

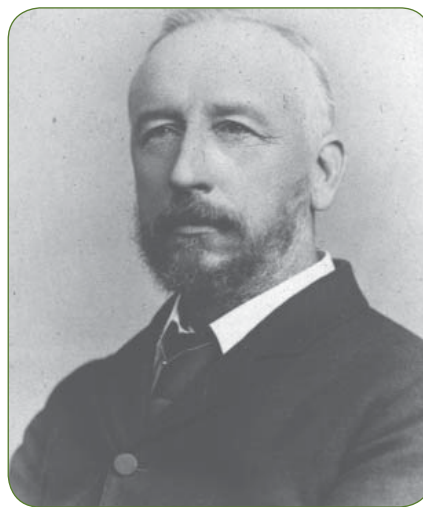
The South African measurement system and its origin

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The history of the South African measurement system is, without doubt, somewhat confusing, as is the relationship between old South African units of length, English measure, and the legal and international metre. The English and metric systems have influenced the establishment of the "commercial" Cape units, and, also, of the unit of the Geodetic Survey of South Africa.

The earliest units of land measurement in South Africa were derived from the units that were used by the Dutch pioneers in the 17th century. The "Rhymland rood", then in use in Holland, comprising of twelve "Rhymland feet", remained the official unit of length in the Cape for two centuries. During this period, because there was no accurate standard of reference at the Cape, measuring rods and tapes in use became unconnected to the "Rhymland rood". This situation led to significant discrepancies in surveys. At the beginning of the 19th century, the problem was brought to the attention of the authorities and, in 1858, a commission was appointed "for the purpose of ascertaining and fixing the unit of land measure in the Colony of the Cape of Good Hope". The commission, under the chairmanship of Sir Thomas Maclear, confirmed what Hertzog, then the Deputy Surveyor-General, had suspected in 1844, noting that, although the "true" Rhymland foot was equal to 1,030 English feet, this ratio looked different in the Cape, where 1 Rhymland (Cape) foot = 1,033 English feet.

In 1859, the recommendations of the commission were lawfully declared by the Act No 9, which established the "Cape foot" (1 Cape rood = 12 Cape feet) – a unique and truly South African entity, used in the whole country, except KwaZulu Natal, where the English foot dominated. Similarly, a "Cape Morgen", equal to 600 square Cape roods, was created as an equivalent unit of area. The ratio of 1 Cape foot = 1,033 English feet was binding on all land surveys, and, for a period of over 60 years, was the legal relation between the "Cape foot"



Sir David Gill (1843-1914), her Majesty's Astronomer at the Royal Observatory at the Cape of Good Hope between 1879 and 1907.

and the "English foot". In 1922 it was slightly modernised, i.e., referred to the "international metre" using the Benoit's 1896 relation of 1 Eng. ft. = 0,304 799 734 8 Int. metres [5].

The "Weights and Measures Act No. 32 of 1922 (as amended by Acts: No. 13 of 1933, No. 13 of 1958, No. 44 of 1964, No. 55 of 1969, No. 76 of 1973, No. 24 of 1998, and its newest version: No. 18 of 2006) provided the ratio between the "Cape foot" and the "international metre" (see Table 1), which was used for converting fairly short distances (up to approximately 6 km). Moreover, in surveys on a local system, where length determination and co-ordinates were adjusted to a base measured in "English feet", the Benoit's relation was employed. Since precise leveling started in South Africa in the late 1920s, for the conversion of elevations from metres to feet, and

reverse, the Sears-Johnson-Jolly foot/metre relationship of 1928 (1 Eng. ft = 0,304 799 471 8 Int. metres) was adopted by the Trigonometrical Survey Office (now Chief Directorate: National Geo-spatial Information, CD: NGI). Farm surveys, however, were connected to the S.A. Gauss Conform (Lo) System using the "South African Geodetic Foot" (S.A.G. foot).

The "South African Geodetic foot" was the fundamental unit of the survey of the national triangulation network, known as the Geodetic Survey of South Africa (1879-1907). This survey was initiated, and supervised, by Sir David Gill (1843-1914), her Majesty's Astronomer at the Royal Observatory at the Cape of Good Hope, between 1879 and 1907. When the survey commenced in 1883, the Cape Geodetic Standard consisted of the "Cape Standard Bar A". It was one of two identical ten-foot iron bars, brought from England in 1839, and used by Sir Thomas Maclear for the verification of the measurement of Lacaille's Arc of 1752. The "Standard Bar B" was returned to England in 1842 after measurement of the Zwartland baseline, between 1840 and 1841, while Maclear's Arc, which extended from Cape Agulhas via Cape Point to Springbok, was completed only in 1848 [5].

The "Cape Bar A" was standardised by Benoit in 1886, in Paris, at Gill's request. As a consequence, all geodetic baselines were expressed in terms of the "international metre". In order to reduce his results, and define them in English units, Gill used Clarke's 1866 ratio, the only foot/metre ratio available at that time (1 Eng. ft = 0,304 797 265 4 Legal

Unit (length)	Equivalent
Foot	0,304 8 m
Foot (Cape)	0,314 858 1 m
Foot (Geodetic Cape)	0,314 855 575 16 m
Foot (South African Geodetic)	0,304 797 265 4 m
Inch	0,025 4 m
Mile	1 609,344 m
Nautical mile (International)	1 852 m
Rood (Cape)	3,778 297 2 m
Rood (Geodetic Cape)	3,778 266 9 m
Yard	0,914 4 m
Unit (area)	Equivalent
Acre	4 046,86 m ²
Are	100 m ²
Hectare	10 000 m ²
Morgen	8 565,32 m ²
Square foot	0,092 903 04 m ²
Square inch	0,000 645 16 m ²
Square mile	2 589 988 m ²
Square yard	0,836 127 36 m ²

Table 1: List of conversion factors, for length and areas, which are relevant in South Africa today.

metre). Due to the implications with the "legal" and "international metres", it appeared that the results of the geodetic triangulation were computed not in "English feet" but in terms of the untrue unit, now called the "South African Geodetic foot". This caused the reference ellipsoid to be renamed the "Modified Clarke 1880 ellipsoid". The parameters of this ellipsoid

and the initial point of the datum, Buffelsfontein (near Port Elizabeth), defined the Cape Datum, which formed the basis of the South African geodetic system, and which served well for a century. The Cape Datum was replaced, on 1 January 1999, by the Hartebeesthoek94 Datum, using the WGS84 reference ellipsoid and the ITRF91 (epoch 1994.0) co-ordinates of the Hartebeesthoek Radio Astronomy Telescope as the datum point.

When the Gauss Conform projection was launched in South Africa in 1921, another two fictitious units were introduced: the "Geodetic Cape foot" and the "Geodetic Cape rood". Thus, up to 1970, all the rectangular trigonometrical co-ordinates in South Africa were given in:

- The South African Geodetic foot
- The Geodetic Cape foot (not the same as the Cape foot)
- The Geodetic Cape rood (not the same as the Cape rood)

It was lawfully established that, from 1 January 1970, all units of land measure in South Africa were to be based on the "international metre". From that date, an amendment in the Land Survey Act No. 9 of 1927 (repealed by Act No. 8 of 1997) made it compulsory, for the purpose of converting co-ordinates on the

national survey system, to use the specified factors, which were then also provided by the Act No. 76 of 1973 [2]. The 5th of July 1974, when this act came into operation, is the date of the official introduction of the International Metric System (SI) in South Africa.

There are many versions of linear and area conversion factors, of which some are incorrect. The CD:NGI has done thorough research into this matter and has compiled a list of conversion factors, for length and areas, which are relevant in South Africa today.

The list is based on the legislation legally binding in South Africa [4] (see Table 1). Thus, the conversion factors have the force of law.

Some of these units of length might be applied in engineering metrology only, and not necessary in land records. The "are" is not recognised in South Africa in connection with surveying and mapping. There are also other units, still to be found on old "Natal" survey diagrams and plans (i.e., chains – used for length; perches and roods – used for areas), but they do not have the same legal status as those listed in the table.

Table 1 contains equivalents of units, expressed in terms of a metre (m), which is the only length unit of the SI and one of seven "base units". The others are: kilogram (kg), second (s), ampere (A), kelvin (K), mole (mol) and candela (cd). The "square metre" (m²) is the "derived unit" of an area, of the SI. The "millimetre" (mm) and the "kilometre" (km) are respectively a submultiple and a multiple of the SI unit of length, but are not SI units. The "hectare" (ha) and "nautical mile (international)" are classified as units which may only be used with the SI for a limited time. The "micron" (μ) may not be used at all [3]. Furthermore, the Act No. 76 of 1973 specified that other factors might too have a legal standing. Any equivalent, which can be derived from the "main" equivalents "is also an equivalent of the units concerned". Moreover, as stated in the Act No. 18 of 2006, "all regulations made in terms of the Measuring Units and National Measuring Standards Act, 1973 (Act No. 76 of 1973), must be regarded as having been made in terms of this Act". This means that, all the

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conversion factors provided by the Act No. 76 of 1973 are still valid.

It should be stressed that, the terms "British foot" ("British Imperial foot") or "English foot" appear in literature and are deemed to mean the same. The "South African Geodetic foot" was commonly known as "English foot". Hendrikz wrote [1]: "For all ordinary topographical and cadastral purposes the S.A.G. foot may be mistaken for the British foot", or the English foot, as just explained.

Finally, it is worth noting that, in Table 1, the grouping of thousands (in threes) and the use of the decimal comma, as opposed to the decimal point, was effected, to be in accordance with the applicable legislation of South Africa: "where the magnitude of a quantity is expressed in terms of a unit, a comma on the line is used as the decimal sign in the numerical part of the expression and the digits are separated into groups of three digits on either side of the comma by means of spaces..." [2]. The exception was made, for land

registration purposes, by the then Director-General of Surveys, who judged, in his Circular No. 2 of 1971: "it has been decided to abandon the writing of areas, such as 45,236 1 ha with a space after the 3rd decimal figure and to advocate that as in the past the four figures be grouped together viz. 45,2361 ha". Here, a space was left between the number and the symbol of a unit, as required [2]. These rules were highlighted in an old Land Survey Act No. 9 of 1927 (Regulation 24.1), but an amended Land Survey Act No. 8 of 1997 does not contain such information.

English-speaking countries (plus China, India and Japan) use the decimal point. There seems to be a general tendency to formally declare its use worldwide and the International Organisation for Standardization, ISO, also tends towards using the decimal point over the decimal comma. In view of the South African law, however, the comma shall still be employed in South Africa as "the only recognised decimal indicator for all numbers" [3].

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