Preparing Danish and Greenlandic coordinate reference systems and transformations for the EPSG registry

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Agency for Data Supply and Efficiency

First, A Quick EPSG Primer

IOGP Publication 373-7-2 – Geomatics Guidance Note number 7, part 2 – September 2019 To facilitate improvement, this document is subject to revision. The current version is available at www.epsg.org.



4.1 Coordinates

The high level abstract model for spatial referencing by coordinates is shown in the diagram below:

Geomatics Guidance Note Number 7, part 2

Coordinate Conversions and Transformations including Formulas

Revised - September 2019



A coordinate is one of a sequence of values describing a position. The sequence is sometimes called a coordinate tuple. Coordinates are referenced to a *coordinate reference system* (CRS). A coordinate reference system is a *coordinate system* (CS) – an abstract mathematical concept without any relationship to a physical object – that is referenced through a *datum* to the Earth or some other object such as a vessel. A *coordinate operation* may be used to change coordinate values which are referenced to one CRS to being referenced to a second CRS.



The Problem ...

- Many important transformations and CRSs are not in the EPSG registry
- Discontinued CRSs still in wide-spread use

... The Cause

- Several old systems does not fit todays standards
- Lacking documentation
- We've been busy doing other things

Overview of DK and GL

System 👻	Country 🗸	Priority 🖵	Deprecated	CRS Documented	Transformations	System	Transformationer	CRS in	Transformatio	ins
					documented 💌	publish	published 💌	EPSG 💌	in EPSG	-
System34/45	DK	1	х	х	(x)	х	(x)			
ETRS89 (EUREF-DK94)	DK	2		(x)	x		(x)	х	(x)	
Kotesystemer i bygder	GL	3	x							
GVR2016	GL	4			(x)			х	x	
GR96	GL	5		(x)				х		
DVR90	DK	6		(x)	(x)	(x)	(x)	х	x	
DKLAT	DK	7		х	x					
DKMSL	DK	8		х	x					
GLLAT	GL	9		х	x					
DNN	DK		x			(x)	(x)	х		
ED50	DK		x			(x)	(x)	х		
DKTM	DK			x	x	x	x	х	x	
KP2000	DK		x	x	x			х	x	
Ammassalik 1958	GL		x					х	x	
Qornoq 1927	GL		x					х	x	
Scoresbysund 1952	GL		x					х	x	
GVR2000	GL		x		(x)			х	x	

Let's look at the top three

System 34

- Cadastral system introduced in the 1930's
- Very poorly defined
- The go-to system for most cadastral surveys (still!)
- Transformations to ETRS89 exist but are non-standardised polynomial mappings

Local height systems in Greenland

- 77 local disconnected height systems in cities and settlements
- Still in widespread use by surveyors etc
- ... because transformations to the new GVR2016 are not available

ETRS89 (NKG Transformations)

- Technically in the EPSG DB but only as a null-transform between WGS84 and other global frames
- Publication missing
 - Both for the Danish realisation and the transformations
- ... but otherwise good to go

The Problem with System 34

- An attempt to construct a transverse cylinder projection system, that would be equally useful for cadastral and topgraphical uses
- Failed miserably and resulted in a pseudooblique projection on a badly tensioned network with imaginary absolute orientation
- To save the phenomena, an ad-hoc empirical polynomium transformation served as the de facto definition of System 34



But let's pretend it was a success anyway!

- Determine the best fitting (or at least reasonably well-fitting) transverse mercator projection
- Then treat the difference between this and the "defining" polynomiums as if it was a datum shift modelled by NADCON style grids
- i.e. ignore the deterministic causes of the catastrophe, just treat them as stochastic
- And obtain a wonderfully simple transformation, fitting modern geodetic software, and replicating the polynomiums to within 2 mm



Magnitude of grid shift

- Blue: 0 m, yellow: 40 m
- I.e. System 34 can be approximated by a transverse mercator projection with an accuracy less than 40 m



Deviation from polynomiums

- Blue: 0 μm, yellow: 2000 μm
- ... and combined with the grid adjustment we more or less replicate the old transformations
- But this time in a way that is recognized by the EPSG and most geospatial software





The EPSG Fix

- Split System 34 into a fake datum and projection
- The fake datum is defined by the grid adjustment
- And the projection is based on the transverse mercator
- Publish a report that details the new transformation
- Submit fake datum and projections to the EPSG

Local height systems in Greenland

- Introduced 50+ years ago referenced to local mean sea level
- 77 different height systems
- +/- 0.25 m from current height system GVR2016
- Not named or registered with the EPSG





The EPSG Fix

- Claim that all 77 systems are the same
- Call it Greenland Local Mean Sea Level, in short GLLMSL
- Create a grid that corrects the local heights to GVR2016
- Publish a formal GLLMSL system definition
- Submit the new height system GLLMSL and the grid with the EPSG

The Danish ETRS89 realisation

- Only published in a rather obscure German journal (EUREF-DK94 campaign)
- Has secretly been re-realised since the original publication
- Transformations available but not in the EPSG registry
- Is known as the ambiguous "ETRS89"





The EPSG Fix

- Properly document all Danish realisations of ETRS89
- Possibly name the realisations so they are easily distinguishable
- Submit realisations and NKGtransformations to the EPSG

The NKG and EPSG elaborated

- Various entities need to be submitted:
 - Extents for NKG2008 and NKG2020
 - Scope descriptions
 - NKG_ETRF00 and NKG_ETRF14 intermediate reference frames
 - Transformation parameters (all countries)
 - Grid files
- Possibly add coordinate operation for time-dependant gridshifting



Questions?