Sailing Vehicles

ArduRover now supports sailing vehicles. Only sail boats have been tested so far, although there is no reason land based vehicles wouldn't work. It is recommended that the user familiarises themselves with the basic principles and terminology of sailing and sailboats.

https://www.youtube.com/watch?v=zoNLZ-xE-_0

NOTE

Sailboat support is new to ROVER 3.5.xxx. Please bear in mind that the new code may some issuers however the more people try out and test sailing support the faster the bugs can be found and fixed.

Hardware setup

Sailing vehicles require a rudder or movable wheel or wheels for land vehicles. This is setup in the normal rover way by setting the correct servo output channel to function 26 – Ground Steering.

Sailing vehicles also require some method of controlling the sails. The servo must pull in and let out the sails in a symmetrical way. I.e. no change of servo position should be required to set the sails at the same angle on a new tack. This is typically achieved through the use of sail winch servo and a main sheet system. The sail winch servo is output function – 89.

Although not absolutely required for best results a wind vane should be fitted to allow the vehicle to sense the wind direction. A further improvement can be gained by fitting a wind speed sensor, the faster your vehicle goes relative to the wind speed the more important the wind speed sensor is. See optional hardware – wind vane.

Sailing vehicle are supported by and flight controller, however if a wind vane is to be fitted one analogue ADC input must be available, on newer beta-flight style controllers this is typically labelled as rssi. In order to fit a wind speed sensor two more analogue inputs are required, although just a single additional input can be used with a small loss in accuracy. Ideally a sail vehicle flight controller would have three analogue inputs. Pixhawk1 and the CUBE both fit this criteria.

What to expect in different control modes

This outlines the differences in sailboat behaviour over the standard Rover mode.

- Manual

Sail position is directly controlled by throttle position. Minimum throttle is sail fully in maximum throttle is sail fully releaser. You may find you disarm the controller when tacking to the left when going upwind with the sails in tight. If this is an issue disable stick disarming with the rudder arming parameter.

- ACRO

The Sail is automatically trimmed to the wind direction using the wind vane. A Tack can be triggered from an aux switch, the vehicle will match its current angle to the true wind on the new tack.

- Hold

The sail is released and the vehicle steers directly into the wind to reduce its speed.

https://youtu.be/k_uv4jtqh70?t=3m32s

- Loiter

The vehicle will keep moving within the loiter area.

https://youtu.be/NCUF66rQXFg

- RLT

The vehicle will tack upwind back to the home location if required.

- AUTO

The vehicle will tack upwind to reach the next waypoint if required. Note that if the vehicle has to tack it will not stay on the line between waypoints. While traveling upwind a tack can be triggered from an aux switch or a full rudder input in the correct direction.

https://www.youtube.com/watch?v=zoNLZ-xE-_0

Configuration

Vehicle steering channel should be set to servo function 26 – Ground steering and sail output channel should be set to servo function 89 - mainsail sheet.

All sailing parameters can be found by searching for the prefix SAIL_ (link to parameter list), the sailing code relies heavily on getting correct information on the wind direction and strength from the wind vane (link to optional hard ware windvane).

The range of the sail travel should be set up. This can be tested by arming in manual mode. The throttle will directly control the sail position. Throttle stick down (towards you) should result in the sail being sheeted in towards the centre line. If the sail is sheeted out the servo should be revered. The servo min and max parameters can then be used to set up the range of travel. The min and max values should be set such that the boom is brought in towards the centre line of the boat but not pulled down tightly. The boom should be able to be let out until it reaches the shrouds, if no shrouds are fitted the boom shouldn't go too far past 90 degrees to the boat centre line. You may want to set it so the mainsheet becomes tight just before the boom touch the shroud to prevent rubbing. The sheet should not become too lose if the boom is on the shrouds at it may have enough slack to get tangled.

The sail angle min and max parameters. Should be set to the angle to boom is to the centre line at each extreme of its travel. This allows the angle of the boom to be calculated at any point between.

The ideal sail angle to the wind should then be set. This defines the angle between the boom and the wind direction as reported by the wind vane. An angle of zero here would result in the boom staying parallel to the wind vane. The boom will keep this angle to the wind until it reached either its maximum or minimum limit. If the sails are too loose this number should be increased. This can be tested in ACRO mode.

The SAIL_NO_GO_ANGLE parameter defines the no go zone into witch the sailing vehicle cannot travel. In auto heading modes the vehicle will tack at this angle into the true wind If the desired heading is within the no go zone. The best way to set this is to sail in ACRO mode try sailing at a few angles to the wind set this to the one that seems to work best. Note that this angle will be used whatever the wind strength and should be set with that in mind.

The SAIL_MAX_XTRACK parameter defines the maximum cross track error in auto mode that is allowed before the vehicle will tack. This keep the vehicle within a corridor of width 2* SAIL_MAX_XTRACK. If set to zero the vehicle will ignore the cross track error and only tack once it can reach its destination.

SAIL_MAX_ST_RT defines the maximum turn rate of the vehicle when sailing upwind but not tacking. This can be used to reduce the aggressiveness with which the vehicle will change is heading to react to a change in wind direction.

PIVOT_TURN_RATE defines the maximum rate used for tacking, a lower value will result in slower tacks a higher one in faster tacks. This should be reduced if the vehicle is tacking too sharply and losing momentum while tacking.

SAIL_LOITER_RAD defines the radius of the loiter point the vehicle will try and stay within, the vehicle will keep moving and tack on once it reaches this radius.

SAIL_HEEL_MAX defines the angle at which the sail heel control PID controller kicks in to control the heel angle. If the heel is larger than this angle the PID controller will target this angle however if the heel is less than this angle the controller will not try and reach it.

SAIL_GCS_TRU_WND parameter controls if true or apparent wind speed and direction are reported to the ground control station. This is particularly useful for correctly setting up the wind vane.

Heel control PIDs values are set using (link to param set). The effect of changing the value can be seen in ACRO mode by manually heeling the vehicle. Most control should be do using the P and I terms. D gain is usually too quick for the relatively slow response of the sail winch servos so should be left at zero.

Tacking in ACRO and AUTO mode while traveling upwind can be triggered through the use of an aux switch. This can be setup by setting the RCxOption parameter to function 60 – sailboat tack.

Tuning

The steering rate and navigation should be tuned in the usual way. Care should be taken that the final parameters work well on all points of sail and a range of wind speeds. Rather than the recommended box test auto mission for tuning the navigation controller it is recommended that a simple two point mission is run. The mission should be set up such that the boat travels at 90 degrees to the wind. This can be achieved using a do_jump waypoint. Note that the L1 controller is only used when the vehicle is not tacking close to the wind.

If the vehicle very aggressively responds to changes in wind direction when traveling upwind. Either the wind vane direction filter frequency can be reduced or the maximum straight line rate reduced. Reducing the filter frequency will also slow the response of the sails whereas reducing the rate only effects the steering.

The heel angle controller can be set in a number of ways, a low I term can be used and a low max heel angle. In this case the controller will never hold at the max heel angle but will progressively

sheet out as the heel is increased. Alternately the heel angle can be set at the actual maximum desired heel and then higher gains used to more aggressively let the sails out. In this case a larger I and I max value should be used. Unlike the P and I terms the D term is always active, due to the slow response of typical sail winch servos it is unlikely to prove useful, vehicles with faster servos may benefit from a small amount of D gain.

Feedback

Sailing support is new to Ardurover and we need your feedback to continue improving the code, join the discussion here and let us know how you got on:

https://discuss.ardupilot.org/t/sailboat-support/32060

If you have found a bug or other issue with the code fill in an issue report here:

https://github.com/ArduPilot/ardupilot/issues/