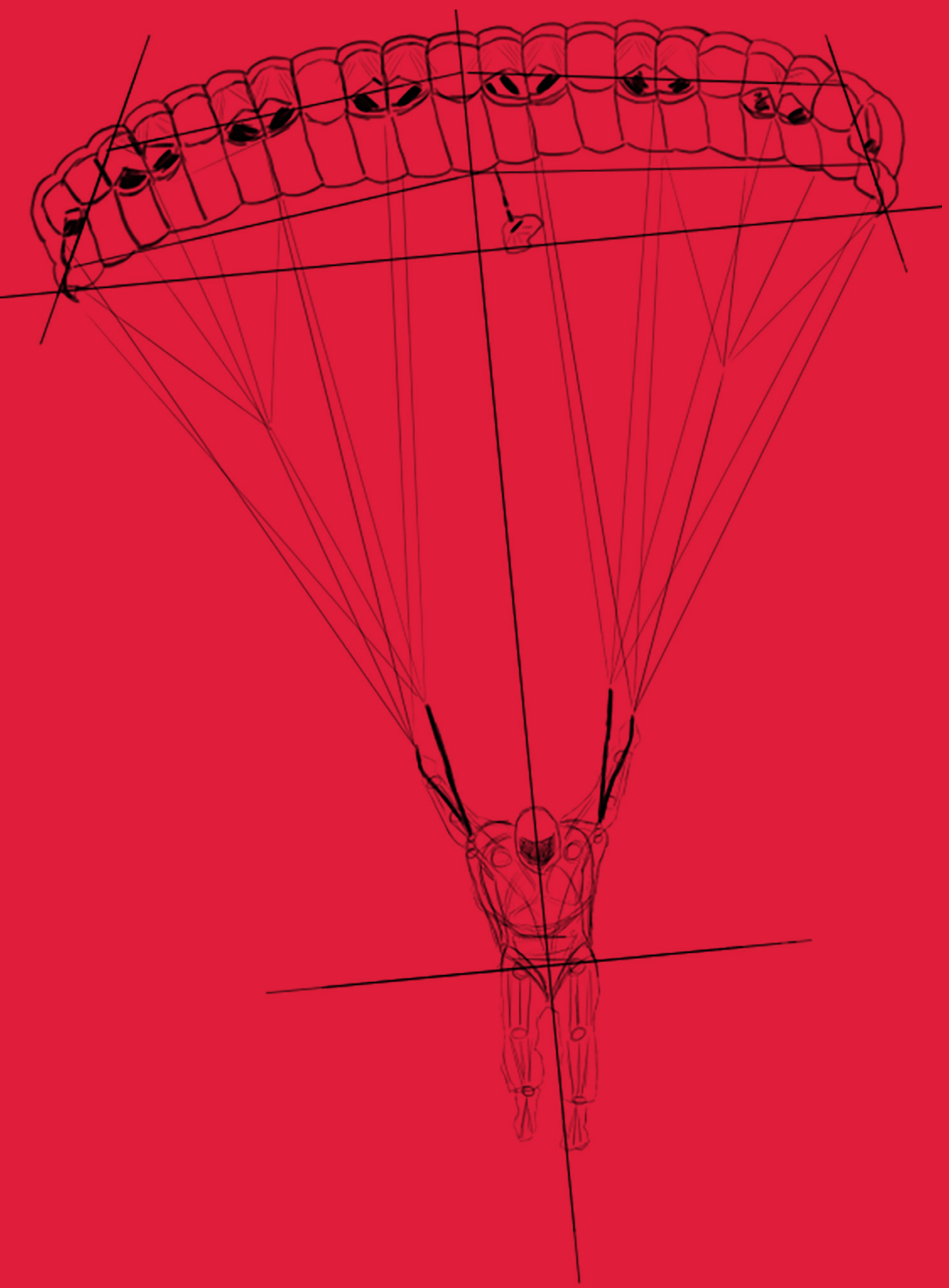

PARACHUTE FLIGHT DYNAMICS

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PHOTOS AND ILLUSTRATIONS BY NIKLAS DANIEL

The goal of any skilled canopy pilot is to take command of the parachute system so as to dictate his location under the wing at any given time. To become a more proficient canopy pilot, it's important to understand that the jumper is not separate from the canopy but is in fact part of an integrated system. Without delving too much into design specifics of parachutes, let's examine how a jumper's choices and actions affect the system as a whole. For example: Though turning low to the ground is not advisable, it is also not inherently dangerous. In fact, such a maneuver may be necessary to avoid danger, and what matters most in such a situation is how the jumper performs the turn. As with many things in flight, the lifesaving move may be counterintuitive.

THE BASIC PHYSICS

Parachutes are flexible wings that fall into the weight-shift category. A jumper has mass, which is suspended underneath the parachute. The jumper is free to move under the parachute like a pendulum, either laterally (side to side) or longitudinally (front to back). The canopy acts as the suspension point for the skydiver (the pendulum's weight), and the lines act as the pendulum's rope. The rules of inertia govern the jumper's body, while the rules of aerodynamic forces govern the parachute. These two unrelated systems, human and parachute, work together despite their apparent differences. The canopy pilot's input greatly affects how the suspended body and the wing interact. Therefore, it's best to think of the jumper and the canopy as a completely integrated system.

Any pilot input (toggle, riser or harness) makes the canopy move before the jumper moves. This is because the jumper has much higher inertia than the canopy. Incidentally, this same phenomenon applies during turbulence: Turbulence affects the canopy first (producing turbulence-induced oscillation) and then affects the jumper. As a jumper affects the shape of the wing, the wing's aerodynamic behavior changes, producing changes in airspeed, direction or both. The pendulum action restores the system to its stable state after the initial input. However, in the process, the jumper may oscillate because he's free to swing back and forth under the wing.

Weight shift augments a canopy pilot's input and affects canopy distortion. As the body swings under the wing, it affects the parachute's angle of attack and therefore the airspeed of the system. Changes in the angle of attack are fleeting, because the jumper's body pendulums back underneath the wing to its equilibrium location in short order. The elapsed time varies based on how far the jumper was displaced from the equilibrium position. So any flight mode other than full flight is an intermediate state from which the system is trying to recover.

The length of the suspension lines is one particular design aspect of the parachute that does not scale with its size. When a jumper downsizes to a smaller canopy, the lines have to be shorter than they were on the previous model in order to maintain the proper stability and opening characteristics. This in turn brings the pilot's suspended weight closer to the parachute. Changing the line length of a pendulum has a huge impact on its periodic motion (back and forth swings or oscillation). So shorter suspension lines on a parachute equate to more responsiveness to input because the pilot's location under the wing changes much more quickly.

INFLUENCING THE CANOPY'S RESPONSE

A skydiver is not at the mercy of this natural recovery phase. In fact, it is the pilot's job to counter oscillation in order to achieve the most desirable flight setting as quickly as possible. Additionally, holding a specific input creates a new system. This means that holding your canopy at half brakes creates a new flight mode (i.e., a new starting point). Therefore, the canopy's response to your inputs will be different than they were when you were in full flight.

A jumper's input has a certain magnitude and speed, which are both important to influencing the canopy's response. When the jumper moves his hands from point A to point B, it creates a response, but the speed at which that move is executed is also important. A skydiver can influence the canopy system by reducing (neutralizing) or countering oscillations through optimal application of these inputs.

Damping is the term for decreasing oscillation. Every maneuver performed with a parachute will create one of these three states:

1. **Under-Damped** (The jumper feels very obvious changes in his flight.)

A canopy pilot generally initiates an under-damped maneuver with a sharp, quick input and overshoots the desired flight mode. A large system oscillation follows this type of maneuver, and the system takes time to recover. One example: If a jumper stabs the brakes during a flare because he's too low, he may then pop up only to surge forward again and have a hard landing. Another example: When a jumper quickly releases from a full stall, this often results in a dramatic surge.

Excessive control inputs—large and rapid control reversals such as wrestling with the toggles and flapping—make for inefficient flight. Pilot-induced oscillation is essentially the overcorrection of inputs and is associated with poor piloting skill.

2. **Over-Damped** (The jumper feels little to no change in his flight.)

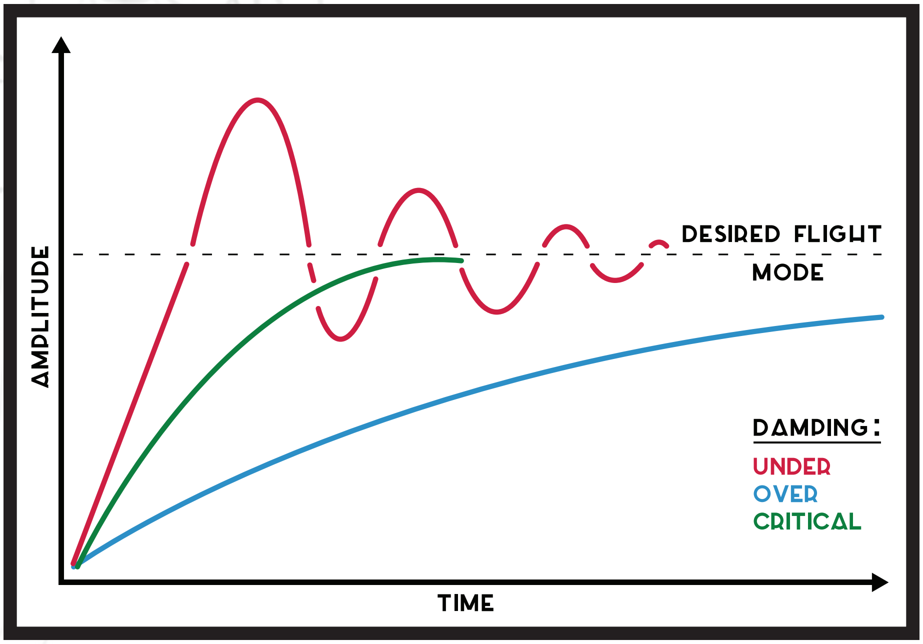
Over-damped (soft) inputs are those that the jumper initiates with a low magnitude or over a long time period or both. This may result in the pilot achieving the desired flight mode too late or not at all. One example: The jumper starts a flare too early and continuously pulls the toggles down slowly until touch-down, resulting in a hard landing. Another example: During a stall, the jumper takes too long to release the brakes and loses a large amount of altitude.

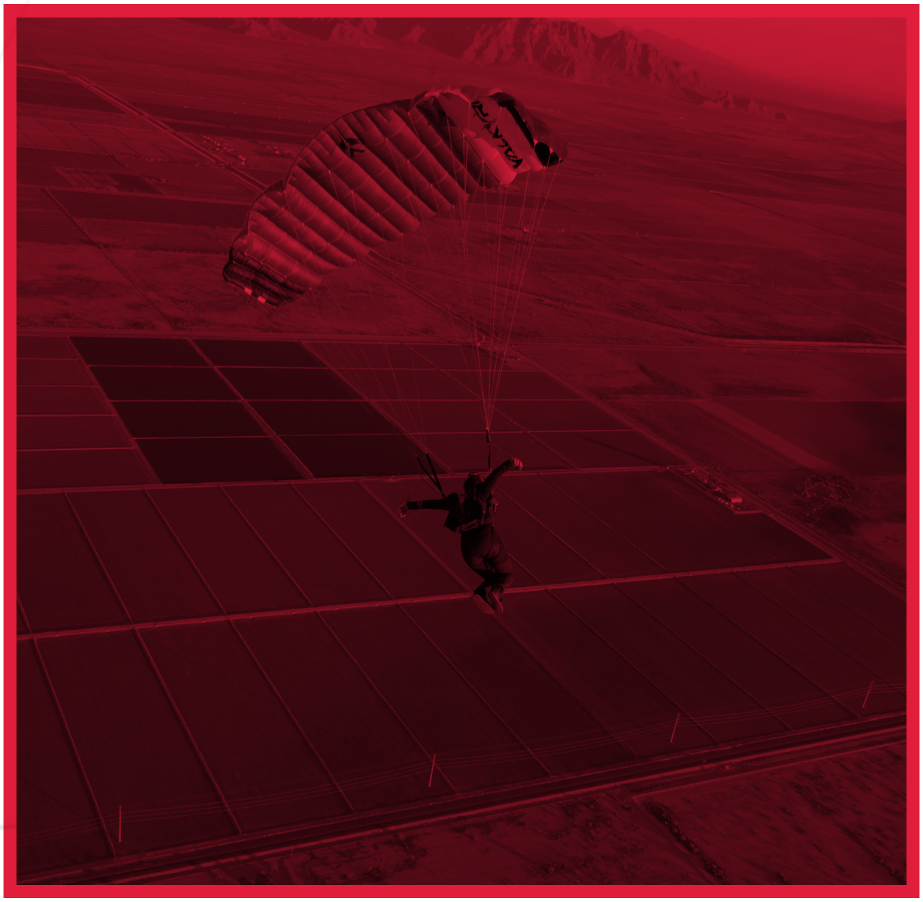
3. **Critically Damped** (The jumper reaches the desired flight mode as soon as possible.)

Optimal inputs create a seamless transition from one flight mode to another and achieve a new flight mode in the minimum amount of time. Someone who flies in this manner appears to be stable and in control at all times. This is what every canopy pilot should strive to do!

Aerodynamic drag on the wing and the pilot's body provides the damping forces to counteract system oscillation. The jumper effectively neutralizes oscillation by applying input at the correct speed and magnitude. Jumpers learn this best by repeating specific exercises designed to help them command their wings better and feel the feedback. Smooth transitions between flight modes allow experienced jumpers to make no-momentum landings because the jumpers' weight transfers smoothly from their harnesses to the ground. One example: A jumper makes a flawless transition between using the front risers, rear risers and brakes or makes a smooth transition with a single input (such as seamlessly transitioning from full flight to quarter brakes) and lands perfectly. Another example: The jumper smoothly recovers from a stall with a minimum amount of altitude lost.

While learning how to optimize your damping skills, the assistance of a coach or instructor can be invaluable. Although maneuvers such as stalls make your damping skills very recognizable (because stalls look and feel very dramatic), subtle moves such as transitioning from half brakes to quarter brakes are harder to assess. Instructors and coaches can see these changes and will be able to help you assess how well you're flying a particular wing.





ABOUT THE AUTHOR

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