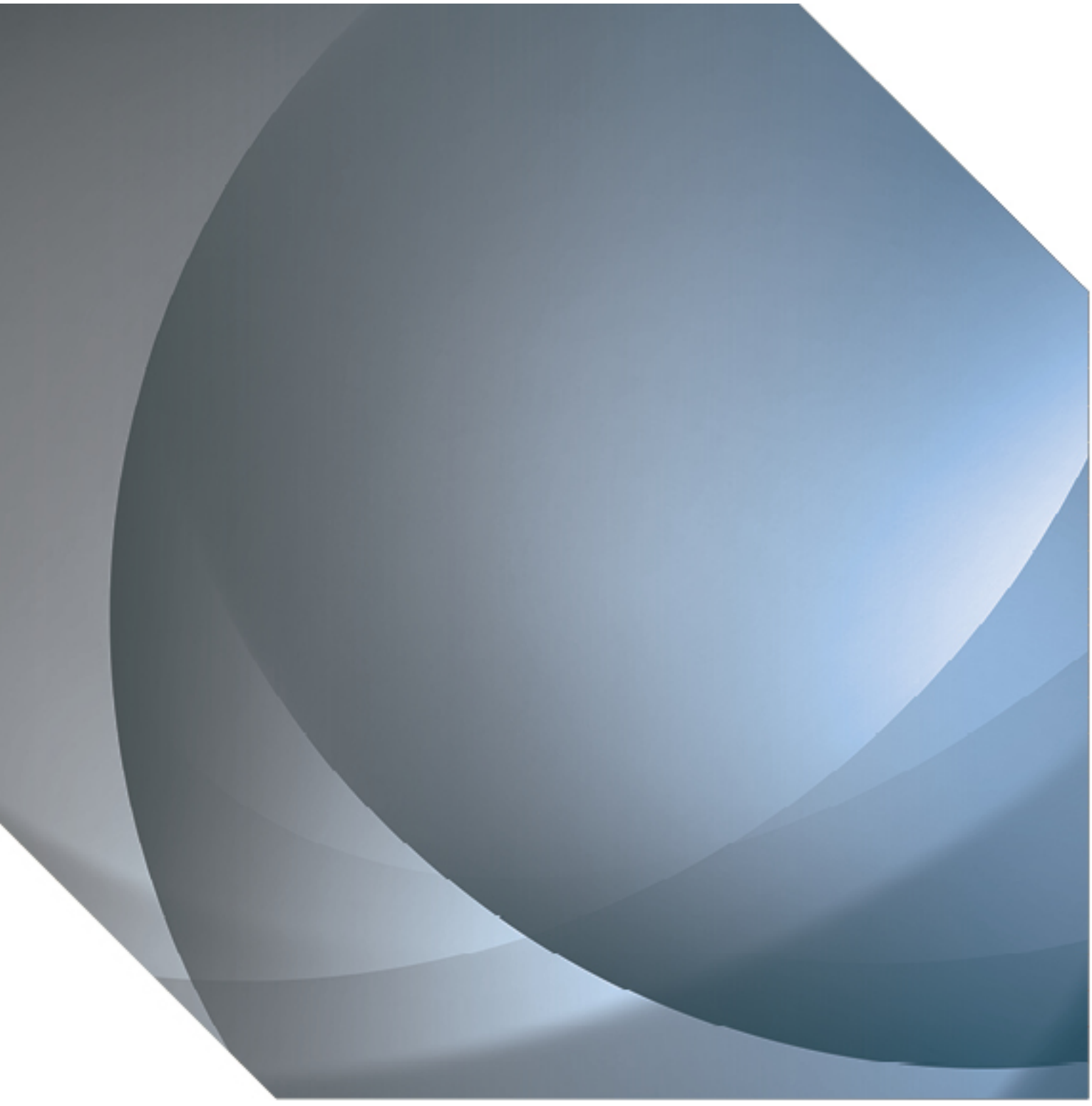
Safety and Airspace Regulation Group

Units of Measurements in Civil Aviation

CAP 2264



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Chapter 1

Abbreviations and Definitions

Introduction

1.1 This document contains specifications for the use of a standardised system of units of measurement in international civil aviation air and ground operations in the UK. This standardised system of units of measurement is based on the International System of Units (SI) and certain non-SI units considered necessary to meet the specialised requirements of international civil aviation (for non-SI units see paragraph 1.6 below).

1.2 The International System of Units are developed and maintained by the General Conference of Weights and Measures (CGPM).

1.3 This document complements and gives additional guidance to that contained in the Units of Measurement Regulations (1986), as amended.

Meanings

1.4 When the following terms are used concerning the units of measurement, they have the following meanings:

Ampere (A). The fixed numerical value of the elementary charge *e* to be 1.602 176 634 × 10^{-19} when expressed in Coulombs, which is equal to A s, where the second is defined by taking the unperturbed ground-state hyperfine transition frequency of the caesium-133 atom, to be 9 192 631 770 when expressed in the unit Hz, which is equal to s^{-1}.

Becquerel (Bq). The activity of a radionuclide having one spontaneous nuclear transition per second.

Candela (cd). The luminous intensity in a given direction. Defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency 540 x 10^{12} Hz, K_{cd}, to be 683 when expressed in the unit lm W^{-1}, which is equal to cd sr W^{-1}.

Celsius temperature (t°C). The Celsius temperature is equal to the difference t°C = T – T0 between two thermodynamic temperatures T and T0 where T0 equals 273.15 kelvin.

Coulomb (C). The quantity of electricity transported in 1 second by a current of 1 ampere.

Degree Celsius (°C). The special name for the unit kelvin for use in stating values of Celsius temperature, with 0°C having a value of 273.16K.

Farad (F). The capacitance of a capacitor between the plates of which there appears a difference of potential of 1 volt when it is charged by a quantity of electricity equal to 1 coulomb.

Foot (ft). The length equal to 0.3048 metre.

Gray (Gy). The energy imparted by ionizing radiation to a mass of matter corresponding to 1 joule per kilogram.

Henry (H). The inductance of a closed circuit in which an electromotive force of 1 volt is produced when the electric current in the circuit varies uniformly at a rate of 1 ampere per second.

Hertz (Hz). The frequency of a periodic phenomenon of which the period is 1 second.

Human performance. Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

Joule (J). The work done when the point of application of a force of 1 newton is displaced a distance of 1 metre in the direction of the force.

Kelvin (K). The Kelvin is defined by taking the fixed numerical value of the Boltzmann constant k_B to be 1.380649×10^{-23} when expressed in the unit J K^{-1}, which is equal to kg m^2 s^{-2} K^{-1}.

Kilogram (kg). The kilogram is defined by taking the fixed numerical value of the Planck constant, h, to be $6.62607015 \times 10^{-34}$ when expressed in the unit J s, which is equal to kg m^2 s^{-1}, where the metre and the second are defined in terms of the speed of light, c, and the unperturbed ground-state hyperfine transition frequency of the caesium-133 atom respectively.

Knot (kt). The speed equal to 1 nautical mile per hour.

Litre (L). A unit of volume restricted to the measurement of liquids and gases which is equal to 1 cubic decimetre.

Lumen (lm). The luminous flux emitted in a solid angle of 1 steradian by a point source having a uniform intensity of 1 candela.

Lux (lx). The illuminance produced by a luminous flux of 1 lumen uniformly distributed over a surface of 1 square metre.

Metre (m). The distance travelled by light in a vacuum during 1/299 792 458 of a second, where the second is defined in terms of the unperturbed ground-state hyperfine transition frequency of the caesium-133 atom.

Mole (mol). One mole contains exactly $6.02214076 \times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, N_A, when expressed in the unit mol^{-1} and is called the Avogadro number.

Note: An elementary entity may be an atom, molecule, ion, electron, any other particle or specified group of particles.

Nautical mile (NM). The length equal to 1 852 metres.

Newton (N). The force which when applied to a body having a mass of 1 kilogram gives it an acceleration of 1 metre per second squared.

Ohm (Ω). The electric resistance between two points of a conductor when a constant difference of potential of 1 volt, applied between these two points, produces in this conductor a current of 1 ampere, this conductor not being the source of any electromotive force.

Pascal (Pa). The pressure or stress of 1 newton per square metre. Radian (rad). The plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.

Second (s). Defined by taking the fixed numerical value of the caesium frequency Δv_{Cs}, the unperturbed ground-state hyperfine transition frequency of the caesium 133 atom, to be 9 192 631 770 when expressed in the unit Hz, which is equal to s^{-1}

Siemens (S). The electric conductance of a conductor in which a current of 1 ampere is produced by an electric potential difference of 1 volt.

Sievert (Sv). The unit of radiation dose equivalent corresponding to 1 joule per kilogram.

Steradian (sr). The solid angle which, having its vertex in the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

Tesla (T). The magnetic flux density given by a magnetic flux of 1 weber per square metre.

Tonne (t). The mass equal to 1 000 kilograms.

Volt (V). The unit of electric potential difference and electromotive force which is the difference of electric potential between two points of a conductor carrying a constant current of 1 ampere, when the power dissipated between these points is equal to 1 watt.

Watt (W). The power which gives rise to the production of energy at the rate of 1 joule per second, where the second has the meaning given in the definition of “Ampere”

Weber (Wb). The magnetic flux which, linking a circuit of one turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in 1 second.

World Geodetic System — 1984 (WGS-84). The horizontal (geodetic) reference system for air navigation.

SI unit prefixes

1.5 The following prefixes are used to represent large or small factors of numbers:

Multiplication factor	Prefix	Symbol
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	K
100 = 10^{2}	hecto	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001= 10^{-3}	milli	m
0.000 001= 10^{-6}	micro	µ
0.000 000 001= 10^{-9}	nano	n
0.000 000 000 001= 10^{-12}	pico	p
0.000 000 000 000 001= 10^{-15}	femto	f
0.000 000 000 000 000 001= 10^{-18}	atto	a

Non-SI units

1.6 The following non-SI units shall be used either in lieu of, or in addition to, SI units as primary units of measurement. No termination date has been established for the use of these non-SI units in civil aviation operations.

Quantity	Unit	Symbol	Definition
mass	tonne	t	1 t = 10^3 kg
plane angle	degree minute second	° ' "	1° = (π/180) rad 1' = (1/60)° = (π/10 800) rad 1" = (1/60)' = (π/648 000) rad
temperature	degree Celsius	°C	1 unit °C = 1 unit K
time	minute hour day week, month, year	min h d -	1 min = 60 s 1 h = 60 min = 3 600 s 1 d = 24 h = 86 400 s
volume	litre	L	1 L = 1 dm^3 = $10^{-3}m^3$
distance (long)	nautical mile	NM	1 NM = 1 852 m
distance (vertical)	foot	ft	1 ft = 0.304 8 m
speed	knot	kt	1 kt = 0.514 444 m/s

SI Derived Units

1.7 The International System of Units is a complete, coherent system which includes three classes of units:

a) base units;

b) supplementary units; and

c) derived units.

1.9 Derived units of the SI are formed by combining base units, supplementary units and other derived units according to the algebraic relations linking the

corresponding quantities. The symbols for derived units are obtained by means of the mathematical signs for multiplication, division and the use of exponents. Those derived SI units which have special names and symbols are listed below:

Quantity	**Unit**	**Symbol**	**Derivation**
absorbed dose (radiation)	Gray	Gy	J / kg
activity of radionuclides	becquerel	Bq	1 / s
capacitance	Farad	F	C / V
conductance	siemens	S	A / V
dose equivalent (radiation)	sievert	Sv	J/kg
electric potential, potential difference, electromotive force	Volt	V	W/A
electric resistance	Ohm	Ω	V/A
energy, work, quantity of heat	Joule	J	N m
force	newton	N	kg m / s^2
frequency (of a periodic phenomenon)	hertz	Hz	1 / s
illuminance	lux	lx	lm / m^2
inductance	Henry	H	Wb / A
luminous flux	lumen	lm	cd sr
magnetic flux	weber	Wb	V s
magnetic flux density	Tesla	T	Wb / m^2
power, radiant flux	Watt	W	J / s

pressure, stress	pascal	Pa	N / m^2
quantity of electricity, electric charge	coulomb	C	A s

Human Factors

1.10 Suitable means and provisions for design, procedures and training should be established for operations in environments involving the use of standard and non-SI alternatives of specific units of measurement, or the transition between environments using different units, with due consideration to human performance.

Chapter 2

Units of Measurement

Standard application of units of measurement

2.1 The following table gives the standard units of measurement.

Quantity	**Primary unit (symbol)**	**Non-SI alternative unit (symbol)**
Direction /Space / Time		
altitude	m	ft
area	m^2	
distance (long) *Note 1*	km	NM
distance (short)	m	
elevation	m	ft
endurance	H and min	
height	m	ft
latitude	º ′ ″	
length		
longitude	º ′ ″	
plane angle (when required, decimal subdivisions of the degree shall be used)	º	
runway length	m	
runway visual range	m	
tank capacities (aircraft) *Note 2*	L	
time	s min h d	

	week month year	
visibility *Note 3*	km	
volume	m^3	
wind direction (wind directions other than for a landing and take-off shall be expressed in degrees true; for landing and takeoff wind directions shall be expressed in degrees magnetic	º	
Mass Related		
air density	kg / m^3	
area density	kg / m^2	
cargo capacity	kg	
cargo density	kg / m^3	
density (mass density)	kg / m^3	
fuel capacity (gravimetric)	kg	
gas density	kg / m^3	
gross mass or payload	kg t	
hoisting provisions	kg	
linear density	kg / m	
liquid density	kg / m^3	
mass	kg	
moment of inertia	kg m^2	
moment of momentum	kg m^2/s	
momentum	kg m/s	
Force-related		

air pressure (general)	kPa	
altimeter setting	hPa	
atmospheric pressure	hPa	
bending moment	kN m	
force	N	
fuel supply pressure	kPa	
hydraulic pressure	MPa	
modulus of elasticity	mN / m	
pressure	kN	
torque	N m	
vacuum	Pa	
Mechanics		
airspeed *Note 4*	km / h	kt
angular acceleration	rad / s^2	
angular velocity	rad / s	
energy or work	J	
equivalent shaft power	kW	
frequency	Hz	
ground speed	km / h	kt
impact	J / m^2	
kinetic energy absorbed by brakes	MJ	
linear acceleration	m / s^2	
power	kW	
rate of trim	°/s	
shaft power	kW	
velocity	m / s	
vertical speed	m / s	ft / min

wind speed *Note 5*	m / s	kt
Flow		
engine airflow	kg / s	
engine waterflow	kg / h	
fuel consumption (specific) piston engines turbo-shaft engines jet engines	 kg / (kW h) kg / (kW h) kg / (kN h)	
fuel flow	kg / h	
fuel tank filling rate (gravimetric)	kg / min	
gas flow	kg /s	
liquid flow (gravimetric)	g / s	
liquid flow (volumetric)	L / s	
mass flow	kg / s	
oil consumption gas turbine piston engines (specific)	 kg / h g / (kW h)	
oil flow	g / s	
pump capacity	L / s	
ventilation airflow	m^3 / min	
viscosity (dynamic)	Pa s	
viscosity (kinematic)	m^2 / s	
Thermodynamics		
coefficient of heat transfer	W / (m^2 K)	
heat flow per unit area	J / m^2	
heat flow rate	W	
humidity (absolute)	g / kg	

coefficient of linear expansion	$°C^{-1}$	
quantity of heat	J	
temperature	°C	
Electricity and magnetism		
capacitance	F	
conductance	S	
conductivity	S / m	
current density	A / m^2	
electric current	A	
electric field strength	C / m^2	
electric potential	V	
electromotive force	V	
magnetic field strength	A / m	
magnetic flux	Wb	
magnetic flux density	T	
power	W	
quantity of electricity	C	
resistance	Ω	
Light and related electromagnetic radiations		
illuminance	lx	
luminance	cd / m^2	
luminous exitance	lm / m^2	
luminous flux	lm	
luminous intensity	cd	
quantity of light	lm s	
radiant energy	j	
wavelength	m	

Acoustics		
frequency	Hz	
mass density	kg / m^3	
noise level	dB *Note 6*	
period, periodic time	s	
sound intensity	W / m^2	
sound power	W	
sound pressure	Pa	
sound level	dB *Note 7*	
static pressure (instantaneous)	Pa	
velocity of sound	m / s	
volume velocity (instantaneous)	m^3 / s	
wavelength	m	
Nuclear physics and ionizing radiation		
absorbed dose	Gy	
absorbed dose rate	Gy / s	
activity of radionuclides	Bq	
dose equivalent	Sv	
radiation exposure	C / kg	
exposure rate	C / kg s	

Notes:

1. As used in navigation, generally in excess of 4 000 m.

2. Such as aircraft fuel, hydraulic fluids, water, oil and high pressure oxygen vessels.

3. Visibility of less than 5 km may be given in m.

4. Airspeed is sometimes reported in flight operations in terms of the ratio MACH number.

5. A conversion of 1 kt = 0.5 m/s is used in ICAO Annexes for the representation of wind speed.

6. The decibel (dB) is a ratio which may be used as a unit for expressing sound pressure level and sound power level. When used, the reference level must be specified.

7. The decibel (dB) is a ratio which may be used as a unit for expressing sound pressure level and sound power level. When used, the reference level must be specified.

Horizontal (geodetic) reference system for air navigation

2.2 WGS-84 shall be used as the horizontal (geodetic) reference system for air navigation. Reported aeronautical geographical coordinates (indicating latitude and longitude) shall be expressed in terms of the WGS-84 geodetic reference datum.

Vertical reference system

2.3 Mean sea level (MSL) datum, which gives the relationship of gravity-related height (elevation) to a surface known as the geoid, shall be used as the vertical reference system for air navigation.

Note: The geoid globally most closely approximates MSL. It is defined as the equipotential surface in the gravity field of the Earth which coincides with the undisturbed MSL extended continuously through the continents.

Temporal reference system

2.4 The Gregorian calendar and Coordinated Universal Time (UTC) shall be used as the temporal reference system for air navigation.