New Techniques for Orienteering Maps: GPS and Electronic Printing

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Abstract

Creating maps for orienteering sport is a special segment of cartography. The evolution of cartographic production techniques has had an impact also on the orienteering map genre. But interestingly, the field work of orienteering maps has not met any profound changes during the modern orienteering mapping era, i.e. during the last 25 years. A Finnish orienteering club wanted to renew the most time consuming stages of orienteering mapping: field work and digitizing. The solution was GPS.

The accuracy of GPS is fully satisfactory for large-scale orienteering maps. But to gain good accuracy, careful planning is needed. Using GPS for data collection can substantially reduce the time needed for field work and digitizing, thus saving a lot of money from the most expensive part of the mapping process.

As an other major redefinement, the first map of Korahdus was printed by using a high-quality color laser printer. Electronic printing reduced the costs of printing by 50 % and also enabled flexible work flow.

1 Introduction

Orienteering club Kokkosenkylän Rasti ja Risahdus, or Korahdus for short, was founded in 1993 to act as an R&D body within the field of orienteering sport. The first real project we carried out was to make a 1:10,000 map for a national orienteering competition by using GPS. The area, Arvila–Hanttu (3,5 km^2), is located in Mäntyharju, some 170 km north-east of Helsinki. From a mappers point of view it is not the easiest area, due to thick spruce coverage and a dominating slope facing north.

Earlier, GPS has not been fully used for orienteering mapping purposes. Several experiments have been made, but not any full map had been mapped by GPS. Some of the early experiments were conducted using heavy instruments and at a time when not all 24 Navstar satellites were operational. In our project, a handheld GeoExplorer GPS receiver and PFINDER software (both from Trimble) were used. OCAD (of Steinegger Software) was used for digital cartography.

Even the best stereobase has some white spots in it, due to shades or obstacles. Filling these holes is the primary task of an O mapper. To simplify, all features specified in the International Specification for Orienteering Maps must be mapped.

2 The Mapping Process

A schematic overview of the mapping process can be seen in Figure 1. For the project, we set up a mapping office (our club house) in the middle of the area to be mapped so we could easily process the data.

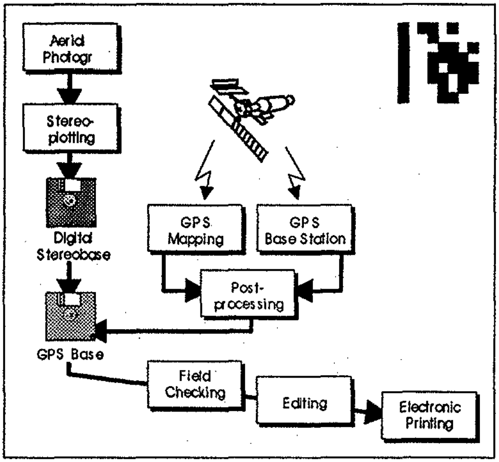

Figure 1: Mapping process overview.

2.1 *Aerial Photogrammetry*

To provide new aerial photos over the area, an aerial photogrammetry was conducted in May 1994. The flight was carried out by National Land Survey of Finland. The flying height was 3400 m (10800 ft). GPS navigation was used to guide the flight and camera (Leica RC-20) so that the photos were taken at the pre-set locations for optimal recovery of the terrain in stereoplotting.

2.2 *Stereoplotting*

Stereoplotting was done by a specialized stereomapping company (Suuntakartta) in the end of July. The plotting took two days and it was done by using a modernized stereoplotter (Kern PG-2), yielding digital data in OCAD format. An important part of the stereoplotting was to georeference the stereo models and thus the digital base map to the national coordinate system (ZCS). To achieve this goal, accurately measured (through aerial triangulation) control points were used in the orientation of the stereo models.

2.3 *GPS Base Station*

We had a GPS base or reference station (Trimble Community Base Station) located in Helsinki. The base station recorded the reference point measurements at an interval of five seconds. Each set of 720 successive fixes or measurements (corresponding to one hour of elapsed time) was packed in separate file and uploaded to a BBS server.

2.4 Creating Project Database

A database was created for the mapping project. Datum, map projection and coordinate system were defined. A data dictionary was created, defining and coding 30 different features: boulders, small knolls, paths etc. No attributes were defined.

2.5 Mission Planning

Rough mission planning was done prior to any GPS measurements. A graphical almanac was created, showing the best time windows for measurements and proposed breaks, respectively. This plan reveals the best satellite constellations for accurate measuring.

2.6 Setting the Origin

An origin point was set by

1. moving the OCAD map file so that the origin point had internal OCAD coordinates of (0, 0);
2. measuring the real ZCS coordinates of the origin point with GPS; and
3. creating an OCAD conversion file (CRT), having these coordinates as the shift parameters required by OCAD.

This origin point serves as the pivot for the transformation between GPS measurements and OCAD software.

2.7 GPS Field Checking

The GPS field checking was done during the lushest time of the year, end of July.

Before starting measurements, a rover file must be opened; all measurements will be stored in this file. A feature was measured simply by standing on it (or walking along it) and pressing the *start* and *stop* function buttons. In theory, a single fix or measurement would have been enough in most cases, but a minimum of five fixes was stored. Since fix interval was set to 1 s, measuring a point type feature took 5 seconds or more. GeoExplorer processes the fixes of a point type feature so that the feature gets the average coordinates of the fixes.

After measuring the last feature of a session, the rover file was closed. At the mapping office, the data was uploaded from the GPS receiver to a PC. The required base station measurements were downloaded from the BBS over a modem line. After this, differential corrections were made and the corrected data was written to a DXF file. This file was imported to OCAD using its DXF interface. During the transfer, the feature codes of the GPS file were automatically converted to those of OCAD.

2.8 Field Checking and Editing

Especially elevation contour lines – the most important and hard-to-map part of a modern orienteering map – were field checked traditionally and edited, using OCAD. Essential savings were achieved in this step, since the GPS field checking had produced a very good framework for fine-tuning the other features.

2.9 *Electronic Printing*

The map was printed electronically. To accomplish this, the map was transferred from OCAD to a PostScript (EPS) file and taken to a service bureau (Kuva-Pulssi). The EPS file was processed using Fiery RIP image processing system and printed with Canon CLC 500 laser printer. The output resolution of the printer was only 400 dpi, but the quality was surprisingly good.

3 Conclusions

3.1 *GPS*

Since averaging is used in determining the coordinates of a feature, it was soon found out that in poor conditions more than five fixes were needed in order to get an accurate positioning.

The accuracy of the our mapping method was questioned by many professional mappers and mapping authorities both in Finland and throughout the world. A vivid discussion was conducted over the Internet [3]. So far, the only way we have demonstrated the usefulness and accuracy of the method has been showing a tracking map from our orienteering event (September 24, 1994), where one competitor was equipped with a GPS receiver (similar to the one used in the mapping). The recorded data was dowloaded to a PC and overlaid on the Arvila–Hanttu digital map (in OCAD). No postprocessing was needed, since the SA code was disabled (due to US activities in Haiti). The results of this tracking can be seen in Figure 2. During tracking, the PDOP mask was set to 10. The PDOP diagram of the tracking can be seen in Figure 3.

Figure 2: GPS recorded track of an orienteer: GPS tracking data overlaid on the Arvila–Hanttu map. Map scale here approximately 1:5000.

In a sense, orienteering mapping in a typical Finnish terrain is an extreme test for GPS, since the topography and tree coverage introduce a tough challenge to the receiver. We believe that if a receiver fits our requirements – as it did in this project – it can be recommend for use in any mapping project with comparable accuracy requirements. Our experiences show, that the claimed accuracy of 2–5 m CEP was reached. This was also our requirement for absolute accuracy. Trimble's Pro XL was also tested, giving even much better results: 1 m RMS accuracy. Detailed error studies are presented in [1].

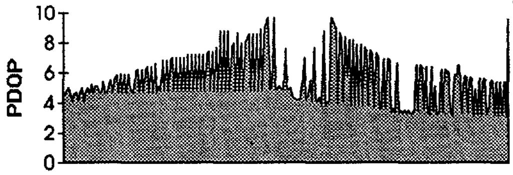

Figure 3: PDOP during the tracking [1].

GPS saved a lot of time, although the method introduced some new steps in the process. GPS was found to be most useful in the thickest bushes, i.e. in areas where the stereo model could not show any details, saving up to 70 % time. Traditional field checking methods (precision compass and tape measures) were made purposeless. Since the data collected with GPS is digital from the very beginning, there is no longer a chance for typical errors found in traditional orienteering map process: once a feature is collected, it can not be 'forgotten' or accidentally misplaced at any later stage. Another major advantage of GPS is its insensitivity to weather. Extensive discussion of GPS usability for O mapping can be found in [2, 3].

In near future, we will use real-time RDS/DGPS for another mapping project.

3.2 Print Quality

In our premier event, we had some 300 competitors, who can be said to be professional map users. All were asked a simple question about the map: "How do you compare this to traditional maps?" Written answers were surveyed and the collective answer was very positive and encouraging: "Better than normal maps."

If the terrain had been a very detailed one, the output resolution of the printer would not have been good enough. Furthermore, the situation would have been even worse, if a map scale of 1:15,000 was used.

References

[1] Donner Jan: *(A manuscript on DGPS for mapping.)* In Finnish. To be presented as a Master's Thesis at Helsinki University of Technology, May 1995.

[2] Korahdus: *Korahdus and GPS.* An online World Wide Web document at `http://www.mmh.fi/maa/kepa/co/korahdus/GPS-facts.html`, 1995.

[3] Korahdus: *O-net GPS-talk.* An online World Wide Web document at `http://www.mmh.fi/maa/kepa/co/korahdus/GPS-talk.html`, 1995.