The Northern Greenland Mapping Project: A Report.

Lars Tyge Jørgensen
Geodetic Institute, Topographic Division
Denmark
Comission IV, Working Group 6.

Abstract

At the ISPRS congress 4 years ago in Hamburg it was stated, that orthophotomaps at scale 1:100 000 were to be printed in 1980, but until now no maps have been printed.

In the meantime approximately 750 models have been scanned, checked, oriented and converted into orthophotos, coastlines plotted into sheets at several scales, all to meet the needs of the Geological Survey of Greenland.

Introduction

In the summer of 1977 the Geodetic Institute of Denmark (GID) began the mapping process of Northern Greenland. The area of interest covers approximately 300 000 km^2 of uninhabited waste mountainous ice-desert, and the project was scheduled to run for five years, beginning in 1978. It was decided to work out an orthophoto map at scale 1:100 000 with computerized contour lines.

The first thing to do was to carry out a new photomission at scale 1:150 000. This was done in the summer of 1978, succesfully. The next thing was to purchase instruments for the project: monocomparator, instrument for height information collection, and an orthophoto projector. The monocomparator and a point transfer device were delivered in the autumn of 1978, and a Wild B8S and an OR1 in the winter of 1979.

1978 was the first of three years of geodetic field work in this area to obtain geodetic control. The number of sheets was estimated to 110. They were to be produced in parallel to the field work at a rate of two or three map sheets per month.

The project was split into smaller projects and delegated to the departments of GID: ground control and calculation of aerotriangulation to the Geodetic departments, copying and printing to the

Technical Department, and the rest to the Topographic Department. The photoflight was carried out by a private firm, Mark Hurd Aerial Survey Inc.

The project introduced modern technology to the Topographic Department. The use of computers started years ago in the Geodetic Department, but when this mapping project started in 1978 the Topographic Department was a production unit using hand engraving and drawing, enlargement by cameras etc. A flat bed plotter was used to plot grids and sheet limitations, but the plotter was situated outside the house of GID.

Aerotriangulation

The Geodetic Departments had no experience in aerotriangulations or in photogrammetric measurements at all, but the job was carried out very professionally, and was not at any time behind time schedule. The area was separated into large blocks and ajusted separately. The results were stored in index sequential files on the computer and made available for the Topographic Department by direct acces. The aerotriangulation has been delayed for some years to the benefit of other parts of the project, but it will be finished at the end of this year or in the beginning of 1985.

Acquisition of height information

The acquisition of height information serves two purposes: the calculation of orthophotos and the calculation of a digital terrain model, from which the contour lines are to be derived.

The basic instrument in the process is a Wild stereoplotter B8S equipped with a coordinate registration device EK20 and a scanning device PEB8.

The scanning of models takes place only in relative oriented models in order to save the time for absolute orientation. The model scale is 1:75 000, and in this scale a grid of 3 x 3 millimeters is scanned. The instrument is operated in one shift per day, and before the start of the project it was estimated, that the scanning rate would be two models per day. Due to the rough terrain it has been necessary to reduce the scanning speed, hardware, to the half. The model scanning rate is now approximately 200 models per year or one model a day. The number of models was originally estimated to 1300 but has now been corrected to approximately 1100 models. At the end of 1983 750 models have been scanned, and the scanning of the total area is expected to be completed at the end of 1985.

In the years of 1979 and 1980 a severe error appeared in the tape station of the PEB8. The error occured unsystematically, and the effects were blocklength errors on the tape, missing data etc. The most serious fault was the missing data, because the digital terrain model program required data in a grid, so when data were missing the model had to be remeasured. Up to 30% of the models had to be rejected, and the operators were demoralized. The control of tapes took place in the Geodetic Departments some 10 km from the Topographic Department, and the tapes had to be transported by car to the computer. It took hours, and in the meantime the model in the instrument was replaced by a new one, and thus it was impossible to "repair" the measurements. After several visits of technical personnel - without any effect - it was decided to replace the tape station. Since this was done very few errors have been reported on the tape station.

Before the tape station was changed it was discussed to perform a preliminary check of data "on location", and a desc calculator HP9825 was purchased together with a small plotter. The aim was to insert the calculator between the EK20 and the tape station. Then it would be possible to plot control points and coast lines and to calculate and plot contour lines scan by scan. Problems arose concerning buffering the data, and a discette station was purchased. In the meantime the tape station was replaced, and the errors related to "non human" sources disappeared. The person who programmed the desc calculators was the same person who was programming the calculation of contour lines, so this programming was heavily delayed. This became inacceptable, and the project concerning the desc calculators was rejected, and all the effort was concentrated on the contour line calculating program. Until now the desc calculators have not been connested to the B8S. Instead a new setup was adapted, a fast connection to the main computer was installed, and the measurements are now transmitted to the computer. A plot consisting of control points, coast lines, and contour lines are computed and transmitted back to a Tektronix 4014 graphic screen. Before the plot is made a numerical control is made wether all scanlines are present, and the coast lines are counted and controlled visually. Most errors are found in this way. Very few models have been rejected by the operators because of the visual control of the model plot.

Production of orthophotos

The soft ware to calculate orthophotos was planned to be the 16-bit version SORA-program from Wild Heergrugg. The program was installed in the computer of GID, but after one year the program was abandonned due to problems concerning the Danish 24-bit computer, and it was decided to develop a quite new program based on the same principles as the SORA-program. The programming time was about one year, and the program was put into production in 1980. Test showed that the minimum slit of 5 millimetres, delivered with the OR1, was too long, taking into account the terrain in Greenland and the scale of 1:100 000. So slits of 3 and 4 millimetres were purchased, and the 3 millimetre slit seems to be suitable for the terrain of Greenland. Standard input to the program is two models. The program itself calculates coordinates for the corners of the orthophoto, finds the photocoordinates in the resultfile from the aerotriangulation, interpolates the digital terrain model, and calculates the controldata for the orthophotoprojector. Then the data are taken over by an interactive program, which simulates the orthophotoprojector, i.e. asks for the basic magnification, and then calculates the profiles in which zoomlens and doveprism alarm will occur. The construction principles of the OR1 allow the zoom alarm to be moved from one scan to another. In this way it is often possible to move the alarm to one of the edges of the orthophoto, and later on to cut off the edges. The limitations of the movements of the doveprism is +-85 degrees, but never the less alarms occur often caused by dead angles in the photograph, and therefore these alarms can not be moved. The orthophoto has to be reduced to avoid doveprism alarms. The orthophotos are claculated with an overlap of 60% to give a possibility to cut the edges. Until now it has been possible to cover all areas with orthophotos. The projecting time in the OR1 is approximately one hour, and the minimum speed has been halved to avoid the violent movements of the zoomlens and the doveprism.

The first testprints showed a bad photographic quality of the orthophotos. Investigations have showed, that the demands to a diapositive, from which an orthophoto for printing is to be made, is incompatible to the demands to a diapositive used in a stereoplotter. This new production of diapositives is also utilized to make the differences of densities in the different diapositives more equal, because in average 20 orthophotos add up one sheet.

Calculation of contour lines

The original demand to the contour lines was an interval of 20 metres, but it showed very soon, that an interval of 100 metres was more realistic. Test plots of the calculated contour lines showed, that many problems had to be solved, before the demands of the cartographers were fulfilled. Two tasks shall be mentioned.

From the beginning of the project it was decided to devide the total area into two parts: "water" and "not water", and the digital terrain model was initialized to "water" overall. This was done to avoid computation of contour lines in the water areas. When a model has been scanned the recorded movements of the measuring mark ande the coast lines make it possible to devide the model into these two categories. The basic principle in the calculation of contour lines from the digital terrain model is to compute small parts of the lines in a square formed by foru points. If just one of the points was labelled "water" the calculation was omitted in the square. The consequence of this strategy was, that a contour line close to the coast was interrupted and often not calculated at all. This was not acceptable, and a new label "almost land" was introduced. Together with these points a fictive height is stored making it possible to calculate the xy-position of the coast line, and now it is possible to prevent the calculated contour lines from crossing the coast line.

Single points recorded in the stereoplotter are plotted to give the cartographer the possibility of putting spot heights on the sheets. During this process it was discovered, that contour lines were missing due to the fact, that a digital terrain model tends to cut off maximas and minimas of the terrain. Therefore the top contour line is often missing. The contour lines become unreadable, and this is not acceptable. Now all single points are stored in the digital terrain model causing a deformation of the grid of the model. This ensures, that all contour lines are calculated. The problem is now, that not all maximas or minimas have been provided with a single point, because the single points originally were intended for the reparation of the scanning in areas, where the quality of the scanned points was expected to be poor. This happens in areas of bad stereoscopic sight, dark shadows, pure white snow, or in areas of dead angles. In fact those points were intended to be a kind of substitution of break lines, which were decided not to be measured. This decision must be seen in the light of the (very optimistic) expectations to the map itself, the intended publication rate (5 years total production time), and the accuracy of the existing maps covering the area. Further more a loss in accuracy due to the absence of break lines is not tantamount to a loss in information, because the information is still in the orthophoto. The information is just slightly displaced according to the fact, that the slit of the OR1 occupies 300 metres in the terrain.

Cartographic design

The original demand to the map series was an orthophotomap, scale 1:100 000, with superinposed contour lines, placenames, a grid, and information at the margin of the map. This is a very simple design - the orthophotomosaic speaks for itself. The map series mainly intend to serve one user, The Geological Surway of Greenland, with a special need: a base map as a tool for working out a geological map series covering the area. It was decided to use minimal human effort in working out the final map. The orthophotos were to be mosaiced along straight lines, without retouche, the watermasks were to be produced directly from the plotted coastlines etc.

Because the coastlines are used to devide the entire area into "water" and "not water" the same coastline may be recorded up to four times in different models. The models may be measured by different operators, and these may disagree in the exact coastline. The coastline is often very difficult to locate because it is hidden behind pack ice pushed into the coast by sea or wind, or because glaciers gush out to the sea and hide the coastline. It has not been possible to find a practical way of combining all those small parts of coastlines to one single coastline. Therefore the decision was taken, that the mask for water should be scribed by hand using the plotted coastline only as a key. These efforts were made to obtain blue water on the maps, but later on it was decided to change the pure blue to blue combined with a pack ice screen to avoid the perception that this sea is navigable.

The layout of the contour lines has been testprinted too. The test included positive, negative or coloured lines. The colours tested were blue, orange and grey. Negative (white) contour lines would have the advantage to disappear in areas covered by snow. In these areas scanning is more doubtful than in other areas, and the contour lines often degenerate to meander lines. It has been decided to print the contour lines in black, alternating thick/thin to improve the readability of the contour lines.

The datum of the map series was originally decided to be World Geodetic System 1972, but the strongly delayed production made it possible to change this decision to North American Datum 1983. The area of Northern Greenland is covered by 10 UTM zones, zone 18 to 28. The zones 20, 23, and 27 have been chosen as construction zones. This can be done, because the zones at these latitudes are so narrow, that there is no risk of scale distortion. At an early stage of planning two versions of the map series were planned, one with a geographical grid and one with a UTM grid. These two versions have been combined to one version. The sheet margin will be in three languages: Greenlandic, Danish and English. All authorized placenames will be on the maps.

The sheet index has been defined on the basis of plots of the coast line and a geographical grid. Each sheet will be a half degree of latitude high, and the width will be approximately 75 km.

Four sheets form a block according to a later map series at scale 1:250 000. The total number of sheets are now estimated to 100.

Substituting remedies

It has been mentioned, that the map series mainly serve one user: The Geological Survey of Greenland. The absence of maps has, of course, been of great inconvenience to the Geological Survey, but the GID has made great efforts and spent resources to remedy the lack of maps. More than half the area has been covered by orthophotos and these were delivered to the Geological Survey. In the area of Peary Land contour lines have been computed model by model and plotted. These plots have been mosaiced by the Geological Survey itself to serve as preliminary maps in field service. About 40 sheets have been calculated and plotted in scale 1:100 000 including all control prints and all coastlines, lakes and islands. Tests have been done concerning stereo orthophotos, but it turned out, that the cost for stereo orthophotos is too high. The publishing order has been prepared to serve the Geological Survey as well as possible.

Latest

In April 1984 the first sheet was released for printing.

References

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