NASA
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Information Summaries

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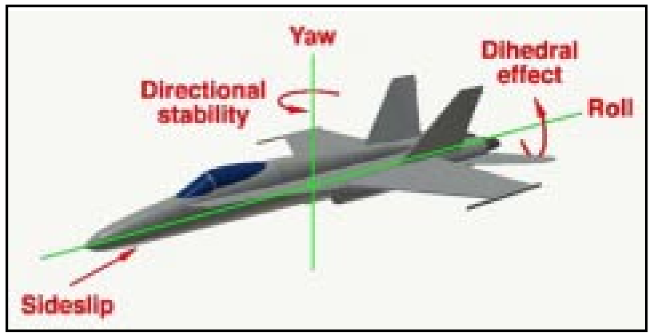
Steady Sideslip

Background

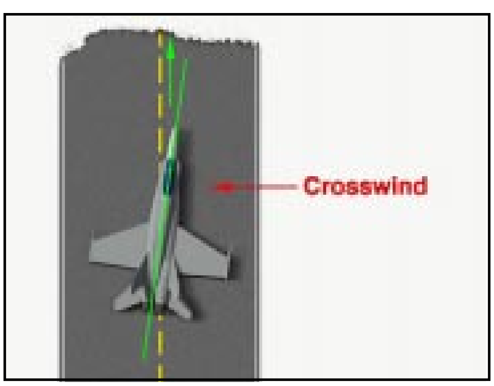


Sideslip will induce both yawing motion (due to directional stability) and rolling motion (due to dihedral effect). The combined motions in yaw and roll are therefore coupled together, since they are both related to sideslip. (Fig. SS-1)

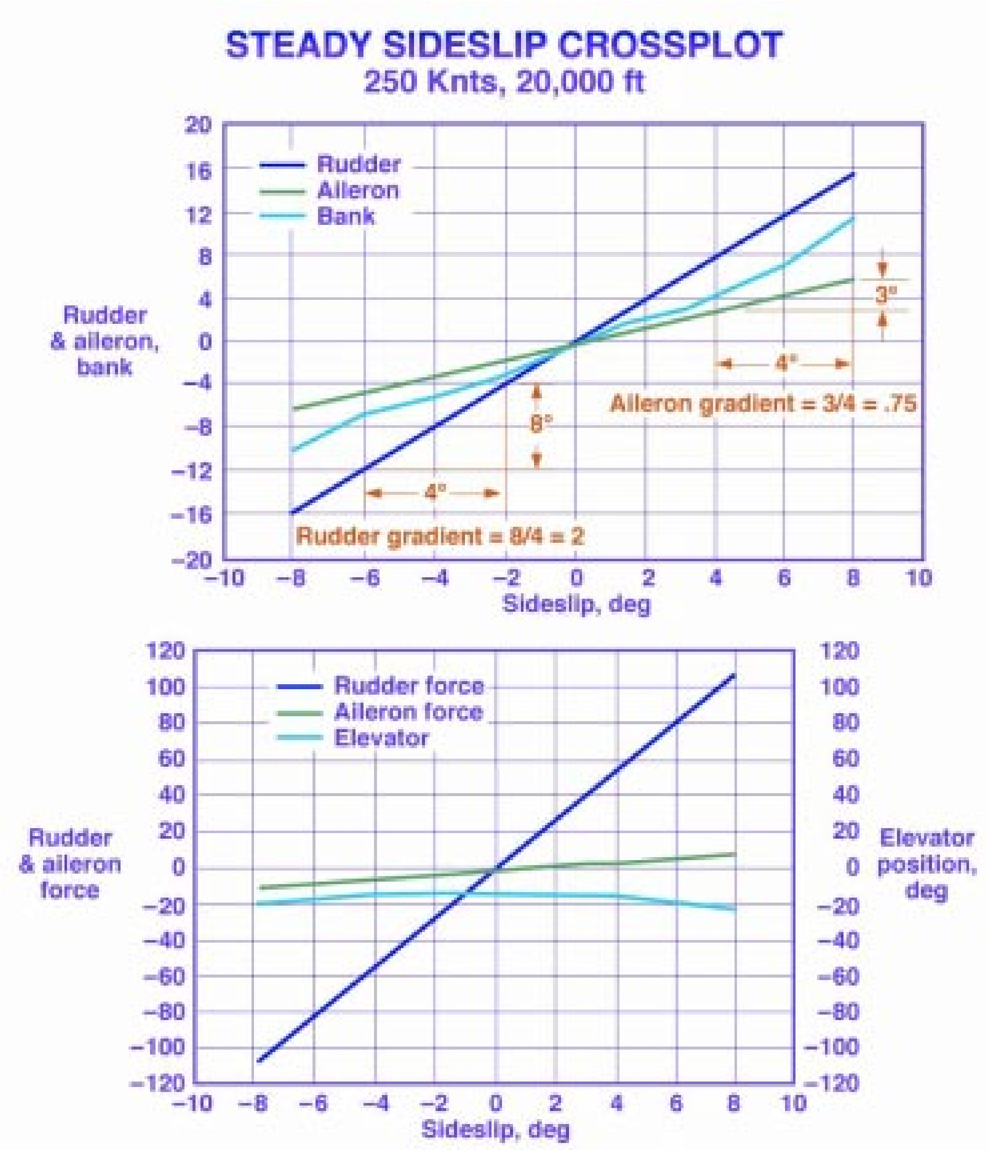
The strength of these coupling effects can be found by measuring the amount of rudder and aileron deflection that the pilot must use to hold the airplane in a steady sideslip. The higher the rudder deflection, the higher the directional stability. The higher the aileron deflection, the higher the dihedral effect.

Directional stability and dihedral effect are measures of the restoring tendency when ONLY sideslip is present (no control deflections). Since both the aileron and rudder are deflected during a steady sideslip, this measure of directional stability and dihedral effect can only be an approximation. Directional stability and dihedral effect can be determined more accurately by analyzing dynamic maneuvers. (See Control Pulses.)

The pilot effort required to maintain the rudder and ailerons at these deflections (pedal force and lateral stick force) are also important to the control harmony of the airplane. Occasionally an airplane will exhibit a characteristic called "rudder lock" where the force on the rudder pedals reverse as the rudder deflection approaches its maximum deflection. The rudder will tend to "float" all the way to maximum deflection without any further effort by the pilot. This is a potentially hazardous situation for a multi-engine airplane where the loss of an engine on one side will require large amounts of rudder deflection to maintain straight and level flight.



For normal flight conditions there is little reason for a pilot to intentionally sideslip an airplane. The exception is during a crosswind landing, (wind trying to blow the airplane off the side of the runway). Intentional sideslips are then necessary to keep the airplane over the runway just before touchdown. The steady sideslip maneuver in the low speed, landing configuration (gear and flaps down) is, therefore, more than just a test maneuver. It is a measure of how easily the pilot can compensate for crosswinds during landing. (Fig. SS-2)



1. Specific Objective of the Test

Determine the gradient of rudder deflection per degree of sideslip, and aileron deflection per degree of sideslip for one flight condition. Secondary objectives are to determine the amount of bank angle required to maintain a constant heading during the sideslip, to measure any pitch trim change that might result from the sideslip, and to identify any region ofthe flight envelope where "rudder lock" is present. (Fig.SS-3)

2. Critical Flight Conditions

The steady sideslip is used as a flight test maneuver to measure directional stability and dihedral effect over most of the flight envelope. The steady sideslip is used additionally as a measure of crosswind capability for the landing and takeoff configuration. The flight conditions that generally influence steady sideslip are:

- Airspeed
- Mach number
- Configuration (flaps and landing gear position)

In most cases the amount of sideslip that can be commanded by the pilot is limited by the amount of available rudder deflection. In some instances there may be a "placard" on sidelip at high airspeeds due to high loads on the vertical tail.

3. Required Instrumentation

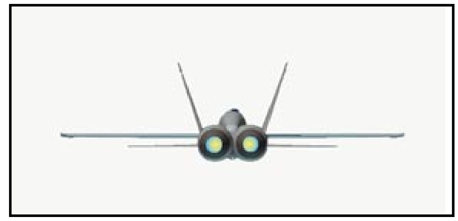
The parameters usually measured and recorded during a Steady Sideslip are shown in Table (1-1)

A continuous time history of these parameters is needed for the trim point, and throughout each sideslip maneuver. A sampling rate of at least 10 data samples every second is necessary to accurately record the maneuver, and each data sample must be accurately time correlated with the data samples of the other parameters. That is, we must be able to relate a particular measurement of aileron and rudder position with a measurement of sideslip at the same instant in time.

4. Starting Trim Point

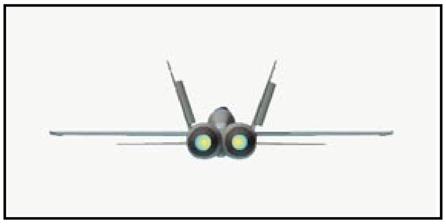
The flight test engineer will establish a table of flight conditions where Steady Sideslips are desired. This table usually calls for particular speeds, altitudes and aircraft configurations covering the entire flight envelope of the airplane. A typical sample table of flight conditions for Steady Sideslips is shown in Table (1-2)

A test begins with the initial trim point. The pilot establishes the airplane in level flight at one of the desired flight conditions of speed, altitude and power setting. The pilot then uses the trim devices in the airplane's control system to allow the airplane to continue in stable, level flight, but with the pilot's hands and feet off of the controls. A short data recording is taken of this condition, usually referred to as a "trim shot" (Fig. SS-4).

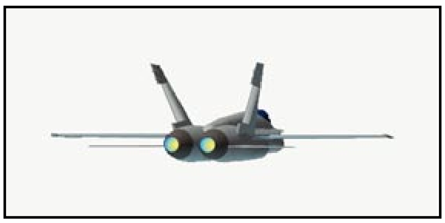


5. Description of a Steady Sideslip

The pilot begins the maneuver by applying a small amount of rudder force to one rudder pedal, then holding the force constant (Fig. SS-5).



The airplane will begin to yaw and enter a skidding turn toward the applied rudder (Fig. SS-6).



The airplane must be banked in the opposite direction of the applied rudder in order to stabilize at a constant heading (that is, a left bank if the right pedal was applied).

A steady heading can be verified by either sighting on a landmark over the nose, or watching the compass on the instrument panel. The pilot will adjust the aileron control until the heading and the bank angle are steady, thus establishing one data point. The rudder pedal is then depressed further and the bank angle is again adjusted to stabilize the heading to obtain another data point. This process is repeated several times until full rudder (or a sideslip limit) is reached.

After completing the sideslips in one direction, the pilot will release the rudder and recheck the trim condition. The process is then repeated in the other direction by applying rudder force to the other rudder pedal in a series of short stabilized points, until full deflection or a sideslip limit is reached.

The recorded data from a Steady Sideslip is shown in Fig. SS-8.

The brief pauses at each data point are apparent as flat spots in the recording of each parameter. The flight test engineer will select an instant when the aircraft was stabilized. The values of each of the individual parameters will be read at these instants and used in subsequent analyses.

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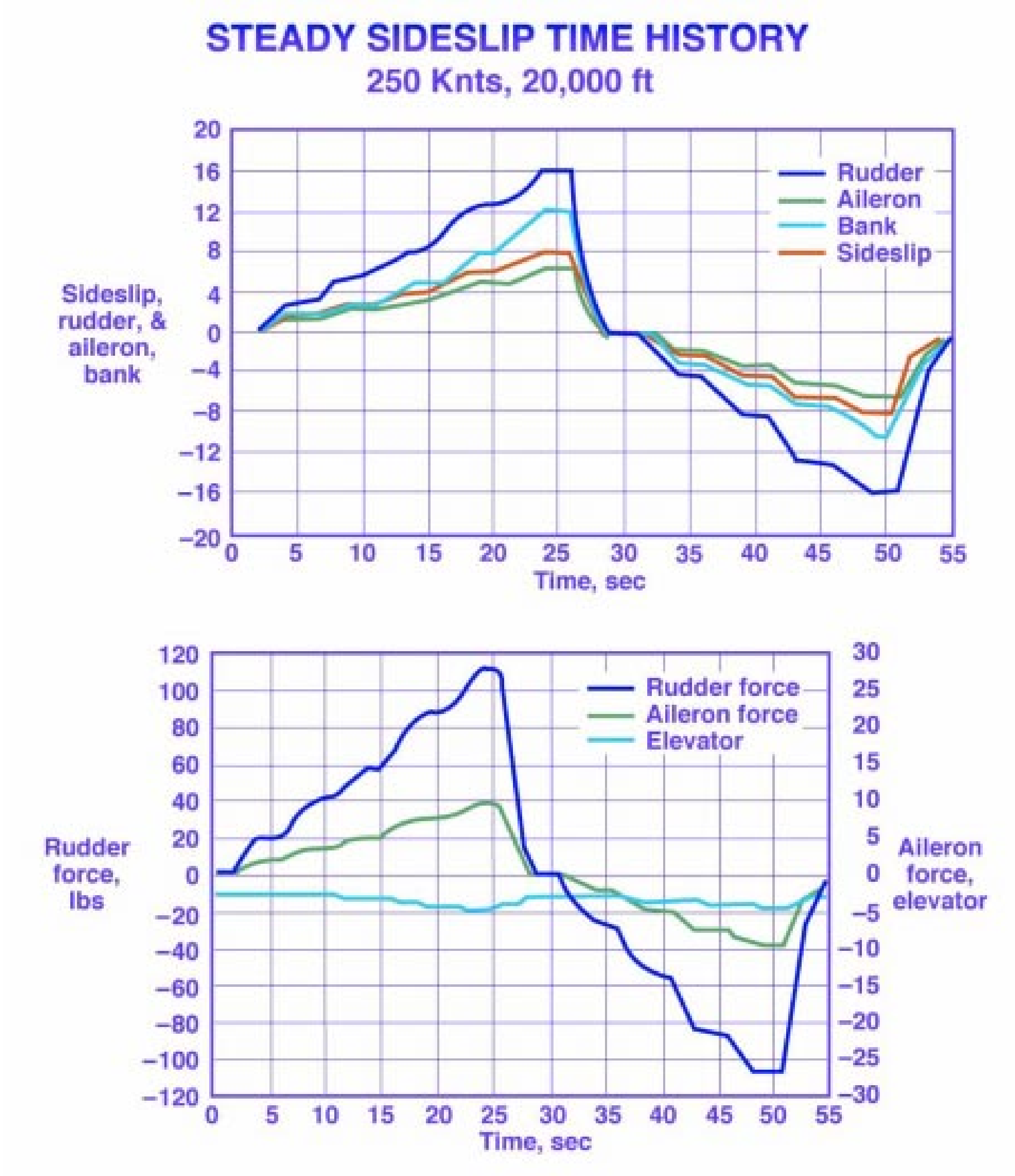

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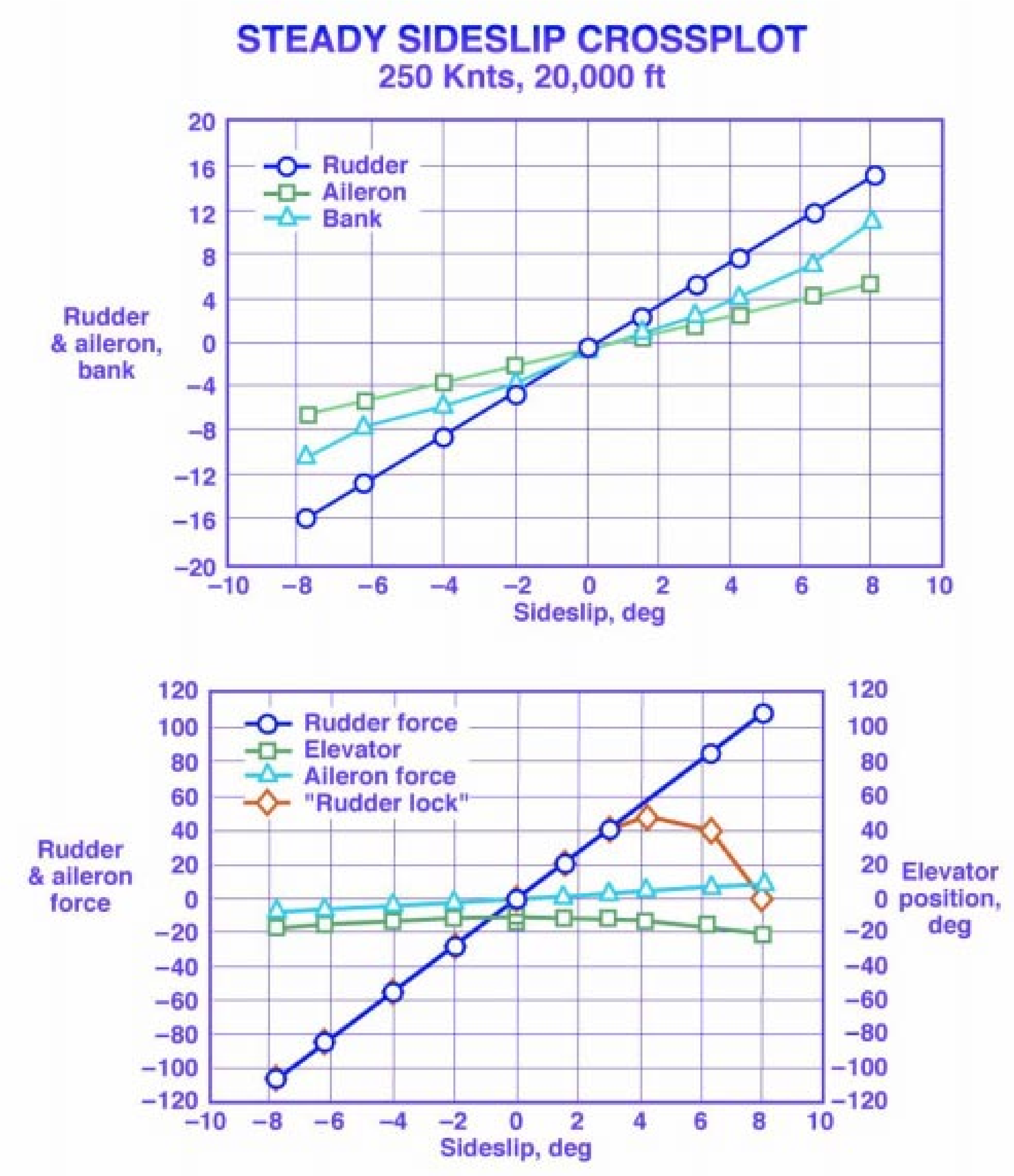
6.Measures of Success

A successful steady sideslip will meet the following test criteria:

1.All instrumented parameters recorded properly.
2.Speed did not change more than 5 knots during the maneuver.
3.A sufficient number of stabilized points were obtained to identify the gradients with sideslip.
4.Any tendency toward "rudder lock" is identified.



Any nonlinear tendencies in the rudder force gradients (that is, lower rudder forces needed at the higher rudder deflections) will be carefully reviewed. If a rudder lock condition is suspected, a repeat maneuver, or an additional maneuver at a slightly different flight condition, might be flown.

An example of a completed Steady Sidelip chart to establish gradients is shown in.

Table 1-1

Listing of Instrumentation Parameters

Parameter	Used For
Airspeed	Compute mach and dyn. pres.
Pressure Altitude	
Outside Air Temperature	
Rudder Position	Directional Stability
Rudder Force	Control harmony, "rudder lock"
Aileron Position	Dihedral effect
Aileron Stick force	Control harmony
Elevator Position	Trim change due to sideslip
Elevator Stick Force	Pilot Effort to control trim change
Angle of Sideslip	Control Surface Gradients
Bank Angle	Required for constant heading
Angle of Attack	Influence on dihedral effect
Roll Rate	Determine stabilized flight
Yaw Rate	Determine constant heading

Table 1-2

Steady Sideslip Flight Test Conditions

Config.	Alt	Airspeed	(Mach)
Clean	10000	140	.26
		200	.36
		250	.45
		300	.54
	20000	200	.44
		250	.55
		300	.65
		350	.75
	30000	200	.54
		250	.67
		300	.79
		350	.90
Gear, Flaps	5000	120	.20
		140	.23
		180	.30