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Telecommunication security

Telebiometrics related to human physiology

Recommendation ITU-T X.1082



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Recommendation ITU-T X.1082

Telebiometrics related to human physiology

Summary

Recommendation ITU-T X.1082 uses the framework defined in Recommendation ITU-T X.1081 for optimal safety and security in telebiometrics. It gives names and symbols for quantities and units concerned with emissions from the human body that can be detected by a sensor, and with effects on the human body produced by the telebiometric devices in its environment. It is applicable to both physiology and biometrics (the measurement of physiological, biological and behavioural characteristics). A taxonomy of wetware and hardware/software interactions is defined. Thresholds specified using the set of international system of quantities (ISQ) and the related international system of units (SI) are specified.

Source

Recommendation ITU-T X.1082 was approved on 13 November 2007 by ITU-T Study Group 17 (2005-2008) under Recommendation ITU-T A.8 procedure.

Keywords

Human physiology, IN and OUT modalities, personal identification, personal privacy sphere, sensory-motor modalities, symbols for telebiometric devices, telebiometrics, verification and authentication, wetware.

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Introduction

This Recommendation is an adaptation of IEC 80000-14. The ISO/IEC 80000-series of standards consists of many parts with the common title: *Quantities and units*. The current and proposed parts of that International Standard are:

ISO 80000-1 – Part 1: General

ISO 80000-2 – Part 2: Mathematical signs and symbols to be used in the natural sciences and technology

ISO 80000-3 – Part 3: Space and time

ISO 80000-4 – Part 4: Mechanics

ISO 80000-5 – Part 5: Thermodynamics

IEC 80000-6 – Part 6: Electromagnetism

ISO 80000-7 – Part 7: Light

ISO 80000-8 – Part 8: Acoustics

ISO 80000-9 – Part 9: Physical chemistry and molecular physics

ISO 80000-10 – Part 10: Atomic and nuclear physics

ISO 80000-11 – Part 11: Characteristic numbers

ISO 80000-12 – Part 12: Solid state physics

IEC 80000-13 – Part 13: Information science and technology

IEC 80000-14 – Part 14: Telebiometrics related to human physiology

Names and symbols for physiological units and quantities that are in widespread use are specified in this Recommendation.

The basis for the determination of the quantities and units to be addressed is the taxonomy specified in the telebiometric multimodal model (TMM, see Recommendation ITU-T X.1081). In the TMM, ten aspects of the interaction between the human body and its environment are recognized (base modalities). These interactions are assumed to occur at various scales of propinquity and at various intensities across the "personal privacy sphere" (see Figure 1 of Recommendation ITU-T X.1081).

Using the terminology of the TMM, these interactions (base modalities) are classified as follows (see the definition of terms in clause 3):

- TANGO-IN
- TANGO-OUT
- VIDEO-IN
- VIDEO-OUT
- AUDIO-IN
- AUDIO-OUT
- CHEMO-IN
- CHEMO-OUT
- RADIO-IN
- RADIO-OUT

It is also recognized that the temperature of (parts of) the human body are important both for safe operation of a telebiometric device and for its use in providing telebiometric security. This aspect of the interaction of a human body with its environment uses the base modalities TANGO-IN,

TANGO-OUT, VIDEO-IN and VIDEO-OUT, but is sufficiently important that it is defined in this part of this Recommendation as an additional derived modality:

- CALOR-IN describes the absorption of heat by the whole human body mediated by electromagnetic radiation (including infra-red or microwave radiation), heat conduction (by direct contact) or heat convection (by a heat-transporting liquid or gas).
- CALOR-OUT describes the loss of heat by the whole human body mediated by electromagnetic radiation, heat conduction, heat convection or evaporation.

Each of the main clauses of this Recommendation defines quantities and units for the in and out aspects of one of the interactions of the human body with a telebiometric device.

The terminology used in this classification is derived as follows:

TANGO: from Latin: tangō, -ēre, tetigī, tāctum (from tango) Latin, meaning "I touch"

NOTE 1 – TANGO-IN has been listed first because in terms of the development of life, skin sensitivity came first, and other input organs were specializations of that.

NOTE 2 – There are two forms of skin, glabrous and hairy (see Figures 1 and 2). These have different properties for sensitivity, giving rise to different TANGO-IN units.

VIDEO: from Latin: videō, -ēre, vīdī, vīsum Latin, meaning "I see"

AUDIO: from Latin: audiō, -īre, -īvī (īī), -ītum Latin, meaning "I hear"

CHEMO: from medieval Latin: chemia, from Arabic: al-kimia Medieval Latin meaning "chemistry"

RADIO: from Latin: radiō, -āre, -āvi, ātum Latin, meaning "I radiate"
and from Latin: radius, radiī (m) Latin, meaning "ray, beam"

CALOR: from Latin: calor, calōris (m) Latin, meaning "warmth, heat"

In Annex C a code is specified that can be applied to classify a telebiometric device, and a compact graphical symbol that can be used to represent that code. This is based essentially on whether the device is an actuator or a sensor and on which modalities it uses.

Recommendation ITU-T X.1081 provides a framework for establishing thresholds related to safety and security in the telebiometric multimodal model, but does not contain any such thresholds. The thresholds to be used in telebiometrics are based on units standardized in the International Standards of the ISO/IEC 80000-series, and in particular on the quantities and units of IEC 80000-14.

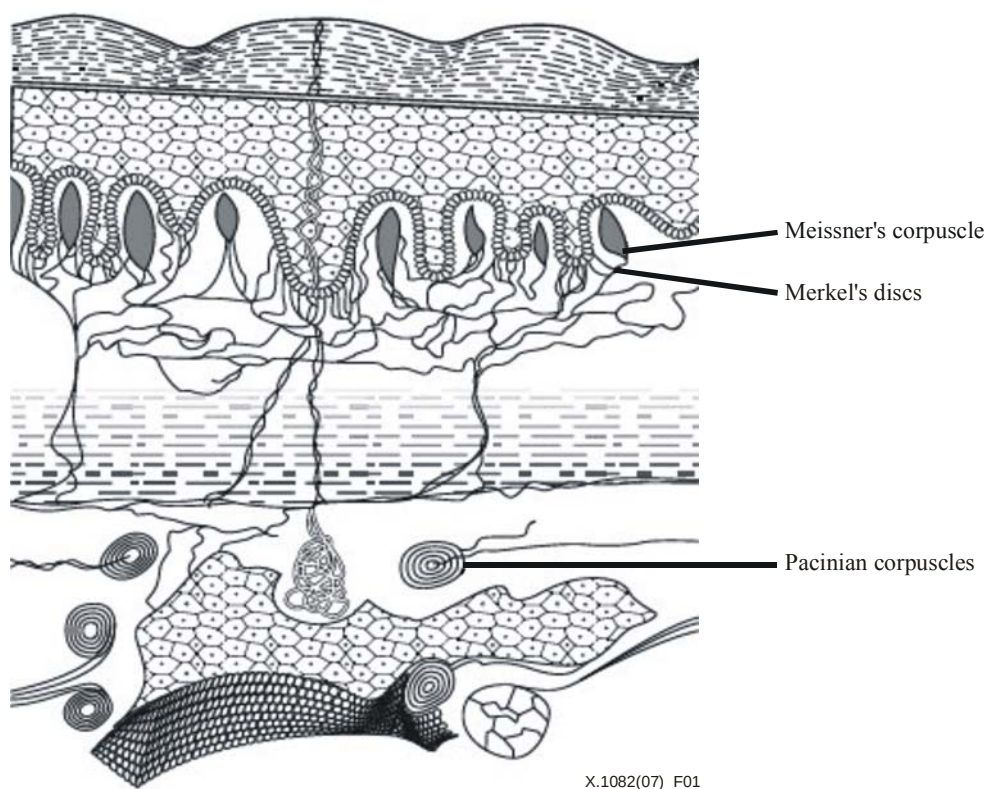


Figure 1 – Schematic drawing of a cross-section of glabrous skin

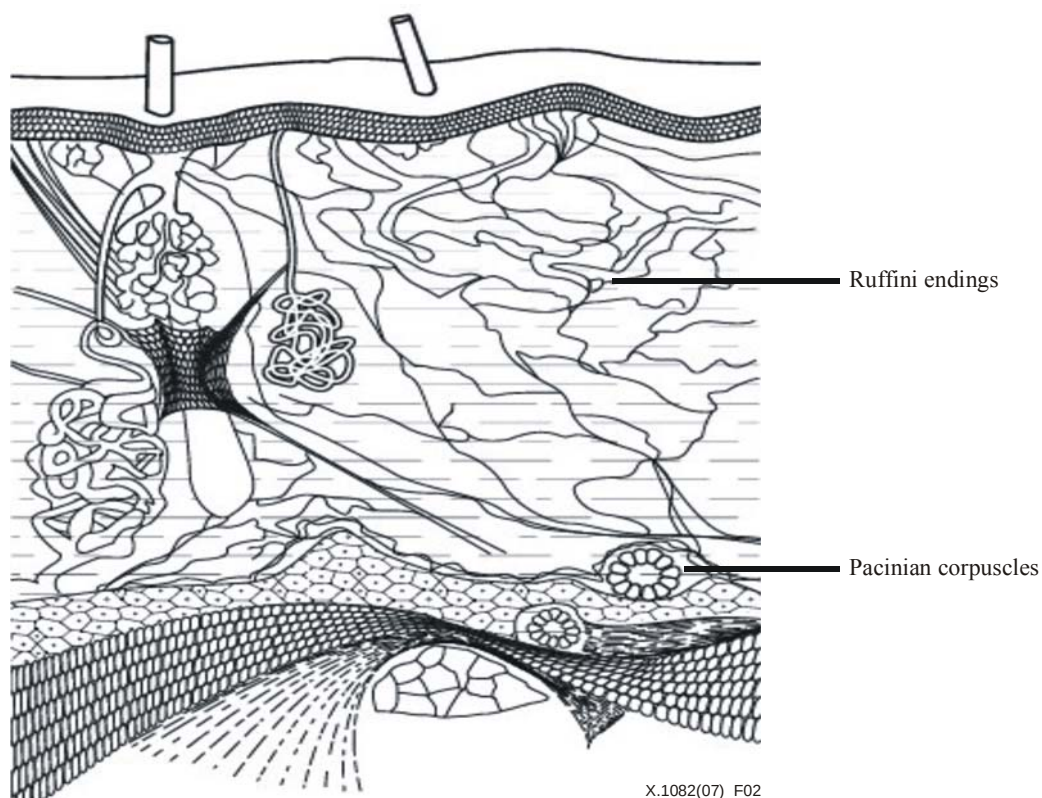


Figure 2 – Schematic drawing of a cross-section of hairy skin

Recommendation ITU-T X.1082

Telebiometrics related to human physiology

1 Scope

This Recommendation specifies names and definitions for quantities and units (and associated symbols) for telebiometrics related to human physiology.

This Recommendation defines quantities and units for physiological, biological or behavioural characteristics that might provide input or output to telebiometric identification or verification systems (recognition systems), including any known detection or safety thresholds.

It also includes quantities and units concerned with effects on a human being caused by the use of a telebiometric device.

NOTE – The quantities and units, their names and letter symbols specified here are those widely used in the disciplines and specialities related to telebiometrics: the telebiometric industry and telebiometry. Telebiometric units are SI units (see [b-ISO/DIS 80000-1]).

A code and an associated graphical symbol for the identification of the type of a telebiometric device are also specified in this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T X.1081] Recommendation ITU-T X.1081 (2004), *The telebiometric multimodal model – A framework for the specification of security and safety aspects of telebiometrics*.
- [ISO 80000-3] ISO 80000-3:2006, *Quantities and units – Part 3: Space and time*.
<http://www.iso.org/iso/catalogue_detail?csnumber=31888>
- [ISO 80000-4] ISO 80000-4:2006, *Quantities and units – Part 4: Mechanics*.
<http://www.iso.org/iso/catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31889>
- [ISO 80000-5] ISO 80000-5:2007, *Quantities and units – Part 5: Thermodynamics*.
<http://www.iso.org/iso/catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31890>
- [IEC 80000-6] IEC 80000-6:2008, *Quantities and units – Part 6: Electromagnetism*¹.
<http://www.iso.org/iso/catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31891>
- [ISO 80000-8] ISO 80000-8:2007, *Quantities and units – Part 8: Acoustics*.
<http://www.iso.org/iso/catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40669>
- [ISO/FDIS 80000-9] ISO/FDIS 80000-9:draft, *Quantities and units – Part 9: Physical chemistry and molecular physics*¹.
<http://www.iso.org/iso/catalogue/catalogue_tc/catalogue_detail.htm?csnumber=31894>

¹ In preparation.

3 Definitions

For the purpose of this Recommendation, the following definitions apply.

3.1 Definitions in [ITU-T X.1081]

The following definitions in [ITU-T X.1081] are used in this Recommendation:

- a) TMM metric layer;
- b) TMM scientific layer;
- c) TMM sensory layer;
- d) telebiometrics;
- e) telebiometrology;
- f) telebiometronomy.

3.2 General concepts

3.2.1 base modality: One of the classifications of the interaction of a human body with its environment based on the physical nature of the interaction or on the human sensory system that it affects (see clauses 3.5.1 to 3.5.10).

NOTE – If the interaction is from the environment to the human body, it is described as an in-modality. If it is from the human body to the environment, it is described as an out-modality

3.2.2 derived modality: One of the classifications of the interaction of a human body with its environment based on a property of the human body that is determined or changed using one or more of the base modalities (see clauses 3.5.11 and 3.5.12).

NOTE – The temperature of the human body or parts of the human body can be detected (CALOR-OUT) by an infrared radiation detector or by conduction to a thermometer and can be changed by convection, conduction or various forms of radiation (CALOR-IN).

3.2.3 in-modality: Modality of interactions from the environment to the human body.

3.2.4 out-modality: Modality of interactions from the human body to the environment.

3.2.5 wetware: That physical aspect of a human being that is affected by or affects telebiometric devices.

NOTE – This term is not used in the normative text, but it is extensively used in Appendix I and the definition is provided here for completeness.

3.2.6 biometric: Of or having to do with biometrics.

NOTE – The use of "biometric as a noun to mean, for example, biometric characteristic, is deprecated.

EXAMPLE Incorrect usage #1: ICAO resolved that face is the biometric most suited to the practicalities of travel documents.

EXAMPLE Correct usage #1: ICAO resolved that face recognition is the biometric modality most suited to the practicalities of travel documents.

EXAMPLE Incorrect usage #2: The biometric recorded in my passport is a facial image.

EXAMPLE Correct usage #2: The biometric characteristics recorded in my passport is a facial image.

3.2.7 biometrics: Automated recognition of individuals based on their behavioural and biological characteristics.

NOTE 1 – "Individual" is restricted in scope by SC37 to humans.

NOTE 2 – The general meaning of biometrics encompasses counting measuring and statistical analysis of any kind of data in the biological sciences including the relevant medical sciences.

3.2.8 telebiometrics: Application of biometrics to telecommunications and of telecommunications to remote biometric sensing.

3.2.9 telebiometric device: Sensor or actuator interacting remotely with a human being, using telecommunication means.

3.2.10 telebiometric multimodal model (TMM): Model of the interactions of a human being with its environment using modalities based on the human senses.

3.2.11 TMM metric layer: Layer in the TMM taxonomy that identifies the SI units used to describe an IN or OUT interaction.

3.2.12 TMM scientific layer: Layer in the TMM taxonomy that identifies the scientific discipline that investigates the properties and thresholds of an IN or OUT interaction.

3.2.13 TMM sensory layer: Layer in the TMM taxonomy that identifies the human senses involved in producing or detecting an IN or OUT interaction.

3.3 Thresholds

3.3.1 threshold: Boundary between two identifiable regions of the stimulus to response curve for human sensors.

3.3.2 detection threshold: Level at which a stimulus applied to a conscious human subject just produces a response.

3.3.3 suprathreshold stimulus: Stimulus greater than the detection threshold.

3.3.4 comfort threshold: Levels (above or below) which a stimulus is known to cause discomfort for most human beings.

3.3.5 safety threshold: Level at which a stimulus changes from being safe to not being safe.

NOTE – In many cases a stimulus is safe below a safety threshold (a maximum safe level) and unsafe above (for example a hot object), but there are cases where the stimulus is safe above a safety threshold (a minimum safe level) and unsafe below (for example a cold object).

3.3.6 pain threshold: Level above which a stimulus is known to cause the sensation of pain.

3.3.7 damage threshold: Level above which a stimulus may cause temporary or permanent damage.

NOTE – Damage thresholds often depend on the duration of the exposure to a stimulus as well as the level of that stimulus.

3.4 Safety and security

3.4.1 safety: Property of a physical device or procedure that determines (and limits through mechanisms, procedures, regulations and permitted operating thresholds) the extent of the damage that the device can cause to one or more human beings.

NOTE – Examples of mechanisms, procedures, regulations and permitted operating thresholds are permitted electronic emissions from devices, the temperature of surfaces on operating devices, the volume of sounds in public entertainment, and mechanisms to ensure the shut-down of nuclear power plants in the event of some failure. In many cases, the operation of a device within these limits can be both sensed and controlled by telecommunications.

3.4.2 security: Protection of a human being's activities (particularly those involving privileges and financial activities) from attack by other human or computer activities, usually achieved by the use of mechanical or electronic devices or mechanisms associated with the protected human being.

NOTE – Examples of security devices and mechanisms are physical door-locks, the use of PINs or biometrics to protect credit cards or passports, and the use of biometrics for access control. In many cases, these devices and mechanisms use telecommunications as an essential part of their operation.

3.4.3 safe telebiometric device: Telebiometric device that is harmless to human physiology, culture, psychology and meets public information rights requirements and privacy requirements.



NOTE 1 – The telebiometric multimodal model (see [ITU-T X.1081]) provides a framework for the identification of safety aspects of biometric devices and for the specification of limits (safety thresholds) by analysing and categorizing the interactions between a human body and its environment.

NOTE 2 – Safe telebiometric devices meet a specified set of conditions derived from identified safety thresholds.

3.4.4 telebiometric security: Security obtained through the use of telebiometric devices for authentication of a human being, using one or more of the modalities of interaction between a human body and its environment, meeting public information rights requirements and privacy requirements.

NOTE – The "out" modalities specified in the telebiometric multimodal model (see [ITU-T X.1081]) provide a framework for the identification of devices that can provide telebiometric acquisition and processing.

3.4.5 telebiometric identification: Telebiometric system function that performs a one-to-many comparison to obtain a candidate list using telecommunications to access one or more biometric systems.

3.4.6 telebiometric verification: Telebiometric system function that performs a one-to-one comparison to show true or false, using telecommunications to access one or more biometric systems.

3.4.7 identify (biometrics): Biometric search against an enrolment database to find and return the biometric reference identifier(s) attributable to a single individual.

3.4.8 biometric identification: Process of identifying.

NOTE – The term identifying, in the above definition, refers to **identify (biometrics)**.

3.4.9 verify (biometrics): Confirm a biometric claim through biometric comparisons.

NOTE 1 – Criteria for confirmation will be determined by policy.

NOTE 2 – It is understood that Popperian's argue claims can never be verified, only falsified.

3.4.10 biometric verification: Process of verifying.

NOTE – The term verifying, in the above definition, refers to **verify (biometrics)**.

3.5 Modalities

3.5.1 TANGO-IN: Characterization of any stimulus that can be detected by nerve endings in the human body, other than by the specialized nerves active in seeing, hearing, tasting and smelling, or that affects or damages human cells.

NOTE 1 – The term TANGO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a TANGO-IN stimulus.

NOTE 2 – The human body is sensitive to the impact of objects or to irritation by (for example) nano-particles or abrasion or chemical substances related to the use of telebiometric devices, and this forms part of the safety levels associated with TANGO-IN.

NOTE 3 – Safety levels for TANGO-IN also include the pain caused by pressure to activate a telebiometric device (or other mechanical effects of a device on the body) or by chemical substances.

3.5.2 TANGO-OUT: Characterization of any force or other non-sound effect produced by a part of the human body, including but not limited to blows with or without an associated instrument or tool, that can be detected by a sensor or another human being.

NOTE 1 – The term TANGO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a TANGO-OUT specific output.

NOTE 2 – TANGO-OUT includes quantities and units related to the ability of the human body to produce a force or physical effect, including measurements of both muscular and lung capability. This also includes quantities and units used in measurements of obesity and of general fitness.

3.5.3 VIDEO-IN: Characterization of any stimulus that can be detected by, affects or is likely to affect or damage, the human eye.

NOTE 1 – The term VIDEO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a VIDEO-IN stimulus.

NOTE 2 – VIDEO-IN includes quantities and units related to the sensing by the eye of (non-ionizing) electromagnetic radiation at various wavelengths and at various intensities.

3.5.4 VIDEO-OUT: Characterization of any output from a human being that can be detected by the human eye or an image sensor, including but not limited to behaviour or signs produced by a human being that can be observed by another human being or a sensor.

NOTE – The term VIDEO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a VIDEO-OUT specific output.

3.5.5 AUDIO-IN: Characterization of any sound stimulus that can be detected by, affects or is likely to affect or damage, the human ear or otherwise impair hearing.

NOTE 1 – The term AUDIO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to an AUDIO-IN stimulus.

NOTE 2 – AUDIO-IN includes quantities and units related to both the effect of loud sounds on the ear, and the frequency range and possible impairment of human hearing.

3.5.6 AUDIO-OUT: Characterization of any sound produced by the vocal chords of a human being, or through activators for disabled speech, or by mechanical, possibly amplified, production of sound that can be detected by the human ear or a sensor.

NOTE 1 – The term AUDIO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to an AUDIO-OUT specific output.

NOTE 2 – AUDIO-OUT includes quantities and units related to the production of sound by the vocal chords, including musical ranges (alto, tenor, etc.) or production of sound with amplification and the quantification of the loudness of such output, where it affects the human physiology or may be used in telebiometrics.

3.5.7 CHEMO-IN: Characterization of any stimulus that can be detected by, affects or is likely to affect, the human sense of taste or smell or to damage these chemo senses.

NOTE 1 – The term CHEMO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a CHEMO-IN stimulus.

NOTE 2 – CHEMO-IN includes quantities and units related to the ability of the human body to smell or taste chemical substances, including both descriptions of tastes and smells (for example of food and wine) and the lethality of specific chemicals.

3.5.8 CHEMO-OUT: Characterization of any chemical emission from the human body that can be detected by the chemical sensing organs of a human being or by a sensor (including but not limited to the use of sniffer dogs, sniffer wasps and olfactory chips as sensors).

NOTE – The term CHEMO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a CHEMO-OUT specific output.

3.5.9 RADIO-IN: Characterization of any stimulus from external sources of radiation (except those covered by VIDEO-IN and AUDIO-IN) that can affect or damage the human body or implanted devices.

NOTE 1 – The term RADIO-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a RADIO-IN stimulus.

NOTE 2 – An implanted device may be any of (not exclusive):

- a cochlear-implant that activates ear nerves directly by signals from a signal processor;
- a pacemaker to control the heart beat;
- an implanted cardioverter-defibrillator to provide immediate defibrillation of the heart;
- a transcutaneous electrical nerve stimulator (an electronic pain reducer);

- a muscle activator;
- an implanted radio frequency identification tag (RFid tag).

3.5.10 RADIO-OUT: Characterization of any output from the human body (or from implanted devices) that is a source of radiation (except those covered by VIDEO-OUT and AUDIO-OUT).

NOTE 1 – The term RADIO-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a RADIO-OUT specific output.

NOTE 2 – RADIO-OUT is concerned with the measurement of all sources of radiation from the human body, for example after exposure to or ingestion of radio-active material, except those radiations covered by VIDEO-OUT and AUDIO-OUT.

NOTE 3 – The base modalities do not encompass non-ionizing electromagnetic radiation from and to the human body that is outside the visible spectrum.

3.5.11 CALOR-IN: Characterization of any stimulus that can be detected by thermo sensors (cold receptors and warm receptors) in the human skin and mucous surfaces and any kind of heat transfer into the human body.

NOTE 1 – The term CALOR-IN is used both as an adjective applied to a stimulus, but more commonly as a noun referring to a CALOR-IN stimulus.

NOTE 2 – CALOR-IN is a derived modality.

NOTE 3 – Heat transfer into the human body can occur by conduction of hot surfaces, by convection of air above skin temperature, by radiation from the sun, heat bulbs, thermo cameras, etc., and by microwave radiation.

3.5.12 CALOR-OUT: Characterization of any kind of heat transfer from the human body.

NOTE 1 – The term CALOR-OUT is used both as an adjective applied to a specific output, but more commonly as a noun referring to a CALOR-OUT specific output.

NOTE 2 – CALOR-OUT is a derived modality.

NOTE 3 – Heat transfer from the human body can occur by conduction to cold surfaces, by convection of air below skin temperature, by infra-red radiation to a cold environment and by evaporation.

4 Abbreviations, symbols and conventions

4.1 Abbreviations

This Recommendation uses the following abbreviations:

CGPM	General Conference on Weights and Measures (Conférence Générale des Poids et Mesures)
CIPM	International Committee for Weights and Measures (Comité International des Poids et Mesures)
ICRU	International Commission on Radiation Units and Measurement
TMM	Telebiometric Multimodal Model

4.2 Symbols used in telebiometrics

The following symbols are used to denote telebiometric devices (see Annex C and threshold tables):

* ^) _ + ~ & % (- = ` ! *F*

The symbol ! represents conformance to safety and security limits for a given modality or set of modalities; where possible, this symbol should be displayed in green.

The symbol *F* is used to denote a threshold, with subscripts that denote, or are related to, the modality that the threshold references.

4.3 Conventions

4.3.1 Where a quantity relates to a safety threshold which if exceeded might cause discomfort, pain or damage to the human body, it is, where possible, characterized in the remarks column of the tables by a safety threshold value.

4.3.2 Quantities and units that are applicable to several modalities are given in clause 5. Quantities and units that are specific to a single modality are given in clauses 6 to 11.

5 Quantities and units used for more than one telebiometric modality

The following table contains the base quantities of the international system of quantities (ISQ) and its units which are the seven base units of the international system of units (SI) and additionally those derived quantities and units which are relevant for more than one telebiometric modality.

NOTE – This table (and all following tables of quantities and units) is arranged so that quantities appear on the left-hand page and the corresponding units are aligned by rows on the right-hand page in a printed document.

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Table 1 – Quantities, units and definitions for multiple modalities

Multiple modalities				Quantities	
Item No.	Name	Symbol	Definition	Remarks	Modality
14-5.1.1	length <i>fr longueur</i> (f)	l, L	one of the base quantities in the International System of Quantities (ISQ), on which the International System of Units (SI) is based	Length is that quantity that can often be measured with a measuring rod. 14-5.1.1 to 14-5.1.13 are various quantities that are used to specify a length.	TANGO VIDEO AUDIO CHEMO RADIO CALOR
14-5.1.2	breadth <i>fr largeur</i> (f)	b, B			TANGO VIDEO
14-5.1.3	height <i>fr hauteur</i> (f)	h, H			TANGO VIDEO AUDIO
14-5.1.4	thickness <i>fr épaisseur</i> (f)	d, δ			TANGO AUDIO
14-5.1.5	radius <i>fr rayon</i> (m)	r, R			TANGO AUDIO
14-5.1.6	radial distance <i>fr distance</i> (f) <i>radiale</i>	r_Q, ρ			TANGO VIDEO AUDIO
14-5.1.7	diameter <i>fr diamètre</i> (m)	d, D			TANGO VIDEO
14-5.1.8	length of path <i>fr longueur</i> (f) <i>curviligne</i>	s			TANGO VIDEO AUDIO
14-5.1.9	distance <i>fr distance</i> (f)	d, r			TANGO VIDEO
14-5.1.10	cartesian coordinates <i>fr coordonnées cartésiennes</i> (f)	x, y, z			TANGO VIDEO AUDIO RADIO
14-5.1.11	position vector <i>fr rayon</i> (m) <i>vecteur</i>	r			TANGO VIDEO AUDIO
14-5.1.12	displacement <i>fr déplacement</i> (m)	Δr			TANGO AUDIO
14-5.1.13	radius of curvature <i>fr rayon</i> (m) <i>de courbure</i>	ρ			TANGO VIDEO AUDIO

Table 1 – Quantities, units and definitions for multiple modalities

Units			Multiple modalities	
Item No.	Name	Symbol	Definition	Remarks
14-5.1.a	metre	m	length of the path travelled by light in a vacuum during a time interval of $1/299\,792\,458$ of a second.	This definition implies that the speed of light in a vacuum is exactly $299\,792\,458$ m/s. [17th CGPM (1978)]. See [ISO 80000-3].

Table 1 – Quantities, units and definitions for multiple modalities

Multiple modalities			Quantities		
Item No.	Name	Symbol	Definition	Remarks	Modality
14-5.2	curvature <i>fr courbure</i> (f)	κ	$\kappa = 1/\rho$ where ρ is the radius of the curvature		TANGO VIDEO
14-5.3	area <i>fr aire</i> (f)	$A, (S)$	$A = \iint dx dy$ where x and y are cartesian coordinates	For an element of area dA , $d\sigma$ is sometimes used.	TANGO CALOR
14-5.4	volume <i>fr volume</i> (m)	V	$V = \iiint dx dy dz$ where x, y and z are cartesian coordinates	$V = \int dV$ For an element of volume dV , $d\tau$ is sometimes used.	TANGO CHEMO
14-5.5	angle, plane angle <i>fr angle</i> (m), <i>angle plan</i>	$\alpha, \beta, \gamma,$ ϑ, φ	for the angle between two half-lines terminating at the same point, $\alpha = s/r$ where s is the length of the included arc of the circle, with its centre at that point, and r is the radius of that circle	Other symbols are also used. See [ISO 80000-3].	TANGO VIDEO AUDIO CHEMO
14-5.6	solid angle <i>fr angle</i> (m) <i>solide</i>	Ω	$\Omega = A/r^2$ where A is the area of the included surface of a sphere in a cone with its apex at the centre of the sphere, and r is the radius of the sphere		TANGO VIDEO AUDIO CHEMO RADIO CALOR
14-5.7	mass <i>fr masse</i> (f)	m	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-4], item 4-1.	TANGO CHEMO
14-5.8	time, duration <i>fr temps</i> (m), <i>durée</i> (f)	t	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-3], item 3-7.	TANGO VIDEO AUDIO CHEMO RADIO CALOR

Table 1 – Quantities, units and definitions for multiple modalities

Units			Multiple modalities	
Item No.	Name	Symbol	Definition	Remarks
14-5.2.a	metre to the power minus one	m^{-1}		
14-5.3.a	square metre	m^2		
14-5.4.a	cubic metre	m^3		
14-5.4.b	litre	l, L	$1\text{ l} := 10^{-3}\text{ m}^3 = 1\text{ dm}^3$	In international standards only the lower case l is used
14-5.5.a	radian	rad	$1\text{ rad} := 1\text{ m/m} = 1$	The radian is the angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.
14-5.6.a	steradian	sr	$1\text{ sr} := 1\text{ m}^2/\text{m}^2 = 1$	The steradian is the solid angle of a cone that, having its apex in the centre of a sphere, cuts off on the sphere a surface equal in area to a square with sides of length equal to the radius of the sphere.
14-5.7.a	kilogram	kg	unit of mass equal to the mass of the international prototype of the kilogram	See [ISO 80000-4]. [3rd CGPM (1901)]
14-5.8.a	second	s	duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom	See [ISO 80000-3]. [13th CGPM (1966-67)]

Table 1 – Quantities, units and definitions for multiple modalities

Multiple modalities			Quantities		
Item No.	Name	Symbol	Definition	Remarks	Modality
14-5.9	electric current <i>fr courant (m)</i> <i>électrique</i>	I	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-6], item 6-1.	TANGO VIDEO AUDIO CHEMO RADIO CALOR
14-5.10	thermodynamic temperature <i>fr température (f)</i> <i>thermo-dynamique</i>	T	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [IEC 80000-5], item 5-1.	TANGO CHEMO CALOR
14-5.11	Celsius temperature <i>fr température (f)</i> <i>Celsius</i>	t, ϑ	$t = T - T_0$ where T is thermodynamic temperature and $T_0 := 273.15$ K	The thermodynamic temperature T_0 is exactly 0.01 K below the thermodynamic temperature of the triple point of water.	TANGO CHEMO CALOR
14-5.12	amount of substance <i>fr quantité (f) de matière</i>	$n, (v)$	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [ISO 80000-9], item 9-1.	TANGO CHEMO
14-5.13	luminous intensity <i>fr intensité (f)</i> <i>lumineuse</i>	$I, (I_v)$	one of the base quantities in the international system of quantities (ISQ), on which the international system of units (SI) is based	See [b-ISO/FDIS 80000-7], item 7-33.	VIDEO TANGO CHEMO

Table 1 – Quantities, units and definitions for multiple modalities

Units				Multiple modalities
Item No.	Name	Symbol	Definition	Remarks
14-5.9.a	ampere	A	that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed one metre apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre ([9th CGPM (1948)])	This definition implies that the magnetic constant μ_0 (see item 6-25.2 of [IEC 80000-6]) is exactly $4\pi \times 10^{-7}$ H/m. [9th CGPM (1948)] See [IEC 80000-6].
14-5.10.a	kelvin	K	fraction 1/273.16 of the thermodynamic temperature of the triple point of water	The units of thermodynamic and Celsius temperature intervals are identical. [9th CGPM (1971)] See [ISO 80000-5], item 5-1.a.
14-5.11.a	degree Celsius	°C	special name for the kelvin for use in stating values of Celsius temperature $1^\circ\text{C} := 1\text{ K}$	
14-5.12.a	mole	mol	the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilograms of carbon 12. [14th CGPM (1971)]	When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles or specified groups of such particles. The definition applies to unbound atoms of carbon 12, at rest and in their ground state. [14th CGPM (1971)] See [ISO 80000-9], item 9-1.a.
14-5.13.a	candela	cd	luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} Hz and that has a radiant intensity in that direction of 1/683 W/sr	See [b-ISO/FDIS 80000-7], item 7-33.a. [14th CGPM (1971)]