How does it work?

L/D Magic runs Kalman Filter based on Wingsuit Equations to determine flight parameters. Various Kalman Filter models are available that use combinations of sensors — accelerometer, gyroscope, GPS, and magnetometer.

Kalman Filter links measurements (“observation variables”) to model’s internal parameters (“process variables”) that describe the state of the system and its evolution in time. For each incoming data sample, Kalman Filter first calculates an estimate of the new state of the system, using gliding flight equations of motion — Wingsuit Equations. It then compares this predicted state with the observations and calculates the optimal correction (“Kalman gain”) to the state estimate that takes into account the new observation data. The amount of correction depends on the difference between prediction and observation, and the specified noise levels (“covariances”) of both process and observation variables — if measurements are very precise, Kalman gain gives more weight to measurements; if measurements are very noisy, more weight is given to predicted state. The newly calculated state of the system is used as a starting point in the next processing cycle.

For example, the simplest Kalman Filter model, “❶ Accelerometer”, uses 2 observation variables:

- $y_1 = g_1$ (Z-component of apparent gravity (perpendicular to screen), in units of g — acceleration of gravity)
- $y_2 = g_2$ (Y-component of apparent gravity (from the bottom of screen in portrait mode to the top), in units of g)

and 4 process variables:

- x_1 = LD (lift-to-drag ratio)
- $x_2 = K_d$ ("magic" coefficient of drag in the Wingsuit Equations)
- $x_3 = V_x$ (current horizontal airspeed)
- $x_4 = V_y$ (current vertical airspeed)

When iOS device is aligned with the relative wind, the observation variables are linked to the process variables with the following equations:

$$g_1 = K_l \cdot V^2$$
$$g_2 = K_d \cdot V^2$$

where K_l is the "magic" coefficient of lift in the Wingsuit Equations ($K_l = LD \cdot K_d$), V is total airspeed ($V^2 = V_x^2 + V_y^2$). Thus, we have

$$y_1 = x_1 \cdot x_2 \cdot (x_3^2 + x_4^2)$$
$$y_2 = x_2 \cdot (x_3^2 + x_4^2)$$

The time evolution of process variables is described with the following differential equations:

$$dLD/dt = 0$$
$$dK_d/dt = 0$$
$$dV_x/dt = g \cdot V \cdot (K_l \cdot V_y - K_d \cdot V_x)$$
$$dV_y/dt = g \cdot (1 - V \cdot (K_l \cdot V_x + K_d \cdot V_y))$$

The first two equations simply indicate that LD and K_d are “relaxed” variables — we cannot predict how they change (since this depends on the flyer, not equations), so we let Kalman Filter find the optimal estimates for them using noise to “drift” them. The last two equations are simply the Wingsuit Equations. Thus,

$$dx_1/dt = 0$$
$$dx_2/dt = 0$$
$$dx_3/dt = g \cdot (x_3^2 + x_4^2)^{\wedge}½ \cdot (x_1 \cdot x_2 \cdot x_4 - x_2 \cdot x_3)$$
$$dx_4/dt = g \cdot (1 - (x_3^2 + x_4^2)^{\wedge}½ \cdot (x_1 \cdot x_2 \cdot x_3 + x_2 \cdot x_4))$$

For each timestep (between previous and new measurements) the linearized equations of motions are used to estimate the new state using the 4th order Runge-Kutta algorithm.

Once the new estimates for LD, K_d, V_x, V_y are obtained, we can calculate other useful parameters, for example:

- glide ratio $GR = V_x/V_y$
- sustained horizontal airspeed $V_{xs} = K_l/(K_l^2 + K_d^2)^{\wedge(3/4)}$
- sustained vertical airspeed $V_{ys} = K_d/(K_l^2 + K_d^2)^{\wedge(3/4)}$
- lift force $L = W \cdot K_l \cdot V^2$
- drag force $D = W \cdot K_d \cdot V^2$
- lift coefficient $C_l = 2 \cdot W \cdot K_l/(\rho \cdot S)$
- drag coefficient $C_d = 2 \cdot W \cdot K_d/(\rho \cdot S)$

where W is total weight, S is planform area, ρ is density of air.

These parameters are used for immediate visual and audio feedback to the pilot. The pairs of sustained horizontal and vertical airspeeds [V_{xs}, V_{ys}] make points of the polar curve.

This is how L/D Magic works. It's magic... pure flying magic!

For more information about Kalman Filter, read "What is Kalman Filter?" topic in FAQ, or visit Wikipedia page:
http://en.wikipedia.org/wiki/Kalman_filter

For more information about Wingsuit Equations, read "What are Wingsuit Equations?" topic in FAQ, or visit original post:
http://www.dropzone.com/cgi-bin/forum/gforum.cgi?post=2563135