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Flight dynamics — Vocabulary —

Part 8:
Dynamic behaviour of aircraft

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 8, *Aerospace terminology*.

This second edition cancels and replaces the first edition (ISO 1151-8:1992), which has been technically revised.

The main changes are as follows:

— new terms related to types of aircraft motion have been added.

A list of all parts in the ISO 1151 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Flight dynamics — Vocabulary —

Part 8:
Dynamic behaviour of aircraft

1 Scope

This document defines terms related to the concepts and quantities characterizing some classes of aircraft motion and their fundamental dynamic characteristics.

The aircraft is assumed to be rigid, of constant mass and of constant inertia. It is not equipped with systems modifying its natural dynamic behaviour. However, most of the definitions can be applied to the case of a flexible aircraft, of variable mass and of variable inertia.

The general concepts defined in this document are applicable to the atmospheric flight phase.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 General

3.1.1
flight variable
physical quantity, the value of which as a function of time characterizes aircraft motion

3.1.2
flight state
set of values of the *flight variables* (3.1.1)

Note 1 to entry: This concept should not be confused with that of *flight point* (ISO 1151-7:1985, 7.5.5).

3.1.3
steady flight state
flight state (3.1.2) in which the *flight variables* (3.1.1) considered remain constant with time

3.1.4
quasi-steady flight state
flight state (3.1.2) in which the *flight variables* (3.1.1) considered vary so slowly with time that their variations can be disregarded in the study

3.1.5
unsteady flight state
flight state (3.1.2) in which at least one of the *flight variables* (3.1.1) considered varies so rapidly with time that its variations cannot be disregarded in the study

3.1.6
reference flight state
flight state (3.1.2) chosen as reference in a given study

Note 1 to entry: In most cases, a *steady flight state* (3.1.3) or a *quasi-steady flight state* (3.1.4) is chosen as reference.

Note 2 to entry: In a study covering a certain period of time, it is normal to choose the flight state immediately prior to this period as a reference.

3.1.7
control input
action on aircraft intended to alter or to maintain the *flight state* (3.1.2)

3.1.8
disturbance
involuntary action which results in a modification in the *flight state* (3.1.2)

Note 1 to entry: The nature of this action can be, for example:

— human;

— atmospheric;

— mechanical.

3.1.9
input variable
element of the set of quantities characterizing the *control input* (3.1.7) or *disturbance* (3.1.8)

3.1.10
output variable
element of the set of *flight variables* (3.1.1), the developments of which over time characterize the response of aircraft to the *control input* (3.1.7) or *disturbance* (3.1.8) considered

3.2 Types of aircraft motion

3.2.1
flight-path
trajectory
three-dimensional locus of origin of the flight-path axis system, usually the centre of mass, relative to the Earth

3.2.2
aircraft plane motion
motion of aircraft characterized by a *flight-path* (3.2.1) contained within a plane

3.2.3
straight flight
aircraft plane motion (3.2.2) characterized by a straight *flight-path* (3.2.1)

3.2.4
horizontal flight
aircraft plane motion (3.2.2) characterized by a *flight-path* (3.2.1) contained within a horizontal plane

3.2.5
symmetrical flight
flight state (3.1.2) of aircraft with zero angle of sideslip

Note 1 to entry: The angle of sideslip is defined in ISO 1151-1:1988, 1.2.1.1.

Note 2 to entry: The geometry of aircraft and the flow are not necessarily symmetrical.

3.2.6
turn
motion of aircraft resulting in a change of *flight-path* (3.2.1) azimuth angle

Note 1 to entry: The flight-path azimuth angle is defined in ISO 1151-2:1985, 2.3.1.

3.2.7
horizontal turn
turn (3.2.6) in *horizontal flight* (3.2.4)

3.2.8
steady turn
horizontal turn (3.2.7) for which the airspeed and the load factor are held constant

Note 1 to entry: If the wind speed, V_w (ISO 1151-2:1985, 2.2.3), is zero, the *flight-path* (3.2.1) is circular.

3.2.9
longitudinal motion
isolated longitudinal motion
motion characterized by variations of *flight variables* (3.1.1), related to the three degrees of freedom in the aircraft plane of symmetry

Note 1 to entry: Longitudinal motion is characterized by variations in relation to a *reference flight state* (3.1.6) of

— angle of attack, α (ISO 1151-1:1988, 1.2.1.2),

— inclination angle, Θ (ISO 1151-1:1988, 1.2.2.2),

— airspeed, V (ISO 1151-1:1988, 1.3.1),

— *flight-path* (3.2.1) inclination angle, γ (ISO 1151-2:1985, 2.3.2), and

— rate of pitch, q (ISO 1151-1:1988, 1.3.6),

while the variations of

— angle of sideslip, β (ISO 1151-1:1988, 1.2.1.1),

— rate of roll, p (ISO 1151-1:1988, 1.3.6), and

— rate of yaw, r (ISO 1151-1:1988, 1.3.6)

are zero or negligible.

3.2.10
lateral motion
isolated lateral motion
motion characterized by variations of *flight variables* (3.1.1), related to the three degrees of freedom outside of the aircraft plane of symmetry

Note 1 to entry: Lateral motion is characterized by variations in relation to a *reference flight state* (3.1.6) of

— angle of sideslip, β (ISO 1151-1:1988, 1.2.1.1),

— bank angle, Φ (ISO 1151-1:1988, 1.2.2.3),

— azimuth angle, Ψ (ISO 1151-1:1988, 1.2.2.1),

— rate of roll, p (ISO 1151-1:1988, 1.3.6), and

— rate of yaw, r (ISO 1151-1:1988, 1.3.6),

while the variations of

— angle of attack, α (ISO 1151-1:1988, 1.2.1.2),

— airspeed, V (ISO 1151-1:1988, 1.3.1),

— *flight-path* (3.2.1) inclination angle, γ (ISO 1151-2:1985, 2.3.2), and

— rate of pitch, q (ISO 1151-1:1988, 1.3.6)

are zero or negligible.

3.2.11
aerodynamic stall
aerodynamic loss of lift caused by the angle of attack, α, exceeding its critical value

Note 1 to entry: The angle of attack, α, is defined in ISO 1151-1:1988, 1.2.1.2.

3.2.12
aeroplane upset
flight state (3.1.2) characterized by aircraft *flight variables* (3.1.1) unintentionally exceeding their limits normally experienced in line operations or training

Note 1 to entry: Aeroplane upset is normally defined by the existence of at least one of the following parameters:

a) inclination angle, Θ (ISO 1151-1:1988, 1.2.2.2) (pitch attitude), greater than 25°, nose up;

b) inclination angle, Θ (ISO 1151-1:1988, 1.2.2.2) (pitch attitude), less than −10°, nose down;

c) absolute value of bank angle, Φ (ISO 1151-1:1988, 1.2.2.3), greater than 45°;

d) within the above parameters, but flying at airspeed, V (ISO 1151-1:1988, 1.3.1), inappropriate for the conditions.

3.3 Types of aircraft motion and natural modes of aircraft motion

3.3.1
short period oscillation
oscillatory longitudinal motion characterized by variations in the angle of attack, α, and the rate of pitch, q, at a nearly constant airspeed, V, with a frequency, f, higher than that of the *phugoid* (3.3.2) mode

Note 1 to entry: The angle of attack, α, is defined in ISO 1151-1:1988, 1.2.1.2. The rate of pitch, q, is defined in ISO 1151-1:1988, 1.3.6. The airspeed, V, is defined in ISO 1151-1:1988, 1.3.1.

Note 2 to entry: The *damping coefficient*, δ (3.4.2), of short period oscillation is generally large.

Note 3 to entry: The modes considered correspond to small motions superimposed on a steady or quasi-steady reference flight state. These are motions of aircraft following a control input or disturbance.

3.3.2
phugoid
phugoid oscillation
oscillatory *longitudinal motion* (3.2.9) characterized by variations in the horizontal and vertical components of the aircraft velocity, $\vec{V}$, and the inclination angle, Θ, of the aircraft, at a nearly constant angle of attack, α

Note 1 to entry: The aircraft velocity, $\vec{V}$, is defined in ISO 1151-1:1988, 1.3.1. The inclination angle, Θ, is defined in ISO 1151-1:1988, 1.2.2.2. The angle of attack, α, is defined in ISO 1151-1:1988, 1.2.1.2.

Note 2 to entry: The frequency, f, and the *damping coefficient*, δ (3.4.2), are generally low.

Note 3 to entry: The modes considered correspond to small motions superimposed on a steady or quasi-steady reference flight state. These are motions of aircraft following a control input or disturbance.

3.3.3
aperiodic longitudinal mode
longitudinal motion (3.2.9) characterized by variations in the vertical component of the aircraft velocity, $\vec{V}$

Note 1 to entry: The aircraft velocity, $\vec{V}$, is defined in ISO 1151-1:1988, 1.3.1.

Note 2 to entry: The *damping coefficient*, δ (3.4.2), is generally large.

Note 3 to entry: The modes considered correspond to small motions superimposed on a steady or quasi-steady reference flight state. These are motions of aircraft following a control input or disturbance.

3.3.4
roll mode
aperiodic *lateral motion* (3.2.10) characterized by variations in the bank angle, Φ, at nearly zero angle of sideslip, β, and rate of yaw, r

Note 1 to entry: The bank angle, Φ, is defined in ISO 1151-1:1988, 1.2.2.3. The angle of sideslip, β, is defined in ISO 1151-1:1988, 1.2.1.1. The rate of yaw, r, is defined in ISO 1151-1:1988, 1.3.6.

Note 2 to entry: The *damping coefficient*, δ (3.4.2), is generally large.

Note 3 to entry: The modes considered correspond to small motions superimposed on a steady or quasi-steady reference flight state. These are motions of aircraft following a control input or disturbance.

3.3.5
Dutch roll
Dutch roll oscillation
oscillatory *lateral motion* (3.2.10) characterized by variations in the angle of the sideslip, β, the bank angle, Φ, and the azimuth angle, Ψ

Note 1 to entry: The angle of sideslip, β, is defined in ISO 1151-1:1988, 1.2.1.1. The bank angle, Φ, is defined in ISO 1151-1:1988, 1.2.2.3. The azimuth angle, Ψ, is defined in ISO 1151-1:1988, 1.2.2.1.

Note 2 to entry: The modes considered correspond to small motions superimposed on a steady or quasi-steady reference flight state. These are motions of aircraft following a control input or disturbance.

3.3.6
spiral mode
aperiodic *lateral motion* (3.2.10) characterized by slow variations in the bank angle, Φ, and the angle of sideslip, β

Note 1 to entry: The bank angle, Φ, is defined in ISO 1151-1:1988, 1.2.2.3. The angle of sideslip, β, is defined in ISO 1151-1:1988, 1.2.1.1.

Note 2 to entry: The *damping coefficient*, δ (3.4.2), positive or negative, has generally a small absolute value.

Note 3 to entry: The modes considered correspond to small motions superimposed on a steady or quasi-steady reference flight state. These are motions of aircraft following a control input or disturbance.

3.4 Characteristic parameters of individual modes of motion

3.4.1
amplitude
A
time function, defined by

$$A = |A_0| \cdot e^{-\delta t}$$

where

δ is the *damping coefficient* (3.4.2);

A_0 is the initial value of the *flight variable* (3.1.1)

3.4.2
damping coefficient
δ
quantity defining the decreasing or increasing of the *amplitude* (3.4.1) with time

Note 1 to entry: Damping coefficient is linked to the amplitude, A, by the following formula:

$$\delta = -\frac{1}{A} \cdot \frac{dA}{dt}$$

3.4.3
time constant
τ
quantity defined by

$$\tau = -\frac{1}{\delta}$$

where δ is the *damping coefficient* (3.4.2)

Note 1 to entry: Where δ is positive, τ is the time interval during which the *amplitude*, A (3.4.1), is divided by e, the base of natural logarithms (1/e = 0,367 9).

Note 2 to entry: Where δ is negative, τ is the time interval during which the amplitude, A, is multiplied by e.

Note 3 to entry: Where the amplitude, A, is constant, τ is not defined.

3.4.4
time to half amplitude
$\tau_{1/2}$
time interval during which the *amplitude* (3.4.1) is reduced by half where the amplitude, A, is a decreasing function of time (*damping coefficient* (3.4.2) $\delta > 0$)

Note 1 to entry: $\tau_{1/2}$ is a constant linked to the damping coefficient, δ, by the following formula:

$$\tau_{1/2} = \frac{\ln(1/2)}{\delta} = \frac{0,693\ 1}{\delta}$$

3.4.5
time to double amplitude
τ_2
time interval during which the *amplitude* (3.4.1) has doubled where the amplitude, A, is an increasing function of time (*damping coefficient* (3.4.2) $\delta < 0$)

Note 1 to entry: τ_2 is a constant linked to the damping coefficient, δ, by the following formula:

$$\tau_2 = -\frac{\ln(2)}{\delta} = -\frac{0,693\ 1}{\delta}$$

3.4.6
oscillation period
T
period of the sinusoidal factor of the oscillatory function

Note 1 to entry: T is a constant linked to the *oscillation frequency*, f (3.4.7), by the following formula:

$$T = \frac{1}{f}$$

Note 2 to entry: The period of the oscillatory function is the time interval separating two successive passages through zero in the same direction.

Note 3 to entry: The term "pseudo-period" can be used to point out that an oscillatory function is not strictly periodic.

3.4.7
oscillation frequency
f
frequency of the sinusoidal factor of the oscillatory function

Note 1 to entry: f is a constant linked to the *oscillation period*, T (3.4.6), by the following formula:

$$f = \frac{1}{T}$$

3.4.8
logarithmic decrement
Λ
product of the *damping coefficient*, δ (3.4.2), and the *oscillation period*, T (3.4.6)

$$\Lambda = \delta \cdot T$$

Note 1 to entry: The logarithmic decrement is the natural logarithm of the ratio of the *amplitude*, A (3.4.1), at time t to the amplitude at time $(t + T)$:

$$\Lambda = ln \frac{A(t)}{A(t+T)}$$

3.5 Standard input signals

3.5.1
step
input signal, equal to zero before initial instant t_0 and maintained to equal to constant value starting from initial instant t_0

Note 1 to entry: The input signal changes as time function in accordance with the following formula:

$$\Gamma_i(t_0) = \begin{cases} = 0 & if\ t < t_0 \\ = a & if\ t \geq t_0 \end{cases}$$

where

a represents a constant value;

i characterizes the input quantity considered;

t_0 represents the initial instant of the signals.

Note 2 to entry: See Figure 1.