



Kartverket

# Monitoring EGNOS in Norway

*NKG General Assembly 2014, Göteborg, Sweden*

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EGNOS

# Outline

1. Motivation for NMA's involvement in EGNOS
2. Brief description of the EGNOS system
3. Examples of results and performance shortcomings in northern areas

# Why does NMA analyse EGNOS?

- The Norwegian government has invested a considerable amount of money in the development of EGNOS and Galileo.

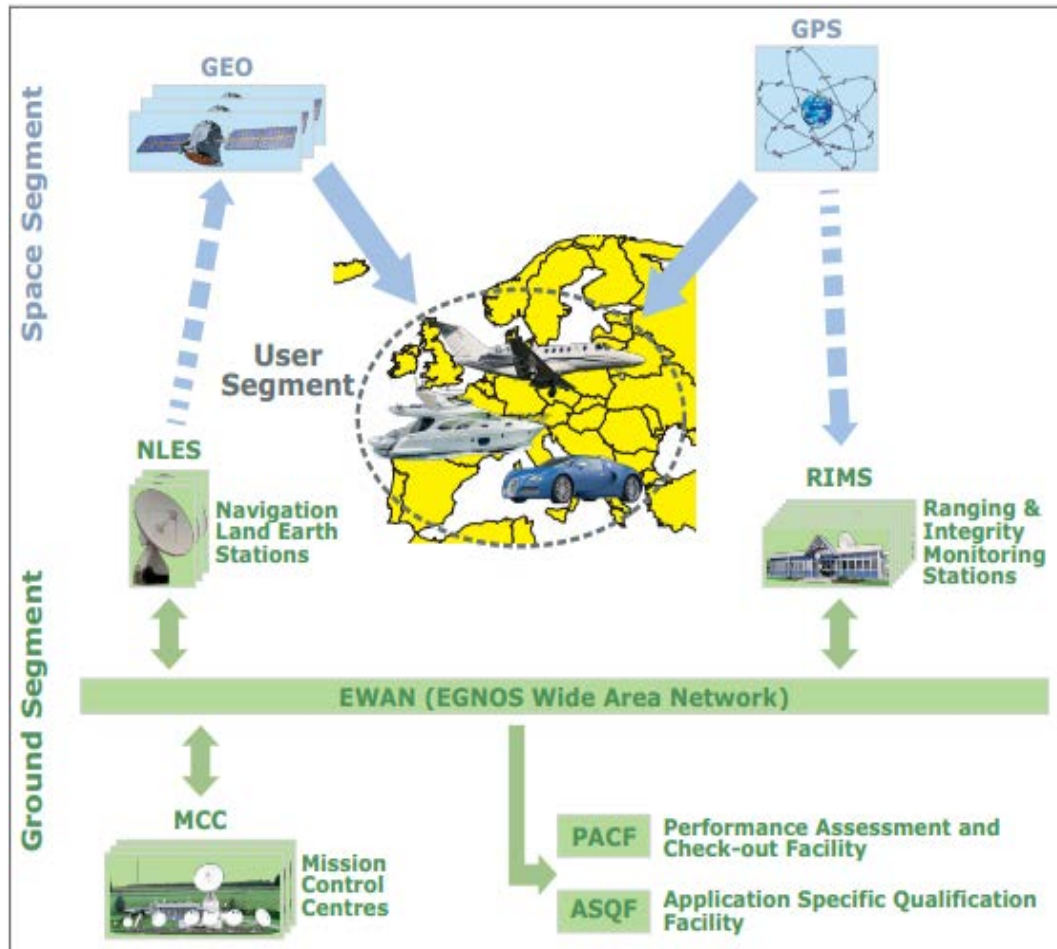
*→Someone should independently check that the system performance reaches its target, also in Norway*

- NMA is the only public entity in Norway that has both the necessary infrastructure and knowledge for monitoring EGNOS performance.

Maintaining this knowledge gives opportunities to identify weaknesses in the system performance, especially at high northern latitudes

*→ Possible to contribute to future improvements*

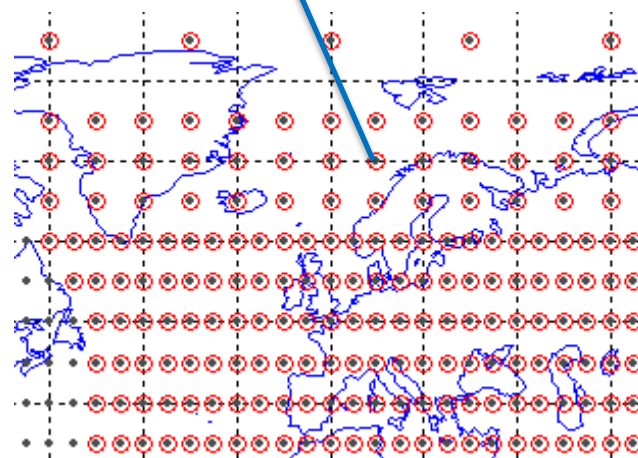
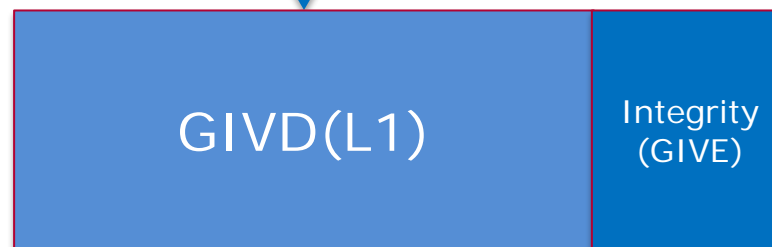
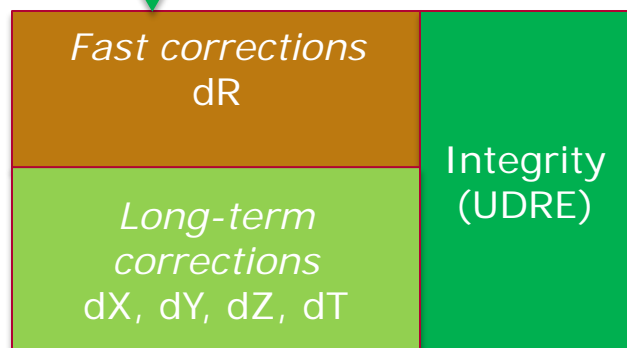
# EGNOS system overview



*RIMS network*

# SBAS output

- Orbit and clock corrections for each GNSS satellite
- Ionosphere correction grid model
- Degradation factors



# SBAS integrity concept (RTCA DO-229)

High level error budget:

$$\sigma_i^2 = \sigma_{i,orb\&clk}^2 + \sigma_{i,iono}^2 + \sigma_{i,tropo}^2 + \sigma_{i,rec}^2$$



$\sigma_i^2$  are used for:

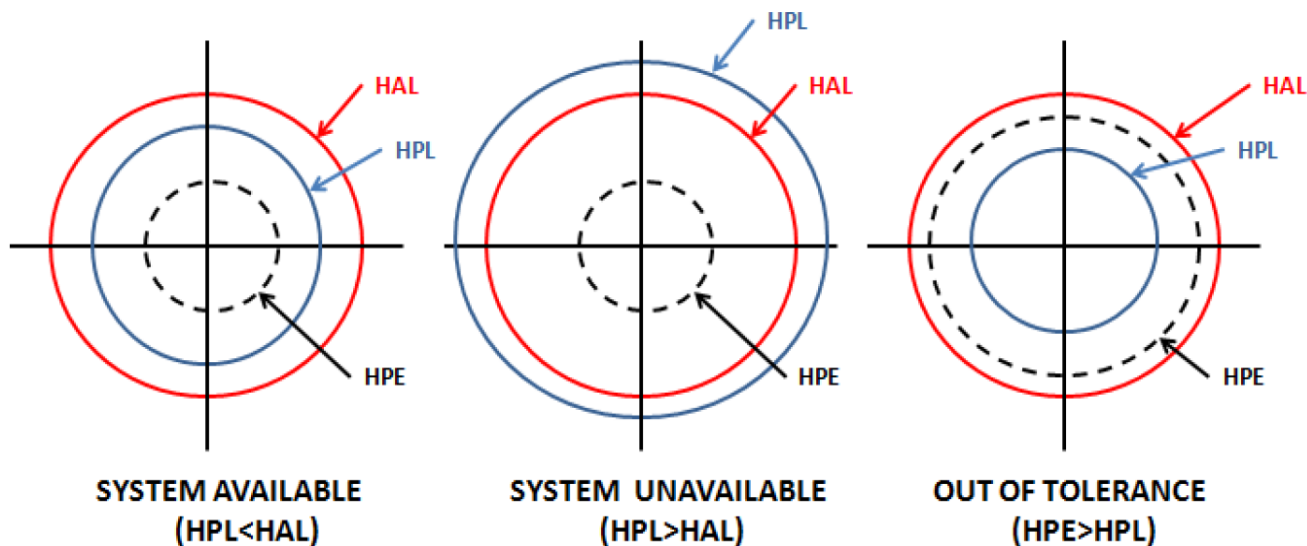
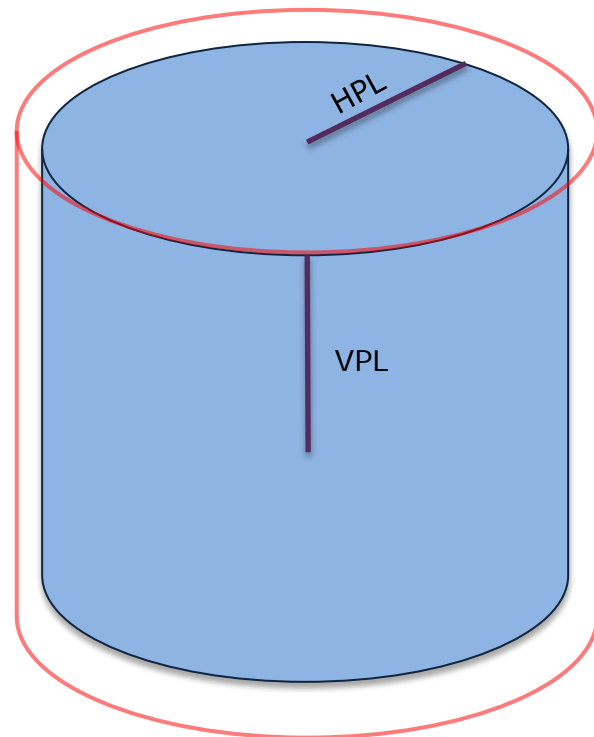
1. Weighting the different GNSS satellites in position solution
2. Calculating Protection Levels

# Protection levels and alert limits

$$P(PE > PL) \leq 2 \cdot 10^{-7}$$

$$HPL = 6 \cdot s_{HorizMax}$$

$$VPL = 5.33 \cdot s_{Vert}$$



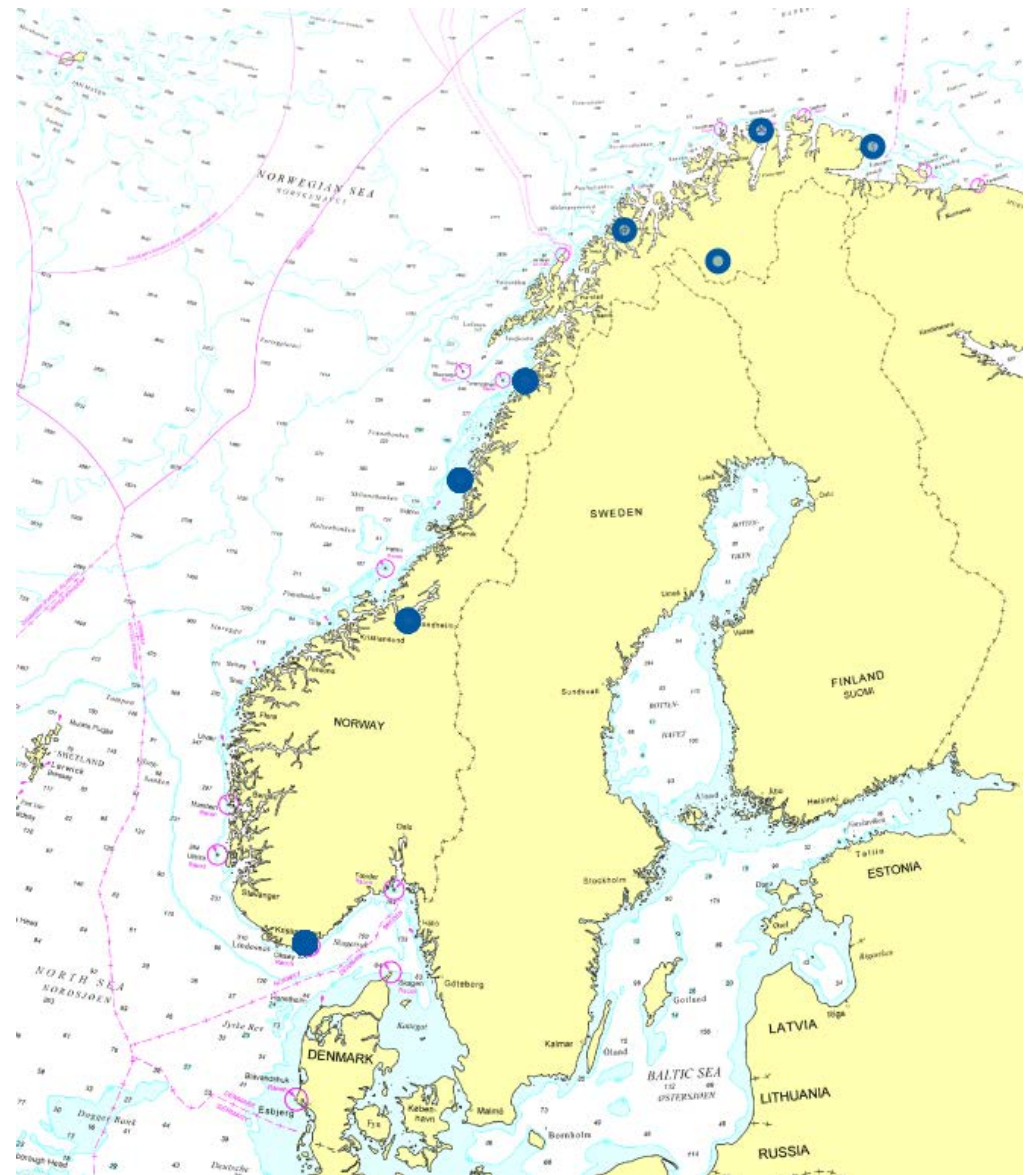


# NMA monitor stations

8 stations are used:

Station	Abbreviation	Latitude	Longitude
Kristiansand	krss	58.083°N	7.907°E
Trondheim	trds	63.371°N	10.319°E
Vega	vegs	65.673°N	11.964°E
Bodø	bod3	67.288°N	14.434°E
Tromsø	tro1	69.663°N	18.940°E
Kautokeino	kaus	69.022°N	23.020°E
Honningsvåg	hons	70.977°N	25.965°E
Vardø	vars	70.336°N	31.031°E

These are ordinary GNSS reference stations providing 1 Hz observation data and are part of e.g. the CPOS NRTK service.





# NMA monitoring system

Processing tool:  
PEGASUS (developed by  
EUROCONTROL)

In-house SW made for automatic  
daily data retrieval and processing

Input:

- 24 hours 1 Hz RINEX GPS obs
- 24 hours RINEX GPS brdc navmsg
- 24 hours RINEX SBAS msg

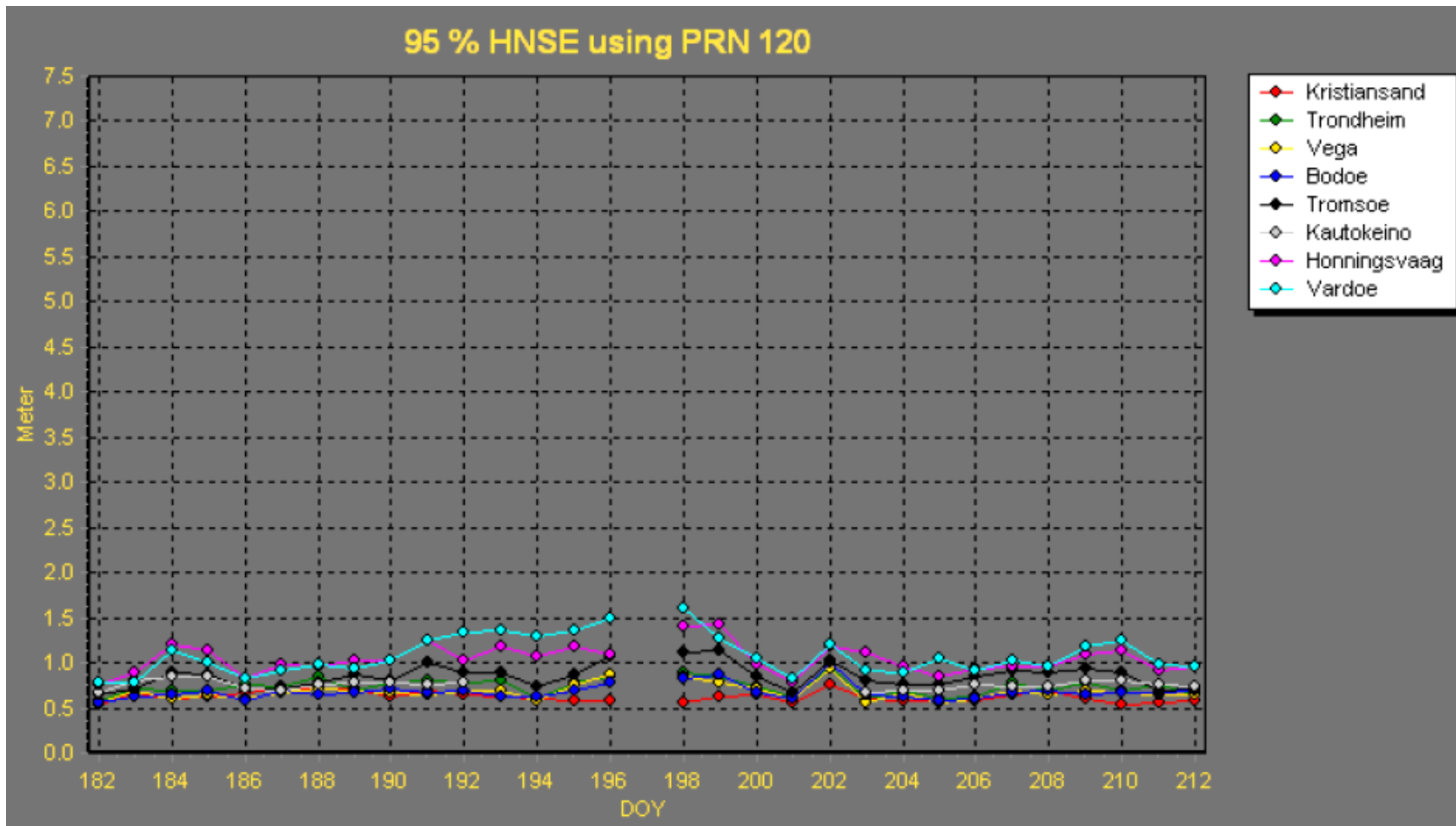
The screenshot displays the AutoPegasus software interface (Version 10.9.0, Build: 2006). The main window is titled "AutoPegasus" and contains a table of station data. The table has columns for "Enable", "Geo data", "Worst Case", "Station name", "ID", "EDCN ID", "Geo PRN", "Latitude", "Longitude", and "Height". The data rows include stations like Kristiansand, Trondheim, Vega, Bodo, Tromsø, Kautokeino, Honningsvåg, Vardø, Lofoten, Trysil, Stavanger, Hoenefoss, Oslo, and Dagali. Below the table are buttons for "Load Monitor Station Config" and "Save Monitor Station Config".

At the bottom of the main window, there are status indicators for "Station analysis idle" and "DOY analysis idle", and a "Clear Counters and Log" button. A summary bar shows "Number of Errors: 0", "Number of Warnings: 0", and "Number of bad files: 0".

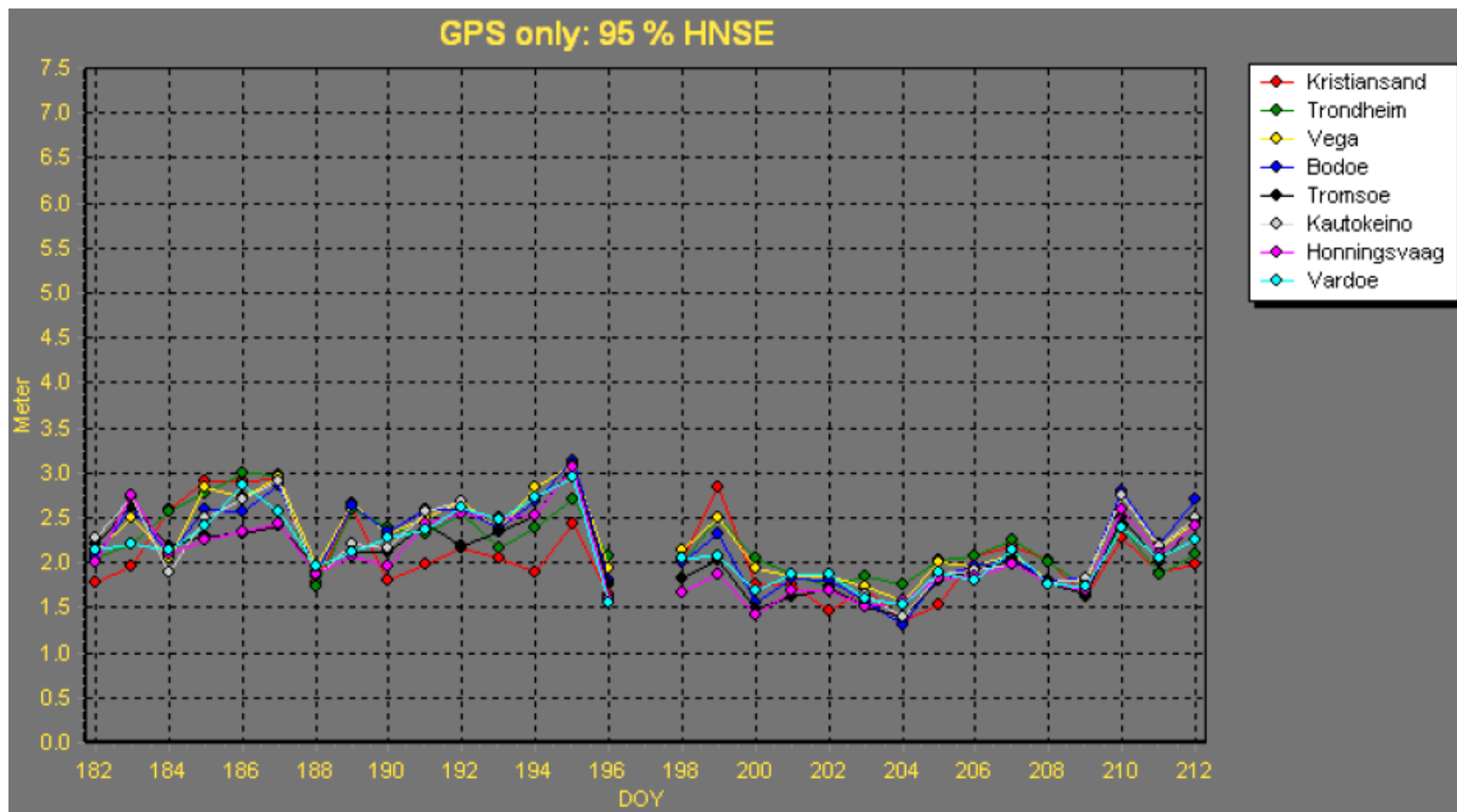
On the right side, there is a "Status" panel with a progress bar and a list of tasks. The tasks are categorized into "Clean directories", "DOY Processing Completed", "Station Processing Completed", "GNSS Solution", "MFileRunner", "XMLizer", "GNSS Solution WC", "MFileRunner\_EDCN", "Send to EDCN", "GNSS Solution\_GPS", and "Compare GPS/SBAS". Each task has a status indicator (e.g., "Completed", "Not started") and a progress bar.

Below the status panel is the "EGNOS Analysis Tool" section with "Save Main Config" and "Load Main Config" buttons. At the bottom right is the "Auto Start" section, which includes a "Launch time" dropdown set to "00:00", "Auto Run" and "Auto Run Help" buttons, and a radio button selection for "Automatic Daily Processing" (selected) and "Batch Processing". An "Exit" button is located at the very bottom right.

# EGNOS: Horizontal accuracy, July 2014

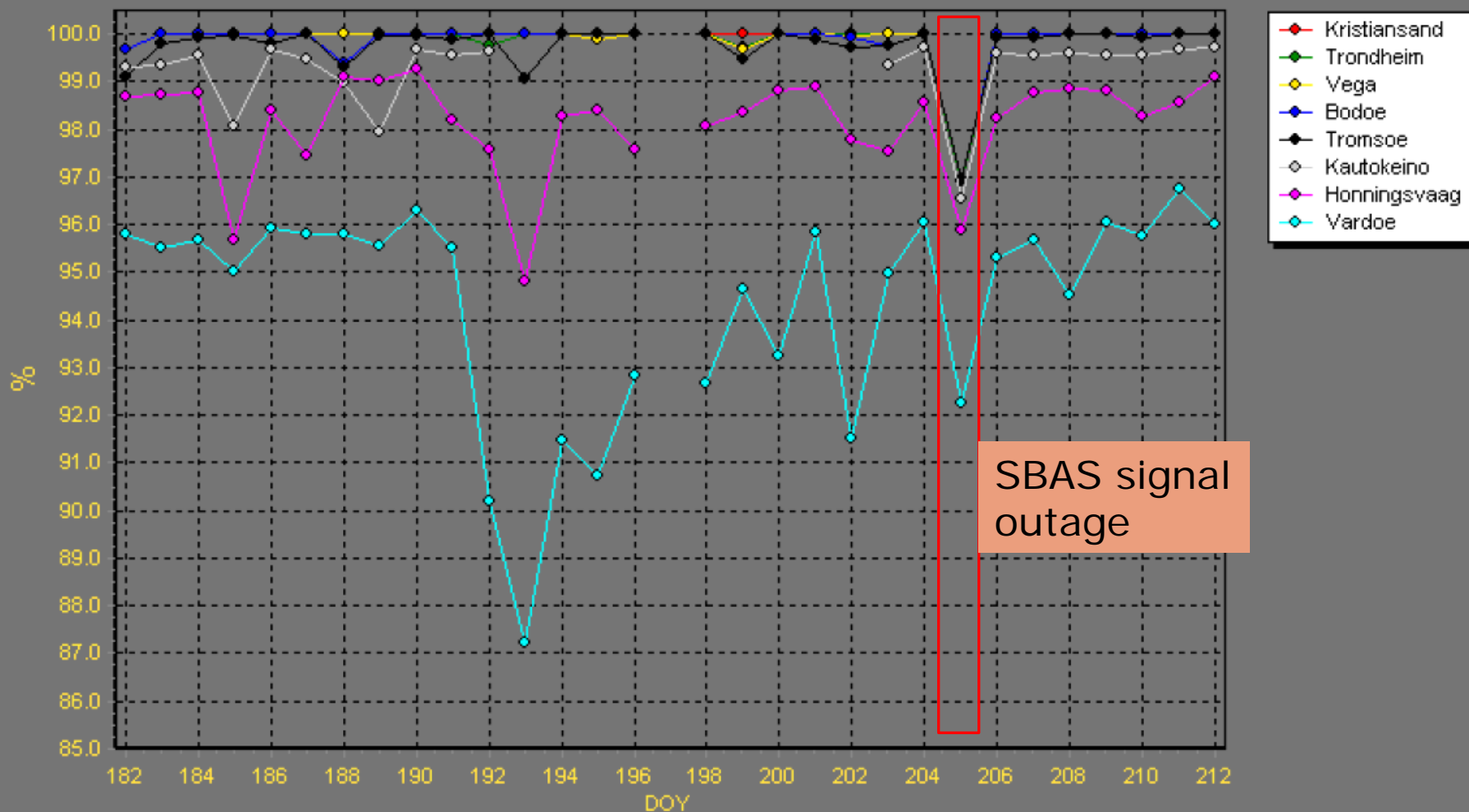


# "Uncorrected" GPS: Horizontal accuracy, July 2014



# EGNOS: July 2014

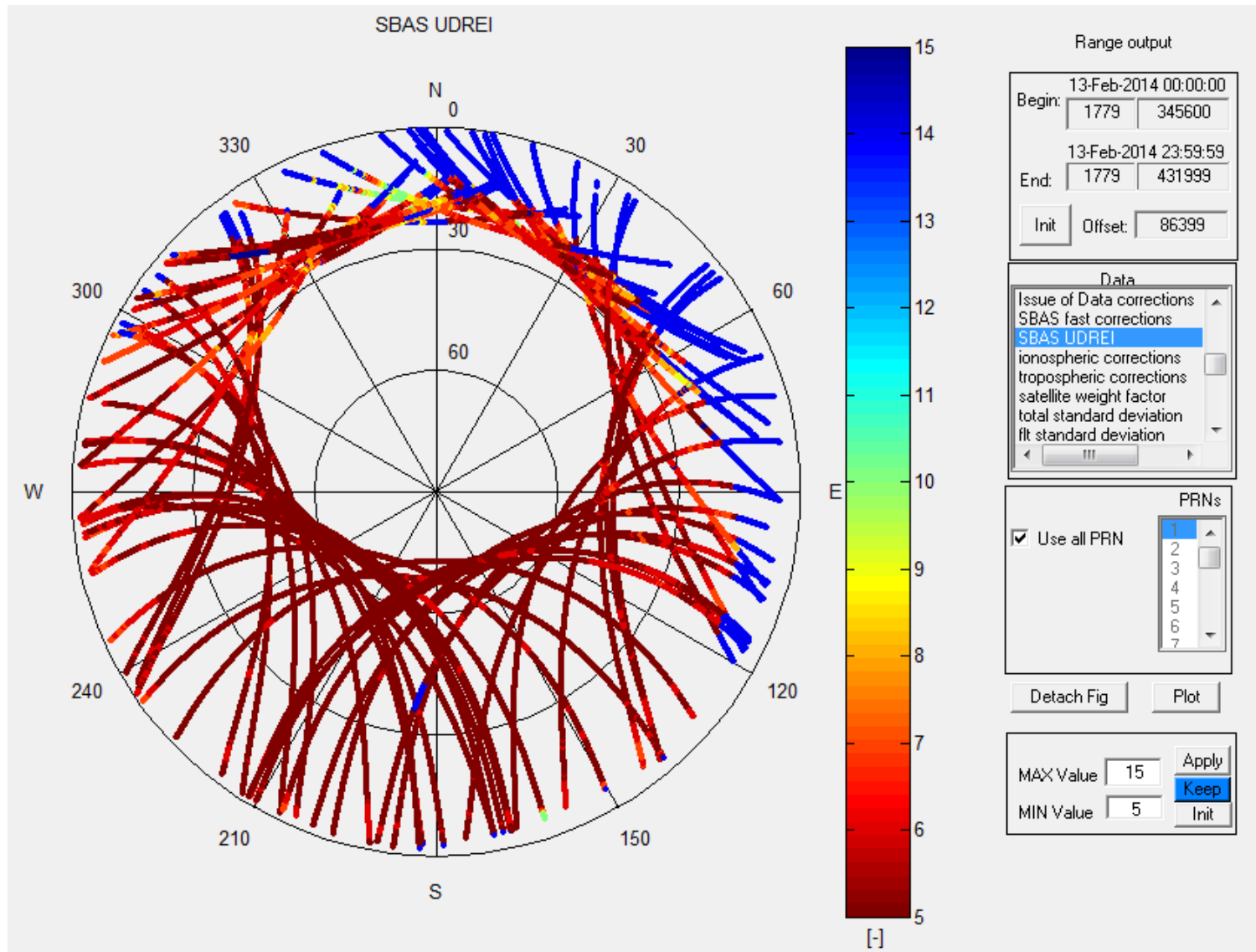
## APV-1 Availability using PRN 120

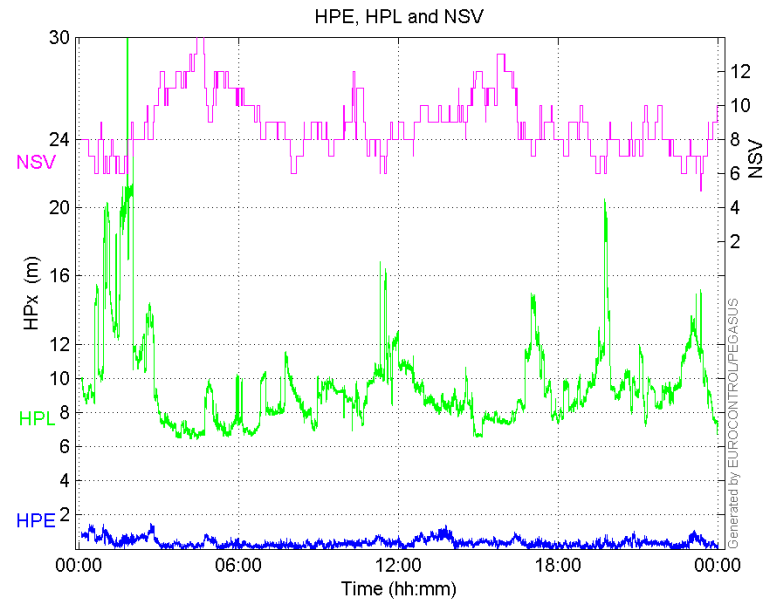
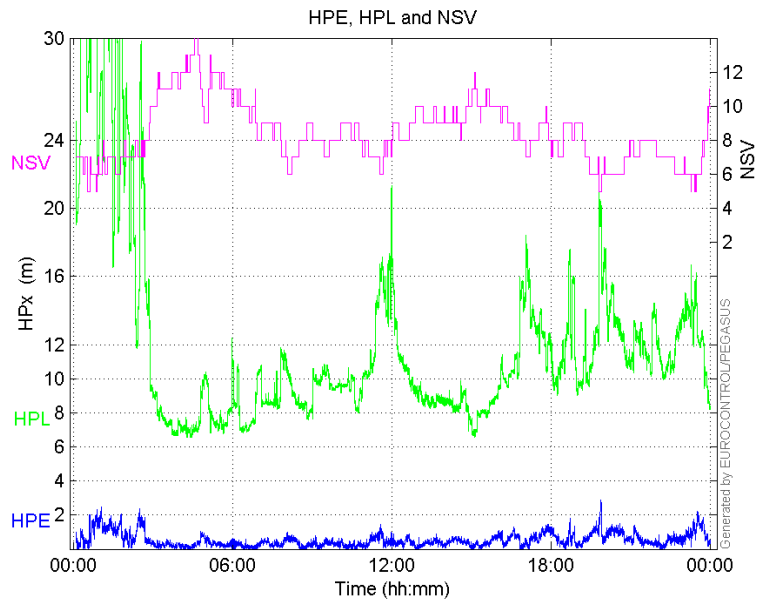


SBAS signal outage

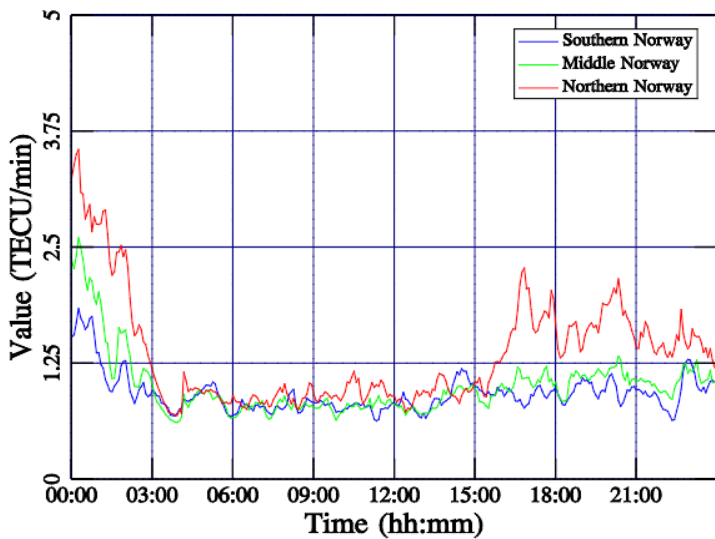
# Unstable performance at high latitudes

Example: Tromsø, 13-02-2014

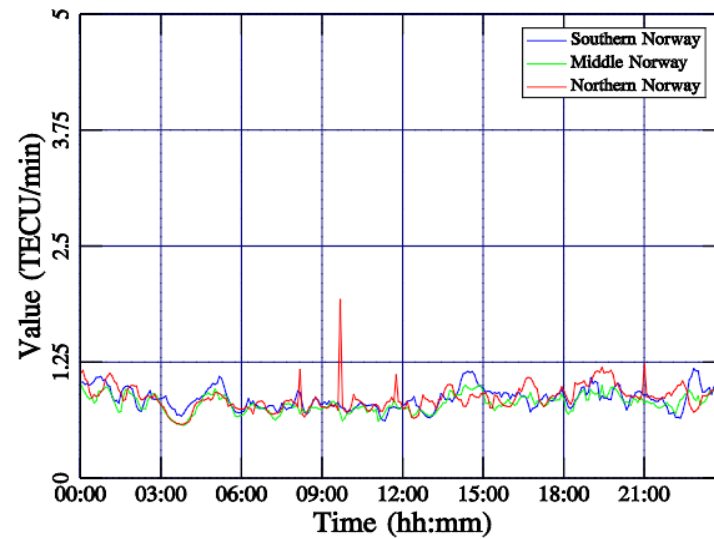




2014-02-12 00:00 to 2014-02-12 23:59 UTC  
Rate of TEC Index at ground



2014-02-13 00:00 to 2014-02-13 23:59 UTC  
Rate of TEC Index at ground





# Thank you!

## Questions?



*Jan Mayen.  
Photo: Rune Hanssen*