Implementation of New Reference Systems in Denmark

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SUMMARY:

In year 2000 new reference systems for horizontal coordinates (UTM/ETRS89) and heights (DVR90) were defined. For 5-6 years National survey and Cadastre (KMS) has coordinated the implementation of the new reference system in all existing geographical data. Governmental authorities, municipalities and the private sector have transformed large amount of data from the old systems to the new ones. This year the cadastre map will be transformed to the UTM/ETRS89. By the end of 2006 it is expected that 75% of the horizontal data in the municipalities has been transformed to UTM/ETRS89.

One of the central elements for making this implementation project a success is the accessibility of transformation programs. The transformation procedure between the old systems and UTM/ETRS89 is rather complex, as it cannot be described with a set of parameters. In the beginning of the implementation project, no Geographical Information (GI) systems handled the Danish transformation procedures as a standard. Today all GI systems and GPS systems have built in the official transformation procedures which can be downloaded free of charge.

The implementation process and experiences from the process, which is long and deadline free, is described.

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1. INTRODUCTION

In Denmark, the uptake of new reference systems for both horizontal and vertical coordinates has been characterised by a long and slow implementation process, which has been ongoing since 2000. It was then that the new systems-- UTM/ETRS89 for horizontal coordinates and DVR90 for heights-- were defined. Since that time, Denmark's National Survey and Cadastre (KMS) has worked towards putting the new reference systems into practice its own work and coordinating the application of the systems throughout Denmark.

The long timelines for implementation of the new reference systems were foreseen, as the implementation is based on voluntary decisions. There are no deadlines stating last day of working in the old system. However, over the past six years, Danish governmental authorities, municipalities and the private sector have transformed significant volumes of data from the old systems to the new ones.

Because the likelihood for miscalculations and mistakes is higher, adoption of the new height reference system DVR90 has been deemed more precarious than the transition to UTM/ETRS89. As a result, implementation of DVR90 has been given a higher priority. This has also been eased by wide acceptance of DVR90 among geographical stakeholders in Denmark, while UTM/ETRS89 has met uncertainty among some geographical stakeholders. The direct benefits of the transition to the new European standard system from the old Danish one are less apparent, as compromises in correction of distances and transformation work are a consequence of adopting new standardised European systems.

The following pages will chronicle the progress made by KMS in the past six years towards full implementation of DVR90 and UTM/EUREF89 in Denmark. It is hoped that the challenges and lessons learned from this process will be of use to other national authorities that face similar situations.

2. MAP PROJECTIONS

As figure 1 illustrates, the projections used in Denmark are UTM zone 32 and, for the island of Bornholm, UTM zone 33. These projections require distance corrections of up to 40 cm/km, which in Denmark are considered as very large. In System 34, which preceded UTM in Denmark, distance corrections of only ± 5 cm were required.

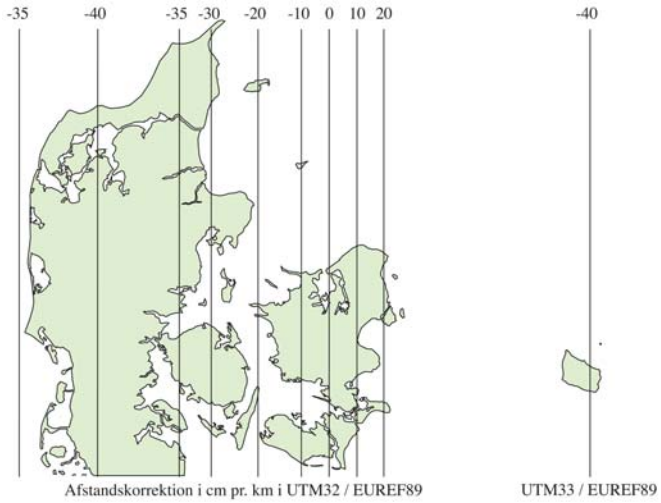

Fig. 1 UTM32 and UTM33/ETRS89.
Distance correction in cm/km

Especially the Danish Road Directorate wanted early in the process an alternative to this UTM projection. They feared that road workers who measure distances on Danish roads would overlook the distance corrections of up to 40 cm/km and generate significant errors in their work. The Kp2000 map projection was identified as a good alternative to UTM. Kp2000 is actually a "Danish" Transverse Mercator projection with 3 sections (False Eastings). The distance correction with Kp2000 is ± 5 cm/km and, on Bornholm, 0 cm/km.

Figure 2 provides the parameters for Kp2000 and UTM/ETRS89. Easting values in the interval 400 to 600 km are found in both projections, but do not refer to the same location.

Zone **Kp2000**	Central-Meridian	Scale	False Easting	Zone Interval
Jutland / Funen	9.5°	0.99995	200 km	Easting 100-300 km
Zealand	12.0°	0.99995	500 km	Easting 400-600 km
Bornholm	15.0°	1.00000	900 km	Easting 850-950 km
UTM32/ **ETRS89**	9.0°	0.99960	500 km	Easting 400-750 km

Fig. 2 Parameters for the map projections in ETRS89 in Denmark

KMS recommends the use of UTM/ETRS89 for application, storage and exchange of geographic information.

3. NEW HEIGHT REFERENCE SYSTEM

DVR90 is the new height reference system in Denmark. It stands for "Danish Vertical Reference - 1990". It replaces Denmark's old height system DNN, which stands for Dansk Normal Nul. The difference between the two reference systems is approximately + 2 cm in Northern Jutland and –14 cm in Southern Jutland. Transformation procedure between the height systems is available.

DVR90 was introduced in Denmark on May 27, 2002. Since that date, the country's geodetic database has provided the levels of all official height benchmarks in Denmark in DVR90. This database is accessible to its subscribers via the internet, and has been supplemented by a major information campaign to warn data users of possible mistakes if data in the old and new system are mixed up. Brochures and articles in engineering magazines and newspapers have been used to this end. The database provided DVR90 and DNN data side-by-side during a transition period, but now the DNN data has been archived and is only available as historical data.

In 2004, Denmark's municipalities and other public authorities set January 1, 2005 as their deadline for transition from DNN to DVR90. All data exchanged after that date was expected to occur in DVR90 in order to minimise errors. Transformation of the authorities' data banks was expected to follow. Figure 3 illustrates the municipalities' status in transitioning from DNN to DVR90. By the end of 2006, 80% to 90% of the municipalities' existing height data is expected to exist in DVR90.

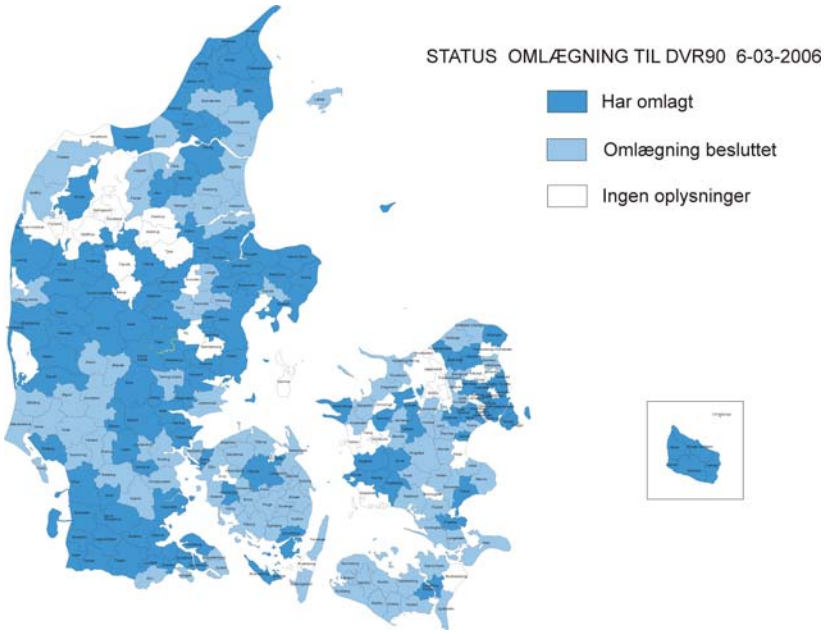

Fig. 3 Municipalities have already (dark blue) or have decided to transform data to DVR90 in 2006 (pale blue).

4. HEARINGS

Implementation of the two new reference systems in Denmark has involved a number of interest groups. Almost all geographical data in Denmark, except hydrographical and topographical maps, have historically been based on the old System 34. These include:

- Digital technical maps for viewing in scales of 1:1.000 - 1:10.000 and
- The Digital Cadastral Map.

To ensure broad awareness and engagement in the transition from System 34 to UTM, KMS invited all relevant interest groups to hearings in 2000 and 2001. The focus of these hearing was the process by which the new reference systems would be implemented.

On the basis of the first hearing, KMS issued a recommendation for the use of map projections in Denmark. Although KMS had supported a balanced and equal introduction of UTM/ETRS89 and Kp2000, a majority of interest groups supported the introduction of UTM as Denmark's principal projection. As a result, KMS' now recommends that UTM/ETRS89 is used as the **primary** map projection and Kp2000 as the **secondary** map projection.

This means that *only* UTM/EUREF89 is used for working, storage and exchange purposes. Kp2000 can be used as a standard projection *within* organisations that shift between map coordinate data and measurement data or where the differences in distance corrections are crucial.

KMS used the second hearing in 2001 to inform all users of these new recommendations and to solicit feedback. The interest groups supported the recommendations and accepted the adoption of a new common European reference system (ETRS89) as a natural and necessary development.

This positive attitude also encompassed the new height system DVR90.

The transition to the new reference systems has been open and reasonably unstructured among all users and interest groups. KMS continues to provide the new reference systems, but conversion of users' own data to the new reference systems is optional. This means that users can convert their data to the new systems if and when they want to.

5. PILOT PROJECT

A second result of the hearings in 2000 and 2001 was the launch of a pilot project for the transition of municipal data to the new reference systems. Local Government Denmark (LGDK) was aware that the conversion process would cost money and suggested that the municipalities would benefit from the lessons learned through a pilot project. LGDK requested that KMS engage in a cooperative initiative to ease the transition among municipalities, to which KMS agreed.
The chief aim of the pilot project was to investigate the administrative, technical and economical consequences of converting municipal data to UTM/EUREF89 *and* to establish

practical methods and technical solutions. Experiences from the pilot project were gathered in a ”cookbook”, which was intended for use by other municipalities in the transition process. In this way, the cookbook saved the cost of hiring consultants to manage the municipalities' conversion to the new reference systems.

The pilot project itself started in October 2001. In a little over two years, the project successfully transformed all the horizontal coordinates of one municipality's geographic data. By Christmas 2003, all of that municipality's drain databases (N & E components), digital technical maps, plans and registers with coordinate data and other spatial information to the new reference system.

6. STATUS OF TRANSFORMING HORIZONTAL DATA TO UTM/ETRS89

Following the pilot project, LGDK and KMS agreed upon a common aim: to recommend that all of Denmark's municipalities transform as much data as possible to the new reference systems. All exchange of height data from January 1, 2005 should be in DVR90 and all exchange of horizontal data should be in UTM/ETRS89 from January 1, 2006.

While the reference system transitions have begun among Denmark's municipalities, the country has embarked upon a general structural reform. On January 1, 2007, the country's 275 municipalities will be merged into 99 municipalities. A secondary effect of the reform has been the encouragement of municipalities to structure their data homogeneously and convert to UTM/ETRS89 before the merger.

By the end of 2006, 75% of municipal horizontal data is expected to be transformed to UTM/ETRS89.

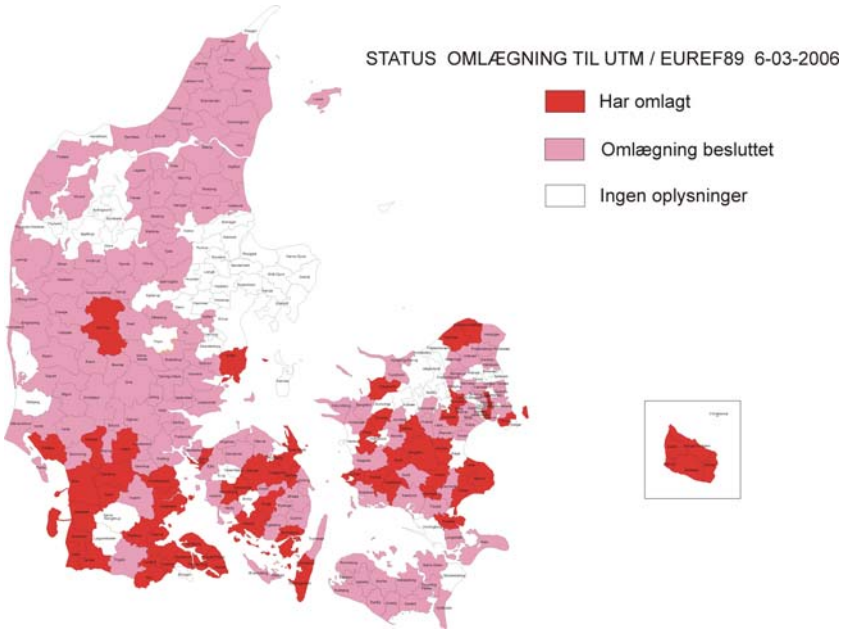

Fig. 4 Municipalities have (dark red) or have decided to transform data to UTM/EUREF89 in 2006 (pale red).

At the same time, most of the Danish governmental authorities and counties have also finalized transformation to the new reference systems. KMS's own topographical database has been transformed from UTM32/ED50 to UTM32/EUREF89, while the Cadastre map will be transformed from the Old Danish System 34 to the UTM/ETRS89 this year.

The Danish Cadastre map will be transformed to UTM/ETRS89 at the end of 2006, in connection with the launch of a new modern Cadastre system. This new system will increase the private sector's involvement in the implementation process, as chartered surveyors will perform their cadastral work and data exchanges in UTM/ETRS89.

As the Old Danish System was defined with a scale close to 1, Danish surveyors are not accustomed to performing a scale correction of a measured distance in their daily work. When the new reference system is implemented, surveyors will face the challenges of handling scale corrections in UTM/ETRS89 and other changes in their work routines.

The Association of Chartered Surveyors has declared that the reference system of the future will be UTM/ETRS89. Parts of the cadastre work (documentation of the measurements) will in a transition period be allowed in local system, including the old system. The transition period is estimated to be two years where new and modern data formats will be developed.

7. TRANSFORMATION PROCEDURE

One of the central elements for making this implementation process a success is the accessibility of transformation programmes. The transformation procedure between the old systems and UTM/ETRS89 is complex and cannot be described with a single set of parameters. KMS has developed transformation procedures to a 13^{th} degree polynomial. The standard deviation of this transformation is 2 cm for the entire country.

When the transition to the new reference systems began, no Geographical Information systems (GISs) handled the Danish transformation procedures as a standard. Most GIS products come from the USA, where there is little consideration of little Denmark's transformation concerns. This has meant that implementation of Danish transformation parameters has never been a high priority.

For Danish mapping, however, this single transformation is crucial. It is a necessary component of GIS applications used in Denmark. Therefore, KMS has encouraged GIS system developers to program their products to include these official transformation procedures. Today, all GISs and GPS systems have built in the official Danish transformation procedures. These include:

- ESRI products
- MapInfo
- MicroStation v. 8
- GeoMedia - Warehouse converter

The transformation procedure has also been built into KMS's own interface "KMSTrans" as well as other format transformation programmes. In some cases, KMS has paid a part of the development expenses to expand GIS functionality to include the transformation techniques. However, this has been on the condition that the GIS applications are freely provided to other users who want to transform data to UTM/ETRS89. Some examples are the *MIFTtrans* and *SHAPETtrans.* All transformations (dll's) can be freely downloaded from KMS's home page.

8. CONCLUSIONS

As the transition to new reference systems throughout Denmark is voluntary and deadline-free, the process is expected to take a significant period of time. Users have little impetus to rush to convert to the new system, as it is possible to continue working in the old systems.

Best practice in the transition process is expected to continue developing, while the aims are repeated again and again. Information is a very important part of the implementation process. In Denmark the real development has appeared when large users and organisations have decided to convert to the new reference systems. Specifically, the counties' and LGDK's decisions have been landmarks in the process.

Among the lessons learned thus far is that technical tools must be available to ease the implementation process and conversion work. Making the transformation procedure free of charge and the transformation programmes freely available has also proved a factor of success.

The National Survey and Cadastre's (KMS's) main tasks in the process have been the coordination of interest groups, the development of transformation procedures and programmes, and the management of a great deal of information.

We wish our international colleagues good luck with the implementation of new reference systems in their countries.

BIOGRAPHICAL NOTES

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