



NATIONAL REPORT of DENMARK

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O.Brande-Lavridsen, Editor

INTRODUCTION

The congress period has been one of changes. The National Survey and Cadastre was reorganized, and most of its data collection is now done by external producers. There has also been structural changes in the private sector, where only two large companies are left. The methods are changing rapidly. The country has had a total coverage of digital maps for several years, but new specifications gives place for new mapping with more consideration to object oriented information systems. Automated digital systems gives orthophotos a new possibility. And the European Union rules for tenders have resulted in that most of the governmental topographic mapping is done abroad, but are also giving jobs to the Danish companies.

The Danish National Report will have chapters from the various actors in photogrammetry and remote sensing, production as well as research.

THE NATIONAL SURVEY AND CADASTRE (KMS)

Introduction

At the congress in Washington it was reported, that a new organisation was to be built up. This has been implemented and the new organisation is operational. One major task has been to convert the production lines into digital mapping. At present most production is done digitally and the plan is to complete this conversion before the end of 1997.

Topographic Mapping

Denmark. During the last 10 years work has been carried out to define and specify a topographic database covering Denmark. The intention is, within a short period of time, to establish a total coverage of Denmark. The name of the database is TOP10DK indicating that the "scale of use" is approximately 1:10,000. The content of the database was determined in a process where several experiments and projects were carried out. This was done in cooperation with potential users, in order to decide on strategy for establishing and frequency of updating.

The production began in 1994, presenting the first two stages for EU tendering. More than 90% of the work is carried out using external producers, leaving less than 10% for internal production. For this reason, the production capacity at the KMS has been cut down to consist of only a few analytical instruments. At present five stages are in work, involving four different producers: one Danish and three foreign companies. At the moment the production of geometry takes place in 30% of the country. The aim is to reach a complete coverage of Denmark in the year 2001.

Greenland. The activities in Greenland have been at a very low level except concerning aerotriangulation.

The plan is to cover the part of Greenland that is not covered permanently with ice. At present approximately 3000 frames are triangulated. The total job is estimated to 4000 frames, and the annual rate varies between 200 and 500 frames.

The Faroe Islands. In 1982 a new digital photogrammetric map covering the Faroe Islands was started. The map scale was chosen to 1:20,000 and the plotting scale to 1:8,000. The islands were covered by aerial photographs in 1:30,000 for aerotriangulation and colour photographs in 1:15,000 for plotting. Most of the plotting was done using the 1:30,000 photography. In December 1994 the plotting was completed, leaving only the final cartographic work to be done. The total number of sheets is 37, the area covered is app. 1400 km² and the last sheet will be published in 1997.

Lars Tyge Jørgensen

THE PRIVATE PHOTOGRAMMETRIC COMPANIES

KAMPSAX GEOPLAN

Introduction

In the period 1992-1996, photogrammetric map production in Denmark has continued the development towards more object oriented maps, suited for use in geographic information systems.

This is documented in the description of two major mapping projects in Denmark and in the description of a new specification for base mapping.

Digital photogrammetry has been introduced, with a major production of digital orthophotos.

The company has an export of about 50 % of the production and has subsidiary companies in Germany, Spain and Sweden.

New standard map specifications

In 1993, a new set of standard map specifications for base maps, the TK-standard, has been agreed-on with the Association of Local Authority Technical Directors. Compared to the previous specifications from 1988, the new ones will ensure base maps, which are more suited for use in geographic information systems. The basic idea is, that the user who wants to enhance the data for real use in a GIS should be able to do so.

New map products

The Danish Road Directorate and the Danish counties have specified a new map standard for maps for road administration. These specifications are setting a new trend: the base maps will be used in GIS, and ability to calculate areas of the different elements of the road is one of the important aims. The maps should therefore consist of a great number of different areas. Until now, Kampsax Geoplan has performed mapping of motorways and highways in three Danish counties.

With the Danish ministry of agriculture and fishery as client, Kampsax Geoplan has fulfilled a mapping project of the Danish agricultural areas. Groups of fields, with stable borders as roads, fences etc. have been mapped and attributed with an individual number. The field maps are intended for the ministry's control of subsidies from the European Union.

Digital photogrammetry

Kampsax Geoplan started in 1994 working with digital photogrammetry. Until now, a great number of digital orthophotos have been produced. A total coverage of Denmark with digital orthophotos, based on aerial photography in colours, in photo scale 1:25,000, is planned.

Equipment

Kampsax Geoplan has renewed the photogrammetric cameras, now using Zeiss TOP 15 cameras with T-Flight management systems, FMC and gyro-stabilized mounts. The company is using 16 analytical instruments (Leica BC-3, SD2000, Zeiss P2, P3) in Denmark and 9 analytical instruments in subsidiaries abroad. For digital photogrammetry Leica Helava equipment is used.

Kristian Skak-Nielsen

THE SCANKORT-LLO GROUP

The SCANKORT-LLO GROUP was formed in 1991 by the two photogrammetric companies SCANKORT I/S and LLO A/S, who have been carrying out photogrammetric mapping in Denmark and neighbouring countries since 1961.

Activities in Denmark

Aerial photography using black-and-white and colour film.
Digital mapping based on aerial photography at scales from 1:4,000 to 1:25,000.

Registration of pipelines and cables: sanitary sewers, water pipes and telecom cables.
GPS surveying by means of Ashtech Z12 receivers.
Consultancy to state, regional and local authorities as well as statutory companies.
Digital orthophotos.

Activities in Europe outside Denmark

SWEDEN Aerial photography, GPS surveying, digital mapping, digital orthophotos.
GERMANY Digital mapping.
ESTONIA/LATVIA Aerial photography, GPS survey, digital mapping.
RUSSIA Pilot project: land registration and digital cadastral maps.

Equipment and personnel

The SCANKORT-LLO GROUP disposes of:
Two aircrafts for aerial photography
Three Zeiss cameras
Seven Zeiss Planicomps
15 Intergraph MicroStations
The company group employs appr. 50 persons.

Anders Foghsgaard

RESEARCH AND TEACHING

AALBORG UNIVERSITY (AAU)
Laboratory for Photogrammetry and Surveying

Education

As part of the 5-year education of the chartered Danish land surveyor, standard courses in photogrammetry and mapping are given to about 30 students each year. These courses include exercises like control point determination, stereoscopic measurement with various systems, photomap production, aerotriangulation and photogrammetric mapping. After a common 3 year-study programme, the students can specialize. Courses are offered in remote sensing and image processing, digital mapping with vector and raster techniques, terrestrial photogrammetry, digital photogrammetry, GIS, and other subjects. As all teaching is organized in projects, photogrammetry is integrated with neighbouring fields like surveying, cartography, remote sensing, GIS, adjustment theory, and information technology. About half of the students specialize in these areas and graduate with a MSC degree.

Staff

The teaching staff consists of 13 academic persons, 2 of these have a PhD degree in photogrammetry and two are enrolled as PhD students at the research school of Aalborg University dealing with photogrammetric subjects.

Equipment

The photogrammetric equipment of the laboratory consists of some analogue instruments (various mirror stereoscopes with parallax bar, two mechanical stereoplotters, one rectifier, one orthoprojector), an analytical stereoplotter and two digital stereo workstations. The digital workstations "DiAP" made by the Canadian firm ISM have been used in the education since 1993. Furthermore, an Intergraph workstation, IP 6280, with the MGE platform and several application packages ("Imager", "Mode-

ler", "IRAS B", "GeoVec", "ModelView") are used for training in digital photogrammetry, raster mapping, height modelling and GIS. Three workstations of Silicon Graphics, type INDY, were recently procured together with a software package for the automatic generation of height models ("Match-T"). A PC based image processing system is also available. Various triangulation packages such as "MR2", "Bingo", "BLUH" are used in project work. Some terrestrial cameras are available: one UMK (Carl Zeiss Jena), one Rollei 6006 with réseau, a Hasselblad camera and a low cost digital camera. Scanning of images can be carried out by a document scanner (HP's "Scan Jet") with limited geometric quality.

Besides the photogrammetric and image processing equipment the laboratory possesses a number of graphical and GIS workstations which are equipped with software packages such as AutoCAD, Microstation, Mapinfo and GeoCAD.

The laboratory has quite a number of surveying equipment, such as levels, theodolites, total stations, GPS receivers including PC based processing stations which are used by the students for control point determination.

Research

"GeoCAD" software system. The mapping and GIS package "GeoCAD" which is jointly developed and marketed of AAU and two surveying companies has now received some photogrammetric features. Besides object-oriented data collection from an analytical plotter, software routines were added for plotting from single photographs and for height models. The complete package is running under the operating systems UNIX, Next-Step and Windows NT.

Automatic orientation of images by means of existing maps. Updating of digital maps requires orientation of new aerial images. This process can be automated by using special objects from an existing topographic data base. An optimal fitting of new information into the existing data base should use a large amount of objects. A Ph.D. work is investigating what type of objects and procedures will have to be used in the matching between map and pictorial information. First results show that point type objects such as man hole covers and gratings can be measured nearly automatically by means of a templet which is derived from an adjustable graphical mark. Road intersections can also be converted into templets and matched with sections of the image which contain the same road intersection. Various types of correlation techniques as well as image pyramids are applied. The investigations are of importance to various mapping techniques including the production of ortho-images.

Semi-automatic generation of digital elevation models incl. editing and visualization. In an other Ph.D. project the accuracy, completeness and speed in the generation of elevation models by means of matching techniques are investigated. Areas with dense vegetation, poor texture, as well as built-up areas are problematic for an accurate height determination by image matching techniques. Efficient checking and editing facilities are important for a successful application. Appropriate analyzing and visualization methods have been used and will be further developed. The parameters which have influence on the results are studied by means of various test models covering different types of the Danish landscape. The investigations have importance for the derivation of a nationwide height model and orthoimage coverage.

Computer-assisted learning for digital photogrammetry.

New tools from the computer technology influence the production of CAL software for photogrammetry. Investigations of advanced PC models, new storage media like CD-ROM and Photo-CD as well as object-oriented programming techniques and authoring software were carried out. Several CAL programs from other fields were studied. Some of the new tools and techniques were applied in the development of a new CAL program "Learning about digital photogrammetry" ("LDIP"). Finished themes and exercises deal with image correlation and their application. Parts of the program were already used in the education of chartered surveyors at Aalborg University.

Photogrammetry for 3D visualization. Photorealistic models of planned constructions and their surroundings render possible a better communication. In order to derive a 3D wire model of houses and to add pictorial information to the facades, amateur photography, scanned and stored on a Photo-CD, was used. By means of existing map data the exterior orientation of the camera was computed and dimensions inside and outside of the facades were then derived from single images in order to complete a 3D-wire model of the town houses. The images were resampled and cut so that they could be placed to the facades of the houses. All of the computations were carried out on PCs. Other project work in this field dealt with the visualization of windmills and their surrounding landscape. New perspective images of the landscape were generated from a coloured orthoimage and then combined with the 3D-model of the planned windmills. Professional workstations were used in this work.

With regard to **remote sensing** various program packages like "Imager" (Intergraph), "Imagine" (Erdas), "Chips" (University of Copenhagen) and others were tested and used in project work of the students.

Experiences from earlier research about digital ortho-images and photogrammetric surveying of underwater areas were used by the Danish mapping industry in various and extensive projects.

Joachim Höhle

DANISH CENTER FOR REMOTE SENSING

The Danish Center for Remote Sensing (DCRS) is one of the centres of the Danish National Research Foundation. It is located at the Department of Electromagnetic Systems (EMI) at the Technical University of Denmark. The centre conducts research relating to instruments for remote sensing and their application to Earth Observation and Earth Science. DCRS primarily uses data from synthetic aperture radar (SAR) systems, which are high resolution imaging, airborne or space borne radars. EMI has developed a dual-frequency, fully polarimetric and interferometric system, EMISAR, which is operated on a Danish Air Force Gulfstream G-3 aircraft.

DCRS has in collaboration with Aalborg University conducted a pilot project examining the potential of using polarimetric SAR data for updating of maps. Another project with the same objective has just been launched in collaboration with the National Survey and Cadastre. The principal DCRS activity in the field of photogrammetry and remote sensing is, however, related to the generation of digital elevation models (DEMs) using SAR interferometry - both single pass and repeat pass.

EMISAR single pass SAR interferometer. The EMISAR system has been augmented with a single pass

across-track capability. Two antennas displaced across-track acquire two images observing all image points from two slightly different angles of incidence. By overlaying the two complex SAR images during processing and determining the phase differences (interference generation), slant range differences can be determined with fractional wavelength accuracy. From slant range, differential slant range measurements, and knowledge of the baseline, i.e. the displacement from one antenna to the other, the 3-D target location can be determined in a fully automated process.

The system presently uses a combination of an inertial navigation system and a P-code GPS system to provide the required navigational information. A more accurate navigation and attitude measurement system is presently under procurement.

The initial test of the EMISAR single pass mode showed that the limiting performance factor was multi-path on the radar platform and limited isolation between the two interferometric antennas which can be seen to be equivalent to a multi-path reflection of the other antenna. Fortunately, the calibration phase screen has been found to be basically identical from mission to mission.

Significant amounts of data were acquired during 1995 in both Denmark and Greenland indicating height accuracies before multi-path calibration in the order of 5 to 10 meter. By applying the above described phase screen calibration technique, systematic errors have been drastically reduced. Analyses of data acquired in Denmark where the topographic relief is moderate (heights vary from 0 to 137 m in the data analysed) indicates that the height error after removing a tilted plane is from 1 m in the near range to 3 m in the far range (at 10 m horizontal pixel spacing) when operating from 41,000 ft. Data acquired in the double baseline mode on a 25,000 ft. pass over the same area indicates stochastic RMS height errors of 0.6 m in the far range. Studies are presently on-going to evaluate the height error performance in more detail, however, sufficiently accurate reference data are not readily available. A shaded relief image of a subsection of a 25,000 ft. pass is shown in Fig. 1.

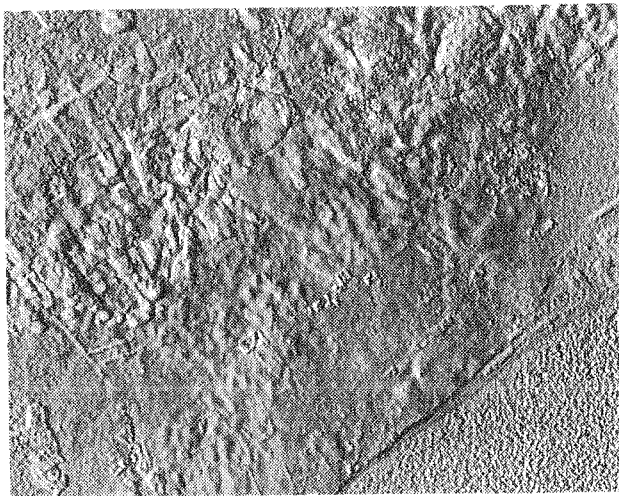


Fig. 1. Shaded relief map of a 5.2 x 3.8 km subsection of a radar generated height map. Data were acquired from an altitude of 25,000 ft. Note the clear signature of the buildings near the centre of the image. The area in the lower right hand corner is water.

EMISAR repeat pass SAR interferometry. In case of repeat pass interferometry the two images are acquired from two successive tracks. The mutual displacement of

the two tracks defines the baseline, and hence the baseline size and orientation are not fixed. They have to be measured/estimated, through the aircraft position (as distinct from attitude). That is why the repeat pass baseline is less well known.

The fact that the two images are not acquired simultaneously introduces a 'temporal' baseline. For DEM generation this temporal baseline is undesirable as it make non-stationary targets decorrelate. Still, repeat pass interferometry is justified, one reason being that it allows a larger baseline to be formed, thereby giving a higher sensitivity to terrain elevation.

To obtain a sufficient navigational accuracy for repeat pass applications the radar has been enabled to steer the aircraft via the instrument landing system (ILS). A desired reference track is input into the radar control computer, as well as programmable across-track and height off-sets (typically in the order of 20 m). The control computer receives continuous inputs from the real-time P-code GPS, and calculates position off-sets and across-track velocities, which are used to emulate ILS receiver signals for the flight director computer. When the autopilot is set up appropriately the emulated ILS signals control the horizontal and vertical manoeuvres of the aircraft. The track control system has proved capable of synthesising baselines deviating no more than 5 to 10 m from the desired baselines. This is surprisingly good considering that the GPS position is specified at 15 m.

The DEMs generated with repeat pass interferometry typically have a height noise in the order of 10-20 cm in areas with little vegetation. In forested areas the technique fails due to decorrelation. The systematic height errors are believed to be in the order of 1-3 m, typically with a correlation length of one to several kilometres. A contour map of a parabolic sand dune in Northern Jutland, Denmark, is shown in Fig. 2. Major contour lines are separated by 10 m, minor lines are separated by 2 m.

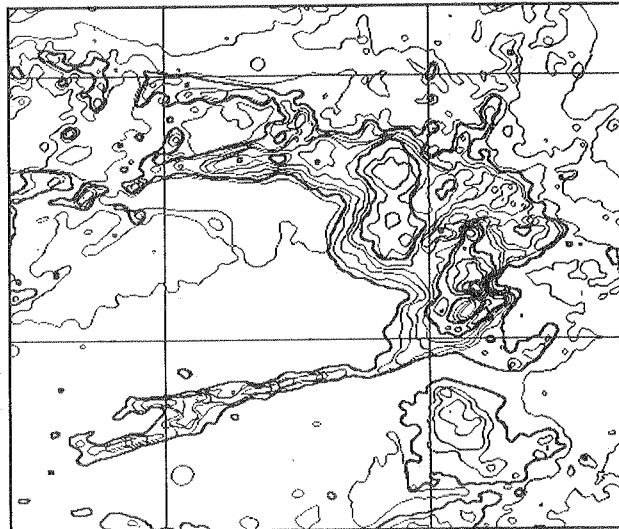


Fig. 2. Contour map of Raabjerg Mile generated from EMISAR repeat pass interferometry data.

Jørgen Dall and Søren Nørvang Madsen

TECHNICAL UNIVERSITY OF DENMARK
Department of Planning - Surveying

The Institute of Surveying and Photogrammetry at the Technical University of Denmark in Lyngby is merged

with other institutes into a new department. Our name is Department of Planning - Surveying.

Photogrammetric research activities within the past four years has been focused on digital and geological photogrammetry. In digital photogrammetry the subjects have been automatic measurements and extraction of topographic information from aerial photographs and radar images. In geologic photogrammetry the multimodel method, where ordinary small-frame cameras are used by geologists for photogrammetric analysis and mapping, has been used extensively in Greenland. Besides, a number of multimodel projects have been carried out around the world in co-operation with Statoil Norway for detailed quantitative studies of sedimentary rocks in oil exploration. A PC based system for geologists is under development with the aim of inexpensive desk top photogrammetry utilising off-the-shelf PC hardware, the Multimodel software, and digitised small-frame photographs.

In order to illustrate activities, a couple of current projects are outlined below:

Radar images and topographical mapping: Images from the newly developed EMISAR constructed by the Department of Electromagnetic Systems, Technical University of Denmark are investigated. The aim is to evaluate the capability of the radar to produce elevation models as a supplement to traditional methods for topographic mapping. Various resolutions of the radar, data acquisition procedures such as repeat-track and across-track interferometry and rectification methods are evaluated. The pixel size varies from 2 to 4 meters. Elevation data as well as the planimetric information will be compared with photogrammetrically produced maps from large scale aerial photographs.

Multimodel photogrammetry on the Blosseville Coast in East Greenland: A large scale geologic mapping project is carried out on the Blosseville Coast in East Greenland in co-operation with the Danish Lithosphere Centre. The Blosseville Coast is characterised by steep fjords with mountains that raise from sea level to elevations of three to four kilometres, sometimes with near vertical cliffs of up to two kilometres in height. Bordered by the ice covered fjords and glaciers from the inland ice it is one of the most remote and inaccessible areas of the world. During the summers of 1994 and 1995, a team of geologists carried out systematical stereo photography from a Twin-Otter aeroplane. Oblique colour photographs of the mountain sides were taken with hand-held small-frame cameras. In total 2200 kilometres were photographed. By early 1996 some 2000 colour stereo models have been orientated in the analytical plotter on app. 50 template sets covering 900 kilometres. The stereo models are used by the geologists for detailed planning of sample collection in the field and will be used for the final compilation of geological maps and structural measurements in the area.

Keld Dueholm

THE SCHOOL OF ARCHITECTURE IN AARHUS Department O, Restoration, Urban and Building Renewal. Laboratory for Photogrammetry

In connection with the Department for Restoration, Urban and Building Renewal of the School of Architecture in Aarhus is a Laboratory for Photogrammetry. Here the students are trained in photogrammetric measuring of buildings, monuments and architectonic building details. Sometimes the students carry out minor commissioned

tasks. The students have during the last few years used photogrammetry in connection with various study courses in Stralsund, Görlitz and Malta.

An example is a project where two fifth year students carry out a photogrammetric survey of a Neolithic temple, Ta Hagraat, in Malta. The temple is very dilapidated, and a proper survey has never been conducted. The construction of the temple made it impossible to perform a traditional survey with a grid of strings. The photogrammetric method also made it possible to avoid to touch the ruin, had the potential to obtain a greater precision, and finally it reduced the duration of field work.

It was decided to make a plane and a facade mapping. From a roof nearby control points were measured, and photography was carried out from a crane basket.

The photogrammetric measurements are done in the Laboratory in Aarhus, using a Zeiss Stecometer, with Filmaker Pro 2.1 for data collection. The drawings are made in MiniCad 5.0.2.

Alette Skov-Hansen and Louise Kjær Christoffersen

UNIVERSITY OF COPENHAGEN Institute of Geography

Research, development and education within remote sensing, digital image processing and geographical information systems.

The Institute of Geography has for several years been using remote sensing, digital image processing and geographical information systems (GIS) in relation to studies of the physical environment. 15 scientists are currently working within the fields of remote sensing, image processing and GIS. GIS and remote sensing project activities are ongoing in Greenland, Denmark, Senegal, Burkina Faso, Niger, Ghana and Tanzania. The institute has been responsible for establishing facilities for satellite image processing and GIS at three African institutions as part of partnership arrangements.

Main areas of activities in relation to remote sensing and image processing have been:

Methodologies for application of NOAA AVHRR data for monitoring of agro climatological parameters, vegetation, crop yield and bush fires.

Mapping of vegetation and land-use on the basis of SPOT, Landsat and radar and airborne scanner data.

Methodologies for estimation of surface energy- and radiation balance components using satellite data.

Development of the PC based image processing system, WinChips used for education and research.

A graduate remote sensing / digital image processing course is currently offered.

Major GIS-application activities have focused upon

Land evaluations.

Change detection of agricultural systems.

Studies of urban structure and growth.

Methods and algorithms.

In connection with the newly established education in geoinformatics the institute has procured the UNIX ARC/INFO Lab Kit and three GIS-courses are now offered for students at all levels.

Henrik Steen Andersen

DANISH SOCIETY FOR PHOTOGRAMMETRY AND SURVEYING (DSFL)

Society activities

The Danish Society for Photogrammetry and Surveying represents Denmark in the ISPRS.

The objectives of the society are to work for the development and use of photogrammetry, remote sensing and other surveying methods in theory and practise. However, GIS and digital mapping are important elements of the activities of the society as well.

The society has approximately 550 members. 125 of these are companies, institutions or organisations while the majority is personal members.

The society work through member meetings, working groups, seminars, publications etc.

10 to 15 meetings are arranged a year, usually organised as lectures on specific subjects such as digital photogrammetry, surveying, setting out and controlling large constructions, digital map production, data exchange, GIS and GPS applications and theory.

Within the society a number of self-governing groups can be establish. At the moment two groups are active - one working with surveying instruments and methodology and the other with the exchange format for digital map information (the DSFL-format). This standard is a de facto standard in Denmark and widely used by public map producers, engineering companies, municipalities and utility owners. A new updated versions has been released in the spring of 1996 including extended object definitions and a comprehensive code list. The standard now meets the requirements of the most important Danish authorities like The Road Administration, The National Survey and Cadastre, The Danish State Railways, Tele-Com Denmark, the computing centre for Danish municipalities and the electricity sector.

In the congress period the society has participated in establishing a new specification for digital maps, better suited for use in GIS.

A photo-copied magazine of 4 - 10 pages is issued 9 - 10 times a year. It contains notice and reports of meetings and publish other relevant professional activities.

The society arranges visits to private companies and public institutions, exhibitions, professional excursions abroad, one or two-day seminars and publish the Danish contributions to the ISPRS congresses including the national report.

During the later years, seminars (200 - 400 participants) and workshops (100 - 150 participants) have been arranged in cooperation with The Danish Cartographic Society and a closer coordination of the activities of the two societies are foreseen in the near future.

Besides the Danish Cartographic Society, DSFL cooperates closely with the newly established Danish Academy for Spatial Information (DAISI) and DSFL has close contact with its sister organisations in the Nordic countries.

Poul Frederiksen

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