

Status on GNSS Applications in the Nordic Countries

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Lantmäteriet, the Swedish Mapping Cadastral and Land Registration Authority

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Agenda

1. CORS networks and positioning services (e.g. network RTK services)
 - Operated by both National mapping agencies (NMA's) and private sector operators
2. GNSS Applications
3. Nordic Collaborations
4. Acknowledgements and Contact Information

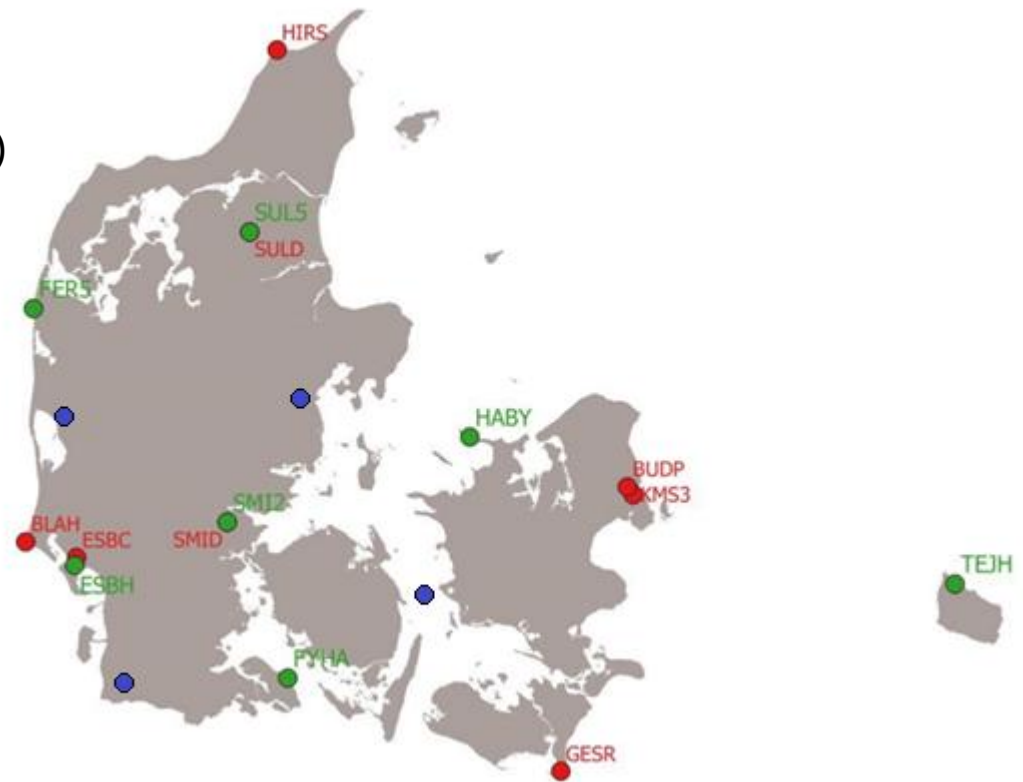
Denmark – CORS status

- NMA network
 - 10 CORS (14 in 2019)
 - New twin stations at HIRS, BUDP, GESR and ESBC (2020)
 - Realizing reference frame
- Private Network RTK operators
 - Geoteam 39 CORS
 - Leica 50 CORS
 - Topcon 62 CORS

Red: GPS and GLONASS only

Green: Galileo ready

Blue: New stations to be established



New eGOVERNMENT strategy 2016-2020

- In cooperation with central government, regions and municipalities
- An initiative concerning an infrastructure for positioning and navigation
- Aim to analyze the potential for using Galileo and GNSS in connection with a more intelligent administration, e.g. in connection with asset tracking and smart cities in general

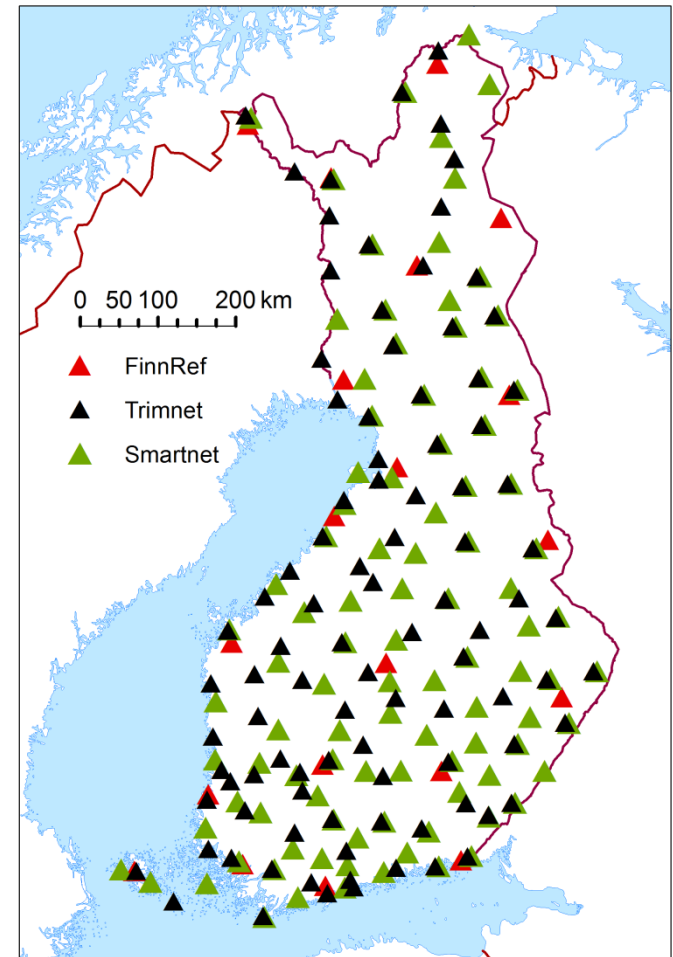


Denmark – Digital Strategy (eGOVERNMENT)

- Densification of the geodetic infrastructure
- Testbed in Århus, dense CORS network
 - Discussions on open network RTK positioning service
 - Investigations on accuracy of height measurements with network RTK
- Implementation of Galileo satellite system
 - Network RTK
 - RINEX storage

Finland – CORS Status

- NMA
 - Realizing reference frame (FinnRef)
 - NLS (Service)
 - FGI (Research)
- Private companies
 - Network RTK services
 - Geotrim (Trimnet)
 - Leica Geosystems Finland (Smartnet)

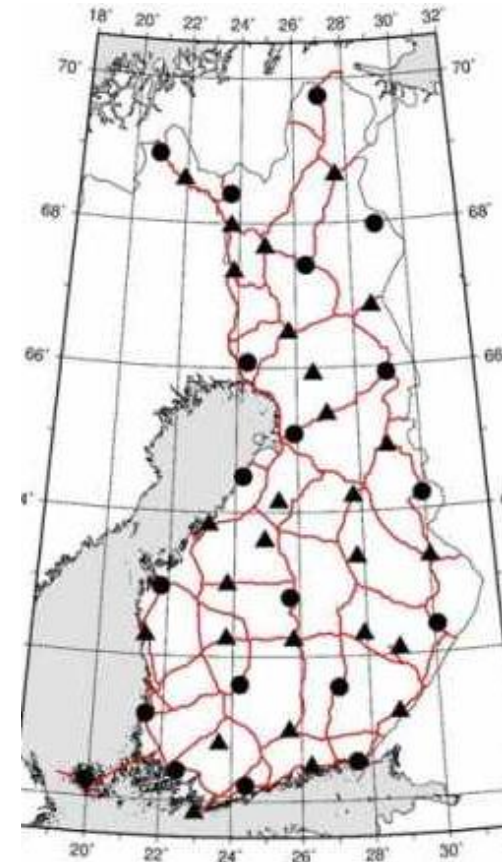


Finland – CORS Status

	TrimNet	SmartNet	FinnRef
Owner	Geotrim Oy	Leica Geosystems Finland	NLS/FGI
Stations	~100	~100	20 2019 (40-50)
Free services			DGNSS
Commercial services	DGNSS, Network RTK	DGNSS, Network RTK	
Research services			DGNSS, Network RTK

Finland – FinnRef

- CORS stations mostly mounted on bedrock
- Development project on densifying the network
- DGNSS service (open data)
- Network RTK service, open for research- and educational purposes



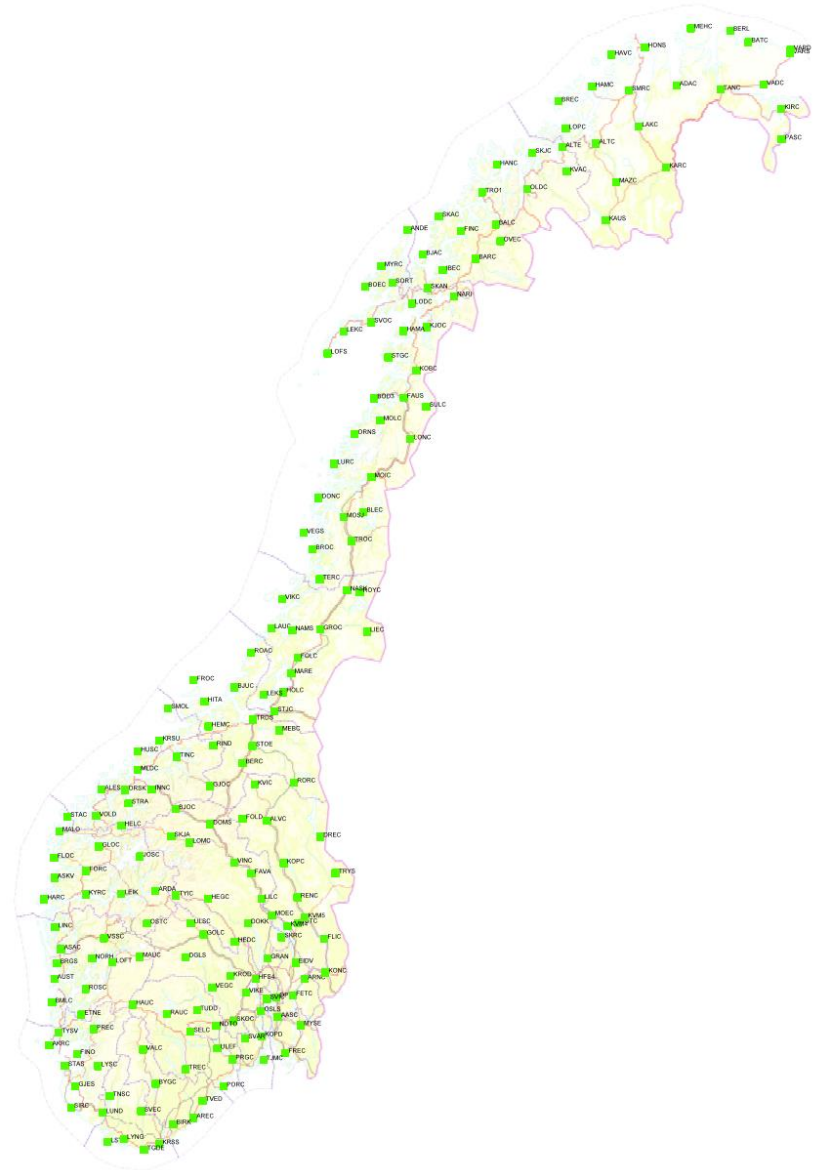
Norway – SATREF (NMA)

- ~200 CORS
- Control Center at Norwegian NMA in Hønefoss



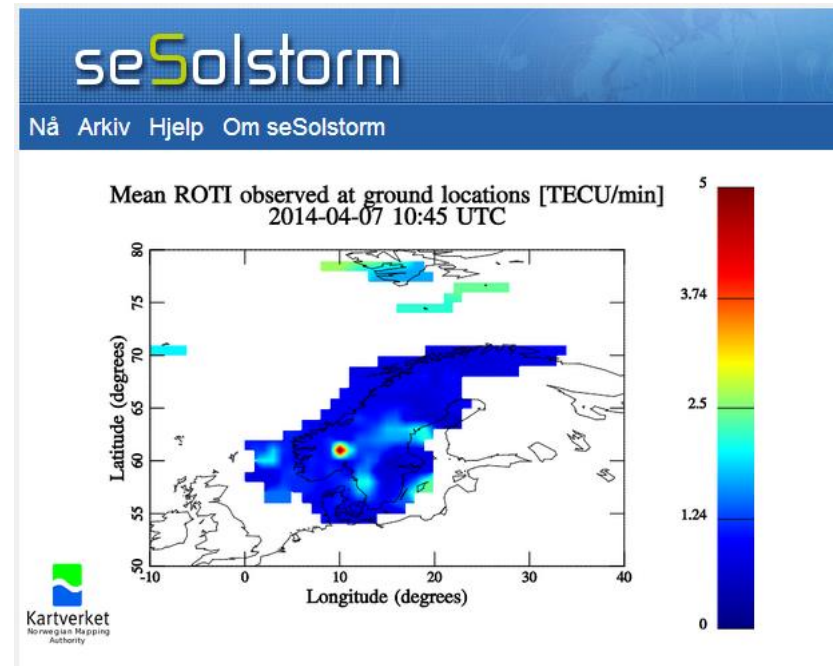
Norway - CORS Status

- **CORS spacing:**
 - Core areas: 35km
 - Normal spacing: 70km
 - Remote areas: ~70-100km
- CORS from external parties include both border stations from Sweden, Denmark and Finland
- Observation data streams from all of NMA's stations are available for external service providers
- Private network RTK service providers
 - Leica Smartnet, Own CORS-network
 - TopNet Live, uses NMA CORS-network



Norway - Services

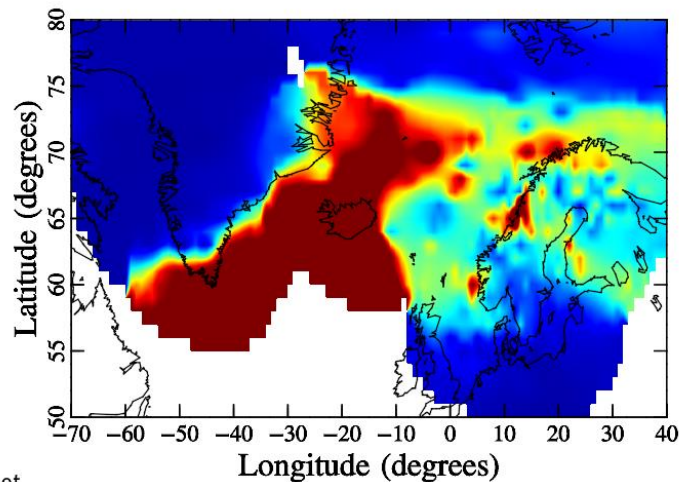
- Real-time Services with National coverage
 - Network RTK service
 - DGNSS
- Post processing
 - RINEX data
- Web-based services;
 - seSolstorm (ionosphere monitor)



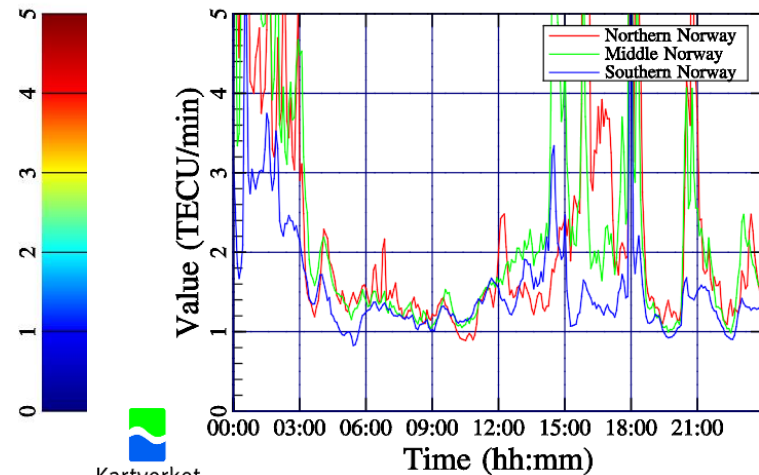
Norway - Monitoring services

- Real-Time Ionosphere monitoring (TEC, Scintillations, Rate of TEC Index)
 - Public website at ESA's space weather portal
- Daily Galileo Monitoring (OS and Iono Model)
- ESA's Arctic Test Bed. EGNOS Experimentation Platform. Contributing to EGNOS v3 development
- Daily EGNOS monitoring (Navigation performance monitoring and Iono Model monitoring)

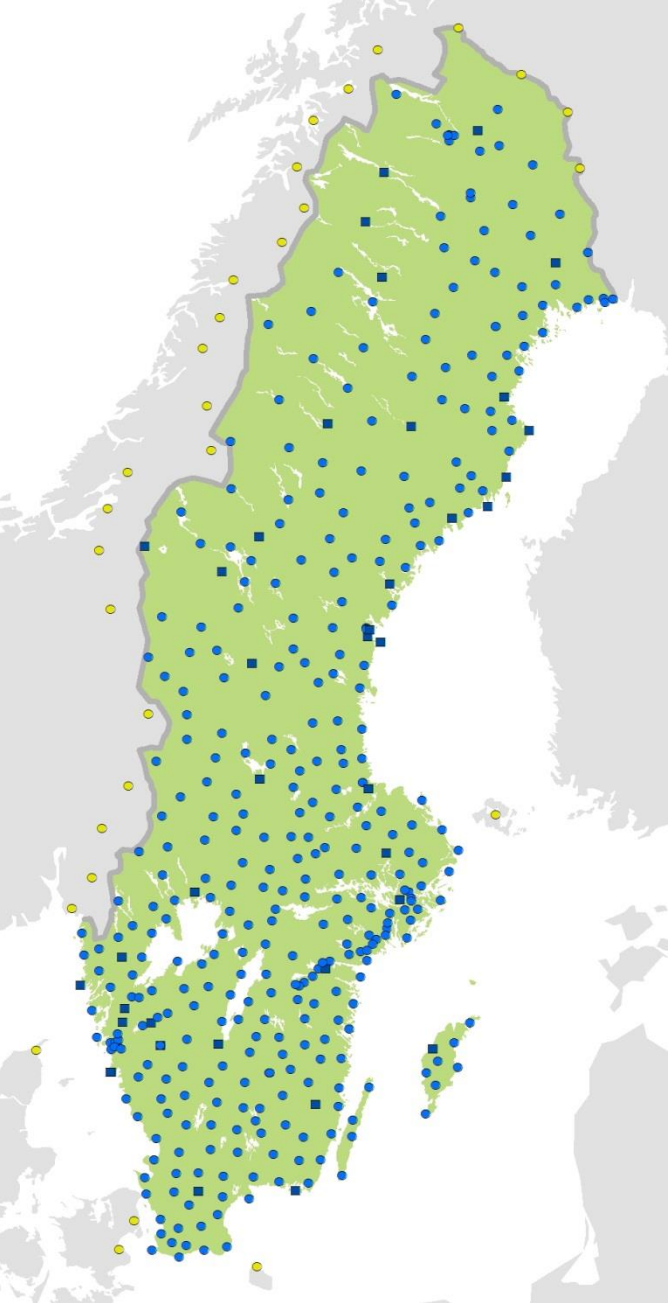
ROTI [TECU/min]
2017-09-08 18:05 UTC



2017-09-08 00:00 to 2017-09-08 23:59 UTC
Rate of TEC Index at ground



Sweden – CORS Status SWEPOS (NMA)



39 class A stations



344 class B stations

8 IGS and 24 EPN stations

SWEPOS® - Partners



- Maximizing social benefit of SWEPOS data
- Secures the usage of high precision GNSS positioning throughout the nation
- The use of a common geodetic infrastructure secures the data quality and prevent local variations depending on correction distributors

SWEPOS® - Services

- Real time services with national coverage
 - DGNSS (open data)
 - Network RTK
- Post processing
 - Automatic calculation service
 - RINEX-data
 - Virtual RINEX data
- Project adapted network RTK



SWEPOS® - Future plans

- Including Galileo in network RTK service
 - Field tests have been performed indicating a higher availability when using Galileo satellites
- Local densification projects in collaboration with municipalities and other projects (mainly Swedish Transport Administration)



Applications

The central diagram illustrates the sensor ranges for a vehicle equipped with various autonomous driving technologies. The vehicle is shown from a top-down perspective with "GNSS" labeled on its roof. The sensor ranges are represented by overlapping colored areas:

- Long-Range Radar:** Represented by a dark green cone extending forward.
- Short/Medium Range Radar:** Represented by light green areas around the vehicle.
- LIDAR:** Represented by a grey area around the vehicle.
- Camera:** Represented by a grey area around the vehicle.
- Ultrasound:** Represented by blue areas around the vehicle.
- GNSS:** Represented by an orange area around the vehicle.

Key features and sensors shown in the diagram include:

- Blind Spot Detection
- Rear Collision Warning
- Park Assistance/Surround View
- Park Assist
- Surround View
- Adaptive Cruise Control
- Lane Departure Warning
- Cross Traffic Alert
- Traffic Sign Recognition
- Emergency Braking
- Pedestrian Detection
- Collision Avoidance

Legend:

- Long-Range Radar
- Short/Medium Range Radar
- LIDAR
- Camera
- Ultrasound
- GNSS



GNSS collaboration between the Nordic countries



- Both NMA 's and other governmental organizations share resources and experiences for common tasks within geodesy and geodynamics through the Nordic Geodetic Commission (NKG), e.g.:
 - Common classification of CORS
 - Common transformation model to ITRF
 - Establishment of a GNSS analysis center of CORS data for monitoring station velocities
 - Exchange of CORS data for better performance of network RTK services in in border areas and along the coasts (also for private services)
- Working Group of Positioning and Navigation

Conclusion

CORS networks and positioning services (e.g. network RTK services)

- Operated by both National mapping agencies (NMA's) and private sector operators
 - Situation a bit different in the different countries

GNSS Applications

- Monitoring (Galileo, EGNOS, Iono, Geophysical effects on the crust)
- Machine control (Agriculture, construction)
- Surveying
- Reference in prototype testing

Nordic Collaboration through NKG

Thank you for your Attention!

Any Questions?

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