of oscillation which coincide with the pilot-control system response lag. Also, the high q flight condition provides the aerodynamic capability for failing flight loads during the oscillation.

If a pilot induced oscillation is encountered the pilot must rely on the inherent dynamic stability of the airplane and immediately release the controls. If the unstable excitation is continued, dangerous oscillation amplitudes will develop in a very short time.

ROLL COUPLING

The appearance of "inertia coupling" problems in modern airplanes was the natural result of the progressive change in aerodynamic and inertia characteristics to meet the demands of high speed flight. Inertia coupling problems were unexpected only when dynamic stability analyses did not adequately account for the rapid changes in aerodynamic and inertia characteristics of airplane configurations. The The term of "intertia coupling" is somewhat misleading because the complete problem is one of aerodynamic as well as inertia coupling.

"Coupling" results when some disturbance about one airplane axis causes a disturbance about another axis. An example of uncoupled motion is the disturbance provided an airplane when subjected to an elevator deflection. The resulting motion is restricted to pitching motion without disturbance in yaw or roll. An example of coupled motion could be the disturbance provided an airplane when subjected to rudder deflection. The ensuing motion can be some combination of yawing and rolling motion. Hence, the rolling motion is coupled with the yawing motion to define the resulting motion. This sort of interaction results from aerodynamic characteristics and is termed "aerodynamic coupling."

A separate type of coupling results from the inertia characteristics of the airplane configuration. The inertia characteristics of the complete airplane can be divided into the roll, yaw, and pitch inertia and each inertia is a measure of the resistance to rolling, yawing, or pitching acceleration of the airplane. The long,slender, high-density fuselage with short, thin wings produces a roll inertia which is quite small in comparison to the pitch and yaw inertia. These characteristics are typical of the modern airplane configuration. The more conventional low speed airplane may have a wingspan greater than the fuselage length. This type of configuration produces a relatively large roll inertia. A comparison of these configurations is shown in figure 4.34.

Inertia coupling can be illustrated by considering the mass of the airplane to be concentrated in two elements, one representing the mass ahead of the c.g. and one representing the mass behind the c.g. There are two principal axis systems to consider: (1) the aerodynamic, or wind axis is through the c.g. in the relative wind direction, and (2) the inertia axis is through the c.g. in the direction of the two element masses. This axis system is illustrated in figure 4.34.

If the airplane shown in figure 4.34 were in some flight condition where the inertia axis and the aerodynamic axis are alined, no inertia coupling would result from rolling motion. However, if the inertia axis is inclined to the aerodynamic axis, rotation about the aerodynamic axis will create centrifugal forces and cause a pitching moment. In this case, a rolling motion of the aircraft induces a pitching moment through the action of inertia forces. This is "inertia coupling" and is illustrated by part B of figure 4.34.

When the airplane is rotated about the inertia axis no inertia coupling will exist but aerodynamic coupling will be present. Part C of figure 4.34 shows the airplane after rolling 90° about the inertia axis. The inclination which was initially the angle of attack (α) is now the angle of sideslip ($-\beta$). Also the original zero sideslip has now become zero angle of attack. The sideslip induced by this 90° displacement will affect the roll rate