# Route Concepts

Here we define some core concepts for understanding how routes for AX-1 should be created.

## AX-1 behaviour

Understanding how AX-1 maneuvers is essential for creating routes that it actually manages to follow and without damaging crops.

AX-1 essentially has two ways of maneuvering:

1. Rotate (yaw) - turn to face some direction while maintaining GPS-position.
2. Line-following - forward and make turn adjustments to follow the line between two points.

A track can be followed by rotating towards and driving forward to its first waypoint and then do line-following between two successive waypoints until the end of the track is reached.

In Line-following mode there are PD-controllers aimed to minimize (1) the distance from the line and (2) the robot direction compared to the line direction.

> Currently sharp turns (more than 35 degrees) in the middle of a track can cause overshoots large enough to stop the robot.

## Terminology

| Term | Typical usage | Definition |
|------|---------------|------------|
| Point sequence / Work Data | Data to identify row and headland tracks on an agricultural field.<br><br>Usually comes from recorded field operations on a tractor, such as sowing or tilling. (Tilling is preferred) | A list of GPS-points that is, or could be, sorted in the order they were recorded |
| Waypoint | Essential part of a track. | A point defined by geodetic coordinates (WGS84). |

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| --- | --- | --- |
| Track | | A polyline of waypoints that AX-1 can follow without damaging the crops.<br><br>Being on a track does not generally allow for any rotation without damaging crops. |
| Headland track | In the final route AX-1 will follow headland tracks to get from one row track to another. Valid headland tracks avoid AX-1 driving into crops or other obstacles.<br><br>Valid headland tracks should cover all ends of the row tracks in the same task. | A specific type of track in which the robot can do any amount of rotation without damaging crops.<br><br> |
| Row track | Represents a crop-row that is to be sprayed once in the final route. | A specific type of track where AX-1 can do very limited amounts of rotation without damaging crops. |
| Route | Today this is a GeoJSON file that is created or placed in a folder onboard AX-1. This GeoJSON consists of LineString features that are either (1) spraying passes of row tracks or (2) transport paths. They should be traversed in order of their index property. | A collection of information that uniquely determines where AX-1 should drive on a single agricultural field to spray each row track exactly once. A route can only go along tracks.<br><br>Includes at least:<br>• Row tracks in order of traversal<br>• Headland tracks<br><br>The same row track can be added twice in the order of traversal if a non-spraying pass is needed for transport. Thus, Transport paths can be determined from only from row track order and headland tracks. |
| Transport track | A path to some untreated row track. There is no application of herbicide when following this path.<br><br>Is either a stretch of headland track or a non-spraying pass of a row track. | Track in route that serves as transport between treatment tracks.<br><br>Only used about tracks in a route |

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|------|---------------|------------|
| Spray (treatment?) track | | A track in a route that should be applied herbicide.<br><br>All spray tracks are row tracks, but not all row tracks have to be spray tracks.<br><br>> Treatment can be herbicide application or data collection<br><br>> Only used about tracks in a route |
| Outer boundary | To be used for geofencing of the robot. It is not used to create routes today, nor are there plans to use it for route creation in the near future.<br><br>Geofencing serves as a safety measure in case AX-1 has a malfunction. It also serves to move legal liabilities away from Kilter in the very unlikely case of an accident within the geofence. | A polygon defining the overall area in which the robot is allowed to drive.<br><br> |