3 DEGREES OF INCIDENCE

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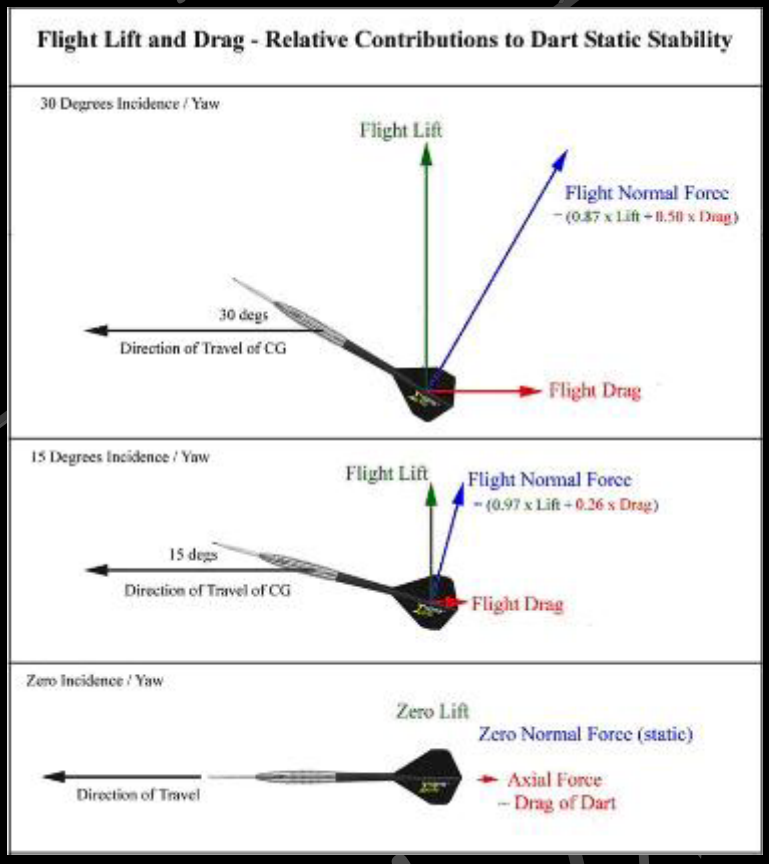
So this is my 112th UniBlog, but only number 3 in my refresher course on the science of dart flight. To help keep track, I've decided to number it and future ones accordingly. If you've not read numbers 1 and 2 ("Still Geeky" and "Wait Lift" respectively - accessible via "Quick Links" on the Unicorn darts website), it might be worth doing so before proceeding further. Apart from anything else, if you don't find those to be of any interest, you'll know to avoid yet greater tedium herein!

Last time I talked about the aerodynamic forces acting on a dart in flight. I suspect many folk would imagine the most important one of these is drag, but, for a reasonably well-thrown dart, they'd be wrong. By far the most important aerodynamic force here is lift.

This is because, unless it's thrown going almost sideways, or even backwards, it's mostly the lift acting on the flights that causes a dart to hit the board point first.

The above diagram (nicked from UniBlog 86) attempts to illustrate this. When a dart tips up, away from the line of its trajectory, the difference in air pressure between the upper and lower surfaces of the flight generate what's called a "Normal Force" ("Normal" in maths-speak means "at right-angles to", so the Normal Force is at right angles to the flight's surface). The Normal Force pushes the back of the dart up, hence straightening it (this self-righting mechanism is called static stability - in fact the dart overshoots, like a pendulum, but more on that another time)..

As the diagram shows, Normal Force has two components, drag and lift. If the dart were going completely sideways, the Normal Force would be entirely due to drag, but at angles below 45 degrees it's more due to lift. In fact, for a dart at 15 degrees "incidence" (aero-jargon for angle to its direction of travel – 15 degrees being a not unreasonable limit for it to be called "well-thrown") 97% of the Normal Force goes into lift with only 26% going towards drag. At 3 degrees that becomes 99.9% compared to just 5% (these components do add up to 100% when re-combined – honest!).



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Ah, you might say, that's all very well, but pressure difference, and hence Normal Force, is not the only contributor to the drag on the flights. After all, there's still some drag on things flying straight. What about skin friction, for example?

For a dart flying straight (at "zero incidence") its drag is also called "Axial Force" (to go with "Normal Force"). To show how small this is in reality, you can try a little experiment. Throw a dart as straight as you can, whether at a board or, better still, out in the garden, (taking care of vulnerable objects/wildlife/people!). Next unscrew the shaft and flights as a unit and throw it in exactly the same way. You should find comparatively little difference in the trajectory of the two projectiles. Given that the shaft is maybe 20 times lighter than the whole dart, which means the effect of drag on its trajectory will be 20 times more, you can see that, when it comes to darts, drag really isn't that big a deal.

OK, still with me? Couple more things to clarify. In the diagram the dart is point-up and hence lift is acting upwards. But in projectile aerodynamics lift can also act sideways or even downwards, so the same stabilising mechanism applies no matter which direction the dart decides to point off the line of its trajectory.

Now something for any super-geeks out there who might have taken exception to my diagram's use of the term "Yaw" for incidence in the vertical plane. Yes, I know, for flying things where there's a "right way up", like aeroplanes, "pitch" is upward incidence, yaw is sideways. However, in the maths of projectiles which, like darts, don't have a "right way up", they aren't useful definitions. Instead incidence is treated as a variable called "complex yaw", often just shortened to yaw, which is what I'll mostly be doing. I might still sometimes use phrases like "pitched up", though!

So that's it for this time. But I can't sign off without mentioning the very sad losses the world of darts has experienced recently. Jim Bowen, Phil Jones, and then Eric Bristow. Each leaving, in their own way, an indelible legacy on the sport they loved. RIP.