SENSORS

Redundancy in Dynamic Positioning (DP) Applications Based on Satellite Navigation

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DYNAMIC POSITIONING CONFERENCE, HOUSTON, 7-8 October 2008

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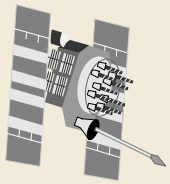
- Background
- Satellite navigation correction methods
- Distribution of corrections
- Global Navigation Satellite Systems (GNSS)
- New Dual Frequency GPS+GLONASS service
- Conclusions

- Satellite navigation is the preferred position reference for today's rapidly expanding DP fleet.
- Today, two Differential GPS systems are accepted (if they are independent):
  - Independent provision of DGPS corrections.
  - Independent setups onboard the vessel.
- In addition to GPS, other Global Navigation Satellite Systems (GNSS) are under way:
  - The Russian GLONASS has 14+ satellites available today, and is expanding
  - The EU is developing Galileo
  - China is developing Compass

Traditional DGPS NETWORK vs ORBIT/CLOCK



Orbit Error

Clock Error

PRC

In DGPS traditional Network systems, pseudorange corrections (PRC) towards each satellite are measured at the reference station and sent to the user.

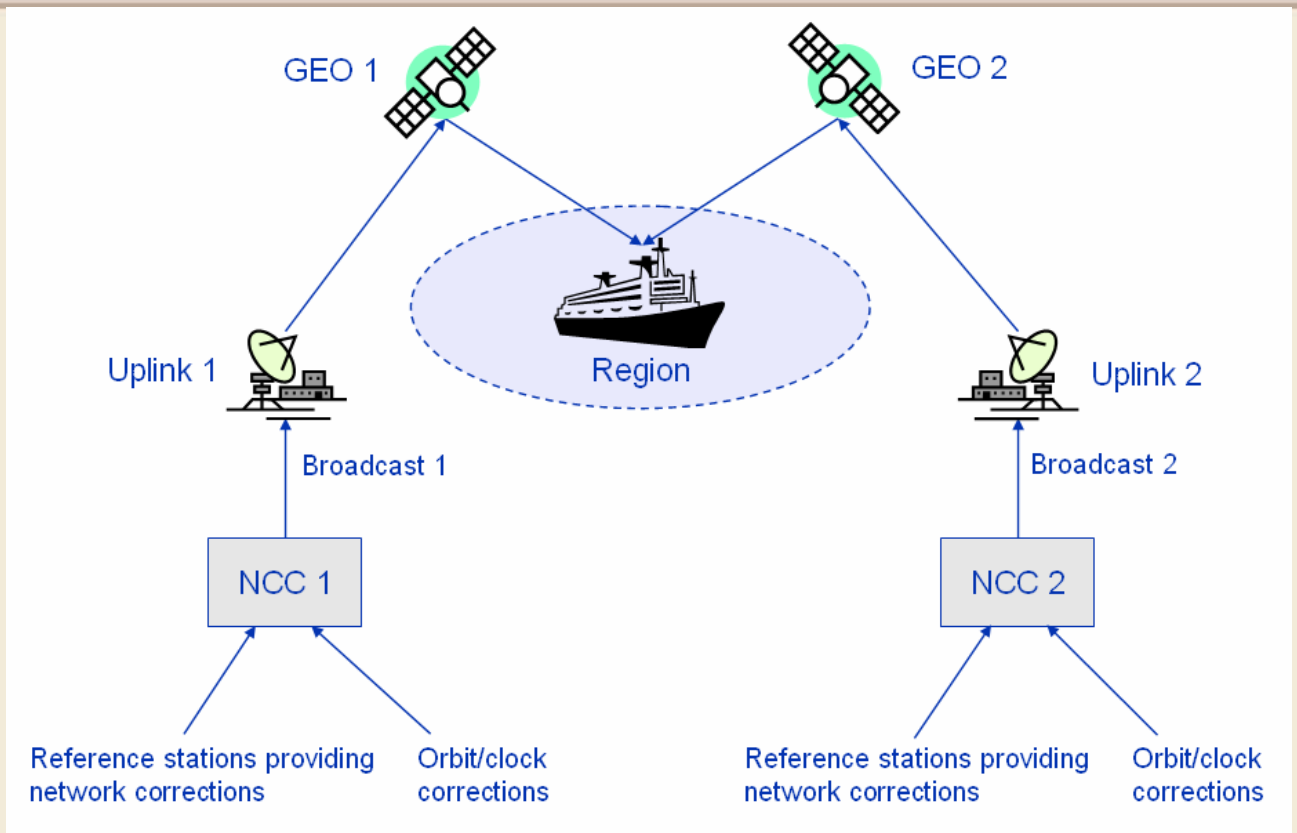
The orbit part of the PRC gets less accurate as distance to the reference station increases

In Orbit/Clock correction systems, the orbit and clock error for each GPS satellite is calculated centrally and sent to the user.
Orbit/clock corrections are valid world wide.

Reference Station

User

Independent broadcasts

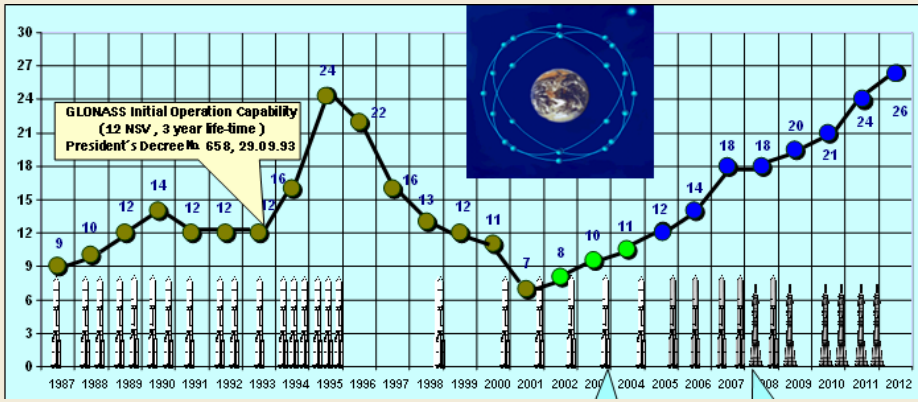


For DGNSS services, it is important that each region in the world is covered by two independent broadcasts

- Different Network Control Centers (NCC)
- Different uplink sites
- Different geostationary satellites

Global Navigation Satellite System (GNSS)

- GPS (USA)
  - 30 satellites now
  - Operational since 1994
- GLONASS (Russia)
  - 14+ satellites now
  - Fully operational from 2011
    will eventually have 30 satellites
- Galileo (EU)
  - Operational 2013+ with 30 satellites
- Compass (China)
  - Operational 2013 (?) with 35 satellites



1995 **2008**

Fugro has provided DGLONASS service for more than 10 years

GLONASS

- 3 satellites launched 25 Sept. 2008
- 3 satellites to be launched 26 Dec. 2008
- 6 satellites to be launched 2009 and in 2010
- USD 2.6 Billion allocated for operations 2012-2020

GLONASS Constellation Status at 07.10.2008 based on both the almanac analysis and navigation messages received at 14:00 07.10.08 (UTC) in IAC PNT TsNIImash

Orb. pl.	Orb. slot	RF chnl	# GC	Launched	Operation begins	Operation ends	Life-time (months)	Satellite health status		Comments
								In almanac	In ephemeris (UTC)	
I	1	07	796	26.12.04	06.02.05	04.05.08	45.4	-	- 08:00 07.10.08	Maintenance
	4	06	795	10.12.03	29.01.04		58.0	+	+ 11:15 07.10.08	In operation
	6	01	701	10.12.03	08.12.04		58.0	+	+ 14:00 07.10.08	In operation
	7	05	712	26.12.04	07.10.05		45.4	+	+ 14:15 07.10.08	In operation
	8	06	797	26.12.04	06.02.05	16.06.08	45.4	-	- 06:15 29.08.08	Decommissioning Phase
II	9	-2	722	25.12.07	25.01.08		9.4	+	+ 09:00 07.10.08	In operation (L1 only)
	10	04	717	25.12.06	03.04.07		21.4	+	+ 10:30 07.10.08	In operation
	11	00	723	25.12.07	22.01.08		9.4	+	+ 12:00 07.10.08	In operation
	13	-2	721	25.12.07	08.02.08		9.4	+	+ 14:15 07.10.08	In operation
	14	04	715	25.12.06	03.04.07		21.4	+	+ 14:15 07.10.08	In operation
	15	00	716	25.12.06	12.10.07		21.4	+	+ 14:15 07.10.08	In operation
III	17	-1	718	26.10.07	04.12.07		11.4	+	+ 06:15 07.10.08	In operation
	18		724	25.09.08			0.4			Commissioning Phase
	19	03	720	26.10.07	25.11.07		11.4	+	+ 09:30 07.10.08	In operation
	20	02	719	26.10.07	27.11.07		11.4	+	+ 11:15 07.10.08	In operation
	21		725	25.09.08			0.4			Commissioning Phase
	22		726	25.09.08			0.4			Commissioning Phase
	23	03	714	25.12.05	31.08.06		33.4	+	+ 14:15 07.10.08	In operation
	24	02	713	25.12.05	31.08.06		33.4	+	+ 14:15 07.10.08	In operation

Total satellites in constellation	19 SC
Operational	14 SC
In commissioning phase	3 SC
In maintenance	1 SC
In decommissioning phase	1 SC

http://www.gpsdaily.com/reports/Putin_Orders_Additional_Funding_On_Glonass_Development_999.html

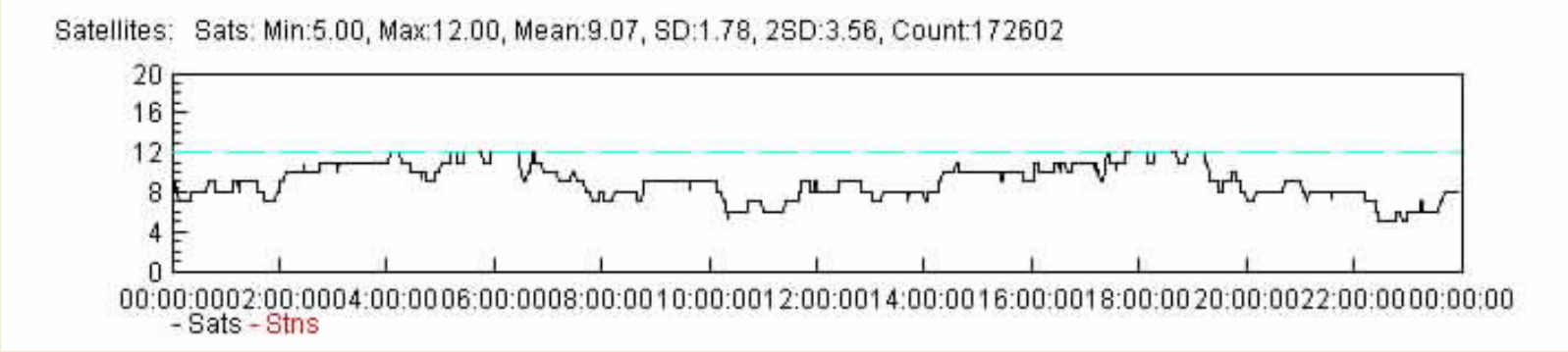
Improved Performance with several GNSS

- Independence
  - When more systems become fully operational, they can be used as independent systems in safety critical applications
- Availability
  - Combined systems will improve availability of satellite navigation in situations where parts of the sky are obscured. This will be the case close to oil rigs, during ionosperic scintillations etc.
- Reliability
  - Increased redundancy of data (additional lines of position) will help to identify bad measurements
- Accuracy
  - Improved accuracy with more satellites (improved geometry)
  - Improved convergence time in phase based decimeter level systems

New Fugro Service:

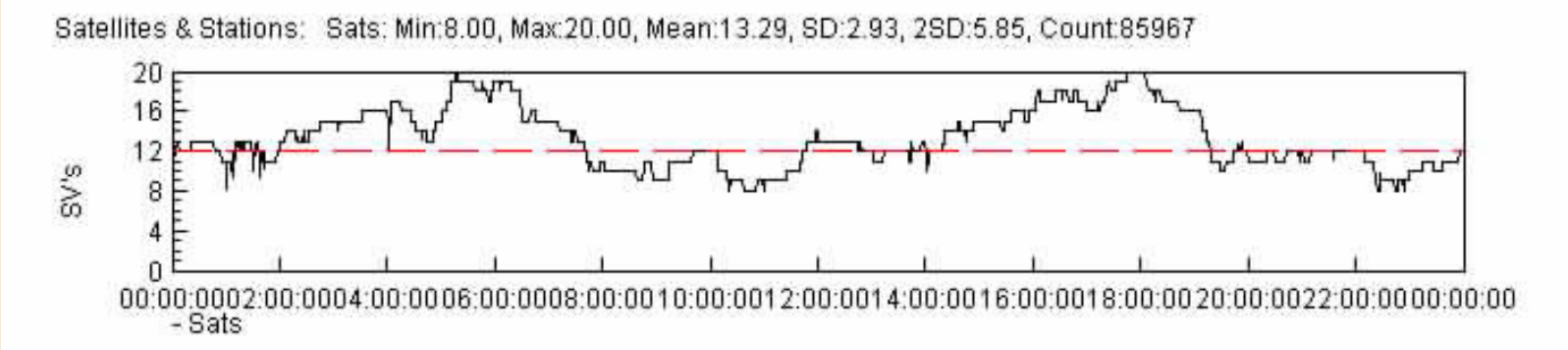
- Dual frequency GPS and GLONASS (Ionospheric delay measurements)
- Carrier phase based service (Decimeter level)
- Orbit and Clock service (Word Wide)
- Tests on vessels being performed
- Operational introduction early 2009

Number of Satellites GPS vs GPS+GLONASS



GPS: Mean: 9 satellites

Period covered on next slides



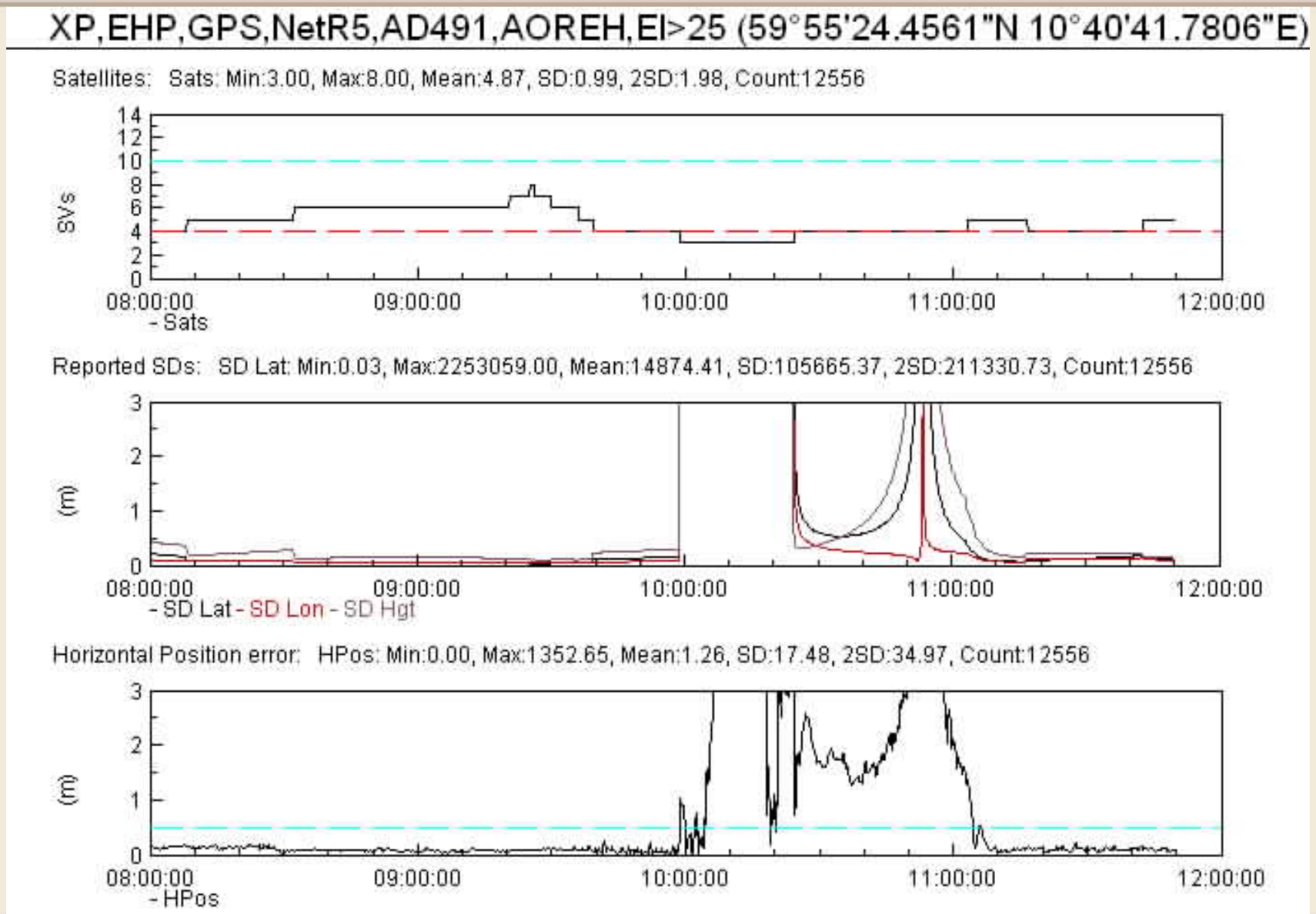
GPS+GLONASS:

Mean: 13 satellites

Period covered on next slides

Oslo, 20 Sept 2008, 8 deg elevation mask

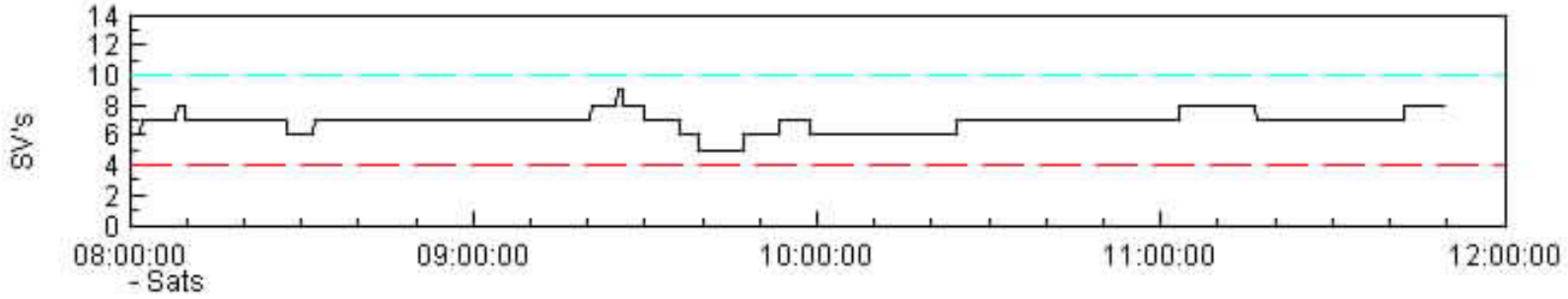
GPS, Elevation Mask 25º, 20/09/08, Oslo



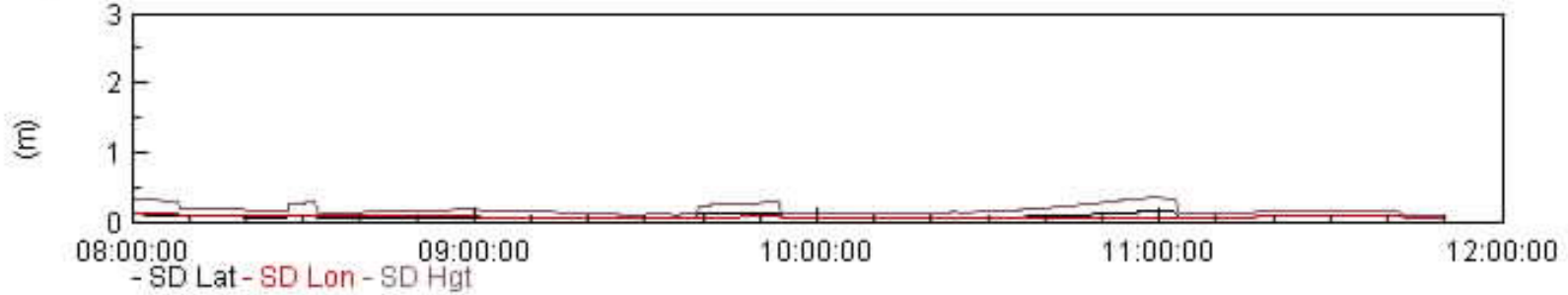
GPS+GLONASS, El. Mask 25º, 20/09/08, Oslo

EHP,GPS+GLO,NetR5,AD491,AOREH,El>25 (59°55'24.4561"N 10°40'41.7806"E)

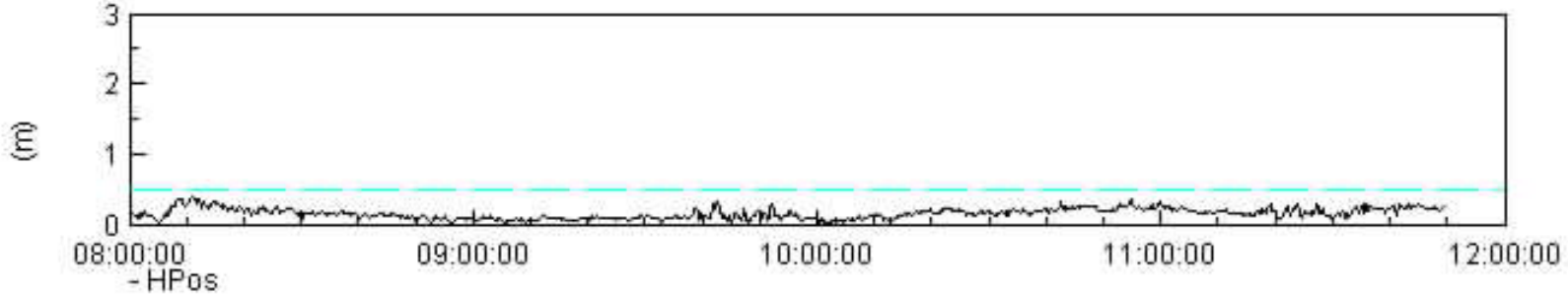
Satellites: Sats: Min:5.00, Max:9.00, Mean:6.89, SD:0.67, 2SD:1.34, Count:13738



Reported SDs: SD Lat: Min:0.04, Max:0.14, Mean:0.07, SD:0.03, 2SD:0.05, Count:13738



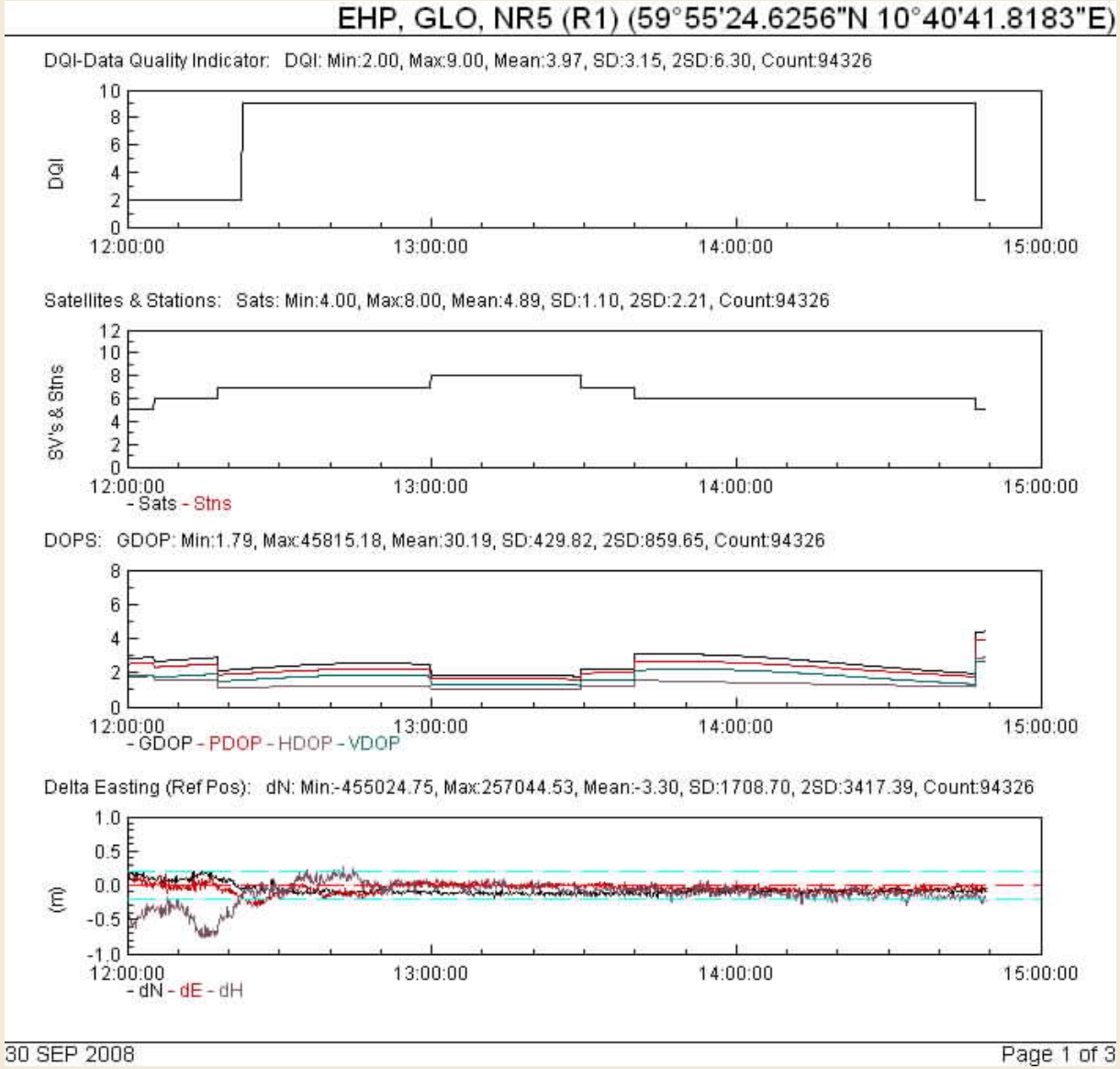
Horizontal Position Error: HPos: Min:0.00, Max:0.40, Mean:0.15, SD:0.07, 2SD:0.14, Count:13738



GLONASS Only, 30/9 2008, Oslo

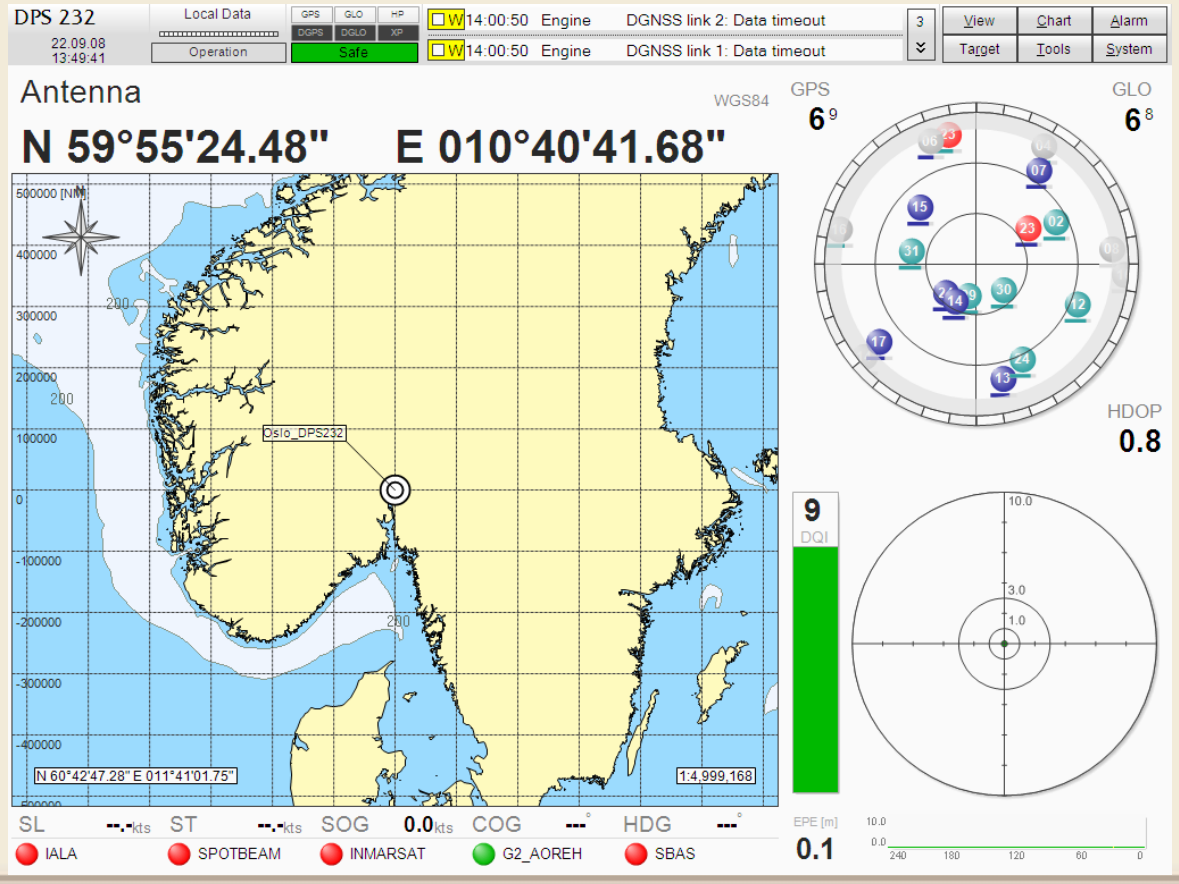
During periods with enough GLONASS satellites, the solution is at the decimetre level using only GLONASS satellites.

dN = North error
dE = East Error
dH = Height error



User Equipment with dual frequency GPS/GLONASS Capability

- Kongsberg Seatex DPS 232 has dual frequency GPS/GLONASS capability and can use the new Fugro correction service.
- Fugro StarPack
- Other user equipment to follow



Conclusions

- Using different correction methods provides robustness
  - Network corrections and Orbit Clock corrections
- Dual independent high power deliveries in all regions of the world provide high availability
- Four Global Navigation Satellite Systems will provide 120 satellites in 5-10 years
- GLONASS is being revived with full constellation in a couple of years
  - 14+ satellites today, full constellation 2011
- *Fugro will introduce dual frequency world wide decimeter level GPS and GLONASS service in 2009*
  - *Vessel trials going on*