Kongsberg DGNSS infrastructure solutions

General Overview

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DGNSS Service

- The DGNSS service was established in order to improve safety and efficiency of navigation
- More than 300 reference stations (IALA) in operation around the world
- The removal of Selective Availability (SA) in year 2000 did not remove the requirement for GNSS augmentation
- Without augmentation GNSS accuracy may contain significant errors for extended periods of time and no integrity information is provided

Definitions

- **Availability (ref. IMO Res. A860)**
  - ✓ The percentage of time that an aid, or system of aids, is performing a required function under stated conditions. The non-availability can be caused by scheduled and/or unscheduled interruptions
- **Continuity/reliability**
  - ✓ Continuity is the ability of a system to function within specified performance limits without interruption during a specified period (normally short term)
- **Integrity**
  - ✓ Integrity is the ability to provide users with warnings within a specified time when the system should not be used for navigation
- **Accuracy**
  - ✓ Absolute horizontal accuracy should be better than 10m (95%) inside the coverage area. 1m at the reference station. Degradation around 1m pr 150km from the broadcast site

System characteristics

- The International Maritime Organisation (IMO) issued a performance standard, IMO A.815(19) in 1995, containing the main system characteristics.
- The resolution A.815(19) was revoked by A.953 (23) in 2004 and provides standards for accuracy, availability and continuity from a satellite radio navigation system.
- Technical parameters of IALA DGNSS, ref A.953;

Position Accuracy:	10m (95%)
Availability - Coastal/harbor with low level of risk - Coastal/harbor with high level of risk	*Calculation; IALA Rec. R-121* >99.5% over 2 years >99.8% over 2 years
Reliability/continuity - Coastal/harbor with low level of risk - Coastal/harbor with high level of risk	 ≥99.85% over 3 hours ≥99.97% over 3 hours
Integrity	Time to Alarm less than 10 sec

Technical parameters

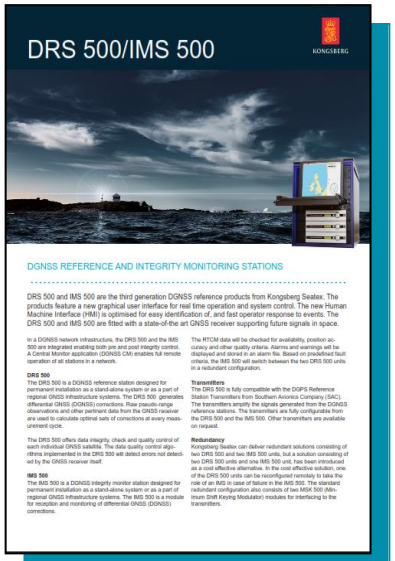
- The transmission of the DGNSS correction and integrity data are based on the ITU-R.M 823-2 (message format).
- The main technical characteristics of the IALA DGNSS beacons are;

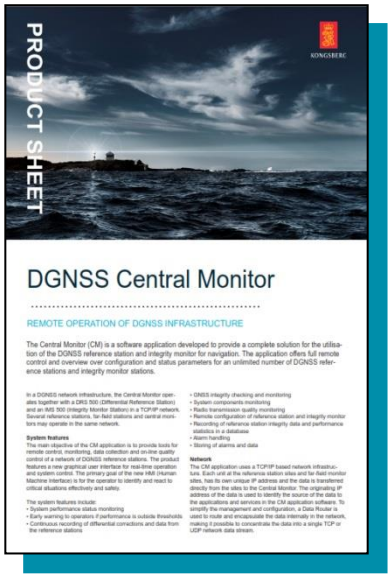
Frequency band	283.5 – 315.0 kHz in Europe 283.5 – 325.0 kHz in other regions
Modulation	Minimum Shift Keying (MSK)
Data Rate	50, 100 or 200 Bit/s. Since S/A has been removed most countries use 100/200 Bit/s
Data Format	**RTCM SC104 V 2.3** Messages for DGPS Messages available for DGLONASS V 2.4 on draft autumn 2009 embracing new satellite navigation systems as well
International Standard	ITU- Recommendation M. 823-2

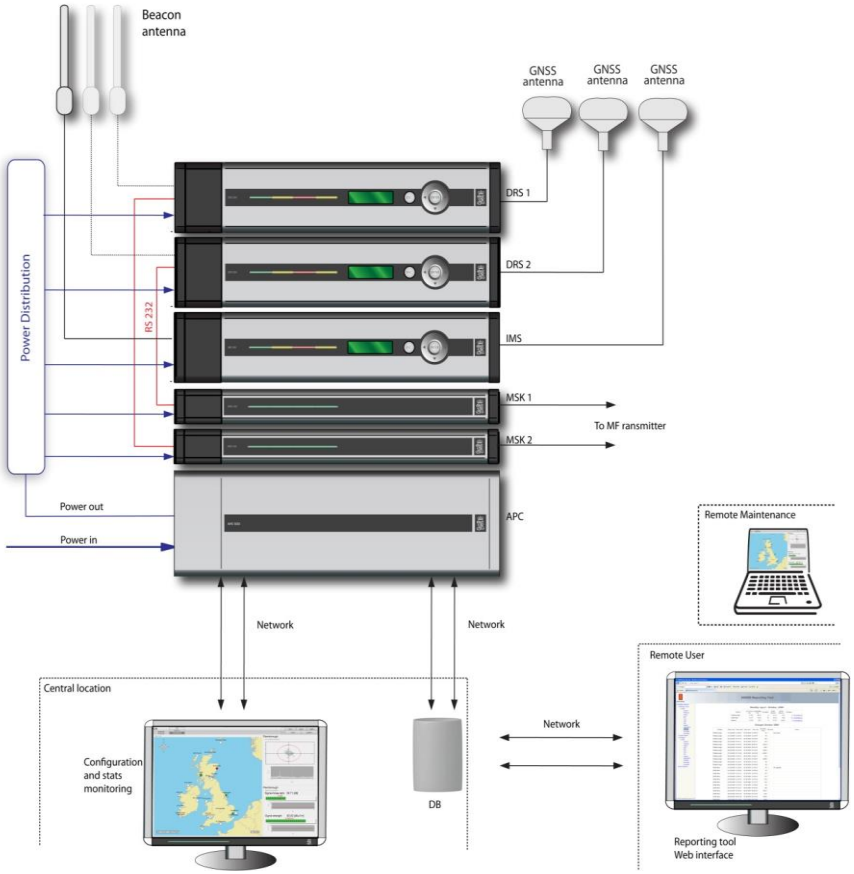
Standards and recommendations

- IMO A. 815(19) states main system characteristics. Accuracy, availability, reliability and integrity. Revoked by A.953(23).
- IALA Recommendation R-121, the performance and monitoring of DGNSS services in the frequency band 283,5 – 325 kHz, Edition 2.0, May 2015.
- IALA Guideline No. 1112, the performance and monitoring of DGNSS services in the frequency band 283,5 – 325 kHz, Edition 1, May 2015
  - ✓ Performance and monitoring requirements for a DGNSS system.
- ITU-R M.823-2 states the message format and transmission characteristics.
- RTCM SC104 v2.3 – states the RTCM message data format.
  - ✓ V2.4 on draft level autumn 2009 and is introducing significant changes.
- RTCM SC104 RSIM v 1.2- outlines the performance, functional, interface, and environmental parameters for DGPS reference stations, integrity monitors and transmitter/RSIM interface modules.

Kongsberg DGNSS infrastructure

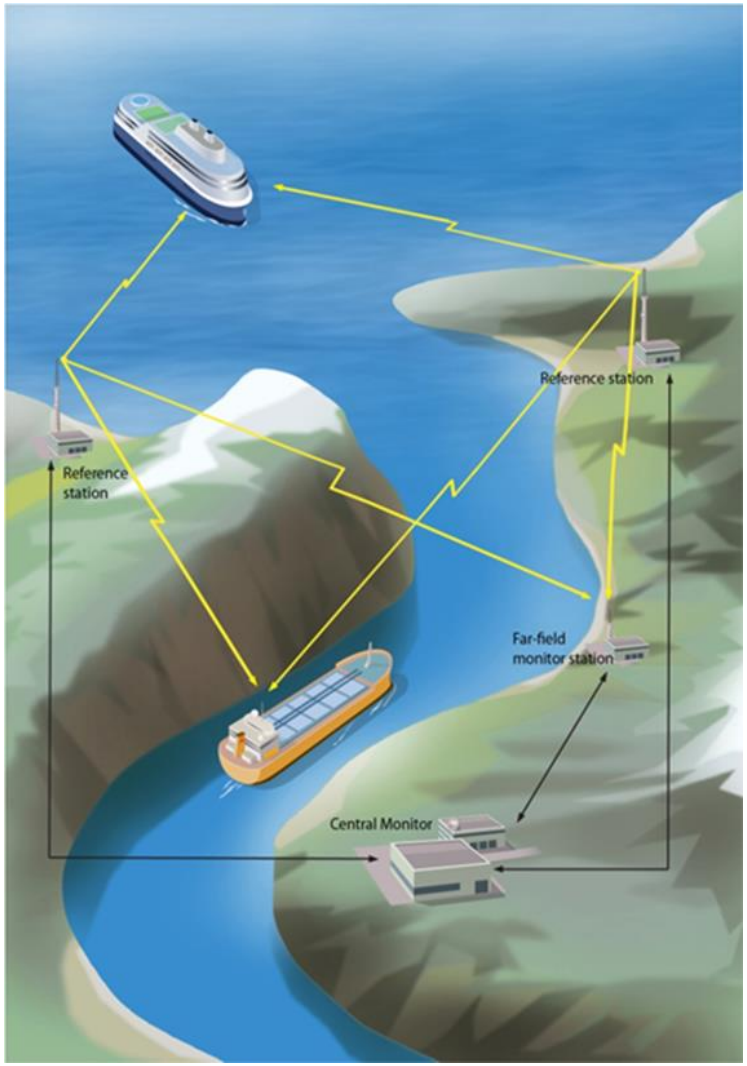






System Architecture

- IP based network infrastructure.
- Continuously monitoring of reference and far field stations from CM, incl. alarm management.
- Automatic database update if line of communications are down
- Autonomus operation of reference stations even though lines of communication to central is down.
- All sites are remotely operated from Central Monitor.



DGNSS Network Components, overview

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Hardware modules

The following modules are typical components on a reference site. Redundancy is achieved by great flexibility in HW.

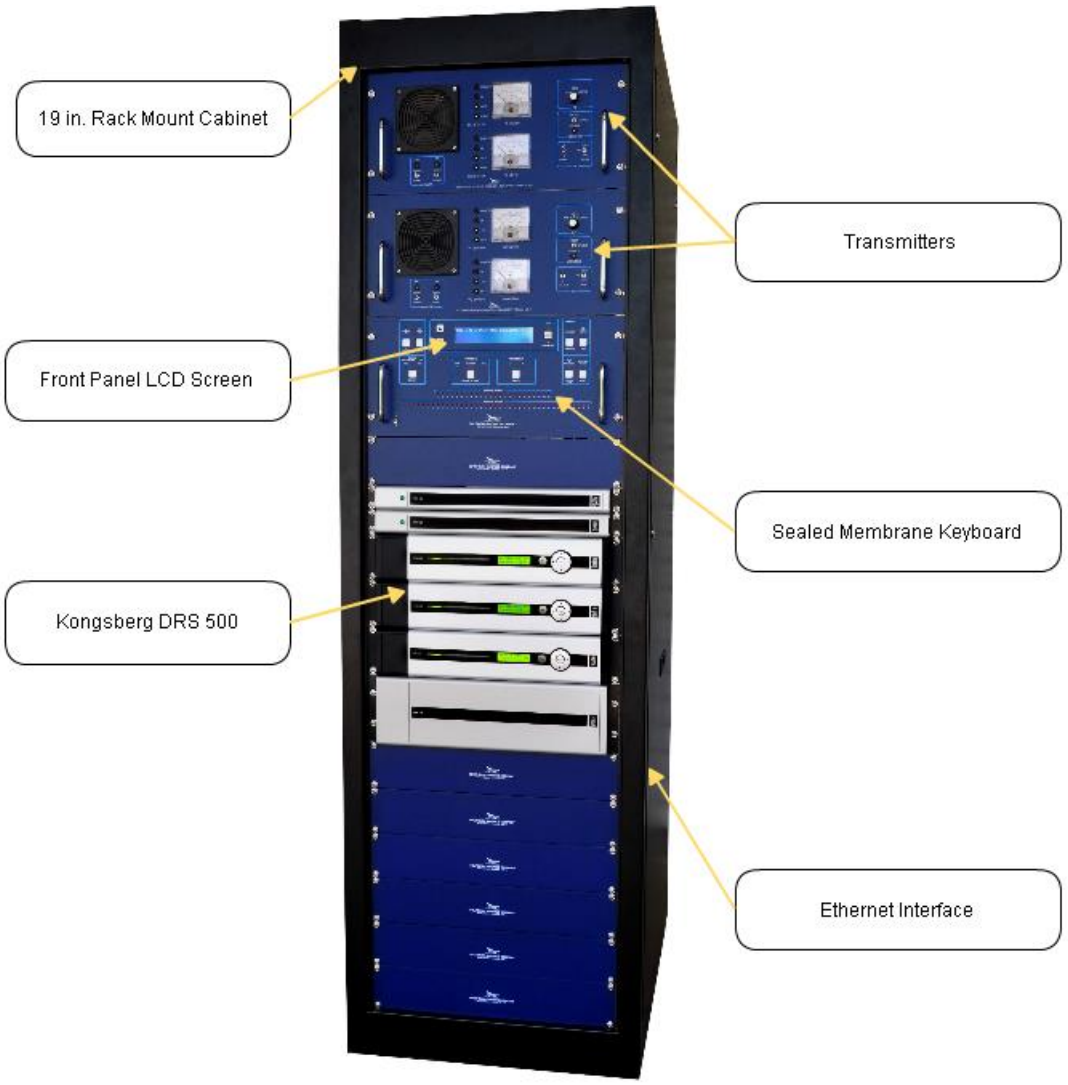
✓DRS 500, Reference station
✓IMS 500, Integrity Monitoring
✓APC 500, Power Control Unit
✓MSK 500, Minimum Shift Keying (MSK) modulator
✓Keyboard and display and KVM switch

✓Using Southern Avionics (SAC) MF radio systems

Software Modules, Control Center

✓DGNSS network, Central Monitor (CM)
✓DGNSS network, Reporting Tool

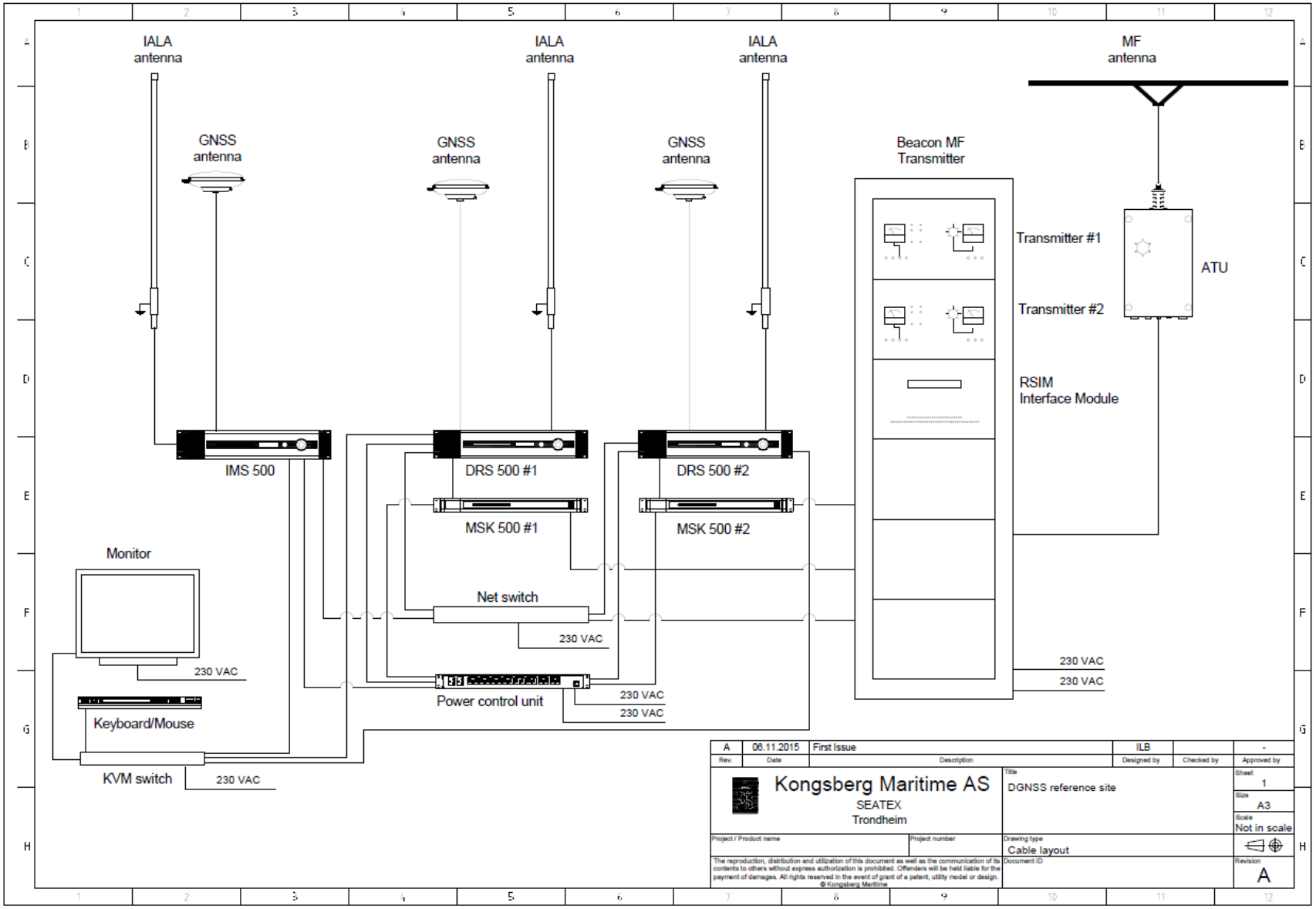
Southern Avionics MF Radio System



Southern Avionics MF Radio System

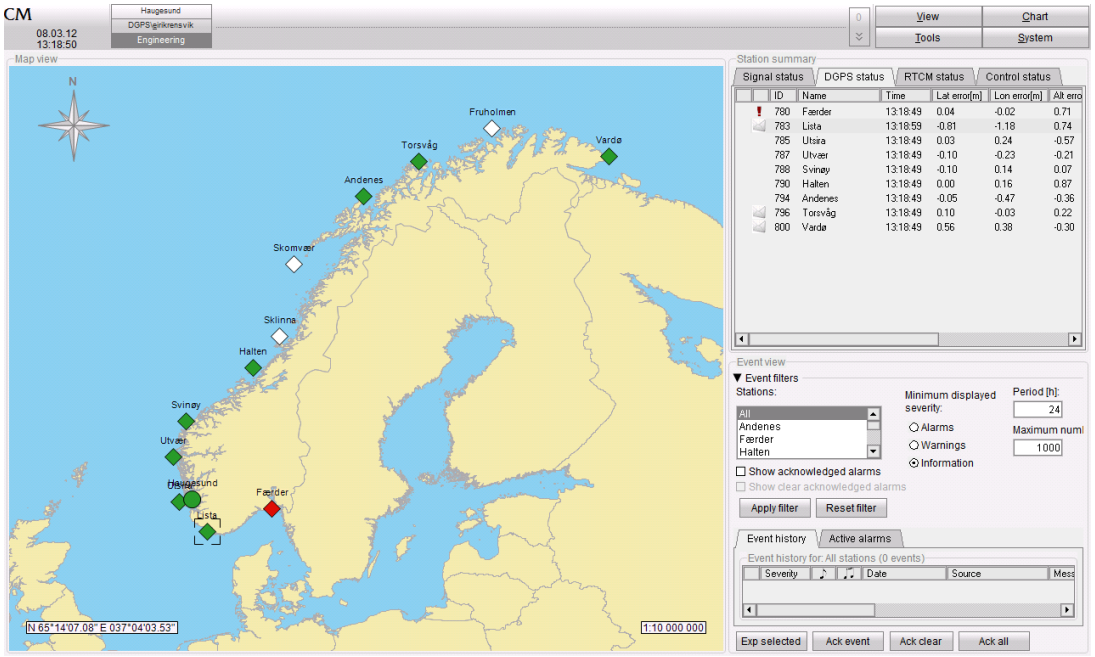
FEATURE	SPECIFICATION
Frequency	283.5 – 325 kHz 5 mW MSK sinewave signal
Power Output	Carrier power into 50 Ohms continuously adjustable from 10 – 500 W max
Spurious Emission	Less than -70 dBc
Radiated Harmonics	Less than -60 dBc
Type of Emission	NON, G1D
Noise and Hum Level	Less than -40 dB
Input Power	115/230 V +/-10%, single phase 50 – 60 Hz; or 144 VDC or both with switch over to batteries
Nominal AC input power	688 W at 500 W output
Nominal DC input power	575 W at 500 W output
Temperature Range for Working Conditions	-15°C - +55°C
Relative Humidity for Working Conditions	0 - 95%
Metering	Forward power output, reflected power output, PA voltage and PA current
Height	78 in. (198cm)
Length	32 in. (81cm)
Width	23 in. (58cm)
Temperature Range for Working Conditions	-15°C - +55°C

Architecture example – Reference Site



Central Monitor

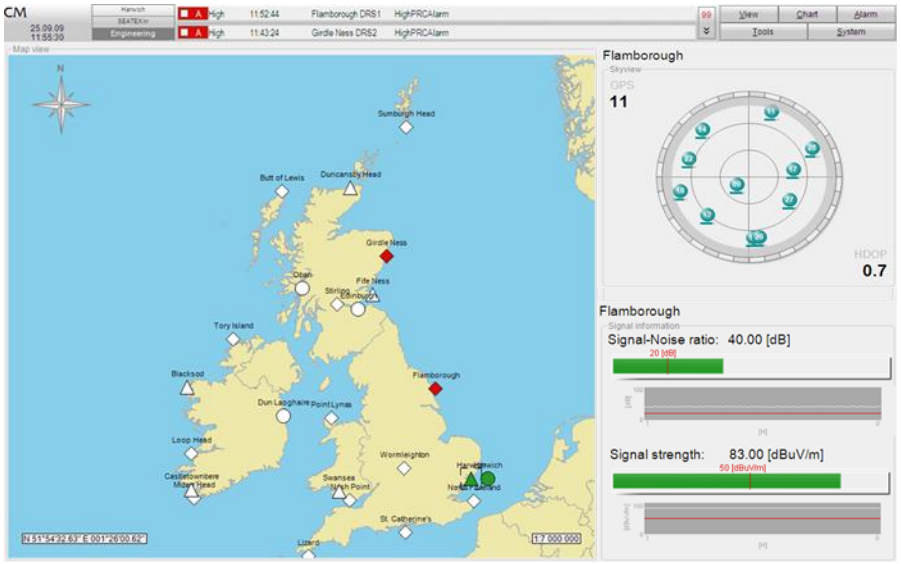
- The Central Monitor (CM) is an application developed to provide a complete solution for the utilization of the DGNSS reference station and integrity monitor.
- CM offers full remote control and overview over configuration and status parameters for an unlimited number of DGNSS reference stations and integrity monitor stations.



- Tailored for real time operation and service with special focus on:
  - ✓ Status and system integrity
  - ✓ Efficient operation and remote maintenance
  - ✓ User friendlyness
- User interface developed in close co-operation with end users
- Local user interfaces (DRS/IMS) are built upon the same principles as the CM in order to ease the training and day to day operation

Main Objectivities of the CM

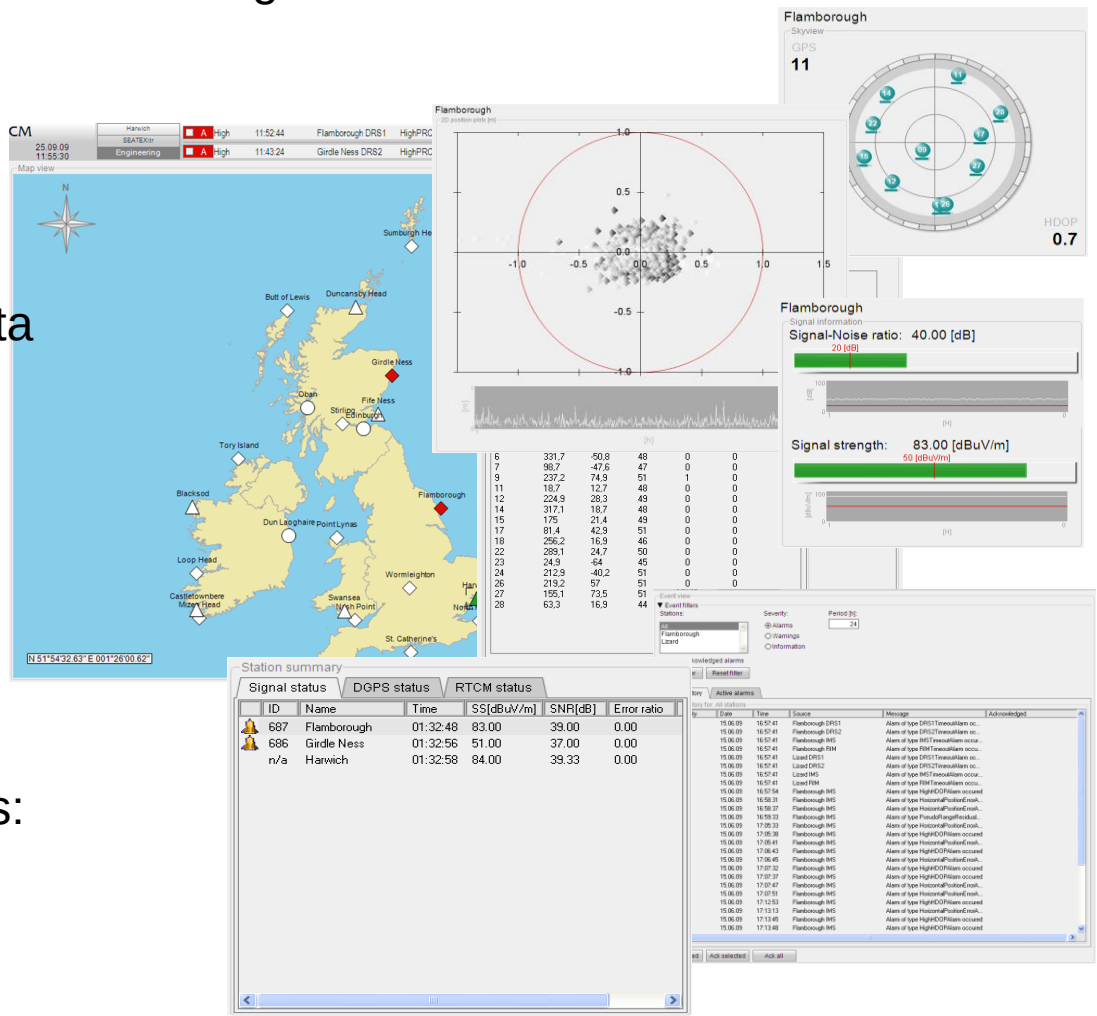
- GNSS integrity checking and monitoring
- System components monitoring (e.g. Mimic diagram)
- Radio transmission quality monitoring
- System performance status monitoring
- Early warning if performance is outside thresholds
- Alarm system
- Alarms and RSIM data stored in central DB. Raw data stored locally
- Remote configuration of equipment at reference and FFM sites
- Tool for automatic verification and reporting of system performance



Views

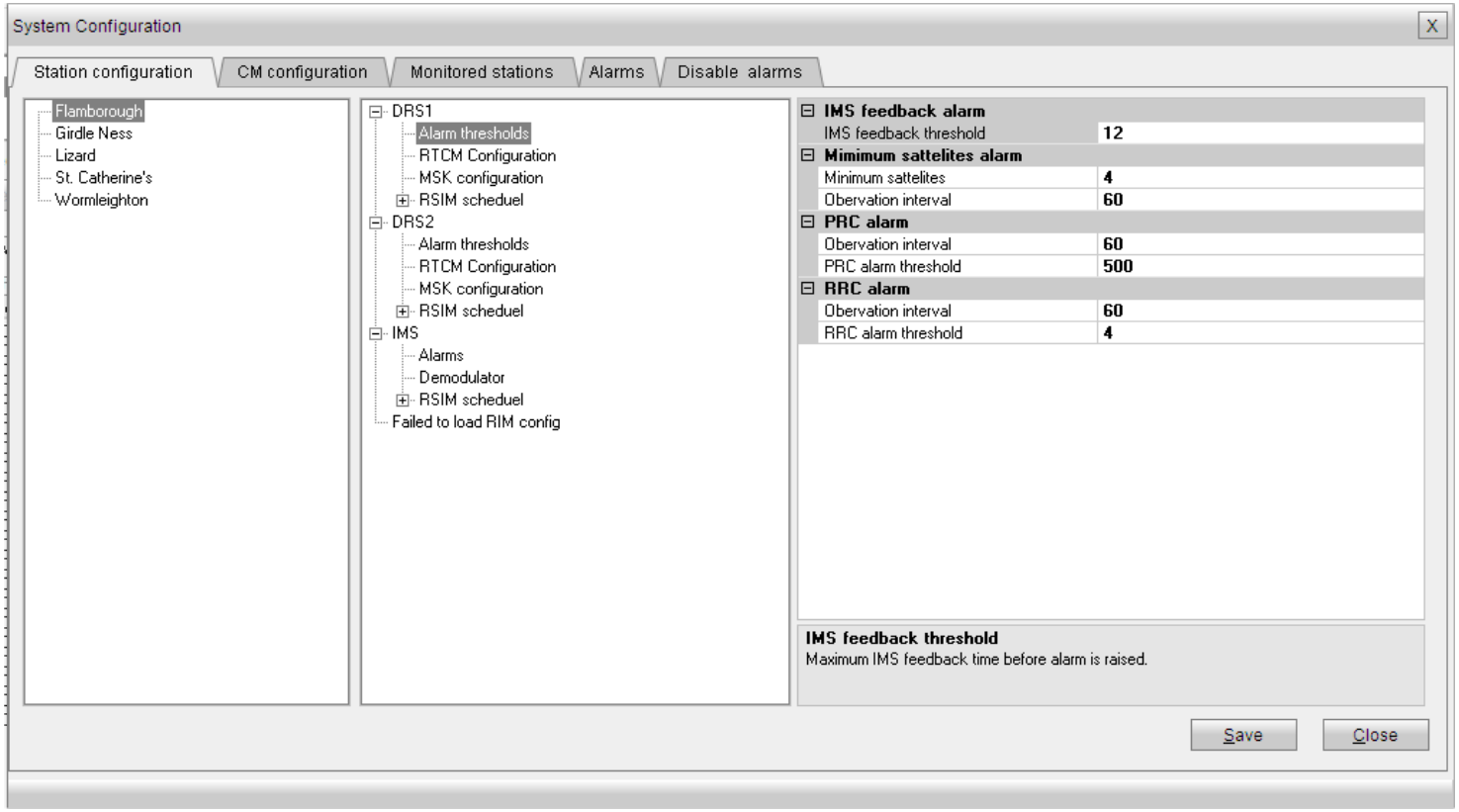
The operator may select between the following views:

- Map view
- Satellite status view
- Sky view
- 2D position plots
- Reference station correction data
- Signal information
- IMS correction data
- Mimic status diagram
- RIM information view
- Event view
- Active alarms view
- Station summary which includes:
  - ✓ Signal status view
  - ✓ DGPS status view
  - ✓ RTCM status view



Configuration

All configurations for the different sites and units may be carried out remotely via the CM. Alarm settings are also managed from the configuration view.



Web reporting tool

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Monthly report

Select year: 2013

Select month: February

Sample mode: (•) Instantaneous ( ) Hourly mean

Select station(s): All, Makis

Generate report

Monthly report - February, 2013

Station	Accuracy [m]	Availability [%]	Integrity [#]	MTBF [hours]	MTTR [hours]	Outages [#]	Continuity [%]	Charts
Makis	0.392	99.79	0	708.00	0.70	2	99.58	2D SS SNR SVs

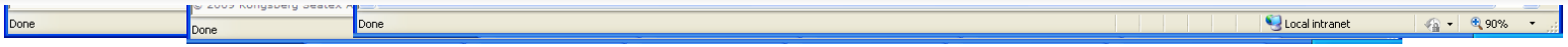
Continuity is the ability of a system to function within specified performance limits without interruption during a specified time interval (normally 3 hours). Continuity considers overlapping coverage and ignores planned outages, and is based on last 24 months (rolling). The MTBF/MTTR values are based on last 12 months (rolling).

Outages

Station	Date start	Time start	Date end	Time end	Duration [sec]	Planned	Cause	Comment
Makis	27/02/2013	14:24:05	27/02/2013	15:34:40	4234	☐	Zero signal strength	
Makis	27/02/2013	15:42:06	27/02/2013	15:55:15	789	☐	Zero signal strength	

Total planned outage:0 seconds. Total unplanned outage: 5023 seconds.

Report was generated using all samples.



References

DGNSS Infrastructure, latest generation product range

- UK and Ireland
  - 14 + 3 x Reference Station sites
  - 6 x Far-field stations
- Norway
  - 12 x Reference Station Sites
  - 8 x Far-field Stations
- Belgium
  - 1 x Reference Station Site
  - 1 x Far-field Stations
- Serbia
  - 1 x Reference Station Site
  - 2 x Far-field Stations
- Malaysia
  - 2 x Reference Station Sites
  - 2 x Far-field Stations

November 2015

- The Netherlands
  - 3 x Reference Station Sites
  - 3 x Far-field Stations