

Norm for RTK-Services and Good GNSS Survey Practice in Denmark

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SUMMARY

In the spring of 2008 The National Survey and Cadastre of Denmark (KMS) has launched a norm for RTK-services in Denmark [1]. The act of KMS (act no. 749 3., (1) and (2)), [2] open the possibility to lay down guidelines for completion of survey and mapping. These guidelines must be executed in cooperation with affected authorities, private companies and organisations. Thus a new Danish Norm for RTK-services has been developed after negotiation with concerned parties.

A norm consists of lines of directions, which are rooted in a law with status like a departmental order or guidance. The Norm for RTK-services is based on a wish of ensuring the quality in measurements applied in connection with mapping and registration in Denmark and to obtain uniformity. Securing of the RTK-services is not a guaranty for the quality; also the users of the services have responsibility of preserving a satisfying quality. Therefore KMS launch the guidance of good GNSS survey practice in Denmark together with the Norm for RTK-services.

The process towards the norm has shown that the need for the Norm for RTK-services and good GNSS survey practice in Denmark exists.

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1. INTRODUCTION

For many years the mapping and land registration in Denmark has been handled through a close cooperation between the National Survey and Cadastre of Denmark (KMS) and chartered surveyors working at private or public organisations.

So far the chartered surveyors have had the responsibility for their measurement methods, as they have carried them out all by them selves. It is traditional that a big responsibility, connected to the measurements applied for land registration, lies within the concept of '*Good chartered surveyor practise*'. Thus the chartered surveyors and KMS have had a trustful cooperation for a long time. In line with the technological development and with the possibility to lighten the tasks, especially with respect to the use of RTK, the chartered surveyors have now practically delegated some of the measurement responsibility to the private GNSS service providers in Denmark.

For that reason KMS, as authority in that field, find it necessary, with some regulations, to ensure a fundamental quality for RTK-services that are used for mapping and land registration.

Via its legislative foundation, KMS has introduced a norm for RTK-services in Denmark in order to ensure quality of performance for public GNSS survey activities. The Norm for RTK-services, in addition to a new '*Good GNSS survey practice*' [3], has been introduced in the spring of 2008.

2. THE BACKGROUND OF THE NORM FOR RTK-SERVICES

2.1 GNSS to define National reference frame

Because of the rapid technological development KMS has realized that the way of defining national reference system has evolved. The reference system of Denmark was originally defined through conventional measurements, where each point was connected to its neighbour point and all points together constituted a network with discrepancies. Nowadays with GNSS it is possible to measure all defining point at the same time in a solid network. This results in a national entirety, as each point is not only connected to the neighbour point, but to all points in the network.

Methods of connecting new measurements for cadastral purposes to the Danish reference frame must be in respect with the Act of Cadastral Work [4]. Usually the announcement prescribed that new boundary points must be connected to known fix points by measuring new points together with known fix point. The implementation of the new Act of Cadastral

Work this year (2008) entails the possibility to connect to Danish reference frame, simply by applying an RTK-service that respects the Norm for RTK-services, as it demands that RTK-corrections are given in the Danish reference frame. This new initiative is taken due to the fact that GNSS measured points provide better national solutions.

2.2 The Danish Infrastructure

Compared to the other Nordic Countries the structure of the GNSS network is specific to Denmark. KMS owns and operates the defining reference stations and fix points, but the RTK-services are operated by private companies, with KMS as authority. In for instance Sweden and Norway, the RTK-services are both operated and owned by the authorities. The reference stations owned and operated by KMS are shown in fig 2.1 and 2.2.

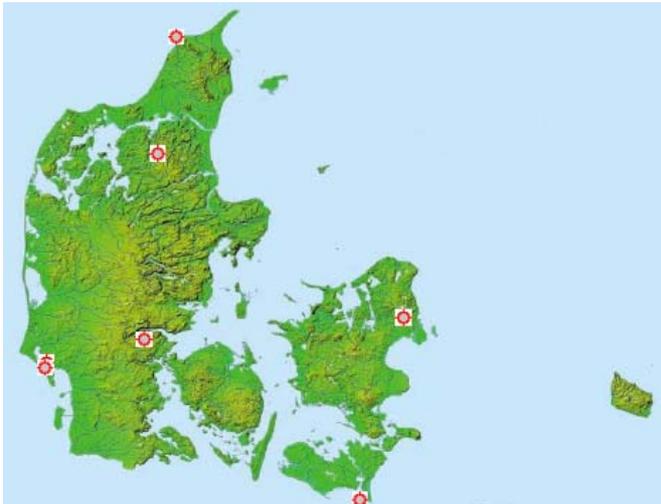


Figure 2.1. GNSS Reference stations owned and operated by KMS



Figure 2.2. Picture of a KMS Reference station (Gedser)

However, the two existing RTK-services in Denmark, GPS-Referencen and GPSnet.dk respectively have previously been cooperating with KMS, as KMS has carried out quality control of the coordinates of the reference stations in the networks. Thereby KMS has good knowledge of the two services and is in principle approving their functioning. For that reason, the Norm for RTK-services is basically designed in such a way that the two existing services should be able to comply with it.

GPS-Referencen and GPSnet.dk are both efficient and their networks are well distributed in Denmark. The dots on figures 2.3. and 2.4. show the location of the reference stations in the GPS-services.



Figure 2.3. Reference stations in GPS-referencen [5]



Figure 2.4. Reference stations in GPSnet.dk [6]

An important purpose of the Norm for RTK-services is to monitor the application of new services on the market in mapping and registration tasks, and make sure that the existing services preserve high quality.

3. CONTENTS

3.1 Norm for RTK-services

The composition of the Norm for RTK-services is based on requirements for infrastructure and documentation. The services must provide different kinds of documentation at the time they register, continuously when changes happen at the reference stations and in the system, and once a year for routinely control.

In detail KMS has requirements for, and subsequently register the following items:

- There must be at least 5 stations in the RTK-service.
- A description of the area, the service cover, must be available.
- The service must make its own inspection in the form of control measurements and calculations.
- The service must forward corrections in an open format.
- The reference stations in the RTK-service must be connected to correct Danish reference system.
- Quality calculations will be executed by KMS.
- The requirements for availability, continuity, integrity and accuracy must be complied.

The last point is elaborated in the following, as the Norm for RTK-services primary concerns these four concepts. The connection between the individual concepts can be visualized as follows:

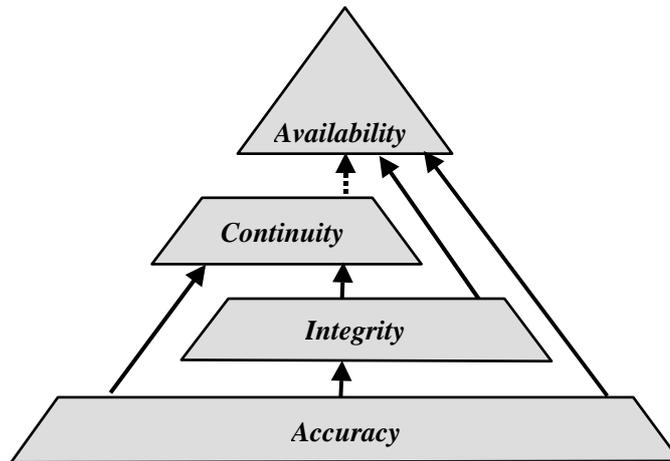


Figure 3.1 The concepts of the Norm for RTK-services. The arrows show how the concepts depend on each other. The accuracy is the fundament as all other concepts depend on it. The placement of the concepts expresses how many of the other concepts that depend on it. The figure is inspired by a presentation from Kongsberg [7]

In the following table the concepts and the matching demands are described:

The concepts	Description of the concepts	Demands connected to the concepts
<i>Availability</i>	A measure of the period, where the system delivers the promised accuracy, continuity and integrity.	The availability must be at least 98% per year (calculated for the period 7am-5pm on workdays), which will be documented through logs.
<i>Continuity</i>	The systems ability to deliver continuous integrity and basis for the required accuracy.	The system must be insensitive to drop out of one reference station. If more than one reference station falls out, the users must be informed. The continuity must be documented through own inspection by the service provider.
<i>Integrity</i>	The systems ability to warn and protect users, if the system can not fulfil the requirements on accuracy.	The service must keep control on received satellite data. The service has to inform the users, if the demand on accuracy can not be fulfilled. The service must mention how and when the user will be informed in case of a regional break down.
<i>Accuracy</i>	The vertical and horizontal accuracy, the system provides basis for.	The services must form the basis of accuracies better than 5 cm in the horizontal plane and 10 cm in the height. The accuracy in this connection is expressed as the deviation between a measured value and a known value. The demands on accuracy must be fulfilled for more than 95% of all deviations. This must be documented through the service providers own inspection.

If a registered service terminates observance, KMS is able to cancel the registration.

3.2 Good GNSS practice in Denmark

In consequence of launching the Norm for RTK-services, KMS found it natural to introduce a set of directions: 'Good GNSS practice in Denmark'. The idea started with the acknowledgement that satisfactory measurements with GNSS, by involving an RTK-service, includes correct handling of the equipment.

‘Good GNSS practice in Denmark’ is a basic introduction in good survey practice with GNSS equipment.

The contents of the directions include primary some advices to circumvent big error sources in GNSS measurements. In brief the guidance contains the following instructions:

- *Measure all points again after reinitialising.*
- *Place the antenna away from buildings trees and other obstructions to receive signals from an optimum number of satellites and to avoid cycle slips and multipath.*
- *Use modern equipment.*
- *Centre the antenna above the point to be surveyed, and always keep track of the antenna height.*
- *Be aware of warnings from the receiver concerning accuracy.*
- *Try to obtain fixed solutions, instead of float solutions.*
- *Be aware of the DOP values.*
- *Keep an eye on the initializing time, as the accuracy can depend on it.*
- *Apply receivers and antennas that match together.*
- *Measure at least one known point and compare the new coordinate determinations with known coordinates.*
- *Do not use broken cables, as they introduce noise on the signals, which can lead to bad accuracy.*

Contrary to the Norm for RTK-services that contains demands to the RTK-services, the ‘Good GNSS practice in Denmark’ is a set of well-meaning advices to the users.

4. ASSESMENT OF THE PROCESS

The Norm for RTK-services has been circulated among different institutions (authorities, universities, some private companies, and others) for consideration. Last opportunity for comments and objections occurred just before Easter 2008. Nine organisations responded.

KMS has only received positive responses, which indicates that the need for the Norm for RTK-services has been reasonable. Actually the response has shown, that the Norm for RTK-services is more relevant, and for more people and organisations, than first assumed.

Also ‘Good GNSS practice in Denmark’ has received surprisingly positive reactions. Some of the considerations in the process with this guidance concerned the level of the content. Was it too elementary? The responses of the hearing have disproved this concern. It has shown that there has been a need for such guidance. Especially The Danish Association of Licensed Surveyors in Private Practice has received the guidance with appreciation.

During the process, the cooperation with the two RTK-services has been positive and constructive. One of the reasons might be that both services have an interest in that the rival firm go through the same quality checks as it self. Perhaps the services also find it advantageous to be able to achieve some sort of acknowledgement through the ‘label’ they get

through registration. Naturally the services have paid attention to aspects in the Norm for RTK-services, which could influent users charge.

KMS wish for an even closer cooperation with the RTK-services; for instance to get better insight in the techniques and operations at the services.

It is also possible that the work connected to the Norm for RTK-services can bring cooperation with other countries and the exchange of experiences from each other.

5. CONCLUSIONS

Now, the Norm for RTK-services is prepared. Next step is to discuss with the private services how the data transfer, documentation, etc. shall progress. Not forgetting; it is elective for the RTK-services to comply with the Norm for RTK-services, unless they wish to be applied to connect measurements to the Danish reference frame.

KMS wish that the two existing RTK-services apply for registration.

From now on the challenge is to implement the Norm for RTK-services and to organize the procedures. This requires learning by doing processes, since working with a Norm for RTK-services is a new and untested thing in this field.

An important point must be to emphasize that the Norm for RTK-services is not finished. It must undergo constant evolution in line with development of competences. And probably the Norm for RTK-services would be tightening on account of higher demands from the users.

It is also possible that the Norm for RTK-services will be applied to other fields than mapping and cadastral work. It is not inconceivable that other parties, for instance private mapping and GIS companies would appreciate that services applied for their products follows a Norm for RTK-services.

There is big focus on quality at the moment, so perhaps the Norm for RTK-services, or a future version of it, will find applications in many new fields. Hopefully the evolution of this Norm for RTK-services has encouraged others to make something similar.

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