of time after opening while checking your airspace and turning to the DZ, and a bit with turning into wind for landing.)

2000 ft useful height and an average descent rate of 6.5 m/s gives us 92 seconds under canopy. In this time we can cover 1200 m. The maximum jumprun would then be 2400 m. This 2400 m length is always the same and will just shift over the DZ, depending on the winds.

For example:

Nil wind		$13 \text{ m/s} \times 92 \text{ s} = 1200 \text{ m}$ both sides of the DZ
Wind 7.5 m/s (15 kts) East		$(13 + 7.5) \text{ m/s} \times 92 \text{ s} = 1900 \text{ m}$ East side
		$(13 - 7.5) \text{ m/s} \times 92 \text{ s} = \underline{500} \text{ m}$ West side
		= 2400 m

## Jumprun into the East

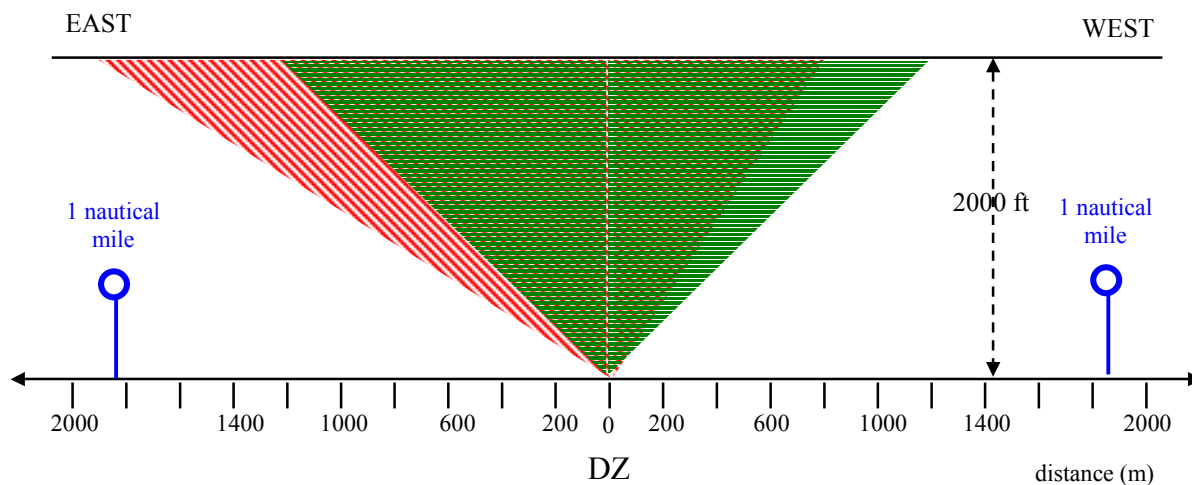


Figure 1: position of jumprun relative to DZ, for different winds

The time taken to cover this 2400 m depends on the groundspeed of the plane.

The following table tells us the time to cover 2400 m for a corresponding groundspeed of the plane.

Plane Groundspeed		Time to Cover
(knots)	(m/s)	2400 m (seconds)
40	20	120
50	25	96
60	30	80
70	35	68
80	40	60
90	45	53
100	50	48
110	55	43
120	60	40
130	65	37
140	70	34

Table 1: time to cover 2400 m, different groundspeeds

## Conclusion

We should always aim to put all skydivers out within the time to cover the 2400 m and still have a safe horizontal separation between all of them. If this is not possible, we have a few options:

- The last groups out open higher (but always with the necessary horizontal separation.)
- 2 jumpruns, but making sure the 2nd run checks for high or premature openings from the 1st.

## Exit Separation on a Nil Wind Day

**How much separation do we need between two groups, falling straight down, flying the same discipline, on a nil wind day?**

Studies have shown that for the average person, it takes 3 seconds<sup>2</sup> to recognize a collision situation and take some action to avoid it.

The average canopy these days has an airspeed of about 13 m/s.

This means we need an absolute minimum distance between two opening canopies of 78 m.

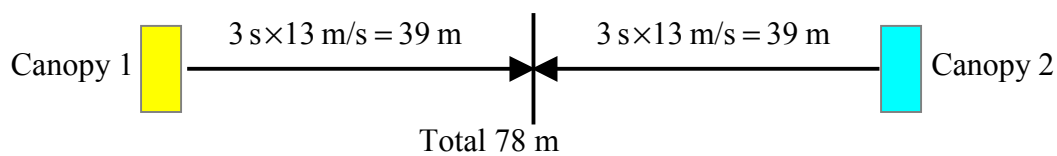


Figure 2: canopy separation for 3-second reaction

Now that we know how much the minimum space needed between two opening canopies is, we can calculate the required tracking distance and the size of the group at deployment, for different groups. For example, an 8-way:

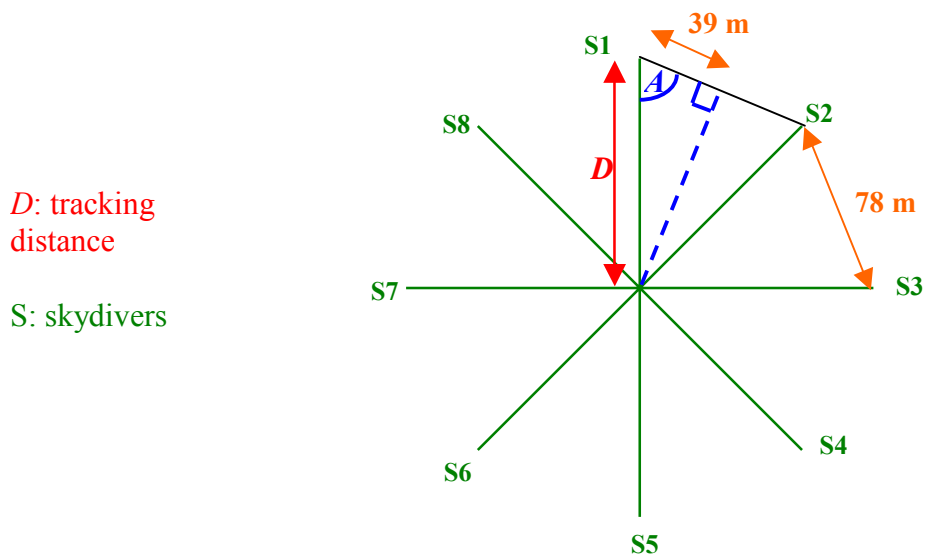


Figure 3: size of group due to tracking

So what we want to calculate is the distance from the centre when the skydivers reach a separation of 78 m. With the use of some trigonometry we first calculate angle A.

$$A = 90 - \frac{180}{S} \quad \left( 90 - \frac{180}{8} = 67.5^\circ \right)$$

and then

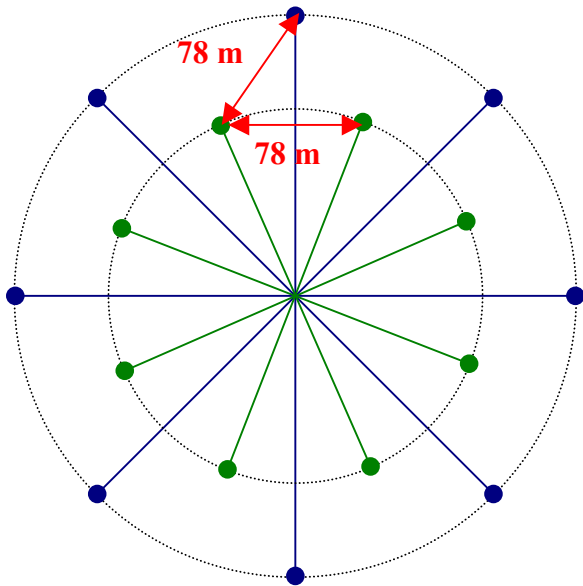
$$D = \frac{39}{\cos A} \quad \left( \frac{39}{\cos 67.5} = 102 \text{ m} \right)$$

The following table shows tracking distance and diameter of the group on deployment, for different size groups.

Group Size	Tracking Distance (m)	Group Diameter on Deployment (m)
1	0	39
2	39	78
3	45	90
4	55	110
5	66	132
6	78	156
7	80	180
8	102	204
9	114	228
10	126	252
16	200	400

Table 2: tracking distances for different size groups

This table can effectively be used up to a group size of 10. Above 10 the diameter of the group on deployment will actually be smaller because people can fill up the space closer to the centre and still have a safety distance of 78 m between each other (break off in waves, outside tracks further and longer than inside people.) For example 16-way:



The inner circle of 8 have to track 102 m to get their 78 m separation. The outer circle has to track an extra 70 m to get their 78 m. Considering this, the diameter of the group on deployment will only be 344 m and not 400 m as we see in the table above.

Figure 4: diameters of larger groups

However, I don't think we often need to calculate such big groups (the biggest jump plane in Australia takes around 20 jumpers.) If we need to, using the table above for calculating for example, a 4-way and a 16-way, will add extra separation between the groups, which is not a problem.

If we know how big the diameter of the groups are at deployment, and we know the minimum distance between two canopies on opening is 78 m (in order to have time to avoid collisions), then we can find the exit distance needed between two groups. For example, an 8-way and a 4-way:

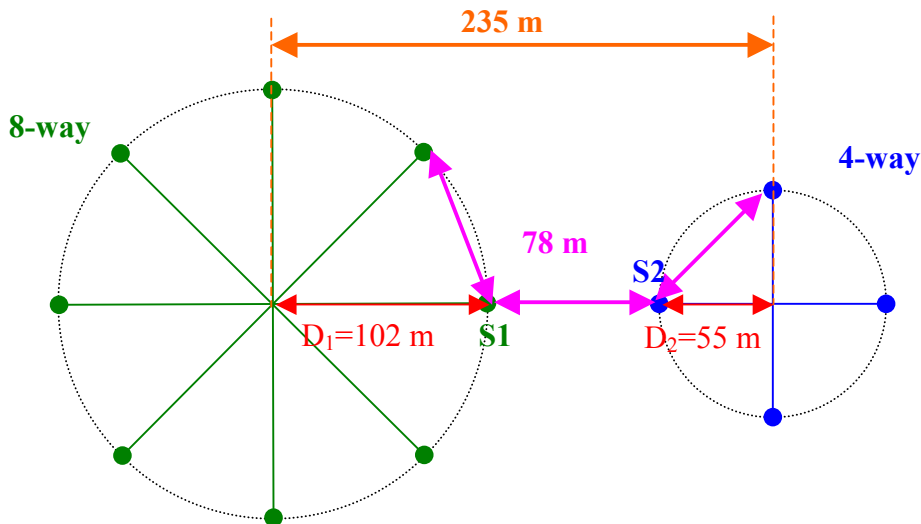


Figure 5: exit separation between 8-way and 4-way, nil wind, not accounting for canopy airspeed

Exit distance =  $D_1 + D_2 + 78$  m, where  $D_1$  and  $D_2$  are the tracking distances. In this example  $D_1 + D_2 + 78 = 102 + 55 + 78 = 235$  m.

However, this 235 m will not be enough to have a safe distance between the canopies!

Imagine we have a plane traveling at 40 m/s (80 kts). The 8-way exits and the 4-way then exits 235 m further along. It takes the plane 5.7 seconds ( $235 \text{ m} \div 40 \text{ m/s}$ ) to cover the 235 m. This means skydiver S1 will open their parachute 5.7 seconds before S2. S1's canopy (assuming an on-heading opening) will fly directly to the next group and will cover a distance 74 m in 5.7 seconds ( $13 \text{ m/s} \times 5.7 \text{ s}$ ). This is only 4 metres from where S2 will open their parachute! So we need to leave more time/distance between the groups.

If we take the speeds of the plane ( $v_p = 40$  m/s) and canopy ( $v_c = 13$  m/s) and use our original distance ( $D = 235$  m), we can find the time between exits  $t_e$  required so that the groups never interfere with each other.

$$t_e = \frac{D}{v_p - v_c} \quad \rightarrow \quad \frac{235 \text{ m}}{40 \text{ m/s} - 13 \text{ m/s}} = 8.7 \text{ s}$$

Exit distance needs to be  $8.7 \text{ s} \times 40 \text{ m/s} = 348$  m.

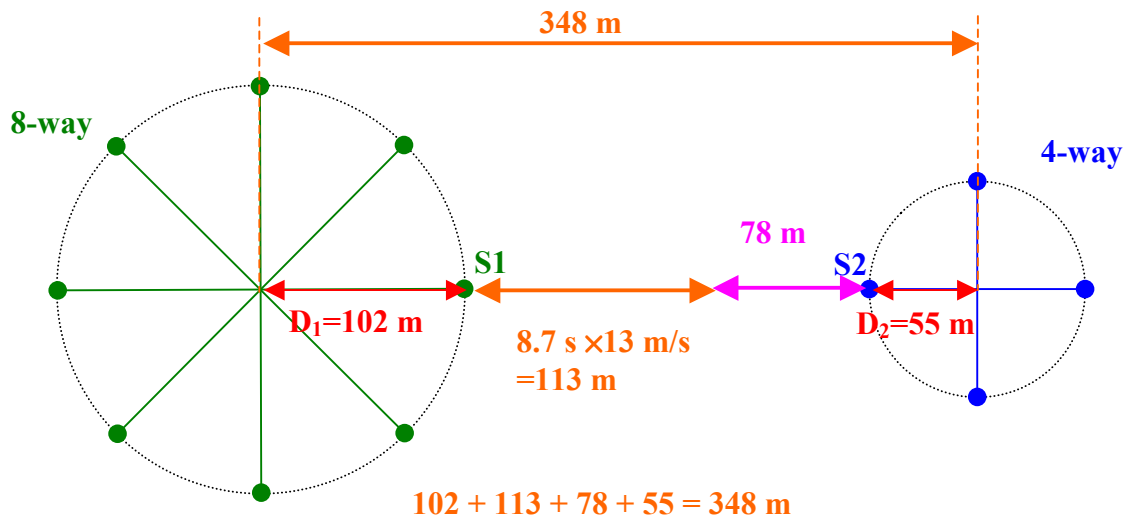


Figure 6: exit separation between 8-way and 4-way, nil wind, accounting for canopy airspeed

## Conclusion

So now we can calculate distance/time between the exits for different size groups. We can also calculate the length of the jump run.

Next we will talk about how the winds can influence our distance and time.

Note: all the calculations in this thesis require only senior high school mathematics, and the formulae used can be found in most math textbooks<sup>3</sup>.

## The Effect of Winds on Exit Separation

**In this section I will give some thoughts on how different winds can influence timing between exits. We'll talk about two groups doing the same discipline (formation skydiving or freeflying) with different possible winds at different altitudes.**

In the previous chapter we found that

$$t_e = \frac{D}{v_p - v_c} \quad \text{where } t_e = \text{time between exits}$$

$D$  = distance between exits

$v_p$  = speed of the plane

$v_c$  = speed of the canopy

Previously we assumed nil wind, so we could say that the airspeeds of the plane and the canopy were equal to the groundspeed (groundspeed is the rate at which ground is covered.) When there are winds, the airspeed and groundspeed will be different. Which speed should we use for our calculations? Air or groundspeed?

Airspeed is not very useful because it's constant unless the pilot changes the power or the skydiver uses their brakes. What we really need to look at is the groundspeed. And not only the groundspeed of the plane (a term often mentioned in the plane on run-in) but also the groundspeed of the canopies. We actually use the *difference* between the groundspeed of the plane and the groundspeed of the canopies.

The canopy we have to look at is the one from group 1 that is heading straight on jumprun in the direction of group 2.

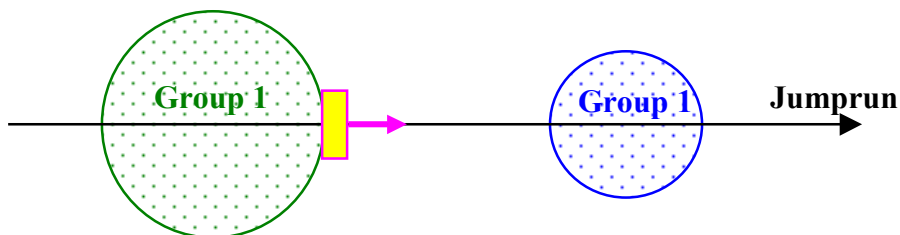


Figure 7: which canopy is important to the calculations

To do this we need to consider both the wind at exit altitude and the wind at opening altitude. If we would consider only the groundspeed of the plane, we would calculate the separation of the skydivers if they didn't open their parachutes!

**Some Examples:**

We look at a few different situations to illustrate this theory. I'm taking the same example as before (an 8-way followed by a 4-way) in different winds. In these examples we take the plane airspeed to be 50 m/s (100 kts) and canopy airspeed 13 m/s (26 kts).

**(A) A normal situation**

Wind at exit altitude	10 m/s (20 kts) East
Wind at opening altitude	5 m/s (10 kts) East
Run-in	East
Groundspeed of the plane	$v_p = 40$ m/s (80 kts)
Groundspeed of the canopy	$v_c = 8$ m/s (16 kts)

$$t_e = \frac{235 \text{ m}}{40 \text{ m/s} - 8 \text{ m/s}} = 7.3 \text{ s}$$

**(B) High Upper Winds**

Wind at exit altitude	25 m/s (50 kts) East
Wind at opening altitude	5 m/s (10 kts) East
Run-in	East
Groundspeed of the plane	$v_p = 25$ m/s (50 kts)
Groundspeed of the canopy	$v_c = 8$ m/s (16 kts)

$$t_e = \frac{235 \text{ m}}{25 \text{ m/s} - 8 \text{ m/s}} = 14 \text{ s}$$

**(C) Groundspeed of the plane is 0 kts**

Wind at exit altitude	50 m/s (100 kts) West
Wind at opening altitude	24 m/s (48 kts) West
Run-in	West
Groundspeed of the plane	$v_p = 0$ m/s (0 kts)
Groundspeed of the canopy	$v_c = -11$ m/s (-22 kts) → backwards

$$t_e = \frac{235 \text{ m}}{0 \text{ m/s} - (-11) \text{ m/s}} = 21 \text{ s}$$

**(D) Upper Winds opposite to lower winds**

Wind at exit altitude	20 m/s (40 kts) West
Wind at opening altitude	10 m/s (20 kts) East
Run-in	West
Groundspeed of the plane	$v_p = 30$ m/s (60 kts)
Groundspeed of the canopy	$v_c = 23$ m/s (46 kts)

$$t_e = \frac{235 \text{ m}}{30 \text{ m/s} - 23 \text{ m/s}} = 34 \text{ s!!}$$

So if you want to you can put your own scenarios together and see what the result is. You can change nearly all the data (upper and lower winds, run-in direction, airspeed of the plane, and group sizes.)

**From these examples we can see that**

- The bigger the difference in groundspeed between the plane and the canopies, the shorter the time between our exits.
- The smaller the difference, the longer we have to wait between exits.

Example (C) shows us that it's not only groundspeed of the plane that gives us separation. The groundspeed of the plane is 0 kts and we still get enough separation if we wait 21 seconds. It's a pretty extreme example, but I have been in a plane with groundspeed 0 on exit and I have gone backwards under canopy. What I wanted to show with this example is that it's the combination of the groundspeeds of both the plane and canopies that gives us our horizontal separation.

- In situations where ***upper and lower winds are in opposite directions***, we can end up in ***very dangerous situations***.

In a situation like this people would need to start exiting well before the DZ (so that the lower winds are in their favour to fly back to the DZ), and they would fly straight into the second group unless they left a gap of 34 seconds!

Leaving 34 seconds is not possible because the jump run would be too long. Swinging the run-in around 180° would give us enough separation but the last people out would land off DZ because the groundspeed of the plane would be too fast.

What should we do? Have two jump runs? A lot of aircraft operators don't like this, and it can also create problems if we operate more than one plane, or if someone has a premature deployment.

**Solution**

*It's the skydivers who have to bring about the solution here.* As soon as they can control their parachutes, they need to turn 90° to jump run and watch the next group open before flying back to the DZ. Sometimes a crosswind drop would also be a good solution, but only if the ground wind isn't too strong, otherwise the jumprun would be too short.

The following graph shows the time needed for different relative groundspeeds, for a given exit distance.

Remember the relative groundspeed  $v = v_p - v_c$ , where  $v_p$  is the plane groundspeed and  $v_c$  is the canopy groundspeed. So you need to know winds at exit altitude and opening altitude to find  $v$ .

We recall that using Table 2, page 10, we can find the exit distance (tracking distance of group 1 + tracking distance of group 2 + 78 m). Find the required distance on the x-axis, and make a straight line up to the line representing the relative groundspeed  $v$ . Drawing a straight line across to the y-axis will give the time needed between exits.

For example, if we need separation of 300m, and we have relative groundspeed of 20 m/s, we will need to leave 15 seconds between exits of groups doing the same discipline.

On the graph we see that the smaller  $v$  becomes, the more time we require for separation. If  $v$  gets to 0 we can never have separation.

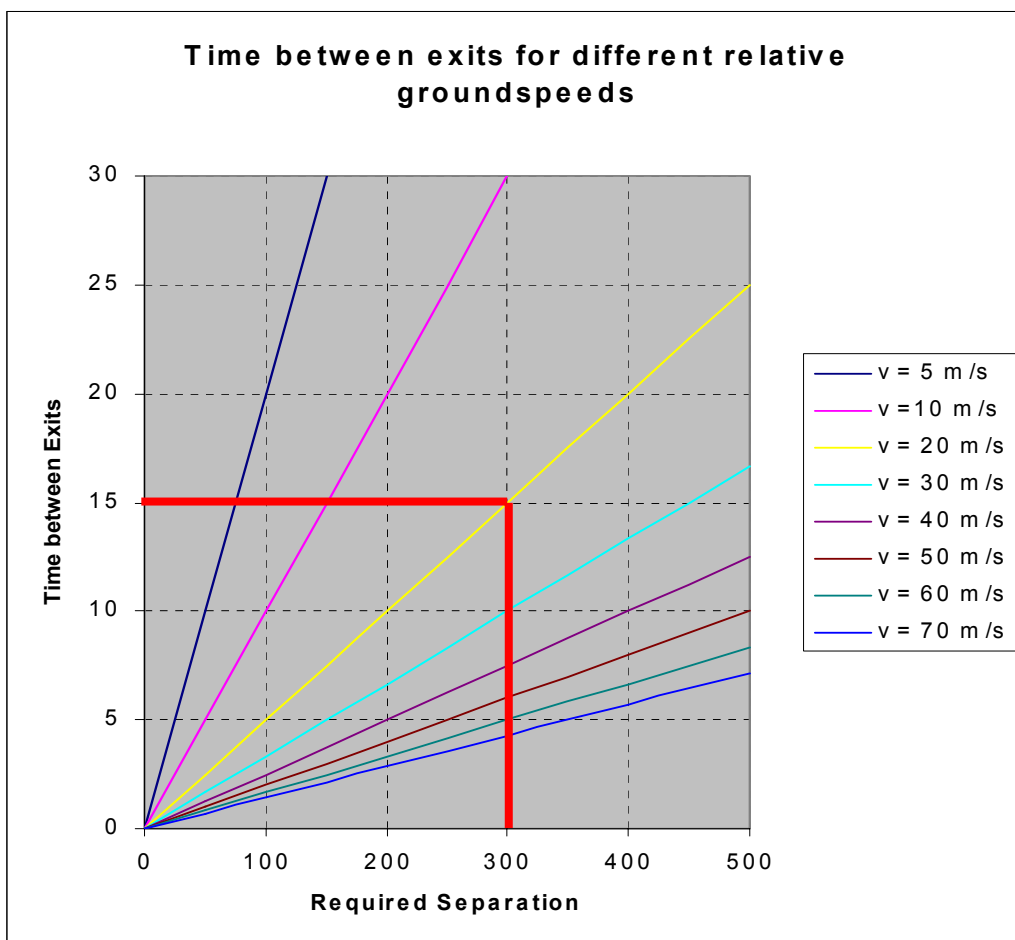


Figure 8: exit separation time/distance for different relative groundspeeds

## Disciplines with Different Vertical Speeds

The last 10 to 12 years have seen a big evolution in skydiving. New disciplines have come onto the scene. The biggest one of them is definitely freefly. When putting these new disciplines together in the plane we have seen some surprising results in relation to separation on opening.

For years now discussions have been going on about exit order for freefly and formation skydiving. So let's have a look at the different physics of a fast falling group (Freefly, FF) and a slow falling group (formation skydiving, FS) and see if we can find out what is really happening up there.

### Freefall Drift

Freefall Drift is horizontal drift in freefall caused by moving layers of air (wind). After about 10 seconds in freefall we are moving with the same horizontal speed as the layer of air we are falling through<sup>4</sup>. So this means the stronger the upper winds are, and the longer we are falling through them, the more freefall drift we will have.

The time spent in freefall is the most important factor for us because that is what will change the separation on opening between groups of slow and fast fallers. From 14000 ft a formation skydiving group (average speed 190 km/h or 53 m/s) will spend 70 seconds in freefall. A group of freeflyers (average speed 260 km/h or 73 m/s) will spend 50 seconds in freefall (both groups opening between 2000 and 2500 ft.) That means that the slower falling group will be blown horizontally for an extra 20 seconds longer than the fast fallers.

How can we find out how big the difference will be? First we have to know how strong and in which direction the winds are that we are falling through. Here there are 2 options: first we can call the metrology report or secondly we can read instruments in the plane on the way to height.

For example:

4-way FS team & 3-way FF team

Airspeed of plane 80 kts (40 m/s)

Winds	0000→ 5000 ft, 270°	15 kts/7.5m/s
	5000→ 10000 ft, 270°	30 kts/15m/s
	10000→ 14000 ft, 270°	40 kts/20m/s

We can first calculate the time needed between exits for groups flying the same discipline (see chapter **The Effect of Winds** page 13). The time needed is 12 seconds. The plane covers 240 m in 12 seconds. The next step is to find the average wind for the whole freefall if the skydivers open at 2500 ft.

$$\text{Av. Wind Speed} : \frac{(2500 \text{ ft} \times 15 \text{ kts}) + (5000 \text{ ft} \times 30 \text{ kts}) + (4000 \text{ ft} \times 40 \text{ kts})}{11500} = 30 \text{ kts}$$

The average freefall drift for the whole skydive will be 30 kts (15 m/s). The heading we will drift at is 90°.

The freefall drift for the 4-way FS is  $70 \text{ s} \times 15 \text{ m/s} = 1050 \text{ m}$ .

The freefall drift for the 3-way FF is  $50 \text{ s} \times 15 \text{ m/s} = 750 \text{ m}$ .

So the FS team will drift 300 m further than the FF team. If we take this back in the plane we get the following results.

The plane runs into the uppers (headwind). The 3-way FF team exits first and the 4-way FS team exits 12 seconds (240 m) later. This scenario will have the 4-way FS open *almost directly on top of* the 3-way FF 32 seconds after they opened!

If we reverse the exit order, the freefall drift will create an extra spacing of 300 m. The two groups will open 540 m from each other!! (The 3-way FF opens 8 seconds before the 4-way FS.)

### Conclusions

- Putting slow fallers out before fast fallers on a day with reasonable upper winds will create extra separation. Keep in mind that if the jumprun is turned around 180° this would make the separation smaller but I don't think any skydiver would run a plane in with a 40 kt tailwind without a good reason.
- Even on light wind days it would be a better idea to put slow fallers out before fast fallers. If fast fallers would go first they will open their canopies an extra 20 seconds before the slow fallers, and they can spread out a lot more in that time.

The table below shows the amount of freefall drift for different average wind speeds and time spent in freefall.

Time (sec) in freefall	Average Wind					
	60 kts 30 m/s	50 kts 25 m/s	40 kts 20 m/s	30 kts 15 m/s	20 kts 10 m/s	10 kts 5 m/s
70	2100	1750	1400	1050	700	350
60	1800	1500	1200	900	600	300
50	1500	1250	1000	750	500	250
40	1200	1000	800	600	400	200
30	900	750	600	450	300	150
20	600	500	400	300	200	100
10	300	250	200	150	100	50
Drift in metres						

Table 3: Freefall drift in different winds

## Forward Throw

When we leave the plane our bodies keep traveling for a certain time in the same direction as the plane. How far depends on the airspeed of the plane and on the relationship between mass and drag of the bodies.

For instance, a tandem will have more forward throw than a single body. Freeflyers who only expose head-shoulders-arms and a part of their legs (head down) or feet (head up) will have more forward throw than belly flyers who expose a lot more of their body surface to the wind.

Computer simulations have shown this result. A fast faller will be thrown a distance equal to the ground covered by the plane in 4 seconds (nil wind situation), further than a slow faller<sup>2</sup>.

For example:

4-way FS team & 3-way FF team

Nil wind day

Airspeed of plane 80 kts (40 m/s)

Calculated time/distance between exits 6.5 s – 260 m

Distance covered by plane in 4 s = 160 m

If the FF team leaves before the FS team, the horizontal separation will be *reduced to 100 m*, which is not enough. Switching the exit order around increases the separation to 420 m.

## Conclusion

Even on nil wind days it's better to have slow fallers exit before fast fallers because the forward throw will make extra separation!

## Disciplines with Horizontal Movement

The disciplines we are talking about here are tracking, atmonauti and flocking dives. Usually there are no separation problems with these kinds of dives. Some problems I have seen with them are

- Off DZ landings because the group misjudged the distance they planned to cover.
- Off DZ landings because the heading of the group was not so good
- Canopies opening on top of each other because the heading was so far wrong that they ended up flying along jump run.

## Recommendations

- Horizontal movement should always be planned 90° on jumprun unless there is only one group exiting.
- If we have more than one group with horizontal movement, then one group should go 90° left and the next 90° right etc.
- We *must be aware of our heading* during the jump.
- Experienced people must lead these dives.
- Plan a slightly higher break-off because a fast tracking dive can cover  $\pm 1200$  m in a minute.

What order should they get out? It doesn't matter! First – last – in the middle. If the groups do their movement 90° to jumprun there is no problem with separation because they open far enough from jumprun.

What we should aim for is to have them open in a spot where they can more easily make it back to the DZ. The easiest for them would be if they were to open slightly upwind. The diagram below shows this.

Everyone opening in the circle, around 2500 ft can land on the DZ. Tracking, flocking and atmonauti should exit in the shaded area. Then they can move a lot further and still land back on the DZ.

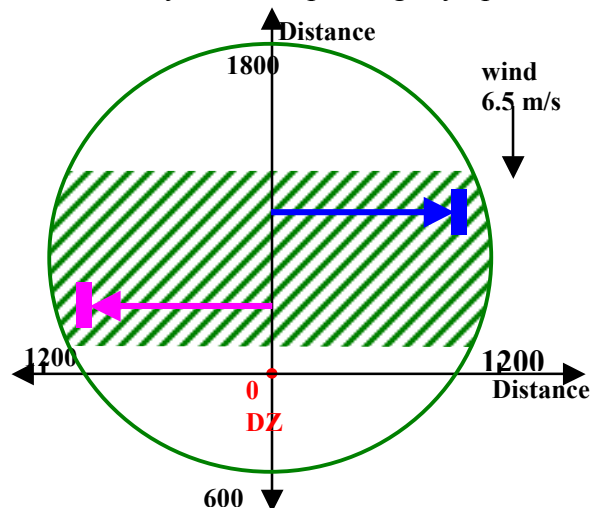


Figure 9: exit area for tracking - flocking - atmonauti

**Conclusion**

There is no problem with separation if the groups move 90° to jumprun. The best order for disciplines with horizontal movement would be in the middle of the stack-up, because that gives them the best chance to land on the DZ.



## High Openings

Some skydives require higher opening altitudes. CRW usually open straight out of the door. Skysurf, students, Tandems open around 4000 ft, and people who want to do some canopy exercises open high too. Basically if we have done all our calculations correctly, the order shouldn't matter much because we calculate a safe horizontal separation between the groups.

### Practically

- CRW likes to exit early because it works better for them (heading and groundspeed of the canopies.)
- Most skysurfers like to get out early too because its usually a lot easier for them to be close to the door for attaching their boards and exiting.
- The aim with students should be to give them a spot where they can easily make it back to the DZ, as they are slower at locating the DZ and assessing their situation. For this reason, they can end up at any place in the exit order. Logically we would put students out after the FS but usually we put them out after the FF because students have slower climb-outs and they open a little higher. If you have students going after the fast fallers, make sure you leave extra time to compensate for freefall drift and forward throw. It also depends a lot on the situation of the day. At my DZ for example we put the students out early if the jumprun is east and late if the jumprun is west because the student landing area is on the west side of the DZ.
- Tandems exit after FS, FF and students because its easier for them to open a bit higher if the spot is long.
- People who do canopy exercises usually exit very last because they have plenty of altitude to make it back to the DZ.

## Exit Order

Now that we have seen what switching around the exit order of different groups can do to separation, and have looked at what different disciplines want and need to do their jumps in the best and safest conditions. How would the exit order look if we had all these disciplines in one plane and on one jumprun?

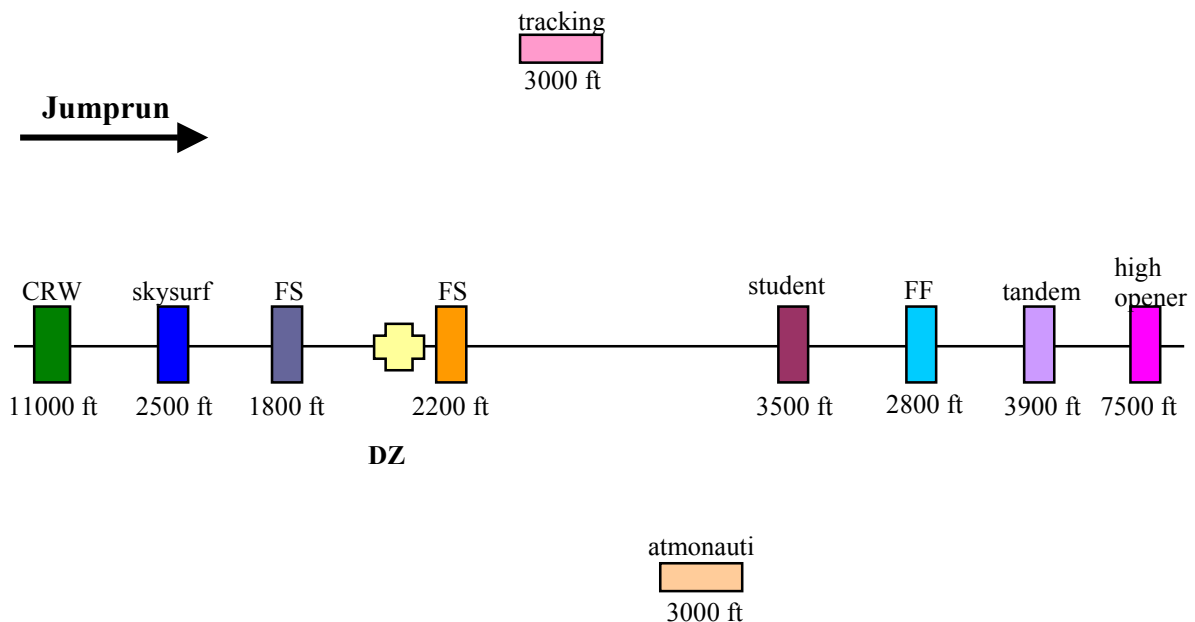
There are probably a few good solutions and it can also change from DZ to DZ and day to day.

A good solution for all disciplines could look like this:

### On a Normal Day

E.g. Low ground winds (0-10 kts)  
Moderate uppers (10-20 kts)  
Ground winds and uppers in the same direction

### *View one minute after last exit*



This scenario is going to give us the shortest jumprun. Similar exit order plans (excluding tracking and atmonauti) can be found at [www.skydivetheranch.com/exit\\_point.htm](http://www.skydivetheranch.com/exit_point.htm)<sup>5</sup>. If we were to change the order, the jumprun would need to be longer to achieve the same separation, which could result in some groups having difficulty landing on the DZ. So this exit order can be used as a basic plan for achieving safe separation, making minor changes depending on the situation of the day.

Most days we would switch FF and students and leave a bit more space between them to compensate for FF drift and forward throw.

## Conclusions

In the previous sections we learnt how to calculate our exit spacing for different size groups – disciplines – winds – exit orders.

As you see we have a lot of different possibilities and we need a lot of data. Realistically I don't think its possible every time and every load to actually calculate our spacing. If you have a bad weather day at the DZ you can create some different situations, do all the calculations and see what happens.

So how would I use this thesis practically?

First, try to get as much information as you can about the winds. Look at wind indicators – moving clouds, use the weather report or ask for a metrology report. Basically what I try to assess is whether we have a normal day or a more complex situation.

Then have a look at the load. How many exits, what disciplines and group sizes, and put them in the best possible order. On a normal day (light to moderate winds, uppers and lowers in the same direction) I'm going to take a minimum distance for groups under 4 of 300 m and 500 m for groups of 4-10. These distances (300 and 500 m) consist of tracking distances, 3-second reaction time (78 m) and an extra safety buffer of 130 m (3 seconds under canopy) if one canopy would fly straight to the next group after they open.

On the way up I double check with the GPS to see if my guess about winds was right. On jumprun I check the groundspeed of the plane on the GPS – that number tells me how long the plane is going to take to cover 300 or 500 m (1 kt = 0.5 m/s.) If there is no GPS in the plane I can look for landmarks on the ground and estimate my distance that way. On a normal day this system is going to work without any problem.

Now on days where we have abnormal situations a very important thing to do is brief all the people on the load about the situation. On the following page I will give a summary of abnormal situations and the solution.

Situation	Solution
Low groundspeed (below 60 kts)	<ul style="list-style-type: none"> <li>- Long time between exits</li> <li>- Tell people to be patient at the door</li> <li>- Fly off wind line as soon as you have control of your parachute</li> </ul>
High groundspeed (above 110 kts)	<ul style="list-style-type: none"> <li>- Short time between exits</li> <li>- Tell people to be ready in the door</li> </ul>
Fast fallers exiting before slow fallers	<ul style="list-style-type: none"> <li>- Leave extra spacing of 100 m per 10 kts average upper wind + 4 seconds extra spacing to compensate for forward throw</li> </ul>
Groups exiting before the DZ	<ul style="list-style-type: none"> <li>- Fly off wind line as soon as you have control of your parachute</li> <li>- Don't fly to DZ until you see the group after you open</li> </ul>
Upper and lower winds opposite	<ul style="list-style-type: none"> <li>- Brief the whole group on the importance of flying off wind line as soon as they control their parachutes</li> <li>- Don't take students or inexperienced people aboard unless you can put them somewhere where they can't interfere with others</li> </ul>
Crosswind jumprun	<ul style="list-style-type: none"> <li>- Brief the whole group on the fact that they will open off wind line</li> <li>- Take extra care for groups with horizontal movement. The direction they head toward is important if they want to land on the DZ</li> </ul>
High breakoffs	<ul style="list-style-type: none"> <li>- Don't track on aircraft heading for too long because you end up in another groups airspace (a good track can do 20 m/s)</li> </ul>
Lots of exits	<ul style="list-style-type: none"> <li>- Tell first and last groups they might have to open higher to make the DZ or else do two runs</li> </ul>
Run in with tailwind	<ul style="list-style-type: none"> <li>- See if it's worth switching slow and fast fallers around. Use freefall drift and forward throw to make your decision</li> </ul>

In all these situations what we see repeated a lot is “as soon as you control your parachute fly off wind line”. In recent years a lot of new skydivers don't really bother about jumprun and spotting because it's usually done for them (e.g. GPS, pilot puts lights on for OK). A GPS is more accurate than a person (especially from 14000 ft) but the

jumprun direction and where you are going to open are very essential things in making a skydive safe.

So that's why this is a subject we really should emphasize as early as possible in a skydiver's career. Every jump, every skydiver should know what the jumprun is so they know where to turn their parachute after opening. If we are in the habit of doing this every jump (even on normal days) and also spot the groups opening after and before us, we can create a lot more awareness amongst skydivers. Another advantage we have with people doing this is that it is more natural for them to follow the group in front of them to the landing area and thus land in a staggered sequence. Also, if people are learning freefly (freefly beginners tend to move a lot forwards or backwards), we can tell them to do their practice 90° to jumprun, so they don't move into the airspace of other groups.

## **Author's Note**

Our sport is constantly changing. Disciplines change, new disciplines show up. Who knows what is going to change in the future. I know that there are some things in this thesis that people might not agree on, but I'm always open to discussions or new ideas to make our sport safer.

What I really wanted to do with this thesis was to give people a better insight into what to do and what to avoid. I also wanted to show that on some days the situation can be difficult and complex to create safe separation.

I would like people to have more discussions about this subject, especially with new people in the sport, because a lot of the subject matter might sound very abstract to them. I wish that not everyone had to experience a close call or near miss before they start thinking about order and spacing.

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Steven Geens, November 2003

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