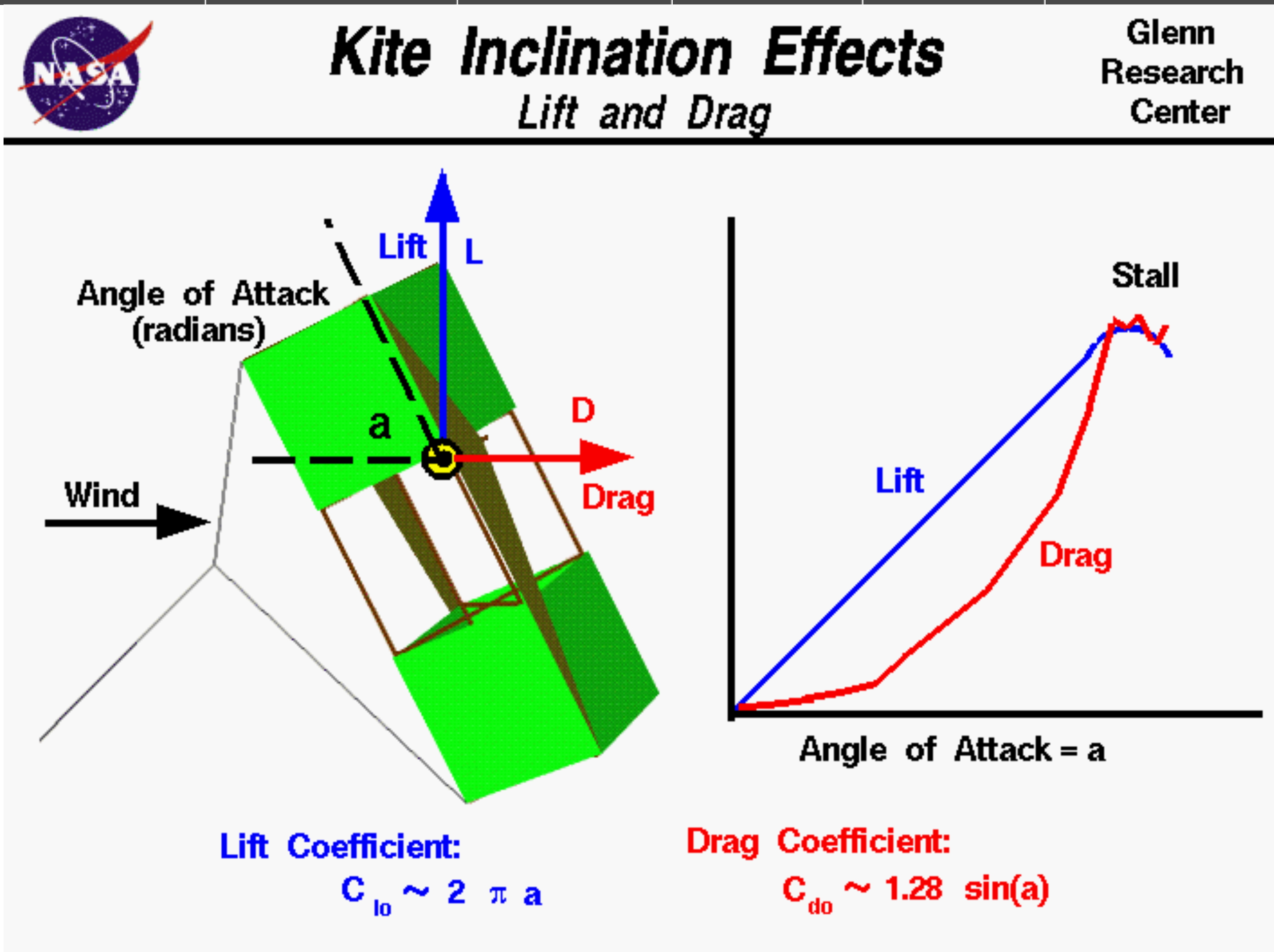

An excellent way for students to gain a feel for aerodynamic forces is to fly a kite. Kites fly because of forces acting on the parts of the kite. Though kites come in many shapes and sizes, the forces which act on the kite are the same for all kites. You can compare these forces to the forces that act on an airliner in flight and you will find that, with the exception of thrust, they are exactly the same. Since the forces on a kite are the same as the forces on an airplane, we can use the mathematical equations developed to predict airplane performance to predict the aerodynamic performance of a kite.

The aerodynamic force on a kite is a vector quantity having both a magnitude and a direction. The aerodynamic force is resolved into the lift which acts perpendicular to the wind direction and the drag which acts along the wind direction. There are several factors that affect the magnitude and the direction of the aerodynamic force. On this page we show the effects of inclination angle on the lift and drag. The graphic shows a side view of the flying kite with the aerodynamic lift shown by the blue vector, and the drag by the red vector. The wind is blowing parallel to the ground. The kite is inclined to the wind at an angle of attack, **a**, which affects the lift and drag generated by the kite. Other factors affecting the lift and drag include the wind velocity, the air density, and the downwash created by the edges of the kite.

For any object, the lift and drag depend on the lift coefficient, **Cl**, and the drag coefficient, **Cd** of the object. These coefficients are usually determined experimentally for aircraft, but the aerodynamic surfaces for most kites are simple, thin, flat plates. So we can use some experimental values of the lift and drag coefficients for flat plates to get a first order idea of our kite performance. For a thin flat plate at a low angle of attack the lift coefficient **Clo** is equal to 2.0 times **pi (3.14159)** times the angle **a** expressed in radians (180 degrees equals pi radians):

$$Clo = 2 * pi * a$$

The drag coefficient **Cdo** is equal to 1.28 times times the trigonometric sine, sin, of the angle **a**:

$$Cdo = 1.28 * \sin(a)$$

We use Clo for the lift coefficient and Cdo for the drag coefficient because there is another aerodynamic effect present on most kites. If we think of a kite as an aircraft wing, and use the terminology associated with aircraft wings, most kites have a low wing **span** or distance from side to side. Near the tips of a wing the flow spills from the under side to the top side because of the difference in pressure. This creates a downwash which changes the effective angle of attack of the flow over a portion of the wing and affects the magnitude of the lift and drag.

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