International Vocabulary of Metrology
Fourth edition – Committee Draft (VIM4 CD)

Significant changes of the VIM4 with respect to the VIM3
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shall not be quoted in any publication

This document lists the most significant changes introduced in the fourth edition of the VIM (VIM4) with respect to the previous edition (VIM3). For each change, a summary explanation of the reasons that led to the change is provided. Content-related changes are presented first, in sections A, B, and C, followed by changes in the structure of chapters, in section D, while the last section E mentions all other significant changes. The first sections are organized into short sub-sections, one for each change or coordinated set of changes. For the reader's convenience, each sub-section begins with a table in which the relevant VIM3 and VIM4 texts are quoted and the changes highlighted.

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A. Main content-related significant changes

1. Entries about quantity

VIM4 terms and definitions	VIM3 terms and definitions
1.1 quantity <general> *general quantity* *quantity in the general sense* *kind of quantity* property whose instances can be compared by ratio or only by order 1.2 quantity <individual> *individual quantity*: instance of a general quantity	1.1 quantity property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference 1.2 kind of quantity aspect common to mutually comparable quantities
1.30 ordinal quantity <general> *general ordinal quantity* *ordinal quantity in the general sense* property whose instances can be compared by order but not by ratio 1.31 ordinal quantity <individual> *individual ordinal quantity* instance of a general ordinal quantity	1.26 ordinal quantity quantity, defined by a conventional measurement procedure, for which a total ordering relation can be established, according to magnitude, with other quantities of the same kind, but for which no algebraic operations among those quantities exist
6.1 nominal property <general> *general nominal property* *nominal property in the general sense* *kind of nominal property* property whose instances can be compared only by equivalence 6.2 nominal property <individual> *individual nominal property* instance of a nominal general property	1.30 nominal property property of a phenomenon, body, or substance, where the property has no magnitude

It is widely acknowledged that the term "quantity" is used with two related but distinct meanings: for example, it is accepted both that mass is a quantity (like when it is considered that mass is a base quantity in the International System of Quantities) and that any given mass is a quantity (like when it is considered that a measurand, such as the mass of a given object, is a quantity). On this matter the three previous editions of the VIM provide differing accounts:

– VIM1: "The term "quantity" may refer to a quantity in a general sense or to a specific quantity." (1.01, Note 1);

– VIM2: "The term quantity may refer to a quantity in a general sense or to a particular quantity." (1.1, Note 1);

– VIM3: "The generic concept 'quantity' can be divided into several levels of specific concepts ... These are generic concepts for the individual quantities …" (1.1, Note 1).

Hence, in the example above, mass would be called a "quantity in the general sense" (VIM1 and VIM2) and a given mass would be called a "specific quantity" (VIM1), or a "particular quantity" (VIM2), or an "individual quantity" (VIM3).

Furthermore, in order to highlight the distinction between the two meanings of "quantity" the VIM3 introduced an entry for 'kind of quantity', related to comparability of (individual) quantities and used in the sense 'to be of the same kind as' and 'to be a given kind': for example, the mass of an object and the mass of another object are said to be (individual) quantities of the same kind, their common kind being the quantity (in the general sense) mass.

With the aim of making this key concept clearer, whilst maintaining the traditional lexicon that uses "quantity" with both meanings, and thus maintaining terms that are as simple as possible, the VIM4 therefore has two entries for 'quantity', where individual quantities are simply defined to be instances (i.e., examples, cases) of quantities in the general sense. The one term, "quantity", is then qualified by what is referred to in IEC and ISO standards as "specific

use", in this case either "<general>" or "<individual>", each with the corresponding expanded admissible term, "general quantity" and "individual quantity". This allows the most flexible use of the term "quantity": whenever there is no ambiguity whether it refers to a general quantity or an individual quantity, "quantity" is used without any qualifier, thus the reader can understand the intended meaning (with the support of a note if required for clarity: for example in the entry about 'system of quantities' (1.3) Note 1 says "The quantity mentioned in the definition is a general quantity having a unit."); in cases where it is preferred to avoid the ambiguity, a full term may be used, for example "general quantity" but also "kind of quantity", which is accepted here as a synonym.

The same principles can be applied to 'ordinal quantity' and 'nominal property'.

This change also solves the problem created in the VIM3 by the concept 'magnitude', which was introduced in the definition of 'quantity' to avoid the substantial circularity of the definitions in the VIM1 and the VIM2 ("attribute of a phenomenon, body or substance, which may be distinguished qualitatively and determined quantitatively"), where then 'quantity' was defined in terms of a quantitative determination. Three problems were identified regarding the undefined concept 'magnitude':

– according to the VIM3 quantities are properties that have a magnitude, but it is ambiguous whether what is referred to as having magnitudes are general or individual properties (e.g., does mass have a magnitude or does any given mass have a magnitude?), and the two meanings are different;

– contrary to the idea that (general or individual) quantities have magnitude, the traditional position is that magnitudes are quantities that vary in a continuous way, in contrast with multitudes, which are quantities that vary in a non-continuous way: accordingly, the relation between 'magnitude' and 'quantity' is that magnitudes are quantities, not that quantities have magnitudes; clearly, this is a source of possible confusion;

– the term "magnitude" is difficult to translate in some languages, and even the official French text of the VIM3 has the following definition for 'quantity' ("grandeur"), "*propriété d'un phénomène, d'un corps ou d'une substance, que l'on peut exprimer quantitativement sous forme d'un nombre et d'une référence*" ("property of a phenomenon, body, or substance, where the property can be expressed quantitatively as a number and a reference"), in which a reference to 'magnitude' does not appear.

From this perspective, with an explicit reference to the conditions of invariance of comparison the three coordinated concepts now have an operational definition:

– quantities: comparability "by ratio or only by order";

– ordinal quantities: comparability "by order but not by ratio";

– nominal properties: comparability "only by equivalence".

2. Entries about scale

VIM4 terms and definitions	VIM3 terms and definitions
1.19 measurement scale ordered set of individual quantities of the same kind, where each quantity is associated with an element of a set of ordered identifiers	1.27 quantity-value scale *measurement scale* ordered set of quantity values of quantities of a given kind of quantity used in ranking, according to magnitude, quantities of that kind
1.32 ordinal scale measurement scale, accepted by agreement, whose elements are related by order only	1.28 ordinal quantity-value scale quantity-value scale for ordinal quantities
	1.29 conventional reference scale quantity-value scale defined by formal agreement
6.3 reference set of nominal properties *nominal scale* set of individual nominal properties of the same kind, accepted by agreement, where each nominal property is associated with an element of a set of identifiers	

The VIM3 introduced some entries about measurement scales, under the assumption that a scale is an ordered set of values. The VIM4 refines this position, by acknowledging that scales are ordered sets of individual quantities, each mapped to an ordered identifier that represents it, and in particular to a number in the case of the scales for quantities

having a unit. For example, the scale of lengths in metres is a set of lengths such that the length that is equal to x metres is represented in the scale by the number x.

An analogous consideration applies to the case of nominal properties, with the difference that in this case, due to the absence of an algebraic structure among nominal properties, each nominal property of the reference set (the term "nominal scale" is admitted) is represented by a generic identifier instead of a number. For example, the scale of blood groups in the ABO system is a set of blood groups such that each blood group is represented by one of the labels A, B, AB, or O.

The somewhat unusual terms used in the VIM3 ("quantity-value scale" and "ordinal quantity-value scale") are streamlined in the VIM4, as "measurement scale" and "ordinal scale" respectively. Finally, the VIM3 entry about conventional reference scales is removed, because the concept is unclear given that each scale is ultimately defined by convention, in particular the choice of the unit in the case of the scales for quantities having a unit.

3. Entries about value

VIM4 terms and definition	VIM3 terms and definition
1.20 value of a quantity *quantity value* *value <quantity>* individual quantity identified as the product of a number and a measurement unit or on an ordinal scale 1.33 value of an ordinal quantity *value <ordinal quantity>* individual quantity identified on an ordinal scale 6.4 value of a nominal property *value <nominal property>* individual nominal property identified in a reference set of nominal properties	1.19 quantity value *value of a quantity* *value* number and reference together expressing magnitude of a quantity

The VIM3 definition did not actually provide a superordinate of 'value', given that 'number and reference' is not a single concept. In order to fix this problem, and at the same time to provide a template for the new definitions of 'value of an ordinal quantity' and 'value of a nominal property', the new definition of 'value of a quantity' was chosen to be consistent with the understanding of units when given as individual quantities chosen by convention. In this sense, if, for example, the metre is a given length, the concatenation of two metres, i.e., the entity usually written "2 m", is also a given length. This is consistent with the position, mentioned above, of avoiding the need to refer to the ambiguous concept 'magnitude'.

The basic idea that a value of quantity is an individual quantity that, in the case of quantities having a unit, is identified in reference to a unit is depicted in the following figure.
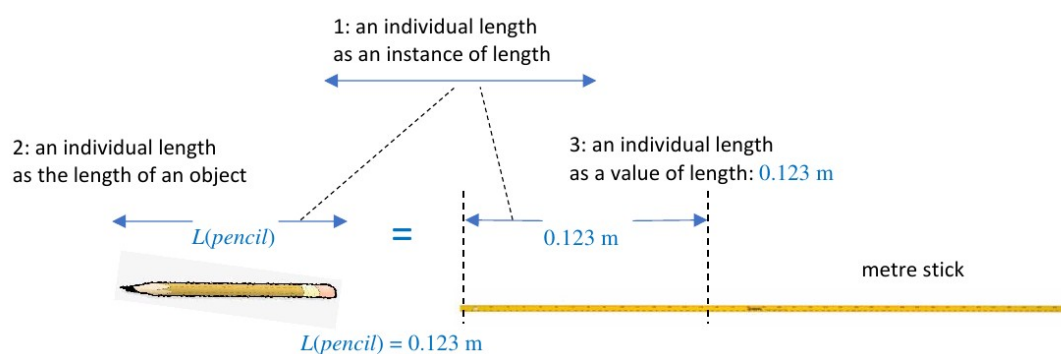
Moreover, in the VIM4 the more common term "value of a quantity" is accepted as the preferred term, and a note mentions that "quantity value" may be used in order to take advantage of the adjectival use of a noun in the English language.

Finally, the short term "value" is also allowed for values of ordinal quantities and nominal properties, as qualified by the specific use "<quantity>", "<ordinal quantity>", and "<nominal property>", whenever the linguistic context is sufficient to prevent the ambiguity.

4. Entries about measurement accuracy

VIM4 terms and definition (changes are underlined)	VIM3 terms and definition (terms updated in the VIM4 are underlined)
3.15 measurement accuracy *accuracy of measurement* *accuracy* closeness of agreement between a measured value and a reference value of a measurand	2.12 measurement accuracy *accuracy of measurement* *accuracy* closeness of agreement between a measured quantity value and a true quantity value of a measurand
3.16 measurement trueness *trueness of measurement* *trueness* closeness of agreement between the average of measured values obtained by replicate measurements and a reference value	2.13 measurement trueness *trueness of measurement* *trueness* closeness of agreement between the average of an infinite number of replicate measured quantity values and a reference quantity value

The role of true values in measurement in the VIM3 was based on a hybrid approach, for example 'measurement accuracy' is defined as related to a true value but 'measurement error' as related to a reference value. In the VIM4 the general approach has been followed to adopt operational definitions whenever possible to be consistent in particular with the position of ISO 5725. Since 'reference value' is the superordinate of 'true value' and 'value' is the superordinate of 'reference value' (all true values are reference values and all reference values are values, but not all values are reference values and not all reference values are true values), the relevant definitions are phrased in terms of values or reference values and mentioning true values in notes an encompassing position is obtained:

– if "true value" is considered the right term in a given definition, the definition remains at least partially correct, though generic because it subsumes the intended concept but also something else;

– if "true value" is considered meaningless or should not or need not be used, the definition is acceptable.

For the same reason, in the definition of 'measurement trueness' the average is no longer required to be computed on an infinite number of values, and a note has been added to highlight that the number of averaged values must be large enough to make random variability of the result negligible (and an analogous note has also been added regarding 'random measurement error').

Finally, new notes highlight that measurement accuracy and measurement trueness can pertain to either

– a measurement procedure or a measuring instrument / a measuring system, and in these cases they are generally known quantities, or

– a single measured value or a set of measured values, and in these cases the reference value is a true value and they are generally unknown quantities.

5. Entries about nominal properties and their examination

VIM4 terms and definition	VIM3 terms and definition
6.1 nominal property <general> *general nominal property* *nominal property in the general sense* *kind of nominal property* property whose instances can be compared only by equivalence All other entries in Chapter 6	1.30 nominal property property of a phenomenon, body, or substance, where the property has no magnitude

While the VIM3 has only one entry for 'nominal property', a new chapter has been added to the VIM4 about nominal properties and the process of their evaluation, called "examination" as in the *Vocabulary on nominal property,*

examination, and related concepts for clinical laboratory sciences (IFCC-IUPAC Recommendations 2017), from which all new entries have been taken and adapted.

B. Other significant content-related changes

1. quantity dimension

VIM4 definition (1.7) (changes are underlined)	VIM3 definition (1.7) (terms updated in the VIM4 are underlined)
relation of a quantity to the base quantities of a system of quantities as a product of powers of factors corresponding to the base quantities, omitting any numerical factor	expression of the dependence of a quantity on the base quantities of a system of quantities as a product of powers of factors corresponding to the base quantities, omitting any numerical factor

The VIM3 definition presents dimensions as expressions, plausibly with an implicit reference to the mathematical meaning of "expression", which is however generic. In the VIM4 the definition is phrased to emphasize that the dimension of a quantity is the relationship of the quantity to the base quantities of the chosen system of quantities.

2. quantity with unit one

VIM4 (1.8) first term	VIM3 (1.8) first term
quantity with unit one	quantity of dimension one

The conceptualization of the quantities traditionally called "dimensionless" is still open to debate, and not surprisingly the lexicon is not yet available. In the VIM4, the term "quantity with unit one" has been adopted instead of "quantity of dimension one", in agreement with the use in the current (9th) Edition of the SI Brochure.

3. International System of Units

VIM4 definition (1.16) (changes are underlined)	VIM3 definition (1.16) (terms updated in the VIM4 are underlined)
system of units, based on a set of defining constants, together with rules for their use, adopted by the 26th General Conference on Weights and Measures (CGPM)	system of units, based on the International System of Quantities, their names and symbols, including a series of prefixes and their names and symbols, together with rules for their use, adopted by the General Conference on Weights and Measures (CGPM)

An explicit reference has been introduced to highlight the fact that in its recent revision the SI now is based on defining constants. Furthermore, in the SI the names of the units and the prefixes are different in different languages, for example "kilogram" in English, "kilogramme" in French. To avoid possible misinterpretation that these differences imply that there are different systems, the reference to such names has been removed in the VIM4 definition. The rules mentioned in both definitions can be considered to include the names and symbols of the units and the prefixes: a note has been expanded to make this explicit.

4. true value of a quantity

VIM4 (1.22) definition (changes are underlined)	VIM3 (2.11) definition (terms updated in the VIM4 are underlined)
value consistent with a quantity, as it is defined	quantity value consistent with the definition of a quantity

According to the VIM3 definition, the relationship that characterizes a true value is that between the value of a quantity and the definition of the quantity. This was considered unclear and contrary to the basic idea that a quantity "cannot be specified by a value but only by a description" (as in JCGM 100 (the GUM), D.1.1). Hence, the VIM4 definition has been rephrased to show that the relationship is between a value and a quantity. This makes it more explicit that a value is true if the equation quantity = value is true, where the quantity could be the measurand, as it is defined.

5. measurement

VIM4 definition (2.1) (changes are underlined)	VIM3 (2.1) definition
process of experimentally obtaining one or more values that can reasonably be attributed to a quantity <u>together with any other available relevant information</u>	process of experimentally obtaining one or more quantity values that can reasonably be attributed to a quantity

The expression "together with any other available relevant information" has been added to the VIM4 definition to align it with the definition of 'measurement result' ("set of values being attributed to a measurand together with any other available relevant information"). In this way, the basic message that measurement is the process that produces measurement results is conveyed more clearly.

6. primary method of measurement

VIM4 definition (2.6)	VIM3
measurement method used to obtain a measurement result without reference to a measurement standard for a quantity of the same kind	not defined

This entry has been added to the VIM4, in acknowledgment of the importance of the concept to metrology.

7. correction

VIM4 definition (2.17) (changes are underlined)	VIM3 definition (2.53) (terms updated in the VIM4 are underlined)
<u>quantity, in a measurement model,</u> compensating for an estimated systematic <u>error</u>	<u>compensation</u> for an estimated systematic <u>effect</u>

The definition has been rephrased to make it clear that the corrections are intended to be quantities, i.e., what is used for correcting, and not the actions to be performed. Moreover, the ambiguous term "systematic effect" has been changed to "systematic error".

8. coverage interval

VIM4 definition (3.12) (changes are underlined)	VIM3 definition (2.36) (terms updated in the VIM4 are underlined)
interval containing <u>the value of a quantity</u> with a stated probability, based on the information available	interval containing <u>the set of true quantity values of a measurand</u> with a stated probability, based on the information available

The new definition, which is consistent with the general idea of not referring explicitly to 'true value' in definitions (see the related explanation in the entry about 'measurement accuracy'), has been taken from JCGM 101, 3.12.

9. coverage probability

VIM4 definition (3.13) (changes are underlined)	VIM3 definition (2.37) (terms updated in the VIM4 are underlined)
probability that <u>the value of a quantity</u> is contained within a specified coverage interval	probability that <u>the set of true quantity values of a measurand</u> is contained within a specified coverage interval

The new definition, which is consistent with the general idea of not referring explicitly to 'true value' in definitions (see the related explanation in the entry about 'measurement accuracy'), has been taken from JCGM 101, 3.13.

10. repeatability condition of measurement

VIM4 definition (3.22)	VIM3 definition (2.20)
condition of measurement that is held fixed while performing two or more measurements over a short period of time	condition of measurement, out of a set of conditions that includes the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same or similar objects over a short period of time

The definition has been simplified, and the additional information in the VIM3 definition has been provided in a Note to the VIM4 entry.

11. operating condition

VIM4 definition (4.19)	VIM3
state of a measuring instrument or measuring system when it is in operation	not defined

This entry has been added to the VIM4, in acknowledgment of the importance of the concept to metrology.

12. selectivity

VIM4 definition (4.24) (changes are underlined)	VIM3 definition (4.13) (terms updated in the VIM4 are underlined)
property of a measuring instrument, whereby it provides indications that are independent of quantities other than the quantity being measured but that are of the same kind as the measurand	property of a measuring system, used with a specified measurement procedure, whereby it provides measured quantity values for one or more measurands such that the values of each measurand are independent of other measurands or other quantities in the phenomenon, body, or substance being investigated

The VIM3 definition has been simplified and made more specific: in particular it acknowledges that selectivity is a property that also applies to non-calibrated instruments and as such it relates to indications, and not only to measured values.

13. instrumental drift

VIM4 definition (4.31) (changes are underlined)	VIM3 definition (4.21) (terms updated in the VIM4 are underlined)
gradual undesirable change over time in indication of a measuring instrument due to its limited stability for the same quantity being measured	continuous or incremental change over time in indication, due to changes in metrological properties of a measuring instrument

The VIM3 definition has been simplified and more explicitly connected to the lack of sufficient stability of the relevant instrument.

14. international measurement standard

VIM4 definition (5.2) (changes are underlined)	VIM3 definition (5.2)
measurement standard recognized by signatories to an international agreement and intended to serve worldwide and used as the basis for assigning values to other measurement standards for the kind of quantity concerned	measurement standard recognized by signatories to an international agreement and intended to serve worldwide

The VIM3 definition has been expanded to make the concept clearer.

15.   certified reference material

VIM4 definition (5.13)	VIM3 definition (5.14)
reference material, characterized by a metrologically valid approach for one or more specified properties, accompanied by an RM certificate that provides the values of the specified properties, associated uncertainties, and statements of metrological traceability	reference material, accompanied by documentation issued by an authoritative body and providing one or more specified property values with associated uncertainties and traceabilities, using valid procedures

The new definition has been taken from ISO Guide 30:2015.

16.   certified value of a CRM

VIM4 definition (5.14)	VIM3
value, assigned to a property of a certified reference material (CRM) that is accompanied by an uncertainty and a statement of metrological traceability, identified as such in the CRM certificate	not defined

This entry has been added to the VIM4, in acknowledgment of the importance of the concept to metrology.

17.   calibration

VIM4 definition (5.18) (changes are underlined)	VIM3 (2.39)
operation performed on a measuring instrument or a measuring system that, under specified conditions 1. establishes a relation between the values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and 2. uses this information to establish a relation for obtaining a measurement result from an indication	operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

This crucial definition has been slightly restructured to make it more understandable. A specification has been added to show that objects of calibration are measuring instruments or measuring systems.

18.   calibration function

VIM4 definition (5.19) (changes are underlined)	VIM3 (4.31) (terms updated in the VIM4 are underlined)
functional relation between indications and corresponding measured values	expression of the relation between indication and corresponding measured quantity value

The VIM3 definition uses the phrase "expression of a relation", plausibly with an implicit reference to the mathematical meaning of "expression", which is generic. In the VIM4 the definition is made more explicit, in terms of "functional relation".

C. Deleted entries

The following VIM3 entries do not appear in the VIM4:

– kind of quantity (1.2): see the explanation in Entries about quantity;

– conventional reference scale (1.29): see the explanation in Entries about scale;

– range of a nominal indication interval (4.5): considered redundant;

– resolution of a displaying device (4.15): considered redundant;

– variation due to an influence quantity (4.22): considered redundant;

– calibrator (5.12): included as a specific case of working measurement standard (VIM4, 5.7).

D. Changes in the structure of chapters

The VIM entries are organized into chapters, where each chapter covers a key subject of metrology. Each new edition of the VIM was seen as an opportunity to revise and improve this structure. This process continued in the VIM4, including the addition of a new chapter about nominal properties and examinations.

The starting point was the VIM3 structure:

VIM3 structure
1 Quantities and units: 33 entries
2 Measurement: 52 entries
3 Devices for measurement: 12 entries
4 Properties of measuring devices: 28 entries
5 Measurement standards (Etalons): 17 entries

In this structure the following points were noted:

– Chapter 2 includes very diverse contents: the criterion of inclusion is not always clear;

– Chapter 3 has very specific contents: it includes entries for measuring devices but not their properties;

– Chapter 4 has very diverse contents, including a few entries about uncertainty and calibration, both defined in entries in Chapter 2;

– Chapter 5 artificially separates measurement standards from their usage, i.e., calibrations, and context, i.e., traceability chains.

According to this analysis, the following structure has been adopted for the VIM4:

VIM4 structure (*with respect to VIM3*)
1 Quantities and units: 33 entries (*no changes*): devoted to the characterization of quantities, both quantities having a unit and ordinal quantities, thus including units, scales, and values
2 Measurement: 17 entries (*subset of Ch 2*): devoted to the characterization of the structure of measurement, thus including measurement principle, method, procedure, and model
3 Measurement quality: 31 entries (*merged part of Ch 2 and part of Ch 4*): devoted to the characterization of the quality of measuring instrument and systems, and of measurement and its results, thus including measurement uncertainty and measurement accuracy and error
4 Measuring devices and their properties: 33 entries (*merged Ch 3 and part of Ch 4*): devoted to the characterization of measuring instrument and systems, thus including properties such as sensitivity, selectivity, resolution, and stability
5 Measurement standards (etalons) and metrological traceability: 28 entries (*merged Ch 5 and parts of Ch 2 and 4*): devoted to the characterization of metrological systems, thus including measurement standards and calibration, and what is required to guarantee the metrological traceability of the outcomes of measuring systems
6 Nominal properties and examinations: 17 entries (*new*): devoted to the characterization of nominal properties and the process of their evaluation

E. Other changes

– Several definitions and notes have been simplified.

– Simpler / shorter terms have been used whenever appropriate (e.g., "value" instead of "value of a quantity" or "quantity value").

– Explicit references to concepts have been removed (e.g., "quantities can be classified as..." instead of "the concept 'quantity' may be generically divided into...").

– Terms for quantities have been formatted in italic whenever it improves the readability (e.g., "the quantity *number of entities* can be regarded...").

– Bibliographical references have been updated and expanded.