COMPUTERISATION OF OVERHEAD LINE SURVEY AND DESIGN IN THE ELECTRICIAL SUPPLY INDUSTRY

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ABSTRACT

The application of computers to 33kV and 11 kV overhead line surveys in the South of Scotland Electricity Board has called for a review of our traditional surveying methods. The Central and South West Area of the SSEB is a large rural one with a complex network of some 9000 km of overhead distribution lines. The constant maintenance, extension and reinforcement of the network results in approximately 100 km to be surveyed per annum. The two overhead line types account for approximately 80% of all the industry's surveyed overhead supply system. The major reason for the application of computers was to speed up the route selection and design process. This was achieved by using digital recording equipment and automatically processing the data on a computer and plotter. This paper describes the methods we used to achieve this.

DESIGN REQUIREMENT

The design and construction of overhead lines requires about 80% civil and 20% electrical engineering. It requires a type of survey that has little comparison in any other activity. An optimisation is obtained from the profile of pole heights, pole positions and span lengths according to the terrain in order that uplift condition is avoided and the statutory conductor-to-ground clearance may be maintained at maximum operating temperature giving the greatest sag.

The design criteria is catered for by having a standard specification for each type of line to be constructed. This regulates maximum span lengths, pole diameters, staying arrangements etc. The profile is required to show, not only the rise and fall of the ground line, but also positions where supports could be erected to the best advantage. Obstructions to the line route must be shown such as trees, buildings, existing lines crossing the proposed route or positions where erecting a pole would be impracticable, e.g., gullies, rivers, roads etc. On this ground-line profile the supports and conductor catenary is plotted.

For accuracy of vertical measurements the profile is enlarged to a ratio of 1:10 vertical to horizontal.

CONVENTIONAL METHOD OF SURVEYING

Most overhead line surveys are carried out 'on-line', i.e. the instrument is set up on the route of the overhead line (see Fig 1), which enables the route lengths to be measured by stadias and by arranging the stations to fall on angle positions, the angle of route deviation can be measured by the instrument. This enables angle pole staying arrangements to be identified.

Another method is the 'off-line' survey which offers the advantage of overcoming sighting obstacles in the line of the route, and usually requires less stations, but has the disadvantage that route lengths have to be chained, or measured by tachometry, (Fig. 2).

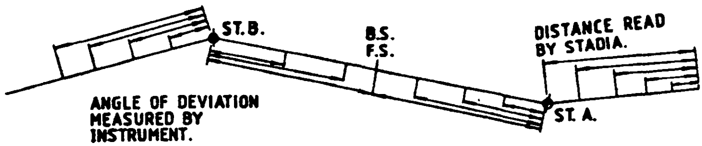

FIG.1.

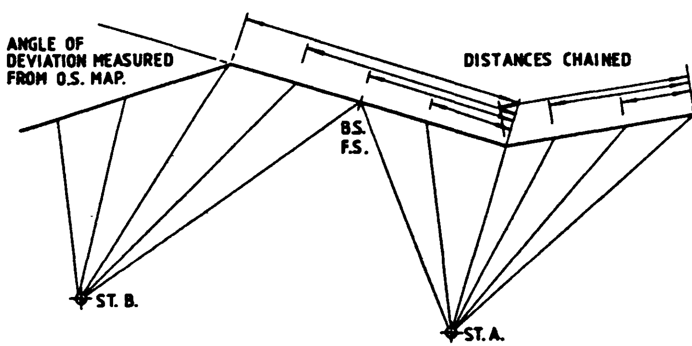

FIG.2.

The booking method is usually the 'height of collimation' which, with an average of 50 level points per kilometre, is laborious and liable to error.

By using a total station instrument, consecutive route lengths can be calculated by the instrument automatically using the more attractive 'off-line' method.

COMPUTER AIDED SURVEY EQUIPMENT

The instrument used at the SSEB Central and South West Scotland Area is the GEODIMETER 140 Total Station Instrument and the GEODAT 122 numerical data logger.

The GEODAT has four standard programs to chose from to enable the surveyor to input data in sequence, with the option of programming the GEODAT to suit himself. We found that one of the standard programs was suitable for our type of data.

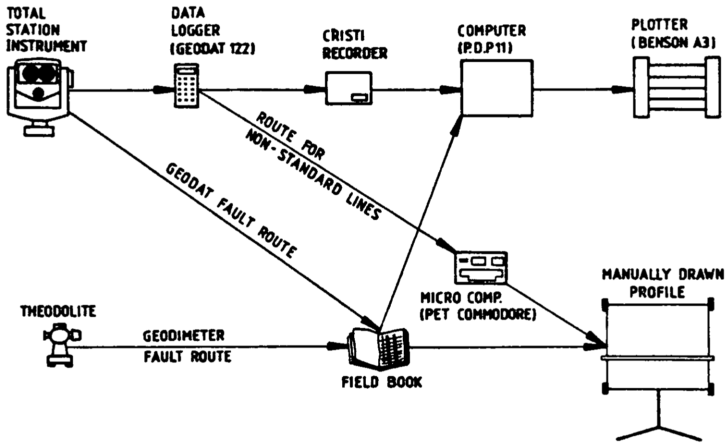

FIG.3.

SURVEY METHOD AND ACCURACY REQUIRED

Surveyors may find the methods used at Hamilton unconventional, but not all surveys require the degree of accuracy that most civil construction work demands. In order to explain our modification of standard surveying methods, it should be understood that when a pole is planted in the ground, usually to a depth of 1.5 -2.0 metres dependant on pole height, that most pole holes are mechanically excavated. A tolerance of ± 0.1M is practical with the depth of the excavatiion being difficult to determine with any greater accuracy. Ground levels can be indistinct e.g., levels taken across a recently ploughed field can vary by this amount depending upon whether the target is placed at the top or bottom of a furrow.

Profiles have been standardised throughout the industry to a scale of 1:200 vertically, so 0.1M at this scale becomes little more than a pencil line, hence no greater accuracy is required. The horizontal scale is 1:2000.

Limiting the accuracy means that input field data could be simplified and it was decided to dispense with the station height measurement. As the target height can be set at the same height as the instrument and need never vary, except for the addition of a set extension section, then the reduced levels obtained, show a profile of the ground line, parallel to and station height above the actual ground line. The only time the station height is required, is when the height to an obstruction or overhead line crossing has to be measured, then the instrument height is added to the target-to-obstruction height. To overcome this, an average station height was introduced into the program of 1.55M, this relates to a surveyor 1.78M tall but can easily be altered if required.

Off-line surveying becomes much more attractive with a total station instrument as route lengths can be calculated from accurate horizontal angles and distances recorded by the instrument.

CONVERSION SOFTWARE

A programme was written in BASIC for a 'PET Commodore' micro-computer to present the data in a straight forward x-y display, subdividing the data into sections of straight lengths between route deviation positions. The program will cater for on-line or off-line surveys taking the instruction from the initial 'info.' line on the data logger. A sample of the print-out is shown in Appendix A.

A FORTRAN program was also developed to use the same data to produce a complete profile of ground line and supports on a drum-plotter. Span lengths and pole heights are optimised, with the surveyor having the option to select pole positions. The program recognises obvious "no-pole' areas such as, roads, rivers, ditches, etc., but can be instructed on 'no-pole' areas either in the code, the data logger, or by the computer keyboard, e.g. where required by the land-owner or for planning considerations.

With all survey readings being transferred automatically to the Geodat, the surveyors involvement is reduced to sighting the instrument, pressing a button and coding the level point. The decision as to where the level point is required falls more onto the shoulders of the targetman because the longer range of the instrument isolates him from close supervision and necessitates the use of portable R/T units. There is now an argument for surveyor and targetman to change places as the responsibility of code identification can be made in either position.

SURVEY CODES

At the start of a survey, an eleven figure information code is fed into the GEODAT data logger stating, on or off-line survey; day month and year; district of survey; and job number. The surveyor has the chance to monitor and edit the data either during or after the survey.

A code system was evolved to satisfy both data output routes as shown in Appendix B. This four figure code is decided by the surveyor from his knowledge of the terrain, requirements of the specification, and from information given to him by the targetman. The codes give the surveyor the opportunity to dictate pole positions or increase the ground to conductor clearance height, in the field or in the office. Boundaries are normally preferred pole positions and can be supported by a figure 1 in the third column.

Side-slope in the fourth column, saves the surveyor the trouble of taking off-set levels in order to determine the increased conductor height (Fig. 3). The drum plotter will show the side-slope line as a dotted line above the centre line of the route. The amount of side-slope can be easily estimated by the surveyor using a hand-held inclinometer.

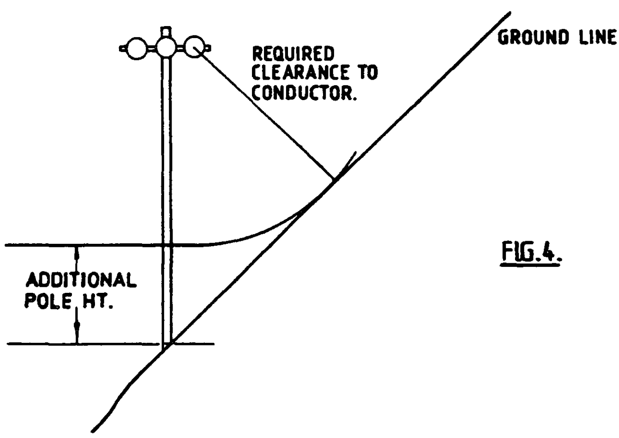

FIG.4.

When reading onto a backsight, the same point number is fed into the Geodat and the program will calculate the new height of collimation, unless a figure of 4, 5, 6 or 7 is entered in the first column in which case the program will expect the next reading to be a vertical angle in order to find the height of the crossing.

COMPUTER PRINT-OUT

The print-out shown in Appendix A is used for all non-standard overhead lines (re-stringing etc.), which have to be plotted manually, but it is possible to use the drum plotter to produce the ground line only.

Two print-outs are provided by the drum plotter, one is the complete profile as shown in Appendix C, and the other a material list compiled from the profile and line specification data. For clarity unnecessary information was omitted from the profile. Pole numbers, height of poles in metres, diameter at 3M from butt in milimetres, and type of pole, i.e., terminal, section angle, intermediate or straight line section, is shown above the pole. All hedges, fences, walls etc., are shown as boundaries. A pole fixed by the surveyor is marked with an 'F' below the ground line but if he is not happy with the plot then he is able to delete his fixed positions, re-run the plot with new positions or allow the computer to select positions.

Heights of lines crossing the proposed route are given in a table at the end of the profile as these have to be adjusted for the temperature of the day and position of intersection. We found that it was simpler to plot these onto the profile on completion of the plot after all the essential information had been gained and the equivalent height calculated.

The program will always chose the smallest support to give the required clearance with the most economical span length. A material list is then compiled from the completed profile summating all the materials required to construct the line. This is a normal requirement at the end of a profile, however the computer output allows the production of lists for wayleave negotiations or tree felling schedules etc.

CONCLUSION

The application of computer equipment has resulted in a much quicker turnover of profiles, the involvement in the Drawing Office has meant that a full day's plotting time is reduced to little less than ½ hour at a work station and field work has been reduced by 50% on former conventional methods.

ACKNOWLEDGEMENTS

I wish to thank the SSEB for allowing me to present this paper to the conference and also my colleagues for preparing software and carrying out field trials.

APPENDIX 'A'

SPECIMEN PRINT-OUT

OFF LINE SURVEY
DATE 30.01.86
CENTRE FALKIRK
JOB NUMBER 374
SURVEY FILE NAME HEATHHALL 1
SHEET 1

NO.	CODE	DESCRIPTION	HEIGHT	RED.LEV.	LENGTH
1	0100	PASTURE	-	40.33	
2	0100	PASTURE	-	41.00	32.48
3	0100	PASTURE	-	41.94	68.35
4	0100	PASTURE	-	42.84	98.93
4	5100	11 kV XING PASTURE	10.2M		
5	1100	BOUNDARY PASTURE		43.25	127.40
6	2100	WATER EDGE PASTURE	-	41.83	152.75
7	2175	WATER EDGE PASTURE SLOPE START	-	41.85	184.83
8	0303	ROUGH SLOPE ADD 2.63M (7.83)	-	43.33	206.46
9	0303	ROUGH SLOPE ADD 2.63M (7.83)	-	46.87	246.83
10	0762	TREES ANGLE POSITION SLOPE			
		ADD 1.43M (6.63)	-	49.21	305.10
11	0780	TREES SLOPE ENDS	-	51.74	19.47
12	0605	ROAD	-	52.93	31.13
13	1105	BOUNDARY PASTURE	-	52.78	40.15
14	1200	BOUNDARY ARABLE	-	54.53	78.19
15	0200	ARABLE	-	58.60	92.29
15	6200	33 kV XING ARABLE	9.6M		
16	0200	ARABLE		56.46	124.73
17	1200	BOUNDARY ARABLE	-	59.21	156.84
17	1200	BOUNDARY ARABLE	-	59.21	156.84
18	0200	ARABLE	-	61.51	189.21
19	0200	ARABLE	-	62.69	234.52
20	0200	ARABLE	-	66.81	268.10
21	0200	ARABLE	-	70.11	291.85
22	1360	BOUNDARY ROUGH ANGLE POSITION	-	72.03	352.15
23	0300	ROUGH	-	73.82	5.82
24	0100	PASTURE	-	71.18	48.20
25	0100	PASTURE	-	68.08	108.32
26	0100	PASTURE FIXED POLE	-	61.72	152.01

ANGLES OF DEVIATION

Point Number	Angle (Degrees)
10	31.75
22	5.18

SSEB - C & SWS AREA - GEODAT CODES FOR PET COMMODORE PRINTOUT & PDP11 PLOT APPENDIX B

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
1 BOUNDARY (walls, fences, hedges) 2 WATER EDGE (lakes, ponds, etc.) 3 DITCH 4 L.V. CROSSINGS 5 11 kV CROSSINGS 6 33 kV CROSSINGS 7 TRANSMISSION Next reading must be a sighting onto the crossarm or conductor. (PET or PDP11) ALL CODES IN THIS SECTION ARE SINGLE POINT READINGS	1 PASTURE 2 ARABLE 3 ROUGH 4 BOG 5 TURF 6 ROAD 7 TREES 8 WATER 9 RAILWAY <u>PDP11</u> ALL CODES IN THIS SECTION WILL CONTINUE WITH THE STATEMENT UNTIL CHANGED, i.e. END OF BOGLAND WILL BE DEFINED BY ZERO OR ALTERNATIVE CODE	1 FIXED POLE Plots pole in this position. (PDP11) Prints 'Fixed Pole'. (PET) 2 NO-POLE START 3 NO-POLE END Personal requirement for a pole not to be placed in this area. This code is not required for river, railway road or lake (PDP11) 4 EXTRA CLEARANCE START 5 EXTRA CLEARANCE END Program will ask what extra clearance is required if these codes are used (PDP11) 6 ANGLE Horizontal angle will be printed on profile (PDP11) and on print-out. (PET) Also route length will be zeroed. 7 SIDE SLOPE START 8 SIDE SLOPE ENDS Plot dots a side slope line from ground line to level of slope in last column (PDP11) 9 PE's & TEE-OFFS Add 1m to height of pole equipment or Tee-off crossarm (PDP11)	1 15° SLOPE Plots dotted line 0.5m above reduced level and allows extra conductor clearance. (PDP11) Prints 'add 0.5m (5.7m)' (PET) Bracketed figure is minimum total reduced level to conductor height required. 2 25° SLOPE Plots dotted line 1.43m above reduced level. (PDP11) Prints 'add 1.43 6.63m)' (PET) 3 35° SLOPE Plots dotted line 2.63m above reduced level (PDP11) Prints 'add 2.63 (7.83m)' (PET) 4 45° SLOPE Plots dotted line 4m above reduced level. (PDP11) Prints 'add 4m (9.2m)' (PET) 5 ADDITIONAL TARGET HEIGHT Subtracts 1.5m from reduced level.

APPENDIX 'C'

SOUTH OF SCOTLAND ELECTRICITY BOARD

CENTRAL AND SOUTH WEST SCOTLAND AREA
FALKIRK SERVICE CENTRE
HEATHHALL 1

SURVEYED BY W. IRONS. DATE 30. 01. 86.
CHECKED BY RIP DATE 3. 2. 86.