

Line Follower Tools

The Line Follower system also provides the chair with a number of different “tools”.

None

The chair ignores any tape it sees on the floor.

Line Following On



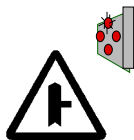
With Line Following turned on the chair will follow track on the ground. In this mode the chair will ignore any junctions it finds.

If you want short sections of track for guiding the chair through doorways or tight spaces this is the tool to choose.

Line Following with Junctions



This tool lets the chair follow the tape track laid on the floor, perhaps around home, between rooms in school, or around the classroom. When a junction is found, the driver selects the track to be followed by pressing the appropriate switch (i.e. left, right, forward or back), or by selecting from the choices offered visually or aurally by the Scanner and Observer.



When Control is switched off, choices at line junctions are presented simultaneously: e.g. forward and left lights up at the same time, even if they are driving the chair directly with the Scanner. It may be easier if they are offered only one choice at a time. Some children may be driving with a single switch, but if they come to a Right junction they don't have a *Right* turn option. This lets the pilot control the chair but offers a choice of scanning.

Not available yet - junctions are always scanned

Safety fence



The chair stops when it detects a line. Tapes can be laid around dangerous features like stairwells, to stop the chair reaching them. The safety fence can work just like bumpers by programming i.e. whatever the bump tool is set to when the chair detects a line it will treat it as a bump or it can work independently of the bump tool and just stop the chair.

The programming for the sa.

Parameter	User Switch	Control knob	Bump Tool	Line Tool	Scan Tool
Safety with bump ON	Forward	-	Momentary	Safety	None
Safety only	Forward	-	Momentary	Safety	None

User / chair Line Control



User Control: if the pilot wants to turn off the line at any point, s/he simply turns to the right or left until the chair is free of the line. Then the chair stops and says “Lost Line”.

Chair Control: any instructions to turn off the line are ignored.

Line Follower accuracy

When following a track, the chair speed is limited to give reasonable accuracy. The speed can be turned down below this maximum value, and it is also possible to change the ‘sensitivity’ and ‘damping’ of the line follower. If the chair seems to waver when following the line, try turning the speed down a little. Heavier users may need the line following speed increased a little. Note that the chair will always follow the line at the set speed - turning the *Speed* knob on the Smart Controller only effects the speed away from the line and has no effect when line following.

NOTE: The Line Sensitivity is there to let us adjust the Line Follower to different types of wheelchair - don’t adjust it unless you’re sure you really need to!

Parameter	User Switch	Control knob	Motion Tool	Bump Tool	Line Tool	Scan Tool
Line following speed	Forward	Speed	Momentary	None	LineFollow On	None
Line following sensitivity	Right	Speed	Momentary	None	LineFollow On	None

Programming the Line Speed

Line Follower box and tape

The Line Follower is a black box mounted on the front of the chair, with infra-red sensors which detect retroreflective tape. The sensors work regardless of background light and don't care whether the line is on dark or light floor coverings, whether carpet or lino. Their function is to detect where the line is in relation to the chair so that the chair can follow it. If the middle two sensors 'see' the tape, the chair goes straight. If sensors to left or right come on, the chair adjusts the heading to try and get back on line.

50 yards of tape is supplied with the chair and more tape can be ordered from Smile Rehab.

The Line Detector plugs into the connector on the front of the Smart Wheelchair Controller. Switch the power off before you connect the line follower.

Who might use a Line Follower?

The line follower might be considered for several reasons and for several groups of children.

First, if a child has learning difficulties, then using the chair with or without collision sensors may be too complex to understand: in order to move around the child must have an idea of where they wish to go, of the sequence of movements that will take them there, and the ability to correct this plan if unexpected events like obstacles are encountered. A line follower is much simpler to operate: the child just needs to know that if he or she presses the switch, the destination will be reached (assuming that the line goes somewhere interesting and the child knows that).

A second use might be to motivate a child who seems unexcited by the wheelchair and bump tools, possibly again for cognitive reasons. One of the reasons for the child's lack of interest may be that he or she doesn't connect the simple movements of the chair with going anywhere useful or interesting - the basic understanding of the use of mobility is not there. By pressing the switch and travelling around, the usefulness, and hopefully motivation, of mobility are experienced with the minimum of cognitive, physical and perceptual demands on the pilot.

A third group are those children who have very limited physical control skills: single switch

users, possibly with unreliable control over a second switch. Again, while bump tools offer exploration in unstructured environments and limited functional mobility in structured environments, a line follower enables the child to move from place to place without the need for supervision.

The final potential user group are pilots who do have good control skills, but suffer from fatigue and cannot maintain a high level of control for long periods. They could use the line follower like a bus, which can be joined and left at any point, to reduce the effort involved in moving around.

Discussion: a comparison between Line Follower and Bump Tools

It should be clear that the line follower has quite different uses compared to the bump tools. Line following can provide a means of independent functional mobility for quite severely disabled children who might find the bump tools too challenging. *Bump & Stop* and *Bump & Reverse* are mainly safety tools: usually, the pilot will be reasonably capable of moving, stopping and steering. *Bump & Turn* provides exploration in a different sense to the line follower, and functional mobility for single switch users in certain situations such as games but again requires the user to have an idea of where and why they want to move. The line follower makes fewer demands on children's physical, cognitive and perceptual skills and so can be used by more severely disabled children. It provides a complementary set of experiences to the bump tools: while the bump tools give the child quite direct control of movement - moving for the sake of moving because the actual motion and collision is fun, the line follower takes more of the load and gives experience of mobility as a skill for moving around to where you want to be.

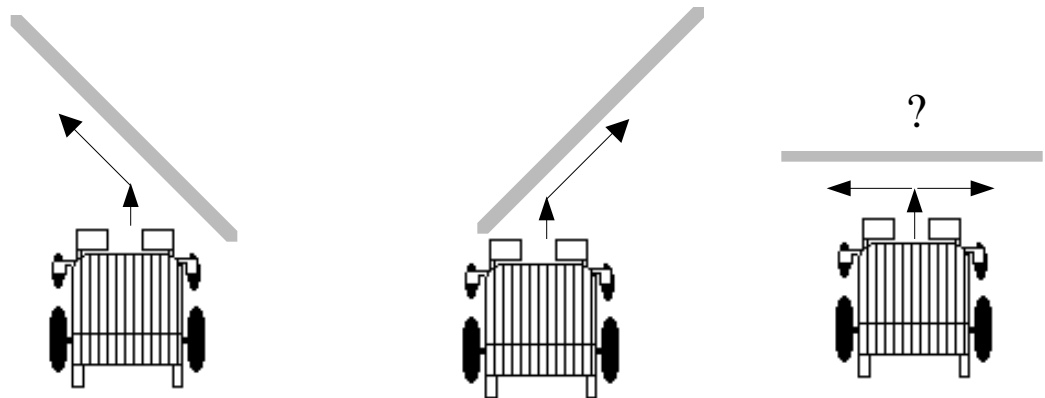
Expanding these ideas a little further, we might class bump tools as get-you-out-of-trouble; Sonar Bump tools (using the experimental obstacle detection system which is still in development) as help-prevent-you-getting-into-trouble; and line follower as stop-you-getting-into-trouble-in-the-first-place; with corresponding implications for control demands and learning experiences.

There is consequently a danger that in relying on the line follower the child will not have a chance of developing or learning new skills. With the bump tools and motion tools, we have an expectation that children will develop new skills and a "path" to get them there (start off with one switch, add another, then a third, and so on).

Lastly, bump tools (particularly bump and turn) often require supervision from adults since they do not prevent pilots getting stuck in corners completely whereas a child should be able to follow the line from one place to another and have reasonable confidence of getting there, thereby giving experience of successful mobility without help from others.

Finding the line

The line follower has no effect on the chair's motion until it finds a line to follow. If a line is detected under the chair it will stop and say "Found line". If you want to follow the line, press *Forward*. If you don't, steer away from it until it says "Lost line". Generally the chair follows the line in the direction you approached it, but sometimes it might get it wrong and try to move in the opposite direction (see the diagram below). Also, if you travel up to the line very quickly, you may overshoot it before the chair stops - this should not be a problem because the chair will remember where it saw the line and turn towards it, but occasionally it might miss and the chair will say "Lost line" and you'll have to reverse back to it until it says "Found line". If you cross the line very fast, the sensors may not see the track at all - but most line follower users will not be driving that fast.



Finding and joining a line

Following the line

The key fact to remember is that once the chair has found the line it will follow it unless a) you tell it to leave by steering off or b) the chair runs straight off the end of it (as for leaving a doorway funnel). Once on the line, the chair moves at a limited speed while told to go forward (or reverse - the chair will also follow the line backwards but not very well - like an articulated truck reversing with a drunk driver). The Line Follower works with the motion tools as you would expect: momentary, timed and latched. It also works with the bump tools, although inevitably it changes the way they work a little. With bump and stop, the chair will stop on collision and allow you to back off or turn. If you reverse, the chair will go back along the line. If you turn, it will leave the line. With bump and backoff it will stop and reverse back along the line. With bump and turn it will stop, back along the line and then try to turn off it: whether it succeeds depends on the angle of turn you've set.

Leaving the line

If the chair is following the line and the line suddenly stops, it will stop and say “Lost Line”. The user can either try to find it again by turning around or go straight on and leave it behind. If Line User Control is on, the pilot can also leave the line at any point just by turning off it. If Line User Control is off, the chair will ignore any instructions to turn right or left off the line.

Line Junctions

The Line Follower will detect junctions like the ones below, stop, and offer a choice using the Observer and/or Scanner about which track to take. The pilot presses any switch to select a line, and the chair will move on to the correct track, and then stop and wait for a new command. If you don't want the chair to offer choices at junctions, select the line following tool and it will just carry straight on and ignore the junction.

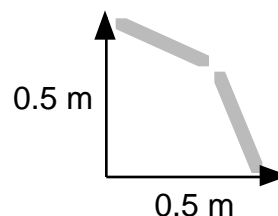
Laying out a line

Line Follower Tape

The tape is quite sticky and reasonably robust. Before sticking it down permanently, it's best to lay it on the floor and try out the chair along it. It might also be worth while sticking the tape down for a few days with sellotape, blue tac or velcro until you're sure about the position. As well as being annoying if you stick it down in the wrong place, it's also quite expensive. Give some thought to where you want the tape to go before you start laying.

Corners

The line tape consists of straight and corner sections. When laying through tight gaps, keep in mind the obvious, like the width of the chair. You can make the corners as tight as you want and the chair will try to follow them, but if you make them too tight it will swing out from the tape and not follow it accurately - it will still get there in the end, but not exactly on top of the line. It's best to try and lay corners no tighter than the one shown below.

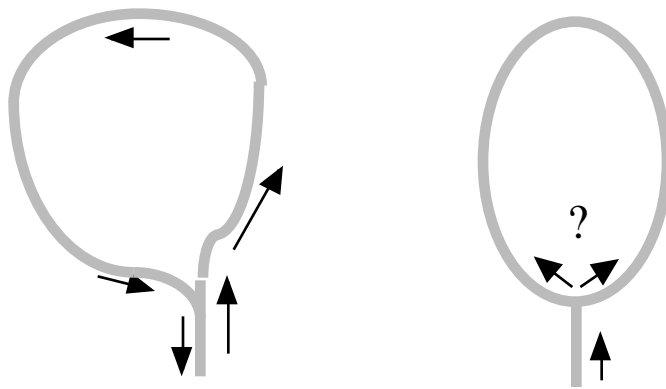


Suitable corner section made up of two segments

Line Follower ‘circuits’

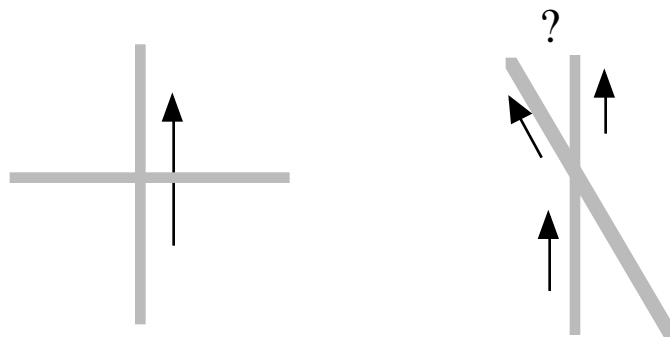
In a classroom, you might want a circuit of the room taking in various interesting “stations”. These stations can be activity areas, or different floor materials such as knobby man-hole cover type things, ramps, grids, or pressure pad switches connected to Mains Switchers, Big Macks or toys.

In the school generally, try to arrange circuits rather than single lines - note that you can have the line going along corridors and into loops in rooms. You can make sure the chair follows the line round the loop consistently (assuming you don’t want to choose at junctions) by using layout (a) below because the chair tends to follow the path it is currently on. Occasionally you might find the chair following the loop the wrong way round. If you don’t care which way round the loop the chair should go, make the loop symmetrical (layout (b)).



(a) *Laying loops round a room* (b)

For crossings where you have the Doorway Funnel on, **and you want the chair to ignore the junction**, layout (a) shown below works best. If the two lines cross at an acute angle there is a danger that the chair will follow the wrong one (b).



The ideal line crossing (a)

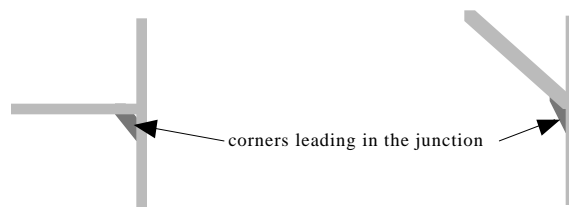
A potentially confusing crossing (b)

Line Junctions

The chair recognises a junction when three or more of the sensors see tape. To detect a junction, the chair must be following the line reasonably accurately, without weaving, otherwise it might miss the junction.

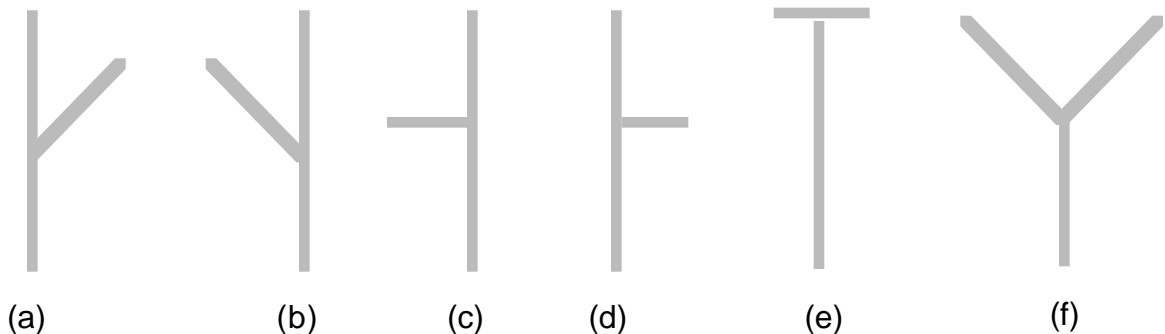
Here's how it works. If the chair is accurately tracking the track, the middle two sensors are on. If the far right sensor detects tape as well, the chair stops, nudges forward a bit and then has another look. If it can still see the line it offers *Forward* or *Right*. If there is no line going forward it assumes that it has found a 'T' or 'Y' junction.

When you have the junction tool on, and you want the chair to detect a junction, it helps the chair recognise it if you have a small piece of tape 'leading in' to the junction.

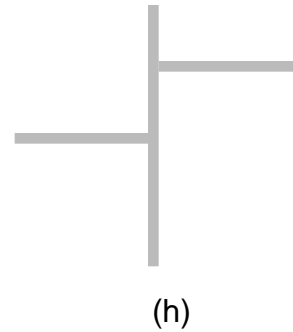
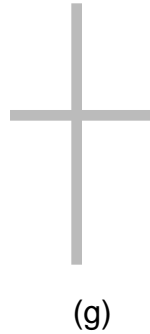


Leading into line junctions

The chair recognises junction types (a) to (f) below, but the most reliable type is the 'T' (e) or 'Y' (f).

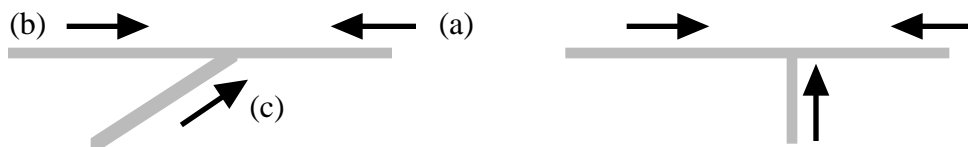


At the moment, it will not reliably recognise a cross-road (g) - if you need a crossroads, try staggering the junctions so you have a left, then a right junction in succession (h).



Use staggered junctions (h) instead of crossroads (g)

If you are laying out a track where you want pupils to choose at junctions in all three directions try and use 'T' or 'Y' junctions. At the moment the chair will recognise the junction when going from right to left (a), but may not recognise it properly when going from left to right (b) or when joining the main line from the 'spur' (c). Sometimes it will offer *Left* or *Right* and sometimes it will go straight on following the line. Use 'T' or 'Y' junctions to get a consistent response.



Use 'T' or 'Y' junctions where chairs are coming from all three directions

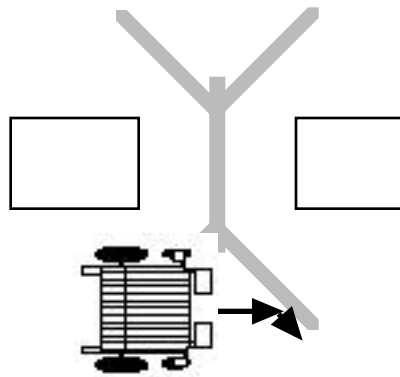
Who might use a doorway funnel?

Some pilots have full (using three or four switches, a joystick or communication aid) but erratic control over the chair and find it difficult to get through tight or awkward spaces such as doorways. For these children, some help in negotiating these contexts would increase independence and reduce frustration. We know that Bump tools can help a little, but often they help too late due to the sharp irregularities of doors. Using a line follower section should solve the problem almost completely if the line is laid to give clearance of the sides of the doorjamb or obstacle.

Using the doorway funnel

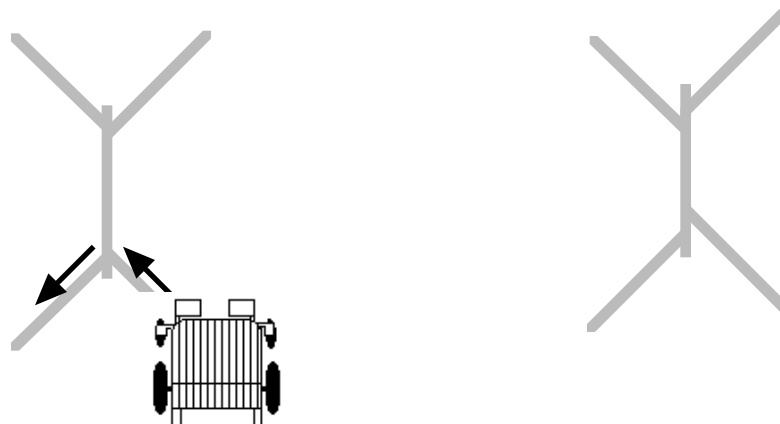
The basic doorway funnel layout is given below. The user drives up to the line and doesn't have to be too careful about accuracy provided the chair goes over the line. When the chair detects it, it will stop and say "Line found". The pilot then presses *Forward* and the chair will follow the line through the doorway until it reaches the end of the straight piece, when it will stop and say "Line Lost", leaving the pilot to move on. Note that the user can leave the line at any point by turning off it (provided Line Control is set to User).

The Doorway Funnel is not clairvoyant and so may occasionally get it wrong. For example, if you approach the capture funnel at a really extreme angle the chair might follow the line in the wrong direction.



Joining the funnel at an acute angle

If you approach the line very fast there is a small but finite possibility that the chair will overshoot the line and lose it, although this is unlikely since the chair remembers where it last saw the line and should turn towards it. It is also possible for the chair to join one side of the funnel and when it comes to the neck, to follow the *other* side of the funnel rather than the neck. To avoid this, "stagger" the two funnel sides where they join the neck.



Chair follows other funnel instead of neck...

avoided by staggered funnels

Laying tape for a doorway funnel

Key features of a successful funnel are sufficient width to capture all the traffic approaching the door, and sufficient clearance in front of the door to stop and turn speed freaks before they hit the wall. The angle of the funnel is not particularly important, although the shallower the angle the tighter the chair has to turn: 45° is probably a good compromise. Note that the funnel joins the neck a little from its end: this “tail” is needed so that when the chair goes through the neck to the far side, it carries straight on until the line is lost. If the tail was not there, the chair would try to follow one of the funnel sides on the way out.

