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## Flight dynamics — Concepts, quantities and symbols —

## Part 4:
Concepts, quantities and symbols used in the study of aircraft stability and control

*Mécanique du vol — Concepts, grandeurs et symboles —*

*Partie 4: Concepts, grandeurs et symboles utilisés pour l'étude de la stabilité et du pilotage des avions*



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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1151-4 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Sub-Committee SC 3, *Concepts, quantities and symbols for flight dynamics*.

ISO 1151 consists of the following parts, under the general title *Flight dynamics — Concepts, quantities and symbols*:

— *Part 1: Aircraft motion relative to the air*

— *Part 2: Motions of the aircraft and the atmosphere relative to the Earth*

— *Part 3: Derivatives of forces, moments and their coefficients*

— *Part 4: Concepts, quantities and symbols used in the study of aircraft stability and control*

— *Part 5: Quantities used in measurements*

— *Part 6: Aircraft geometry*

— *Part 7: Flight points and flight envelopes*

— *Par 8: Concepts and quantities used in the study of the dynamic behaviour of the aircraft*

— *Part 9: Models of atmospheric motions along the trajectory of the aircraft*





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ISO 1151 is intended to introduce the main concepts, to include the more important terms used in theoretical and experimental studies and, as far as possible, to give corresponding symbols.

In all the parts comprising ISO 1151, the term "aircraft" denotes a vehicle intended for atmosphere or space flight. Usually, it has an essentially port and starboard symmetry with respect to a plane. That plane is determined by the geometric characteristics of the aircraft. In that plane, two orthogonal directions are defined: fore-and-aft and dorsal-ventral. The transverse direction, on the perpendicular to that plane, follows.

When there is a single plane of symmetry, it is the reference plane of the aircraft. When there is more than one plane of symmetry, or when there is none, it is necessary to choose a reference plane. In the former case, the reference plane is one of the planes of symmetry. In the latter case, the reference plane is arbitrary. In all cases, it is necessary to specify the choice made.

Angles of rotation, angular velocities and moments about any axis are positive clockwise when viewed in the positive direction of that axis.

All the axis systems used are three-dimensional, orthogonal and right-handed, which implies that a positive rotation through $\pi/2$ around the $x$-axis brings the $y$-axis into the position previously occupied by the $z$-axis.

The centre of gravity coincides with the centre of mass if the field of gravity is homogeneous. If this is not the case, the centre of gravity can be replaced by the centre of mass in the definitions of ISO 1151; in which case, this should be indicated.

**Numbering of sections and clauses**

With the aim of easing the indication of references from a section or a clause, a decimal numbering system has been adopted such that the first figure is the number of the part of ISO 1151 considered.

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# Flight dynamics — Concepts, quantities and symbols —

## Part 4:
## Concepts, quantities and symbols used in the study of aircraft stability and control



### 4.0 Introduction

This part of ISO 1151 deals with the concepts, quantities and symbols used in the study of aircraft stability and control.

### 4.1 Controls

The following definitions, except for those in 4.1.4, are applicable to an aircraft whose main controls (7.2.1.1) are:

— stick or wheel for pitch (4.1.1.1) and roll (4.1.2.1) controls;

— pedals for yaw control (4.1.3.1).

NOTES

1 Where there is no possibility of confusion, the letter $\delta$ may be omitted from the symbols given in 4.1.1 to 4.1.4.

2 The symbols adopted for the displacements of the controls are usual ones but do not necessarily conform to the normally adopted conventions.

#### 4.1.1 Pitch control

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.1.1.1** | Pitch control | Control (7.2.1.1) enabling the pilot to change the pitching moment (1.5.5). | — |
| **4.1.1.2** | Displacement of the pitch control | Displacement of a reference point fixed to the pitch control (4.1.1.1) within a suitably chosen reference system. It is positive in the forward direction (6.0.4). | $D_{\delta\mathrm{m}}$ |
| **4.1.1.3** | Effort on the pitch control | Force exerted by the pilot on the pitch control (4.1.1.1). It is positive in the forward direction (6.0.4)("pushing force"). | $E_{\delta\mathrm{m}}$ |
| **4.1.1.4** | Pitch trim control | Control enabling the pilot to change the force on the pitch control (4.1.1.3).<br>NOTE — In most cases, this control is used to reduce or to cancel the force on the pitch control (4.1.1.3) for a considered flight state (8.1.2). | — |

### 4.1.2 Roll control

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.1.2.1** | Roll control | Control (7.2.1.1) enabling the pilot to change the rolling moment (1.5.5). | — |
| **4.1.2.2** | Displacement of the roll control | (1) Stick: Displacement of a reference point fixed to the roll control (4.1.2.1) within a suitably chosen reference system. It is positive in the port direction (as defined in 6.0.4).<br>(2) Wheel: Angle of rotation of the roll control, negative in the clockwise direction for the pilot. | $D_{\delta l}$ |
| **4.1.2.3** | Effort on the roll control | (1) Stick: Force exerted by the pilot on the roll control (4.1.2.1). It is positive in the port direction (6.0.4).<br>(2) Wheel: Moment resulting from the force applied by the pilot on the wheel divided by the wheel radius. This force is negative when the mentioned torque is exerted in the clockwise direction for the pilot. | $E_{\delta l}$ |
| **4.1.2.4** | Roll trim control | Control enabling the pilot to change the force on the roll control (4.1.2.3).<br>NOTE — In most cases, this control is used to reduce or to cancel the force on the roll control (4.1.2.3) for a considered flight state (8.1.2). | — |



### 4.1.3 Yaw control

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.1.3.1** | Yaw control | Control (7.2.1.1) enabling the pilot to change the yawing moment (1.5.5). | — |
| **4.1.3.2** | Displacement of the yaw control | Displacement of a reference point fixed to the yaw control (4.1.3.1) within a suitably chosen reference system. It is positive when the left foot of the pilot moves in the forward direction (6.0.4). | $D_{\delta n}$ |
| **4.1.3.3** | Effort on the yaw control | Force exerted by the pilot on the yaw control (4.1.3.1). It is positive when the pilot pushes in the forward direction (6.0.4) with his left foot. | $E_{\delta n}$ |
| **4.1.3.4** | Yaw trim control | Control enabling the pilot to change the force on the yaw control (4.1.3.3)<br>NOTE — In most cases, this control is used to reduce or to cancel the force on the yaw control (4.1.3.3) for a considered flight state (8.1.2). | — |

### 4.1.4 Lift control

This type of control is used on helicopters. This control acts on the collective pitch of the blades of the main rotor. It is in general a lever at the side of the pilot.

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.1.4.1** | Collective pitch control; lift control | Control (7.2.1.1) enabling the pilot of a helicopter to modify the lift (1.6.2.8) by varying the mean setting of the blades of the main rotor. | — |
| **4.1.4.2** | Displacement of the collective pitch control | Displacement of a reference point fixed to the collective pitch control (4.1.4.1) within a suitably chosen reference system. It is positive in the upward direction (as defined in 6.0.4). | $D_{\delta z}$ |

## 4.2 Stability parameters

This subclause deals with the concepts and quantities used in simplified studies of aircraft stability.

These studies are based on a model where the coefficients of the components of the airframe aerodynamic moment (1.7.2.8) are assumed to be continuous and differentiable functions of the following flight variables (8.1.1): the angle of attack, $\alpha$ (1.2.1.2), the angle of sideslip, $\beta$ (1.2.1.1), the three motivator deflections $\delta_l$, $\delta_m$, $\delta_n$ (1.8.3.11, 1.8.3.12, 1.8.3.13 respectively) among others, the variations of which are small.

In most cases, it is necessary to specify the independent variable, the variables which are assumed to be fixed and the relationship between variables.

For example, the study of longitudinal stability:

a) excludes, a priori, cases of flight in steady turn (8.2.8);

b) considers, in general, the following two cases:

1) motivator fixed:

— the independent variable is the angle of attack,

— the angular speeds $p$, $q$ and $r$ (1.3.6) are zero,

— the pitch motivator is fixed [$\delta_m$ (1.8.3.12) constant];

2) motivator free:

— the independent variable is the angle of attack,

— the angular speeds $p$, $q$ and $r$ are zero,

— the pitch motivator is free; its position $\delta_m$ depends only on the angle of attack so that its hinge moment (1.9.1) remains zero. The function $\delta_m(\alpha)$ is assumed to be differentiable. (This excludes the case where the motivator is controlled by an irreversible servo-control.)



### 4.2.1 Aerodynamic centres

| No. | Term | Definition | Symbol |
|---|---|---|---|
| 4.2.1.1 | Aerodynamic centre for the angle of attack motivator fixed | Point P situated on the longitudinal axis (1.1.5), with respect to which the aerodynamic pitching moment coefficient $\left(C_m^A\right)_P$ (1.7.2.8) remains constant when the angle of attack varies, the pitch motivator being fixed. $\frac{\partial \left(C_m^A\right)_P}{\partial \alpha} = 0$ with $\delta_m$ = constant | — |
| 4.2.1.2 | Aerodynamic centre for the angle of attack motivator free | Point P situated on the longitudinal axis (1.1.5), with respect to which the aerodynamic pitching moment coefficient $\left(C_m^A\right)_P$ (1.7.2.8) remains constant when the angle of attack varies, the pitch motivator being free. $\frac{\partial \left(C_m^A\right)_P}{\partial \alpha} = 0$ | — |

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.2.1.3** | Aerodynamic centre for the angle of sideslip motivators fixed | Point P situated in the aircraft reference plane (6.1.1), with respect to which the aerodynamic rolling $\left(C_l^A\right)_P$ and yawing $\left(C_n^A\right)_P$ moment coefficients (1.7.2.8) remain constant when the angle of sideslip varies, the motivators being fixed. $\frac{\partial\left(C_l^A\right)_P}{\partial\beta} = 0$ and $\frac{\partial\left(C_n^A\right)_P}{\partial\beta} = 0$ with $\delta_l$ and $\delta_n$ = constant | — |
| **4.2.1.4** | Aerodynamic centre for the pitch control deflection | Point P situated on the longitudinal axis (1.1.5), with respect to which the aerodynamic pitching moment coefficient $\left(C_m^A\right)_P$ (1.7.2.8) remains constant when the pitch motivator deflection varies, the angle of attack being constant. $\frac{\partial\left(C_m^A\right)_P}{\partial\delta_m} = 0$ with $\alpha$ constant | — |
| **4.2.1.5** | Aerodynamic centre for the yaw control deflection | Point P situated in the aircraft reference plane (6.1.1), with respect to which the aerodynamic yawing moment coefficient $\left(C_n^A\right)_P$ (1.7.2.8) remains constant when the yaw motivator deflection varies, the angle of sideslip being constant. $\frac{\partial\left(C_n^A\right)_P}{\partial\delta_n} = 0$ with $\beta$ = constant | — |



### 4.2.2 Static margins

In definitions 4.2.2.1 and 4.2.2.2, it is assumed that the longitudinal axis $x$ (1.1.5) is parallel to the axis $x_b$ of the basic axis system of the wing (6.6.11).

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.2.2.1** | Static margin motivator fixed | Quantity defined by the relationship $\frac{x_1 - x_2}{l}$ where $x_1$ is the longitudinal coordinate (1.1.5) of the centre of mass; $x_2$ is the longitudinal coordinate of the aerodynamic centre for angle of attack motivator fixed (4.2.1.1); $l$ is the reference length (1.4.6). NOTES 1 This quantity is generally given as a percentage of the reference length (1.4.6). 2 The reference length generally used is the aerodynamic mean chord length (6.6.17). 3 The static margin is positive when the corresponding aerodynamic centre is situated behind the centre of mass. | — |

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.2.2.2** | Static margin motivator free | Quantity defined by the relationship<br>$$\frac{x_1 - x_3}{l}$$<br>where<br>$x_1$ is the longitudinal coordinate (1.1.5) of the centre of mass;<br>$x_3$ is the longitudinal coordinate of the aerodynamic centre for angle of attack motivator free (4.2.1.2);<br>$l$ is the reference length (1.4.6).<br>NOTES<br>1 This quantity is generally given as a percentage of the reference length (1.4.6).<br>2 The reference length generally used is the aerodynamic mean chord length (6.6.17).<br>3 The static margin is positive when the corresponding aerodynamic centre is situated behind the centre of mass. | — |



### 4.2.3 Centre of pressure

| No. | Term | Definition | Symbol |
|---|---|---|---|
| **4.2.3.1** | Centre of pressure | Point with respect to which the aerodynamic moment (1.6.2.9) is zero.<br>For the particular case of a given flight state (8.1.2) with<br>$$\begin{cases} Y^A = 0 \\ L^A = 0 \\ N^A = 0 \end{cases}$$<br>this term designates the point P on the longitudinal axis (1.1.5) defined by its longitudinal coordinate<br>$$x_P = -\frac{M^A}{Z^A}$$<br>where<br>$Y^A$ and $Z^A$ are the aerodynamic force components (1.6.2.2) with respect to the origin of the body axis system (1.1.5);<br>$L^A$, $M^A$, $N^A$ are the aerodynamic moment components (1.6.2.10) with respect to the origin of the body axis system (1.1.5). | — |