FLIGHT AT HIGH LIFT CONDITIONS

It is frequently stated that the career Naval Aviator spends more than half his life "below a thousand feet and a hundred knots." Regardless of the implications of such a statement, the thought does connote the relationship of minimum flying speeds and carrier aviation. Only in Naval Aviation is there such importance assigned to precision control of the aircraft at high lift conditions. Safe operation in carrier aviation demands precision control of the airplane at high lift conditions.

The aerodynamic lift characteristics of an airplane are portrayed by the curve of lift coefficient versus angle of attack. Such a curve is illustrated in figure 1.15 for a specific airplane in the clean and flap down configurations. A given aerodynamic configuration experiences increases in lift coefficient with increases in angle of attack until the maximum lift coefficient is obtained. A further increase in angle of attack produces stall and the lift coefficient then decreases. Since the maximum lift coefficient corresponds to the minimum speed available in flight, it is an important point of reference. The stall speed of the aircraft in level flight is related by the equation:

$$V_s = 17.2\sqrt{\frac{W}{C_{L_{max}}\sigma S}}$$

where

V_s = stall speed, knots *TAS*
W = gross weight, lbs.
$C_{L_{max}}$ = airplane maximum lift coefficient
σ = altitude density ratio
S = wing area, sq. ft.

This equation illustrates the effect on stall speed of weight and wing area (or wing loading, W/S), maximum lift coefficient, and altitude. If the stall speed is desired in *EAS*, the density ratio will be that for sea level (σ = 1.000).

EFFECT OF WEIGHT. Modern configurations of airplanes are characterized by a large percent of the maximum gross weight being fuel. Hence, the gross weight and stall speed of the airplane can vary considerably throughout the flight. The effect of only weight on stall speed can be expressed by a modified form of the stall speed equation where density ratio, $C_{L_{max}}$, and wing area are held constant.

$$\frac{V_{s_2}}{V_{s_1}} = \sqrt{\frac{W_2}{W_1}}$$

where

V_{s_1} = stall speed corresponding to some gross weight, W_1
V_{s_2} = stall speed corresponding to a different gross weight, W_2

As an illustration of this equation, assume that a particular airplane has a stall speed of 100 knots at a gross weight of 10,000 lbs. The stall speeds of this same airplane at other gross weights would be:

Gross weight, lbs.	*Stall speed, knots EAS*
10,000	100
11,000	$100 \times \sqrt{\frac{11,000}{10,000}} = 105$
12,000	110
14,400	120
9,000	95
8,100	90

Figure 1.15 illustrates the effect of weight on stall speed on a percentage basis and will be valid for any airplane. Many specific conditions of flight are accomplished at certain fixed angles of attack and lift coefficients. The effect of weight on a percentage basis on the speeds for any specific lift coefficient and angle of attack is identical. Note that at small variations of weight, a rule of thumb may express the effect of weight on stall speed—"a 2 percent change in weight causes a 1 percent change in stall speed."

EFFECT OF MANEUVERING FLIGHT. Turning flight and maneuvers produce an effect on stall speed which is similar to the effect of weight. Inspection of the chart on figure 1.16 shows the forces acting on an airplane in a steady turn. Any steady turn requires that the *vertical* component of lift be equal to