A NEW ON-LINE FACILITY FOR PROJECTION COMPUTATION

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Abstract

In the age of digital web-cartography, new on-line facilities are needed for an on-demand computation of geographic graticules, the transformation of data into appropriate map projections and also for a general use in the digital map production process. After several years of research, the Institute of Cartography at ETH Zurich developed a map projection program called KAPRO. Beside other projects, it was successfully used for the computation of all geographic graticules and data transformations in in the context of the editorial work of the Swiss School Atlas. The original software KAPRO, written in PASCAL code, is running as a batch-process under NT/Windows. The institute of cartography has now started a pilot project for converting the program KAPRO into an on-line www-version. This paper outlines the steps its implementation requires, describes the typical work-flow and presents first results. In addition, plans for further on-line program services are mentioned.

1. Introduction

In the last years the internet has become an important factor in the information society, and thus also in the sector of digital cartography. A new branch of cartography, the web cartography, has arisen. This new technology, now available for everybody, largely influences the actual map production process and requires categorically an adaptation of the conventional techniques to these modern map production facilities. On one side, today's cartographers must deal with this new working tools and learn to handle it reasonably. On the other side, a danger exists, that the high graphic quality, reached using conventional cartographic tools, is lost, especially if these tools are inadequately applied by laymen.

Currently the Institute of Cartography at the Swiss Federal Institute of Technology (ETH) has several web mapping projects under way. In this way we intend to get familiar with the available on-line mapping facilities. We would also like to point out new map production ways, which help the users to generate their maps in a high graphic quality. One of these facilities is a tool, that allows the on-line computation of geographic graticules, and the transformation of data into the appropriate map projection. In the following it will be reported from the experiences we gained by carrying out this project and the required steps for its implementation. Further on, the typical work-flow of such a computation is described and first results are presented.

2. Existing on-line programs for graticules computation and data transformation

On the internet, only a few links for on-line map projection programs can be found. "Map maker" (http://wubot.wustl.edu/mapmaker.htm)l is one of them, which seems to be very comfortable in it's use. It allows the specifications of various graticule parameters. It is an essential requirement, that allows the cartographer to produce graticules according his visions. Unfortunately, in "Map maker" the transformation of own data sets is not available as well as the visualization of the graticule deformation. Other programs are very restricted with respect to available map projections, to the specification of

projection parameters and to the definition of grid spacing. Therefore, such programs could rarely be used by a cartographer at his desire for the computation of geographic graticules.

One aim in our project for an on-line map projection tool was to offer a very flexible tool, that allows the handling of all map projection problems in an easy and comfortable way.

3. KAPRO-program (*KA*rten*PRO*jektions Programm)

The Institute of Cartography at ETH Zurich has developed a map projection program called KAPRO over several years. At the moment, more than 140 different map projections are incorporated. It was used successfully for the computation of all geographic graticules and necessary data transformations in connection with the editorial work of the Swiss School Atlas. The original software KAPRO is running as a batch-process under Intergraph-UNIX (CLIX) and Windows NT. Formerly it was conceived in a modularly manner. A program frame, which is valid for all projections, serves as a ground construction. For an implementation of a new map projection only the specific transformation equations had to be programmed and inserted at the right program position. Thereby, further projections may be integrated quickly and efficiently. With the program KAPRO the user is able to compute geographic graticules, to transform data given in geographic coordinates and to visualize graticule-deformations by means of the Tissot's indicatrices (fig.1). The specific projection parameters e.g. projection, scale, standard parallels, central meridian, origin, grid spacing etc. as well as the data must be made available as files, which are handed over to the program. The input data file must be written in ASCII code. The used data format is rather simple. Beside the geographical coordinates, latitude and longitude in decimal degrees, additional information concerning line start and successive points, as well as a layer definition must be specified. The output file is organized in the same manner, but instead of the geographical coordinates the x- and y-values of the transformed points into the appropriate map projection are listed. By the means of two plugins, which were programmed in-house, the output file data could be imported either as an Intergraph Microstation graphic design file or in Freehand format.
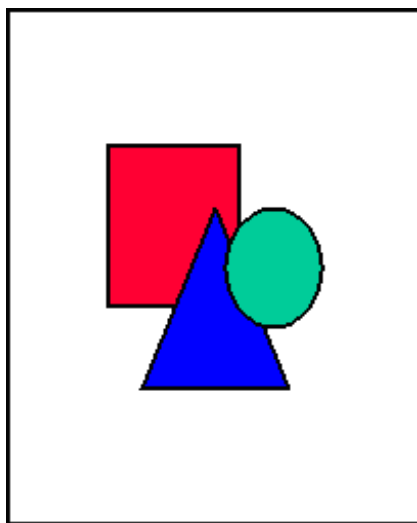

Fig. 1 The flow chart of program KAPRO

4. On-line Version of KAPRO and typical workflow

4.1 Advantages of the CGI-script technology

For the web-based version of KAPRO we used the powerful technology of the Common Gateway Interface (CGI). For this purpose the existing program was compiled in a LINUX environment. Then the executable was integrated in a CGI-Script, that was placed on our application server. The general workflow of CGI script application runs as described as follows. If a request from a potential user is received by the web server, it passes the needed parameters to the application server and call the

demanded CGI script for execution. The output is also transferred by CGI script back to the web server and then returned to the user's system by Hypertext Transport Protocol (HTTP) or File Transport Protocol (FTP). Figure 2 shows a typical workflow for a CGI script process.

The CGI script technology gives us the possibility to permanently control the KAPRO program. The user must not deal with numerous program versions and program failures or inadequateness. Moreover, the correction of program errors can be made by specialists, which are familiar with the voluminous program code. The delivery of the program source code to users is superfluous. Due to different compilers and/or PC specifications the exchange of program code could cause problems.
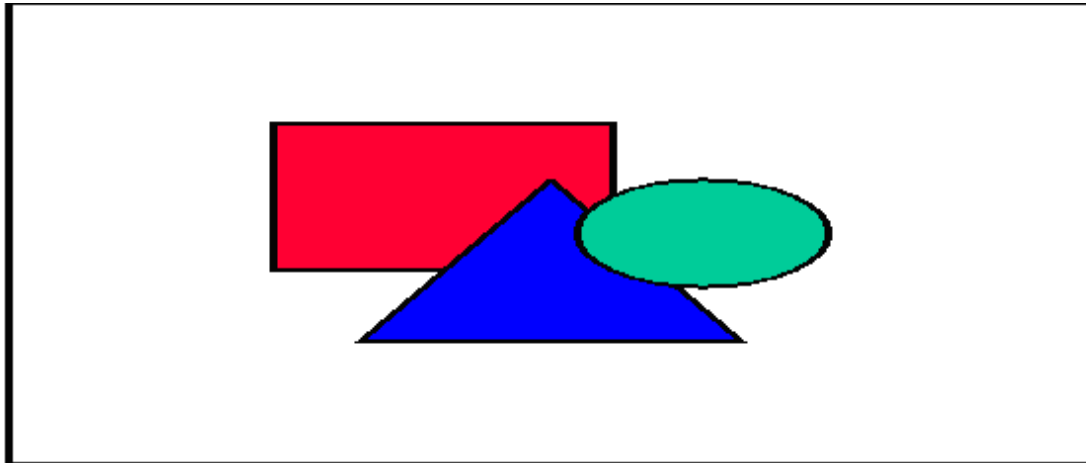

Fig.2 The flow of a CGI application.(from S.Guelich (2000) in CGI Programming with Perl)

4.2 The six work steps of the KAPRO on-line version

A typical on-line map projection application with KAPRO passes through six different steps. Some steps are performed on the user's system by means of a web browser, other on the server of the Institute of Cartography at ETHZ. For the data transfer between the user and the application server, HTTP-, respectively FTP–transfer protocols are used. Both protocols are very powerful for an exchange of large data volumes.
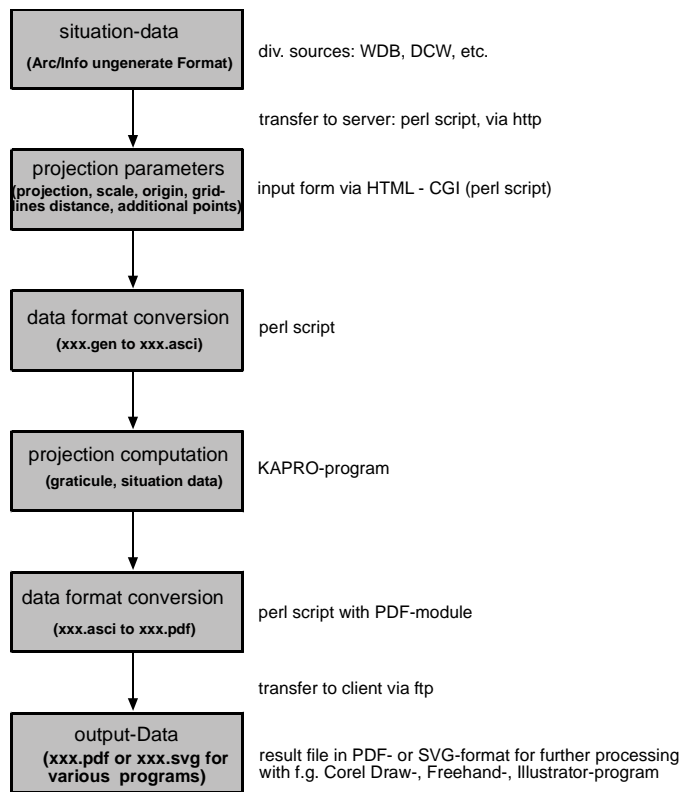
| situation-data | div. sources: WDB, DCW, etc. |
| **(Arc/Info ungenerate Format)** | |

transfer to server: perl script, via http

| projection parameters | input form via HTML - CGI (perl script) |
| **(projection, scale, origin, grid-lines distance, additional points)** | |

| data format conversion | perl script |
| **(xxx.gen to xxx.asci)** | |

| projection computation | KAPRO-program |
| **(graticule, situation data)** | |

| data format conversion | perl script with PDF-module |
| **(xxx.asci to xxx.pdf)** | |

transfer to client via ftp

| output-Data | result file in PDF- or SVG-format for further processing |
| **(xxx.pdf or xxx.svg for various programs)** | with f.g. Corel Draw-, Freehand-, Illustrator-program |

Fig.3 The six working steps for an on-line KAPRO application.

4.2.1 First step: The specification of the source data

Today a large amount of free digital data is available on the Internet. Possible sources may be: World Data Base I and II, which are given in geographic latitude and longitude. Both of these data sets covering the whole world are no more updated, especially impedimentary by using the international boundaries, where all the dramatic changes of the international border lines in the eastern part of Europe are not actualized. A second world wide digital data set, with coast lines, is The World Vector Shoreline (WVS). It is suited for a map production with a scale 1 : 250'000 and smaller. The data is very detailed and so voluminous that it is recommended to transform only small data sections of the whole file. Another wide usable data source is the Digital Chart of the World Database (DCW). The data are split into several layers and are arranged in 5x5 geographic degree tiles.
For the European area, the Seamless Administrative Boundaries of Europe (SABE) is offered. A data set with the administrative boundaries up to the layer of communities of 26 European countries. A proto-type for an European wide data set called Pathfinder towards the European Topographic Information Template (PETIT) is under way.
The input data format for KAPRO is ARC/INFO ungenerated. This format is well known and supposed in many commercial GIS-Systems as input or output filter. This specified input data were transferred to the institute server by a PERL script, using the HTTP protocol.

4.2.2 Second step: The declaration of specific projection parameters

The user can define the necessary parameters for the projection computation in an input form under HTML and a special CGI script. An access to this input mask is available by consulting the institute's home page (http://www.karto.ethz.ch/cgi-bin/projection.pl) (fig.4). The input parameters are grouped in two sections, a section for general parameters and another for projection specific parameters.
In the general parameter section the following parameters are specified:

Fig.4 The input form for the specification of the projection parameters (general and projection specific parameters).

1. The geographical extent to be considered, fixed with the minimal latitude and longitude respectively theirs maximal values. In the CGI script, a control, that refuses latitude values > 90 degrees or < –90 degrees is implemented. For the longitude this value is fixed for +/- 180 degrees. In this manner invalid input data, which can lead to unintended program failures can be avoided.
2. The desired map projection is chosen according to their name by using a pop up menu. At the moment more than 30 different projections are disposable. This practice demands, that the user has some knowledge about referring map projections, because the available place for additional description is very limited in this pop up menu.
3. The spacing between parallels and meridians can be defined at the appropriate position in the input form.
4. A very nice feature, that has not be seen until now anywhere else in a projection program is a possibility for defining the numbers of vertices within one meridian segment respectively one parallel segment. Thus the user is able to control the bending of the geographical graticule lines. This is a very useful and important parameter for getting smooth net lines without any visible break points.

In the section for projection, the following specific parameters were defined:
1. According to the selected projection further parameters must be defined. E.g. in azimuthal projections with an oblique aspect an origin must be fixed. Any desired central meridian is definable by almost all projection. Conical projections are normally laid out for one or two standard parallels.
2. For the computation of the Tissot's indicatrices a scale factor must be determined. A specification of the value null disables the computation and the output of the indicatrices.
3. In two additional boxes the spacing of the indicatrices along the meridians and parallels are defined.
4. In a further field the desired map scale can be entered.
5. The user can choose between two possible output data formats: Portable Data Format (PDF) and Scalable Vector Graphic (SVG). Both formats are rather new but will be implemented more and more in the most commercial graphic programs and browsers as input filter, so for example in Adobe Illustrator version 9 and Freehand version 9.

If the user is choosing SVG as output format, then a sub input form appears when activating the computation program button. In this form the specifications for the definitive symbolization of eventually to transform and to rotate symbols are also defined (see fig. 5) At the moment the user has 10 different symbols as default at disposition. The connecting link between the symbol code of the

input data and the specific symbol is realized by a number between 0 and 9. Beside this specification, symbol scale and symbol rotation can be entered.
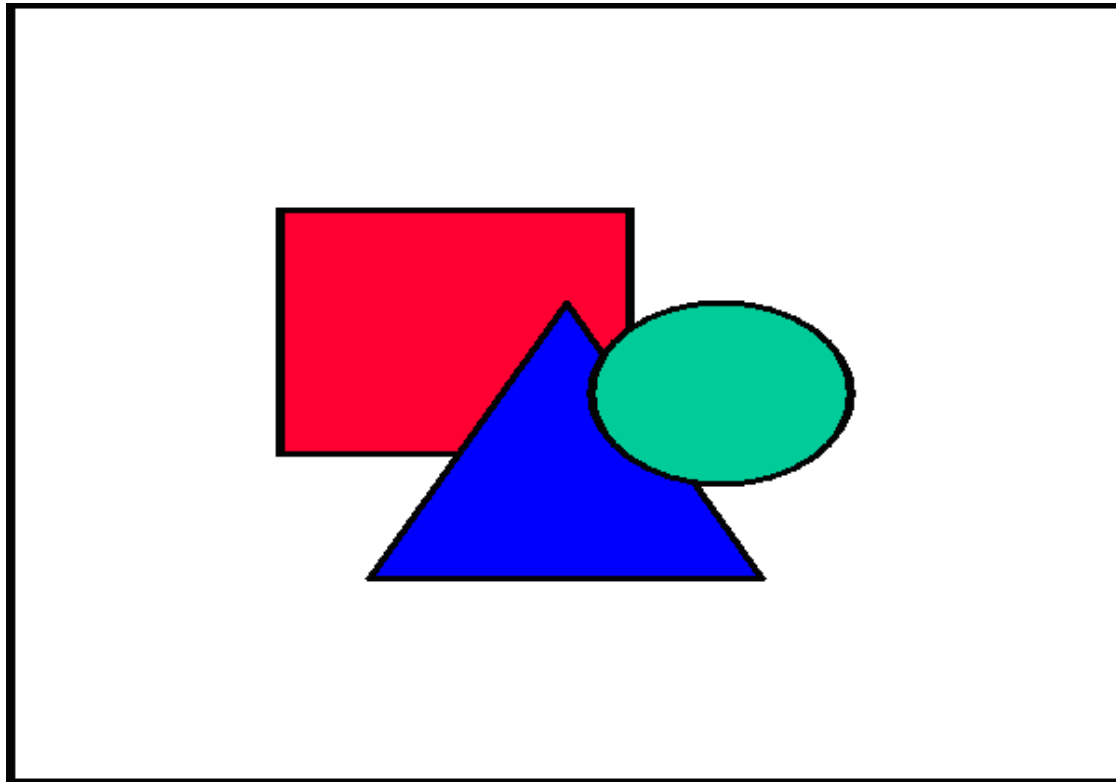

Fig. 5 The input form for the specification of the symbolization parameters for point symbols.

4.2.3 Third step: Data conversion

The input data are checked by a PERL script on their validity. Then they are written back into the corresponding parameter files. Simultaneously, the input situation data, specified in ARC/INFO ungenerated format, are converted into a simple ASCII data format, which is the current standard input data format for program KAPRO.

4.2.4 Fourth step: Projection computation

The PERL script calls up also the KAPRO program for execution and according to the parameters as defined in step 2, the computation of the geographic graticule and the transformation of the input data into the appropriated projection is carried out. The program KAPRO in form of a PASCAL executable stands at disposition, that was compiled before under LINUX. KAPRO generates as output simple ASCII files, which have the same structure as the input data file, after the data transfer by the special PERL script.

4.2.5 Fifth step: Data conversion from ASCII format into a PDF- or SVG data format

According to the specified out-put format in step two, a further PERL script converts the resulting ASCII data in a PDF- or SVG-data file.

4.2.6 Sixth step: Output data

The user can now visualize the resulting data files with an appropriate software (e.g. Acrobat-Reader) or he can transfer the data from the institute's ftp server to his system. The output data are kept only for one hour and is then deleted automatically from the server. The two data formats offered are very common and already implemented as import filters in the following graphic program packages: Corel

Draw, Illustrator and Freehand (only for PDF-format). The generated data are now ready for a further processing in a desktop program system.

5. Practical applications

5.1 Applications in teaching

This new on-line facility for a map graticule computation was successfully used several times for practical applications, like student exercises in a basic cartography course at ETH Zurich. The student is able to "play" with the different available map projections and parameters. He or she is getting thereby a better understanding of the individual properties of the particular projection. At any time he can easily visualize the results. Our experiences have shown, that an image is much more impressive and rememberable as a half page of written text or a long oral explanation.
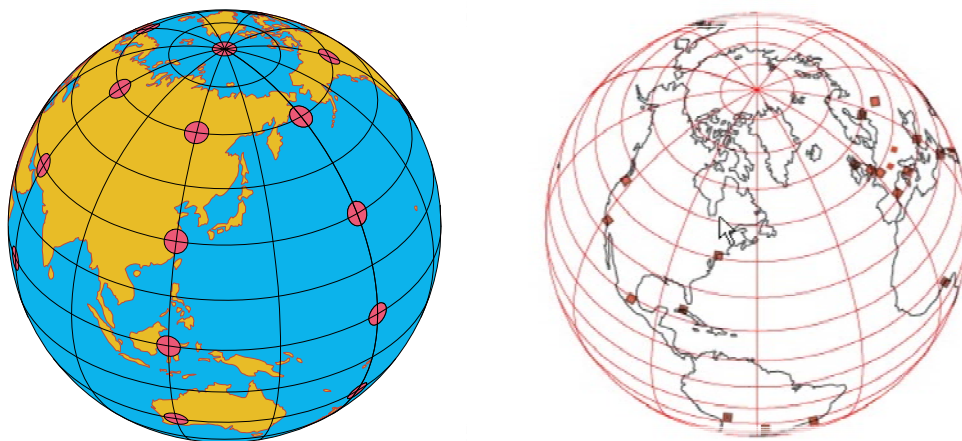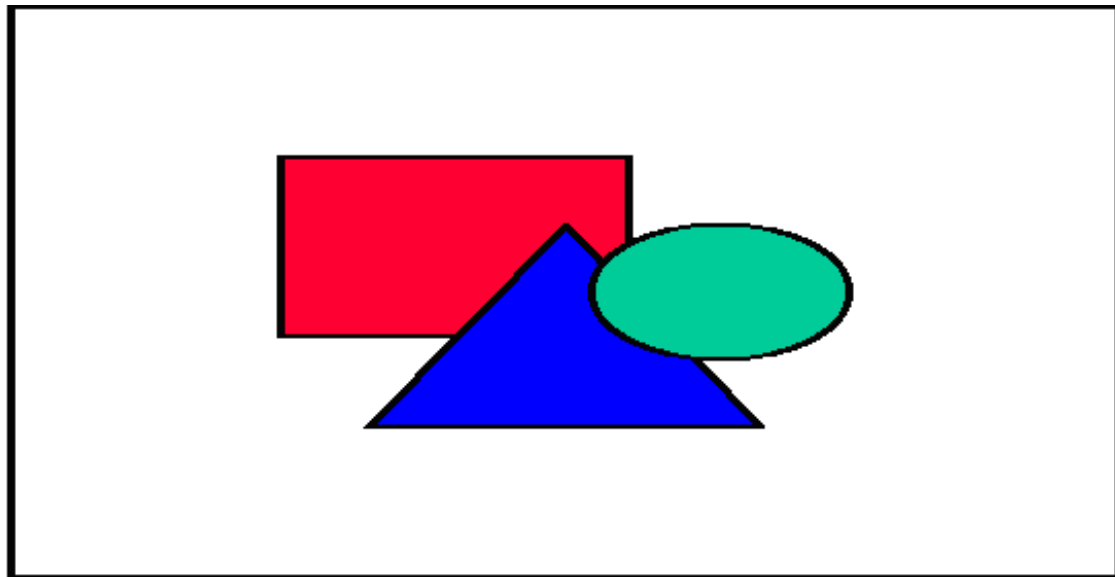

Fig.5 Four typical examples of on-line applications with program KAPRO, established during the exercises for cartography base lectures (from top to bottom and left to right, Robinson, Hammer and twice orthographic projection).

5.2 Illustrations

The Institute of Philosophy at ETHZ is preparing a comprehensive scientific publication about the distributions of the different philosophies . For the production of the numerous book illustrations the on-line KAPRO tool was successfully used. In this manner well fashioned base maps could be produced in an easy and quick way, which serve as starting point for the further map production. The theme will be added afterwards to these base maps and formed out interactively to the definitive map, that are ready directly for printing.

Furthermore, images for the creation of web pages were generated using the projection tool. As we know KAPRO on-line was also employed for the production of figures of a publication, with the goal to compare various projections.
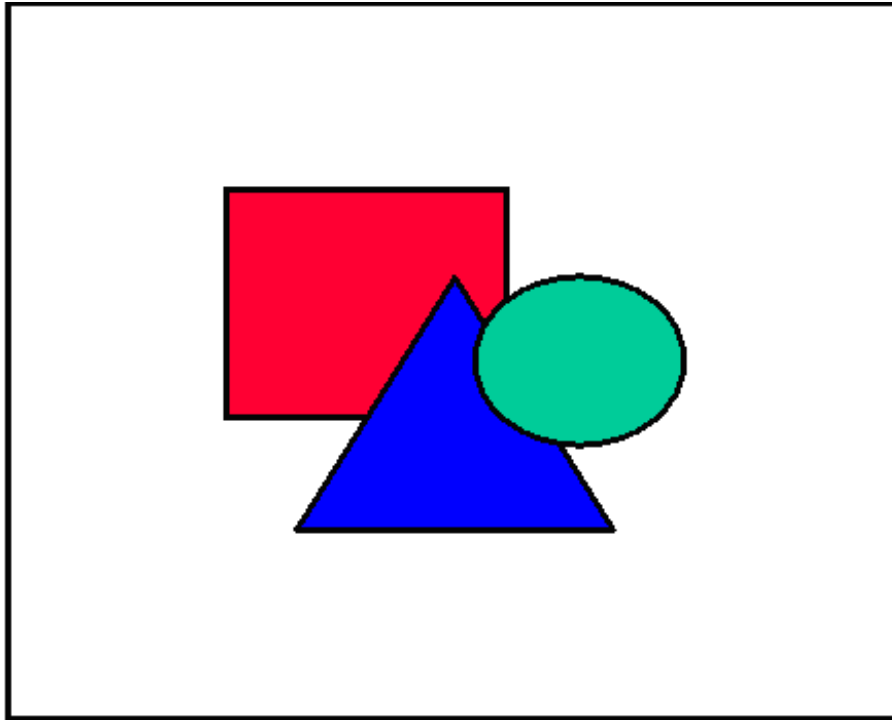

Fig.6 Typical base map produced in high graphic quality by KAPRO on-line.

5.3 Computation and production of base maps for the Swiss World Atlas

In connection with the production and updating of the Swiss World Atlas, this web based projection tool was been several times successfully used. The cartographer in charge has a tool at hand, that allows him to generate geographical graticules and to transform source data into the appropriate projection.
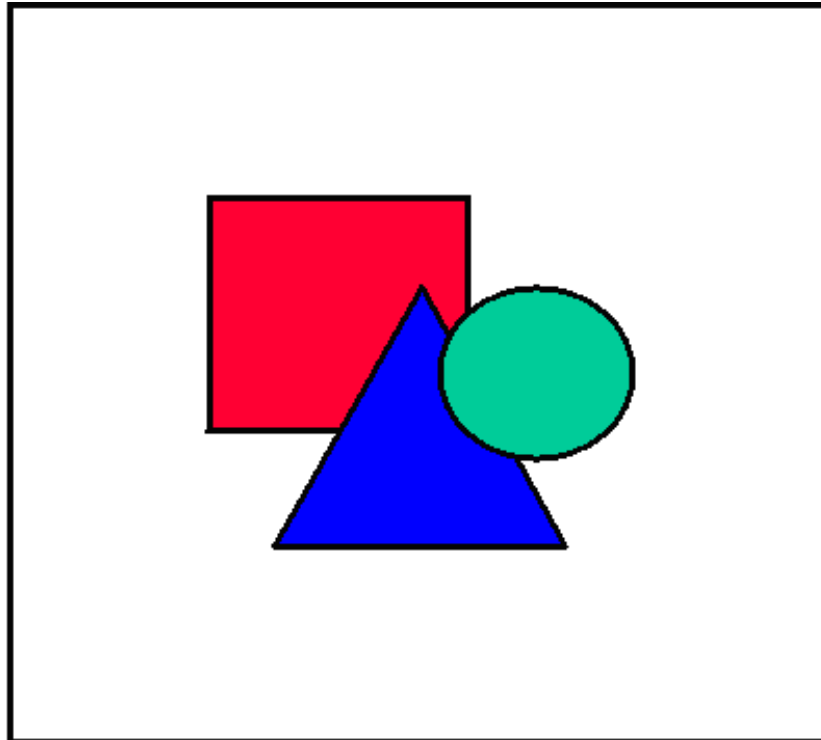
Fig.7 The result of a typical graticule computation by program KAPRO for a map of the Swiss School Atlas, with a rough outline of the coasts lines for orientation.

6. Advantages and drawbacks of the on-line KAPRO tool

Our web based projection tool is now available on-line for about one year. During this operating time numerous experiences could be gained, some are very positive others are rather negative.

1. Drawbacks
- Unfortunately the range of available input data formats is restricted to one single format (ARC/INFO ungenerate) at the moment.
- The validation of the specified input parameters must be improved. Otherwise unintentional system failures could occur.
- There are still some numerical computation problems within KAPRO, that should be eliminated step by step. Especially those projections, which have a dual representation of the poles need a special and careful attention with respect to the graticule computation as also in order to obtain a correct sequence of the situation points. Unintentional line connections must be avoided, otherwise an elimination is necessary by interactive editing.
- It is very essential to carefully examine the input situation thoroughly with respect to the correct data format, otherwise uncontrolled system failures can occur.
- At the moment, an automatic working process to build closed areas does not exist.
- The software is strictly restricted to the available projections.

2. Advantages
- The on-line program version of KAPRO available is 24 hours per day.
- KAPRO gives the cartographer a great flexibility for producing tailor made map projections and it is also a very useful tool for transforming existing digital data sets into appropriate projections.
- With the web based KAPRO, students obtained an instrument, which allows them to get familiar with the different existing projections and theirs properties.
- Now, also a helpful facility exists for the non-specialist in order to produce its own geographic graticules and base maps in an efficient manner. It could be used as a basis for the production of figures in books or other visualization media. Thereby the user must not dispose of a deep broad knowledge of map projections for producing acceptable results.

- Further implementations of new projections are easy to realize by the program provider. Also, program failures could be handled quickly and i professionally.
- The whole service is offered worldwide and at no expense.

7. Further program extensions

It is obvious, that such an on-line program environment is never complete. Continuously, new requests and improvements are expressed by the users. Therefore a priority list exists containing plans for further program extensions.
- It is necessary to increase the range of offered map projections soon.
- The number of allowed input data formats must be enlarged, because one available format is not sufficient.
- A way to automatically build closed areas must be evaluated. Thus areas could be filled in with colors or user-defined patterns.
- Very often, large scaled data sets are used as source for small scaled maps. Therefore the transformed data were normally too detailed for a further utilization. Thus appropriate generalization algorithms should be disposable for carrying out adequate on-line generalization. At the moment a very rough generalization algorithm is available in the original program version, namely the method transforming only every n-th point. It is planned to integrate by the time suited post process generalization possibilities into the on-line KAPRO program version.
- Sometimes, a numbering of the graticule is needed. Until now, there exists no option for this task.
- First ideas exist aiming at animating selected projections in such a way, that the viewer has the impression to fly around the world like sitting in a space craft and observing the blue planet passing current below.
- The current program version allows the visualization of the deformation using the Tissot's indicatrices. A second possibility may be a visualization of isocols, which are lines of equal deformation.

8. Further plans for other on-line services

The Institute of Cartography at ETH has made first plans for offering additional on-line services due to the good experiences made when carrying out this first on-line project. In the meantime, a second service has already been installed on the institute's home webserver allowing a point by point transformation of Swiss National coordinates into ellipsoidal longitude and latitude values on Bessel reference ellipsoid, and vice versa. The program offers the option to choose two different origins, for instance one, that is valid for the Swiss national maps and a second for geodetic computations. Further on, additional services for various transformations of digital vector and pixel data between different map projections are under evaluation. Eventually, a service for generating tailor made map projections with low error deformations will be made available on-line.

9. Final remarks and conclusions

Our pilot project for transforming an existing program into an on-line version was successful. It has shown, that without a lot of additional work such an adaption is possible, due to the current web technology. Some program modifications are still necessary. Special attention must be given to the validation of all possible input parameters. Further on, great precautions were necessary for keeping the flexibility for choosing any desired central meridian as input parameter. Today we can dispose of a shell, which allows to integrate further programs into a web-based environment in an efficient way and without a lot of additional effort. We think, that in the future this technique will be the normal way in the map production process environment. Therefore it is very important, that cartographers learn quickly to handle such program services in order to use them efficiently. We hoped, that an increasing number of web-based cartographic programs will be offered for free world wide.

10. References

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