DYNPOS

(DYNAMIC COORDINATES IN FINPOS POSITIONING SERVICE)

Pasi Häkli, Topi Rikkinen,
Marko Ollikainen and Simo Marila

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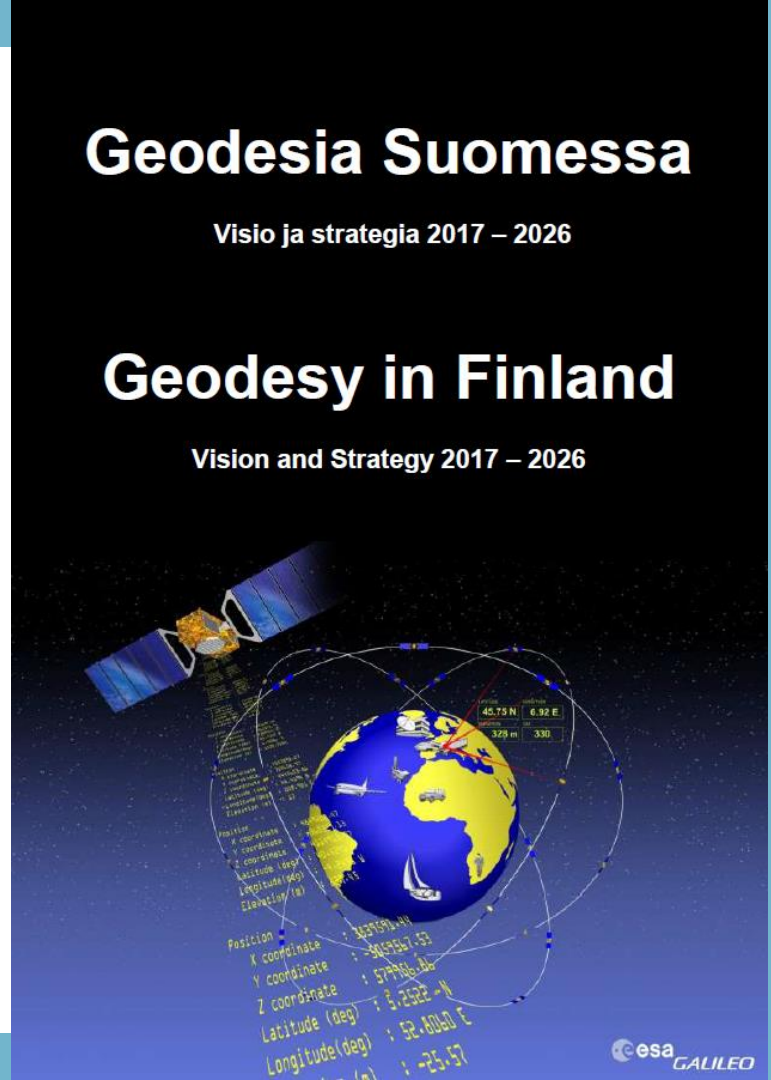
GEODESY STRATEGY – GOALS BY 2026

- preparations carried out for the adoption of a semi-dynamic reference frame to be used in all spatial data production, and investigated possibilities for switching to a fully dynamic reference frame
- investigated the requirements for switching to an active network of control points with regard to different reference systems, and the FinnRef network points have been incorporated into the semi-dynamic reference frame
- the Metsähovi geodetic research station is part of the global network of geodetic stations under the UN resolution, and producing high-quality research
- new land uplift and geoid models provide accurate 3D models for the transformations needed in dynamic and semi-dynamic reference frames and for the maintenance of the height system
- developed methodology for maintaining the national height system
- metrologically reliable and accurate coordinate (3D), height and gravity reference systems enable easily accessible geospatial information for all applications



GEODESY STRATEGY: DYNAMIC REFERENCE FRAME

1. preparations carried out for the adoption of a semi-dynamic reference frame to be used in all spatial data production, and investigated possibilities for switching to a fully dynamic reference frame

Projects:

- 2020: Dynamic coordinates in FINPOS positioning service, DynPos
- 2020: Renewal of the benchmark registry
- 2020: PROJ development (tinshift)

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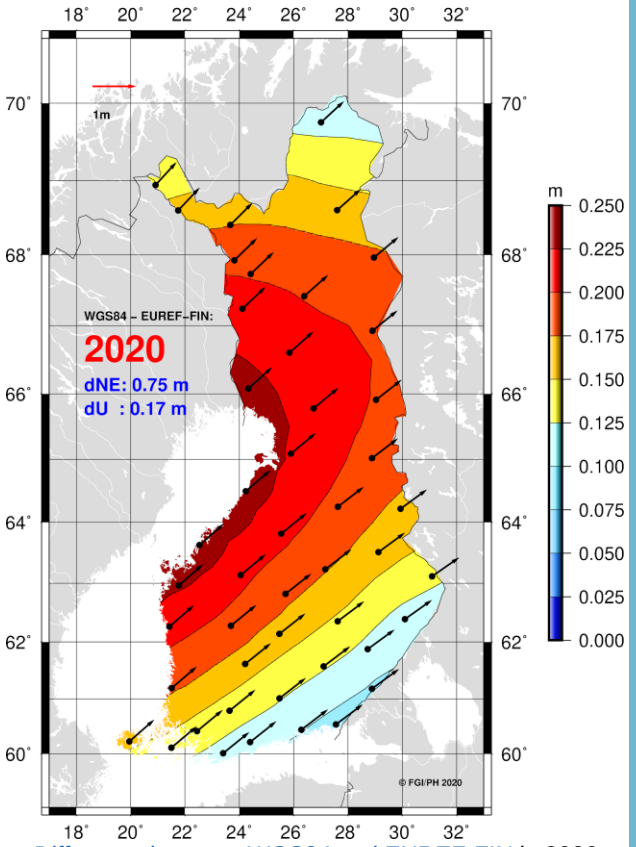
BACKGROUND: DIFFERENT REFERENCE FRAMES

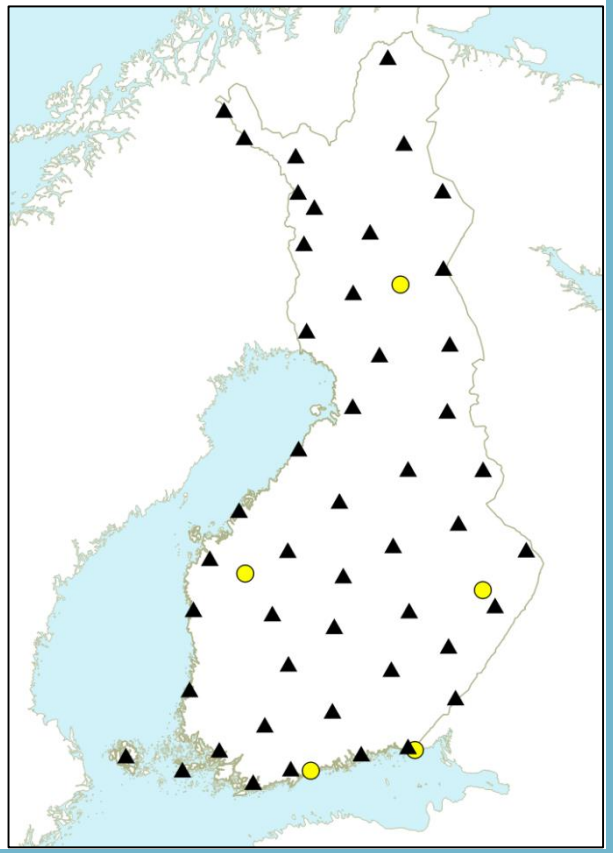
- **Static**
  - Coordinates don't change with time
  - Crustal motions deteriorate accuracy of static coordinates
  - Mostly regional/local reference frames
  - E.g. current EUREF-FIN datum and associated coordinate reference systems, N2000
- **Dynamic**
  - Coordinates time-dependent, thus change with time
  - Enables accounting for crustal motions
  - Mostly global reference frames
  - E.g. ITRF2014, WGS84
- **Semi-dynamic**
  - Combination of above: positioning happens in an accurate dynamic (global) reference frame from which the coordinates are transformed to a static reference frame with a method that accounts for crustal motions
  - For users coordinates seem unchanged (static), thus does not affect (much) e.g. to storing of geospatial data to registries etc.
  - In Finland semi-dynamic EUREF-FIN realized with the NKG transformation (based on Nordic-Baltic co-operation)



Difference between WGS84 and EUREF-FIN in 2020.

BACKGROUND: FINNREF AND FINPOS

- **FinnRef is the network** of continuosly operating GNSS reference stations (CORS) of the NLS. Its main purposes are:
  - to be the **basis for Finnish reference frames**, like EUREF-FIN
  - to act as a **link** between national and global reference frames
  - to enable estimation of **crustal motions** like tectonic plate motions and land uplift, hence time-dependency of the coordinates (velocities)
  - to provide **(dynamic) coordinates** in global reference frames (if necessary)
- **FINPOS is the positioning service** of the NLS that is based on FinnRef data. Its main purposes/goals are:
  - to provide users **accurate coordinates in real time**. They are based on different types of (network) corrections that are applied to satellite-transmitted GNSS signals
  - to provide data for post-processing purposes
- **FINPOS** (like most of the positioning services) **operates with official static EUREF-FIN coordinates** that cannot account for the crustal motions and therefore **become** more and more **inaccurate** in time



DYNPOS: MOTIVATION

- In addition to deteriorating static coordinates, **increased user requirements** (for better accuracy), **international standards** (in different fields) and **globalization** (satellite positioning global by nature, international products and services) are setting new demands for reference frames and positioning services
- Consequently global reference frames (**WGS84, ITRF2014**) and associated **dynamic coordinates are getting more common** in geospatial applications for example in aviation, maritime applications and future intelligent traffic
- **Dynamic reference frames** (or datums) have been noticed in several high level documents like **Finnish geodesy strategy 2017-2026**, **Report on Spatial data policy** and UN GGRF resolution
- **Purpose of the DynPos project is to study if the FINPOS positioning service can:**
  1. **be set up to operate in a dynamic reference frame,**
  2. **provide user positions in dynamic and semi-dynamic reference frames,**
  3. **and if these improve the accuracy of the service**

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DYNPOS: METHODS

- Investigation of settings for positioning service software (GNSMART) for the use with dynamic coordinates
  - Only GNSMART 1 tested due to short project
  - Two servers in parallel:
    - Production service: static EUREF-FIN coordinates (internal deformation corrections to stations)
    - Research service: ITRF2014 coordinates, velocities and transformations
- Necessary data:
  - Dynamic ITRF2014 coordinates for FinnRef stations at epoch 2015.0 (NKG Repro1)
  - Station velocities (ITRF2014), with which GNSMART can determine coordinates to the observation (current) epoch
  - ITRF2014 reference coordinates for the mean epoch 2020.75 of the test
  - Semi-dynamic coordinates using GNTRSRVR transformation module and associated parameter file (system import format, sif)
    - Transformations according to the NKG2008 transformation (NKG2020 not yet available at the time):
      - Helmert parameters
      - Crustal motion corrections from NKG_RF03vel model
    - Transformations sent via RTCM 3.2, message types 1021 and 1023

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DYNPOS: METHODS

- Positioning service tested in a dynamic (DRF), semi-dynamic (semi-DRF) and static (SRF) reference frame with real-time VRS measurements
  - Test performed at two CORS stations (not included in the FINPOS service)
    - CORS data splitted to two GNSS receivers (same data) but corrected with different corrections from the positioning service (different mountpoints) → two of the above (DRF/semi-DRF/SRF) could be compared at the same time
  - Position time series, couple of days of data, new initialisation every minute
  - Positioning results compared to reference coordinates
    - DRF: ITRF2014(2020.75)
    - semi-DRF and SRF: EUREF-FIN

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DYNPOS: RESULTS

Accuracies (see figures):

1. Dynamic ITRF2014@2020.75
2. Semi-dynamic EUREF-FIN (ITRF2014@2020.75 + NKG transformation → EUREF-FIN)
3. Static EUREF-FIN, (without transformation; from ”production” service, software defines coordinate corrections)

- Based on short tests accuracies approximately the same with all three methods
  - Horizontal: ~1cm
  - Vertical: ~2cm

DRF vs. semi-DRF

static vs. semi-DRF

DYNPOS: CONCLUSIONS

- It is possible to set up FINPOS service to operate and provide positions in a global dynamic and semi-dynamic reference frames
  - Enables user positioning in a global reference frame, e.g. for aviation and maritime applications.
  - Enables implementation of a semi-dynamic reference frame as a goal of the Geodesy strategy
- Accuracies approx. same with three methods, thus alternative methods provide same accuracies as the current production service
  - But semi-dynamic EUREF-FIN more correct and transparent compared to the current method
    - Semi-dynamic approach is based on (Nordic and Baltic) agreement how to handle transformations and crustal motions whereas in current method the software defines the corrections itself (”black box”)
    - Recommended approach (see e.g. Geodesy strategy)
- Short test/project, therefore results preliminary and based on older version of the positioning service software, further tests needed before taken into operation:
  - Approach for newer GNSMART2 software
  - More testing needed with different RTK rovers, deeper analysis, etc

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Contact: Pasi Häkli (pasi.hakli@nls.fi)

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