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The South African Coordinate Reference System

1. INTRODUCTION

The Chief Directorate: National Geo-spatial Information (CD:NGI) is mandated, in terms of section 3A(1)*(d)* of the Land Survey Act (Act 8 of 1997) to "establish and maintain a national control survey network". All cadastral parcels and surveys, as well as most engineering surveys and Geographic Information System (GIS) based projects are referenced to this national control survey network.

Numerous map projections and coordinate systems are used in South Africa, especially for mapping purposes. The official "issue" coordinates of the national control survey network (and hence most surveys) are reported in the Gauss Conform coordinate system referenced to the Hartebeesthoek94 datum.

This coordinate system/geodetic datum combination is known as the **South African Coordinate Reference System (SACRS).** These two components are inseparable in the definition of SACRS and a different datum, for example, would constitute and different coordinate reference system.

There is widely held misconception that the coordinate system has changed in 1999, when in fact the geodetic datum has changed, resulting in a new definition of the SACRS. This is perpetuated by the use of the words "Lo" and "WG" for coordinates referenced to Cape Datum and Hartebeesthoek94 respectively.

This paper will define the various elements of the SACRS in detail and, in particular, distinguish between a coordinate system (projected) and a geodetic datum.

2. DEFINITIONS*

* All definitions from (ISO 19111:2007(E)), unless otherwise stated,

2.1 coordinate reference system	• Set of mathematical rules for specifying how coordinates are to be assigned to points that are related to the real world by a datum.
2.2 Datum	• parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system
2.3 easting (*E*)	• Distance in a coordinate system, eastwards (positive) and westwards (negative) from a north-south reference line.
2.4 ellipsoid	• Surface formed by the rotation of an ellipse about a main axis.
2.5 geodetic coordinate system	• Coordinate System in which position is specified by geodetic latitude, geodetic longitude and (in the three-dimensional case) ellipsoidal height.
2.6 geodetic datum	• Datum describing the relationship of a coordinate system to the Earth. • A set of constants specifying the coordinate system used for geodetic control. A complete geodetic datum provides, as a minimum, definition for orientation, scale and dimensions for the reference ellipsoid. The concept is generally expanded to include the published coordinates of control stations within the system. (CGCC 1998)
2.7 map projection	• Coordinate conversion from a geodetic/ellipsoidal coordinate system to a plane.
2.8 northing *(N)*	• distance in a coordinate system, northwards (positive) or southwards (negative) from an east-west reference line
2.9 projected coordinate system	• Two-dimensional coordinate system resulting from a map projection.
2.10 southing (x)	• Distance in a coordinate system, southwards (positive) and northwards (negative) from an east-west reference line.
2.11 vertical datum	• Datum describing the relation of gravity-related heights to the earth. In most cases the vertical datum will be related to a defined mean sea level. Ellipsoidal heights are treated as related to a three-dimensional ellipsoidal coordinate system referenced to a geodetic datum.
2.12 westing (y)	• Distance in a coordinate system, westwards (positive) and eastwards (negative) from a north-south reference line.

3. GEODETIC DATUM: HARTEBEESTHOEK94

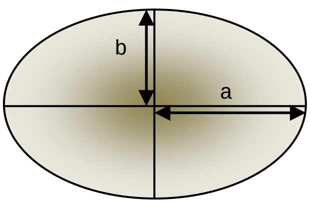
Prior to 1st January 1999, the co-ordinate system, used in South Africa as the foundation for all surveying, engineering and georeferenced projects and programmes, was referenced to the Cape Datum. This datum was referenced to the Modified Clarke 1880 ellipsoid and had its origin point at Buffelsfontein, near Port Elizabeth. The Cape Datum was based on the work of HM Astronomers: Sir Thomas Maclear, between 1833 and 1870, and Sir David Gill, between 1879 and 1907, whose initial geodetic objectives were to verify the size and shape of the earth in the southern hemisphere and later to provide geodetic control for topographic maps and navigation charts.

From these beginnings this initial network was extended to eventually cover the entire country and now comprises approximately 29 000 highly visible trigonometrical beacons on mountains, high buildings and water towers, as well as approximately 20 000 easily accessible town survey marks. As with other national control survey networks throughout the world, which were established using traditional surveying techniques, flaws and distortions in these networks have become easily detectable using modern positioning techniques such as the Global Positioning System (GPS). In addition to these flaws and distortions, most national geodetic networks do not have the centre of their reference ellipsoids co-incident with the centre of the Earth, thus making it applicable to the relevant geographic only. The upgrading, recomputation and repositioning of the South African coordinate system has thus been driven by the advancement of modern positioning technologies and the globalization of these techniques for navigation and surveying.

Since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, commonly known as WGS84, with the International Terrestrial Reference Frame 91 (ITRF91, epoch 1994.0) coordinates of the Hartebeesthoek Radio Astronomy Telescope used as the origin of this system. This system is known as the **Hartebeesthoek94 Datum**. At this stage all heights still remain referenced to mean sea level, as determined in Cape Town and verified at tide gauges in Port Elizabeth, East London and Durban.

3.1 Reference surface:

- Name: World Geodetic System 1984 ellipsoid;
- Defining parameters: (NIMA 2000)
  - Semi-major axis (a): 6378137.0m
  - Ellipsoid flattening (f): 1/298.257223563



a = Semi Major Axis
b = Semi Minor Axis
f = Flattening = (a-b)/a

Figure 3.1: Elements of an ellipsoid

3.2 Three-dimensional origin and orientation:

- Name : 30302S001 HARTEBEESTHOEK VLBI 7232 (Hartebeesthoek Radio Astronomy Telescope, Pretoria)
- Position : International Terrestrial Frame 1991 (ITRF1991) epoch 1994.0 (0h00 SAST, 1 January 1994); [X=5085442.778, Y=2668263.699, Z=2768696.825]
- Orientation: Global Positioning System (GPS) broadcast ephemeris.
- Scale : 1 (no scale factor applied).

3.3 Datum Realisation

The Hartebeesthoek94 datum is realised by :

- the approximately 57 000 precisely coordinated points in the passive (trigonometrical beacons and town survey mark) and
- the network of permanent active GNSS reference stations (TrigNet).

3.4 Hartebeesthoek94 and other ITRF realisations:

- The Earth is constantly changing shape. To be understood in context, when the motion of the Earth's crust is observed, it must be referenced. A Terrestrial Reference frame provides a set of coordinates of some points located on the Earth's surface. It can be used to measure plate tectonics, regional subsidence or loading and/or used to represent the Earth when measuring its rotation in space. This rotation is measured with respect to a frame tied to stellar objects, called a celestial reference frame.
- The International Earth Rotation and Reference Systems Service (IERS) was created in 1988 to establish and maintain a Celestial Reference Frame, the ICRF, and a Terrestrial Reference Frame, the ITRF. The Earth Orientation Parameters (EOPs) connect these two frames together. These frames provide a common reference to compare observations and results from different locations.
- The ITRF is constantly being updated. 11 realizations of the ITRS were set up from 1988. The latest is the ITRF2008 (June 2010). All these realizations include station positions and velocities.
- Hartebeesthoek94 co-ordinates do not take cognisance of the velocities associated with stations contributing to ITRF91 and other realisations.
- The co-ordinates of the Hartebeesthoek94 datum are, therefore, locked in time at the given epoch, being 1994.0.
- Hartebeesthoek94 coordinates may be transformed to other realisations of ITRF by accessing the coordinates of fiducial ITRF stations and their associated velocity vectors, published by the IERS, at the epoch of interest.
- The approximate extent of the difference between these two reference frames (in South Africa) can be gauged by comparing the coordinates of the only fiducial station that existed since the introduction of Hartebeesthoek94 (VLBI 7232), which yields the following difference:

Point	Datum	Epoch	Time since Reference Epoch	Position (Gauss Conform Projection) y (westing) m	x (southing) m	Ellip. Height m	Central Meridian
30302S001 Hartebeesthoek VLBI 7232	ITRF91	1994.0	6.0	-68684.896	2864799.998	1415.755	27 E°
	ITRF2005	2008.02	X.0	-68685.079	2864799.664	1415.714	27 E°
ITRF91(epoch 1994.0) - ITRF2005 (epoch 2008.02)				0.184	0.334	0.041	

Table 4.2: Coordinate difference of 30302S001 HARTEBEESTHOEK VLBI 7232

- This transformation can also be achieved by applying a seven parameter Helmert transformation (see http://lareg.ensg.ign.fr/ITRF/).

3.5 Hartebeesthoek94 and the WGS84 Reference Frame

- The World Geodetic System 1984 (WGS 84) is a Conventional Terrestrial Reference System that includes in its definition a reference frame, a reference ellipsoid, a consistent set of fundamental constants, and an Earth Gravitational Model (EGM) with a related global geoid (Malys et. al, 1997)
- The global geocentric reference frame and collection of models known as the World Geodetic System 1984 Reference Frame (WGS84RF) has evolved significantly since its creation in the mid-1980s. The WGS84RF has been redefined periodically.
- GPS satellite orbits and control segment positions operate in the WGS84RF.
- The WGS84RF should not be confused with the WGS84 ellipsoid.
- Since 1997, the WGS84RF has been maintained within 10cm, and more recently within 5cm of the current ITRF. The latest realisation of the WGS84RF is G1150 (Merringan el at, 2002).
- Hence, the differences between Hartebeesthoek94 and the WGS84RF would be of the same magnitude as Hartebeesthoek94 and the current ITRF realisation (see 3.4 above).

3.6 Connecting/referencing to Hartebeesthoek94

- For a point/data to be referenced to Hartebeesthoek94 datum:
  - **Direct connection**: the position/s must be determined relative to any point in the national control survey network (horizontal), such as the 29000 trigonometrical beacons and 20000 town survey marks. This would constitute direct connection.
  - **Indirect connection:** can be achieved by determining a position that has already been directly connected.
- Note: When data is collected using autonomous GPS (which operates in the WGS84RF, and has a typical accuracy of 5m), it can be deemed to be referenced to Hartebeesthoek94. This is because the uncertainty in position is an order of magnitude larger than the difference in position of a point in the respective datums.
- When using real-time TrigNet services (which is referenced to ITRF2005), users will have to occupy points referenced to Hartebeeshhoek94 to establish a localised relationship between the respective datums.

4. THE TRANSVERSE MERCATOR PROJECTION

Johann Heinrich Lambert was a German/French mathematician and scientist. His mathematics was considered revolutionary for its time and is still considered important today. In 1772 he released both his Conformal Conic projection and the Transverse Mercator projection. The Transverse Mercator projection is the transverse aspect of the Mercator projection, which is a cylindrical projection, turned about 90° so that the projection is based on meridians and not the parallels.

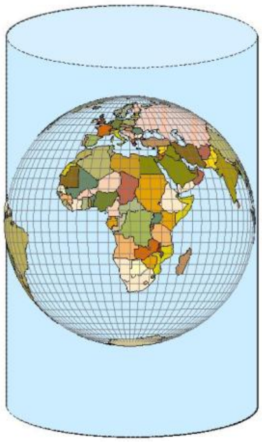


Figure 4.1: Normal aspect of the Cylindrical Projection, eg: Mercator

Figure 4.2:Transverse aspect of the Cylindrical Projection, eg: Transverse Mercator

The Transverse Mercator projection, in its various forms, is the most widely used projected coordinate system for world topographical and offshore mapping. All versions (e.g. Gauss Conform, Gauss Kruger, and Universal Transverse Mercator) have the same basic characteristics and formulas.

The differences which distinguish the different forms of the projection, and which are applied in different countries arise from variations in the choice of the coordinate transformation parameters, namely the latitude of the origin, the longitude of the origin (central meridian), the scale factor at the origin (on the central meridian), and the values of false easting and false northing, which embody the units of measurement, given to the origin. Additionally there are variations in the width of the longitudinal zones for the projections used in different territories.

The following table indicates the variations in the projection parameters which distinguish the different forms of the Transverse Mercator projection:

Name	**Areas used**	**Central meridian(s)**	**Latitude of origin**	**CM Scale Factor**	**Zone width**	**False Easting at origin**	**False Northing at origin**
Transverse Mercator	Various, world wide	Various	Various	Various	Usually less than 6°	Various	Various
Gauss Conform (Transverse Mercator south oriented)	**South Africa**	**2° intervals E of 11°E**	**0°**	**1**	**2°**	**0m**	**0m**
UTM North hemisphere	World wide	6° intervals° E & W of 3° E & W	Always 0°	Always 0.9996	Always 6°	500000m	0m
UTM South hemisphere	World wide	6° intervals E & W of 3° E & W	Always 0°	Always 0.9996	Always 6°	500000m	10000000m
Gauss-Kruger	Former USSR , Germany, S. America	Various, according to area of cover	Usually 0°	Usually 1.000000	Usually less than 6°, often less than 4°	Various but often 500000 prefixed by zone number	Various

Table 4.1: Different forms of the Transverse Mercator Projection

5. THE GAUSS CONFORM COORDINATE SYSTEM

The Gauss Conform coordinate system (as used in South Africa) uses the Transverse Mercator map projection formulae modified to produce westings (y) and southings (x) instead of northings (*N*) and eastings (*E*). Note: The Gauss Conform projection is used in the southern hemisphere only.

This projection is used for the computation of the plane westings ($y_{Lo)}$ and southings ($x_{Lo)}$ coordinates, commonly (but **incorrectly**) known as the “Lo coordinate system".

5.1 Coordinate System Conventions

5.1.1 Reference longitude / central meridian (zone/belt)

- These 2° longitude wide zones (belts) are centred on every odd meridian, i.e. (15°E, 17°E, …. 35°E as well as 37°E for (Marion and Prince Edward Islands) as central meridian. Example; Longitude 19°E is the central meridian (CM) of the belt between 18°E and 20°E.
- The origin of each belt is the intersection of each uneven degree of longitude (longitude of origin = Lo) and the equator.
- Each zone is named after the longitude of origin i.e. Lo 17°, Lo 19°, Lo 21° etc. and is **independent of geodetic datum**

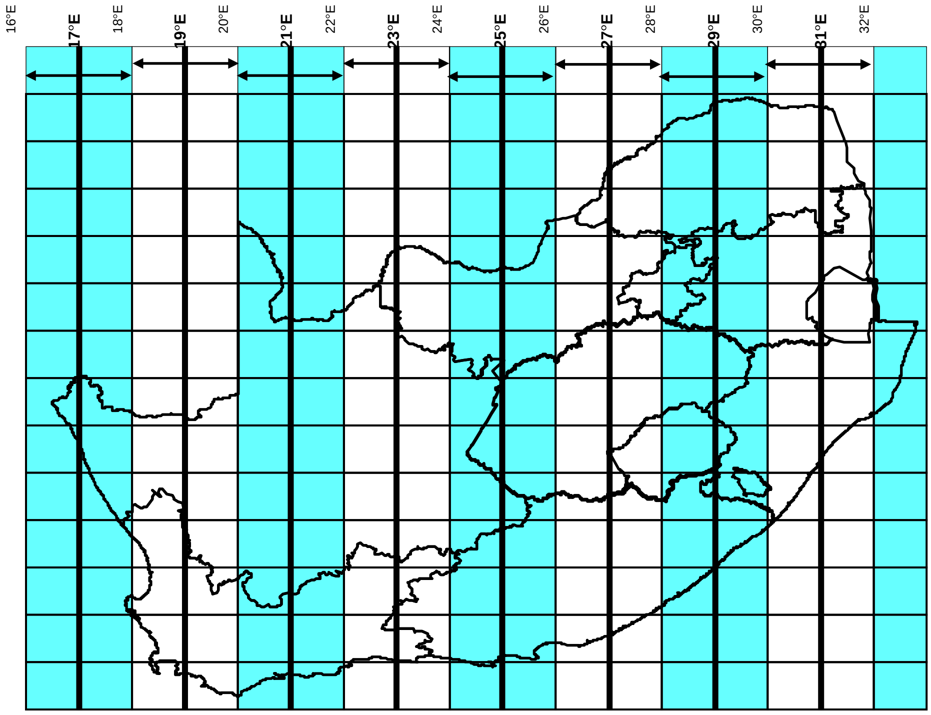


Figure 5.1: Gauss Conform zones (continental South Africa*)
Note: Marion and Prince Edward Islands on Lo 37°E,

5.1.2 <u>Latitude at natural origin /reference Latitude:</u>

- The equator 0°E, is the latitude of reference or origin of the Gauss Conform Coordinate System.

5.1.3 x (<u>southings</u>)

- Coordinates are measured southwards from the equator
- Increases from the equator (where x = 0m) towards the south pole (with a maximum of ± 3 840 000m for continental South Africa).
- Similar to the "northing" coordinates but sign in opposite.

5.1.4 y (<u>westings</u>)

- Coordinates are measured from the Central Meridian (Lo) of the respective zone.
- Increases from the CM (where y=0) in a westerly direction.
- "y" is +ve west of the CM and –ve east of the Central Meridian.
- Since the zone width is 2° (1°) either side of the Central Meridian, the "y" value should range between +105000 m and - +105000 m in South Africa.
- Unless specifically intended, a feature with a "y" ordinate exceeding the abovementioned values should be referenced to the adjacent Central Meridian.

5.1.5 False Origin

- There is no false origin (y = 0m at Central Meridian and x = 0m at equator)

5.1.6 Order of Coordinates

- Coordinates are given in the order: y (westings), x (southings), H (orthometric height).

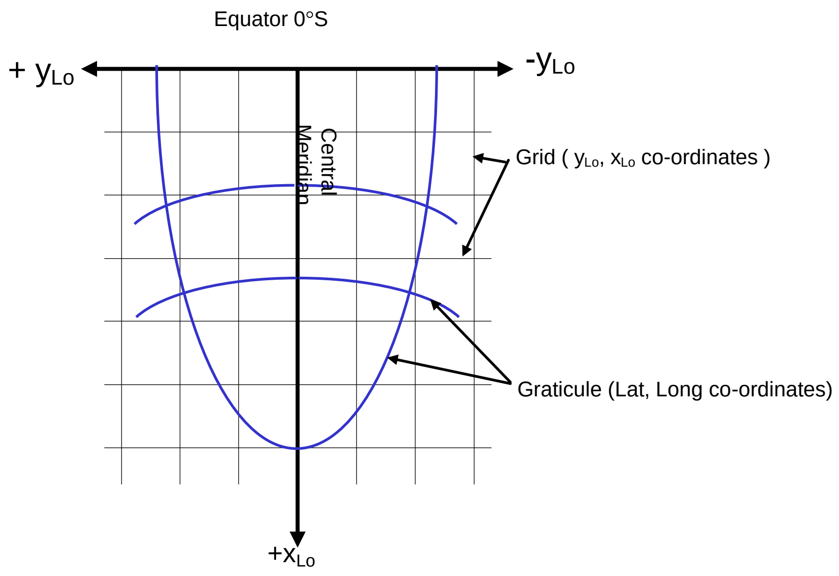
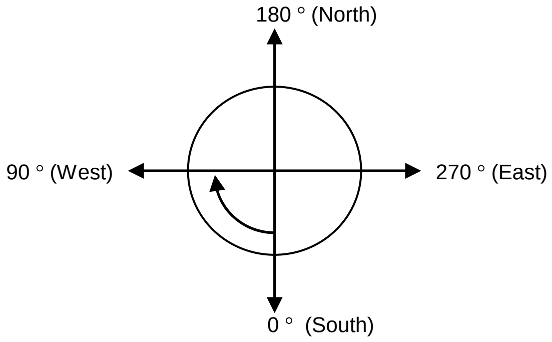


Figure 5.2: Gauss Conform coordinate conventions

5.1.7 Direction Measurement Convention

- Directions are measured clockwise from south, so if a point (B) is west of point A, the direction from A to B would be 90°.



5.1.8 Scale at natural origin

- Unity (1) along the central meridian.
- Scale is constant along any straight line on the map parallel to the central meridian.

5.1.9 Distortion

- Infinitesimally small circles of equal size on the globe appear as circles on the map (indicating conformality) but increase in size away from the central meridian (indicating area distortion).
- The central meridian is the **only** line of longitude that is a straight line on the map.
- The equator is the **only** line of latitude that is a straight line on the map.
- There is a scale distortion that increases from zero as you go away from the central meridian. Ie. If points A and B are far from the central meridian, and you walk from A to B and find the distance to be x metres. Then you will find that the distance as shown by the map will not be exactly x metres.
- This significant distortion of scale as you move away from the central meridian was the key reason for limiting zone width to 2°

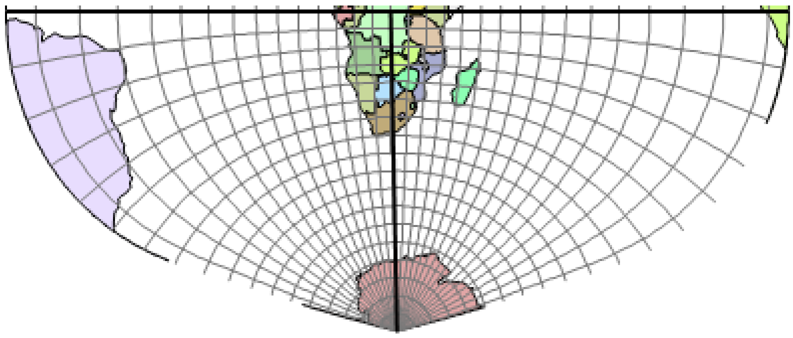


Figure 5.2: Distortion caused by the Gauss Conform projection of South Africa (Lo27°E).

5.2 Projection Formulae (Merry, 2010)

5.2.1 Conversion of Degrees to Radians and vice-versa:

Rad = Deg*π/180   Deg = Rad*180/π

5.2.2 Conversion of Geographical co-ordinates (ϕ, λ) to Gauss Conform co-ordinates (y, x):

a = semi-major axis of the reference ellipsoid in metres.
b = semi-minor axis of the reference ellipsoid in metres.

Given:	ϕ	(Latitude in degrees decimal, positive south)
	λ	(Longitude in degrees decimal, positive east)
	Lo (λ_0)	(Reference Longitude/ central meridian in integer degrees)
Find:	y	(Gauss Conform ordinate in metres, westing)
	x	(Gauss Conform ordinate in metres, southing)

Convert ϕ, λ_0, λ to radians

$\phi = \text{abs}(\phi)$ (i.e. use the absolute value of the latitude)

$$e^2 = \frac{a^2 - b^2}{a^2}$$

$$e'^2 = \frac{a^2 - b^2}{b^2}$$

$\eta^2 = e'^2.\cos^2\phi$; $\tau = \tan\phi$

$$A = 1 + \frac{3}{4}.e^2 + \frac{45}{64}.e^4 + \frac{175}{256}.e^6 + \frac{11025}{16384}.e^8 + \frac{43659}{65536}.e^{10}$$

$$B = \frac{3}{4}.e^2 + \frac{15}{16}.e^4 + \frac{525}{512}.e^6 + \frac{2205}{2048}.e^8 + \frac{72765}{65536}.e^{10}$$

$$C = \frac{15}{64}.e^4 + \frac{105}{256}.e^6 + \frac{2205}{4096}.e^8 + \frac{10395}{16384}.e^{10}$$

$$D = \frac{35}{512}.e^6 + \frac{315}{2048}.e^8 + \frac{31185}{131072}.e^{10}$$

$$E = \frac{315}{16384}.e^8 + \frac{3465}{65536}.e^{10}$$

$$F = \frac{693}{131072}.e^{10}$$

$$B_\phi = a.\ 1 - e^2\ .\left(A.\phi - \frac{B}{2}.\sin 2\phi + \frac{C}{4}.\sin 4\phi - \frac{D}{6}.\sin\phi + \frac{E}{8}.\sin 8\phi - \frac{F}{10}.\sin 10\phi\right)$$

$\ell = \lambda_0 - \lambda$ (where λ_0 is the longitude of the central meridian)

$$N = \frac{a}{\sqrt{1 - e^2.\sin^2\phi}}$$

$$x = B_\phi + \frac{\ell^2}{2}.N\sin\phi.\cos\phi + \frac{\ell^4}{24}.N.\sin\phi.\cos^3\phi.\ 5 + 9\eta^2 + 4\eta^4 - \tau^2$$
$$+ \frac{\ell^6}{720}.N.\sin\phi.\cos^5\phi.\ 61 - 58\tau^2 + \tau^4 + 270\eta^2 - 330\eta^2\tau^2 + \ldots$$

$$y = \ell.N.\cos\phi + \frac{\ell^3}{6}.N.\cos^3\phi.(+ \eta^2 - \tau^2)$$
$$+ \frac{\ell^5}{120}.N.\cos^5\phi.(5 - 18\tau^2 + \tau^4 + 14\eta^2 - 58\eta^2\tau^2) + \ldots$$

Note: The Gauss Conform system is used in the southern hemisphere only.

5.2.3 Conversion of Gauss Conform Co-ordinates (y, x) to Geographical Co-ordinates (ϕ, λ)

a = semi-major axis of the reference ellipsoid in metres.
b = semi-minor axis of the reference ellipsoid in metres.

Given:	y	(Gauss Conform ordinate in metres, westing)
	x	(Gauss Conform ordinate in metres, southing)
	Lo (λ_0)	(Reference Longitude/ central meridian in integer degrees)
Find:	ϕ	(Latitude in degrees decimal, positive south)
	λ	(Longitude in degrees decimal, positive east)

Formulae:

Convert λ_0, to radians

$$e^2 = \frac{a^2 - b^2}{a^2}$$

$$e'^2 = \frac{a^2 - b^2}{b^2}$$

$$n = \frac{a - b}{a + b}$$

$$\sigma = \frac{x.(1 + n)}{a.\left(1 + \frac{1}{4}n^2 + \frac{1}{64}n^4\right)}$$

$$\phi_f = \sigma + \frac{3}{2}.\left(n - \frac{9}{16}n^3\right).\sin 2\sigma + \frac{21}{16}.n^2.\sin 4\sigma + \frac{151}{96}.n^3.\sin 6\sigma$$

$$\tau_f = \tan \phi_f$$

$$\eta_f^2 = e'^2.\cos^2 \phi_f$$

$$M_f = \frac{a.(1 - e^2)}{(1 - e^2.\sin^2 \phi_f)^{3/2}}$$

$$N_f = \frac{a}{\sqrt{1 - e^2.\sin^2 \phi_f}}$$

$$\phi = \phi_f - \frac{y^2}{2}.\frac{\tau_f}{M_f.N_f} + \frac{y^4}{24}.\frac{\tau_f}{M_f.N_f^3}.(5 + \eta_f^2 + 3\tau_f^2 - 4\eta_f^4 - 9\tau_f^2.\eta_f^2)$$

$$\ell = \frac{y}{N_f.\cos\phi_f} - \frac{y^3}{6}.\frac{1}{N_f^3.\cos\phi_f}.(1 + \eta_f^2 + 2\tau_f^2)$$
$$+ \frac{y^5}{120}.\frac{1}{N_f^5.\cos\phi_f}.(5 + 6\eta_f^2 + 28\tau_f^2 + 8\tau_f^2.\eta_f^2 + 24\tau_f^4 - 3\eta_f^4)$$

$\phi = -\phi$ (i.e. make the sign of the latitude negative, for the southern hemisphere)
$\lambda = \lambda_0 - \ell$ (where λ_0 is the longitude of the central meridian)

5.2.4 Sample Coordinates

	Geographical Coordinates		
Name	**Latitude**	**Longitude**	
	dd mm ss.sssss	dd mm ss.sssss	
Cape Town	-33 48 17.26765	18 30 19.23450	
Durban	-29 45 17.23457	29 58 26.56340	
Johannesburg	-26 13 25.23450	28 02 33.03451	
	Gauss Conform Coordinates*		
	Y	**x**	**Central Meridian of Projection (Lo)**
Cape Town	45803.274	3742119.361	19 °E
Johannesburg	-104178.755	2902034.431	27 °E
Johannesburg	95682.219	2901968.897	29 °E
Durban	-94214.530	3293328.957	29 °E
Durban	99235.716	3293372.454	31 °E

* Note: When the same point is projected onto an adjacent central meridian, both the y and x coordinates will change. The y coordinate will differ in sign and substantially in magnitude. The x coordinate will differ by about 100m due to varying distortion characteristics.

6. THE SOUTH AFRICAN COORDINATE REFERENCE SYSTEM

It must be stressed that any position reported in the SACRS must be referenced to both the Hartebeesthoek94 datum **and** the Gauss Conform Coordinate System as defined above. Any position reported in other projections, (e.g. the standard Transverse Mercator or UTM projection), or another datum (e.g. Cape Datum) would, by definition, not be referenced to the SACRS.

To summarise: SACRS = Gauss Conform Coordinate System (south oriented version of standard Transverse Mercator Projection) referenced to the Hartebeesthoek94 Datum.

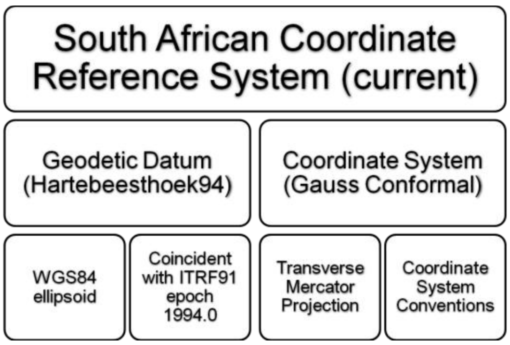


Figure 5.1: Current SACRS definition

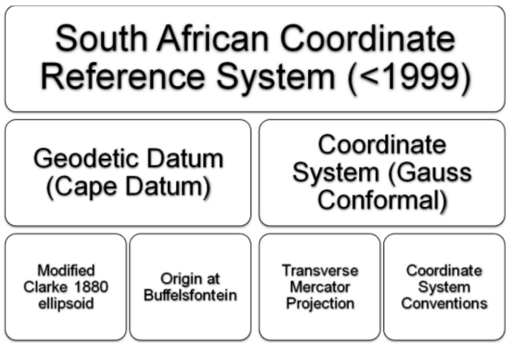
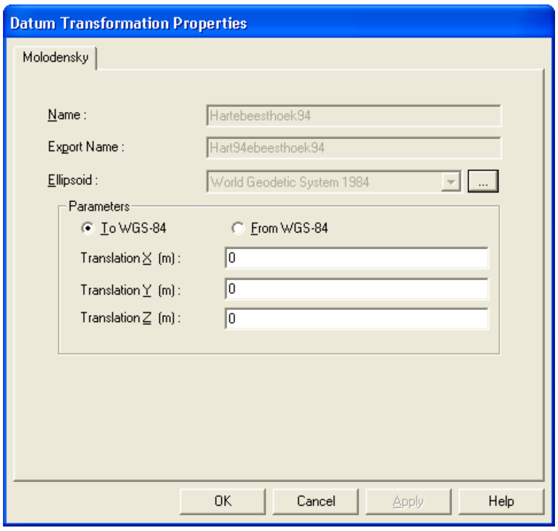


Figure 5.2: SACRS definition prior to January 1999

6.1 DEFINING THE SOUTH AFRICAN COORDINATE REFERENCE SYSTEM IN SOFTWARE

6.1.1 Defining Hartebeesthoek94 Datum within your GIS/GNSS software

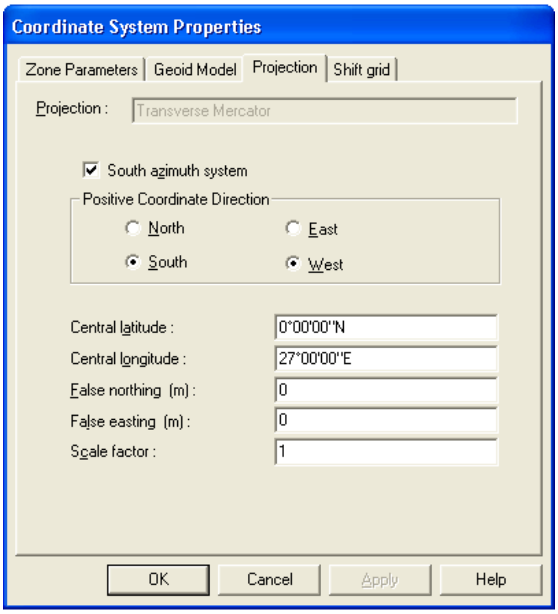
- Choose ellipsoid as WGS 84
- Assign datum name as Hartebeesthoek94
- Define relationship from World Geodetic Reference System 1984 (WGS 84) to Hartebeesthoek94 in terms of Moledensky (3D Cartesian shifts) with Translations dX = 0, dY = 0 and dZ=0 (although this is not strictly true, it is an acceptable in practice)



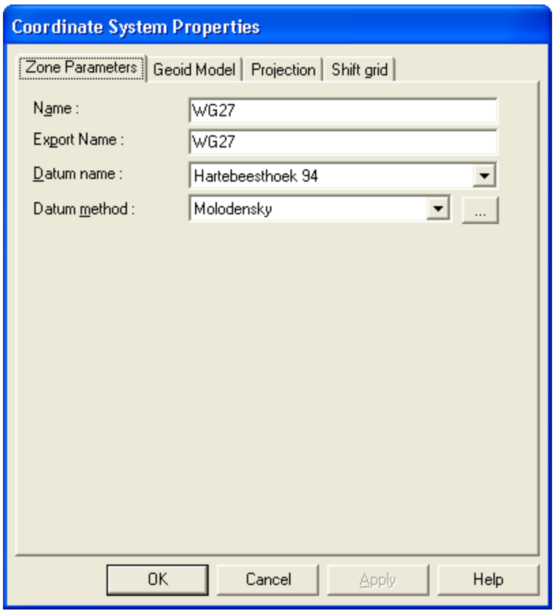
6.1.2 Defining the Gauss Conform Coordinate System within your GIS/GNSS software.

6.1.2.1 Software catering for "South Oriented systems"

- If the software caters for the "South Azimuth system" (0° = south) and have the option of coordinates increasing in south and westerly direction …enable these options.
- Central latitude is equator (0° N/S)
- Central longitude is the Central Meridian of the zone e.g 27°00'00"E
- False northing = 0
- False easting = 0
- Scale factor = 1



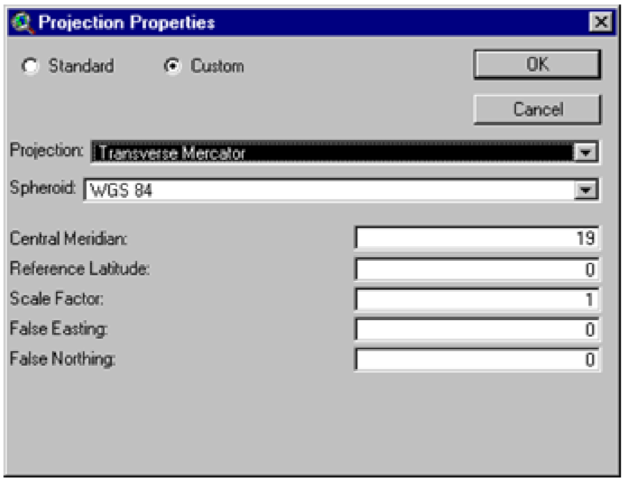
- The name that you assign the coordinate system is arbitrary, but common practice is to use the "WG/Lo" denotion



6.1.2.2 If Software does not cater for the "South Azimuth system" (0° = South),

Strictly speaking, in this case, one cannot reference projects to the SACRS, since Gauss Conform Coordinate System cannot be defined. The closest option would be to use the standard Transverse Mercator Projection. This will result in northings and eastings instead of southings and westings. The coordinates will be identical in magnitude, but opposite in sign.

- Projection = Transverse Mercator
- Central latitude is equator (0° N/S)
- Central longitude is the Central Meridian of the zone e.g 19°00'00"E
- Scale factor = 1
- False northing = 0
- False easting = 0



Until users apply pressure to **major** vendors to implement "south oriented coordinate systems, the SACRS cannot be correctly defined.

7. REFERENCES

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