Best Trip Ever – Darling 2013

Tomasz ZAKIEWICZ, South Africa

Key words: History, geodetic survey, baseline, TrigNet

1. SUMMARY

There must have been something specific in the re-survey of the Zwartland baseline, near Darling, that the four young land surveyors, who assisted the author in this exercise, called it the best?

They without a doubt were also fascinated with the surveying history of South Africa and had a chance to be closer to the core of it. This related to the first geodetic survey, conducted in South Africa 270 years ago by Abbe de Lacaille. 90 years later, the Zwartland baseline, in its recent form, was built and measured by Sir Thomas Maclear. Its length was later adopted by Sir David Gill and incorporated into the geodetic system, which served well for a century, until the Hartebeesthoek94 datum, based on the WGS84 ellipsoid, was introduced in South Africa in 1999.

The aim of the 2013 trip was to verify the baseline length, in order to obtain a comparison of Maclear's value against modern GPS technology.

The author, who retired soon after this survey, provides an outline of the geodetic developments in South Africa, and afterward elaborates on the results received.

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2. INTRODUCTION

The determination of the size and shape of the earth has always been one of the prime tasks of geodesy (Zakiewicz, 1997). The first attempts, to accurately measure the earth's size, were through the direct measurement of the length of a meridional arc and the corresponding latitude difference. Sir Isaac Newton, from his new theory of gravity and observations, concluded that the earth was ellipsoidal in shape. If the earth is an oblate spheroid flattened at the poles, the length of a degree of latitude must increase from the equator to the pole. Therefore, at least two meidional arcs and the latitudes of all end points must be determined. The Paris Academy of Sciences sent in the 1730's two expeditions to places whose difference of latitude was as great as was reasonably possible: one to Peru (now Ecuador) and the other to Lapland in the Arctic Circle (the border of Sweden and Finland). The latitudes of the endpoints of the arcs were obtained astronomically, while triangulation networks were employed to determine the lengths of the arcs. The result of a comparison of the Peruvian with the Lapland arc was a proof of the theory of an earth flattened at the poles. In the Southern Hemisphere the first measurement of an arc of the meridian was done at the Cape by Abbe Nicolas-Louis de Lacaille, in 1752.

3. IN THE PAST

3.1. An outline of an early Geodetic Survey in South Africa

The history of the Cape Colony, thus of South Africa, goes back to 1652, when the Dutch East India Company settled at the Cape. One hundred years later the Paris Academy of Sciences sent Abbe Nicolas-Louis de Lacaille to perform astronomical observations. Then, in his spare time, he measured a short arc of meridian, 1¼ degree in length, from Cape Town northwards. His results were contrary to Newton's theory, having been affected by gravity anomalies.

Lacaille's points did not survive to our time and none of the points, in a physical form, has been found and identified on the ground. Lacaille's astronomical observatory, in Strand Street, Cape Town, can be regarded as the earliest geodetic triangulation station established in South Africa. A brass plaque was erected in 1903 on a wall of a building situated, presumably in a close proximity to his station.

In 1841-1848 Sir Thomas Maclear, Her Majesty's Astronomer at the Royal Observatory at the Cape of Good Hope, undertook the verification and extension of Lacaille's arc. Prior to that, in 1838, Maclear measured his celestial arc, between the Bradley's Zenith Sector stations, situated close to Lacaille's astronomical stations at Rogge Bay and Klipfontein. The sector instrument was sent from Greenwich. Although Maclear observed 40 stars and made 1133 observations and Lacaille 16 stars only, final results were almost identical: astronomical amplitudes, as determined by Lacaille and later by Maclear, differed by only 0.38" (Smith, 2001). Thus, it confirmed the correctness of Lacaille's astronomical observations. Maclear had to perform terrestrial geodetic measurement in order to explain the anomaly. He made certain that the gravitational effect of the mountains did not affect his observations at the astronomical stations, as had happened with his predecessor. He extended Lacaille's arc northwards to Koeberg in latitude 29º44'and southwards to Cape Point, and further to Cape Agulhas. Based on the triangulation, Maclear was able to compute total distance between Lacaille's sector stations. Maclear adopted latitude value of the Royal Observatory. Then, he computed latitudes of Lacaille's end-stations using triangulation, with Airy's factors, and as determined by sector astronomical observations. The difference of 8.55" was attributed to gravitational effect of the mountains (Maclear, 1866). Maclear proved that both hemispheres were equal in shape as Newton had predicted. Thus, Maclear's terminals of his Zwartland baseline are among the oldest geodetic stations in South Africa.

Sir David Gill (1843-1914) succeeded Maclear at the Royal Observatory at the Cape of Good Hope. Gill wrote: *"Soon after my appointment as Her Majesty's Astronomer at the Cape in 1879 I began to study the general question of the Geodetic Survey of South Africa. The tradition of my office appeared not only to justify but to demand that some portion of my time and attention should be devoted to this work"* (Gill, 1896).

Gill designed the gridiron network of trigonometrical chains to cover the then four states of South Africa: the Cape Colony, Orange River Colony, Natal and Transvaal. The scheme was prepared with the view of incorporating Maclear's triangulation within a network. Sir David Gill visualised this project as being very important not only for practical but also for scientific purposes. Gill's idea was to extend a chain of triangles from the Cape to Egypt and even further north. When connected with Struve's arc, the whole arc would terminate at the North Cape, and would then have amplitude of 105º (Zakiewicz, 1997). Such a long arc would certainly contribute to a better knowledge of the size and shape of the earth.

In June 1883, the survey of the Cape Colony and Natal commenced, under Captain Morris. In October 1892, the fieldwork was finished. Three baselines were measured along the chains. The length of Maclear's Zwartland base has been adopted without changes, and his arc was tied with the new chains. Gill did not manage to continue immediately with the survey through the Orange River Colony and the Transvaal, in order to complete the scheme. This survey began only in 1902, under the superintendence of, now, Colonel Sir William Morris. During this survey, which ended in 1906, five extra baselines were measured. The total length of the observed chains was 3216 km in comparison to 1352 km of the previous surveys of the Cape and Natal.

3.2. The origin of the South African geodetic network

Finally, the South African network formed a system of triangulation arranged in eight circuits. All reductions and computations were done under Gill's supervision, at the Royal Observatory at Cape Town. The geodetic station Buffelsfontein, situated near Port Elizabeth, was adopted as the initial point of the system - the Cape Datum. Geoidal height, at this place, was assumed to be zero (Gill, 1896). The adopted geodetic latitude of Buffelsfontein was the mean astronomical latitude, derived from many nearby situated astronomical stations. The centre of the Cape Transit instrument, of the Royal Observatory in Cape Town, was the origin of all longitudes of the system. The difference of the geodetic longitude, between the Cape Observatory and Buffelsfontein, was computed from the triangulation chain using the elements of the Clarke 1880 ellipsoid, which was originally adopted by Gill at the commencement of the geodetic survey. Due, however, to the implications with the legal and international metres (Zakiewicz, 2004), it appeared later that the results of the geodetic triangulation were computed not in English feet but in terms of the fictitious unit now called the "South African Geodetic foot". This caused the reference ellipsoid to be renamed to the "Modified Clarke 1880 ellipsoid".

3.3. Early base measurements at the Cape

3.3.1. Lacaille's baseline

Abbe Nicolas-Louis de Lacaille measured a base on the Darling flats, which he extended by triangulation to two points – Klipfontein to the North and his Strand Street astronomical observatory to the South. The baseline, 41355.44 English feet (12605 m) long, was measured in October 1752, by means of four iron tipped wooden rods, of the length of exactly 3 toises (5.847 m) long. The field rods were frequently compared with the iron standard rod, which Lacaille brought from France (Smith, 2001).

3.3.2. Maclear's baseline

When Maclear started the verification survey, some eighty years later, he did not have any standard of length at his disposal, because no such standard was in existence in the Cape Colony at that time. In 1838, authority was given in England, on the recommendation of Sir George Airy, Astronomer Royal, for the construction of two iron 10-feet bars. The bars, marked "A" and "B", were produced and compared with the length of the Astronomical Society's standard and sent to Maclear in July 1839, together with the base apparatus. These base compensation bars, of brass and iron, invented by Col. Colby, were lent by the British authorities for the measurement of the base at the Cape of Good Hope (Zakiewicz, 2004).

In September 1840, Sir Thomas Maclear selected a base on the Zwartland Plain, north of Darling, close to Lacaille's old base (none of Lacaille's points remained, as already mentioned). The measurement of the 13 km long Zwartland base started on October 21, 1840, at its west end. "A dot (puncture) on the platinum stud marks the terminal point" (Maclear, 1866). The Colby compensation bars were compared, in the field, with the standard iron bar B (standard A was left at the Observatory). "The east end of the base was reached on April 5, 1841, and the permanent mark was established in nearly the same form as that at the west end, on April 20”. The greatest length measured on one day was 240 metres. On August 19, 1841, comparisons of the compensations bars with the two standard iron bars, and the standard iron bars with each other, were commenced at the Observatory. On December 13, 1842, the base compensation bars and the standard bar B were returned to Greenwich. Then, in 1843 and 1844, bar B was compared with the British standards.

The apparent length of the Zwartland base, in terms of the compensation bars, appeared to be 42818.75 feet (13051.04 m). All results, which were published in feet in the “Report on the Geodetic Survey of South Africa, are in the “South African Geodetic feet”, S.A.G.feet. The following ratio applies: 1 S.A.G. foot = 0.3047972654 International metre. In terms of the British Ordnance standard bar, the base was 42819.065 feet (13051.13 m) long (Maclear, 1866), the length of which was subsequently adopted by Gill for his computation, although he originally intended to re-determine its length again.

Forty years after Maclear’s measurements, when Sir David Gill commenced the Geodetic Survey, the “Cape Standard Bar A” was still kept at the Cape Observatory as a standard reference. While on the subject, it must be observed, with great satisfaction, that at present, the 188 years old “Cape Standard Bar A”, the monument of the Geodetic Survey of South Africa, is still in a good shape, and is preserved for viewing, in the museum of the Chief Directorate: NGI.

Figure 1: Cape Standard Bar A

It is fitting at this moment to comment on the terminals of the Maclear’s baseline. The terminals, both in the form of a 3m high pyramid, were recognised as national monuments: *31 West End Base*, D.S. 3318AD, in October 1980, and *8 East End Base*, D.S. 3318BA, in August 1991. They were built after the baseline was measured and “The angles at the terminal points of the Base were finished on the 4th of December 1841” (Maclear, 1866). “After effecting the triangulation in the neighbourhood of the base, provision was made for the permanent preservation of the points, by a substantial pyramid of stone and lime masonry erected over each, ten feet square at the base and ten feet altitude, - the outside neatly dressed. A niche, at the height of six feet in the eastward face of the west pyramid, and in the westward face of the east pyramid, carries a slab of Robben Island stone, with an inscription cut in the stone”. For *31 West End Base* it reads (all the text in uppercase): “This pyramid covers the west terminal point of the base line measured in the years 1840 1841 under the direction of Thomas Maclear ESQ H.M. Astronomer by command of the Lords Commissioners of Her Majesty’s Navy for the verification of La Caille’s Arc of the Meridian”.

3.4. An outline of the African Arc of the 30th Meridian

A brief historical review of this huge 70-year project may be of interest. Gill aimed that the chain of a triangulation along the 30th degree of longitude would constitute the backbone of the African Arc of the 30th Meridian (Zakiewicz, 1997). This project was initiated with the geodetic survey of the Cape Colony and Natal. Then, a chain of triangulation through the Orange River Colony and Transvaal was surveyed. To continue with an extension of the Arc further north, Gill managed to get the interest of Cecil Rhodes in this project. The triangulation of Southern Rhodesia (now Zimbabwe) was executed by Alexander Simms, between 1897 and 1901. A gap of 2 degrees in the Arc, between Simms's chain in Southern Rhodesia and the newly completed triangulation in the Transvaal, was surveyed by Captain Gordon, from 1906 to 1907. From 1903 to 1906, Dr. Rubin managed to extend the chain of triangulation for almost 800 km. When Sir David Gill retired in 1907, the geodetic survey of South Africa was complete, and the Arc of the 30th Meridian extended from the Cape to the southern shores of Lake Tanganyika.

Between 1908 and 1909 a section of 2 degrees in amplitude was measured; from the Semliki baseline at latitude 1º North, across the Equator, to latitude 1º South. In 1931 Major Hotine, picked up Rubin's points in Northern Rhodesia (now Zambia) and, in 1933, brought the triangulation up to Urundi (now Burundi). The survey of the 400 km of the Arc, across Ruanda (now Rwanda) and Urundi, was later continued by the Tanganyika's Survey Division. Since 1937, the Arc extended from the Cape to the Equator. The northern segment of the African Arc began in Egypt, near Cairo, in 1907, and was completed in 1930. In the 1930's, the geodetic network was extended from Cairo to the western boundary of Egypt. The survey of the Arc across Sudan was executed between 1935 and 1952. In the same year, the US Air Force joined the African Arc with the European triangulation, by an electronic trilateration carried out through the Mediterranean Sea, from Greece. There was also an alternate connection, of the African and European geodetic networks, through the Middle East. From 1952 to 1954, the 1000 km gap, between the Abu Qarn base in Sudan and the Semliki base in Uganda, was closed by the United States Army Map Service. On 27 January 1954, Sir David Gill’s dream of having a continuous meridional Arc, extending from the Cape to Cairo and even to the North Cape, became a reality.

3.5. State of the network prior to 1999

Since Gill’s time, several additions and extensions have been made to the geodetic network. Nevertheless, the adjustment of the original circuits has not been altered, and remained largely unchanged. The basic geodetic network, where the sides were about 60 km, was later filled with the primary triangulation of sides of ± 40 km. Then, the secondary triangulation, with sides of about 15 km was established (Parker, 2008). At last, the South African geodetic network consisted of about 29000 beacons and 20000 the town survey marks (TSM).

Satellite geodesy led to the development of the global geodetic reference systems. In the 1980s, the Doppler satellite positioning technique was used, in South Africa, to fix a network of 23 stations, of about 300 km apart. These showed great distortions between co-ordinates of old Cape Datum and a new satellite based geocentric datum, particularly in the western part of South Africa, where discrepancies of even 30 metres were noticed. In 1992-1996, 200 points of the “zero order network”, of about 100 km apart, using the GPS (Global Positioning System) method, were connected to the Hartebeesthoek Radio Astronomy Observatory. Then, the coordinates of all the trigonometrical stations were computed in a single adjustment, using all the conventional terrestrial observations, that were scrupulously entered into a database and processing software (Parker, 2008). Finally, all the remaining South Africa's town survey schemes were also referred to the Hartebeesthoek Radio Astronomy Observatory.

In South Africa, on January 1, 1999, the Cape Datum was replaced by the Hartebeesthoek94 Datum.

4. PRESENT STATUS

The Chief Directorate: National Geo-Spatial Information or CD: NGI (formerly the Chief Directorate: Surveys and Mapping or CD: SM), is the national mapping agency of South Africa. It is part of the Department of Agriculture, Land Reform and Rural Development, responsible for the national mapping programme, geodetic control network, collection of spatial information and aerial imagery in South Africa.

4.1. Hartebeesthoek94 (Hart94) Datum in South Africa

Thus, since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, known as WGS84, with the International Terrestrial Reference Frame 1991 (ITRF91, epoch 1994.0) co-ordinates of the Hartebeesthoek Radio Astronomy Telescope, used as the origin of this system. This system is known as the Hartebeesthoek94 (Hart94) Datum (Parker, 2008).

Though the datum changed, the coordinate system has remained unchanged (Gauss Conform). The Hartebeesthoek94 X (Lo) co-ordinate is between 290 and 300 metres greater than its Cape Datum (Modified Clarke 1880) equivalent at a point of interest (Parker, 2007). The Hartebeesthoek94 Y (Lo) co-ordinate will always be algebraically greater than Cape, between 20 an 90 metres.

It should be underlined, that all the surveys executed for cadastral purposes must be presented on official Hartebeesthoek94 Datum, irrespective of what survey method was used.

4.2. TrigNet

The International Terrestrial Reference System (ITRS) is a world spatial reference system co-revolving with the Earth in space and has various realizations. Realizations of the ITRS are produced by the International Earth Rotation Service (IERS). The IERS has defined a number of International Terrestrial Reference Frames (ITRF) over the years and has published transformation parameters from new to previous frames (Parker, 2008). ITRF2020 is the newest, most accurate global coordinate system for Earth, released in 2022, replacing ITRF2014. Previous reference frames were ITRF94, ITRF96, ITRF97, ITRF2000, ITRF2005 and ITRF2008.

The main difference between ITRF and WGS84 reference frameworks is the selection of fixed stations used in their adjustments. They all use a network of stations located on sites covering the whole earth. International GNSS Service (IGS) is a global joint venture providing high-precision data and products from Global Navigation Satellite Systems (GNSS).

TrigNet is the South African network of continuously operation Global Navigation Satellite System (GNSS) base stations (Vorster, 2014). It was established in 1999 for the purpose of an extension of the control system. It consists, at present, of over 60 operational GNSS base stations across South Africa. It provides high precision sub-centimetre, positioning data for both real time applications and post processing, with stations being 40-300 km apart. TigNet distant stations record GNSS dual-frequency data (L1, L2), GPS and GLONASS. Data from TrigNet stations is flown back to the Control Centre, located in Mowbray, at a 1 second epoch rate and this is used in the various post processing products and real-time services. Post processing data products, being daily files of L1L2 1 second epoch and L1L2 30 second data, are backed up and archived.

In 2013, when our survey of the Zwartland baseline was conducted, the TrigNet system of the GNSS base stations, composed of about 64 stations, referred to ITRF2008 (epoch 2012.01). The ITRF2008 solution was released on May 31, 2010, as substitution for the ITRF2005 (released in November 2006).

5. SURVEY

5.1. Background

It was just before my retirement, in January 2014, that an email from the late Jim Smith popped up. Jim was a Honorary Secretary of the FIG International Institution for the History of Surveying and Measurement (previously: ad hoc Commission on History). He was a geodesist, lecturer at Southampton University, author of several books, and a great personality, well known by lovers of surveying history. At some stage of his professional career he worked in Africa, and perhaps from that time his affection for Africa has continued. He was instrumental in the proclamation by UNESCO, in 2005, of the Struve Geodetic Arc as a World Heritage Monument. In addition, his efforts for the African Arc of the 30th Meridian to gain the same status were enormous. Jim's contact with the NGI dated back to the 1980s, and resulted in supplying him with information extracted from a large quantity of reports and publications, belonging to the Chief Directorate: NGI departmental library. Jim wrote: "I have recently been reading Brian Warner's book - Piazzi Smyth. Astronomer Artist, Cape Years 1835-1845". He wrote this in 1983. At the bottom of page 43 he is referring to the Zwartland base and says: "The pyramids stand today in the loneliness of the Zwartland plain...... The pyramids were monuments at each end of the base. Are they still there today? If so, has anyone put a Tellurometer on them to get a comparison of Maclear's value against modern technology?" In the following email Jim explained: "As you know by now, I am stuck in the 20th rather than 21st century!! I was thinking "modern" equipment/technique and Tellurometer was the first thing that came to mind. How about a little event: to do a re-measure?" Richard Wonnacott, the then Director: Survey Services, confirmed that it would be a good exercise, but suggested that he would rather use one or two GNSS receivers – "much more efficient besides the fact that it is doubtful whether there are many people left who can use Tellurometers or whether the NGI have any that still work". At this point, it is appropriate to highlight Richard's great contribution to the survey profession that occurred during his tenure of office: just to underline the fact that South Africa switched to the new Hartebeesthoek94 Datum and the GNSS TrigNet system was implemented. His great interest in the history of surveying was evident, for instance, in organising an event on June 8, 2004, in Buffelsfontein, to commemorate the 125th anniversary of the initiation of the 30th Meridian Arc and the 50th of its completion (both anniversaries were counted from the date of Gill's appointment in 1879). A year later, on April 18, 2005, again thanks to Jim's great efforts, the plaque was unveiled at the north end of the African Arc of the 30th Meridian near Cairo.

Aslam Parker, my boss and then the Director: Professional Services, instantly expressed his willingness to make the Professional staff available for the GNSS survey. Right before Christmas 2013, after all other end-year commitments were fulfilled, the team consisting of four young land surveyors, namely: Sumayyah, Zakiyah, Ahmad, Shaakir and myself was ready to depart. We endeavored to perform the survey and explore the wonders of the Darling and Piketberg areas, in the footsteps of Lacaille and Maclear, some 260 and 170 years ago, respectively.

5.2. In the field

On December 9, 2013, we departed, from CD: NGI - our headquarters at Mowbray, to perform the survey. After a 100 km long trip, we arrived at pyramid trig beacon *8 East End Base* of the baseline, at 12:40 and left it at 13:40. Time was spent on placing the Trimble *R8 GNSS Model 3* receiver on top of the 3m pyramid beacon. It was centered precisely, and the tripod secured with ropes and stones (*see photos below*). Another receiver, on a tripod, was set up over an eccentric point No *8.1*, which was placed 11.77m away from the beacon *8*. This was done for the purpose of checking independently the fixing of beacon No *8* during the GNSS survey.

Trig beacon *133 Baronskop* (1m platform) was one of two beacons included in the network adjustment (time spent at beacon: 14:40 - 14:45). Having left another receiver there, we drove to the 3m pyramid beacon *31 West End Base* (time spent: 16:30 - 17:10). Here, another eccentric station *31.1* was placed, over a peg, at a distance of 7.41m from the centre of pyramid beacon *31*. Then, we arrived at beacon *294 Uilenkraal* at 17:40 and stayed there until 20:00. After having collected everything we had left on the beacons, at 9pm we departed back to Mowbray.

Two days later, on December 11, our second day in the field started at 11:00, when we surveyed an eccentric point *8.1*. An additional point was fixed on line to trig beacon *133 Baronskop*. It enabled us to fix, using double polar, the beacon *8 East End Base* to check the correctness of its co-ordinates (obtained directly from the GNSS survey and then from eccentric stations by double polar). A similar survey was undertaken at beacon *31 West End Base*. In addition to an eccentric station *31.1*, another station was placed and fixed on line to trig beacon *294 Uilenkraal*. Also there, the correctness of fixing beacon *31*, by the two ways, was confirmed.

5.3. Computation and results

The Trimble R8 GNSS Model 3 receivers, owned by the NGI, were used. The receivers were used in the static surveys, of 1 hour baselines occupations with processing interval of 30 seconds. The Trimble Business Centre software was used afterwards. The computation was carried out at office by Ahmad and Shaakir.

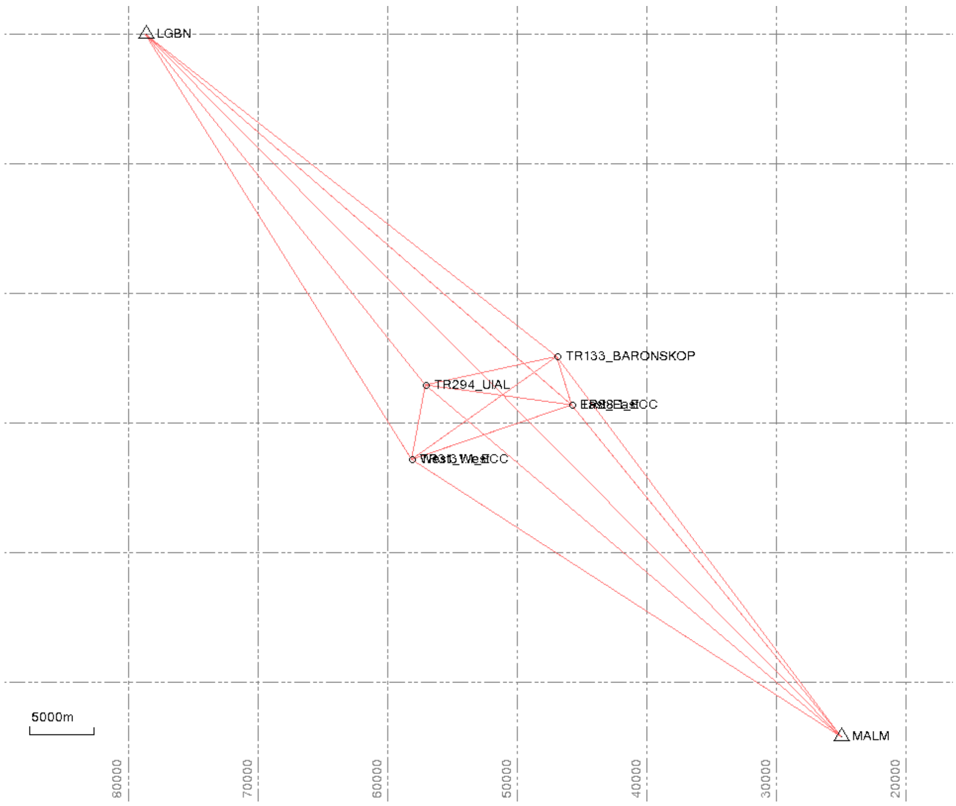
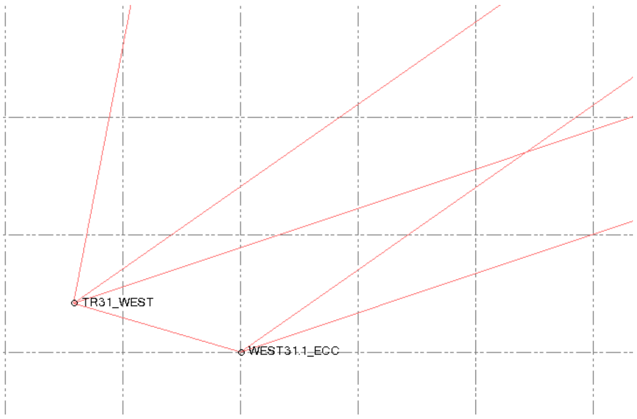
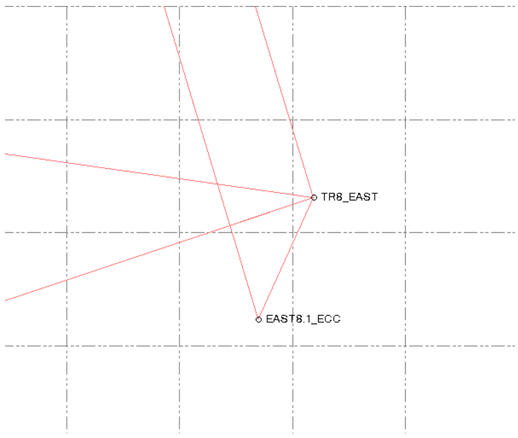


Figure 2: The network of the beacons, which were used and fixed in the survey and the insets below, for more detailed view.





The following attempts were made for the computation, with the Reports as an output:

a) Constrained beacons: Malmesbury MALM and Langebaan LGBN, referenced to ITRF 2008 (Epoch 2012.01)

HART94_Network Adjustment Report_constrained Malmesbury MALM_Langebaan LGBN
ITRF_Network Adjustment Report_constrained Malmesbury MALM_Langebaan LGBN

b) Free Network Adjustment Baseline Reports:

Baseline Processing Report_Clarke 1880_Free
Baseline Processing Report_WGS84_Free

Type	Datum	Ellipsoid	Beacon	Distance	Mean
Constrained	Hart94	WGS84	8 - 31	13051.261	13051.268
			31 - 8	13051.275	
Constrained	ITRF	WGS84	8 -31	13051.261	13051.264
			31 - 8	13051.268	
Free	Cape	Clarke 1880	8 - 31	13051.317	13051.317
Free	ITRF	WGS84	8 - 31	13051.253	13051.253

Table 1: Results of the adjusted distances

It was apparent from the results, that all the computed distances (to be precise: spheroidal distances) were very close to one another, approximately equal, irrespective of which datum and ellipsoid they were computed on.

In conclusion, we agreed that the most representative distance, of all the attempts, is the particular one computed on the Cape Datum, thus on the Modified Clarke 1880 ellipsoid. This is the free network adjustment, without any constrained imposed on it. The distance of 13051.317m is 0.187m longer than that adopted by Sir David Gill, i.e., **13051.13**m, with the difference representing 14 ppm (parts per million).

Here below is a summary of the processing of this specific *free* network adjustment. Seen are all the horizontal precisions of the baselines, which were below 1cm, while the vertical precision was less than 2.2cm.

Project information		Coordinate System	
Name:	C:\Documents and Settings\mdeal.CDNGI_PROF004 \Desktop\MaclearBaseline_CapeDatum.vce	Name:	South Africa
		Datum:	Cape
Size:	265 KB	Zone:	Lo 19
Modified:	2013/12/17 02:20:01 PM (UTC:2)	Geoid:	South Africa Geoid 2010
Time zone:	South Africa Standard Time	Vertical datum:	
Reference number:			
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
TR31_West --- TR294_UIAL (B10)	TR31_West	TR294_UIAL	Fixed	0.005	0.022	190°52'50"	5833.320	-11.232
TR31_West --- West31.1_ECC (B12)	TR31_West	West31.1_ ECC	Fixed	0.001	0.002	286°15'13"	7.407	-0.415
TR133_ BARONSKOP --- West31.1_ECC (B4)	TR133_ BARONSKOP	West31.1_ ECC	Fixed	0.004	0.019	54°55'56"	13723.232	-26.178
TR133_ BARONSKOP --- TR294_UIAL (B7)	TR133_ BARONSKOP	TR294_UIAL	Fixed	0.006	0.011	78°01'08"	10370.618	-36.999
TR133_ BARONSKOP --- TR31_West (B11)	TR133_ BARONSKOP	TR31_West	Fixed	0.004	0.015	54°57'23"	13727.872	-25.783
TR133_ BARONSKOP --- East8.1_ECC (B15)	TR133_ BARONSKOP	East8.1_ECC	Fixed	0.003	0.012	343°12'04"	3915.517	-12.574
TR8_East --- East8.1_ECC (B18)	TR8_East	East8.1_ECC	Fixed	0.001	0.001	24°09'22"	11.766	-0.590
TR8_East --- TR31_West (B19)	TR8_East	TR31_West	Fixed	0.004	0.016	71°28'36"	13051.317	-13.796
TR8_East --- TR294_UIAL (B20)	TR8_East	TR294_UIAL	Fixed	0.007	0.013	97°59'26"	11391.942	-25.035
TR8_East --- TR133_ BARONSKOP (B21)	TR8_East	TR133_ BARONSKOP	Fixed	0.002	0.007	163°04'53"	3906.642	11.976
TR8_East --- West31.1_ECC (B22)	TR8_East	West31.1_ ECC	Fixed	0.005	0.019	71°27'29"	13045.223	-14.190

Figure 3: Baseline processing report of free network adjustment, Cape Datum

5.4. Tale of Unfinished Business

The goal of the trip was achieved. We were satisfied with the outcome of the survey. Thanks to new technology, we were able to confirm that the Zwartland baseline was measured to a high degree of accuracy. Therefore, it appeared once again that it was justified for Sir David Gill to accept and adopt its value, although originally he intended to resurvey the baseline.

All the three Great Astronomers: Abbe Nicolas-Louis de Lacaille, Sir Thomas Maclear and Sir David Gill, performed excellent work, so many years ago, for which they are admired until present as the tributes we pay to them were well earned and deserved.

There is, however, still some unfinished business related closely to our survey, on which I would like to elaborate somehow. On the second day of our survey, we drove 80 km to Aurora to inspect the Northern point of Lacaille's Arc of Meridian. We visited the site on Klipfontein farm, where Lacaille and Maclear performed their measurements. In 1990, the stone, with engraved "B.S 1838", which marked position of Maclear's astronomical Bradley's Sector station at Klipfontein, was discovered. The explanatory description on the plaque, which is built-into the stone wall, next to the beacon, erected to commemorate the finding of Maclear's station states: "This is the site of the Maclear Beacon positioned in 1838 near the original North terminal of the Arc of Meridian positioned by Abbe de la Caille, the first surveyor to introduce Geodetic Surveying into South Africa". The depiction of the facts is correct, contrary to the proclamation note published in the Government Gazette No 15796, Notice No 1085, and dated 17 June 1994, which refers to the Northern Terminal of Maclear's Arc. This information seems to be incorrect and misleading, as it gives the impression that Maclear ended his arc at Klipfontein, as Lacaille did some 90 years earlier, and not in Namaqualand some 400km further to the north. Of course, this historical site is now protected by virtue of the proclamation note, but on other hand, it is confusing that such an inconsistency occurred. This may lead to serious consequences in research work if erroneous information is relied upon.

The request, for changing the incorrectly formulated proclamation note was supported by the Geomatics Division of UCT, as well as by the South African Astronomic Observatory and signed by the Head of the Chief Directorate: NGI, for Director General: Department of Rural Development and Land Reform (at present: Department of Agriculture, Land Reform and Rural Development). The documents were forwarded to the relevant Government Institution, responsible for the matter, in 2014, the year of my retirement. A response is yet to be received. An adage advises patience: "although the wheels of government may turn slowly, eventually one gets to one's destination". Let us be optimistic. Similarly, the description on the label of the stone, which is now at Mowbray, refers wrongly to the Northern Terminal of Maclear's Arc. Here, correcting the wording of the label seems to be easier hopefully, as red tape does not exist. Let us be optimistic here as well.



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BIOGRAPHICAL NOTES

Tomasz Zakiewicz, born in Warsaw, Poland, graduated from the Faculty of Geodesy and Cartography, of the Technical University in Warsaw, in 1971. In 1975, after three years with the government enterprise in Warsaw, he went to Libya, where he worked for six years in the "Polish Consulting Engineers - Polservice Company". In 1982, he emigrated to SA and, in 1987, was registered as a Professional Land Surveyor. He was a public servant, since 1990 with the Chief Directorate: National Geospatial Information, Mowbray. He retired in 2014.

CONTACTS

Mr. Tomasz Zakiewicz
Formerly: CD: NGI, Department of Agriculture, Land Reform and Rural Development
SOUTH AFRICA
At present: Retired
Tel. +27 760950997
Email: tzakiewicz@yahoo.com