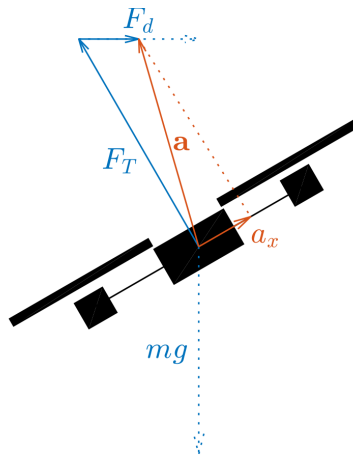


# Drag-based Velocity Estimator

– ‘dragspeed’ module –



During flight, three forces act on the quadrotor: gravity ( $mg$ ), thrust ( $F_T$ ) and drag ( $F_d$ ). The drone's accelerometer measures the acceleration that results from the thrust and drag, but not the gravity<sup>1</sup>. The thrust only acts along the drone's vertical axis, so the only force that remains to be measured on the horizontal axes is the drag. Using a simple drag model, the drag can be transformed back into the drone's velocity. In case of quadrotors, the drag force  $F_d$  and its resulting acceleration  $a_x$  grows approximately linear with velocity:

$$v \approx a / (\mu / m)$$

with  $\mu$  the linear drag coefficient.

The drag term ( $\mu/m$ ), defined by `DRAGSPEED_COEFF_X` and `_Y` can be found through a short test flight when ground truth velocities are available (e.g. through optitrack).

## Usage instructions

1. Add the dragspeed module to your airframe file
  - By default, the velocity estimates are sent as an ABI message to the INS. Set `VEL_DRAGSPEED_ID` to `ABI_DISABLE` to disable this. The velocity estimate can also be read manually from the `dragspeed.vel` struct.
2. Calibrate the drag coefficient and bias (see below) and set the corresponding defines in the airframe file.
3. Set the low-pass filter strength (“GCS → Settings → dragspeed → filter” or `DRAGSPEED_FILTER` in the airframe file) to an appropriate value between 0 and 1 (default: 0.8).
4. Before each flight:

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<sup>1</sup> <https://en.wikipedia.org/wiki/Accelerometer>

- Recalibrate the bias (this helps against small changes in battery/hull position and changes in IMU temperature).
- If the weight of the drone has changed, recalibrate the DRAGSPEED\_COEFF\_X and \_Y.
- The velocity estimated by this module can be compared to the velocity from the INS by plotting the signals in the DRAGSPEED telemetry message.

## Bias calibration

1. Bring the drone to a stationary hover (e.g. with optitrack or optical flow).
2. Under “settings → dragspeed” in the GCS, set “Calibrate Zero” to 1.
3. Keep the drone stationary until the value of “Calibrate Zero” returns back to 0 (click on it to update). This takes approximately one second.
4. (Optional) set the new Zero\_X and Zero\_Y values (click to update) as defines in the airframe file (DRAGSPEED\_ZERO\_X and DRAGSPEED\_ZERO\_Y).

## Drag coefficient calibration

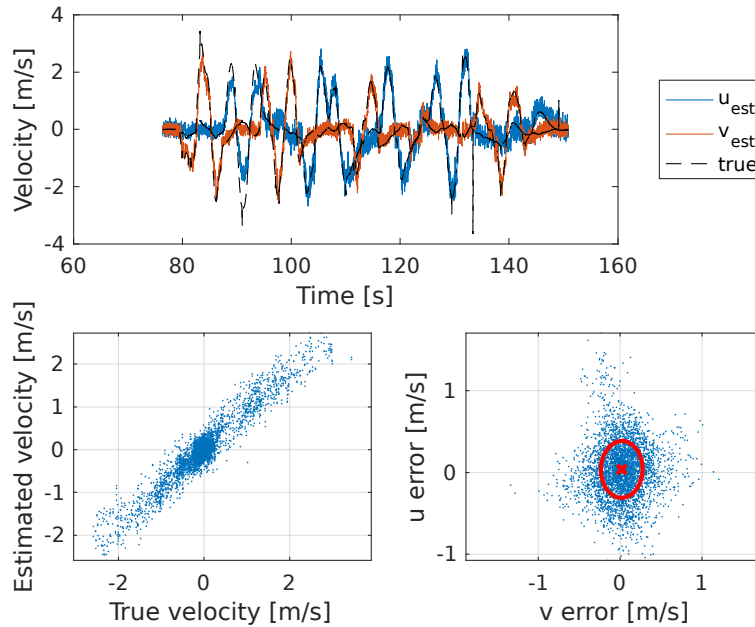
1. Ensure the velocity from the INS is sufficiently accurate (e.g. through optitrack)
2. Under “settings → dragspeed” in the GCS, set “Calibrate Coeff” to 1
3. Fly the drone around (manually or using a flight plan). The drag coefficient is updated while the drone flies faster than 0.5 m/s along each axis.
  - Plot the signals in the DRAGSPEED telemetry message to compare the true and estimated velocities.
4. Calibration is finished when “Calibrate Coeff” returns to 0 (click to update).
5. (Optional) set the new Coeff value (click to update) as a define in the airframe file (DRAGSPEED\_COEFF\_X and \_Y).

## Automatic calibration in flightplans

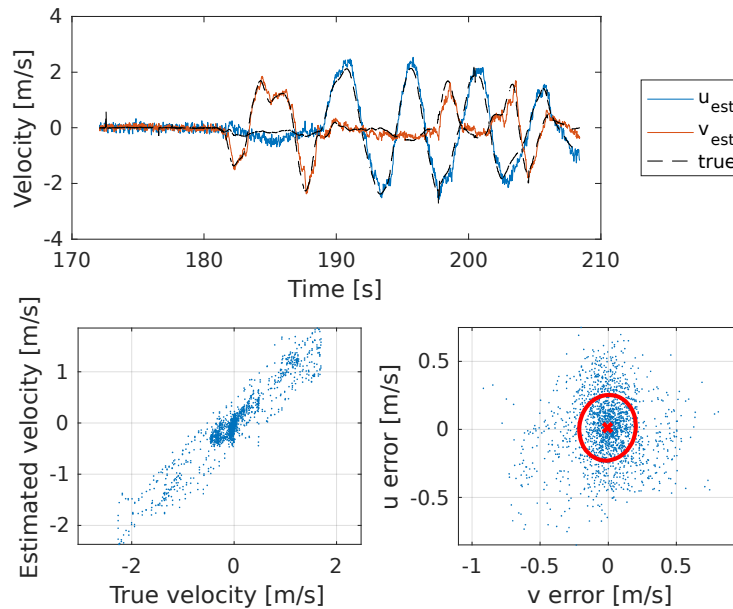
Calibration can be started from the flightplan by calling `dragspeed_calibrate_zero()` or `dragspeed_calibrate_coeff()`. Progress of the calibration can be monitored through `dragspeed_is_calibrating()` which returns TRUE while either calibration routine is in progress.

## Example results

Flight test performed on an AR.Drone 2.0 inside the TU Delft cyberzoo. Ground-truth velocities are obtained using the Optitrack system.



(`DRAGSPEED_FILTER` set to 0.8)



(`DRAGSPEED_FILTER` set to 0.9)

For this AR.Drone, the following drag coefficients were found:

`DRAGSPEED_COEFF_X` = 0.62

`DRAGSPEED_COEFF_Y` = 0.85