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INTERNATIONAL DOCUMENT

## Flight dynamics — Concepts, quantities and symbols —

### Part 1: Aircraft motion relative to the air

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

*Partie 1: Mouvement de l'avion par rapport à l'air*

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 1151-1 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*.

This fourth edition cancels and replaces the third edition (ISO 1151-1:1985) of which it constitutes a technical revision: this fourth edition includes Draft Addenda ISO/DIS 1151-1/DAD 1, circulated in 1986 (addition of a symbol to 1.5.4, 1.6.1.3 and 1.6.2.9; new sub-clauses 1.4.10, 1.4.11, 1.5.10 to 1.5.13 and 1.10) and ISO/DIS 1151-1/DAD 2, circulated in 1986 (addition of annex B).

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

ISO 1151, *Flight dynamics — Concepts, quantities and symbols*, comprises, at present, seven parts:

*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 : Parameters 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.*

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 1:

### Aircraft motion relative to the air

#### 1.0 Introduction

This part of ISO 1151 gives basic definitions and deals with aircraft motion relative to the atmosphere, assumed to be at rest or in translational motion at constant velocity relative to the Earth.<sup>1)</sup>

The aircraft is assumed to be rigid. However, most of the definitions can be applied to the case of a flexible aircraft.

When account is taken of the variations at the Earth's surface in the direction of the vertical (local direction of acceleration due to gravity), the term given in the sub-clauses and figures in question is qualified by the term "local".

#### 1.1 Axis systems

No.	Term	Definition	Symbol
1.1.1	Earth-fixed axis system	A system with both the origin and axes fixed relative to the Earth, and chosen as appropriate.	$x_0 y_0 z_0$
1.1.2	Normal earth-fixed axis system	An earth-fixed axis system (1.1.1) in which the $z_0$ -axis is oriented according to the downward vertical passing through the origin.	$x_0 y_0 z_0$ NOTE — However, $x_g y_g z_g$ is an acceptable alternative
1.1.3	Aircraft-carried earth axis system	A system in which each axis has the same direction as the corresponding earth-fixed axis, with the origin fixed in the aircraft, usually the centre of gravity.	$x_0 y_0 z_0$
1.1.4	Aircraft-carried normal earth axis system	A system in which each axis has the same direction as the corresponding normal earth-fixed axis, with the origin fixed in the aircraft, usually the centre of gravity.	$x_0 y_0 z_0$ NOTE — However, $x_g y_g z_g$ is an acceptable alternative
1.1.5	Body axis system <sup>2)</sup>	A system fixed in the aircraft, with the origin, usually the centre of gravity, consisting of the following axes:	$xyz$
	Longitudinal axis	An axis in the reference plane (see foreword on p. iii) or, if the origin is outside that plane, in the plane through the origin, parallel to the reference plane.	$x$
	Transverse axis	An axis normal to the reference plane and positive to starboard.	$y$
	Normal axis	An axis completing the system.	$z$
		NOTE — This axis lies in the reference plane or is parallel to that plane. It is positive in the ventral sense.	

1) The motions of the atmosphere for which this assumption does not hold true will be examined in another part of ISO 1151

2) Usually, the origins of the axis systems defined in 1.1.5, 1.1.6 and 1.1.7 coincide. If that is not the case, it is necessary to distinguish the different origins by appropriate suffixes

No.	Term	Definition	Symbol
1.1.6	Air-path axis system <sup>1)</sup>	A system with the origin fixed in the aircraft, usually the centre of gravity, consisting of the following axes:	$x_a y_a z_a$
	$x_a$ -axis; air-path axis	An axis in the direction of the aircraft velocity (1.3.1).	$x_a$
	$y_a$ -axis; lateral air-path axis; cross-stream axis	An axis normal to the air-path axis and the $z_a$ -axis defined below; it is positive to starboard.	$y_a$
	$z_a$ -axis; normal air-path axis	An axis <ul style="list-style-type: none"> <li>— in the reference plane or, if the origin is outside that plane, parallel to the reference plane, and</li> <li>— normal to the air-path axis.</li> </ul> The positive direction of this axis is chosen so as to complete the orthogonal, right-handed system $x_a y_a z_a$ .	$z_a$
1.1.7	Intermediate axis system <sup>1)</sup>	A system with the origin fixed in the aircraft, usually the centre of gravity, consisting of the following axes:	$x_e y_e z_e$
	$x_e$ -axis	The projection of the air-path axis on the reference plane, or, if the origin is outside that plane, on the plane through the origin, parallel to the reference plane.	$x_e$
	$y_e$ -axis	An axis normal to the reference plane and positive to starboard.	$y_e$
	$z_e$ -axis	NOTE — This axis coincides with the transverse axis (1 1 5) or is parallel to it An axis completing the axis system. NOTE — This axis coincides with the normal air-path axis (1 1 6) or is parallel to it	$z_e$

1) Usually, the origins of the axis systems defined in 1 1 5, 1 1 6 and 1 1 7 coincide. If that is not the case, it is necessary to distinguish the different origins by appropriate suffixes

## 1.2 Angles

### 1.2.1 Orientation of the aircraft velocity with respect to the body axis system (see figure 1)

No.	Term	Definition	Symbol
1.2.1.1	Angle of sideslip	The angle which the aircraft velocity (1.3.1) makes with the reference plane of the aircraft. It is positive when the aircraft velocity component along the transverse axis (1.1.5) is positive.  According to convention, it has the range:  $-\frac{\pi}{2} < \beta < \frac{\pi}{2}$	$\beta$
1.2.1.2	Angle of attack	The angle between the longitudinal axis (1.1.5) and the projection of the aircraft velocity (1.3.1) on the reference plane. It is positive when the aircraft velocity component along the normal axis (1.1.5) is positive.  According to convention, it has the range:  $-\pi < \alpha \leq \pi$	$\alpha$

**1.2.2 Transition from the aircraft-carried normal earth axis system to the body axis system**

This transition is achieved by three rotations, defined below, performed in the following order:  $\Psi$ ,  $\Theta$ ,  $\Phi$  (see figure 2).

NOTE — Similar angles may be defined with respect to any aircraft-carried earth axis system. The same symbols,  $\Psi$ ,  $\Theta$ ,  $\Phi$ , with appropriate suffixes as necessary, may then be used. However, the terms "azimuth angle", "inclination angle" and "back angle" refer only to the specific case where the  $z_o$ -axis is vertical.

No.	Term	Definition	Symbol
1.2.2.1	Azimuth angle	The rotation (positive, if clockwise) about the $z_o(z_g)$ -axis which brings the $x_o(x_g)$ -axis into coincidence with the projection of the longitudinal axis (1.1.5) on the horizontal plane through the origin.	$\Psi$
1.2.2.2	Inclination angle	The rotation in a vertical plane, following the $\Psi$ rotation (1.2.2.1), which brings the displaced $x_o(x_g)$ -axis into coincidence with the longitudinal axis (1.1.5). It is positive when the positive portion of the $x$ -axis lies above the horizontal plane through the origin.  According to convention, it has the range:  $-\frac{\pi}{2} \leq \Theta \leq \frac{\pi}{2}$	$\Theta$
1.2.2.3	Bank angle	The rotation (positive, if clockwise) about the longitudinal axis (1.1.5), brings the displaced $y_o(y_g)$ -axis into its final position $y$ from the position it reached after the $\Psi$ rotation (1.2.2.1).	$\Phi$

**1.2.3 Transition from the aircraft-carried normal earth axis system to the air-path axis system**

This transition is achieved by three rotations, defined below, performed in the following order:  $\chi_a$ ,  $\gamma_a$ ,  $\mu_a$  (see figure 3).

No.	Term	Definition	Symbol
1.2.3.1	Air-path azimuth angle; air-path track angle	The rotation (positive, if clockwise) about the $z_o(z_g)$ -axis which brings the $x_o(x_g)$ -axis into coincidence with the projection of the air-path $x_a$ -axis (1.1.6) on the horizontal plane through the origin.	$\chi_a$
1.2.3.2	Air-path inclination angle; air-path climb angle	The rotation in a vertical plane, following the $\chi_a$ rotation (1.2.3.1), which brings the displaced $x_o(x_g)$ -axis into coincidence with the air-path $x_a$ -axis (1.1.6). It is positive when the positive portion of the $x_a$ -axis lies above the horizontal plane through the origin.  According to convention, it has the range:  $-\frac{\pi}{2} \leq \gamma_a \leq \frac{\pi}{2}$	$\gamma_a$
1.2.3.3	Air-path bank angle	The rotation (positive, if clockwise) about the air-path $x_a$ -axis (1.1.6) which brings the displaced $y_o(y_g)$ -axis into its final position $y_a$ from the position it reached after the $\chi_a$ rotation (1.2.3.1).	$\mu_a$

**1.3 Velocities and angular velocities**

No.	Term	Definition	Symbol
1.3.1	Aircraft velocity	The velocity of the origin of the body axis system (1.1.5) (usually the centre of gravity), relative to the air, unaffected by the aerodynamic field of the aircraft.	$\vec{V}$
	Airspeed	The magnitude of the aircraft velocity.	$V$
1.3.2	Speed of sound	The velocity of propagation of a sound wave in the ambient air, unaffected by the aerodynamic field of the aircraft.	$a$

No.	Term	Definition	Symbol
1.3.3	Mach number	The ratio of the airspeed (1.3.1) to the speed of sound (1.3.2). Equal to $V/a$ .	$M$ is recommended. The symbols $Ma$ and $\mathcal{M}$ may be used if there is likely to be any confusion.
1.3.4	Aircraft velocity components	<p>The components of the aircraft velocity (1.3.1), <math>\vec{V}</math>, for any of the axis systems used.</p> <p>In the axis systems 1.1.1 to 1.1.4:</p> <p>component along the <math>x_o</math>-axis</p> <p>component along the <math>y_o</math>-axis</p> <p>component along the <math>z_o</math>-axis</p> <p>In the body axis system (1.1.5):</p> <p>component along the longitudinal axis</p> <p>component along the transverse axis</p> <p>component along the normal axis</p> <p>NOTE — In the air-path axis system (1.1.6), the component along the <math>x_a</math>-axis is <math>u_a = V</math>.</p>	<p><math>u_o</math></p> <p><math>v_o</math></p> <p><math>w_o</math></p> <p><math>u</math></p> <p><math>v</math></p> <p><math>w</math></p> <p>The velocity components may be written <math>V_i</math>, where <math>i</math> is a number or letter subscript.</p>
1.3.5	Aircraft angular velocity	The angular velocity of the body axis system (1.1.5) relative to the Earth.	$\vec{\Omega}$
	Aircraft angular speed	The magnitude of aircraft angular velocity.	$\Omega$
1.3.6	<p>Angular velocity components</p> <p>Rate of roll</p> <p>Rate of pitch</p> <p>Rate of yaw</p>	<p>The components of the aircraft angular velocity (1.3.5), <math>\vec{\Omega}</math>, for any of the axis systems used.</p> <p>In the axis systems 1.1.1 to 1.1.4:</p> <p>component along the <math>x_o</math>-axis</p> <p>component along the <math>y_o</math>-axis</p> <p>component along the <math>z_o</math>-axis</p> <p>In the body axis system (1.1.5):</p> <p>component along the longitudinal axis</p> <p>component along the transverse axis</p> <p>component along the normal axis</p>	<p><math>p_o</math></p> <p><math>q_o</math></p> <p><math>r_o</math></p> <p><math>p</math></p> <p><math>q</math></p> <p><math>r</math></p> <p>The angular velocity components may be written <math>\Omega_i</math>, where <math>i</math> is a number or letter subscript.</p>



No.	Term	Definition	Symbol
1.3.7	Normalized angular velocities	The normalized form of the components of the aircraft angular velocity (1.3.5), defined as follows:  In the body axis system (1.1.5):	
	Normalized rate of roll	$\frac{pl}{V}$	$p^*$
	Normalized rate of pitch	$\frac{ql}{V}$	$q^*$
	Normalized rate of yaw	$\frac{rl}{V}$	$r^*$
		where  $l$ is the reference length (1.4.6); $V$ is the airspeed (1.3.1).  Similar normalized quantities can be formed for the other axis systems.	Similar quantities using a constant reference speed in place of $V$ (1.3.1) may also be defined. These require different symbols.

**1.4 Aircraft inertia, reference quantities and reduced parameters**

No.	Term	Definition	Symbol
1.4.1	Aircraft mass	The current mass of the aircraft.	$m$
1.4.2	Moments of inertia	The moments of inertia of the aircraft with respect to the body axes $xyz$ (1.1.5).  Moment of inertia about the longitudinal axis: $\int (y^2 + z^2)dm$	$I_x$
		Moment of inertia about the transverse axis: $\int (z^2 + x^2)dm$	$I_y$
		Moment of inertia about the normal axis: $\int (x^2 + y^2)dm$	$I_z$
			NOTE — $A, B, C$ are acceptable alternatives
1.4.3	Products of inertia	The products of inertia of the aircraft with respect to the body axes $xyz$ (1.1.5). These are:  $\int yzdm$ $\int zx dm$ $\int xy dm$	$I_{yz}$ $I_{zx}$ $I_{xy}$  NOTE — $D, E, F$ are acceptable alternatives

No.	Term	Definition	Symbol
1.4.4	Radius of gyration	<p>The square root of the ratio of the moment of inertia to the aircraft mass (1.4.1):</p> <p>for the longitudinal axis (1.1.5):</p> $\sqrt{I_x/m}$ <p>for the transverse axis (1.1.5):</p> $\sqrt{I_y/m}$ <p>for the normal axis (1.1.5):</p> $\sqrt{I_z/m}$	<p><math>r_x</math></p> <p><math>r_y</math></p> <p><math>r_z</math></p>
1.4.5	Reference area	<p>An area used to define the aerodynamic coefficients and various normalized quantities. In a given document, one single reference area will be used the value of which shall be specified.</p> <p>NOTE — Although hinge moment coefficients are usually defined using specific reference areas, it may be more appropriate, in some cases, to use the single reference area adopted for the aircraft</p>	$S$
1.4.6	Reference length	<p>A length used to define the aerodynamic moment coefficients and various normalized quantities. It is recommended, in a given document, that one single reference length be used the value of which shall be specified.</p> <p>NOTES</p> <p>1 It is, however, acceptable to introduce two different reference lengths as regards the longitudinal motion and the lateral motion. These lengths shall also be specified.</p> <p>2 Although hinge moment coefficients are usually defined using specific reference lengths, it may be more appropriate, in some cases, to use the single reference length adopted for the aircraft.</p>	$l$
1.4.7	Normalized mass	<p>A non-dimensional coefficient defined as follows:</p> $\frac{m}{\frac{1}{2} \rho_e S l}$ <p>where</p> <p><math>m</math> is the aircraft mass (1.4.1);</p> <p><math>\rho_e</math> is a datum (air) density (3.3.2);</p> <p><math>S</math> is the reference area (1.4.5);</p> <p><math>l</math> is the reference length (1.4.6).</p>	$\mu$ or $m^*$
1.4.8	Dynamic unit of time	<p>A quantity defined as follows:</p> $\frac{m}{\frac{1}{2} \rho_e V_e S} = \frac{\mu l}{V_e}$ <p>where</p> <p><math>m</math> is the aircraft mass (1.4.1);</p> <p><math>\rho_e</math> is a datum (air) density (3.3.2);</p> <p><math>V_e</math> is a datum speed (3.3.1);</p> <p><math>S</math> is the reference area (1.4.5);</p> <p><math>l</math> is the reference length (1.4.6);</p> <p><math>\mu</math> is the normalized mass (1.4.7).</p>	$\tau$

No.	Term	Definition	Symbol
1.4.9	Aerodynamic unit of time	A quantity defined as follows: $\frac{l}{V_e}$ where $l$ is the reference length (1.4.6); $V_e$ is a datum speed (3.3.1).	$\tau_A$
1.4.10	Inertia matrix	A symmetrical matrix the structure of which is as follows: $I = \begin{pmatrix} I_x & -I_{xy} & -I_{zx} \\ -I_{xy} & I_y & -I_{yz} \\ -I_{zx} & -I_{yz} & I_z \end{pmatrix}$	$I$
1.4.11	Inverse inertia matrix	The inverse of the inertia matrix (1.4.10). A symmetrical matrix the structure of which is as follows: $I^{-1} = J = \begin{pmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{pmatrix}$ where $J_{11} = (I_y I_z - I_{yz}^2)/\Delta$ $J_{22} = (I_z I_x - I_{zx}^2)/\Delta$ $J_{33} = (I_x I_y - I_{xy}^2)/\Delta$ $J_{12} = (I_{xy} I_z + I_{yz} I_{zx})/\Delta$ $J_{23} = (I_{yz} I_x + I_{zx} I_{xy})/\Delta$ $J_{31} = (I_{zx} I_y + I_{xy} I_{yz})/\Delta$ $J_{21} = J_{12}$ $J_{32} = J_{23}$ $J_{13} = J_{31}$ $\Delta = I_x I_y I_z - 2I_{xy} I_{yz} I_{zx} - I_x I_{yz}^2 - I_y I_{zx}^2 - I_z I_{xy}^2$	$J$

**1.5 Forces, moments, coefficients and load factors**

No.	Term	Definition	Symbol
1.5.1	Resultant force	The resultant vector of the system of forces acting on aircraft, including the airframe aerodynamic forces and propulsion forces, but excluding the gravitational, inertial and reaction forces due to contact with the Earth's surface.	$\vec{R}$
1.5.2	Components of the resultant force	The components of the resultant force vector, $\vec{R}$ . In the body axis system (1.1.5): component along the longitudinal axis component along the transverse axis component along the normal axis In the air-path axis system (1.1.6): component along the $x_a$ -axis component along the $y_a$ -axis component along the $z_a$ -axis	$X$ $Y$ $Z$ $X_a$ $Y_a$ $Z_a$

No.	Term	Definition	Symbol
1.5.3	Force coefficients	<p>Non-dimensional coefficients of the components of the resultant force (1.5.2), defined as follows:</p> <p>In the body axis system (1.1.5):</p> <p><i>X</i> force coefficient:</p> $\frac{X}{\frac{1}{2}\rho V^2 S}$ <p><i>Y</i> force coefficient:</p> $\frac{Y}{\frac{1}{2}\rho V^2 S}$ <p><i>Z</i> force coefficient:</p> $\frac{Z}{\frac{1}{2}\rho V^2 S}$ <p>In the air-path axis system (1.1.6):</p> <p><i>X<sub>a</sub></i> force coefficient:</p> $\frac{X_a}{\frac{1}{2}\rho V^2 S}$ <p><i>Y<sub>a</sub></i> force coefficient:</p> $\frac{Y_a}{\frac{1}{2}\rho V^2 S}$ <p><i>Z<sub>a</sub></i> force coefficient:</p> $\frac{Z_a}{\frac{1}{2}\rho V^2 S}$ <p>where</p> <p><math>\rho</math> is the density (5.1.3) of the ambient air, unaffected by the aerodynamic field of the the aircraft;</p> <p><i>V</i> is the airspeed (1.3.1);</p> <p><i>S</i> is the reference area (1.4.5).</p> <p>NOTE — These definitions are not usually used in helicopter studies.</p>	<p><i>C<sub>X</sub></i></p> <p><i>C<sub>Y</sub></i></p> <p><i>C<sub>Z</sub></i></p> <p><i>C<sub>Xa</sub></i></p> <p><i>C<sub>Ya</sub></i></p> <p><i>C<sub>Za</sub></i></p>
1.5.4	Resultant moment	The resultant moment of the system of forces, forming the resultant force (1.5.1), about a reference point, usually the centre of gravity.	$\vec{Q}$

No.	Term	Definition	Symbol
1.5.5	<p>Components of the resultant moment</p> <p>Rolling moment</p> <p>Pitching moment</p> <p>Yawing moment</p> <p>—</p> <p>—</p> <p>—</p>	<p>The components of the resultant moment.</p> <p>In the body axis system (1.1.5):</p> <p>component about the longitudinal axis</p> <p>component about the transverse axis</p> <p>component about the normal axis</p> <p>In the air-path axis system (1.1.6):</p> <p>component about the <math>x_a</math>-axis</p> <p>component about the <math>y_a</math>-axis</p> <p>component about the <math>z_a</math>-axis</p>	<p><math>L</math></p> <p><math>M</math></p> <p><math>N</math></p> <p><math>L_a</math></p> <p><math>M_a</math></p> <p><math>N_a</math></p>
1.5.6	<p>Moment coefficients</p> <p>Rolling moment coefficient</p> <p>Pitching moment coefficient</p> <p>Yawing moment coefficient</p> <p>—</p> <p>—</p> <p>—</p>	<p>Non-dimensional coefficients of the components of the resultant moments (1.5.5), defined as follows:</p> <p>In the body axis system (1.1.5):</p> $\frac{L}{\frac{1}{2}\rho V^2 S l}$ $\frac{M}{\frac{1}{2}\rho V^2 S l}$ $\frac{N}{\frac{1}{2}\rho V^2 S l}$ <p>In the air-path axis system (1.1.6):</p> $\frac{L_a}{\frac{1}{2}\rho V^2 S l}$ $\frac{M_a}{\frac{1}{2}\rho V^2 S l}$ $\frac{N_a}{\frac{1}{2}\rho V^2 S l}$ <p>where</p> <p><math>\rho</math> is the density (5.1.3) of the ambient air, unaffected by the aerodynamic field of the aircraft;</p> <p><math>S</math> is the reference area (1.4.5);</p> <p><math>V</math> is the airspeed (1.3.1);</p> <p><math>l</math> is the reference length (1.4.6).</p> <p>NOTE — These definitions are not usually used in helicopter studies</p>	<p><math>C_l</math></p> <p><math>C_m</math></p> <p><math>C_n</math></p> <p><math>C_{l_a}</math></p> <p><math>C_{m_a}</math></p> <p><math>C_{n_a}</math></p>
1.5.7	<p>Total load factor vector</p>	<p>The ratio of the resultant force (1.5.1) to the magnitude of the weight of the aircraft, defined by the relationship:</p> $\vec{n}_t = \frac{\vec{R}}{mg}$ <p>where</p> <p><math>m</math> is the aircraft mass (1.4.1);</p> <p><math>g</math> is the acceleration due to gravity at the point considered on the trajectory.</p> <p>NOTES</p> <p>1 The qualification "total" and the suffix t can be omitted, if there is not likely to be any confusion with the load factor, defined in 1.5.9.</p> <p>2 A similar load factor can be defined for take-off and landing conditions, by introducing in the numerator the sum of the resultant force (1.5.1) and the ground contact forces.</p>	<p><math>\vec{n}_t</math></p>

No.	Term	Definition	Symbol
1.5.8	Components of the total load factor vector	<p>Components of the total load factor (1.5.7), <math>\vec{n}_t</math>, defined as follows:</p> <p>In the body axis system (1.1.5):</p> <p>component along the longitudinal axis:</p> $n_{tx} = \frac{X}{mg}$ <p>component along the transverse axis:</p> $n_{ty} = \frac{Y}{mg}$ <p>component along the normal axis:</p> $n_{tz} = \frac{Z}{mg}$ <p>In the air-path axis system (1.1.6):</p> <p>component along the <math>x_a</math>-axis:</p> $n_{txa} = \frac{X_a}{mg}$ <p>component along the <math>y_a</math>-axis:</p> $n_{tya} = \frac{Y_a}{mg}$ <p>component along the <math>z_a</math>-axis:</p> $n_{tza} = \frac{Z_a}{mg}$ <p>NOTES</p> <p>1 The qualification "total" and the suffix t can be omitted, if there is not likely to be any confusion with the load factor, defined in 1.5.9.</p> <p>2 The components of a similar load factor can be defined for take-off and landing conditions, by introducing in the numerator the appropriate components of the sum of the resultant force (1.5.1) and the ground contact forces.</p>	<p><math>n_{tx}</math></p> <p><math>n_{ty}</math></p> <p><math>n_{tz}</math></p> <p><math>n_{txa}</math></p> <p><math>n_{tya}</math></p> <p><math>n_{tza}</math></p>
1.5.9	Load factor	<p>A quantity equal to the ratio</p> $\frac{-Z_a}{mg}$ <p>NOTE — Provided it is specified, the load factor can be defined by the ratio</p> $\frac{-Z}{mg}$	<p><math>n</math></p>



No.	Term	Definition	Symbol
1.5.12	Specific resultant moment	Product of the inverse inertia matrix, (1.4.11), $J$ , by the resultant moment (1.5.4), $\vec{Q}$ :  $\vec{q} = J \cdot \vec{Q}$  NOTE — A similar specific resultant moment can be defined for take-off and landing conditions, by adding the resultant moment of the ground contact forces to the resultant moment, $\vec{Q}$ .	$\vec{q}$
1.5.13	Components of the specific resultant moment	Components of the specific resultant moment (1.5.12), $\vec{q}$ , defined as follows in the body axis system (1.1.5):  $q_x = J_{11} \cdot L + J_{12} \cdot M + J_{13} \cdot N$ $q_y = J_{21} \cdot L + J_{22} \cdot M + J_{23} \cdot N$ $q_z = J_{31} \cdot L + J_{32} \cdot M + J_{33} \cdot N$  NOTE — The components of a similar specific resultant moment can be defined for take-off and landing conditions, by adding the components of the resultant moment of the ground contact forces to the components of the resultant moment (1.5.4), $\vec{Q}$ .	$q_x$ $q_y$ $q_z$

## 1.6 Thrust, resultant moment of propulsive forces, airframe aerodynamic force, airframe aerodynamic moment, and their components

The system of forces acting on the aircraft, the resultant of which is defined in 1.5.1 and the resultant moment of which is defined in 1.5.4, excluding forces due to gravity, inertia and ground contact, may only be separated on an arbitrary basis into thrust forces due to the propulsive system and aerodynamic forces due to the airframe. It is impossible to define a general rule for the separation. The rule adopted shall be specified for each particular case.

In the following paragraphs, definitions are given for:

- the thrust (the resultant force of the system attributed to the propulsive system) and its components, the resultant moment of propulsive forces and its components.
- the airframe aerodynamic force and its components, the airframe aerodynamic moment and its components.

### 1.6.1 Thrust, resultant moment of propulsive forces, and their components

No.	Term	Definition	Symbol
1.6.1.1	Thrust	The resultant vector of the system of forces attributed to the propulsive system (see the introduction to 1.6).  NOTE — It may be convenient, in some cases, to take into account the individual components of the thrust at the inlet and outlet of each engine.	$\vec{F}$
1.6.1.2	Components of the thrust	Components of the thrust, $\vec{F}$ .  In the body axis system (1.1.5):  component along the longitudinal axis component along the transverse axis component along the normal axis  In the air-path system (1.1.6):  component along the $x_a$ -axis component along the $y_a$ -axis component along the $z_a$ -axis	$F_x$ $F_y$ $F_z$  $F_{xa}$ $F_{ya}$ $F_{za}$



No.	Term	Definition	Symbol
1.6.1.3	(Resultant) moment of propulsive forces	The resultant moment of the system of forces attributed to the propulsive system (see 1.6.1.1 and the introduction to 1.6) relative to a point fixed in the aircraft, usually the centre of gravity.  NOTE — This force system may include forces on the airframe generated by the propulsion system and which are not included in the thrust	$\overline{Q}^F$
1.6.1.4	Components of the (resultant) moment of propulsive forces	Components of the resultant moment of propulsive forces.  In the body axis system (1.1.5):  component about the longitudinal axis component about the transverse axis component about the normal axis  In the air-path axis system (1.1.6):  component about the $x_a$ -axis component about the $y_a$ -axis component about the $z_a$ -axis	$L^F$ $M^F$ $N^F$  $L_a^F$ $M_a^F$ $N_a^F$

## 1.6.2 Airframe aerodynamic force, airframe aerodynamic moment, and their components

No.	Term	Definition	Symbol
1.6.2.1	(Airframe) aerodynamic force	The resultant vector of the system of forces attributed to the airframe (see the introduction to 1.6).	$\overrightarrow{R}^A$  NOTE — Where there is no possibility of confusion, the superscript A may be omitted
1.6.2.2	Components of the (airframe) aerodynamic force	Components of the airframe aerodynamic force, $\overrightarrow{R}^A$ .  In the body axis system (1.1.5):  component along the longitudinal axis component along the transverse axis component along the normal axis  In the air-path axis system (1.1.6):  component along the $x_a$ -axis component along the $y_a$ -axis component along the $z_a$ -axis	$X^A$ $Y^A$ $Z^A$  $X_a^A$ $Y_a^A$ $Z_a^A$  NOTE — Where there is no possibility of confusion, the superscript A may be omitted
1.6.2.3	Axial force	The component of $\overrightarrow{R}^A$ (1.6.2.1) along the $x$ -axis of the body axis system (1.1.5), but in the reverse direction, i.e.:  – $X^A$	1)

1) See the table in annex A.

No.	Term	Definition	Symbol
1.6.2.4	Transverse force; side force	The component of $\vec{R}^A$ (1.6.2.1) along the $y$ -axis of the body axis system (1.1.5), i.e. :  + $Y^A$	1)  
1.6.2.5	Normal force	The component of $\vec{R}^A$ (1.6.2.1) along the $z$ -axis of the body axis system (1.1.5), but in the reverse direction, i.e. :  - $Z^A$	1)  
1.6.2.6	Drag	The component of $\vec{R}^A$ (1.6.2.1) along the $x_a$ -axis of the air-path axis system (1.1.6), but in the reverse direction, i.e. :  - $X_a^A$	1)  
1.6.2.7	Cross-stream force; lateral force	The component of $\vec{R}^A$ (1.6.2.1) along the $y_a$ -axis of the air-path axis system (1.1.6), i.e. :  + $Y_a^A$	1)  
1.6.2.8	Lift	The component of $\vec{R}^A$ (1.6.2.1) along the $z_a$ -axis of the air-path axis system (1.1.6), but in the reverse direction, i.e. :  - $Z_a^A$	1)  
1.6.2.9	(Airframe) aerodynamic moment	The resultant moment of the system of forces attributed to the airframe (see 1.6.2.1 and the introduction to 1.6) relative to a point fixed in the aircraft, usually the centre of gravity.	$\vec{Q}^A$
1.6.2.10	Components of the (airframe) aerodynamic moment	Components of the airframe aerodynamic moment.  In the body axis system (1.1.5):  component about the longitudinal axis component about the transverse axis component about the normal axis  In the air-path axis system (1.1.6):  component about the $x_a$ -axis component about the $y_a$ -axis component about the $z_a$ -axis	$L^A$ $M^A$ $N^A$  $L_a^A$ $M_a^A$ $N_a^A$  NOTE — Where there is no possibility of confusion, the superscript A may be omitted.

1) See the table in annex A.

NOTE — In the absence of agreement on suitably simple symbols, the forces considered in 1.6.2.3 to 1.6.2.8 are expressed in terms of the symbols of 1.6.2.2. In order to aid discussions on a national basis geared towards drawing up an international set of symbols, a table showing the correspondence between the symbols in use or coming into use, in various countries, is given in annex A.

## 1.7 Coefficients of the components of the thrust, of the resultant moment of propulsive forces, of the airframe aerodynamic force and of the airframe aerodynamic moment

In definitions 1.7.1.1 to 1.7.2.8:

- $\rho$  is the density (5.1.3) of the ambient air, unaffected by the aerodynamic field of the aircraft;
- $V$  is the airspeed (1.3.1);
- $S$  is the reference area (1.4.5);
- $l$  is the reference length (1.4.6).

## 1.7.1 Coefficients of the components of the thrust, and of the resultant moment of propulsive forces

No.	Term	Definition	Symbol
1.7.1.1	—	<p>Non-dimensional coefficients of the components of the thrust (1.6.1.2), defined as follows:</p> <p>In the body axis system (1.1.5):</p> $\frac{F_x}{\frac{1}{2}\rho V^2 S}$ $\frac{F_y}{\frac{1}{2}\rho V^2 S}$ $\frac{F_z}{\frac{1}{2}\rho V^2 S}$ <p>In the air-path axis system (1.1.6):</p> $\frac{F_{xa}}{\frac{1}{2}\rho V^2 S}$ $\frac{F_{ya}}{\frac{1}{2}\rho V^2 S}$ $\frac{F_{za}}{\frac{1}{2}\rho V^2 S}$	$C_X^F$ $C_Y^F$ $C_Z^F$ $C_{Xa}^F$ $C_{Ya}^F$ $C_{Za}^F$
1.7.1.2	—	<p>Non-dimensional coefficients of the components of the resultant moment of propulsive forces (1.6.1.4), defined as follows:</p> <p>In the body axis system (1.1.5):</p> $\frac{L^F}{\frac{1}{2}\rho V^2 S l}$ $\frac{M^F}{\frac{1}{2}\rho V^2 S l}$ $\frac{N^F}{\frac{1}{2}\rho V^2 S l}$ <p>In the air-path axis system (1.1.6):</p> $\frac{L_a^F}{\frac{1}{2}\rho V^2 S l}$ $\frac{M_a^F}{\frac{1}{2}\rho V^2 S l}$ $\frac{N_a^F}{\frac{1}{2}\rho V^2 S l}$	$C_l^F$ $C_m^F$ $C_n^F$ $C_{la}^F$ $C_{ma}^F$ $C_{na}^F$

1.7.2 Coefficients of the components of the airframe aerodynamic force and of the airframe aerodynamic moment

No.	Term	Definition	Symbol
1.7.2.1	—	<p>Non-dimensional coefficients of the components of the airframe aerodynamic force (1.6.2.2), defined as follows:</p> <p>In the body axis system (1.1.5):</p> $\frac{X^A}{\frac{1}{2}\rho V^2 S}$ $\frac{Y^A}{\frac{1}{2}\rho V^2 S}$ $\frac{Z^A}{\frac{1}{2}\rho V^2 S}$ <p>In the air-path axis system (1.1.6):</p> $\frac{X_a^A}{\frac{1}{2}\rho V^2 S}$ $\frac{Y_a^A}{\frac{1}{2}\rho V^2 S}$ $\frac{Z_a^A}{\frac{1}{2}\rho V^2 S}$	$C_X^A$ $C_Y^A$ $C_Z^A$  $C_{X_a}^A$ $C_{Y_a}^A$ $C_{Z_a}^A$
1.7.2.2	Axial force coefficient	<p>A non-dimensional coefficient defined as follows:</p> $\frac{\text{Axial force}}{\frac{1}{2}\rho V^2 S}$ <p>where the axial force is as defined in 1.6.2.3.</p>	1)
1.7.2.3	Transverse force coefficient; side force coefficient	<p>A non-dimensional force coefficient defined as follows:</p> $\frac{\text{Transverse force}}{\frac{1}{2}\rho V^2 S}$ <p>where the transverse force is as defined in 1.6.2.4.</p>	1)
1.7.2.4	Normal force coefficient	<p>A non-dimensional coefficient defined as follows:</p> $\frac{\text{Normal force}}{\frac{1}{2}\rho V^2 S}$ <p>where the normal force is as defined in 1.6.2.5.</p>	1)

NOTE — Where there is no possibility of confusion, the superscript A may be omitted

1) See the table in annex A

No.	Term	Definition	Symbol
1.7.2.5	Drag coefficient	A non-dimensional coefficient defined as follows:  $\frac{\text{Drag}}{\frac{1}{2}\rho V^2 S}$ where the drag is as defined in 1.6.2.6.	1)
1.7.2.6	Cross-stream force coefficient; lateral force coefficient	A non-dimensional coefficient defined as follows:  $\frac{\text{Cross-stream force}}{\frac{1}{2}\rho V^2 S}$ where the cross-stream force is as defined in 1.6.2.7.	1)
1.7.2.7	Lift coefficient	A non-dimensional coefficient defined as follows:  $\frac{\text{Lift}}{\frac{1}{2}\rho V^2 S}$ where the lift is as defined in 1.6.2.8.	1)
1.7.2.8	—	Non-dimensional coefficients of the components of the airframe aerodynamic moment (1.6.2.10), defined as follows:  In the body axis system (1.1.5):  $\frac{L^A}{\frac{1}{2}\rho V^2 S l}$  $\frac{M^A}{\frac{1}{2}\rho V^2 S l}$  $\frac{N^A}{\frac{1}{2}\rho V^2 S l}$  In the air-path axis system (1.1.6):  $\frac{L_a^A}{\frac{1}{2}\rho V^2 S l}$  $\frac{M_a^A}{\frac{1}{2}\rho V^2 S l}$  $\frac{N_a^A}{\frac{1}{2}\rho V^2 S l}$	$C_l^A$  $C_m^A$  $C_n^A$  $C_{l_a}^A$  $C_{m_a}^A$  $C_{n_a}^A$  NOTE — Where there is no possibility of confusion, the superscript A may be omitted

1) See the table in annex A.

## 1.8 Forces and moments involved in the control of the aircraft<sup>1)</sup>

### 1.8.1 Control force and control moment

The motion of the aircraft is determined by changes in the resultant force (1.5.1) and/or in the resultant moment (1.5.4).

No.	Term	Definition	Symbol
1.8.1.1	Controlling force	<p>The change in the resultant force (1.5.1) intended to control the motion of the aircraft.</p> <p>NOTE — Direct force control is the method consisting of changing the resultant force directly by control forces (for example: direct lift control, direct lateral force control, change in the thrust vector)</p> <p>Direct force control is quite distinct from the method consisting of changing the resultant force by changes of aircraft attitude under the effect of control moments (1.8.1.2)</p>	—
1.8.1.2	Controlling moment	The change in the resultant moment (1.5.4) intended to control the motion of the aircraft.	—

### 1.8.2 Motivators

The control forces and control moments are created by means of motivators.

A motivator is an output component of the aircraft control system and an input component for the aircraft motion.

No.	Term	Definition	Symbol
1.8.2.1	Motivator	<p>A device, or set of devices, provided to create a control force (1.8.1.1) and/or a control moment (1.8.1.2), and brought into play by means of the aircraft control system.</p> <p>The motivators may be of several types (for example, aerodynamic motivators, jet motivators, propulsion motivators).</p> <p>The motivator consists of one or several movable components the angular or linear positions of which are determined by the aircraft control system.</p> <p>NOTES</p> <p>1 It is recommended that the motivator be designated by reference to the resultant force component and/or the resultant moment component that it changes (for example, pitch motivator).</p> <p>2 The same movable component can be a component of different motivators (for example, the elevon is a component of the pitch motivator and the roll motivator)</p>	—
1.8.2.2	Aerodynamic motivator	<p>A motivator (1.8.2.1) consisting of a movable aerodynamic surface (6.5) or of one or several movable components (6.0.2) of an aerodynamic surface.</p> <p>The control forces (1.8.1.1) or control moments (1.8.1.2), generated through an aerodynamic motivator, are components of the airframe aerodynamic force (1.6.2.1) or the airframe aerodynamic moment (1.6.2.9).</p>	—

1) The term "control" is used in the sense of an input to a system.

### 1.8.3 Deflections of aerodynamic motivators

The following definitions refer to the positions of the motivators and not those of the piloting controls.

No.	Term	Definition	Symbol
1.8.3.1	Neutral position of a motivator component	Particular setting (6.1.10 to 6.1.15) of the motivator component (1.8.2.1) in question which shall be specified.	—
1.8.3.2	Geometric deflection of a motivator component	In the case where the setting of a motivator component (6.1.10 to 6.1.15) may be completely defined by a suitably chosen geometric parameter, the geometric deflection is the variation of that parameter relative to the value it takes when the component is in the neutral position (1.8.3.1).  NOTES 1 The deflection may be an angular or linear variation of the setting 2 The positive direction of the geometric deflection of a motivator component cannot be defined in the same way for all motivator components, but it should be specified in each particular case not covered by this part of ISO 1151 (see 1.8.3.6)	$\delta...$  NOTE — The symbol $\delta$ is followed by one or several alpha-numeric suffixes which characterize the element considered
1.8.3.3	Hinge line (of a motivator component)	In the case where the variation of the setting (6.1.10 to 6.1.15) of the motivator component in question is only a rotation, the hinge line is the straight line about which that component pivots.	—
1.8.3.4	Hinge line axis (of a motivator component)	Axis carrying the hinge line (1.8.3.3) the orientation of which is chosen according to convention.  If the hinge line is approximately parallel to an axis of the main part (see 6.0.2) to which the motivator component belongs (1.8.2.1), the hinge line axis is orientated along that axis.	—
1.8.3.5	Reference axis system (of a motivator component)	Reference axis system (6.1.9) for the motivator component.  In the case where a hinge line axis (1.8.3.4) exists, that axis is one of the axes of the reference axis system.	—
1.8.3.6	Deflection angle (of a motivator component)	Angle characterizing the geometric deflection of a motivator component (1.8.3.2) which moves about a hinge line (1.8.3.3).  The positive direction of deflection angles is the positive direction of rotations about the hinge line axis (1.8.3.4).	$\delta...$ (see 1.8.3.2)
1.8.3.7	Motivator deflection	When the motivator consists of a single component, the motivator deflection is identical to the geometric deflection (1.8.3.2) of that component.  When the motivator consists of several components, an equivalent motivator deflection may be defined with a view to its use in the equations of aircraft motion. The definition of equivalence shall be specified.	$\delta_1^{1)}$
1.8.3.8	Longitudinal force motivator deflection	The motivator deflection (1.8.3.7) producing a control force (1.8.1.1) mainly in the direction of the longitudinal axis (1.1.5).	$\delta_x$
1.8.3.9	Transverse force motivator deflection	The motivator deflection (1.8.3.7) producing a control force (1.8.1.1) mainly in the direction of the transverse axis (1.1.5).	$\delta_y$
1.8.3.10	Normal force motivator deflection	The motivator deflection (1.8.3.7) producing a control force (1.8.1.1) mainly in the direction of the normal axis (1.1.5).	$\delta_z$

1) Associated with each motivator is a principal effect that changes one of the components of the resultant force (1.5.2) or the resultant moment (1.5.5). In the symbol assigned to the motivator deflection (1.8.3.7), the suffix relates to that principal effect.

No.	Term	Definition	Symbol
1.8.3.11	Roll motivator deflection	The motivator deflection (1.8.3.7) producing a control moment (1.8.1.2) mainly about the longitudinal axis (1.1.5).	$\delta_l$ or $\xi$
1.8.3.12	Pitch motivator deflection	The motivator deflection (1.8.3.7) producing a control moment (1.8.1.2) mainly about the transverse axis (1.1.5).	$\delta_m$ or $\eta$
1.8.3.13	Yaw motivator deflection	The motivator deflection (1.8.3.7) producing a control moment (1.8.1.2) mainly about the normal axis (1.1.5).	$\delta_n$ or $\zeta$

#### 1.8.4 Control force coefficients and control moment coefficients

No.	Term	Definition	Symbol
1.8.4.1	Aerodynamic control force	The control force (1.8.1.1) created by aerodynamic motivators (1.8.2.2).	—
1.8.4.2	Components of the aerodynamic control	Components of the aerodynamic control force (1.8.4.1) in a reference axis system.  NOTE — According to the problem in question, the reference axis system may be one of those given in clause 1.1 or a special axis system (for example, 1.8.3.5).	—
1.8.4.3	Aerodynamic control force coefficient	Non-dimensional coefficients of the components of the aerodynamic control force (1.8.4.2), defined as follows:  $\frac{\text{Component of the aerodynamic control force}}{\frac{1}{2}\rho V^2 S}$ where $\rho$ is the density of the air (5.1.3); $V$ is the airspeed (1.3.1); $S$ is the reference area (1.4.5).  NOTE — Aerodynamic control force coefficients may be defined using the particular reference quantities appropriate to the problem in question	—
1.8.4.4	Aerodynamic control moment	The control moment (1.8.1.2) created by aerodynamic motivators (1.8.2.2).	—
1.8.4.5	Components of the aerodynamic control moment	Components of the aerodynamic control moment (1.8.4.4) in a reference axis system.  NOTE — According to the problem in question, the reference axis system may be one of those given in clause 1.1 or a special axis system (for example, 1.8.3.5).	—
1.8.4.6	Aerodynamic control moment coefficients	Non-dimensional coefficients of the components of the aerodynamic control moment (1.8.4.5), defined as follows:  $\frac{\text{Component of the aerodynamic control moment}}{\frac{1}{2}\rho V^2 S l}$ where $\rho$ is the density of the air (5.1.3); $V$ is the airspeed (1.3.1); $S$ is the reference area (1.4.5); $l$ is the reference length (1.4.6).  NOTE — Aerodynamic control moment coefficients may be defined using the particular reference quantities appropriate to the problem in question.	—

Definitions similar to the definitions given in 1.8.4.1 to 1.8.4.6 may be given for control forces (1.8.1.1) and control moments (1.8.1.2) created by motivators other than the aerodynamic motivators (1.8.2.2).



## 1.9 Forces and moments acting on the motivators

In 1.9.1 to 1.9.3 the definitions are given for the moments acting on the motivators.

Similar definitions may be drawn up for the forces.

No.	Term	Definition	Symbol
1.9.1	Hinge moment (of a motivator component)	The moment of the system of forces acting on the motivator component about its hinge line axis (1.8.3.4), but excluding forces due to the aircraft control system. <sup>1)</sup>  It is positive in the positive direction of rotation about the axis.	—
1.9.2	Aerodynamic hinge moment (of a motivator component)	Moment of the system of the aerodynamic forces acting on the motivator component about its hinge line axis (1.8.3.4). <sup>1)</sup>	$M_c$
1.9.3	(Aerodynamic) hinge moment coefficient	A non-dimensional coefficient of the aerodynamic hinge moment (1.9.2), defined as follows:  $\frac{\text{Aerodynamic hinge moment}}{\frac{1}{2} \rho V^2 S l}$ where  $\rho$ is the density of the air (5.1.3); $V$ is the airspeed (1.3.1); $S$ is the reference area (1.4.5); $l$ is the reference length (1.4.6).  NOTE — Hinge moment coefficients may be defined using the particular reference quantities, appropriate to the problem in question.	—

1) The definitions 1.9.1 and 1.9.2 may be generalized in cases where a motivator comprises several components. In such cases, it is necessary to specify the hinge line axis chosen

## 1.10 Quantities related to energy

The quantities defined in 1.10.1 to 1.10.4 are related to the energy of the aircraft with respect to the atmosphere. The zero level of the potential energy is chosen arbitrarily as the geopotential altitude  $H = 0$ . The total air-path climb speed (1.10.3) and the total air-path climb angle (1.10.4) are directly accessible by flight measurements.

In definitions 1.10.1 to 1.10.4:

$V$  is the airspeed (1.3.1);

$m$  is the aircraft mass (1.4.1);

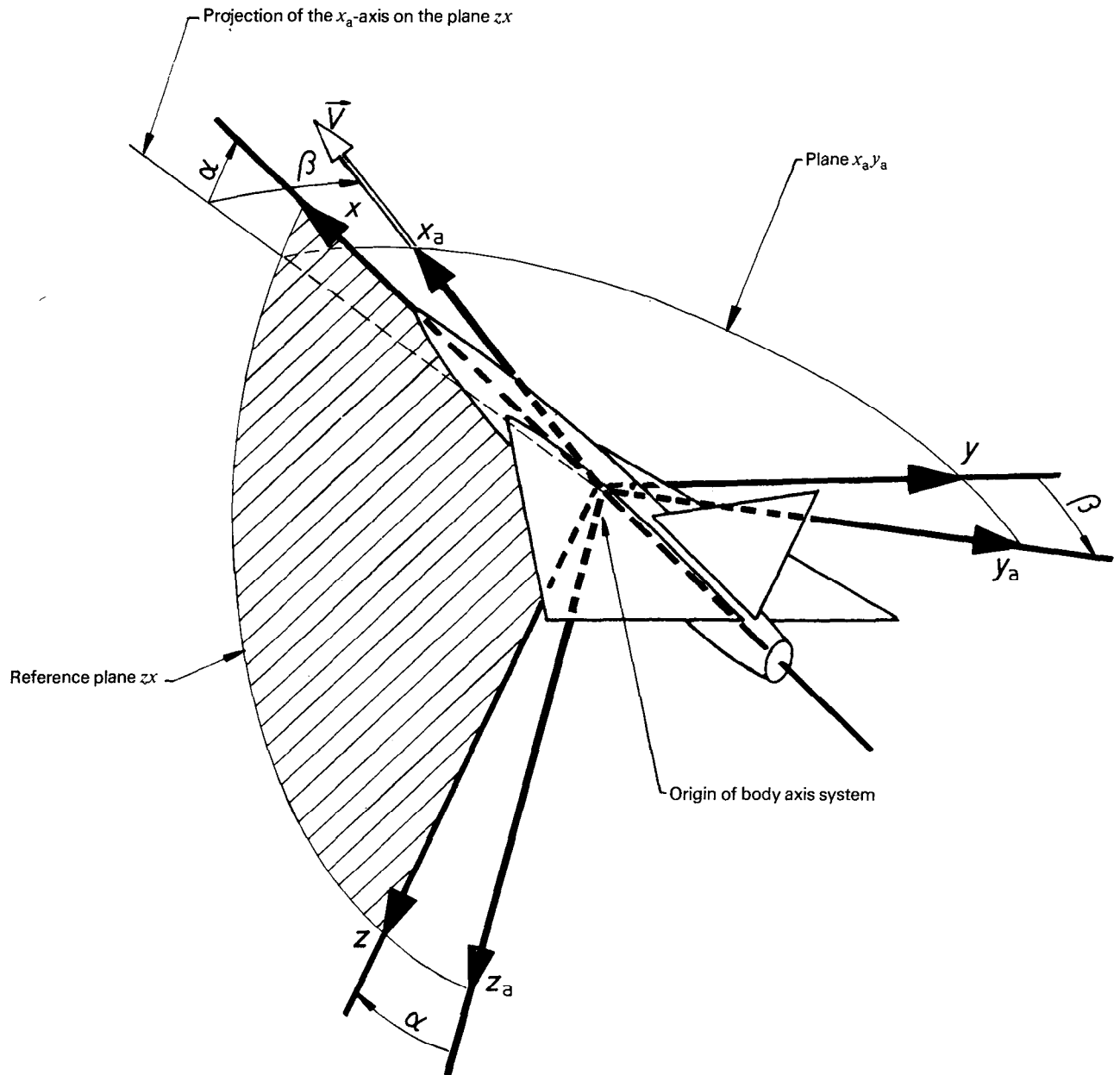
$h$  is the geometric altitude (5.2.1);

$H$  is the geopotential altitude (5.2.2);

$g(h)$  is the acceleration of free fall defined in the standard atmosphere used (ISO 2533) as a function of the geometric altitude  $h$  (5.2.1);

$g_n$  is the standard acceleration of free fall ( $g_n = 9,806\ 65\ \text{m}\cdot\text{s}^{-2}$  according to ISO 2533).

No.	Term	Definition	Symbol
1.10.1	Total air-path energy	Energy defined as follows:  $E_t = mg_n H + \frac{m}{2} V^2$	$E_t$
1.10.2	Total air-path altitude	Ratio of the total air-path energy (1.10.1) to the quantity $mg_n$ :  $H_t = H + \frac{1}{2g_n} V^2$	$H_t$
1.10.3	Total air-path climb speed	Speed defined as being the scalar product between the total load factor vector (1.5.7) and the aircraft velocity (1.3.1):  $V_{Zt} = \vec{n}_t \cdot \vec{V}$ <p>NOTE — When the wind is constant and horizontal, the total air-path climb speed is related to the derivative of the total-air altitude (1.10.2) with respect to time by the following relationship:</p> $V_{Zt} = \frac{g_n}{g(h)} \cdot \frac{dH_t}{dt}$	$V_{Zt}$ or $V_t$
1.10.4	Total air-path climb angle	Angle the sine of which is equal to the ratio of the total air-path climb speed (1.10.3) to the airspeed (1.3.1):  $\sin \gamma_t = \frac{V_{Zt}}{V}$ <p>NOTE — The total air-path climb angle is only defined when the magnitude of the total air-path climb speed is less than or equal to the airspeed.</p>	$\gamma_t$

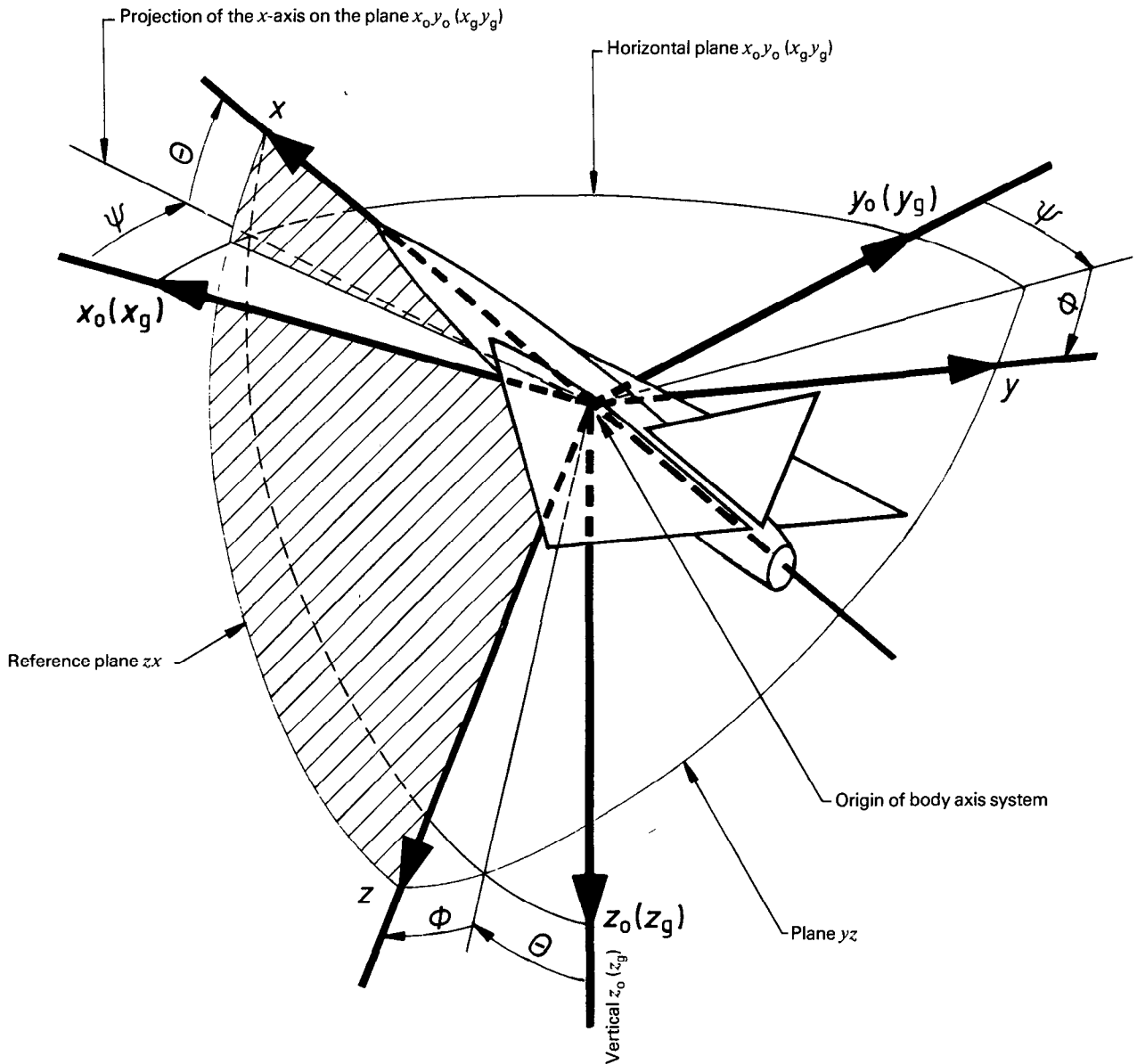


IN BLACK LINES: Body axis system

IN BLUE LINES: Air-path axis system

NOTE — The angles shown are positive. When the origin of the axis systems is not in the reference plane, the  $zx$  plane is parallel to it and the angles are unchanged.

Figure 1 — Orientation of the aircraft velocity with respect to the body axis system

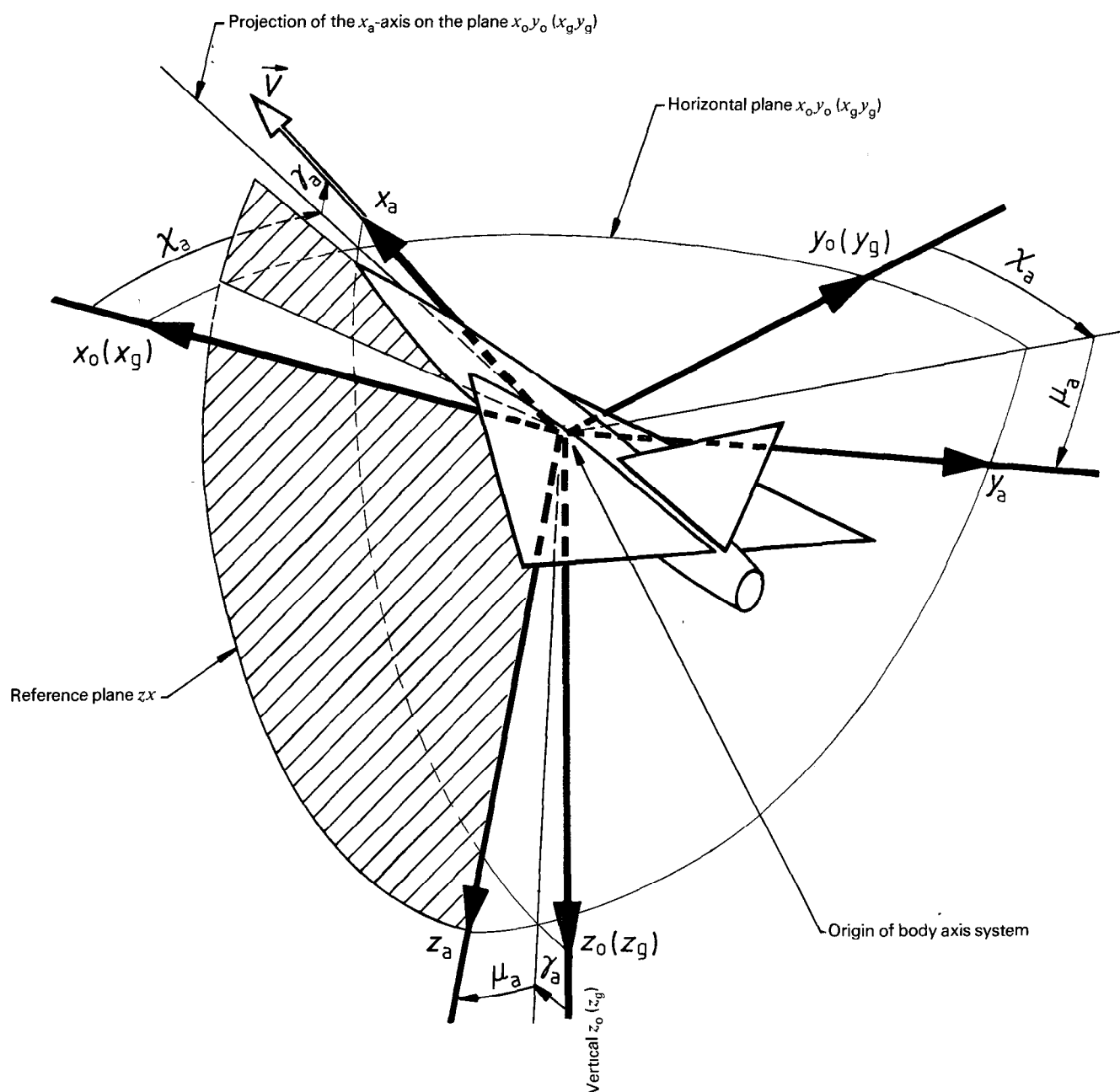


IN RED LINES: Aircraft-carried normal earth axis system

IN BLACK LINES: Body axis system

NOTE — The angles shown are positive. When the origin of the axis systems is not the reference plane, the  $zx$  plane is parallel to it and the angles are unchanged

Figure 2 — Orientation of the body axis system relative to the aircraft-carried normal earth axis system



IN RED LINES: Aircraft-carried normal earth axis system

IN BLACK LINES: Plane of symmetry of the aircraft

IN BLUE LINES: Air-path axis system

NOTE — The angles shown are positive. When the origin of the axis systems is not in the reference plane, the  $zx$  plane is parallel to it and the angles are unchanged.

Figure 3 — Orientation of the air-path axis system relative to the aircraft-carried normal earth axis system

## Annex A

### Symbols of the components of the airframe aerodynamic force and the non-dimensional coefficients of these components in use, or coming into use, in different countries

(This annex does not form an integral part of the standard.)

Axis system	Component or coefficient	ISO symbol <sup>1)</sup>	Symbols in different countries				
			Czecho-slovakia	France	Germany, F.R.	United Kingdom	USSR
Body axis system	Axial force	$-X^A$	$T$	$A$	$T$	$A$	$X$
	Transverse force	$+Y^A$	—	—	—	$Y$	$Z$
	Normal force	$-Z^A$	$N$	$N$	$N$	$N$	$Y$
Air-path axis system	Drag	$-X_a^A$	$W$ or $D$	—	$W$	$D$	$X_a$
	Cross-stream force	$+Y_a^A$	$Q$	—	$Q$	$Y_a$	$Z_a$
	Lift	$-Z_a^A$	$A$ or $L$	—	$A$	$L$	$Y_a$
Body axis system	Axial force coefficient	$-C_X^A$	$C_T$	$C_A$	$C_T$	$C_A$	$c_x$
	Transverse force coefficient	$+C_Y^A$	—	—	—	$C_Y$	$c_z$
	Normal force coefficient	$-C_Z^A$	$C_N$	$C_N$	$C_N$	$C_N$	$c_y$
Air-path axis system	Drag coefficient	$-C_{X_a}^A$	$C_W$ or $C_D$	$C_x$	$C_W$	$C_D$	$c_{x_a}$
	Cross-stream force coefficient	$+C_{Y_a}^A$	$C_Q$	$C_y$	$C_Q$	$C_{Y_a}$	$c_{z_a}$
	Lift coefficient	$-C_{Z_a}^A$	$C_A$ or $C_L$	$C_z$	$C_A$	$C_L$	$c_{y_a}$

1) Symbols of 1.6.2.2 and 1.7.2.1

## Annex B

### Classification of the main parts of flight mechanics

(This annex does not form an integral part of the standard.)

#### B.1 Flight mechanics

No.	Term	Definition
B.1	Flight mechanics	The applied science that deals with the problems of aircraft motion, flight conditions being taken into account.

#### B.2 Flight kinematics

No.	Term	Definition
B.2	Flight kinematics	The branch of flight mechanics (B.1) that deals with the aircraft motion in space and time, without forces or moments generating this motion being taken into account.

#### B.3 Flight dynamics

No.	Term	Definition
B.3	Flight dynamics	The branch of flight mechanics (B.1) that deals with the aircraft motion, the forces or moments generating this motion being taken into account.  NOTE — Flight dynamics studies may concern the motion of the aircraft centre of gravity and/or the motion of the aircraft about its centre of gravity
B.3.1	(Aircraft) performances	The set of values of the variables characterizing the motion of the aircraft centre of gravity and the fuel consumption.
B.3.1.1	(Aircraft) point performances	The instantaneous performances (B.3.1).
B.3.1.2	(Aircraft) integral performances	The performances (B.3.1) characterized by the fuel consumption, the time and the displacement between the beginning and the end of a flight or of a part of flight, according to a relationship existing between certain variables, such as altitude, speed, angle of climb (2.3.2) and load factor (1.5.9), for a given state of the atmosphere (7.4.1).
B.3.1.3	(Aircraft) limit point performances	The set of instantaneous limit values of the variables characterizing the motion of the centre of gravity of the aircraft.  NOTES 1 The limit point performances may be imposed by motivator operating limits or by limits of control forces, by aerodynamic phenomena, such as stalling, by limits of engine performance or by safety conditions (structural limits, flutter, etc ) 2 The limit point performances concern the flight-path acceleration, the angle of climb (2.3.2) and the load factor (1.5.9) 3 Among the limit performances, the following may be mentioned: — in straight and level flight, the absolute ceiling, the maximum lift and the maximum speed; — in level turning flight, the steady maximum turn performance and the instantaneous maximum turn performance

No	Term	Definition
B.3.1.4	(Aircraft) limit integral performances	<p>The set of maximum values and/or minimum integral performances (B.3.1.2).</p> <p>NOTE — Among the limit performances, the following may be mentioned: maximum distance, maximum autonomy, minimum time between two points, maximum altitude obtained by an optimal dynamic manoeuvre ('zoom')</p>
B.3.2	(Aircraft) flying qualities	<p>The set of characteristics consisting of:</p> <ul style="list-style-type: none"> <li>— the ability of the aircraft to maintain a flight-path or an attitude,</li> <li>— the ability of the aircraft to perform manoeuvres,</li> <li>— the aircraft response to disturbances,</li> </ul> <p>having regard for certain requirements concerning flight safety and comfort, as well as piloting precision and ease.</p>
B.3.2.1	(Aircraft flight) stability	<p>The ability of an aircraft, after a disturbance has finished, to return, without pilot intervention, to an equilibrium condition characterized by constant values of certain suitably chosen quantities.</p> <p>NOTE — The stability may be studied in different cases:</p> <ul style="list-style-type: none"> <li>— fixed or free motivators for aircraft without servo-controls,</li> <li>— fixed or free controls for aircraft equipped with servo-controls,</li> </ul> <p>if necessary for different operation states of automatic control systems</p> <p>In each case, if the longitudinal and lateral motions are decoupled, the longitudinal and lateral directional stabilities are studied separately</p>
B.3.2.2	(Aircraft flight) controllability	<p>The set of characteristics of the aircraft and its flight controls which influence the ease and precision with which the pilot may change or maintain variables characterizing the flight.</p> <p>NOTE — In some special cases, the controllability may be defined as the ability of the aircraft to change its flight variables according to deliberate pilot input.</p>
B.3.2.3	Aircraft response without control input from the pilot	<p>The evolution of the variables characterizing the flight of an aircraft without control input from the pilot in response:</p> <ul style="list-style-type: none"> <li>— to changes in the selected situation (7.3.2),</li> <li>— to failure situations (7.3.3),</li> <li>— to disturbances due to environment.</li> </ul>

**B.4 Manoeuvrability**

No.	Term	Definition
B.4	Manoeuvrability	<p>The ability of an aircraft to change its flight-path and/or its velocity taking into account the limit performances (B.3.1.3, B.3.1.4) and flying qualities (B.3.2) requirements.</p>



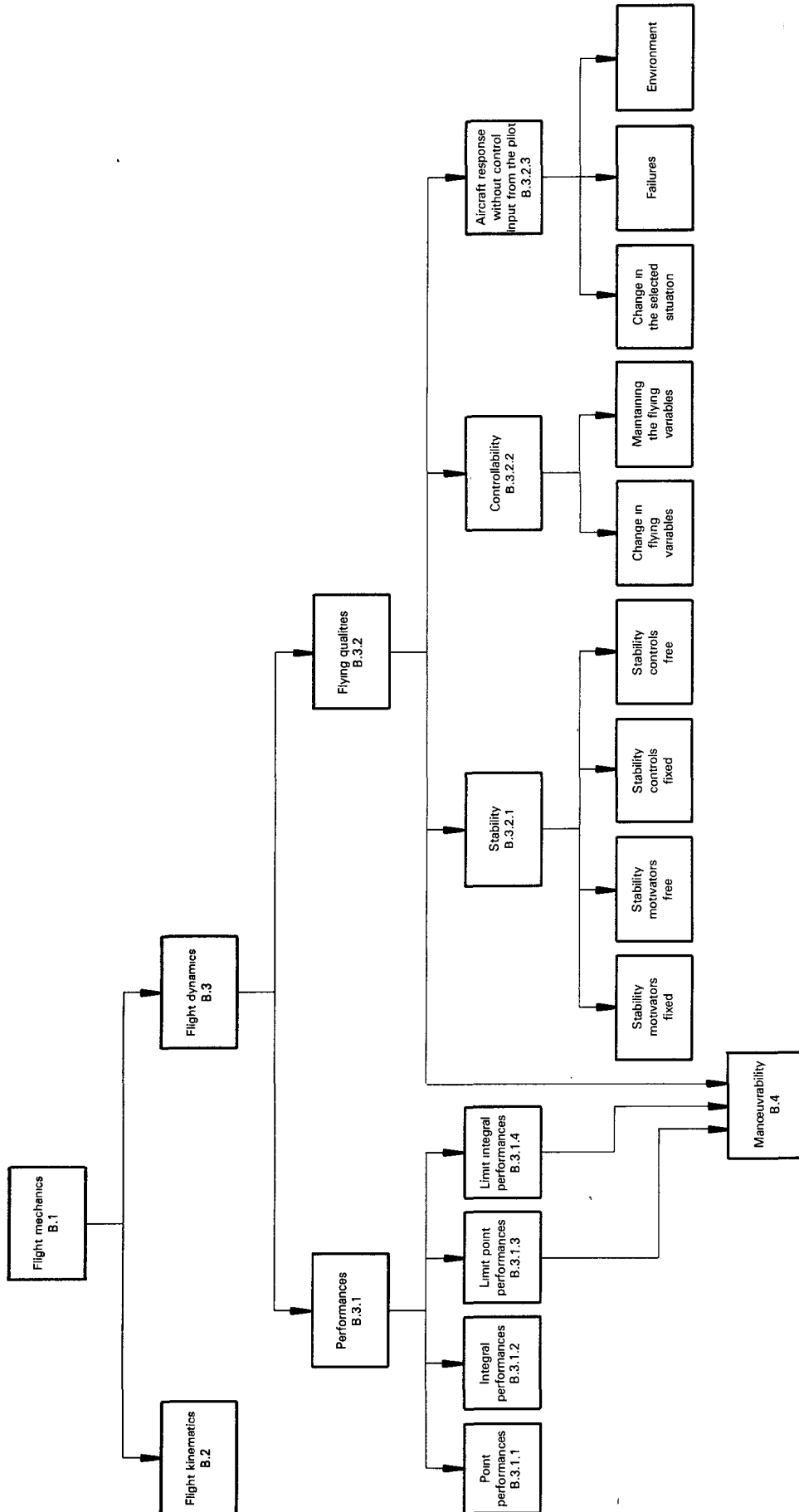


Figure 4 — Schematic diagram illustrating the classification of the main parts of flight mechanics

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**Descriptors :** aircraft, dynamic properties, flight dynamics, aerodynamics, quantities, symbols, definitions.

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