AC NO: 61-50A
DATE: 3/15/76

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: AIRPLANE FLIGHT CHARACTERISTICS AND TECHNIQUES ASSOCIATED WITH OPERATION IN THE "REGION OF REVERSED COMMAND"

1. PURPOSE. This Advisory Circular is intended to provide the general aviation pilot with a ready reference to the basic aerodynamics involved in slow speed flight at or near minimum control speed. Specifically, this discussion explains why the use of proper flying technique and precise control of the airplane is most critical in the region of reversed command.

2. CANCELLATION. AC 61-50, dated February 7, 1972, is cancelled.

3. REFERENCES.

   a. Supersonic Flight Fundamentals, DSA-71, FAA.

   b. AC 61-21, Flight Training Handbook.

   c. AC 61-16A, Flight Instructor's Handbook.

   d. AC 61-27B, Instrument Flying Handbook.

4. DEFINITIONS.

   a. The Region of Normal Command: the regime of flight speeds greater than the speed for minimum required power.

   b. The Region of Reversed Command: the regime of flight speeds between the speed for minimum required power and the stall speed.

   c. Steady Flight: The airplane is in equilibrium where there is no imbalance of force or moment acting on the airplane.

   d. Angle of Attack: The angle measured between an airfoil chord line and the relative wind.

Initiated by: AFS-820

5. BACKGROUND.

a. Pilots engaged in aerial applicator operations have long recognized the need for a sound understanding of airplane performance characteristics associated with the "region of reversed command," and the application of certain operational procedures to all low altitude, slow airspeed flight.

b. Because of the growing interest in aircraft equipped with Short Takeoff and Landing (STOL) components or systems, and greater performance demands being placed on conventional airplanes without STOL modification, it is considered appropriate that this discussion be directed to the general aviation pilot as well as the aerial applicator.

6. CONTROL OF AIRSPEED AND ALTITUDE. In this discussion of airplane control, it is assumed that the airplane is trimmed so that no imbalance of pitch, yaw or roll moments exist, and attention will be given to the forces acting on the airplane (i.e., lift, thrust, weight, and drag).

a. Steady Level Flight. As a contingency of steady, level flight, the net lift being generated must, for all practical purposes, equal the airplane weight. It should be appreciated that a specific airplane, at any given gross weight, achieves equilibrium in both the vertical and horizontal directions at only one airspeed for each given angle of attack. Each angle of attack produces a specific lift coefficient, which requires a specific value of airspeed to provide steady level flight. Therefore, ANGLE OF ATTACK IS THE PRIMARY CONTROL OF AIRSPEED IN STEADY FLIGHT.

b. Steady Climb and Descent. In the case of climbing or descending flight, a component of weight is inclined along the flight path direction, and equilibrium is achieved when thrust is not equal to drag. The rate of climb, if original aerodynamic conditions are maintained, is therefore a direct function of the difference between power available and power required for steady level flight. Also, when there is a deficiency in the available power to balance the power required, a rate of descent results. For this reason, POWER SETTING IS THE PRIMARY CONTROL OF ALTITUDE IN STEADY FLIGHT.

7. FLYING TECHNIQUE.

a. Since the conditions of steady flight predominate during most flying, the fundamentals of flying technique are the principles of steady flight:

(1) Angle of attack is the primary control of airspeed.

(2) Power setting is the primary control of altitude.

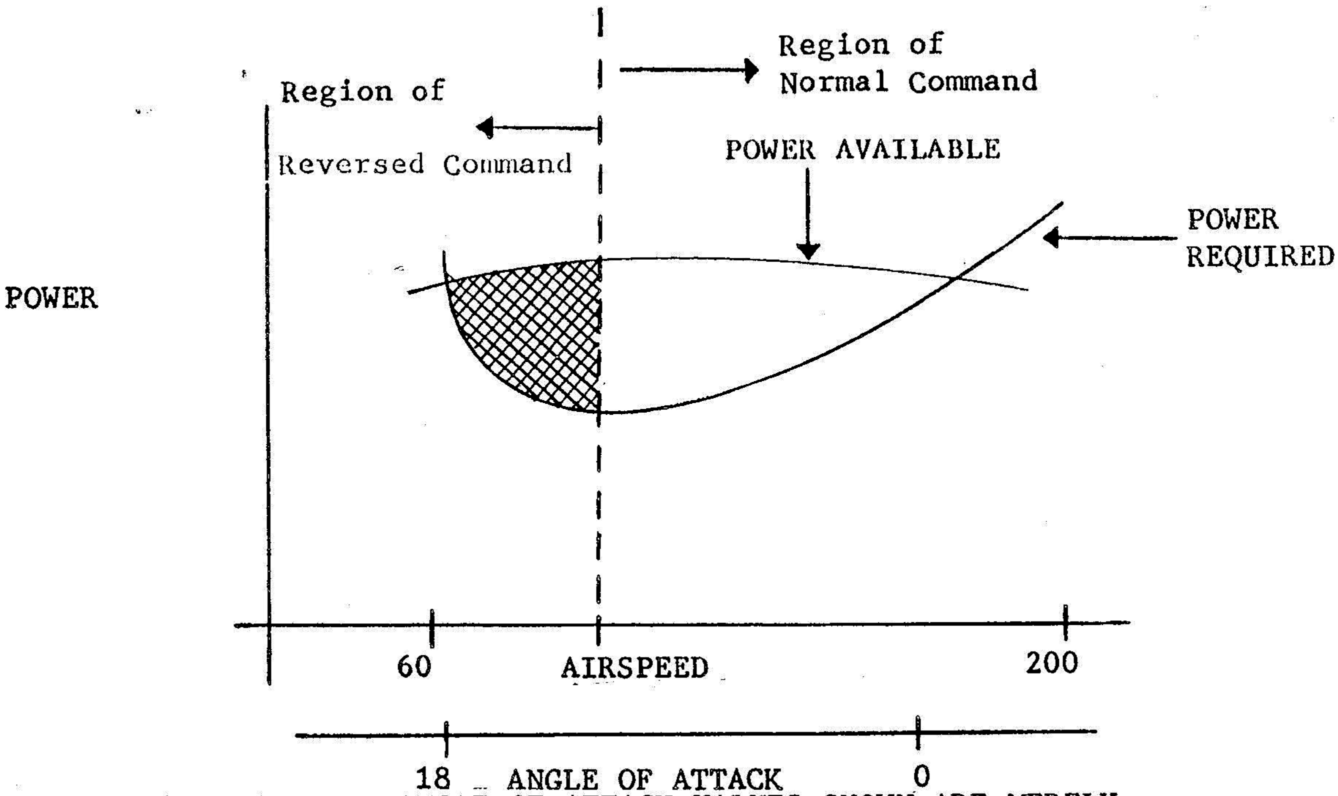
b. With the exception of the transient speed conditions of flight which occur during maneuvers, the conditions of steady flight are always applicable.

c. It should be noted that changes in airspeed will require the pilot to adjust power settings if he wishes to maintain altitude, because of the variation of power required in relation to speed. By the same token, if he wishes to hold airspeed constant during changes in power settings, it will be necessary for him to adjust the pitch attitude of the airplane. These principles form the basis for attitude flying technique, commonly referred to as "attitude plus power equals performance."

NOTE: The Instrument Flying Handbook, AC 61-27B, contains basic information needed to acquire an FAA instrument rating, and a valuable section on attitude instrument flying. In that section, it is brought out that power control must be looked at in relation to its effect on altitude AND AIRSPEED, since any change in power setting can result in a change in airspeed or altitude, or a combination of both. "At any GIVEN (CONSTANT) AIRSPEED, the power setting determines whether the aircraft is in level flight, in a climb, or in a descent. On the other hand, IF YOU HOLD ALTITUDE CONSTANT, THE AMOUNT OF POWER APPLIED WILL DETERMINE AIRSPEED." This is not meant to contradict the earlier stated principles of steady flight, but to present a refined and proven means of control coordination for the attainment of precision performance during attitude instrument flying.

8. THE REGION OF REVERSED COMMAND.

a. Airplane configuration and altitude define a specific variation of POWER SETTING required versus airspeed (jet thrust or propeller power). At low airspeeds near the stall, the power setting required for steady, level flight is quite high. From that point, an increase in airspeed reduces the required power setting until some minimum power is reached at (or near) the conditions for maximum endurance. Increased speed beyond the condition for maximum endurance then increases the power setting required for steady, level flight. The following graph illustrates these facts.



* NOTE: AIRSPEED AND ANGLE OF ATTACK VALUES SHOWN ARE MERELY EXAMPLES.

b. As shown on the POWER/AIRSPEED graph, the "region of reversed command" is the shaded area at the left of the vertical dashed line which represents the speed for maximum endurance. It can be seen that it is possible for one power setting to achieve steady level flight at two different airspeeds.

c. The regime of flight speeds greater than the speed for maximum endurance is termed the REGION OF NORMAL COMMAND. It is characterized by the effects of parasite drag which predominate to produce the need for increased power with increased speed.

d. Flight speeds below the speed for maximum endurance require power settings which increase with a decrease in airspeed, and this regime of flight speeds is therefore termed the REGION OF REVERSED COMMAND. The effects of induced drag are the primary cause of the need for increased power with reduced speed.

. CHARACTERISTICS OF FLIGHT IN THE REGION OF REVERSED COMMAND.

a. Flight in the region of normal command is characterized by a strong tendency of the airplane to maintain the trim speed. Within the region of reversed command, however, it is likely that the airplane will exhibit little inherent tendency to maintain trim speed, and the airplane may in fact be basically unstable.

b. During landing approach, an increase in noseup attitude may produce a greater rate of descent and, without the appropriate power change, only succeed in controlling the airplane to still lower airspeeds or onset of stall.

c. Impressions and habits that can be developed during operation in the region of normal command, such as the impression that rate of climb or descent can be controlled by changes in angle of attack alone, can have serious consequences in the region of reversed command.

d. Operation in the area of reversed command is common during an aerial application swath run or turnaround, and can occur at any time a pilot allows a combination of low airspeed and high power settings to result in a high angle of attack. There are two ways out of the situation - increase power or increase airspeed. If possible, the combined use of both will be the best remedy.

e. If through carelessness or complacency, a pilot permits the speed to get too low while close to the ground (i.e., aerial applicator swath run, or short field takeoff), he may find himself with little or no additional power and no excess airspeed to convert to altitude. There may be no means of obtaining the performance necessary to clear obstacles.

f. Stalls are another problem closely associated with operation in the "region of reversed command." Since the angle of attack is already high, a stall can occur at pullup, turn, or level off for a swath run, or during any tight maneuvering, such as on an excessively steep turn to final. In fact, maneuvering that increases the load factor can lead to stall, even at speeds in the area of normal command.

g. No appreciable change in load factor or stall speed occurs at bank angles of less than 30 degrees. However, at bank angles greater than 45 degrees, the increase in load factor and stall speed is quite rapid, and emphasizes the need to avoid "turn tightening" at low airspeeds - a flight condition common to stall/spin accidents.

10. CONCLUSIONS.

a. While flight in the region of normal command may create doubt as to the primary control of airspeed and altitude, operation in the region of reversed command should leave little doubt about proper flying techniques.

b. In no other flying situation is the association of region of reversed command and stall as intolerant of mishandling than in the low altitude, maximum performance operations typical of aerial application and STOL operations. But these same conditions can be encountered by the careless general aviation pilot, and the aerodynamic factors will prove just as intolerant.

c. Operation in the region of reversed command does not imply that great control difficulty exists, but errors in basic flying technique will be amplified. Proper flying technique and precise control of the airplane are most necessary in the region of reversed command.

J. A. Ferrarese

J. A. FERRARESE, Acting Director
Flight Standards Service