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Tittel
2005 Vinter geophysical program, Espedalen
Volum 1: Summary and conclusions (UTEM Survey)
Including Report on GPS Survey, with CD

Forfatter	Dato	År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Blair, Toni	05.07	2005	Sulfidmalm A/S McKeown Exploration Services

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Råstoffgruppe	**Råstofftype**	
Malm/metall	Cu Ni	

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Oversikt over de 11 2005-UTEM nettene (nr 19-29) som ble målt i løpet av vinteren

Inkludert en CD: Report on GPS Survey.

1246/05

2005 Winter Geophysical Program

Espedalen,
Oppland County, Norway

T. Blair
Falconbridge Limited

On behalf of
Sulfidmalm A/S

July 5, 2005

SUMMARY AND CONCLUSIONS

This report gives the details and results of the 2005 winter geophysical program on the Espedalen project which is located approximately 170 km north of Oslo and 50 km north of Lillehammer, Norway. The project is an option and joint venture between Sulfidmalm A/S (Norway), wholly-owned subsidiary of Falconbridge Limited, and Blackstone Ventures Inc. (Canada). Exploration programs are carried out by Falconbridge Limited on behalf of Sulfidmalm.

In order to evaluate the potential for nickel sulphide mineralization in the Espedalen area, a 466 line km helicopter-borne magnetic and frequency domain electromagnetic survey was contracted out to the NGU and flown in the fall of 2004. In late 2004, the airborne EM anomalies were prioritized and a plan was made for a follow-up ground geophysical program.

The 2005 winter ground geophysical program was carried out during the period February 17^{th} to March 23^{rd}, 2005 and consisted of 77 line km of gridding and UTEM surveying. Grids with a line spacing of 200m were established by McKeown Exploration Services (of Oshawa, Ontario, Canada) using a differential global positioning system (DGPS) with base station and bamboo pickets. The UTEM surveying was carried out by Lamontagne Geophysics Limited of Kingston, Ontario, Canada.

The UTEM survey was successful in detecting and confirming a number of the prospective helicopter EM anomalies on the ground as well as in defining the better conductance targets. Six conductors were selected and submitted to Lamontagne Geophysics for detailed modelling, while three additional conductors were modelled in-house by A. Watts. The modelling indicates that conductances range from approximately 75-2000 siemens for individual UTEM plates.

These results will be used to help select targets for drill testing.

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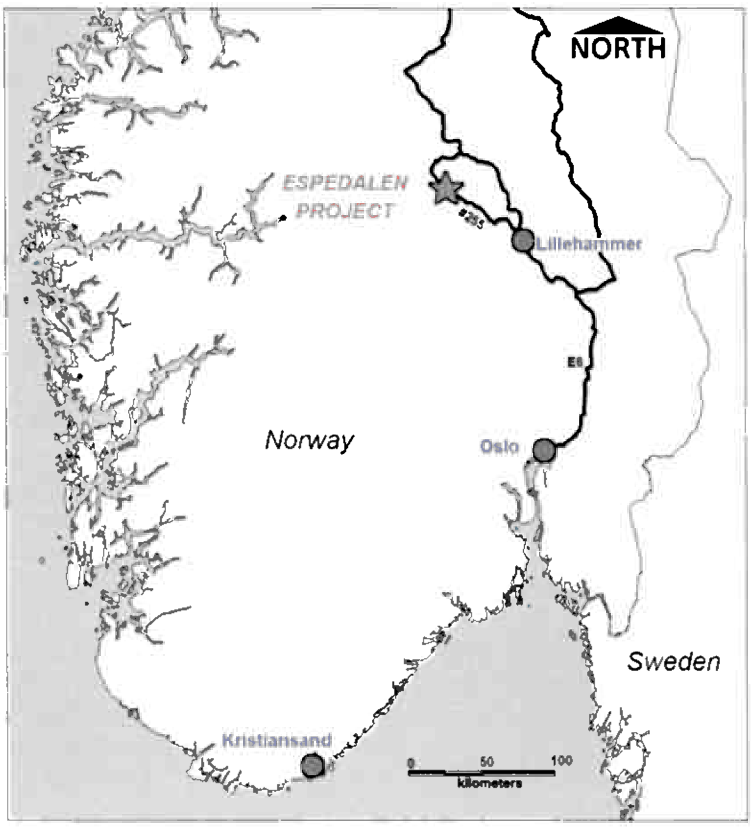
1.0 Location, Topography and Access

The Espedalen project area is located 170 km north of Oslo in south central Norway. The project is situated within the kommunes of Gausdal and Sør-Fron in the Oppland fylke and is easily accessible by car along highway #255 approximately 50 km north of Lillehammer (Figure 1).

Topography in the project area is rugged with local relief of up to 700m. Espedalen Lake trends NW-SE across the centre of property and is flanked on both sides by mountain peaks which reach elevations of up to 1445m. The valley floor and lower portions of the mountain slopes are covered by mixed coniferous and deciduous forest which has been locally logged. Tree cover is replaced by grass, moss and shrubs above an elevation of approximately 1100m.

Access to the field area is generally good via a well-developed system of secondary gravel roads as well as hiking and skiing trails. The majority of the ground in the Espedalen valley is held by private landowners with isolated blocks held under a "communal" designation. Blocks of state-held ground occur along the tops of the mountains. Permission to access the field areas with snowmobile is required from both the local kommunes and the landowners.

Figure 1
Espedalen Project – Location



2.0 Property and Ownership

At the time of the work reported herein, the Espedalen "property" consisted of 381 pre-claims or "mutings" covering an area of 110.35 sq km (Figure 2). The pre-claims are registered to Sulfidmalm A/S (Norway), a wholly owned subsidiary of Falconbridge Nikkleverk (Norway) which is owned by Falconbridge Limited (Canada). Exploration on the project is carried out under an option and joint venture agreement between Sulfidmalm A/S and Blackstone Ventures Inc. (Canada). Work programs are carried out by Falconbridge Limited on behalf of Sulfidmalm.

3.0 Geological Setting

Espedalen is a historic nickel mining area which was active during the period 1848-1878. Numerous old nickel workings and showings are hosted within differentiated mafic and ultramafic bodies which have intruded anorthositic country rocks. This magmatic terrain is collectively referred to as the "Espedalen Complex" and forms the basement of the Gråho subnappe within the larger Caledonian Jotun Nappe.

The Espedalen Complex comprises metamorphosed syenites, norites, anorthosites, gabbros, pyroxenites and peridotites ranging in age from 1698-1250 Ma. The nappe was emplaced in its current position during the Caledonide Orogeny but the original position of this unit is thought to have been west of the Norwegian coastline. Reconstructions place this position close to the west coast of Labrador and Voisey's Bay. The similarity in the ages of the rocks supports such a correlation.

Nickel mineralization is hosted in differentiated mafic to ultramafic intrusions consisting of peridotite, pyroxenite and norite. Disseminated to massive nickel mineralization is exposed in a series of old mine workings and showings, mainly concentrated on the NE side of Espedalen Lake. Grab samples have returned nickel values of up to 3.26% and nickel tenors ranging from 1.8% to 8.8%.

The presence of abundant nickel mineralization at surface combined with the paucity of modern exploration was the impetus for renewing exploration activities in this area in late 2002.

4.0 Previous Work

The record of work completed prior to the 1960's is incomplete. Table 1 gives a brief summary of the known work carried out by Sulfidmalm and Norsk Hydro between mid-1960 and 1980. During this period, 44 drillholes, totalling approximately 3,500-4,000m were completed including 38 at Megrundstjern, 4 at Jorstad and 2 at Melgard. The best intersection was obtained at Megrundstjern and contained 1.01% Ni, 0.32% Cu over 29 metres, including 3.18% Ni over 1m. Preliminary metallurgical testing of this material gave concentrate grades of 15.0% Ni and 5.27% Cu with recoveries of 70.3% for Ni and 76.8% for Cu.

In late 2002, Falconbridge geologists visited the area and initiated a new exploration program. In the winter of 2003, a 29.25 line km UTEM survey (University of Toronto Electromagnetic System) was completed on the SW side of Espedalen Lake and yielded two good EM anomalies. Based on these positive results, a 932 line km helicopter-borne magnetic and frequency domain electromagnetic (EM) survey was contracted out to the NGU and flown in the fall of 2003 (Mogaard & Rønning, 2003). In late 2003, the airborne EM anomalies were prioritized and a plan was made for a follow-up ground geophysical program.

A total of 123 line km of surface UTEM work was completed in the winter of 2004, which outlined numerous prospective targets along known favourable nickel-bearing stratigraphy (Tirschmann, 2005). A drill program followed in the summer-fall of 2004 with a total of 1844.1m of diamond drilling completed in seventeen drillholes. The highlight of the drill program was the discovery of the "Stormyra" nickel sulphide zone. Two holes intersected the zone with the following best results:

ES2004-08: 2.07% Ni, 1.20% Cu & 0.07% Co / 2.70m
ES2004-09: 1.73% Ni, 0.77% Cu & 0.06% Co / 14.60m
including 6.91% Ni, 2.05% Cu & 0.21% Co / 1.90m

Following the favourable drill results, an additional Hummingbird AEM survey was completed in the fall of 2004, totalling 466 line kms (Mogaard, 2005). In late 2004, the airborne EM anomalies were prioritized and a plan was made for a follow-up ground UTEM geophysical program.

Table 1
Summary of Work Completed by Sulfidmalm & Norsk Hydro,
Mid 1960's -1980

Period	Company	Description of Work
Mid-1960's	Sulfidmalm	• recce prospecting & geophysical surveys • claims acquired • slingram anomalies obtained over Andreasberg & Stangruva • no drilling
1970	Norsk Hydro	• helicopter mag-EM survey • 4 holes drilled at Jorstad Grid; best result was 0.35% Ni & 0.09% Cu/18.8m
1973	Sulfidmalm/ Norsk Hydro	• joint venture formed
1974-1978	Sulfidmalm/ Norsk Hydro	• mag, VLF & Mise a la Masse surveys • 40 holes drilled incl. 2 at Melgard Grid, and 38 at Megrundstjern Grid (3143m) • best result at Melgard was 0.47% Ni, 0.21% Cu & 1.95% S/12.75m • large zone of disseminated mineralization outlined at Megrundstjern; poor correlation between sections; best intersection was 1.01% Ni & 0.32% Cu/29m incl. 3.18% Ni/1m
1979-1980	Sulfidmalm	• supported a field mapping program by Michael Heim • 1:50,000 compilation map produced from original 1:5,000 mapping

5.0 2005 Winter Ground Geophysics Program

During the period February 17th to March 23rd, 2005, a winter program consisting of 77 line km of gridding and geophysical surveying was carried out. A list of field personnel involved in the program can be found in Appendix A.

Grid Preparation

Seven grids and eleven geophysical loops were established by McKeown Exploration Services (with help from Falconbridge and Sulfidmalm personnel) during the period February 8th to February 28th. The gridding team consisted of one operator and one or two local mountain guides familiar with the area terrain. Grids were established using a real-time differential global positioning system (DGPS) as well as a locally established base station due to thick tree cover in many of the areas. DGPS control was used on both the grids and the geophysical loops in order to provide the location and elevation (x, y & z) accuracy required for detailed geophysical modelling.

The grids consisted of lines spaced at 100 m or 200m apart with stations set at 25m intervals along each line and marked by thin bamboo pickets (Figure 3). All grids were oriented at AZ 050° and established on a set of local grid coordinates consistent with the 2003 UTEM grids (Appendix B). Bamboo pickets were collected upon completion of the surveying in order to return the survey area to its original state.

Appendix C consists of a detailed report by McKeown Exploration Services on the winter 2005 DGPS surveying and grid work.

UTEM Geophysical Surveying

Lamontagne Geophysics Limited carried out 77 line km of UTEM surveying between the dates of February 17th to March 23rd, 2005 (Figure 4). The UTEM crew consisted of two Lamontagne operators and two Falconbridge/Sulfidmalm helpers.

Surveying was conducted using eleven rectangular to square transmitter loops consisting of narrow gauge copper wire and ranging in size from 800 x 800m to 1300 x 1400m. Loops were numbered sequentially so as to be continuous with the 2003 and 2004 surveys (Figure 5). Data was collected in an "off-loop" configuration on 200m spaced lines at a station interval of 25m. Line spacing was tightened to 75-100m as required in areas of anomalous conductivity.

Appendix E consists of a detailed interpretation report by Lamontagne Geophysics on the winter 2005 UTEM surveying. The report contains a description of the survey logistics and methodology, a full listing of the UTEM profiles and the details of the selected UTEM modeling.

Good correlation was observed between the results of the UTEM survey and the 2004 helicopter EM survey. However, the UTEM survey provided enhanced depth penetration and conductance discrimination. Nine anomalies were deemed to represent potential drill targets based on conductance. Three of these were modeled in-house by A. Watts (see Appendix D) and the remaining six were submitted to Lamontagne for detailed modeling (Figure 6, Appendix E).

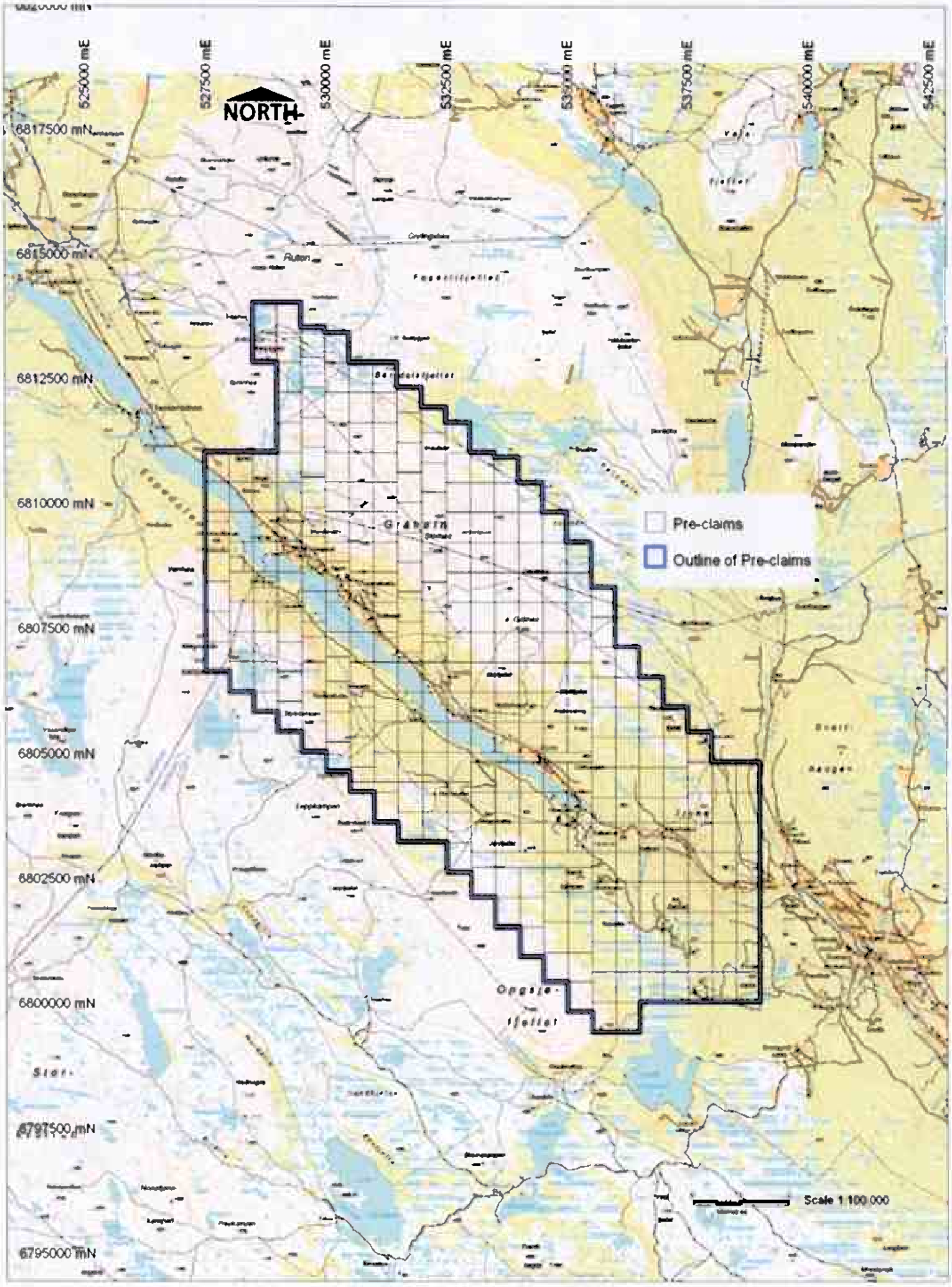
Modeling resulted in the interpretation of one or more conductive plates for each anomaly with the following distribution based on conductance:

- 3 anomalies with conductivities of ≥ 1000 siemens
- 1 anomaly between 400-1000 siemens
- 1 anomaly between 150-400 siemens
- 4 anomalies with conductivities of < 150 siemens

Although none of the conductors are interpreted to outcrop, depths to top/center are typically shallow at < 100m.

Results of the UTEM modeling will be reviewed and used to help select targets for drill testing.

Figure 2
Espedalen Project - Pre-claims

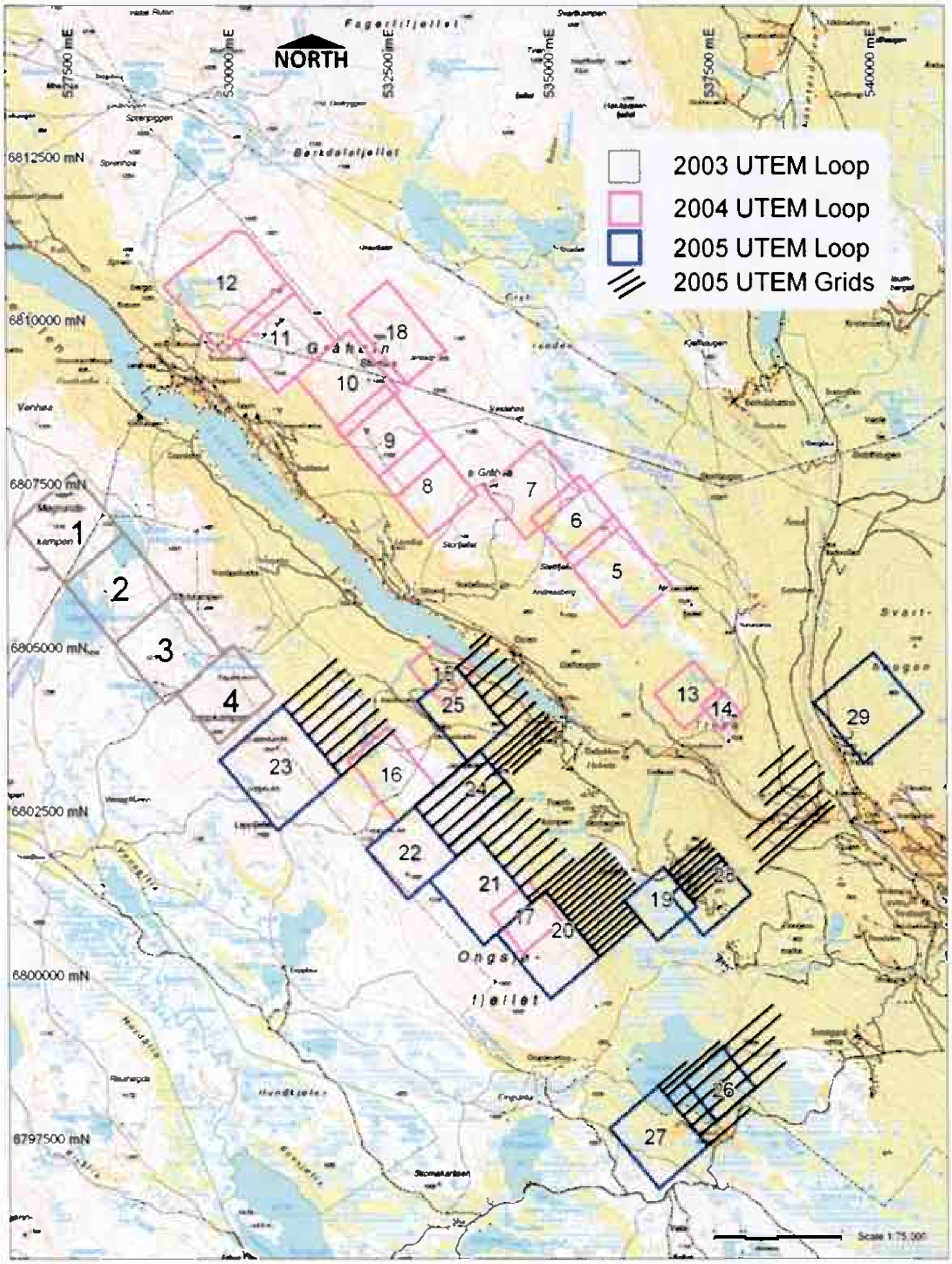


UTM WGS84 Zone 32N

Figure 3: Establishment of DGPS-controlled Grid

Figure 4: UTEM Surveying

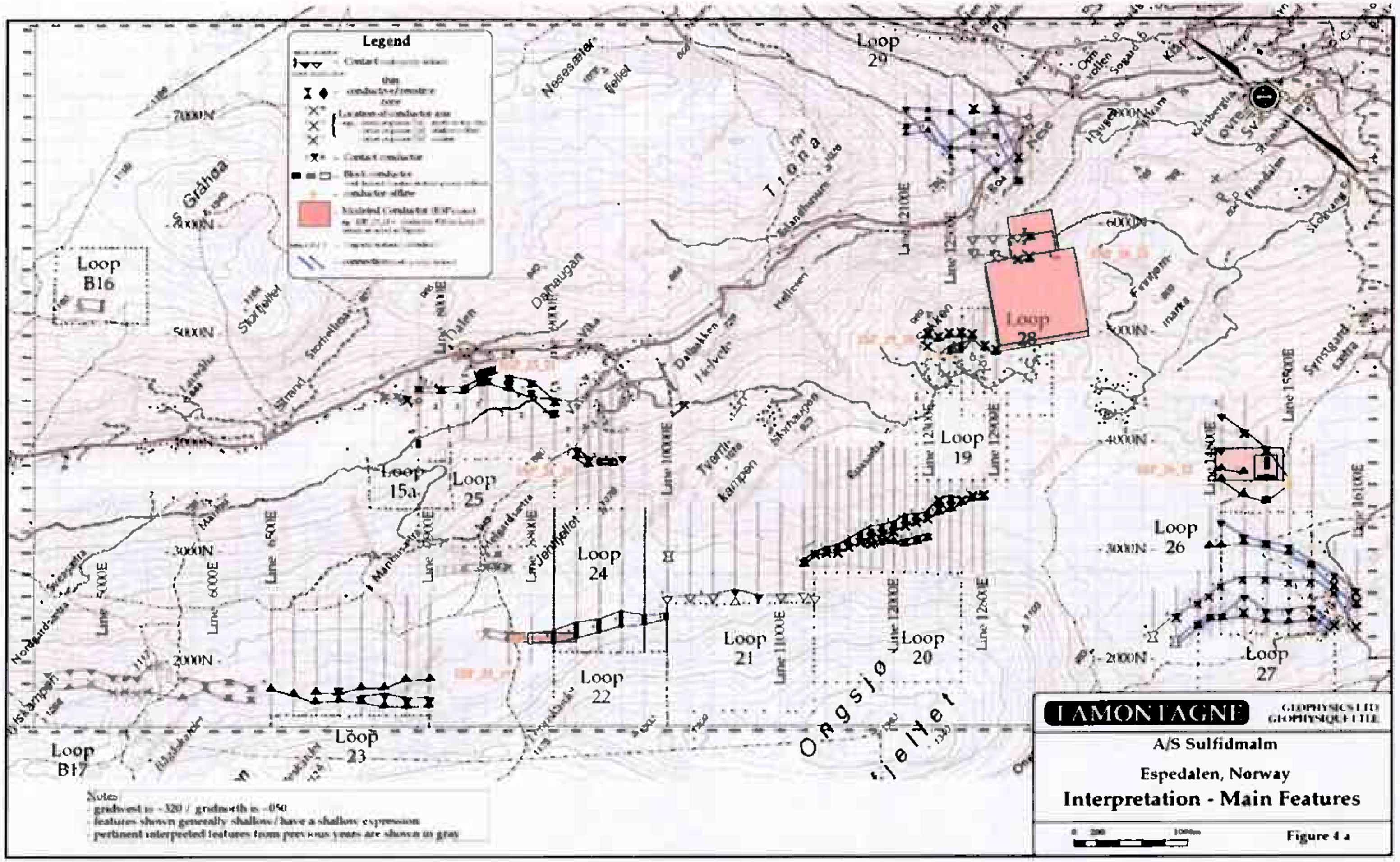
Figure 5
Espedalen Project – 2005 UTEM Grids and Loops



UTM WGS84 Zone 32N

Figure 6
Espedalen Project – 2005 UTEM Conductors

UTM WGS84 Zone 32N



NOTE: Conductors labelled in red are those modelled in detail by Lamontagne Geophysics Ltd. (see Appendix E).

6.0 References

Mogaard, J.O. & Rønning, J.S., 2003
Data Acquisition and Processing - Helicopter Geophysical Survey, Espedalen, Oppland County, Norway (for A/S / Sulfidmalm), NGU Report 2003.093, December 19, 2003, 11p.

Mogaard, J.O., 2005
Data Acquisition and Processing - Helicopter Geophysical Survey, Espedalen, 2004, Oppland County, Norway (for A/S / Sulfidmalm), NGU Report 2005.001, January 25, 2005, 11p.

Tirschmann, P.A., 2005
2004 Winter Geophysical Program, Espedalen, Oppland County, Norway, Falconbridge Limited for A/S Sulfidmalm, May 26, 2005, 9p.

APPENDICES A,B

APPENDIX A
LIST OF FIELD PERSONNEL

Falconbridge Limited:	Patti Tirschmann	Senior Geologist
	Trevor Blair	Project Geologist
Sulfidmalm A/S:	Lars Weierhaeuser	Field Geologist
	Finn Hansen	Project Logistics/crew helper
	Dag Inge Bakke	Mountain Guide/crew helper
	Vilhjalmur Sveinsson	Mountain Guide/crew helper
Lamontagne Geophysics:	Robert Langridge	Senior Geophysicist/UTEM Operator
	Ryan Land	UTEM Operator
McKeown Exploration Services:	Rob McKeown	Contract DGPS Operator

APPENDIX B
LOCAL GRID COORDINATE CONVERSION DATA

Common Coordinates Between the local Espedalen grid and UTM WGS84 Zone 32N are as follows:

	Easting	Northing
Local Espedalen Grid	0	0
Rotation	050°	
UTM WGS84 Zone 32N	525500	6808100

Note: All the Espedalen grids are in the same coordinate system.

APPENDIX C

REPORT ON GPS SURVEY

FOR FALCONBRIDGE LTD.

ESPEDALEN PROECT

OPPLAND PROVINCE, NORWAY

FEBRUARY 2005

McKeown Exploration Services
#55-1330 Trowbridge Drive Oshawa Ontario Canada L1G 7L1
(905) 243-7666 Phone (905) 576-7798 Fax
robmckeown@compuserve.com

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1 Introduction

On 05 February, 2005, a crew was mobilised from Oshawa, Ontario to Falconbridge's Espedalen Project in the Oppland province of Norway, (~70km north of Lillehammer) to fix the position of an exploration grid in three dimensions using Global Positioning System (GPS) satellite receivers. The work was carried out by McKeown Exploration Services of Oshawa, Ontario.

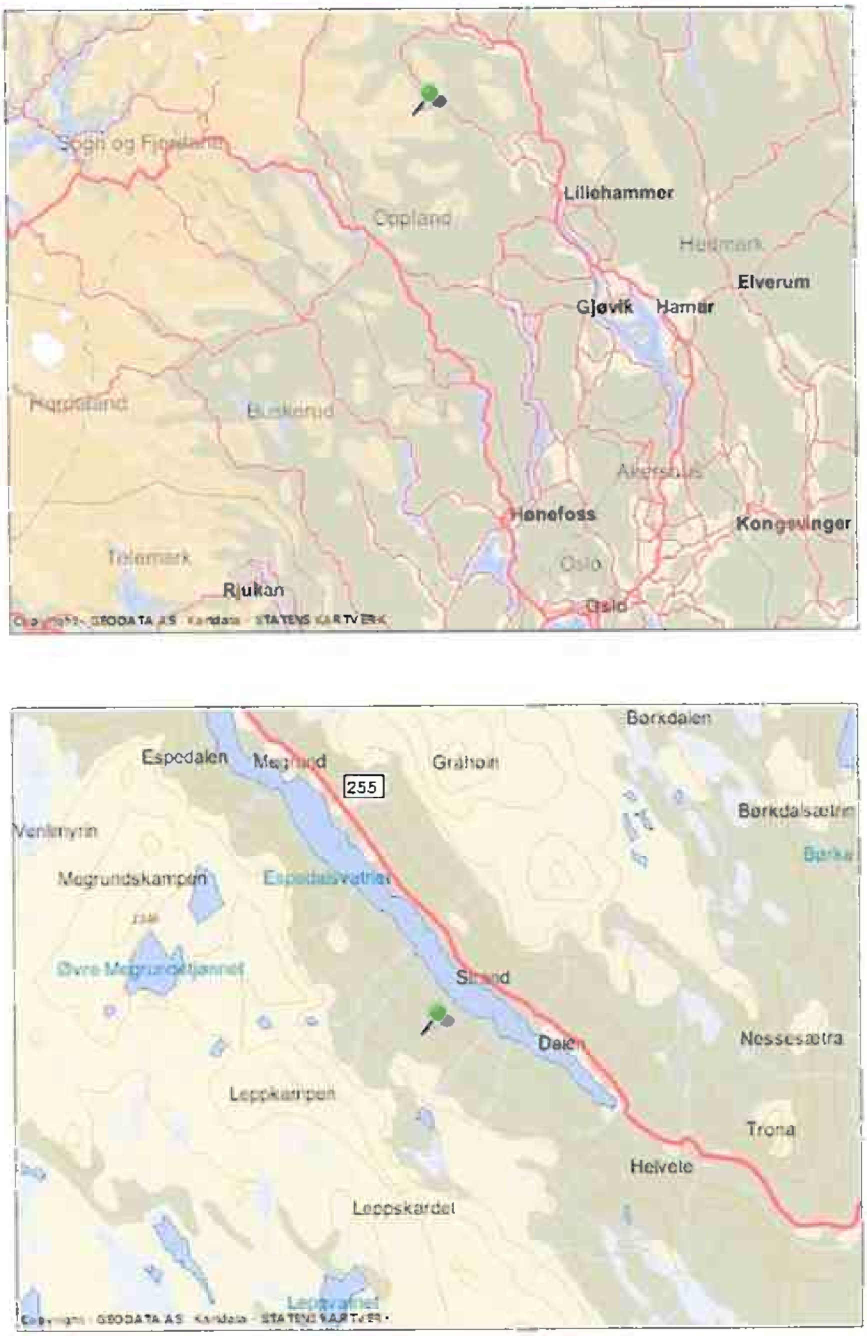


Figure 1.1 Location Map

2 Background

2.1 GPS General Theory

The Global Positioning System (GPS) is a network of twenty four earth orbiting NAVSTAR satellites (SVs) operated by the United States Department of Defense. The satellites orbit the earth every twelve hours at an altitude of approximately 20,200km. Four SVs orbit in each of six different planes inclined at 55deg to the equator, they provide constant positioning and time information by means of radio signals broadcast from each satellite.

Each GPS satellite broadcasts two radio signals known as L1 and L2 (1575.42 MHz, 1227.6 MHz). The L1 signal is modulated with two pseudorandom noise (PRN) ranging codes; P-code, and C/A code. The precision or P-code can be encrypted for military use, while the C/A code is not encrypted. The L2 signal is modulated with the P-code only. Most GPS receivers make use of the L1 signal only, while some survey grade GPS receivers take advantage of both

The US Department of Defense tracks each of the satellites continuously, constantly monitoring and calculating the exact path of the satellite. The exact path of the satellite, as well as atomic clock correction coefficients (each satellite contains several very precise atomic clocks) are broadcast to the satellite daily, this information (called the Broadcast Ephemeris and Almanac) is rebroadcast by each SV and used by the GPS receiver on the ground.

The GPS receiver is capable of receiving signals from several different satellites at once. The incoming code from the satellite contains information regarding the identity of each SV. The receiver calculates the distance that it is from the satellite by looking at the incoming code from the satellite, and then looks at how long ago it (the receiver) generated the same code. The difference in time is multiplied by the speed of light to give the distance, and through the use of triangulation, an exact position of the receiver antenna can be calculated.

2.2 Errors in the GPS Position

The calculated GPS position assumes that light travels at a constant speed, unfortunately this is only true of light travelling in a vacuum. When the GPS signal enters the Earth's atmosphere, the signal is slowed down by both the ionosphere and the troposphere, which may result in incorrect distance calculations. This effect is minimized by calculated correction factors that are broadcast with the Broadcast Ephemeris.

Multipath can be another significant source of error in the calculated GPS position. If the satellite signal is reflected off of objects in close proximity to the GPS receiver, it can interfere with the straight-line signal coming from the satellite, slowing the signal down and "confusing" the GPS receiver. This type of error is more common in areas with man-made cultural influence, such as large buildings, and generally is not a factor in the wilderness setting.

Until recently, the largest single source of error was known as Selective Availability, or the intentional degradation of the GPS signal by the US Department of Defense, it may cause an error in the horizontal positions of the receiver of more than 100m. In the Spring of 2000 the US government removed Selective Availability, as a result, a standard off-the-shelf single frequency GPS may now yield a horizontal position with a +/- 5m precision.

2.3 Real Time Differential Correction

The technique of Real Time Differential Correction (RTC) greatly increases the accuracy of the GPS position and helps minimize the effects of atmosphere, multipath, and selective availability. It employs two GPS receivers, one placed at a known location (the base) and one at an unknown position (the rover). The data collected at the base are used to determine the error in the GPS position, this error is in turn broadcast, through the use of an FM/UHF band radio-modem, to the rover unit and used to remove the errors in the position at the unknown location in real-time.

Using a single frequency GPS receiver (L1 only), with a base-rover separation (base-line length) of less than 10km can yield real-time sub-meter accuracy in both horizontal and vertical position, while use of a survey grade dual frequency L1/L2 GPS receiver can yield real-time 2cm-5cm accuracy in both horizontal and vertical positions.

2.4 Postprocessed Differential Corrections

Similar to the RTC method described above, data can be corrected after-the-fact by collecting data at a base station, and simultaneously collecting data at the rover unit. The data can then be downloaded from the GPS receiver to a computer and "post-processed" to give a differentially corrected position. This is useful in "fixing" base station positions from known geodetic control points where base-rover separation is in excess of 10km (the range of the FM radio modem). The amount of data collected (i.e. the time spent "occupying" a station) to produce a precise position is proportional to the base-rover separation. A general rule of thumb for rover occupation time is fifteen minutes plus one minute for every kilometer over ten kilometers base-rover separation, i.e. a base-rover separation of 100km should be occupied for 15min + (100km- 10km) * 1min / km = 15min + 90 min = 105 minutes.

Post-processed single frequency data can yield 10-15cm precision, while survey grade dual frequency receivers can yield up to part-per-million precision.

2.5 Dilution of Precision (DOP) and Elevation Mask

The DOP is a measure of the geometry of the satellites relative to each other. The best possible position fix, or most accurate, will be possible when the geometry of the satellites is such that the satellites are within range, but as far apart from each other as possible. A low PDOP (position DOP) indicates that the geometry of the satellites, relative to each other, is good for a triangulation fix. If the SVs are close to each other, or are lined up, then the geometry will be poor for triangulation, and the PDOP will be higher. A PDOP less than 4 gives the best position fix, 5-8 is marginally acceptable, and 9 or over is poor. Generally a PDOP mask (or filter) is applied so that if the PDOP is over a certain level (6 is the maximum for this particular survey), then a reading is not possible.

A minimum of four satellites are generally required to give an accurate position fix. The GPS system used for this particular survey uses a proprietary algorithm called "Over-Determined 3D" , which requires at least five common base/rover SVs to compute a position fix.

The elevation mask is a user entered angle filter which will tell the GPS to ignore all SVs within the zero degree above horizon to elevation mask range. When satellites are low on the horizon, the signal is forced to travel farther through the atmosphere, and the low angle of incidence means signals reflect off of objects more readily and the multipath error is increased. The elevation mask for this survey is 13°.

3 Mobilization and Equipment

3.1 Mobilization

On 05 February, a crew was mobilised from Toronto to Falconbridge's Espedalen Project in the Oppland province of Norway, approximately 70km north of Lillehammer.

The crew, which included the author, representatives from Falconbridge Ltd and Lamontagne Geophysics stayed in the Strand Fjellstue Hotel on the east shore of Lake Espedal. Access to Espedal was via the E6 highway north from Oslo to Lillehammer, then highway 255 to Espedalen. The grid was accessed primarily by snowmobile from the hotel. Some grid access was also possible by truck on plowed cottage access roads.

3.2 Equipment

All GPS equipment was rented by the author on behalf of Falconbridge. Two Trimble 5700 dual frequency geodetic grade GPS receivers were employed, along with a Trimble 25 watt base station radio modem, and a similar 25 watt Trimble radio acting as a modem repeater (see Appendix D for specifications).

4 Survey Procedure

4.1 The Local Grid

The local grid was originally designed and oriented to produce lines perpendicular to the geological trend or strike. An arbitrary point was chosen by Falconbridge personnel as the origin of the grid. The grid lines were chosen to run at 050° east of grid north. Magnetic declination in the survey area is zero, so magnetic north and grid north are essentially the same.

Grid Easting	Grid Northing	UTM Easting X	UTM Northing Y	UTM Zone	Grid Azimuth
0	0	525500	6808100	32NORTH	050

Figure 4.1.1. Local Grid Origin

$$X_{UTM} = X_{UTMORIGIN} + (X_{GRID} \cos \theta + Y_{GRID} \sin \theta)$$

$$Y_{UTM} = Y_{UTMORIGIN} - (X_{GRID} \sin \theta - Y_{GRID} \cos \theta)$$

Where: X_{UTM}, Y_{UTM} = unknown UTM
X_{ORIGIN}, Y_{ORIGIN} = origin of local grid in UTM coordinates
X_{GRID}, Y_{GRID} = known local grid coordinates
θ = azimuth of local grid relative to north in degrees

Figure 4.1.2 – Formulae for converting "Local Grid" to "UTM Grid"

The World Geodetic System 1984 (WGS84) UTM reference system was chosen by Falconbridge as the default coordinate system.

Lines were placed at either 100 metre or 200 metre intervals, with a station spacing of 25 metres.

4.2 GPS Base Station and Repeater

On 07 February 2005, the real-time GPS base station was erected at government geodetic control point known as F30T0135 "Vassendass" which was chosen due to it's central location to the grid and easy snowmobile access. This was the only base occupied during the duration of the survey.

A test reading was done adjacent to the base in order to compare coordinates obtained by Falconbridge's single frequency Trimble Pathfinder Pro XRS GPS; a real-time system that receives it's differential correction from a Omnistar or EGNOS satellite (see www.omnistar.com or www.esa.int). The Falconbridge system was used to place grids in a similar fashion during the previous field campaign. It was found that the two systems varied by 11.1cm in X, 15.5cm in Y, 2.9cm in Z; well within the specifications of this survey.

Figure 4.2.1 – GPS Basestation F30T0135 "Vassendaas"

To ensure like coordinate systems, it was decided to occupy two other government geodetic control points, the results are as follows:

ID	Name	UTM_N	UTM_E	Elev.
F30T0135	Vassendaas	6803033.119	534131.190	1078.194
F30T0118	Leppryggen	6801513.582	532751.301	1302.532
F31T0208	Ognsjoefjellryggen	6799492.139	535691.529	1103.244

Figure 4.1.1 – Coordinates of published government control points, ETRS89.

ID	UTM_N	UTM_E	Elev.	dX	dY	dZ
F30T0118	6801513.700	532751.199	1302.625	0.102	-0.118	-0.093
F31T0208	6799492.111	535691.585	1103.245	-0.056	0.028	-0.001

Figure 4.1.2 – Observed coordinates and difference versus published

The observed elevation coordinates were within 10cm of the published coordinates, well within the specifications of the survey.

The published geodetic control point coordinates are in the ETRF89 (or EUREF89) coordinate system, or European Terrestrial Reference Frame. At the startup of the survey, the author nor any of the Falconbridge personnel could locate any detailed information on the definition of the coordinate system. The Norweigan government agency "Statenskart" which is responsible for geodetic control points in Norway responded to an inquiry on the definition with the following: "…EUREF89 is apparently very close to WGS84, the difference is in the order of 20-30cm".

This statement, combined with the evidence from the comparison of the coordinates obtained from the Falconbridge stand-alone system, provided enough support for keeping WGS84 without any detrimental effects.

WGS84 elevations and coordinates were used for the duration of the survey.

The Falconbridge GPS system (Pathfinder) was pre-loaded with a coordinate system definition that included a choice of the Global DMA 10x10 geoid. The Trimble 5700 high precision GPS was therefore also loaded with the same geoid model for consistency, but when the geoid was applied, the 5700 elevations varied from the Pathfinder elevations by approximately 41.5m. This indicates that the Pathfinder is not producing nor displaying elevations with the geoid model applied. For consistency, the geoid heights were not used and everything was kept in WGS84 heights as this is what appears to be generated by the Pathfinder GPS.

A GPS repeater was brought to the survey site but was only used from 24th February to 28th February. The repeater was placed near Line 12500E St 6700N in order to relay the RTK correction signal into Helleren Valley and Loop 29 area.

4.3 The Survey

The author used the RTK GPS to navigate from one ideal station to the next, Falconbridge personnel then placed a labeled bamboo picket at the station. Periodically it was not possible to place the real station at the ideal station location due to trees or topographic obstruction, in such instances the station was moved away from the ideal by up to 5 metres. The station was then staked out, i.e. the real location and elevation observed and recorded in the GPS data controller.

Figure 4.3.1 The author wearing Trimble GPS backpack

The GPS antenna was placed on the GPS backpack, which was 2.00m above "snowshoe" level (see figure 4.3.1). During the course of the survey, the snow depth was approximately 0-100cm, readings were taken on top of the snow and not at ground level where the UTEM geophysical observations would be taken.

The GPS fix, depending on the Dilution of Precision (DOP) value was usually obtained with 3 readings (one per second) taken over the course of at least 5 seconds. If DOPs were low, (<6.0) then a shorter reading was possible, if high (>6.0), then generally a longer observation was necessary to obtain the desired precision, normally less than one minute.

Initially, the desired precision was set to 5cm. This was later changed to one metre L1 initialisations ("Course Initialisation") due to time limitations and the fact that tree cover was causing lengthy L2 or " Fine initialization". The initialization type is displayed in the attached data file in column 9, a "F" indicates fine or L1/L2 high precision observation (+/- 5cm), and a "C" indicates course or L1 only float observation (+/-1m).

Approximately 1% of the observations were repeated, and the change from fine to course initializations appears to have had little affect on the data quality; the highest Z repeat value was 38cm.

Readings were stored in the hand-held GPS computer and downloaded nightly to a laptop computer. Trimble Geomatics Office Version 1.6 (TGO) software was used to transfer and decode binary data. Data were exported from TGO into ASCII format, which was then imported in Excel. An master Excel spreadsheet was created and contained all merged data (see Appendix A).

The production GPS survey was started 08 February 2005, and completed 28 February 2005 (see Appendix C for details on daily progress).

The GPS was also used to fix the positions of all UTEM Loop wires placed by Lamontagne Geophysics. Five loops were surveyed (19, 20, 25, 28, 29), with position fixes taken every 100m, or at any line or elevation break (see Map 7.2).

5.0 Quality Control

To maintain a quality data set, and to test the manufacturer's claim of error/precision, as many random repeats were taken as time would allow. The results of the repeats are outlined below (see Chart 6.1).

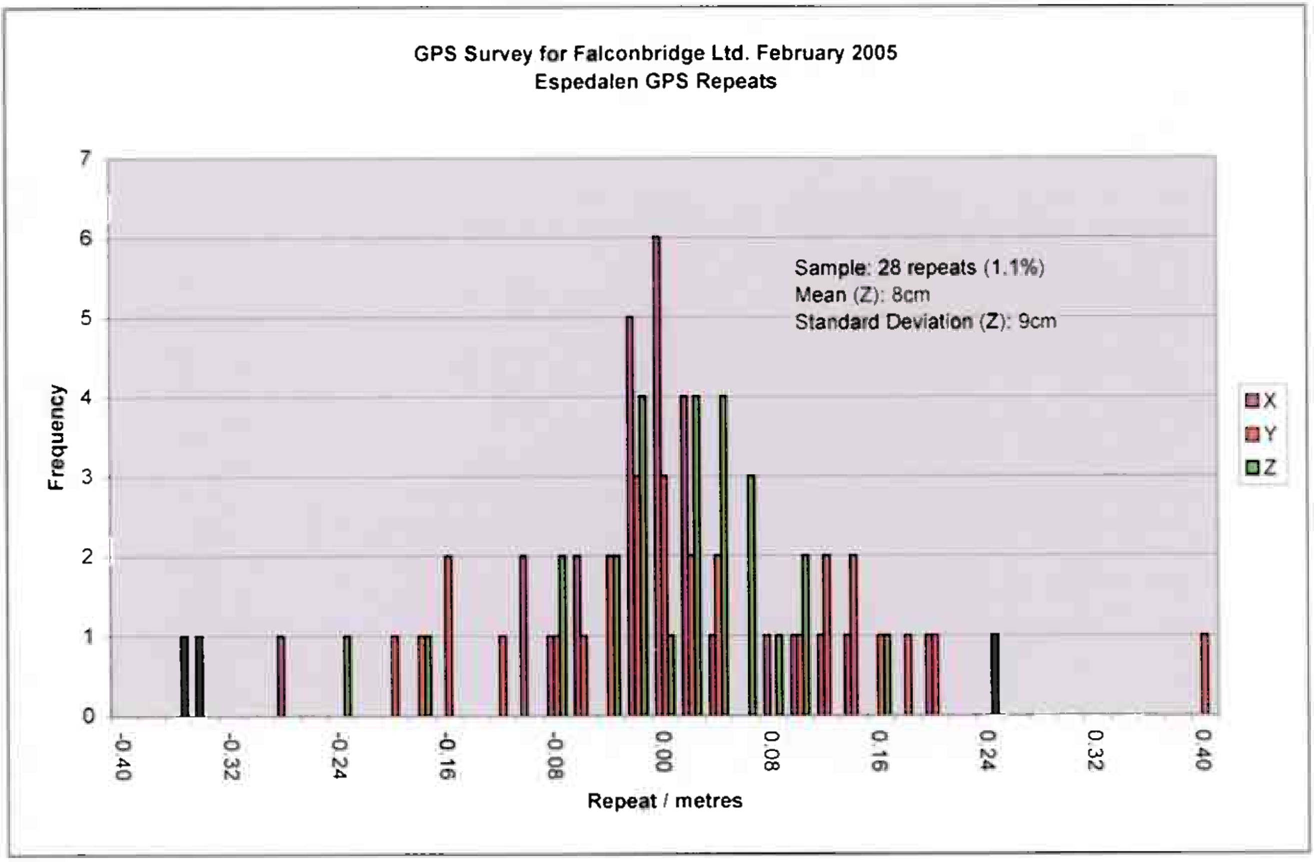


Chart 5.0.1 – GPS Repeats

The above chart illustrates that the precision is as expected (sub-metre). The average of the absolute repeat value is 8cm, with the standard deviation (single population) of 9cm. This implies that if the number of repeats is statistically significant, and approximates a normal distribution, 68% of the readings should have an error in elevation of 17cm or less, and 95% should have an error less than 26cm.

As the error is random as far as being positive or negative in value, the absolute value is considered when calculating averages.

Repeat value is higher where a "course" or L1 float solution only is observed.

Only 28 repeats were taken for approximately 2500 stations, or 1.1%. Ideally 5-10% (125-250 readings) should be randomly repeated for a survey of this size.

6 Comments and Suggestions

6.1 Comments on Satellite Geometry

During the course of a survey day, two significant time periods were observed where satellite geometry was less than ideal; around 10:30 to 13:00, and again after 15:00. During these times it became apparent early in the survey that readings taken in the trees would be difficult to obtain as satellites were either very low on the horizon, or all available satellites were grouped directly overhead and geometry was not favorable for triangulation. With proper planning, usually a survey crew can plan to be working in the clear open areas during these times.

Appendix E contains plots of sample satellite geometry for 25 February 2005.

Graph E.1 shows number of satellites and PDOP plotted against time. Periods of 5 satellites or less, or a PDOP greater than 6 can be difficult times to survey. Obstructions such as mountains or trees can significantly block satellites from the view of the antenna. Plot E.2 shows a "Curtain" or simulated terrain blockage. This plot represents what could be an east west running valley with a 30 degree elevation blockage due to terrain. This is a rough model of the bottom of Helleren Valley where the antenna is in a steep walled valley with an open east and west view of the sky and a 30 degree blockage north and south. The following Graph E.3 represents number of satellites and PDOP with this "curtain" or blockage applied. Obviously the best time to survey in this valley would be after 16:30 and before 21:00. Any attempt to survey in this area at other times of the day would be a very futile effort. Graph E.4 shows that for this location, the bulk of satellites available are in the south, thus one can expect problems when working on a steep north facing mountain.

The satellite geometry changes with time, and it is generally the "luck of the draw" that at a particular location in time that the satellites will have a favorable geometry. One could return to the same survey area in a month or two and the geometry could be favorable all day everyday.

6.2 General Comments

Overall, the GPS survey was completed without any significant problems. , incredible considering the thick foliage and steep terrain.

Considerable time could have been saved had the entire survey been completed in "Course" mode or with low precision L1 float only initializations, although precision / data quality would be sacrificed.

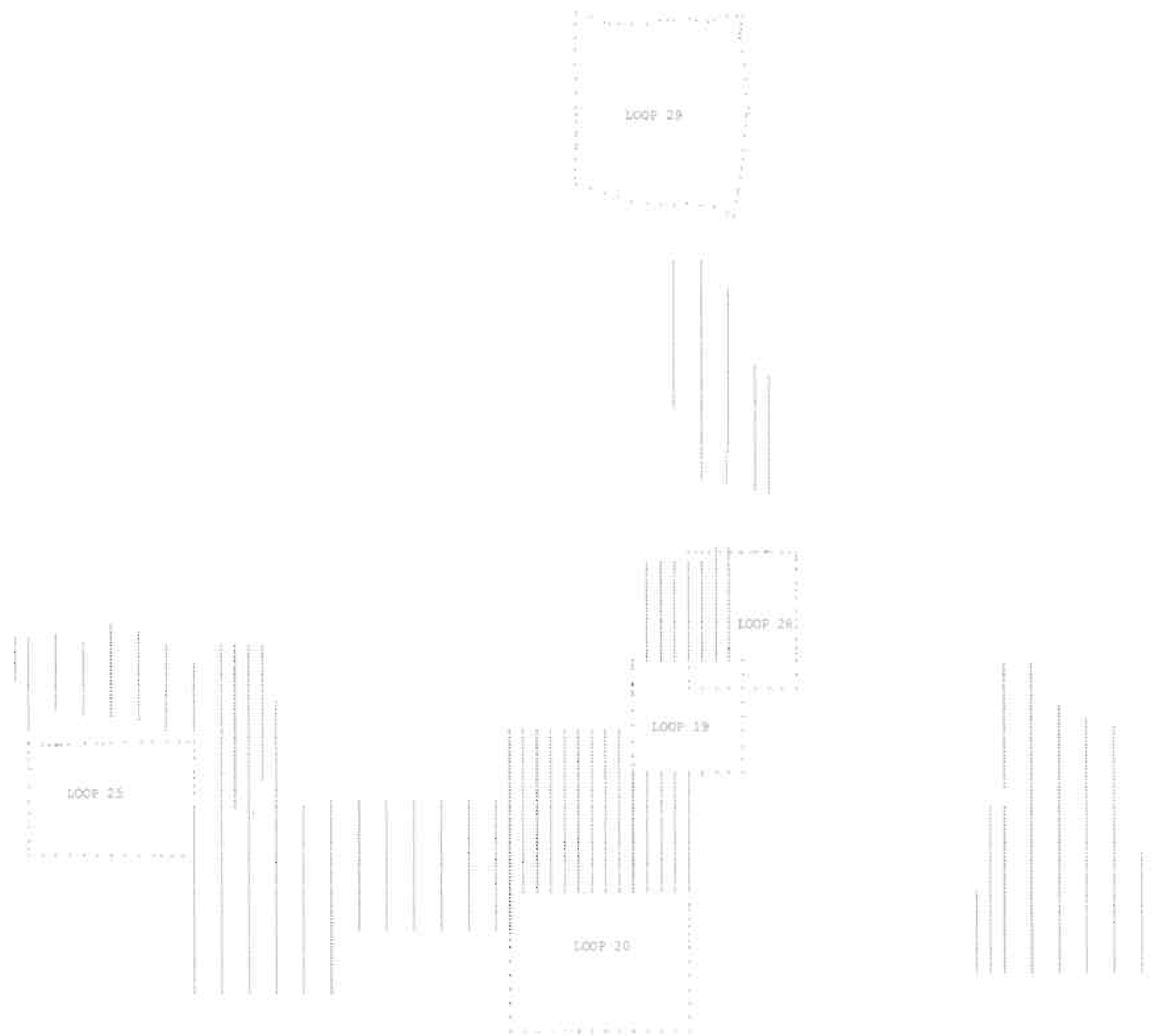
Chart 5.0.1 indicates that the precision of 8-20cm is as claimed by the manufacturer and well within the specifications of the survey. Future surveys should allow for more time to collect a "statistically significant" number of repeats to ensure proper quality control.

Dense foliage and steep terrain are not conducive to GPS surveys, regardless of GPS type. This particular survey could have gone much faster if the Falconbridge GPS unit could have also been used in treed areas as well as in the open. The Pathfinder Pro XRS could have been used in the field as a local RTK rover with the spare Trimble Trimark 3 radio modem. Had there been a spare cable the unit could have been interfaced with the radio and used as an L1 RTK system.

Respectfully Submitted,

Robert L. McKeown, B.Sc.
2005-03-11

Field surveyor:
RLM
Computer operator:
RLM
Reference:



Scale 1:40000
0 1750 m
Meters

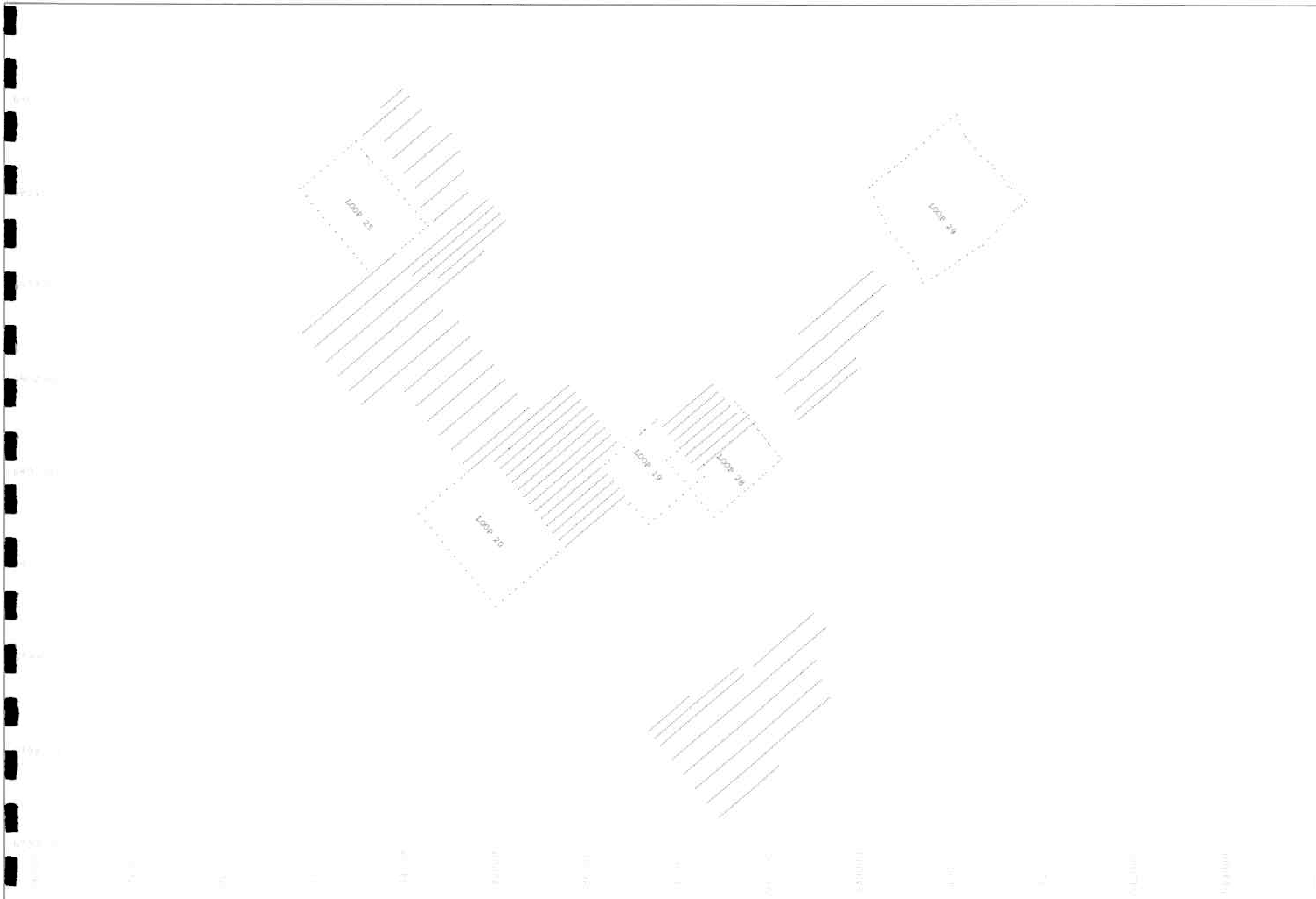
N
050 DEG

Plot Scale: 1:40000

Printed from Trimble Geomatics Office

Site: ESPEDALEN, System: LOCAL GRID
Zone: 32N, Datum: LOCAL GRID

Project: ESPEDALEN
RTK GPS SURVEY FOR FALCONBRIDGE



Field surveyor:
RLM
Computer operator:
RLM
Reference:

Scale 1:40000
0 1750 m
Meters

000 DEG

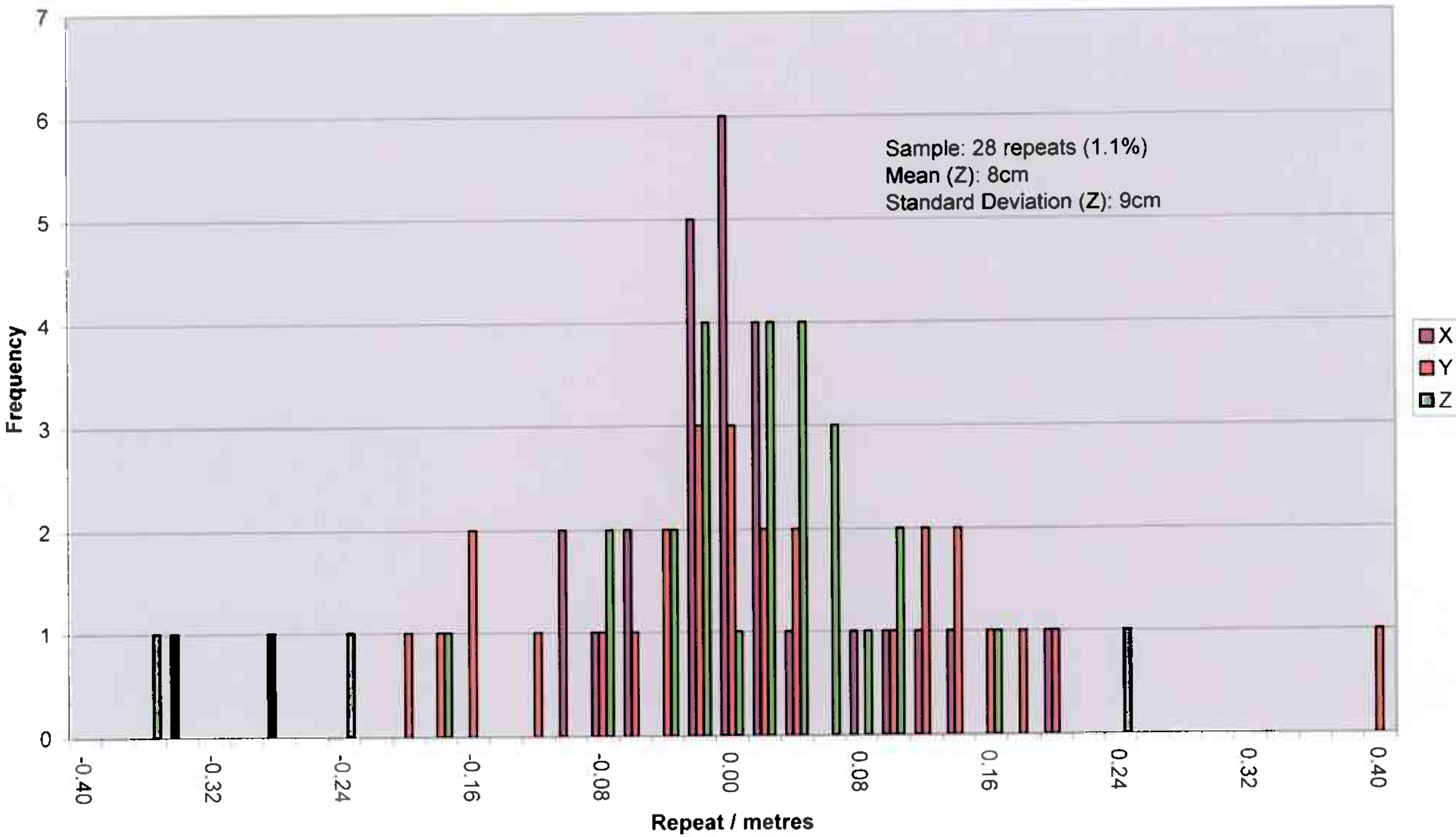
Plot Scale: 1:40000

Printed from Trimble Geomatics Office

Site: ESPEDALEN, System: WGS84 UTM
Zone: 32N, Datum: WGS84

Project: ESPEDALEN
RTK GPS SURVEY FOR FALCONBRIDGE LTD

GPS Survey for Falconbridge Ltd. February 2005
Espedalen GPS Repeats



Appendix A Data CD Information

The attached data CD contains all raw and processed data collected. Raw Trimble binary files are located in the directory :

\GPS\RAWDATA

and are only readable with Trimble Geomatics Office. All binary files were decoded and exported as ASCII text files, then imported into the excel spreadsheet all.xls Geosoft space delimited xyz data was exported from excel and saved in the folder:

\GPS\XYZ

UTEM loops' GPS data are located in the directories:

\GPS\LOOPS

The figure below is a sample of the final data format (Geosoft XYZ) located in the master spreadsheet :

\GPS\XYZ\all.xls

/GPS Survey for Falconbirdge Ltd
/Espedalen Project, Norway
/Local_E Local_N ID UTM_E UTM_N Lat_N Long_E Elev Precision Date Line Station
/

7699.939	4299.978	077004300	533743.400	6804965.477	61.377195451	9.631393679	722.112	F	050223	7700	4300
7699.983	4325.053	077004325	533762.636	6804981.561	61.377338163	9.631756507	722.720	F	050223	7700	4325
7699.975	4350.053	077004350	533781.782	6804997.637	61.377480811	9.632117658	723.583	F	050223	7700	4350
7700.014	4375.328	077004375	533801.169	6805013.854	61.377624700	9.632483330	724.321	C	050223	7700	4375
7701.995	4400.290	077004400	533821.565	6805028.381	61.377753338	9.632867570	726.856	C	050223	7700	4400
7700.120	4424.775	077004425	533839.116	6805045.556	61.377905965	9.633199087	725.621	C	050223	7700	4425
7699.714	4450.222	077004450	533858.349	6805062.224	61.378053938	9.633561968	726.938	C	050223	7700	4450
7700.116	4474.695	077004475	533877.354	6805077.647	61.378190729	9.633920388	727.600	C	050223	7700	4475
7699.971	4500.580	077004500	533897.090	6805094.397	61.378339373	9.634292708	728.875	C	050223	7700	4500
7700.534	4525.292	077004525	533916.383	6805109.850	61.378476409	9.634656492	731.790	C	050223	7700	4525
7699.790	4553.075	077004550	533937.187	6805128.279	61.378640020	9.635049122	731.807	C	050223	7700	4550
7700.044	4575.071	077004575	533954.201	6805142.223	61.378763709	9.635370009	732.522	C	050223	7700	4575
7700.015	4599.862	077004600	533973.173	6805158.181	61.378905299	9.635727901	738.065	C	050223	7700	4600
7799.563	3949.459	078003950	533538.924	6804663.851	61.374505499	9.627513617	755.968	F	050222	7800	3950
7799.403	3974.082	078003975	533557.683	6804679.801	61.374647061	9.627867446	754.175	F	050222	7800	3975
7799.362	3999.431	078004000	533577.075	6804696.127	61.374791940	9.628233182	748.588	F	050222	7800	4000
7799.626	4022.278	078004025	533594.747	6804710.610	61.374920427	9.628566408	746.658	F	050222	7800	4025
7799.002	4050.163	078004050	533615.707	6804729.012	61.375083804	9.628961865	744.284	F	050222	7800	4050
7800.642	4074.825	078004075	533635.653	6804743.609	61.375213106	9.629337667	733.138	F	050222	7800	4075
7800.081	4101.506	078004100	533655.731	6804761.189	61.375369180	9.629716491	723.296	F	050220	7800	4100
7799.952	4124.978	078004125	533673.629	6804776.375	61.375503960	9.630054092	721.534	F	050220	7800	4125
7800.022	4150.024	078004150	533692.860	6804792.420	61.375646331	9.630416790	721.557	F	050220	7800	4150
7800.034	4175.084	078004175	533712.065	6804808.520	61.375789183	9.630779013	721.524	F	050220	7800	4175
7799.986	4200.100	078004200	533731.198	6804824.636	61.375932207	9.631139885	721.529	F	050220	7800	4200
7799.956	4224.997	078004225	533750.251	6804840.663	61.376074417	9.631499262	721.796	F	050220	7800	4225
7799.981	4258.164	078004250	533775.674	6804861.963	61.376263415	9.631978769	723.236	F	050220	7800	4250
7799.978	4275.068	078004275	533788.621	6804872.831	61.376359846	9.632222989	721.462	F	050220	7800	4275
7799.930	4300.051	078004300	533807.729	6804888.926	61.376502679	9.632583404	721.500	F	050220	7800	4300
7799.962	4325.005	078004325	533826.865	6804904.942	61.376644780	9.632944334	721.513	F	050220	7800	4325
7799.991	4350.031	078004350	533846.055	6804921.006	61.376787317	9.633306292	721.521	F	050220	7800	4350

Figure A.1 – Sample Data

GPS Survey for Falconbridge Ltd
Espedalen GPS Repeats

Appendix B

First Reading						Repeat						Difference					
ID	E	N	Elev	Prec	Date	E	N	Elev	Prec	Date		dX	dY	dZ	+dX	+dY	+dZ
078004100	7800.208	4101.693	723.331	F	050222	7800.081	4101.506	723.296	F	050220		0.187	0.127	0.035	0.187	0.127	0.035
082004275	8199.859	4275.073	721.603	F	050222	8200.026	4275.004	721.567	F	050220		0.069	-0.167	0.036	0.069	0.167	0.036
088004450	8799.823	4449.953	721.528	F	050221	8800.012	4449.988	721.499	F	050220		-0.035	-0.189	0.029	0.035	0.189	0.029
090002775	8999.899	2774.948	1038.858	F	050220	9000.100	2775.241	1038.903	F	050219		-0.293	-0.201	-0.045	0.293	0.201	0.045
092003700	9200.135	3700.049	896.877	F	050223	9200.197	3700.076	896.920	F	050223		-0.027	-0.062	-0.043	0.027	0.062	0.043
092004000	9200.751	4000.881	824.333	F	050223	9200.752	4000.861	824.355	F	050223		0.020	-0.001	-0.022	0.02	0.001	0.022
093003575	9299.992	3574.820	967.160	F	050223	9300.081	3574.830	967.245	C	050223		-0.010	-0.089	-0.085	0.01	0.089	0.085
093003850	9299.826	3850.836	861.647	F	050223	9299.848	3850.821	861.658	F	050223		0.015	-0.022	-0.011	0.015	0.022	0.011
096003450	9600.295	3449.873	1037.245	F	050224	9600.344	3449.843	1037.328	C	050224		0.030	-0.049	-0.083	0.03	0.049	0.083
096003575	9599.899	3574.861	977.188	F	050224	9599.925	3574.863	977.182	F	050224		-0.002	-0.026	0.006	0.002	0.026	0.006
096004050	9600.186	4049.929	822.956	F	050224	9600.043	4050.037	823.336	C	050224		-0.108	0.143	-0.380	0.108	0.143	0.38
098003175	9800.101	3176.242	998.605	F	050228	9799.972	3176.161	998.549	F	050217		0.081	0.129	0.056	0.081	0.129	0.056
100003225	10000.019	3226.932	976.169	F	050228	9999.982	3226.817	976.158	F	050217		0.115	0.037	0.011	0.115	0.037	0.011
104003350	10400.076	3349.947	955.504	F	050228	10399.986	3350.039	955.533	F	050212		-0.092	0.090	-0.029	0.092	0.09	0.029
106003400	10599.865	3399.699	944.358	F	050228	10599.986	3399.718	944.133	F	050211		-0.019	-0.121	0.225	0.019	0.121	0.225
108003450	10800.205	3447.689	937.247	F	050228	10800.036	3447.797	937.170	F	050211		-0.108	0.169	0.077	0.108	0.169	0.077
113003325	11300.141	3325.157	941.541	F	050211	11300.036	3325.035	941.531	F	050210		0.122	0.105	0.010	0.122	0.105	0.01
116003800	11600.082	3799.871	904.049	F	050228	11599.969	3799.944	904.014	F	050210		-0.073	0.113	0.035	0.073	0.113	0.035
117003550	11699.950	3549.945	937.492	F	050228	11699.988	3549.970	937.406	F	050209		-0.025	-0.038	0.086	0.025	0.038	0.086
119003525	11900.022	3525.041	942.866	F	050228	11899.989	3525.023	942.711	F	050209		0.018	0.033	0.155	0.018	0.033	0.155
121003525	12099.958	3525.033	941.223	F	050228	12100.136	3525.061	941.174	F	050208		-0.028	-0.178	0.049	0.028	0.178	0.049
123003550	12300.029	3549.980	938.900	F	050228	12300.085	3550.003	938.843	F	050208		-0.023	-0.056	0.057	0.023	0.056	0.057
125003550	12500.095	3550.038	941.384	F	050228	12500.089	3550.107	941.304	F	050208		-0.069	0.006	0.080	0.069	0.006	0.08
125006750	12500.019	6750.051	693.701	F	050224	12500.022	6750.057	693.732	F	050224		-0.006	-0.003	-0.031	0.006	0.003	0.031
127005775	12700.088	5774.877	605.934	F	050227	12700.098	5774.886	605.928	F	050227		-0.009	-0.010	0.006	0.009	0.01	0.006
127006100	12701.726	6098.796	648.006	C	050227	12701.346	6098.792	648.260	C	050225		0.004	0.380	-0.254	0.004	0.38	0.254
129005950	12899.747	5950.111	546.393	C	050227	12899.548	5950.453	546.591	C	050225		-0.342	0.199	-0.198	0.342	0.199	0.198
132005975	13200.216	5975.192	599.283	F	050226	13200.211	5975.208	599.305	F	050226		-0.016	0.005	-0.022	0.016	0.005	0.022

count		28.000					
min		-0.342	-0.201	-0.380	0.002	0.001	0.006
max		0.187	0.380	0.225	0.342	0.380	0.380
average		-0.022	0.012	-0.009	0.069	0.098	0.077
stdev		0.107	0.131	0.118	0.084	0.086	0.088

frequency distribution						
-0.40	0	0	0	0	0	0
-0.38	0	0	0	0	0	0
-0.36	0	0	1	0	0	0
-0.34	1	0	0	0	0	0
-0.32	0	0	0	0	0	0
-0.30	0	0	0	0	0	0
-0.28	1	0	0	0	0	0
-0.26	0	0	0	0	0	0
-0.24	0	0	1	0	0	0
-0.22	0	0	0	0	0	0
-0.20	0	1	0	0	0	0
-0.18	0	1	1	0	0	0
-0.16	0	2	0	0	0	0
-0.14	0	0	0	0	0	0
-0.12	0	1	0	0	0	0
-0.10	2	0	0	0	0	0
-0.08	1	1	2	0	0	0
-0.06	2	1	0	0	0	0
-0.04	0	2	2	0	0	0
-0.02	5	3	4	0	0	0
0.00	6	3	1	0	0	0
0.02	4	2	4	10	5	5
0.04	1	2	4	6	5	8
0.06	0	0	3	0	2	5
0.08	1	0	1	3	1	1
0.10	1	1	2	2	2	4
0.12	1	2	0	3	2	0
0.14	1	2	0	1	3	0
0.16	0	1	1	0	1	1
0.18	0	1	0	0	3	0
0.20	1	1	0	1	2	1
0.22	0	0	0	0	1	0
0.24	0	0	1	0	0	1
0.26	0	0	0	0	0	1
0.28	0	0	0	0	0	0
0.30	0	0	0	1	0	0
0.32	0	0	0	0	0	0
0.34	0	0	0	0	0	0
0.36	0	0	0	1	0	0
0.38	0	0	0	0	0	1
0.40	0	1	0	0	1	0

GPS Survey for Falconbridge Ltd.
Espadelen, Norway

Production Summary

Date	Prod	Line	Station From	Station To	Length	Notes
05/02/05						-p.m. RLM Departs Toronto for Norway
05/02/06						-a.m. RLM Arrives Oslo
						-p.m. RLM arrives in Espadelen
05/02/07						-a.m. setup base station at geodetic point F30T0135
						- visited other bases in area to check ties
						-p.m. transferred Falco horizontal grid adjustment and datum transformation
						to Trimble 5700 GPS receiver
05/02/08	1	12600	2800	3650	850	-a.m. visited drill hole ES2004-08 to check Falco GPS against 5700
		12500	2800	3650	850	- Geoid DMA 10x10 appears not to be used, elevations in agreement with WGS84
		12400	2800	3650	850	
		12300	2800	3650	850	
		12200	2800	3650	850	
		12100	3300	3650	350	
TOTAL					4600	
05/02/09	1	12100	2800	3250	450	
		12100	3675	3950	275	
		12000	2800	3950	1150	
		11900	2800	3950	1150	
		11800	2800	3950	1150	
		11700	2800	3950	1150	
TOTAL					5325	
05/02/10	1	11600	2800	3950	1150	-a.m. low production due to lots of snow in trees
		11500	2800	3950	1150	
		11400	2800	3950	1150	
		11300	3325	3950	625	
TOTAL					4075	
05/02/11	1	11300	2525	3300	775	
		11200	2525	3450	925	
		11000	2525	3450	925	
		10800	2525	3450	925	
		10600	2525	3450	925	
TOTAL					4475	
05/02/12	1	10400	2525	3450	925	-problem today with survey controller battery, dead at 13:00, returned from field early
		10200	2525	3450	925	
		10000	2075	2625	550	
TOTAL					2400	
05/02/13	1	15900	2225	3075	850	-rename: L15300 2850,2825,2800,2775 should be 2900,2925,2950,2975
		15700	2225	3975	1750	-lake grid started
		15500	2700	4025	1325	
		15300	2875	3625	750	
TOTAL					4675	
05/02/14	1	15300	3650	4125	475	
		15100	3575	4100	525	
		14700	2800	2225	575	
		14800	2225	2875	650	
		14900	2225	2800	575	
		15100	2225	3200	975	
		15300	2225	2850	625	
		15500	2225	2675	450	
		14900	3550	4425	875	
TOTAL					5725	
05/02/15	1	15100	4125	4425	300	-lake grid finished
		14800	2900	3400	500	-cottage grid started
		14900	2825	3400	575	
		15100	3550	3225	325	
		12300	4450	5150	700	
		12400	5150	4750	400	
TOTAL					2800	
05/02/16	1	12400	4450	4725	275	
		12500	4450	5150	700	
		12600	4450	5150	700	
		12700	4450	5150	700	
		12800	4450	5250	800	
		12900	4450	5250	800	
					3975	
05/02/17	0.5	10000	2625	3450	825	-a.m. GPSed LOOP 19 (800m x 800m)
		9800	2075	3400	1325	
		9600	2075	3125	1050	
					3200	

05/02/18						-spent day laying wire out for LOOP 20 -GPSed LOOP 20 (1000mx1300m) -thick fog, 10m visibility at times
05/02/19	0.5	9600	3150	3400	250	-a.m. helped lay second strand of wire on west side of LOOP 20 (until 10am)
		9400	2075	3400	1325	-p.m. low production; gridding solo as no helpers available
		9200	2075	2900	825	
		9000	2075	2775	700	
					3100	
05/02/20	0.5	9200	2925	3400	475	-a.m. finished lines near GPS base, attempted to read western most lines, radio signal
		9000	2800	3400	600	is overshooting, need repeater
		7800	4100	4600	500	-p.m. GPSed lake lines close to hotel
		8000	4150	4625	475	-Lillehammer in evening
		8200	4275	4575	300	
		8400	4425	4700	275	
		8600	4450	4650	200	
		8800	4450	4550	100	
					2925	
05/02/21	0.5	9000	3950	4425	475	-GPSed loop 29 eastern edge
		8800	3950	4425	475	-read treed lines on south side Espedal Lake, thick spruce tree cover, steep terrain
		8600	4025	4275	250	and snow in trees, very slow
					1200	
05/02/22	0.5	8400	4400	4050	350	-GPSed N, W, S edges of Loop 29
		8200	4275	4050	225	
		8000	4100		25	
		7800	3950	4100	150	
					750	
05/02/23	1	7700	4600	4300	300	
		8000	4125		25	
		9200	3425	4550	1125	
		9300	3400	4550	1150	
		9400	3400	4550	1150	
					3750	
05/02/24	1	9500	3600	4550	950	- moved to "Hei" grid
		9600	3425	4550	1125	
		12500	6750	7300	550	
					2625	
05/02/25	1	12700	6100	7300	1200	-low production, thick tree cover and steep terrain
		12900	5950	7100	1150	
					2350	
05/02/26	1	13100	5675	6550	875	-low production, thick tree cover and steep terrain
		13200	6475	5650	825	
					1700	
05/02/27	0.5	12700	5750	6075	325	-low production, thick tree cover and steep terrain
		12885	5725	5935	210	-moved south 200m of line 12900 15m west to 12885 due to tick tree cover
					535	-GPSed Loop 29
05/02/28						-GPSed Loop 28 repeats in afternoon
TOTAL					60185	

2005 Espedalen Personnel

APPENDIX C

Name	Company
Patti Tirschmann	Falconbridge Noranda
Trevor Blair	Falconbridge Noranda
Rob Langridge	Lamontagne Geophysics
Ryan Land	Lamontagne Geophysics
Lars Weierhaeuser	Sulfidmalm A/S
Finn Hansen	Sulfidmalm A/S
Dag Inge Bakke	Sulfidmalm A/S
Vilhjalmur Sveinsson	Sulfidmalm A/S
Rob McKeown	MES

Trimble 5700 GPS System

One receiver, many configurations, for greater flexibility and choice

The Trimble® 5700 GPS receiver is an advanced, but easy-to-use, surveying instrument that is rugged and versatile enough for any job.

Combine your 5700 with the antenna and radio that best suit your needs, and then add the Trimble controller and software of your choice for a total surveying solution. The powerful 5700 GPS system will provide all the advanced technological power and unparalleled flexibility you need to increase your efficiency and productivity in any surveying environment.

Advanced GPS receiver technology

The 5700 is a 24-channel dual-frequency RTK GPS receiver featuring the advanced Trimble Maxwell™ technology for superior tracking of GPS satellites, increased measuring speed, longer battery life through less power use, and optimal precision in tough environments. WAAS and EGNOS capability lets you perform real-time differential surveys to GIS grade without a base station.

Modular design for versatility

For topographic, boundary, or engineering surveying, clip the receiver to your belt, carry it in a comfortable backpack, or configure it with all components on a lightweight range pole. With the receiver attached to your site vehicle, you can survey a surface as fast as you can drive! For control applications, attach the receiver to a tripod...it's designed to work the way your job requires.

Full metal jacket...and lightweight

The 5700 GPS receiver boasts the toughest mechanical and waterproofing specs in the business. Its magnesium alloy case is stronger than aluminum, but also 30% lighter—the 5700 weighs just 1.4 kg (3 lb) with batteries. Whether you're collecting control points on a tripod, or scrambling down a scree slope collecting real-time kinematic data, the receiver is light enough and tough enough to carry on performing.

Fast and efficient data storage and communications

Use the receiver's CompactFlash memory to store more than 3,400 hours of continuous L1/L2 data collection at an average of 15-second intervals. Transfer data to a PC at speeds of more than 1 megabit per second through the super-fast USB port. Your choice of UHF radio modem is built in to the receiver to provide RTK communications receiving without the need for cables or extra power!

Your choice of Trimble antenna

Choose the high-accuracy Trimble GPS antenna that best suits your needs: the lightweight and portable Zephyr™ antenna for RTK roving, or the Zephyr Geodetic™ antenna for geodetic surveying.

The Zephyr Geodetic antenna offers submillimeter phase center repeatability and excellent low-elevation tracking, while the innovative design of its Trimble Stealth™ ground plane literally burns up multipath energy using technology similar to that used by stealth aircraft to hide from radar. The Zephyr Geodetic antenna thus provides unsurpassed accuracy from a portable antenna.

Key Benefits

- Industry-leading technology provides superior performance
- Flexible configurations put you in total control
- Rugged, high-performance hardware is built to last
- With the Trimble controller and software of your choice, enjoy seamless integrated surveying

Trimble

Trimble 5700 GPS System

General

- Front panel for on/off, one-button-push data logging, CompactFlash card formatting, ephemeris and application file deletion, and restoring default controls
- LED indicators for satellite tracking, radio-link, data logging, and power monitoring
- Tripod clip or integrated base case

Performance specifications

Measurements

- Advanced Trimble Maxwell technology
- High-precision multiple correlator L1 and L2 pseudorange measurements
- Unfiltered, unsmoothed pseudorange measurement data for low noise, low multipath error, low time domain correlation, and high dynamic response
- Very low noise L1 and L2 carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- L1 and L2 Signal-to-Noise ratios reported in dB-Hz
- Proven Trimble low-elevation tracking technology
- 24 Channels L1 C/A Code, L1/L2 Full Cycle Carrier, WAAS/EGNOS

Code differential GPS positioning[1]

Horizontal .... ±(0.25 m + 1 ppm) RMS
Vertical .... ±(0.5 m + 1 ppm) RMS
WAAS differential positioning accuracy typically <5 m 3DRMS[2]

Static and FastStatic GPS surveying[1]

Horizontal .... ±5 mm + 0.5 ppm RMS
Vertical .... ±5 mm + 1 ppm (× baseline length) RMS

Kinematic surveying[1]

Real-time and postprocessed kinematic surveys
Horizontal .... ±(10 mm + 1 ppm) (× baseline length) RMS
Vertical .... ±(20 mm + 1 ppm) RMS
Initialization time .... Single/Multi-base minimum 10 sec + 0.5 times baseline length in km, up to 30 km
Scalable GPS infrastructure initialization time .... <30 seconds typical anywhere within coverage area
Initialization reliability[3] .... Typically >99.9%

Hardware

5700 GPS receiver

Physical:
Casing .... Tough, lightweight, fully sealed magnesium alloy
Waterproof .... Tested to IPX7 standards
Shock and vibration .... Tested and meets the following environmental standards:
Shock .... MIL-STD-810F to survive a 1 m (3.28 ft) drop onto concrete
Vibration .... MIL-STD-810-F on each axis
Weight .... With internal batteries, internal radio, internal battery charger, standard UHF antenna: 1.4 kg (3 lb)
As entire RTK rover with batteries for greater than 7 hours, less than 4 kg (8.8 lb)
Dimensions (W×H×L) .... 13.5 cm × 8.5 cm × 24 cm (5.3 in × 3.4 in × 9.5 in)

Electrical:
Power .... DC input 11 to 28 V DC with over voltage protection
Power consumption .... 2.5 W receiver only, 3.75 W including internal radio
Battery .... Greater than 10 hours data logging, or greater than 7 hours of RTK operation on two internal 2.0 Ah lithium-ion batteries
Battery weight .... 0.1 kg (3.5 oz)
Battery charger .... Internal with external AC power adapter; no requirement for external charger
Power output .... 11.5 to 20 V DC (Port 1), 11.5 to 27.5 V DC (Port 3) on external power input
Certification .... Class B Part 15 FCC certification, CE Mark approved, C-Tick approved, Canadian FCC

Environmental:
Operating temperature[4] .... -40 °C to 65 °C (-40 °F to 149 °F)
Storage temperature .... -40 °C to 80 °C (-40 °F to 176 °F)
Humidity .... 100%, condensing

Communications and data storage:

- 2 external power ports, 2 internal battery ports, 3 RS232 serial ports
- Integrated USB for data download speeds in excess of 1 Mb per second
- External GPS antenna connector
- CompactFlash advanced lightweight and compact removable data storage. Options of 64 MB or 128 MB from Trimble
- More than 3,400 hours continuous L1+L2 logging at 15 seconds with 6 satellites typical with 128 MB card
- Fully integrated, fully sealed internal UHF radio modem option
- GSM, cellphone, and CDPD modem support
- Dual event marker input capability
- 1 Hz, 2 Hz, 5 Hz, and 10 Hz positioning and data logging
- 1 pulse per second output capability
- CMRII, CMR+, RTCM 2.*x* and 3.*x* input and output standard
- 14 NMEA outputs

Zephyr antenna

Dimensions .... 16.2 cm (6.38 in) diameter × 6.2 cm (2.44 in) height
Weight .... 0.55 kg (1.20 lb)
Operating temperature .... -40 °C to 70 °C (-40 °F to 158 °F)
Humidity .... 100% humidity proof, fully sealed
Shock and vibration .... Tested and meets the following environmental standards:
Shock .... MIL-STD-810-F to survive a 2 m (6.56 ft) drop onto concrete
Vibration .... MIL-STD-810-F on each axis

- 4-point antenna feed for submillimeter phase center repeatability
- Integral low noise amplifier
- 50 dB antenna gain

Zephyr Geodetic antenna

Dimensions .... 34.3 cm (13.5 in) diameter × 7.6 cm (3 in) height
Weight .... 1.31 kg (2.88 lb)
Operating temperature .... -40 °C to 70 °C (-40 °F to 158 °F)
Humidity .... 100% humidity proof, fully sealed
Shock and vibration .... Tested and meets the following environmental standards:
Shock .... MIL-STD-810-F to survive a 2 m (6.56 ft) drop onto concrete
Vibration .... MIL-STD-810-F on each axis

- 4-point antenna feed for submillimeter phase center repeatability
- Integral low noise amplifier
- 50 dB antenna gain
- Trimble Stealth ground plane for reduced multipath

1 Accuracy may be subject to conditions such as multipath, obstructions, satellite geometry, and atmospheric parameters. Always follow recommended survey practices.
2 Depends on WAAS/EGNOS system performance.
3 May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.
4 Receiver operates normally to -40 °C (-40 °F) but some office-based functions such as USB download or internal battery charging are not recommended at temperatures below freezing.
Specifications subject to change without notice.

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Trimble

DATA SHEET

TRIMMARK 3 RADIO MODEM

KEY FEATURES

Versatile: Use as base, repeater or rover

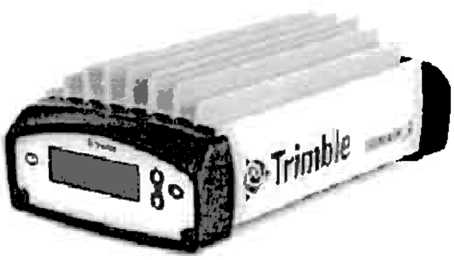
Flexible: 2 W, 10 W, or 25 W power output

Channel spacing programmable at 12.5 kHz or 25 kHz

Easy to use and configure

Built-in channel selector and monitor

Rugged and weatherproof



RUGGED AND VERSATILE MULTICHANNEL RADIO MODEM

The TRIMMARK™ 3 radio modem provides a convenient, versatile means of establishing a robust wireless data broadcast network for real-time, high-precision GPS survey and telemetry applications.

The rugged, compact TRIMMARK 3 radio modem is designed for use in tough environments and in a variety of situations. The single unit is usable as a base station, repeater station, or rover receiver for maximum versatility. However you use it, you'll appreciate its simplicity and famous Trimble reliability and quality.

SELECT THE POWER YOU NEED

The TRIMMARK 3 radio modem provides selectable power outputs of 2 W, 10 W, or 25 W to support both short and long-range operations, conserve battery life and minimize risk of interference with other systems.

A 25 W base unit broadcasts up to 15 km (8 miles) line-of-sight, under optimal conditions. Path obstructions and terrain can reduce the typical effective range to 10 km to 12 km (6 miles to 7 miles). One or two additional units can be networked as repeater stations to extend range, minimize base station moves, and provide seamless coverage around local obstacles such as large buildings or hills. The typical range of a 2 W repeater is 5 km to 8 km (3 miles to 5 miles).

A TRIMMARK 3 radio modem broadcasts or repeats data to Trimble survey-grade GPS receivers, such as the Trimble R8, 5800, Trimble R7, and 5700, that either contain an internal radio modem or are being used with an external rover radio. The TRIMMARK 3 is fully backward compatible with the TRIMMARK IIe radio modem, so it can be used in both new and existing systems.

CONFIGURE IT TO YOUR NEEDS

The TRIMMARK 3 radio modem can be configured completely and easily in the office by using the supplied WinFLASH utility on your computer. Many functions also can be configured in the field from the front panel or from the Trimble Survey Controller™ software used with your GPS survey receivers. The serial port communication settings are easily set to match the default settings on the GPS receiver.

You can configure each broadcast network to operate on one of up to 20 programmed channels via a built-in channel selector. Channel spacing of either 12.5 kHz or 25 kHz is programmable at the factory or by a service provider.

To reduce the risk of interference in a congested RF environment, you can use the built-in audio speaker to monitor activity on the selected channel. The unit also can automatically monitor the channel using its software selectable carrier detect function to detect other users on the channel before transmitting.

The TRIMMARK 3 radio modem is available as a stand-alone product as well as in convenient base and repeater equipment sets. Available in three frequency bands, the TRIMMARK 3 radio modem is designed to meet the licensing requirements of many countries around the world.

Trimble

TRIMMARK 3 RADIO MODEM

STANDARD FEATURES

- Selectable 20-channel capacity
- Rugged weatherproof construction
- Configurable from front panel, survey controller, or from supplied WinFLASH utility on your computer
- Up to 15 km line-of-sight range
- Same unit can function as base station, repeater station, or rover receiver
- Selectable power outputs of 2 W, 10 W, or 25 W
- Programmable channel spacing of 12.5 kHz or 25 kHz
- Built-in channel selector
- Supports up to two repeaters in a network
- 4800, 9600 and 19200 baud rate over the air
- Retrievable/storable radio diagnostic information

TRIMMARK 3 BASE/REPEATER

Physical

Size . . . . 12.5 cm W x 22.9 cm D x 7.9 cm H (4.9" W x 9.0" D x 3.1" H)
Weight . . . . 1.59 kg (3.5 lb)

Electrical

Power:
  Input . . . . 12 V DC to 16 V DC, nominal
Connectors:
  Power . . . . 2-pin LEMO (+VDC, GND)
  Data . . . . 7-pin female LEMO (supports RXD, TXD and SGND)
  Antenna . . . . TNC female

Environmental

Temperature:
  Operating . . . . –40 °C to +65 °C (–40 °F to +149 °F)
  Storage . . . . –55 °C to +75 °C (–67 °F to +167 °F)
Humidity . . . . 100%, fully sealed, weatherproof

TECHNICAL SPECIFICATIONS

Transmit Power[1] . . . . 2 W, 10 W, 25 W
Wireless Data Rate . . . . 4800 bps, 9600 bps, 19200 bps
Frequency Bands . . . . 410–420 MHz, 430–450 MHz, or 450–470 MHz (Only one band per radio modem)
Channel Spacing . . . . 12.5 kHz or 25 kHz (Only one spacing per radio modem)
Number of Channels[2] . . . . . . Can be ordered with up to 20 programmed frequencies, internally stored
RF Modulation Format . . . . Gaussian Minimum Shift Keying (GMSK)

Range (typical)[3]

25 W Base . . . . 10 km to 12 km (6 miles to 7 miles)
2 W Repeater . . . . 5 km to 8 km (3 miles to 5 miles)

Power Consumption[4]	Voltage	Current	Nominal Load
2 W mode	12.6 V	0.8 A	~10 W
10 W mode	12.6 V	3.6 A	~45 W
25 W mode	12.6 V	8.0 A	~75 W

Serial Port . . . . One set of RS-232 signals available. Data is 8 bits with selectable parity and 1 stop bit. Supported data rates are 9600 bps, 19200 bps, and 38400 bps[5]

ANTENNA PHYSICAL SPECIFICATIONS	LENGTH (TYPICAL)	WEIGHT
Standard antenna		
0 dB UHF omni whip	47 cm (18.5 in)	0.5 kg (1.1 lb)
5 dB UHF omni whip	99 cm (39 in)	0.5 kg (1.1 lb)

1. Radios are configured as 25-W units at the factory.
2. Use the same frequency for all radio modems in the same wireless data network.
3. Varies with terrain and operational conditions. Up to 2 repeaters can be used to extend range.
4. Power consumption and battery life depend on the broadcast information content and wireless data rate (e.g., CMR versus RTCM SC-104 Ver 2.x packets at 1 Hz epoch rates).
5. Communications rate between the radio and GPS receiver, not wireless rate.

Specifications subject to change without notice.

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Trimble

www.trimble.com

TSCe Controller

The flexible data collector of choice

The TSCe™ controller is a rugged and adaptable handheld data collector. Running powerful Trimble field software on a Microsoft® Windows® operating system, TSCe provides exceptional control of Trimble GPS and optical sensors, whatever your surveying or construction application.

Exceptional in the field even in extreme temperatures

The TSCe controller is the rugged data-collection solution that fits comfortably in your hand and in your field processes. And because it's designed to take the knocks and drops of the surveying and construction environment, the TSCe controller's ruggedness makes it a reliable and dependable member of your field crew. When you're out working long days, TSCe will keep on working right there with you.

In extremely cold temperatures, TSCe is more robust than ever before. With its new color touch screen, TSCe will easily operate in temperatures as low as -25 °C without the addition of an internal heater.

Full keyboard and touch screen

On the TSCe controller you can choose to drive your data collection software using the full alphanumeric keyboard, or via the easy-to-use color touch screen—TSCe enables you to use the method or method combination that provides you with the most efficient data control.

The instant results of the touch screen offer complete control over data and make light work of navigation, data selection, positioning, and stakeout.

Color graphic display

The color graphic display of the TSCe controller is clearly readable in a wide range of field conditions. The display's reflective LCD technology makes it easy to read in bright sunlight, and it is front lit for when light levels are low, such as on dark winter days.

The color display makes not only simple text easier to read, but also complex maps and technical drawings. Having these graphics in colour right at your fingertips makes navigating and positioning much easier, and speeds up stakeout and data selection. Data management and quality assurance are also greatly improved. Because you can thoroughly check your data in the field, errors and omissions are minimized.

TSCe Applications

- Exceptional in the field even in extreme temperatures
- Full keyboard and touch screen
- Color graphic display
- Large memory capacity
- Adaptable

Large memory capacity

The TSCe controller comes with 512 MB of CompactFlash memory as standard. This large storage capacity means that you can work with larger data files and background maps, and that you can work for longer in the field without backup storage.

Adaptable

The TSCe controller is designed to operate with all your Trimble sensors, including the Trimble® R7 and R8 GPS receivers with R-track technology, the 5700 and 5800 GPS receivers, and the 3600 and 5600 total stations. It also supports many major third-party total stations. In addition, when the Trimble BlueCap module is used, Bluetooth® wireless technology provides cable-free communication with the Trimble R8 and 5800 GPS systems.

Trimble

TSCe Controller

The flexible data collector of choice

Specifications

Power	Internal 3800 mAh NiMH rechargeable battery pack Battery life of 30 hours under normal operating conditions Complete recharge in under three hours
Size	25.8 cm (10.2 in) × 13 cm (5.1 in) × 5.2 cm (2.1 in) 7.4 cm (2.9 in) at handgrip
Weight	990 gm (2.2 lb) including battery
Certification	FCC class B, CE Mark, CSA, and C-tick approval
Serial Port I/O	9-pin serial port–RS232 (115 kB/s), COM1 with 5 V (250 mA) on pin 9
MultiPort I/O	26-pin MultiPort–RS232, COM2, Ethernet 10BaseT, USB client, power in/out and audio in/out 0-Shell Lemo RS-232 (115 kB/s)
Processor	Intel StrongARM SA-1110 @ 206 MHz
Memory	512 MB non-volatile flash disk; 64 MB SDRAM
Display	320 × 240 pixels (¼ VGA) reflective color TFT, frontlight illuminated display
Touch Screen	Passive touch screen, works with stylus or finger
Keyboard	57-key tactile action with separate navigation, alpha and numeric keypads
Audio	Integrated speaker and microphone

Environmental

Temperature:	
Operating	-25 °C to 60 °C (-13 °F to 140 °F)
Storage	-30 °C to 60 °C (-22 °F to 140 °F)
Water	ICE 529, IP 67, sealed against temporary immersion
Drop	1.22 m (4 ft) to concrete on all faces, edges and corners
Sand and Dust	ICE 529, IP 6X and MIL-STD-810E, Method 510.3
Vibration	MIL-STD-810E, I-3.4.9 category 10, Fig 16 and 17
Altitude	MIL-STD-810E, Method 500.3

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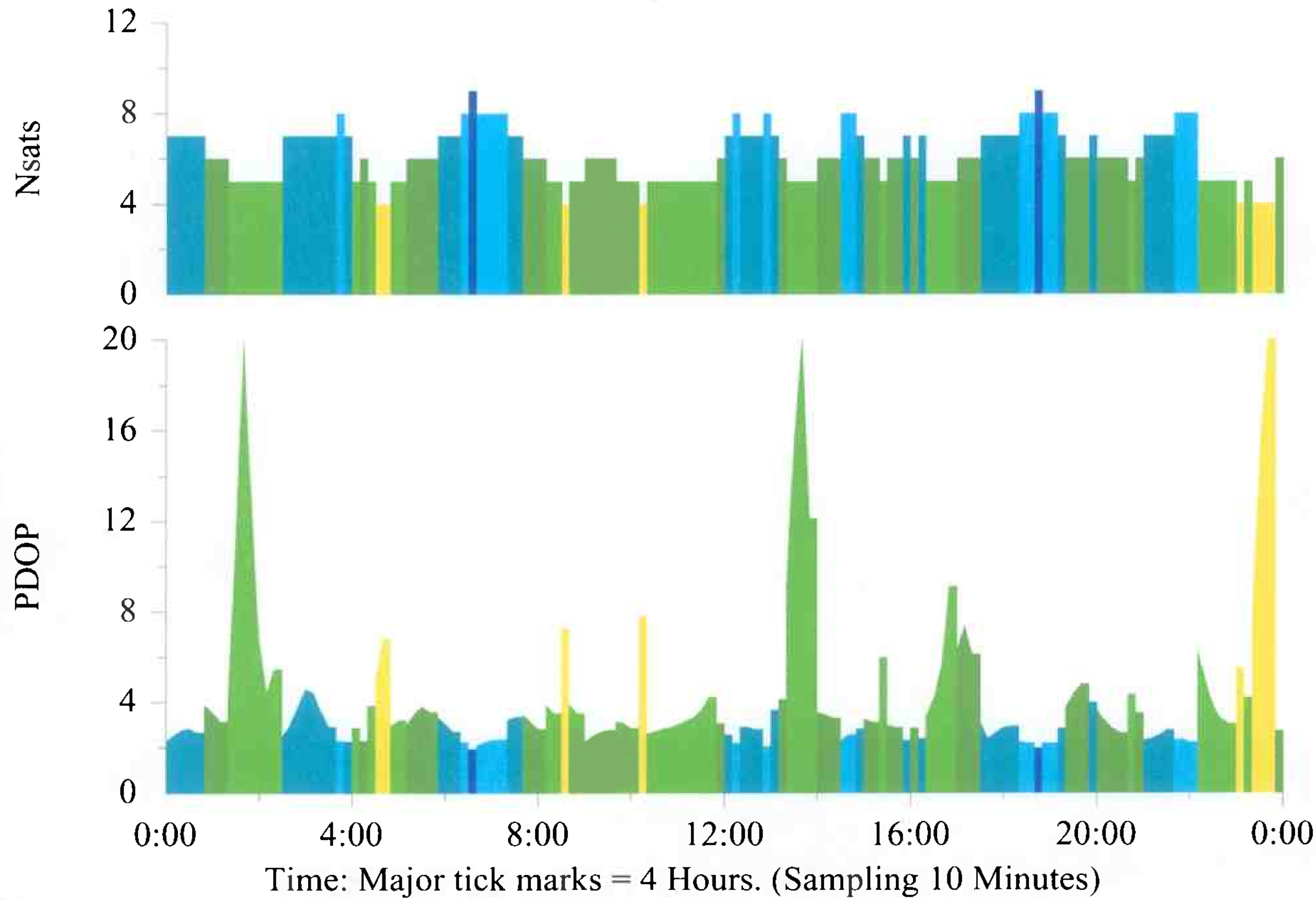
Trimble

Number SVs and PDOP

Point: Espedalen | Lat 61:22:0 N Lon 9:38:0 E | Almanac: ALMANAC.EPH 05/02/25

Date: 2005/February/25 | Threshold Elevation 20 (deg) | Time Zone 'Central European Std' 1:00

28 Satellites considered : 1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 18 19 20 21 22 23 24 25 26 27 28 29 30



APPENDIX E.1

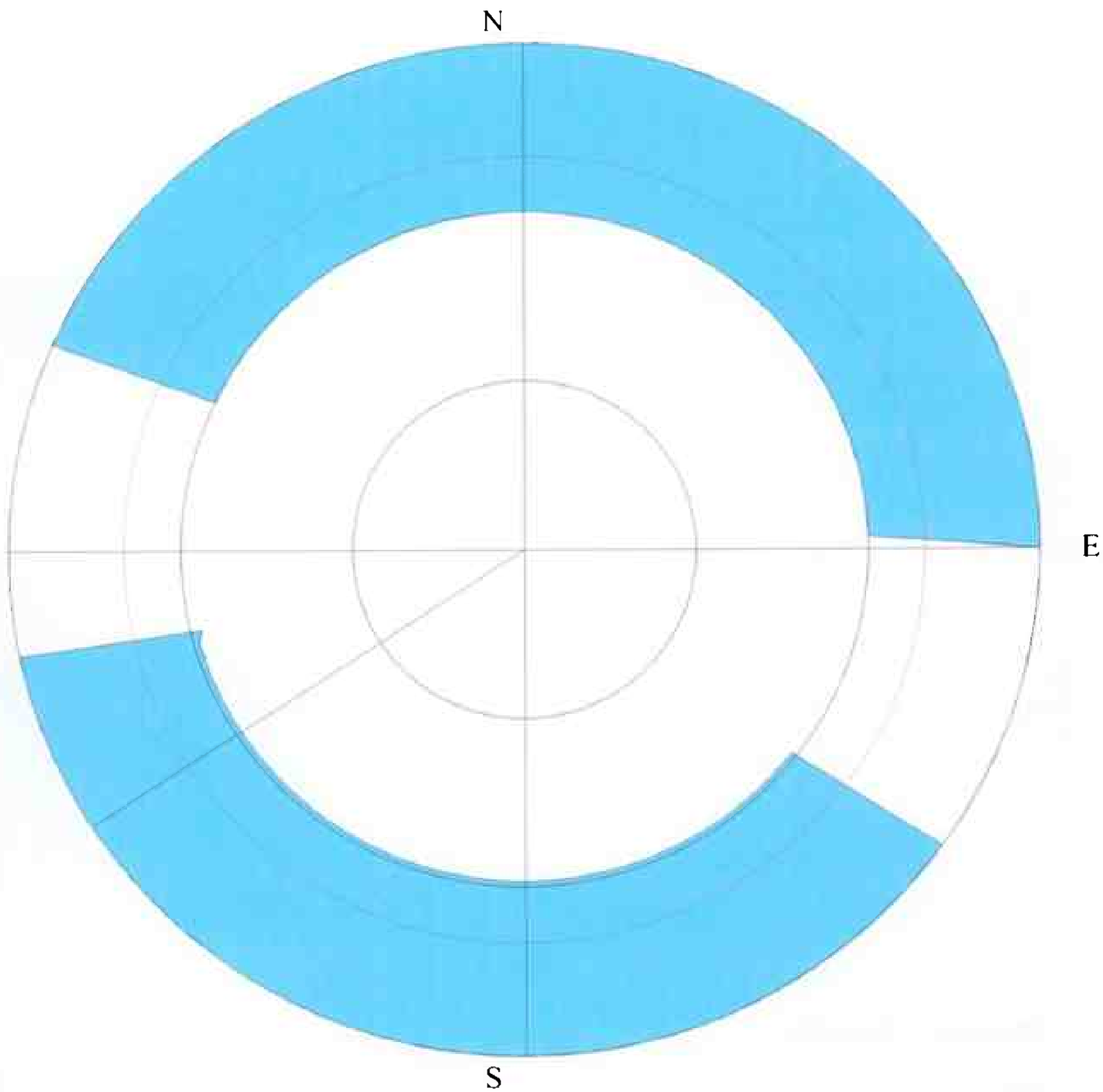
Curtain

Point: Espedalen
Date: 2005/February/25

Lat 61:22:0 N   Lon 9:38:0 E
Threshold Elevation 20 (deg)

Almanac: ALMANAC.EPH 05/02/25
Time Zone 'Central European Std' 1:00

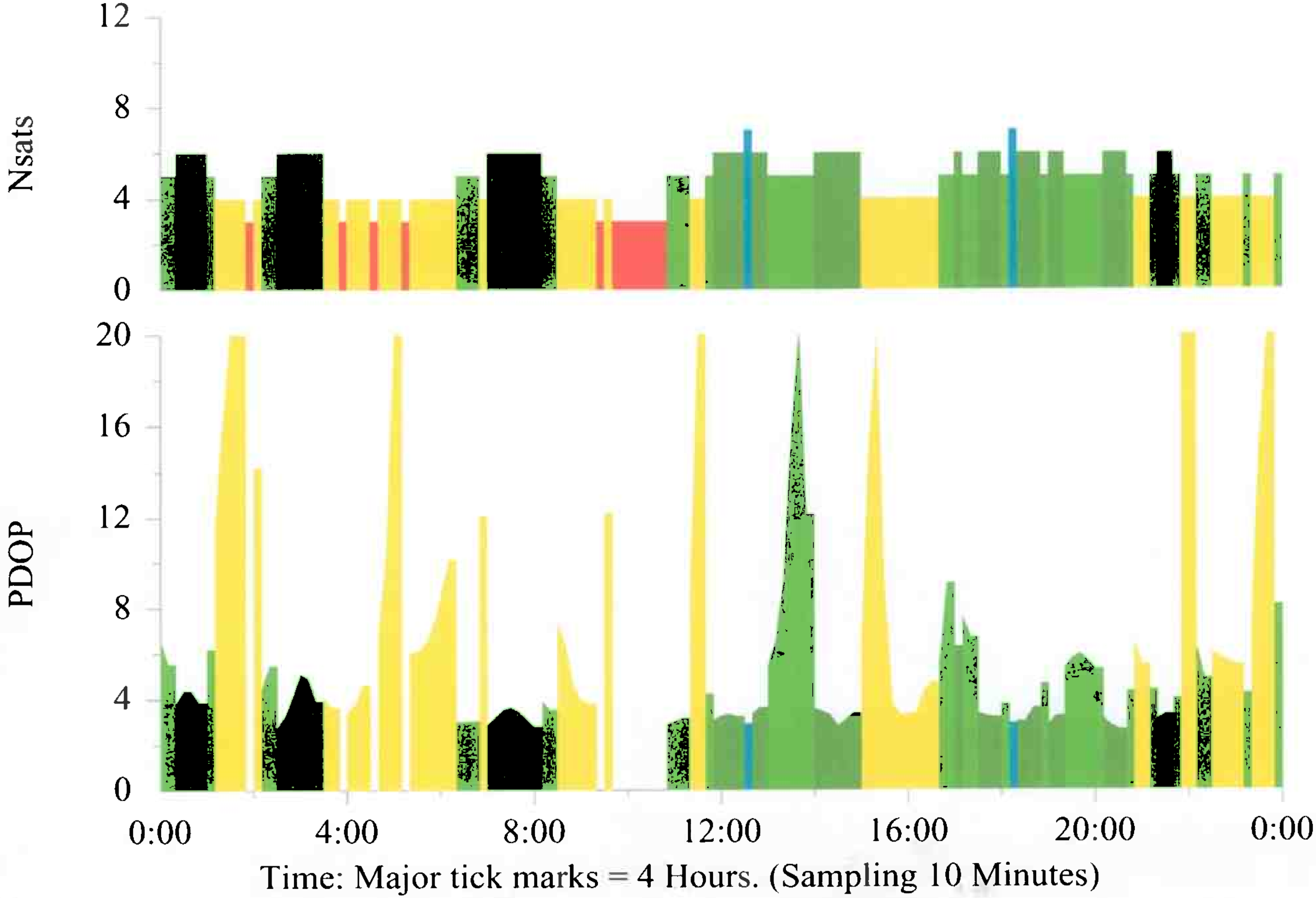
28 Satellites considered : 1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 18 19 20 21 22 23 24 25 26 27 28 29 30



APPENDIX E.2

Number SVs and PDOP

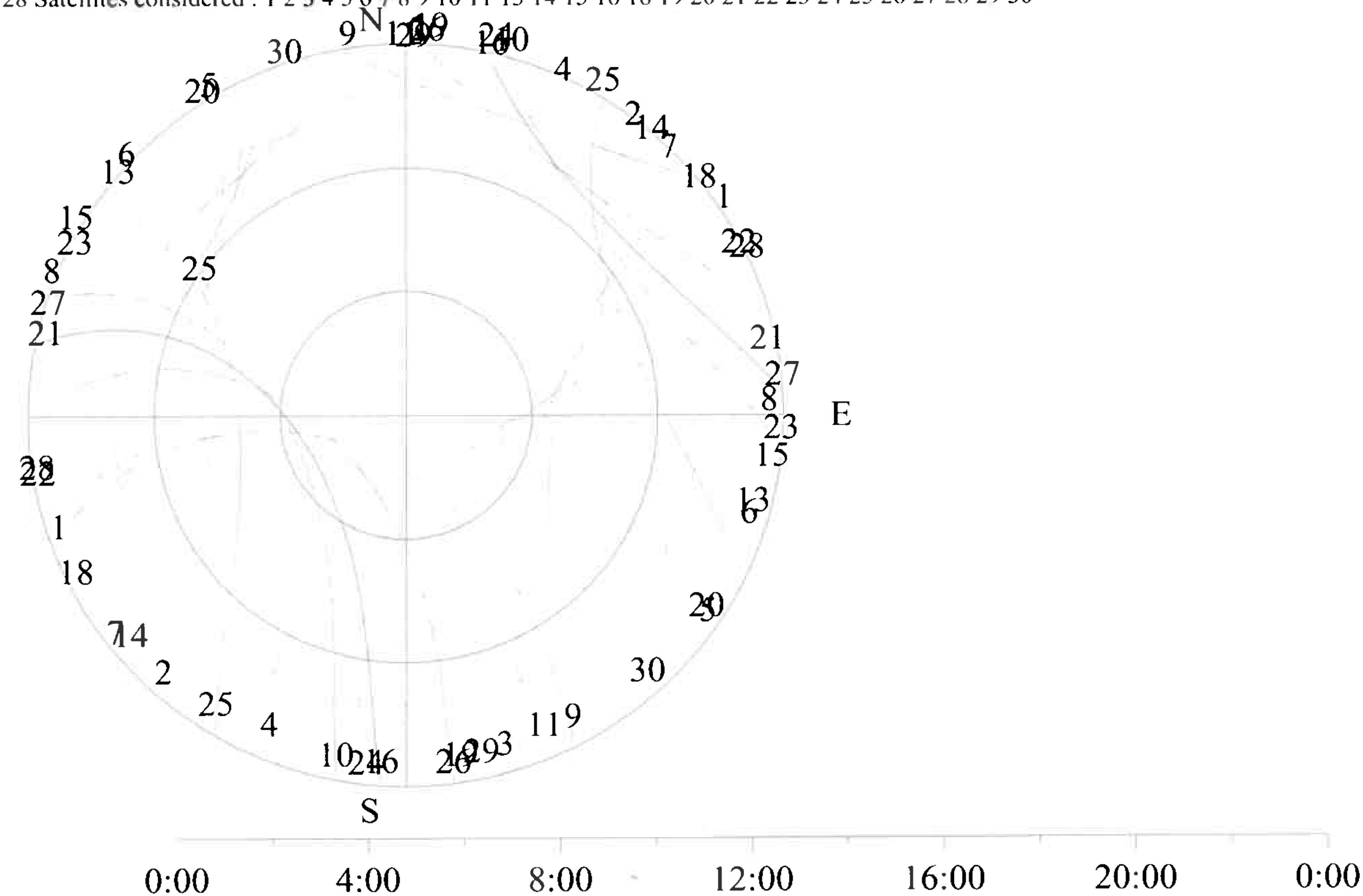
Point: Espedalen
Date: 2005/February/25
Lat 61:22:0 N Lon 9:38:0 E
Threshold Elevation 20 (deg)
Almanac: ALMANAC.EPH 05/02/25
Time Zone 'Central European Std' 1:00
28 Satellites considered : 1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 18 19 20 21 22 23 24 25 26 27 28 29 30



APPENDIX E.3

SkyPlot

Point: Espedalen
Date: 2005/February/25
Lat 61:22:0 N Lon 9:38:0 E
Threshold Elevation 20 (deg)
Almanac: ALMANAC.EPH 05/02/25
Time Zone 'Central European Std' 1:00
28 Satellites considered : 1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 18 19 20 21 22 23 24 25 26 27 28 29 30

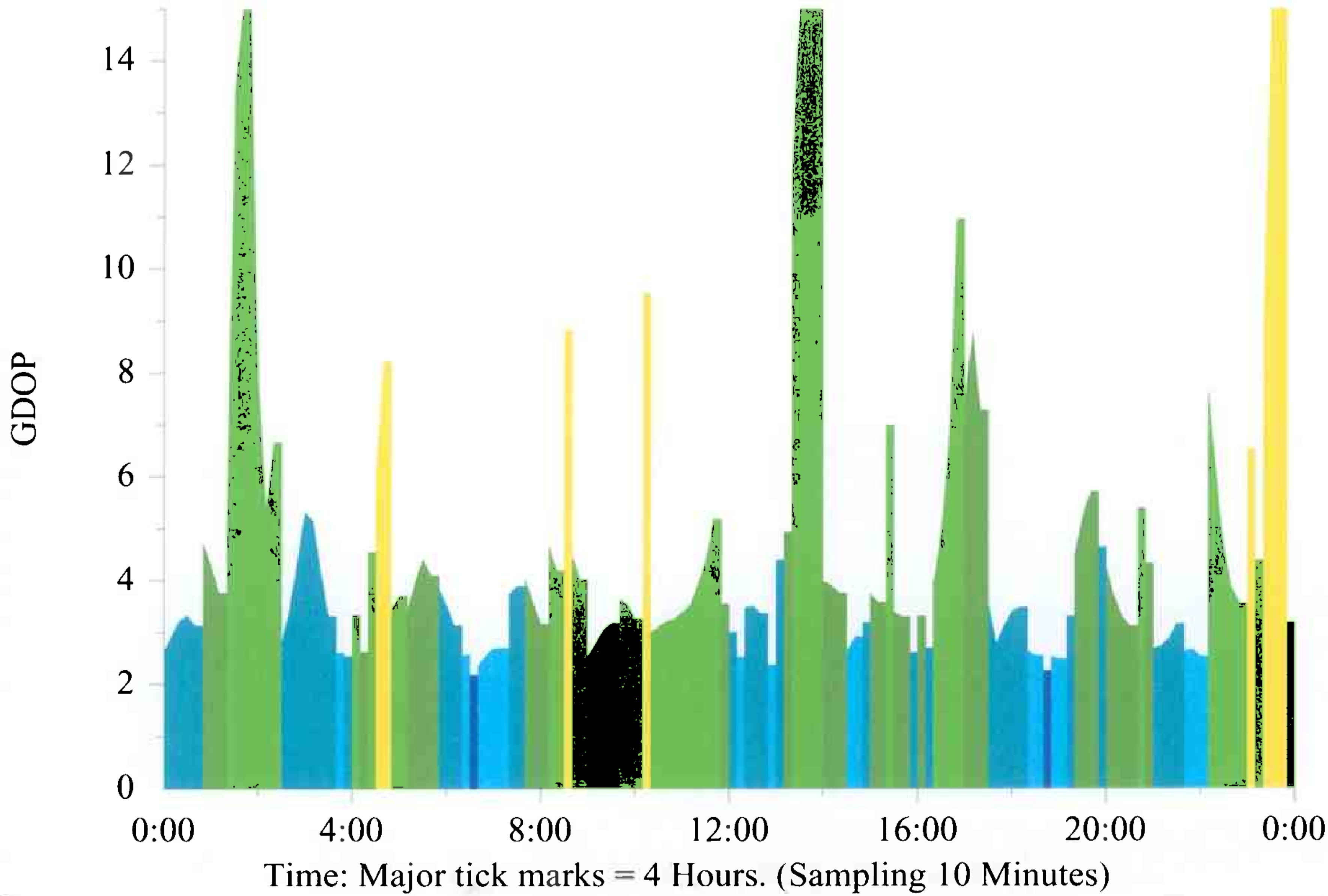


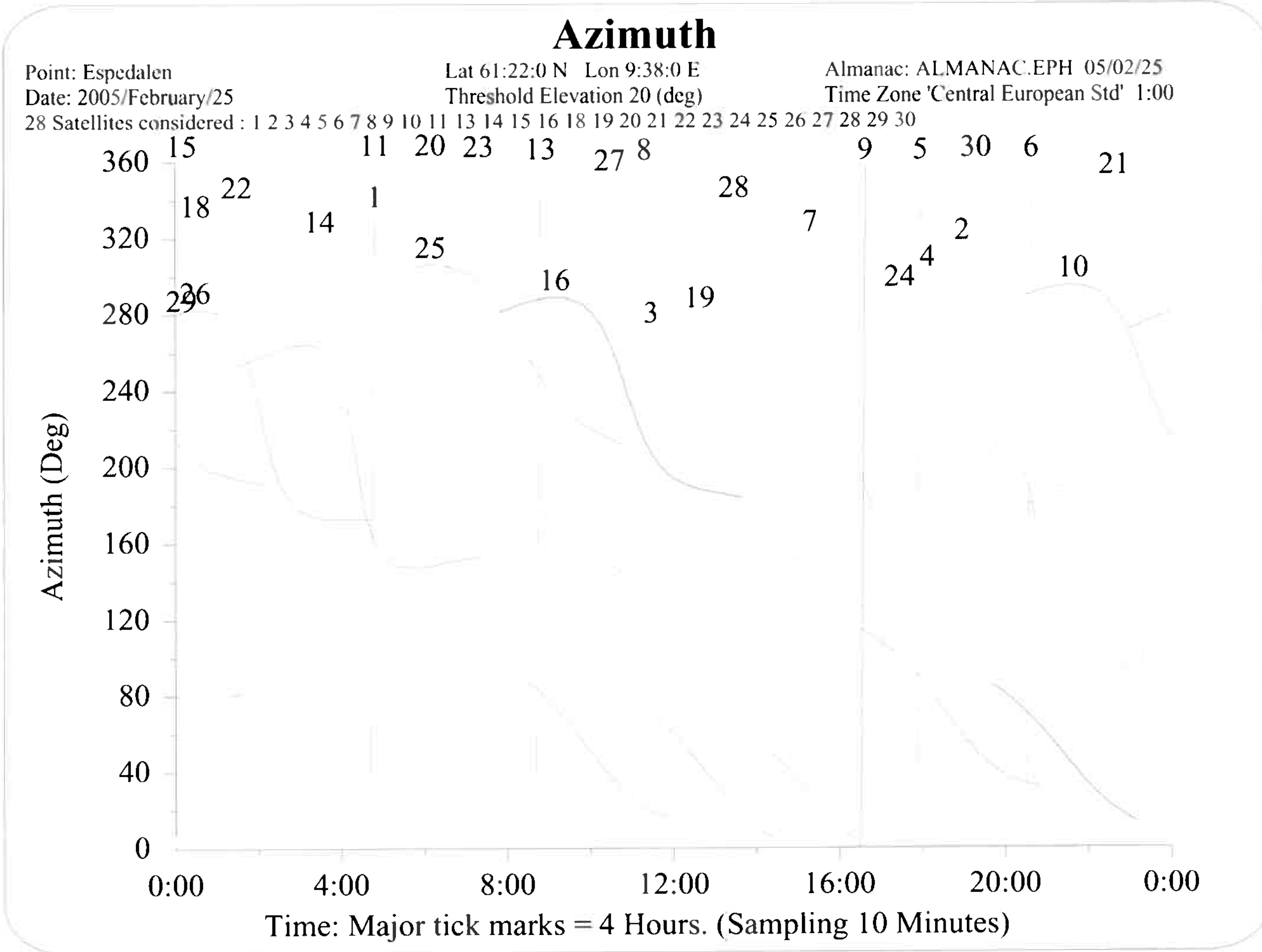
Time: Major tick marks = 4 Hours. (Sampling 10 Minutes)

APPENDIX E.4

GDOP

Point: Espedalen | Lat 61:22:0 N Lon 9:38:0 E | Almanac: ALMANAC.EPH 05/02/25
Date: 2005/February/25 | Threshold Elevation 20 (deg) | Time Zone 'Central European Std' 1:00
28 Satellites considered : 1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 18 19 20 21 22 23 24 25 26 27 28 29 30




Azimuth
Point: Espedalen
Date: 2005/February/25
Lat 61:22:0 N Lon 9:38:0 E
Threshold Elevation 20 (deg)
Almanac: ALMANAC.EPH 05/02/25
Time Zone 'Central European Std' 1:00
28 Satellites considered : 1 2 3 4 5 6 7 8 9 10 11 13 14 15 16 18 19 20 21 22 23 24 25 26 27 28 29 30
Azimuth (Deg)
360
320
280
240
200
160
120
80
40
0
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time: Major tick marks = 4 Hours. (Sampling 10 Minutes)

Appendix F References

Trimble Navigation,2000. *Mapping Systems Manual*

Telford, W.M., Geldhart, L.P., and Sheriff, R.E. 1990. *Applied Geophysics, 2nd Edition,* NY: Cambridge University Press

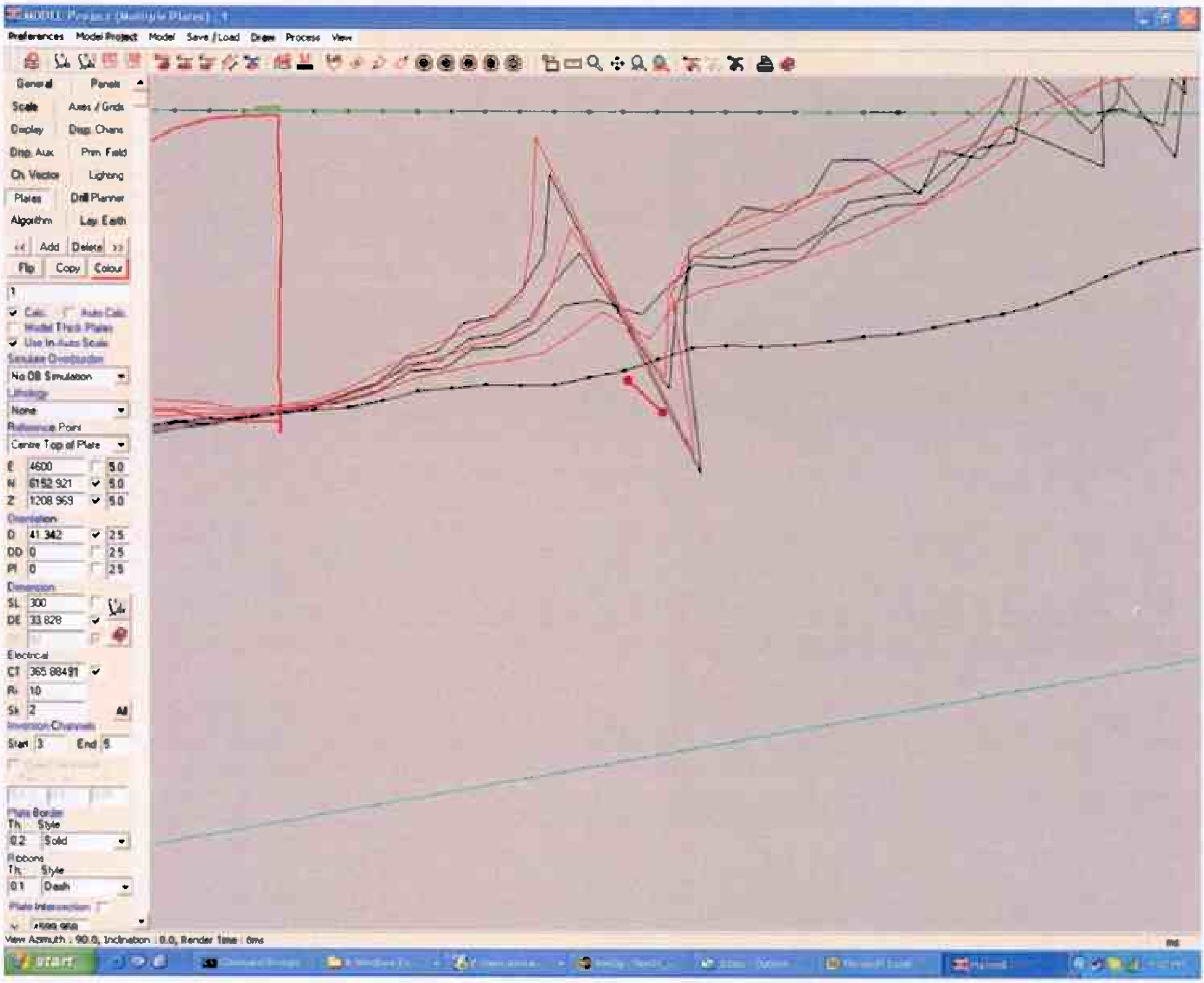
APPENDIX D

2005 In-house UTEM Maxwell Modelling

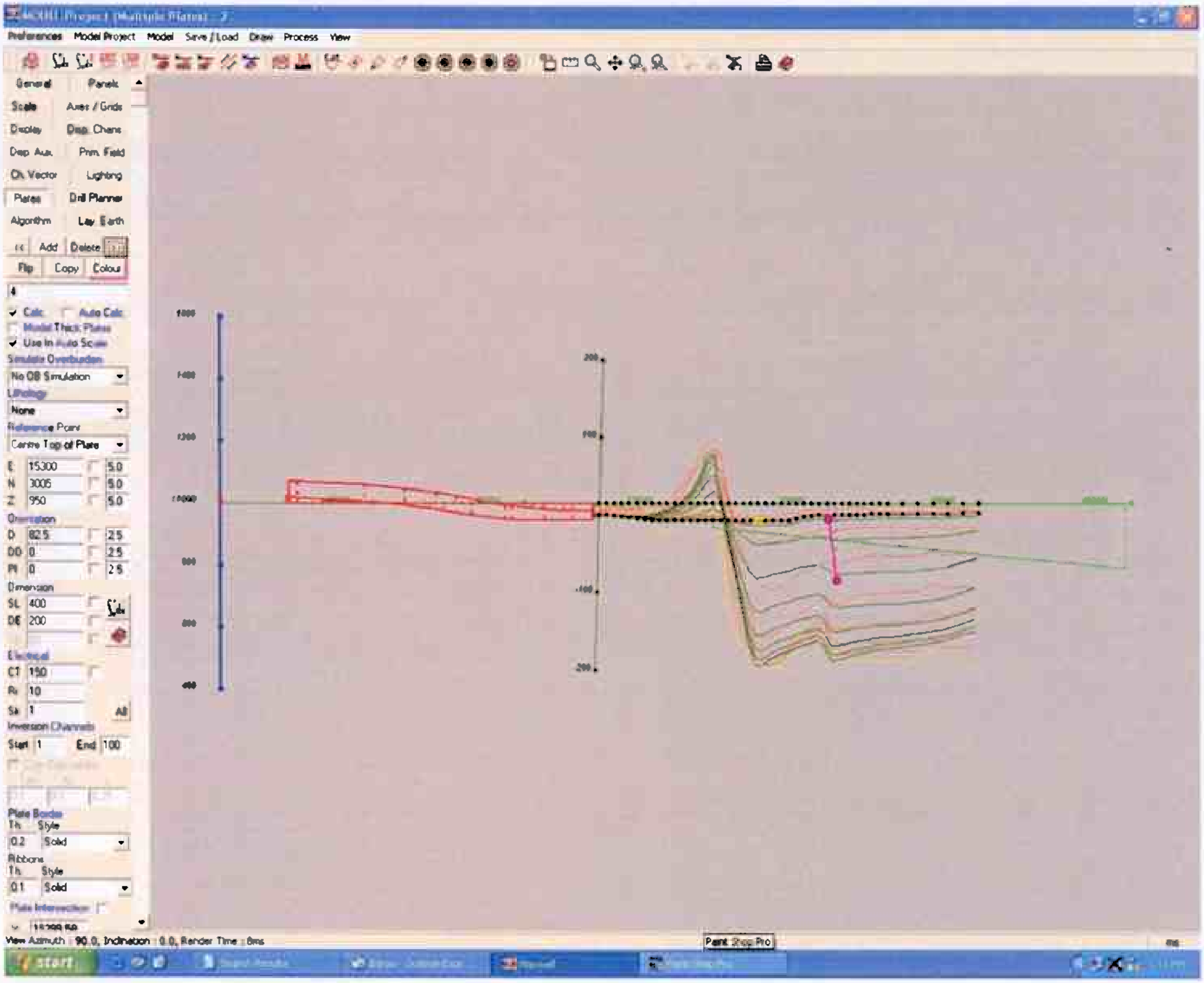
Espedalen Project, Oppland Province, Norway

Anthony Watts, Falconbridge Ltd for A/S Sulfidmalm.

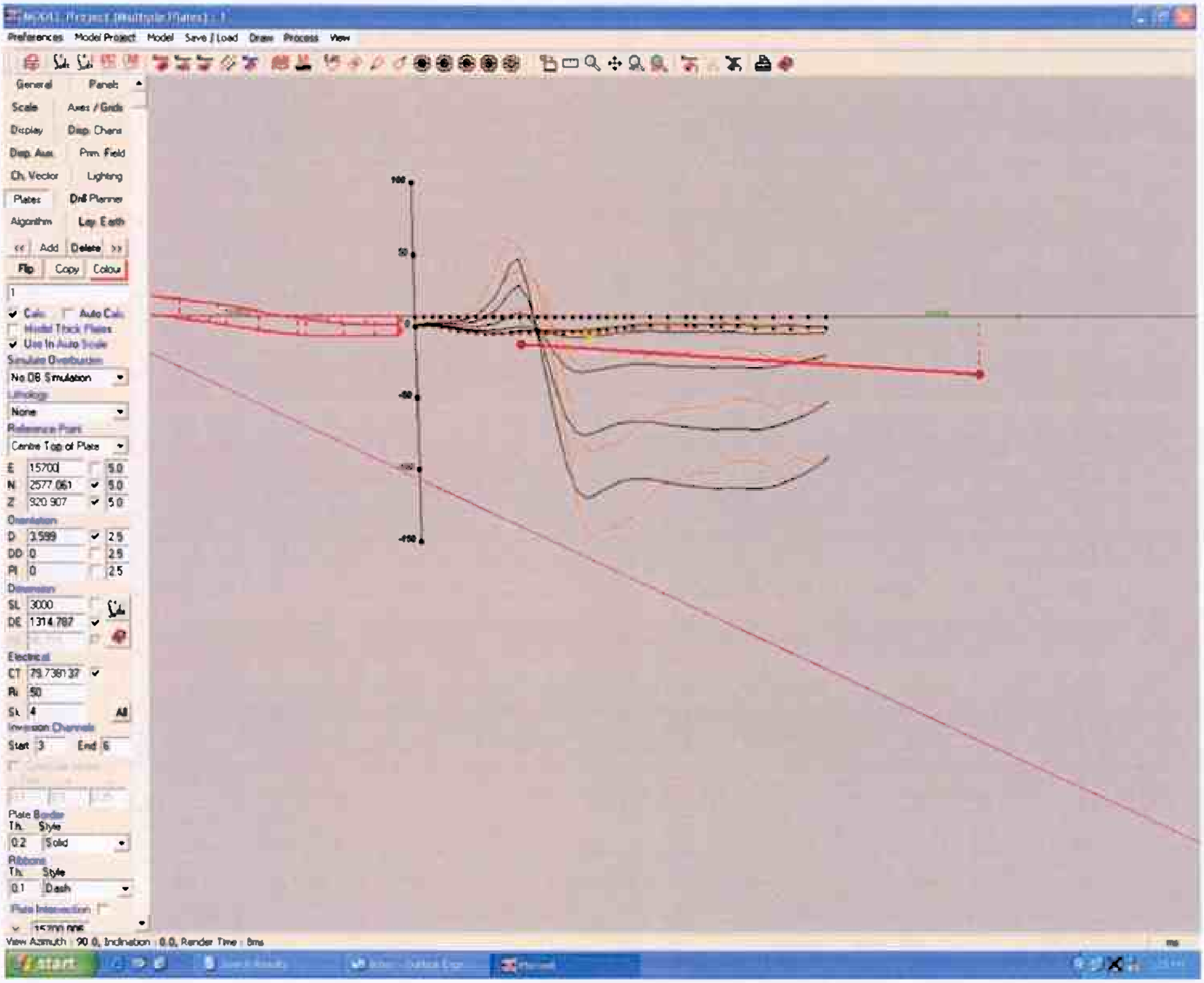
Model 1: Maxwell Model for Loop 9, Line 4600E
Model 2: Maxwell Model for Loop 27, Line 15300E
Model 3: Maxwell Model for Loop 27, Line 15700E
Model 4a: Maxwell Model for Loop 29, Eastern conductor
Model 4b: Maxwell Model for Loop 29, Western conductor



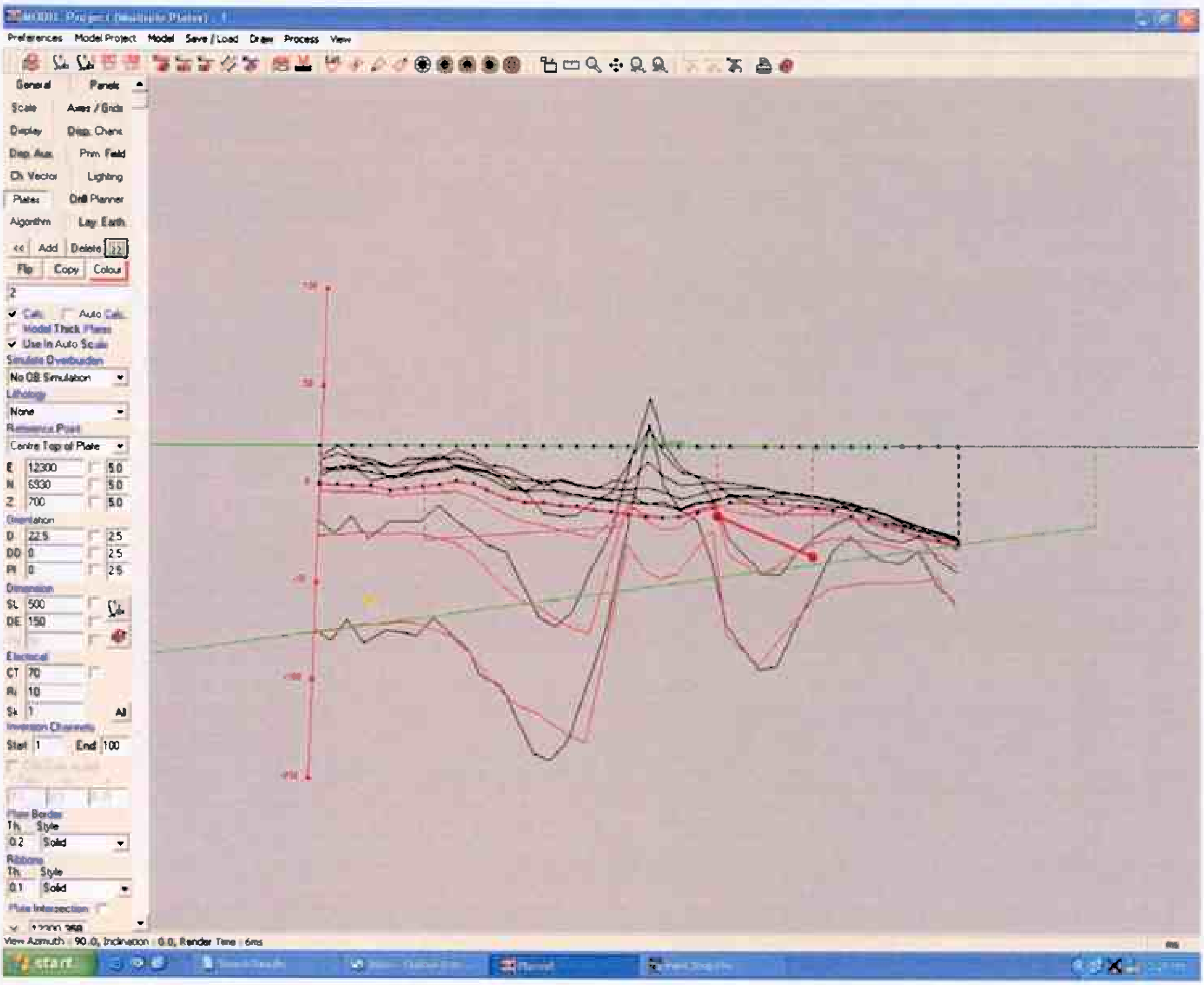
Model 1: Maxwell Model for Loop 9, Line 4600E



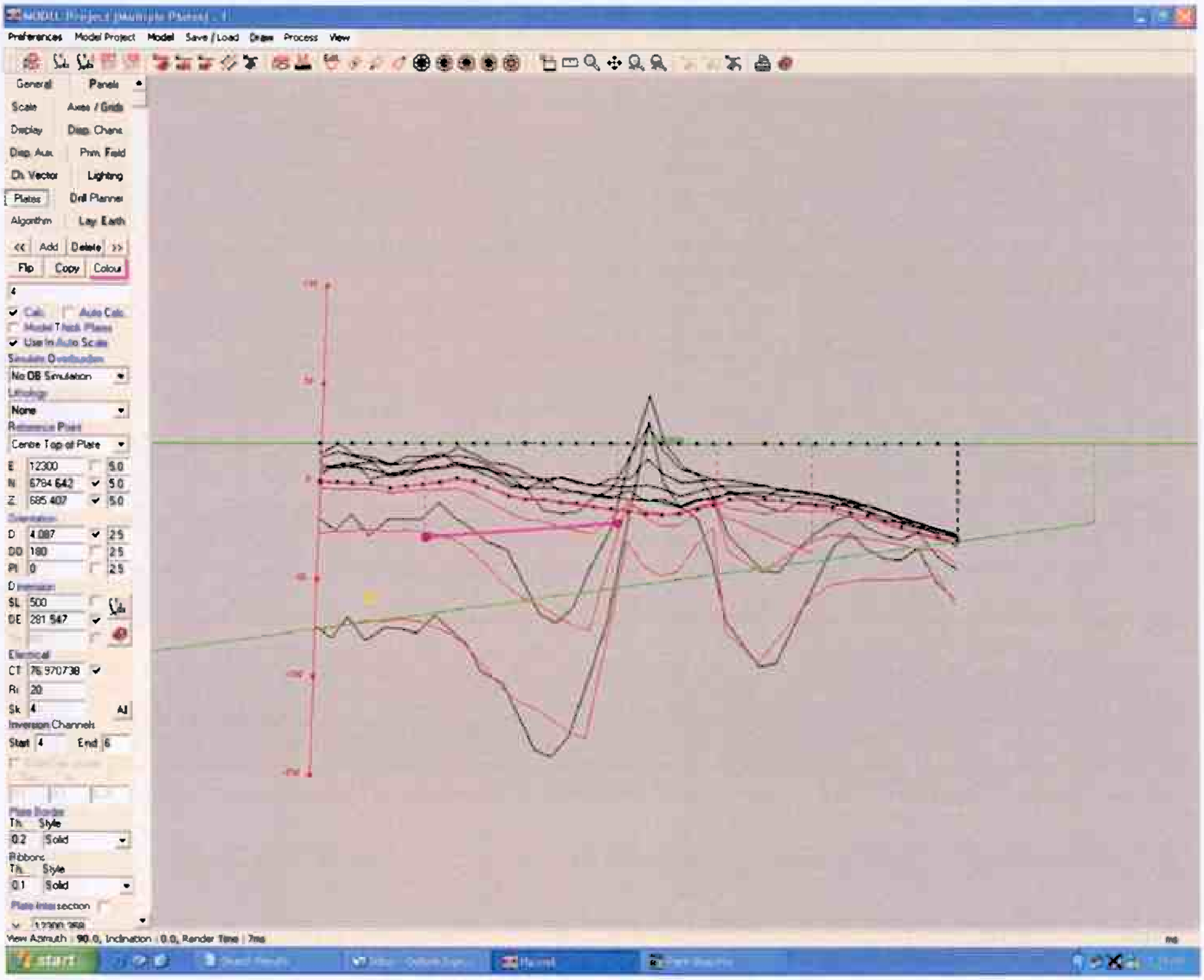
Model 2: Maxwell Model for Loop 27, Line 15300E



Model 3: Maxwell Model for Loop 27, Line 15700E



Model 4a: Maxwell Model for Loop 29, Eastern conductor



Model 4b: Maxwell Model for Loop 29, Western conductor