

# GFO fresh meteorite fall searching advice handbook

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Please ask for details or advice – [gfo.data@gmail.com](mailto:gfo.data@gmail.com), [martin.towner@curtin.edu.au](mailto:martin.towner@curtin.edu.au). We are here to help!

## Overview

Searching for a fresh meteorite fall is about thoroughly searching an area, not quickly searching it: It is usually better to cover half the area slowly, and be sure it was done properly, and then come back for another trip, compared to quickly covering a large area, but not being sure if it was well done. Depending on how remote the area is, it is also often helpful to have a brief visit to the site beforehand, to see what the ground/vegetation is like, and to speak to the land owners.

The basic concept is for a group of people to walk over the ground systematically, based on a fall line prediction. We'll explain each step below. You need some way of keeping track of where people have searched, such as GPS units or survey flags.

We have added meteorite photo examples from the web at the end of this doc to show all team members before searching. Volunteers need to know what to look for!

## Getting started

Your starting point will be a Fall line, and a mass estimate. – here's a couple of examples,

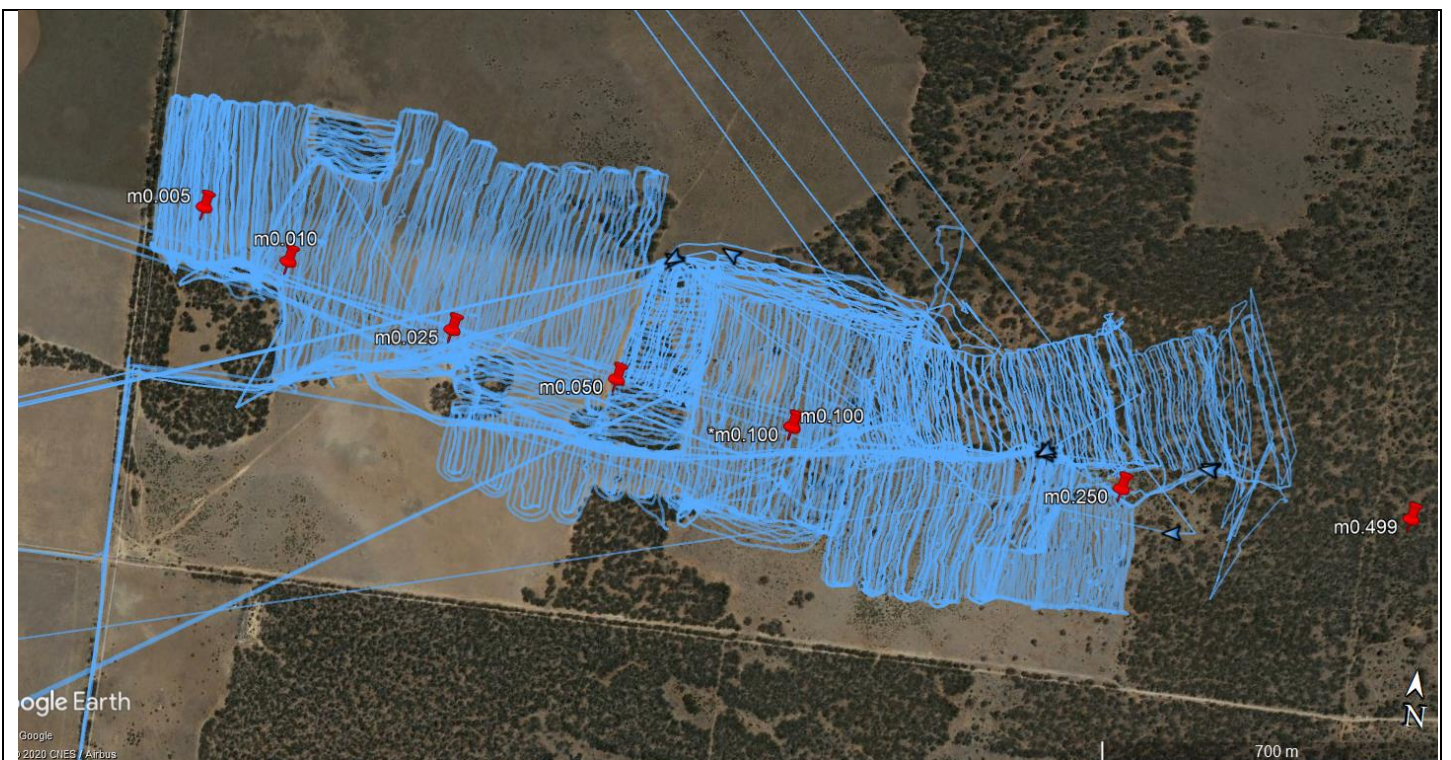


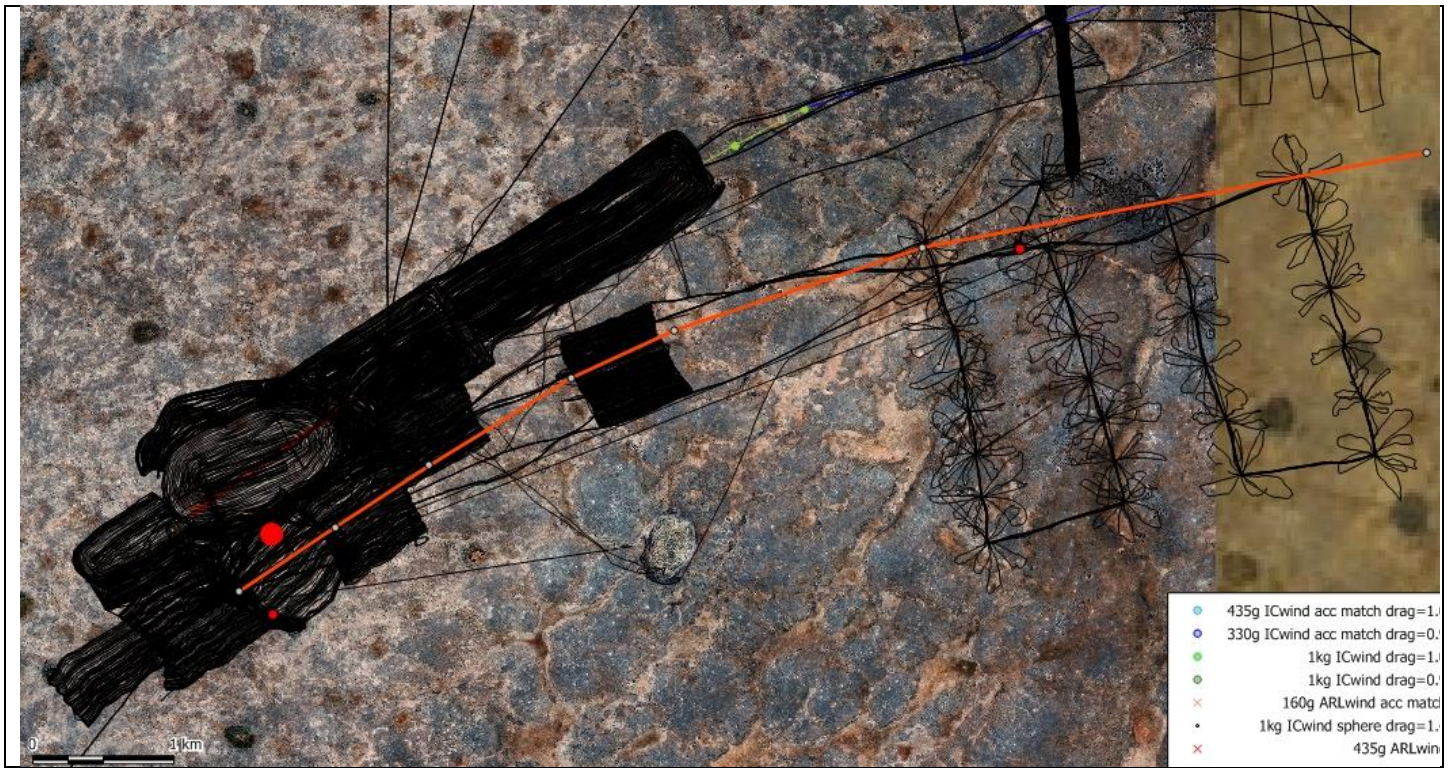


The fall line is calculated by modelling different final masses from the last seen point of the fireball (we basically assume we don't know the final mass and try a suite of options). The points given on this fall line show **where a meteorite would go, if it was that mass**. It is **not** showing that there is a meteorite at 0.5kg, 1kg, 2kg, etc.

Along with the fall line, there is a mass estimate: this indicates which part of the fall line is your target, and also a prediction of the uncertainty, to estimate how far to the sides from the fall line is plausible.

Here's some finished search plots showing how we searched areas.





In the top figure, we walked legs across the fall line, in the lower figure, we walked legs along the fall lines. In the lower figure, there were 2 possible scenarios for the meteorite, so there were 2 fall lines (yellow and red).

The basic approach is to walk together slowly covering the area, just like a police line.



From the maps, you can see that the full area was covered by walking in 'legs' (short sections, usually 500-700m long, either along or across the line. Legs hold structure better; walking really long distances in one go without turning can result in wobble in the line, and loss of concentration. Also, doing legs as units allows planning of the day, and breaks, etc.

Walk slowly as a group, with a fixed spacing, and looking on either side of you towards your neighbour. Keep an eye on the leader and your neighbours to keep the distances roughly constant. Try not to bunch up, and don't get ahead of the leader. If people are not walking straight, it should be ok to just say something – searching is a team sport, not a competition 😊.

*Helpful hint:* Occasionally, just stop and have a look backwards, to see a different viewpoint. Shadows will be different and may help you spot the meteorite.

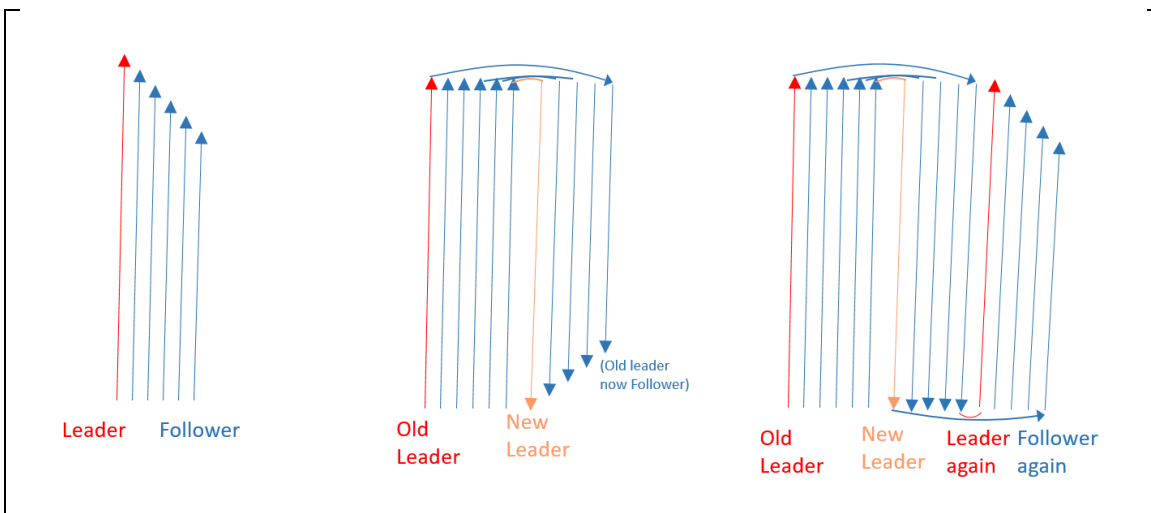
## Walking in lines:

The spacing between people will depend on the ground, and how big a rock you are looking for: Do a quick test, with a random dark rock on the ground. Walk away from it, look back, and think how far away are you confident of seeing it as you walk past. For reference, for DFN searches, our typical spacing varies from 10 m (for example the ground in the figure above, looking for a relatively large 1 kg object), to 1-2 m (looking for a 10 g small rock in more bushes).

1 kg meteorite = baseball/orange size; 100 g = golf ball; 30-50 g = end joint of finger/thumb.

*A note on speed* – you need to be walking reasonably slowly, about 2km/hour, to make sure you have time to look all across the area you're covering. This can be tiring, but you don't want to miss it. Terrain can vary across the line too, and some may have more vegetation than others to cross; if the leader or others are walking too fast for you, ask them to wait a minute for you to catch up. Don't be tempted to avoid thicker patches, it could be under one of those bushes!

Keeping track of where people have walked can be done with flags, or using handheld GPS units which support track recording (there are many apps for phones that can log your GPS coordinates also, some more reliable than others). In both cases, one person leads, and the rest of the team follow this person by trying to stay the right distance from them. At end of a leg, turn around. Usually the furthest follower at the other end of line becomes leader, and old leader becomes a follower:



If you are a follower, check your distance from the team leader, not just your distance from neighbours. If you only follow your neighbours, small errors become amplified, and line gets wavy quite quickly.

## If you find a possible meteorite:

Take a photo of the rock in place, with something for scale. Log the GPS coordinates. It can also be useful to get some pictures of the nearby area for reference. Use sterile bag, ideally teflon or canvas. Try not to touch with hands. Metal tongs are best, or just use a bag over your hand.

*Helpful hint:* Take the photo of the rock with the GPS unit showing the coordinates. You can get both scale and location in one picture. Don't test it with a magnet. Magnets will destroy any remnant magnetism that might be present in the meteorite, which may come from the parent body so is scientifically valuable. Instead, check the magnetism by moving the meteorite quickly over/under a magnetic compass, holding the compass still, and see if the needle moves. Not all meteorites are magnetic! If you are not sure, collect it anyway. Tag the sample bag with either a waypoint number, or coordinates.

*Helpful hint:* Write a numbered list of the samples you collect in a notebook, and write the coordinates/waypoint number there, along with any observations of the area. Then you can write just the sample number on all collection bags.

You will also need to collect 2 field blank samples of the local soil, one in the same type of bag you used to collect your meteorite, and one in aluminium foil. Collect some of the surrounding soil/dirt in both of these containers. Don't forget to tag all your blank sample bags with the sample number, waypoint number, or coordinates.

*Helpful hint:* pre-make small envelopes out of aluminium foil. Do not put your meteorite sample in aluminium foil.



## Advice for leaders

**Maps in the field:** You will need to take maps of the fall line and surrounding area with you into the field. Both A3 print outs and digital copies are recommended. The DFN uses the phone app Maverick ([https://play.google.com/store/apps/details?id=com.codesector.maverick.lite&hl=en\\_AU](https://play.google.com/store/apps/details?id=com.codesector.maverick.lite&hl=en_AU)) to load the fall line KML, and satellite maps. Remember to cache basemaps while you have internet access. This app can also be used by individuals in your team to record their GPS walking track if handheld GPS units are unavailable.

**Establishing the very first line for walking:** a compass is helpful, to get a straight line. To use a compass to walk a bearing will depend on your type of compass, and there are many online guides, on sites such as wikihow or youtube. Remember to correct it for magnetic declination (<http://www.magnetic-declination.com>). Use the compass to walk in a straight line, choosing a bearing to fit (along or across) the fall line. At the same time, use the GPS to measure how far from the start you have walked. After this, for future lines, you should use the GPS or flags.

Remember to **take breaks** – even the best human minds get bored and tired easily. Typically our day would be 8 hour maximum searching. start, do 2 hours searching, 20 min break where we sit down, have snack, chat, then 2 hours searching, lunch break, 2 hours, 20min break, 2 hours finish. Day length is also limited by sunshine and shadows, as mentioned later.

**If people are tired,** just stop – it's better have a break, or to go slower, than to walk over an area and then not be sure if it's been well searched. As a leader, if you see people speed up later in the day, they are tired and just want to finish the distance, rather than looking properly. Time to stop or have a short break. Look to see if they are moving their head and looking around, or just looking straight ahead.

If **people have trouble walking in a straight line.** Some people drift from a straight line quite often. Remind them, and maybe move them to a different position in the line – put wanderers in between disciplined walkers. If you are leading, put them next to you. If you are using flags, put them on the end, so that they have to walk over their flags. If you are using GPS units instead of flags, don't put them on the end! This also happens if one person is too fast, they get ahead of the leader and then start curving off to one side. Just ask them to wait. Similarly, if people are falling behind, you need to stop the line and wait for them to catch up. They could be tired, or maybe they are just dealing with an area of thick vegetation that takes more time to search.

**Planning:** start at the highest probability prediction areas first (so the best prediction for the mass), then work outwards either side of the fall line, and along the fall line.

## Keeping track

For a longer expedition, of several days, a laptop is very helpful to record the areas walked, and plot it over the fall line. Garmin Basecamp software (win 7,10) connects to GPS units well, and will also import KML fall lines. It is free, and sufficient for searching trips. Make sure you have the right USB cables to connect to GPS or phones! Also, make backups! A USB stick is fine, but a daily backup is important in case the laptop fails when you might lose several days' worth of GPS tracks.

During the day, for walking in lines,

For flags:

Survey pin flags work well, such as these:



...but any visible marker will work, such as for example bamboo poles with coloured cloth/tape. If you use flags, you will still need at least one GPS unit for the leader, to record which areas of the fall line you have covered. And more GPS units is more helpful (or ask followers to track their walking lines on a phone app).

- To use flags, the leader and the last follower should both carry 20-30 flags.
- Walking out for the first line, they both put flags in the ground as they walk, at approximately 20m spacing – depending on the vegetation. At least the next two flags should be visible.
- Then at the end of the leg, the team moves over, and the new leader walks back along the flags they have put out, collecting them as they go. At the same time, the follower is deploying new flags, to make the next line.
- The end result is 2 parallel lines of flags on the ground, that move further apart as the team walks each leg



here you can see the flags ahead of the walkers, and the left person is leader, currently collecting the flags. The walking pattern is exactly the same as the earlier figure.



In this figure, the group are equally spaced between tall poles. They walk toward an identical set at the end of the line, and will move to the next set after turning around. It is not necessary to pre-position your flags, rather the alternating leaders can remove and re-position en-route. Depending on the terrain, it can be helpful for the outer follower to position flags en-route to follow and retrieve on their return as new leader.

To use GPS:

Garmin or Magellan are the standard outdoor units. We have used Garmin GPSMAP 60 series (61, 62, 64 etc), but they are quite expensive. You can use smartphones for logging, but people will probably need battery boost/chargers for a full day, as GPS uses phone battery quickly. An example app would be

<https://play.google.com/store/apps/details?id=eu.basicairdata.graziano.gpslogger> or  
<https://play.google.com/store/apps/details?id=com.codesector.maverick.lite>.

But there are plenty of other options.

For GPS units, you need a USB cable to connect to a laptop to record all the data, and gamin Basecamp software (free from Garmin website)

For walking in lines, the leader will be walking looking at the GPS, checking the tracks that show where they have previously walked, and will try to walk parallel to their old line. It needs some concentration and practice. The GPS display track of your current walk will lag your position slightly, so you have to anticipate curves and correct drift. If it is causing wobbles, and big gaps, the solution is to use a compass, and make a fresh straight line. Then at a later day, review the track records in laptop screen and have a session where the team fills in gaps across the whole search area.

If you use GPS units, you will need lots of **batteries**! For Garmin units, budget for 1 AA per person per day, plus 20% extras.

Pros and cons of flags/GPS:

Flags are more thorough. But slower, as one person covers the same ground putting in and then picking out flags. This overlap and loss of person-time is more important for a small searching group of a few people, less so for a big group. Flags mean there are no gaps, and no unsearched areas. This is good if there is lots of vegetation. Also to walk to flags needs less concentration and operator skill.

GPS covers the ground faster as there is no overlap. One person (usually the leader) is half-time busy monitoring the route on GPS, so not fully searching. They need to be good/focussed, or the walked line will drift, and there may be gaps. GPS is better if ground is very clear and people can see a decent distance.

## Think about the angle of sun, and the time of day

Early in the morning and late in the evening, the sun angle is low, and shadows are long. This is not ideal, as shadows confuse the eyes (false alarms, tiredness), and also can hide meteorites. It's one reason why you can't do longer days searching.

Walking towards the sun, you will be looking at a lot of shadows. Walking away from the sun is ideal. So, for fall lines that are east-west (so towards and away from the sun), one direction can be good, but one can be bad. In this case it may be better to plan the expedition to walk across the fall line (as in the first search plot above), as then the sun angle is ok all the time— not terrible, not great, but ok. Cloudy conditions obviously make the shadows problem less critical.

## Star or flower searching large areas for small fragments

Looking at the right area of the 2<sup>nd</sup> searched figure above, you can see searching patterns called star searching (also called flower searching). This allows quickly covering a very large area, but not searching thoroughly. It is suitable for large areas, where it is predicted there may be many small fragments. Such as

- searching for a known exploding meteorite that is predicted to be many small pieces
- or searching at the very small mass end of the fall line when we know there was some fragmentation, from the light curve observations

Mobility really helps here, to move between each star start point – such as 4WD, or quadbikes. Stop at a location, then the team splits up, and walks out for 10min, and back for 10min. Then you move quickly to the next site. Each person needs a GPS or some logging.

## Long trips

Variety in searching is helpful. Have a short break half way through the trip, or go and do a different part of the fall line with a different searching technique. Also, one option is to have a day of filling in gaps, so split into smaller teams that visit all the areas searched where there is a bit missing.

## Remote areas safety

When searching in remote areas, each person must carry a GPS device with spare batteries and base camp (or eg parked vehicles) saved as a waypoint. Also when walking the line, each searcher needs to keep eye on neighbours and call out if they walk out of sight. This is to prevent risk of a person getting lost in a tricky remote terrain with limited visibility, like densely vegetated areas or sand dunes.



## Item checklist:

- Compass
- GPS units (phones with battery packs)
- Flags (optional)
- Fall line maps
- Computer for downloading tracks in the evening, plus accessory cables.
- Sample bags
- Tongs
- Aluminium foil
- Personal health and safety equipment (water, protective clothing, sturdy shoes, sunglasses, suncream etc...)

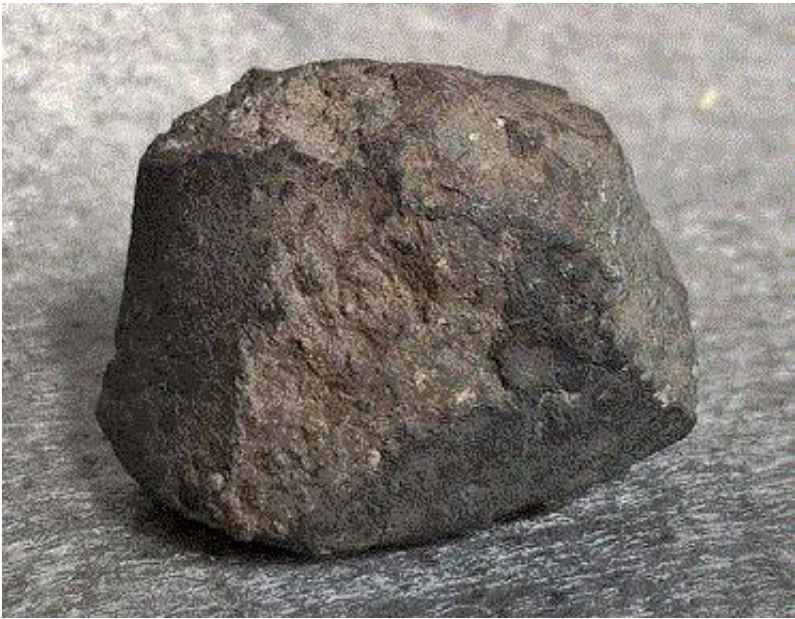
## Meteorite examples

(mostly from google images)















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