DIGITAL MAP PRODUCTION APPLICATION

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1. INTRODUCTION

In many meteorological work station applications, which present data in a graphical form, a map is used as a background on which data is layered. The map provides the means of easily relating data to geographical location. At the Danish Meteorological Institute (DMI), a UNIX/X/Motif based application for producing digital maps for this purpose has been developed. The application extracts map information from the Digital Chart of the World (DCW) which is a CD-ROM based product containing digital map information with full coverage of the world.

This article briefly describes the features of the DCW database and the functionality of the Digital Map Production Application. At the end, a summary of the experiences we have had with the DCW database is given.

2. THE MAP DATABASE

The digital map data previously used for DMI purposes has deficiencies. Therefore it was desirable to select a new map data source to be used by the Digital Map Production Application.

2.1 Selection of a new map database

At DMI, digital map data has previously been obtained from various sources. The most commonly used source has been the CIA map database. This database is sufficient for maps at large scale, e.g. maps covering Europe or the whole world, but not for maps at small scale such as a map of Denmark. The deficiencies of the CIA map database are:

- Some major Danish locations are missing.
  This is of course undesirable for DMI whose main responsibility is the Danish area.
- The resolution is low.
  This means that the distance between the end points of the line segments (vectors) is large, resulting in very coarse coast lines of the Danish islands.
- It supports line features only.
  This means that you cannot have maps with coloured areas such as the oceans or the land since the necessary polygon definitions to be used in fill routines are not available.

- Features are outdated.
  This is particularly the case for boundaries, e.g. the West/East German border.

These deficiencies were found to be adequately annoying for considering an alternative database.

The selected alternative is the Digital Chart of the World database which will be described in the following section. The main reasons for selecting DCW are:

- It has a high resolution.
- It covers the whole world.
- It contains point, text, line and area features.
- It is reasonably up-to-date (July 1992).
- The pricing is low, approximately £250.

2.2 The Digital Chart of the World database

DCW is a digital map database produced by the U.S. Defence Mapping Agency. It contains map data covering the whole world. The map data has been derived from existing map sheets, primarily Operational Navigation Charts and Jet Navigation Charts, and is stored in Vector Product Format (VPF). The size of the database is approximately 1.7 GB.

The map data is divided into four high resolution libraries (1:1,000,000) and a low resolution library (1:31,000,000) in order to ease data management. Each high resolution library contains data for a particular geographical area:

- Europe and Northern Asia
- North America
- South America, Africa and Antarctica
- Southern Asia and Australia

The low resolution library is called Browse and has full world coverage. It is intended for overview maps and contains therefore less feature types than the high resolution libraries.

The libraries are again divided into thematic coverages. A coverage is a collection of map feature types which share some characteristics. In other words, a coverage may be viewed as a map feature category. The main coverages seen from a meteorological application view, is the political/oceans, the hypsography and the drainage coverages. The political/oceans coverage contains feature types like borders, coastlines, land, ocean, etc. The hypsography coverage contains elevation curves and zones. Finally, the drainage coverage

contains all inland water features such as lakes, rivers, canals, wadies etc. Within the coverage, data is stored in relational tables in VPF format. The VPF format divides features into four classes:

- Point features
  This class is used to represent features with minor or no geographical extent. This might for instance be small towns, airports, buildings or spot elevations.
- Text features
  This class is used to represent text associated with other features. This might for instance be the name of an ocean, a town or a mountain.
- Line features
  This class is used to represent features with a linear structure such as roads, borders or coastlines.
- Area features
  This class is used to represent features with a certain geographical extent. This might for instance be an ocean, land, an elevation zone or a lake.

For the high resolution libraries DCW uses a tiling scheme. A tiling scheme is a subdivision of the data of a coverage into data belonging to equally sized geographic areas. In DCW, the tiling scheme used divides the world into 5° x 5° rectangular tiles, the borders of which follow the latitudes and longitudes. The tile borders defines the limits of the line and area features of the tile. This means that the polygons defining area features crossing the tile border are guaranteed to be closed at the tile border, i.e. the polygon will include the tile border. Similarly, line segments of a line feature crossing a tile border are guaranteed to have an end point on the tile border. In other words, if you draw using the line and/or area feature data of a tile, the drawing will be correct. The tiling scheme also provides cross-tile references for following line and area features across the tile borders, if needed.

3. THE DIGITAL MAP PRODUCTION APPLICATION

3.1 High-level Application Goals

The high-level goals which the application shall fulfil are as follows:

- The platform on which the application is to run shall have the following characteristics:
  - The operating system shall be UNIX.
  - The window system shall be X/Motif.
- The application shall allow the user to specify:

  - The map projection to be used.
  - The geographical extent of the map.
  - The map features which the resulting map should contain.
  - The resolution of the map.

- The specified map shall be displayed on-screen in the chosen projection in order to enable the user to verify that the map corresponds to the one wanted.

- The map retrieved shall contain all data of the tiles necessary to cover the specified map area. By retrieving all data of the tiles necessary to cover the specified map area and not just the data exactly within the specified map area, the user application may draw the map without having to close polygons and cut edges at the borders of the map area. Instead, the user application may leave the clipping of the drawn map, such that it fits the desired map area, to the clipping algorithm of the display software.

- It shall be possible to dump the retrieved map in a file such that it can be loaded by other applications.

3.2 Application Features

From the high-level goals stated in the previous section the application functionality was derived. The application was then implemented in C++. Figure 1 below shows the main window of the application.

At the top of the window is a menu bar with two pull down menus denoted "Map" and "Projection". From the "Map" pull down menu, the user may choose to save the map or exit the application. If the user chooses to save the map, he is prompted for the save format and a file name in a dialog window. The save formats supported are:

- Binary (to be implemented)
- ASCII (to be implemented)
- PostScript

From the "Projection" pull down menu the user may choose the map projection to be used. The user selectable map projections are polar stereographic projection or Mercator projection, which are the projections used at DMI. Having selected a projection, the user is prompted for projection specific parameters, e.g. the reference longitude etc.

Below the menu bar are two panes. The pane to the left is a drawing area in which maps are drawn. The pane to the right is a control panel in which map features are chosen, in which the geographical extent of the map,

the resolution and the zoom factor are specified, and finally, in which retrieval and display of the map is initiated.

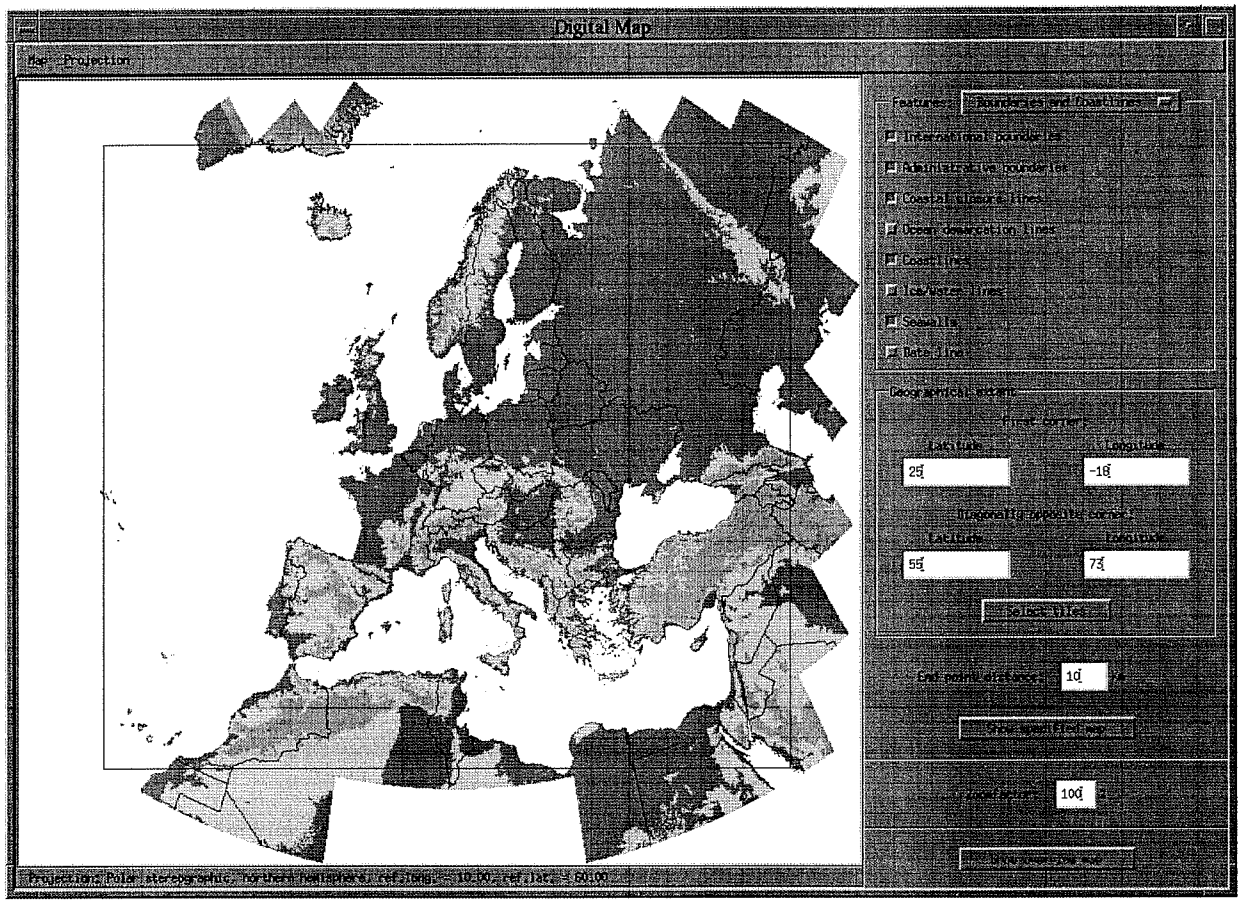

Figure 1: The main window of the application

At the top of the control panel is a subpane denoted "Features" used to select map features. Using the option menu button at the top of the subpane, the user can select the feature category. If a new feature category is selected, the toggle buttons below will be replaced by the toggle buttons for the feature types of the selected category. Using these toggle buttons, the user may select the feature types of the category to include in the map.

The map feature categories (coverages) currently supported by the application are:

- Political/Oceans
- Drainage
- Hypsography

- Roads
- Populated Places

Within these categories the line and area feature classes are supported.

The user may specify the geographical extent of the map in two ways:

- By typing the geographical coordinates of two diagonally opposite corners of the desired map. This will result in a number of tiles being selected which correspond to the tiles necessary to cover the specified geographical area. As a future extension, the tiles selected shall be marked in an overview map displayed in the chosen map projection.

- By mouse selection in an overview map (future extension). The user may select a number of tiles from an overview map, displayed in the chosen map projection, by dragging a "rubberband" with the mouse or by selecting single tiles using mouse-clicks.

The resolution of the map is specified in the text input field denoted "End point distance" as the minimum distance between the two end points of a line segment at the reference latitude of the map projection. The reason for specifying the distance at the reference latitude is that this latitude is where there is 1:1 correspondence between a distance on the earth and on the projection plane.

Zooming in/out on the map may be performed by specifying the zoom percentage.

4. DCW EXPERIENCES

Having implemented an application interfacing the DCW database, quite some experience regarding the quality of this product has been obtained.

Our main impression of DCW is that it is a major step forward compared to the previously used map data sources. The resolution of the maps which may be produced from DCW is quite impressive, and also important to DMI: all major Danish locations are present. Compared to its relatively low price, the quality is quite good.

We have encountered some problems in DCW, but these are minor compared to the deficiencies of the previously used map data sources. The most serious problems encountered are:

- Some of the tile borders, especially in the oceans, are not correctly vectorized, i.e. they consist of a single line segment. If the projection does not project the latitudes and longitudes, and thereby the tile borders, as straight lines, the correctly vectorized tile borders will appear as non-straight lines whereas the incorrectly vectorized tile borders will appear as straight lines. This results in "holes" at

the tile border between polygons of area features crossing an incorrectly vectorized tile border neighbouring a correctly vectorized tile border.

- The tiling scheme is not fully implemented. The Antarctic area (below -60° latitude) is covered by four tiles only instead of several hundred.

- Some polygons for area features have the wrong feature type. E.g. land below sea level in the Netherlands is associated with the feature type for the elevation zone 0-1000 feet above sea level.

- The Browse library is not very useful. The data does not fully conform to the VPF format in the sense that line and area features are not related to entries in the table defining the lines of the line features and the polygons of the area features. This means that you either have to draw all lines and polygons with the same colour, since it is impossible to distinguish these on feature type, or draw none at all. Additionally, the political/oceans coverage contains non-vectorized latitudes/longitudes at 90° intervals. First of all these latitudes/longitudes should not be there at all, and secondly, since these latitudes/longitudes are not vectorized they will erroneously appear as straight lines in a polar stereographic projection.