Particularities in the adoption of the Metric System in Portugal - Some local constraints

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1. Introduction

Portugal, with its nearly nine centuries history, witnessed successive efforts of standardisation of weights and measures until the full adoption of the French Metric System, which occurred in 1852.

As in other European countries and during several centuries, Portuguese reforms of weights and measures failed their purposes, contributing even, in some occasions, to the damage of the situation. However, particular aspects differ from other local histories in the set of the European countries.

The country has a special geographic situation in the extreme west of Europe, sharing with Spain the Iberia Peninsula and facing the Atlantic Ocean. This position, also with a direct entrance into the Mediterranean Sea, explains the different human influences marking the Portuguese national identity. Those influences occurred by temporary occupation of the territory (Roman, Arab, Spanish, French, English people...), by the arrival of different ships with commercial purposes (Greek, Nordic people...) and also by the Portuguese Maritime Expansion (Africa, India and Brazil).

In order to better understand the conditions when the adoption of the Metric System occurred, we will explain briefly the successive attempts to establish the equality of weights and measures in the Portuguese kingdom. All these efforts and the formal adoption of the metric system were made during the Portuguese monarchy[1].

[1] Portuguese Republic was established in 1910 October 5th.

2. The origins

It is possible to notice the use of weights and measures in the Portuguese territory since the Roman domination, at the minimum. After the Arabic occupation, some ancient Roman measures maintained; in other cases, Arabic measures imposed their use.

With the Christian re-conquest, reappeared some of the old Roman units and remained some of the Arabic, or only their nomenclature was adapted to other measures.

From Roman origin we can identify the *milha* (1852,4m), *libra* (343,5g), *onça* (28,68g), *emina* (270,833g) and *modio* (8,67L). From Arabic origin it is possible to name over: *quintal* (4 *arrobas*-58,752kg), *arroba* (32 *arráteis*--14,688kg), *arrátel* (459g), *alqueire* (13,6L) and *almude* (16,8L). Greeks gave us the *dracma* (3,57g)[2].

A long way of attempts was walked since the foundation of the Portuguese Nation.

As in other countries, several centuries passed without standardised units of weights and measures. Units changed from one region to another, units with the same designation changed with their magnitude depending on the goods to be measured, as was the case of the pound for the linen (0,918kg) and the pound for pharmacy (0,3435kg)[3].

The first Portuguese king, Afonso Henriques, when of his Christian re-conquest, distributed different units of weights and measures to the new regions or cities, depending on political reasons. We were in the 12th century in low Mediaeval Age. Laws differed from one region to another and permitted the change of the size of the unit used to pay the tributes, at any time. It was the complete absence of uniformity and provoked abuses and misuses.

During the kingdom of Afonso IV, in the Cortes of Lisbon 1352, the people claimed for standardisation and against the differences between the alnas and côvados (0,68m)[4] and also against the differences among the

[2] The equivalences for the metric system were done by Fradesso da Silveira in 1856, having as base the standards of Lisbon. *Cf.* J.H. Fradesso da Silveira. *Compendio do Novo Systema Legal de Medidas* (1856). Lisboa, Typographia do Centro Commercial.

[3] *In* J.H. Fradesso da Silveira. *Ibidem.*

[4] *Alna* was a unit with French origin- *Aune*. Bento Fernandes (1555) refers that the *alna* corresponds to the *côvado* of Lisbon, however there is a very small difference, because 30 *alnas* contained one additional *côvado*. *Cf.* A. A. Marques de Almeida, *Aritmética como Descrição do Real (1519-1679)* (1994). Lisboa, Imprensa Nacional, Casa da Moeda, Vol.

units of capacity. The king decided that the standard of the measure for tissues will be the *alna* of Lisbon. However, he never took any decision in order to solve the problem of the differences among the units of volume as well as he never succeeded imposing a unique standard for any measure. In Portuguese Mediaeval churches, castles and central market squares, it is frequent to found the côvado engraved in well exposed stones (Fig 1).

Pedro I, in Évora 1361, decided to compare the measures for the cereals with the *alqueire* of Santarém and the measure of wine by the *almude* of Lisbon. He also decided the standardisation of the measures of weight by the *arroba* of Lisbon and forbade the use of stone-weights, imposing the use of iron-weights.

Figure 1 - Standard of côvado in the Church of Mercy in Sabugal, 14th Century[5]

The king Fernando (Lisbon, 1372) affirmed that weights and measures were a royal determination and forbade their change in different regions without authorization.

Pedro I had already forbidden stone-weights; however, João I, in Coimbra 1391, feels the necessity of reinforcing again the imposition to make the units of weight in iron.

Afonso V was the first Portuguese king to impose the organisation of a written juridical code. In Lisbon 1455, he deliberated to establish six different standards for the entire kingdom: Santarém, Porto, Guimarães, Ponte de Lima and Lisbon.[6]

João II (in Évora 1490) determined the existence of only two legal standards for the capacity, one for the North and Algarve (standards of Porto) and the other for the Centre of the kingdom (standards of Lisbon). He imposed a common nomenclature for the capacity of solids

I., p. 229.

[5] IPQ – Portuguese Institute for the Quality, Almada. In Estácio dos Reis, A. 2002. há 150 anos... a introdução do Sistema Métrico Decimal em Portugal. CTT Correiros de Portugal.

[6] *Cf.* S.F. Mendo Trigoso, Sobre os Pesos e Medidas Portuguezas, e sobre a Introdução do Systema Metro-Decimal. *Memórias Económicas da Academia Real das Sciencias de Lisboa para o Adiantamento da Agricultura, das Artes e da Indústria em Portugal, e suas Conquistas* (1815). Tomo V. Lisboa, Typografia da Academia Real das Sciencias, p. 336-411.

and liquids. Existing historical documents permit to notice that until this period all the attempts of standardisation failed completely. Fairs and markets had their trend codes, uses and measures! It was frequent the coexistence of more than one measure in the same place (Fig 2).

Figure 2 - Mediaeval standard of the côvado and vara in the Church of Madalena in Monforte (15th Century)[5]

During the reign of Manuel I, science, art and the external trade developed. Lisbon and its harbour transformed in the main centre of commercial changes in Europe (Fig 3). The time imposed more serious steps of standardisation in Portugal.

This king, during which reign maritime way to India and Brazil were discovered, imposed the use of the measures of Lisbon in the entire kingdom and defined multiples and submultiples of the main units (length-*vara*, weight-*marco* and capacity-*canada*). *Marco* was the chosen unit of weight and their multiples and submultiples were well defined, in a base two relation (Fig 4).

However, he only ordered the construction of sets of bronze-weights, in Flemish Lands. Regional sets of measures for volume, especially made in wood, from the standards of Lisbon, were built in different regions of the country. Apparently, the tentative succeeded in respect to the weight standards.

Figure 3 - Lisbon harbour in the 16th Century[5]

Figure 4 - *Marco*-standard of Manuel Ist, in bronze, weighting one quintal and containing 16 units, from one escrópulo until two *arrobas*.[5]

Practically at the end of the 16th century (in 1575), under the reign of Sebastião the use of all of the standards of Lisbon were reinforced and the king ordered the construction of the units of capacity, in bronze. He also established that every region must build, in Lisbon, its set of standards in bronze and officially calibrated (Fig. 5). However the new

standards never arrived to the entire kingdom. Once again, the necessary and desirable standardisation did not occur.

Figure 5 - Aquarelle of the standards of the units of capacity, from Sebastião[7]

During Spanish domination (1581-1640) the kings Filipe I, Filipe II and Filipe III reinforced the use of the standards of Sebastião. It was the last well-known tentative of standardisation in Portugal until the work developed in order to adopt the Decimal System.

At Lisbon 1755, a strong and destructive earthquake occurred. The mediaeval city practically disappeared. This episode probably was determinant in subsequent decisions concerning weights and measures in Portugal. The majority of the calibrated standards of Lisbon, particularly the standards of length and capacity, disappeared. As written by Mendo Trigoso[8]:

The calamitous earthquake in 1755 and the subsequent fire destroyed all the standards of capacity for dries (cereals) and liquids as well as for length. These last standards were substituted by a beam with the *côvado* and the *vara* engraved[9]. As a consequence it is supposed the distortion of the units built after that. "Where can we search for the measure ordered

[7] *Cf. Anuário de Pesos e Medidas*, nº 1 (1942). Ministério da Economia, Repartição de Pesos e Medidas, Lisboa, Editorial Império.

[8] *Cf.* S.F. Mendo Trigoso, Sobre os Pesos e Medidas Portuguezas, e sobre a Introdução do Systema Metro-Decimal. *Memórias Económicas da Academia Real das Sciencias de Lisboa para o Adiantamento da Agricultura, das Artes e da Indústria em Portugal, e suas Conquistas* (1815). Tomo V. Lisboa, Typografia da Academia Real das Sciencias, p.378.

[9] The necessity of to engrave two different measures is an indicator of the coexistence and permission of use, at the time, of different units for the same measurement.

by that king [Sebastião]? Where could we find the standard for the calibration of the different measures?"

3. Time of Change, Time for Standardisation

We were in 18th century. France was the scientific centre of the world and the French Revolution in 1789 consolidated the ideal of Equality. These two aspects were convergent in a period requiring standardisation.

In the same year occurred the French Revolution and the publication of the Traité Élèmentaire de Chimie, by Lavoisier. Two years before, Lavoisier, Berthollet and Fourcroy created the new Method for the Chemistry Nomenclature. The great quantity and disorder in the names for the chemical substances and the absence of criteria for the designation of new substances were solved[10].

Two years after, in May 1790, the Constitutional Assembly approved a Law requiring the standardisation for all the units of weights and measures. Then, the Royal Academy of Science of Paris formed a Committee including Lavoisier, Lagrange, Monge, Cassini, Coulomb, Berthollet, among others, in order to think about the subject. Laplace suggested the name "metre" for the unit of length. In December 1799 the French Metric System was established.

4. Portugal in the Context of change

In the year of 1802 Portugal imported from France prototypes built by Fortin. This is an interesting aspect to notice that it occurred only three years after the establishment of the Metric System in France.

The standards of the metre, in iron (the original) and a copy in brass, ordered to Paris by D. Rodrigo de Sousa Coutinho in the beginning of the 19th century, are preserved in the Astronomical Observatory of the University of Coimbra (Fig. 6)[11].

[10] *Cf.* B. Bensaude-Vincent; N. Journet, Rien ne se perde, rien ne se crée: Tout se pèse. *Les Cahiers de Science et Vie. Les Peres Fondateurs de la Science. Lavoisier* (1993).

[11] *Cf.* A. Estácio dos Reis, *Há 150 anos... a introdução do Sistema Métrico Decimal em Portugal* (2002). Lisboa, CTT

In 1806 the relation between the kilogram and the old Portuguese standards of weights were already established.

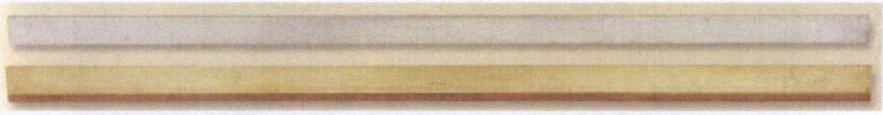

Figure 6 – Standard of the metre imported from Paris in 1802.[5]

Between 1807 and 1811 Portugal was invaded and largely aggressed by the French army. We name that war by "Peninsular War". The 2nd centenary of the beginning of French Invasions occurs exactly in the year 2007; the 1st invasion, commanded by the General Junot, took place in November 19th, with the entrance of the French army by the region of the authors of this study.

There are two different visions about the war. Spain have strongly castigated the French soldiers and that is the reason for the deplorable form how the French army arrived in Portugal; However, far from Lisbon and of the main Portuguese army, but once in Portugal, they had forced the deprived inhabitants to give them lots of food and animals... and they were, initially, well cared... However, a short time after, people rejected the French troops and support actively the Portuguese army. Napoleon persevered two times again (General Soult and General Massena), until the final battle in Buçaco, in 1810 September 27th, and the subsequent incapacity of transposing the intentional fortifications built near Lisbon, the war finished in 1811. Another version[12], probably the more realistic, points out that the French army had the connivance from the passive and compliant Spanish government...

Because of the French invasions the Portuguese Royal Family embarked to Brazil (1807-1821). However, once finished the war, but with the Portuguese Royal Family in Brazil and under the regency of the Prince João, who would be king João VIth, in December 1812, seven members from the Academy of Sciences of Lisbon were integrated in a recent created Commission (Comissão para o Exame dos Forais e Melhoramentos da Agricultura)[13]. Only three months after (February 1813) the Commission

[12] *Cf.* M. Salvadori. *La Storia* (2005). Vol. 12, p. 28.

[13] Three members coming from the Class of Mathematics: Francisco Paula Travasos, Anastácio Joaquim Rodrigues and Matheus Valente do Couto; the others coming from the Natural Sciences Class: Alexandre António das Neves, António Araújo Travassos, Sebastião Francisco Mendo Trigoso e João Bell. The underlined names accompanied all the process, because after the approval of the Reform Plan by the Regent Prince, the Government

presents the Plan of the Reform of the Units of Measure for Portugal (Figure 7). Its name, as we can see in the title is "Map of the Metric-Decimal System reduced to Portuguese nomenclature". However, the metre do not appears, as the unit of length. In August 1814 the regent Prince approved the Plan and ordered its extension to Brazil and to all Portuguese Overseas (only 15 years after the official establishment of the Metric System in France, which obligatory use in that country only occurred in 1840).

MAPPA DO SYSTEMA METRO-DECIMAL REDUZIDO A NOMENCLATURA PORTUGUEZA.

Medidas de Estensão.			Medidas de Capacidade.			Medidas de Peso.		
	Nomes.	*Valores.*		*Nomes.*	*Valores.*		*Nomes.*	*Valores.*
Progressão ascendente.	Milha	10000 Mãos travessas	Progressão ascendente.			Progressão ascendente.		
		1000 Mãos travessas		Tonel	1000 Canadas		Tonelada	1000 Libras
		100 Mãos travessas		Fanga	100 Canadas		Quintal	100 Libras
	Vara	10 Mãos travessas		Alqueire	10 Canadas		Arroba	10 Libras
MÃO TRAVESSA.	Unidade Linear, igual á centesima milionesima parte do Quarto do Meridiano.		CANADA	Unidade de Capacidade, igual ao Cubo da Mão travessa.		LIBRA	Unidade de Peso, igual ao da Agua destillada, contida no Cubo da Mão travessa.	
Progressão descendente.	Decimo	$\frac{1}{10}$ da Mão travessa	Progressão descendente.	Decimo	$\frac{1}{10}$ da Canada	Progressão descendente.	Decimo	$\frac{1}{10}$ da Libra
	Centesimo	$\frac{1}{100}$ da Mão travessa		Centesimo	$\frac{1}{100}$ da Canada		Centesimo	$\frac{1}{100}$ da Libra
							Escropolo	$\frac{1}{1000}$ da Libra
							Decil	$\frac{1}{10000}$ da Libra
							Centil	$\frac{1}{100000}$ da Libra

Mem. Econ. Tom. 5.º pag. 194.

Figure 7 - Table of the Portuguese Metric System (1813).[14]

In their work, the Commission adopted, immediately and unequivocally, the decimal principle. However, the unit of length was defined as the cent-millionth part of a quadrant of a great circle on the earth - this was the tenth part of the French metre. Concerning this aspect, Mendo Trigoso[14] wrote in a footnote:

ordered that these three Officials from the Royal Body of Engineering were associated to the Comission of *Forais* into the plane of the whole Commission. I.e. they also accompanied all the process of the construction of the new standards and of gathering and comparing the old with new standards.

[14] S.F. Mendo Trigoso, Sobre os Pesos e Medidas Portuguezas, e sobre a Introdução do Systema Metro-Decimal. *Memórias Económicas da Academia Real das Sciencias de Lisboa para o Adiantamento da Agricultura, das Artes e da Indústria em Portugal, e suas Conquistas*

"The kilogramme or cubic *mão-travessa* (hand) is not exactly the unit of the French Metric System, but it is a millionth part of that kilogramme, and for that we named it as gramme; but the comparison that we need to do with our actual weights, imposed us as necessary this little change, which does not essentially influence the System. It is well fundamented because it was taking the kilogramme and not the gramme as the base, that in fact, all the experiences in order to determine the unit of weight were done".

The Commission, conscious of the popular repugnance to everything with French connotation, defended in its report the non use of the French nomenclature for the new units to be adopted. As said, the decimal system was adopted but the designations of the fundamental or main units maintained the name of the nearest ancient Portuguese unit: *mão-travessa* (hand – 1dm), *canada* (litre =1dm3) and *libra* (pound – 1kg). Although, the designation of the proposed submultiples, explicitly suggests a decimal relation (except in the case of the *escrópulo*, which is equal to the millionth part of the *libra*). Multiples only adopt ancient designations.

It was a very rational system, because all the fundamental units were directly related among them, and based on the unit of length, *mão-travessa* (one *canada* was exactly the amount of liquid contained in a cube with one unit of length *mão-travessa* by side; one pound was exactly the weight of the amount of water contained inside the *canada*).

In December 1814, the Government imposed the construction, by the Portuguese Army Arsenal, of those new standards of weights and measures. In July1816 two sets of the standards were received in Brazil. Three hundred sets were built; the more completely 50 for the main city Town Halls (heads of District) and they were made in bronze or in brass; the remained 250 for the little Communes and they were made in melted iron or in cupper. The first ones were kept in special cases made in precious wood, and including complementary instruments.

Between May 1817 and March 1818 the king João VIth ordered that all the old standards from the different regions would be brought to Lisbon or Coimbra in order to compare them with the new standards. From this hard work, conversion tables of the units used in each region were organised. In early 1820, communes from the region of Lisbon

(1815). Tomo V. Lisboa, Typografia da Academia Real das Sciencias, p. 336-411.

and Algarve received the order for carrying the new standards in the Army Arsenal and they were informed about the way the payment must be done. Immediately, in March 1820, in a Decree in Law the government ordered that primary teachers oblige children to memorize this new Decimal System with the intention that people had reach sufficient notice before their entrance in practice.

Figure 8 - Set of standards of the units of weight, João VIth[5]

However, once again, a particular episode of the Portuguese History constrained the full adoption of this new "Portuguese" Decimal System, which had the still relieved difference from the French Metric System.

In August 1820 took place the Liberal Portuguese Revolution and few years after (from 1832 to 1834) a Civil War occurred, between absolutists and liberals. All the previous intentions failed and the work in progress stopped. As referred by Silva Lopes[15] (1842) these orders were never executed and may be not even issued the Decree. The Commission seems to have disappeared, because a Decree of the king Pedro IVth, from August 1833, reconstitutes the Commission. Even the principles of the Weights and Measures System were discussed again. New and different solutions, sometimes again far from the French Metric System, were pondered. Since 1843 the academic and deputy Silva Lopes soundly interested himself by the issue. He made, at the minimum, three Law proposals for the standardisation on the base of the French Metric System (1845, 1848 and 1849) that never were completely approved. We must underline that all these proposals refused the French nomencla-

[15] J. B. Silva Lopes, *Memória sobre a Reforma dos Pesos e Medidas em Portugal segundo o Systema Métrico – Decimal* (1849). Lisboa, Imprensa Nacional.

ture. In the table of figure 9, as in the table presented in Figure 7, the title evidences the metre in the title: "Expositive Map of the Portuguese Metric-Decimal System". However, once again, the unit metre is not contemplated among the units. Ancient names were proposed as fundamental units: vara for length, canada for capacity and libra for weight. The unit vara was defined as the ten-millionth part of the quarter of the great circle in the Earth, with the some length of one metre and we can see the unit canada (for capacity) was defined as the cube of the tenth part of the unit vara. Supplementary decimal multiples and submultiples were added in this proposal.

The former complex but inevitable decision in order to adopt the Decimal System initially influenced hard work which was done very quickly. The first set of all the standards were done. However, in the civil war scenario that followed and with the consequent political change, that challenging intention of change had disastrous consequences. Several Town Halls did not follow the order to keep one set of their standards and sent to Lisbon or Coimbra all their measures in order to be compared with the new system. Without the old standards and also without the new standards generalised, the confusion and disorder in the domain of measures augmented in all the territory[16].

Even so, at the same time, with this great confusion, we can interpret it as an impulse to adopt the French Metric System in order to solve the problems caused by this (only) apparently bizarre Portuguese System of Measures, which perplexed the people in lands, fairs and markets and in all commercial transactions and other situations involving measurement.

However, or as a consequence of that, practically until the middle of the 20th century, ancient measures dominated with their regional differences among the units, never definitively solved in the standardisation efforts and governmental orders. What we know is that old names persisted until nowadays, probably due to the reluctance concerning the new proposed designations or due to a country socially centred in a poor and closed agricultural system. By the end of the 20th century, people still used largely the ancient names but they knew their approximate equivalence to the metric system, especially concerning capacity units[17].

[16] *Cf.* J.H. Fradesso da Silveira. *Compendio do Novo Systema Legal de Medidas* (1856). Lisboa, Typographia do Centro Commercial.

[17] A.A. Pinto (1983). Isoléxicas Portuguesas (Antigas Medidas de Capacidade). *Separata da Revista Portuguesa de Filologia,* vol. XVIII, p. 367 a 590.

Mappa Expositivo do Systema Metrico-Decimal Portuguez.

Denominações		*Dimensões*	*Expressões arithmeticas*
		PRIMEIRA CLASSE.	
		Medidas de comprimento — Unidade a vara.	
Legoa		Dez mil varas	10.000,
Milha		Mil varas	1.000,
Astim		Cem varas	100,
Aguilhada		Dez varas	10,
Vara		Decima millionessima parte do quarto do meridiano terrestre	1,
Decimo		Decima parte da vara	0,1
Centessimo		Centessima parte da vara	0,01
Millessimo		Millessima parte da vara	0,001
		SEGUNDA CLASSE.	
		Medidas de capacidade — Unidade a canada.	
Liquidos	*Seccos*		
Tonel	Moio	Mil canadas	1000,
Barril	Sacco	Cem canadas	100,
Almude	Alqueire	Dez canadas	10,
Canada		Cubo do decimo da vara	1,
Decimo		Decima parte da canada	0,1
Centessimo		Centessima parte da canada	0,01
Millessimo		Millessima parte da canada	0,001
		TERCEIRA CLASSE.	
		Medidas de pêso — Unidade a libra.	
Tonellada		Mil libras	1000,
Quintal		Cem libras	100,
Arroba		Dez libras	10,
Libra		Pêso de uma canada d'agua destillada, no maximo da sua densidade	1,
Decimo		Decima parte da libra	0,1
Centessimo		Centessima parte da libra	0,01
Escropulo		Millessima parte da libra	0,001
Decil		Decima millessima parte da libra	0,0001
Centil		Centessima millessima parte da libra	0,00001

Figure 9 – Portuguese Metric System (1849).[15]

After the Civil War, the better solution for the Portuguese Government, under the reign of Queen Maria 2nd, was the immediately adoption of the French Metric System, directly imported to be used. In 1852 December 13th, a Decree in Law imposed the full adoption of the Decimal Metric System in Portugal, with its French original nomenclature directly translated into Portuguese language.

As before, a Decree imposed its obligatory teaching in Primary Schools and also that the assessment to be Primary Teacher must to oblige the knowledge of the Metric System. It was established a period of 10 years to its complete adherence.

The first Compendium for Primary Teachers in order to teach the Metric System was written and published in Lisbon 1856, by Fradesso

da Silveira, official of artillery and Professor in the Polytechnics School of Lisbon. He was named First General Inspector of Weights and Measures of the Kingdom. Among the illustrations, the book presents the schime of the metro defenition (fig. 10).

The Compendium he wrote was commanded by the Government, but its publication was supported by himself. Curiously, the Government orders its free distribution by all the Primary Teachers.

Figure 10 - Illustrative scheme of the metre definition in the Compendium for Primary Teachers[18]

5. Portuguese formal adoption of the Metric System

Portugal integrated the first contingent of 17 countries, participating in Paris in 1875, and signing the formal approval of the First Metre Convention and adhering to and legally adopting the Metric System. In 1900, 35 countries had also done their official acceptance of the Metric System.

Despite its tormented course, Portugal was an always present and active member in the Metre Conventions and General Conferences of Weights and Measures and with the needed regularity, Portuguese governments promulgate metrological legislation actualising and harmonising national legislation with the sanctioned decisions by the International Conferences.

The 11th General Conference of Weights and Measures, that took place in Paris in 1960, changed the designation of Metric System into

[18] *Cf.* J.H. Fradesso da Silveira (1856). *Compendio do Novo Sistema Legal de Medidas*, Lisboa, Tipografia do Centro Commercial. p.2.

International System of Units (IS). New units of measure integrated this important system with new definitions. The Decree in Law number 427/83, from December, imposed the International System of Units (IS) in Portugal.

The International System is far from to be a universal system of units. The Europe Union imposed it to all their members.

The time changed effectively and we are convinced that we are nowadays in the real beginning of the adoption of an equalitarian system of units.