3. Findings of the Pre-Feasibility Study and Topographic Survey Report

3.1 Load Forecast

3.2 Technical Analysis
   3.2.1 Voltage Level Selection
   3.2.2 Alternative line routings
   3.2.3 General Planning
   3.2.4 Project Area

3.3 Environmental Impact Assessment

3.4 Socio Economic Assessment

3.5 Financial and Economical Analysis

3.6 Summary of Recommendations by the Consultant

3.7 Topographic Surveying Report
   3.7.1 Short Summary
   3.7.2 Introduction
   3.7.3 Surveying Campaign
   3.7.4 Instruments Used
   3.7.5 Surveying Procedure
   3.7.6 Documentation of Measurements
   3.7.7 Results
   3.7.8 Difficulties during field Campaign
   3.7.9 Accuracies
3. Findings of the Pre-Feasibility Study and Topographic Survey Report

3.1 Load Forecast

After having reviewed existing load forecast calculations for Rwanda, Burundi and Tanzania prepared by other consultants, Fichtner-RSWI has carried its own load forecasts for these countries. Input data have been collected at site and discussed with representatives of ELECTROGAZ; REGIDESO and TANESCO.

First of all, it had to be clarified which methodology should apply to prepare the load forecast. While mainly concentrating on the end-user approach, which focuses on the structure of the different electricity consumer groups and their specific electricity consumption, some elements of the trend-line and the econometric or statistical approach have also been considered.

Referring to the terms of reference the load forecast models prepared by the Consultant cover a period of 25 years. To reach a realistic forecast, historical data have been reviewed. Afterwards, the following issues have been investigated:

- Relevant consumer groups have been identified, such as ordinary consumers (households) and big consumer (industry, public sector, electricity supply companies themselves)
- The situation of tariff setting has been highlighted in order to determine the impact of tariff changes on the energy consumption and the corresponding load demand.
- Socio-economic parameters such as increase of the GDP, price index, increase of the population and changes in the structure of households have been considered.
- Additionally, a forecast of load shedding and voltage drop down has been carried out. Expected losses have also been considered.
- The load forecasts have been prepared for different load centers.

It can be pointed out that the database for the load forecast was different in the three countries. Whereas intensive discussions in Kigali led to a comprehensive forecast for Rwanda, the forecasts in Burundi and Tanzania are based on real data provided by the client, but also on the Consultant’s own estimates.
The results of the demand forecast considerations can be summarized as followed below:

- In all three countries a shortage of electricity supply has been identified.
- There is a growing demand for electricity due to ambitious national programs, especially for rural electrification and improvement of the infrastructure in the concerned countries.
- The countries are changing their economic structures which will have major repercussions on the electricity need.
- A growing demand has been identified for the Kagera region in Tanzania as well as for the neighboring areas in Rwanda and Burundi which all together form the region directly be influenced by the Rusumo Falls hydropower project.

For each of the countries different scenarios of the load development have been prepared, a high, a medium and a low scenario. These three types of scenarios have been combined with two other options, one with constant electricity tariffs and the other with a reduced tariff structure.

The findings of the Pre-Feasibility Study were discussed and reworked in Phase 2 of the Feasibility Study.

The finalized results are set out in Chapter 4 “Load Forecast”.

3.2 Technical Analysis

3.2.1 Voltage Level Selection

The main project objectives and the required voltage levels are:

- To transmit to the national electricity networks/grids their part of the energy produced by the Rusumo Falls generation plant:
  For evacuating the energy produced by the hydropower plant Rusumo Falls (60 MW) the voltage level of 110 kV or 132 kV in Tanzania is sufficient.
- To improve the stability of the inter-connected network linking the production and transmission of Rwanda, the East DRC, Burundi and Tanzania:
  220 kV voltage level is needed; the planned grid extension in Western Tanzania and in Rwanda will be at this voltage level.
• To improve the security of supply and the flexibility of operation of the above-mentioned networks, and facilitate later the interconnections with the Southern Africa Power Pool (SAPP), East Africa Power Pool (EAPP) and West Africa Power Pool (WAPP), The voltage level of 220 kV is needed whereas 400 kV voltage level will be required if the planned HV ring around the Lake Victoria will be closed via Geita, Biharamulo/Nyakanazi, Rusumo Falls, Birembo, Mbarara, Kampala, Nairobi in the next 10 to 15 years. This information shall be given by the related Power Pools and the World Bank, who have more detailed and actual information about the regional planning.

• To supply energy to the local populations through rural electrification; For the local supply the voltage level of 33 kV (Tanzania) and 30 kV (Burundi and Rwanda) are foreseen in the power plant of Rusumo Falls to create the possibility to connect the local consumers near hydropower plant (one feeder for Rwanda and one feeder for Tanzania).

• Thus to contribute to the poverty reduction and the improvement of the conditions of life of the neighboring populations along the transmission line’s corridors. The design of the layouts and the levels of voltage will be determined by the studies and will have to facilitate technical, economic, social and environmental optimization.

Therefore the Consultant recommends the voltage level of 220 kV for the interconnecting lines Rusumo Falls to Nyakanazi/Biharamulo, Birembo and Gitega, whereas for rural electrification nearby the hydropower plant and the substations medium voltage level (30 kV and 33kV) is recommended.

The operation voltage level for the transmission lines and the substations shall be 220 kV for Burundi, Rwanda and Tanzania.

Referring to the new power plants RUZIZI III (140 MW), SISI 5 (205 MW), Gas plants at Kibuye (100 MW) and Gisenyi (100 MW) which may be realized in a short term, a 220 kV grid in this area will be needed so that as a consequence also the lines from Rusumo Falls to Birembo shall be designed and operated at 220 kV.

3.2.2 Alternative line routings

Several alternative line routings have been analyzed and discussed in detail. Finally the Consultant recommends the following line routing:

Burundi : Rusumo Falls – Ngara (Tanzania) Kabanga (near the border of Tanzania and Burundi) – Rugari – Muyinga – Karuzi - Gitega

Rwanda : Rusumo Falls – Kigali New Airport (at Lake Gashanga) – Birembo (near Kigali)

Tanzania : Rusumo Falls - Nyabugombe – Lusahunga - Nyakanazi
3.2.3 General Planning

The following plans by the three countries and an overall planning for the region are summarized as follows:

**Burundi**
The interconnection line from the hydropower plant Rusumo Falls passes Muyinga, a future place of a HV substation and then continues to Gitega, where via Bujumbura an interconnection to the other power plants in the region (RWEGURA, RUSIZI I, RUSIZI II) and future power plants (RUSIZI III, SISI 5 and gas power plants at Kibuye and Gisenyi) is realized.

The (n-1) planning principle is fulfilled because the power produced for Burundi in Rusumo Falls can be transported to Burundi via Gitega or in case of an outage of this line via Rwanda either via the planned line Kigoma, Rwegura or via Karongi, Mururu 2, Bubanza.

The voltage level shall be 220 kV.

**Rwanda**
The recommended interconnection line from Rusumo Falls to Kigali passes Kigali New Airport because with a future extension to Kigoma a transmission line circuit will be closed around Kigali. The new developing area near Kigali New Airport can be connected to the electrical grid.

The (n-1) planning principle is fulfilled with the interconnected system (remarks: see Burundi).

The voltage level shall be 220 kV

If the new power plants Ruzisi III (140 MW), Sisi 5 (205 MW), Gas plants at Kibuye (100 MW) and Gisenyi (100 MW) will be realized in a short term, than a 220 kV grid in this area is needed and as a consequence and as a good completion, also the lines from Rusumo Falls to Birembo shall be designed and operated in 220 kV.

**Tanzania**
A new 400 kV system is planned from Mbeya in the south via Dodoma, Singida to Shinyanga. From Singida the 400 kV system will be extended to Arusha and then an interconnection to Nairobi is foreseen.

Another branch of the 400 kV system is planned up to Geita. In the far west from Tanzania a 220 kV grid is foreseen. The new masterplan is still in discussion.

Another study for the Western region of Tanzania was established by SWECO. An interconnection from Geita to Nyakanazi and to Rusumo Falls was proposed. A final decision is not yet taken.
In parallel to the masterplan the private company Kabanga Nickel is planning a 220 kV line from Bulyanhulu to Kabanga Nickel near the Burundian border.

These activities shall be coordinated with the NELSAP planning for a line from Rusumo Falls to Nyakynazi/Biharamulo.

As a first result of a discussion between the representatives of TANESCO and the Consultant the following was agreed:

The 220 kV line from Rusumo Falls shall be connected to Nyakanazi/Biharamulo. 
The line from Nyakanazi to Rusumo Falls shall be designed and operated with 220 kV.

The connection of the mine Kabanga Nickel can be realized by:

- Separate 220 kV line from Rusumo Falls
- T-Off connection from the line to Gitega
- OHL from a new substation at the border to Burundi.
- A loop in to the line Rusumo Falls to Nyakanazi/Biharamulo

The final decision will be done when Kabanga Nickel will be realized.
3.2.4 Project Area

Map 3-1: Project area and line routing

3.3 Environmental Impact Assessment

The provisional findings of environmental impact study in the pre-feasibility study pointed out that the proposed OHL projects will have only few impacts of environmental concern. It can therefore be concluded that within the limitations of the environmental impact assessment methods applied during this preliminary study, the project seems to be environmentally sound provided the recommended routing is followed and mitigation measures are considered during construction and operation.
3.4 Socio Economic Assessment

Provision of electricity to this area will improve the situation for the people, directly by enhanced income and employment and more indirectly through impact on social- and cultural aspects of life, including areas as education, health, women’s status etc.

The project area is dependant on agriculture, livestock keeping, handicraft, trade, mining activities and fishing for their livelihood. In the capitals Bujumbura and Kigali an enormous load growth is expected. In Tanzania the mine Kabanga Nickel will be the biggest consumer with 25 MW.

Reliable power supply will benefit the people greatly. It is expected to boost up the economic development in the project area. Through the availability of pumping water people can be assured of two crops per year. It may increase the cropped area, support cropping intensity, and reduce the cost. The use of electric processing machines like fruit canning gives a higher-grade crop, which naturally generate higher price.

3.5 Financial and Economical Analysis

The Consultant has prepared a financial model to show the economic viability of the Rusumo Falls hydropower project. As cost estimates including financing costs of the hydro-electric power plant are not yet available in detail at this stage of the project (deadline March 2010), assumptions had to be made according to similar projects.

Tariffs have been calculated based on the levelized unit costs. The project shows a positive net present value, which means that project is viable.

The cost benefit analysis in the economical analysis is mainly based on the socio-economic survey indicating the potential customer’s ability to pay for electricity. This analysis shows positive results.
3.6 Summary of Recommendations by the Consultant

Several alternative line routings have been analyzed and discussed in detail. Finally the Consultant recommends the following line routing:

**Burundi**: Rusumo Falls – Ngara (Tanzania) Kabanga (near the border of Tanzania and Burundi) – Rugari – Muyinga – Karuzi - Gitega

**Rwanda**: Rusumo Falls – Kigali New Airport (at Lake Gashanga) – Birembo (near Kigali)

**Tanzania**: Rusumo Falls - Nyabugombe – Lusahunga – Nyakanazi

For the transmission lines the use of the voltage level of 220 kV is recommended for the interconnecting lines to Nyakanazi/Biharamulo, Birembo and Gitega, while for the rural electrification nearby the hydropower plant a medium voltage level is recommended.

The operation voltage and the voltage for the substations shall be 220 kV for Burundi, Rwanda and Tanzania.

If the new power plants RUSIZI III (140 MW), SISI 5 (205 MW), Gas plants at Kibuye (100 MW) and Gisenyi (100 MW) will be realized in a short term and all are in service, then a 220 kV grid in this area is needed and as a consequence also the lines from Rusumo Falls to Birembo shall be designed and operated at 220 kV.

The actual planning prefers a voltage of 400 kV for the interregional African connections to Tanzania and Kenya. The voltage level for the interconnection Kenya – Uganda was foreseen for 220 kV but now a change to 400 kV is also in discussion in order to harmonize the transmission levels of the region.

The HV grid ring around the Lake Victoria can be closed via Bukoba in Tanzania or via Rusumo Falls and Birembo (Kigali).

The decision shall be given by the related organizations like SAPP, the financing institutes like AfDB and World Bank and the representatives of the countries Burundi, Rwanda, Tanzania, etc.
3.7  Topographic Surveying Report

3.7.1  Short Summary

From October 2008 to November 2008 two surveying engineers were assigned for the necessary surveys of the Rusumo Falls Transmission lines. During a two-month period, the proposed transmission lines were routed checked and its horizontal and vertical coordinates measured. Significant topographical features as well as angle points and tower positions were surveyed to a general accuracy of less than one (1) meter. The equipment used was a differential GPS unit operating with a correction signal. This state-of-the-art equipment enables fast and precise measurements in real time.

Additionally, the measured points where used to adjust recent satellite imagery which gives further topographic information along the transmission line. These optical images provide current information on land use, settlements and transport routes etc.

To derive a precise profile with a high point density, RADAR satellite images were used. From stereoscopically acquired RADAR images, an elevation model of the transmission line and its surroundings was derived. To attain a high level of accuracy, the surveyed points were used as references along the profile.

During the field campaign, nearly 1,000 points were surveyed and documented. Wherever the line routing needed to be changed slightly, new points were measured and documented in photos, videos or comments. In the countries Burundi and Tanzania, the engineers were accompanied by personal security guards as a protection against dangers in the field and to overcome language barriers.
3.7.2 Introduction

3.7.2.1 Project Area

The project area is located in central Africa and includes the countries Rwanda, Burundi and Tanzania. Starting from the proposed Rusumo Falls hydroelectric dam site, the line routing of the proposed transmission lines passes through the towns:

- direction North: Rusumo – Birembo – Kigali (109 km)
- direction South/East: Nyabugombe – Nyakanazi/Biharamulo (98 km)
- direction South/West: Ngara, Muyinga, Karusi, Gitega (161 km)

The total length of the transmission lines is about 368 km (see map 3-1)

3.7.2.2 Objectives of Surveying Campaign

The overall objective of the surveying campaign was to survey the profile of the final transmission line with horizontal and vertical coordinates. For this purpose, the entire line was inspected by a team of two surveying engineers using DGPS equipment. At an average interval of about 500-700 metres, a point was surveyed with a horizontal and vertical accuracy of less than one (1) metre. All proposed angle points where surveyed and additional information on soils, topography and the general surroundings were recorded to gain a comprehensive impression of the line routing.

3.7.2.3 Satellite Images

Satellite images were used for two purposes. First, they were used to gain an up-to-date picture of urbanization, vegetation, soils and infrastructure, as well as roads and transport routes along the transmission line. The used satellite imagery was a Japanese system called ALOS with an optical resolution of 10 metres. The images were acquired from August 2007 to September 2008, so very recent images where chosen for this project.

In addition to the optical information from ALOS, another sensor was used to derive elevation information. The same satellite system offers a RADAR sensor called PALSAR. The sensors’ electromagnetic radiation passes through clouds and delivers a stereo-optical RADAR view of the landscape. These images were used to derive an interferogram of the land surface. Using the results of the terrestrial survey as reference points, an elevation model with an average point spacing of 40 metres was derived.
3.7.2.4 Topographic Maps

The existing topographic maps of Rwanda, Burundi and Tanzania differ in how current they are. Some of the maps with a scale of 1:50,000 are more than 30 years old. Nevertheless these maps were used to collect information on place names and many other topographic features.

For orientation purposes, these maps were not useful at any time. Some of the routes or tracks shown were not found or there were new tracks not shown in the maps. The combination of satellite imagery and topographic maps gives an up-to-date and complete impression of the topography. In addition to the above maps, recent road maps were used during the surveying campaign for orientation.

3.7.3 Surveying Campaign

The surveying campaign was conducted from 21 October 2008 to 26 November 2008. Two surveying engineers from TRIGIS Vermessung + Geoinformatik GmbH, carried out the survey in Rwanda, Burundi and Tanzania.

3.7.4 Instruments Used

Before starting the field campaign, the most appropriate surveying equipment was chosen:

- a Leica Total Station with remote station and automated target recognition
- two DGPS from Trimble with Omnistar RTK positioning.

3.7.4.1 Leica Total Station

The Total Station used was a Leica TCRP1202. The resolution of the instrument is 0.6 mgon\(^1\) in direction and 3 mm in distance. This device allows points to be surveyed without using a reflector. Thus, in the absence of a GPS signal as might be the case under trees or in deep-sided valleys, surveying can be continued.

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\(^1\) The unit of angle of one milligon (mgon) is one thousandth of a gon. There are 100 gons in a right angle, so to convert from degrees, 1 gon = 90/100 = 0.9°
3.7.4.2 Differential GPS

The OmniSTAR system is a global real-time differential GPS broadcast system delivering corrections from an array of base stations positioned throughout the whole world. OmniSTAR uses a network of reference stations (or base stations) to measure ionospheric interference and other errors inherent in the GPS system. This reference data is then transmitted to both network control centres where it is checked for integrity and reliability and is then up-linked to a geo-stationary satellite, which distributes the data over their respective footprints. This procedure ensures that all reference data generated in a satellite footprint is quickly available to the OmniSTAR receiver.

For 95% of the measurements, the resolution attained will be within 20 centimetres in position and 25 centimetres in elevation using the OmniSTAR HP (High Performance) signal. The accuracy depends on the availability of the GPS and OmniSTAR HP signal. In general, both signals are available in the project area. If one of the signals is lost due to trees or slopes, measurements are taken using a Leica Total Station.

The equipment used consists of an antenna, the unit or receiver itself and a Trimble TDS Recon pocket PC.
Figure 3-2: Used equipment

The device receives its correction signal from a geostationary satellite called AFSAT, which is available in real time for the entire continent. As mentioned, the correction data is determined by ground stations along the coast of Africa.

Figure 3-3: Omnistar AF-Sat, coverage of Africa and reference stations
During the field campaign, the real time kinematics was fixed at 1 metre, so the devices used measured to an accuracy of one metre and better. A higher accuracy was not necessary. The advantage of using one (1) metre accuracy was that the devices could be quickly initialized.
For visual assistance during surveying, a hand-held pocket PC was used, which visualized the line routing and additional topographic information. The surveying engineers could orientate themselves in the field with the help of the implemented GIS (Geographic Information System). The data of the GIS was digitized beforehand.

3.7.5 Surveying Procedure

The location and direction of the line route was identified with the GPS receiver and the connected GIS. Additionally a compass was used. Upon reaching the proposed transmission line the topographic environment was assessed and recorded. Significant points, like high and low terrain, crossroads, railroads or angle points were measured using the GIS by marking the recent position. The GIS automatically opens an attribute table to enter comments on the measured point. The average time to measure one point was 5 minutes.

Figure 3-4: Field work with GPS
The system used for x and y coordinates was UTM (Universal Transverse Mercator), zone 36 south. This coordinate system is a rectangular system which allows measurements to be taken directly in the metric system. The measured elevations are based on WGS84 Ellipsoid. As is usual when using a GPS device, the measured elevations are a geocentric coordinate that is then converted to WGS84 Ellipsoid. To express the elevations as heights above mean sea level (commonly used for elevations), a further conversion was made from WGS84 to Geoid EGM96.

The average point spacing of the profile is 700 metres. Wherever the terrain was characterized by slopes and hills, this was reduced to 200 metres. Even along flat terrain the point spacing never exceeded one (1) km. As a result more than 900 points were measured along the profile. These were documented with videos, photos and text attributes in the GIS environment.

After the surveying campaign, the documentation was harmonised and compiled in a table, including:

- Name
- Status
- Northing
- Easting
- Altitude (WGS84)
- Undulation
- Altitude (EGM96)
- Soil expected
- Vegetation present
- Notes on settlements
- Code
- Special notes

### 3.7.5.1 Measurement of Angle Points

Particular attention was paid to the angle points of the line routing, whose location was fixed using the DGPS.

With GPS an accuracy of better than one meter was attained for well accessible places. In the field, the situation was not always ideal, especially for those places in which the GPS signal was shadowed by the surrounding hills. In these cases, the points had to be measured within a distance of three meters, or more. But still, more than 50% of the angle points could be measured directly, due to their locations on or near roads.
After taking the measurement, the surveyor checked the surrounding area for alternative locations if the one identified was inadequate. Locations were chosen depending on the distance from houses (not closer than 20 m), distance from the road as well as soil consistency and the presence of power and telephone lines.

For cases for which the distance from these objects was too small, new locations were defined.

![Figure 3-5: In this case, the angle point was relocated as it was too close to a building](image)

### 3.7.5.2 Measurement of alternative angle points

For angle points which had been found to be unsuitable, an alternative location in the vicinity within about 50 m was identified. Consequently, these alternative locations represent the best position for an angle point in this area.

### 3.7.5.3 Measurement of Topographic Features

Furthermore, all relevant topographic feature points were surveyed, these being prominent elevations, depressions, roads and paths. Throughout the line routing, all significant elevations were surveyed, because these are often the best locations for the poles. For completing the profile, the low points between two poles were surveyed if the distance between them was greater than 400-500 m. For areas with a greatly varying topography, the point spacing is reduced by surveying intermediate points. If the terrain is flat, point spacing was extended up to 1000 m.
Figure 3-6 shows a part of the transmission line in Burundi. The rolling nature of the terrain on the side slope can be clearly seen. As shown in Figure 3-6, the surveyor had to decide which point was most representative of the terrain, but without wasting too much time by going into excessive detail.

In some cases, the transmission route line couldn’t be reached due to dense vegetation (for example in the southern part, Nyabugombe to Nyakanazi/Biharamulo). The profile was then surveyed in a line parallel to the planned route, with close point spacing.

The points were surveyed during brief stops along the road or by walking down the complete section. It was not possible to take a decision on the best strategy before the field survey and this had to be decided for every section of the transmission line. The result is detailed documentation on the survey and field inspection by the two surveyors.

3.7.6 Documentation of Measurements

The documentation includes, besides the coordinates and elevation, information on the surrounding area in photos and videos with comments, focusing on the surrounding vegetation, buildings, surface characteristics and, if appropriate, reasons for moving the angle point.
After the survey campaign, all data were compiled in a detailed table with the following information:

- Point-No.: type of point: r006-mst
- Consecutive number
- Date of surveying
- Time of surveying (UTC+2)
- Status: RTK-Fix (6) / RTK-Float (2)
- UTM – Northing [m]
- UTM – Easting [m]
- Elevation, WGS84 [m]
- Longitude [Degree]
- Latitude [Degree]
- Geoid undulation for EGM96-WGS84 [m]
- Elevation, EGM96 [m]
- Expected soil
- Notes on villages
- General Notes
- Codes [SPECIFICATIONS FOR SURVEYING, AERIAL PHOTOGRAPHY AND MAPPING OF A PROPOSED TRANSMISSION LINE CORRIDOR]
- Miscellaneous: media, reason for moving angle point (see photos and videos)
3.7.7 Results

3.7.7.1 Reference Points along the Profile

All points along the route where the transmission line changed direction were surveyed and documented. If an angle point was evaluated as not practicable, the surveying engineers had to take a decision on surveying an alternative one. In addition to the measured angle points, at a minimum of every 1000 m another significant point was surveyed, so 1000 m is the maximum distance between two surveyed points. Wherever the terrain and profile required that points be surveyed closer together, the spacing was reduced to about 500 m. This approach took due account of the actual terrain and saved time during the field campaign.

In addition, points of special interest, like topographic points, were measured. All these measured points provide the basis for preparing the profile. They are taken as the reference points for the RADAR satellite imagery, from which the profile was deduced.

3.7.7.2 Photo/Video Documentation

In addition to the measurements, all measured points were documented in detail. The documentation is helpful so that all project partners can gain a good overview of the profile, its topography, soils, vegetation etc. This documentation has been prepared making use of photographs, video recordings and notes.

3.7.8 Difficulties during field Campaign

- During the field campaign, visas for Tanzania and Burundi had to be issued in Kigali, Rwanda. Missing vignettes resulted in an unscheduled waiting period.
- The organisation of accommodation during the field campaign was difficult because of long travelling periods on bad roads and the absence of an electricity supply in some of the accommodations. Electricity was essential to charge the batteries of the surveying equipment every day. If a generator was available, access to electricity was limited to a time period of four hours. This is not enough to fully charge the batteries.
- Discussions with police and military on working permits gave rise to time delays during the field campaign. Additionally, organisation of personal security in Burundi and Tanzania was difficult and led to time delays. Mostly, the problems could be solved in consultation with NELSAP in Kigali.
- Personal security was obligatory in Burundi and Tanzania. Especially in Tanzania, armed guards were needed because of elephants and buffalos in the project area.
• Even though the profile was surveyed close to roads and tracks, it was
difficult to get site access. It was necessary to walk some hundreds of
metres in almost impassable terrain, which took much time. Also altitude
differences had to be overcome. The daily rainfall made tracks
impassable so that detours were necessary. On average, the surveying
engineers surveyed 10 km of the line corridor per day, which required
walking about eight kilometres daily.
• Without local knowledge, orientation in the field was difficult although
GPS and maps were used.
• The surveyors suffered from gastric upsets now and again due to stress
and overwork.
• US$ notes printed before 2000 where not accepted.

3.7.9 Accuracies

For the surveying campaign, endeavours were made to maintain a general
accuracy of one metre. All points where measured in the RTK-fixed mode
of the DGPS receiver. The RTK (real time kinematic) value of the DGPS
receiver was set to one metre. If every measurement was taken in the RTK
fixed mode, the overall accuracy is better than one metre in elevation.

Most of the surveyed points are closer than one (1) metre to the profile line,
so the coordinates of the resulting points have an accuracy of one metre in
elevation and position. An accuracy of one metre may be assumed for
terrestrial surveying.