

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- The resolution A.815(19) was revoked by A.953 (23) in 2004 and provides standards for accuracy, availability and continuity from a satellite radio navigation system.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	<i>Calculation; IALA Rec. R-121</i> >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



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DRS 500/IMS 500

DGNSS REFERENCE AND INTEGRITY MONITORING STATIONS

DRS 500 and IMS 500 are the third generation DGNSS reference products from Kongsberg Seatec. The products feature a new graphical user interface for real time operation and system control. The new Human Machine Interface (HMI) is optimized for easy identification of, and fast operator response to events. The DRS 500 and IMS 500 are fitted with state-of-the-art GNSS receiver supporting future signals in space.

In a DGNSS network infrastructure, the DRS 500 and the IMS 500 act as reference stations and provide integrity control. A Central Monitor application (DGNSS CM) ensures full remote operation of all stations in a network.

DRS 500
The DRS 500 is a DGNSS reference station designed for permanent installation as a monitoring system or as a part of regional DGNSS infrastructure systems. The DRS 500 generates reference data and provides integrity control. The DRS 500 is used to calculate optimal sets of corrections for every receiver in the network.

IMS 500
The IMS 500 offers data integrity, check and quality control of each individual GNSS satellite. The data quality control algorithm implemented in the DRS 500 will detect errors and alert the user by the GNSS receiver itself.

MSK 500
The MSK 500 is a DGNSS integrity monitor station designed for permanent installation as a monitoring system or as a part of regional DGNSS infrastructure systems. The MSK 500 is a module for reception and monitoring of reference (DGNSS) corrections.

MSK 500

MSK MODULATOR

The Kongsberg MSK 500 (Minimum Shift Keying) modulator is designed specifically to work with marine DGNSS radio beacon systems.

The MSK 500 receives differential GNSS corrections from the DRS 500 reference station and transmits corrections to the receiver for broadcast on medium frequency (MF) to non-monitoring users.

TECHNICAL DATA

Date rate	1000 bps
Frequency range	200 to 1250 kHz
Frequency resolution	500 Hz
Frequency stability	0.01 Hz
Generation rate of MSK modulation	50, 100, 200 bps
Output voltage into 50 Ohms	0.8 ± 0.1 V

POWER SPECIFICATIONS

Voltage	24 V DC (18 to 30 V DC)
Power consumption	Max. 20 W

ENVIRONMENTAL SPECIFICATIONS

Temperature range	-15 °C to +55 °C
Operating temperature	Max. 55 °C
Humidity	Operating humidity: Max. 95 % non-condensing
Electromagnetic compatibility	IEC 60945/EN 60945

PRODUCT SAFETY

Low voltage	IEC 60945/EN 60945-1
Flammability	Classified "A" to "B"

DGNSS Central Monitor

REMOTE OPERATION OF DGNSS INFRASTRUCTURE

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

In a DGNSS network infrastructure, the Central Monitor operates together with a DRS 500 (Differential Reference Station) and an IMS 500 (Integrity Monitor Station) in a TCP/IP network. The Central Monitor is a software application that provides remote operation of reference stations and integrity monitors. It is used to calculate optimal sets of corrections for every receiver in the network.

System features

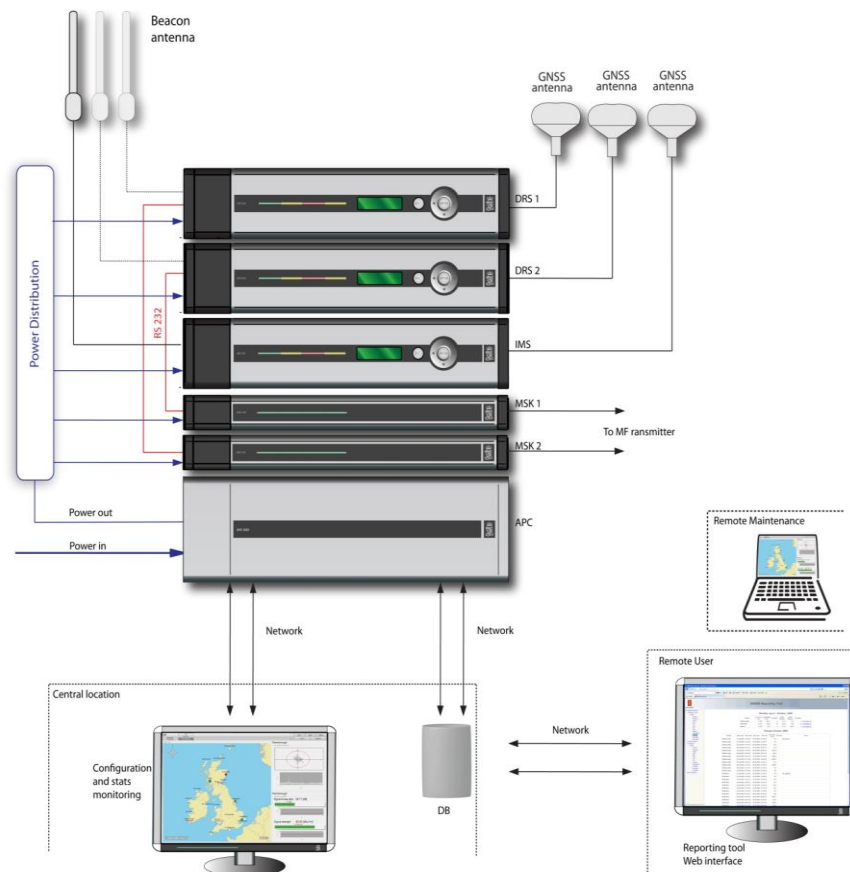
- GNSS integrity checking and monitoring
- System components monitoring
- Radio transmission quality monitoring
- Remote configuration of reference station and integrity monitor
- Recording of reference station integrity data and performance statistics in a database
- Alarm handling
- Printing of alarms and data

Network

The CM application uses a TCP/IP based network infrastructure. Each unit of the reference station and the host monitor also has its own unique IP address and the data is transferred directly from the station to the Central Monitor. This requires IP address to be assigned to the station and the host monitor. To simplify the management and configuration, a data router is used to route and encapsulate the data internally in the network, making it possible to connect the data into a single TCP/IP or UDP network data stream.

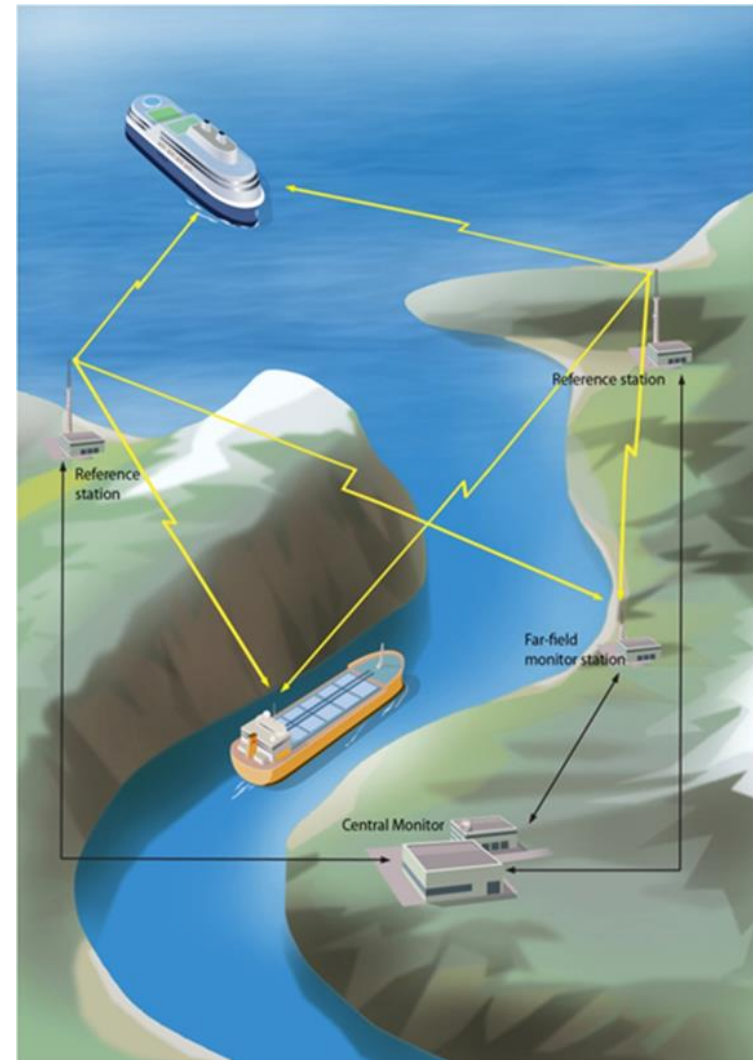
The system features include:

- Alarm handling
- Early warning in operation if performance is outside thresholds
- Continuous recording of differential corrections and data from the reference stations



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

Hardware modules

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

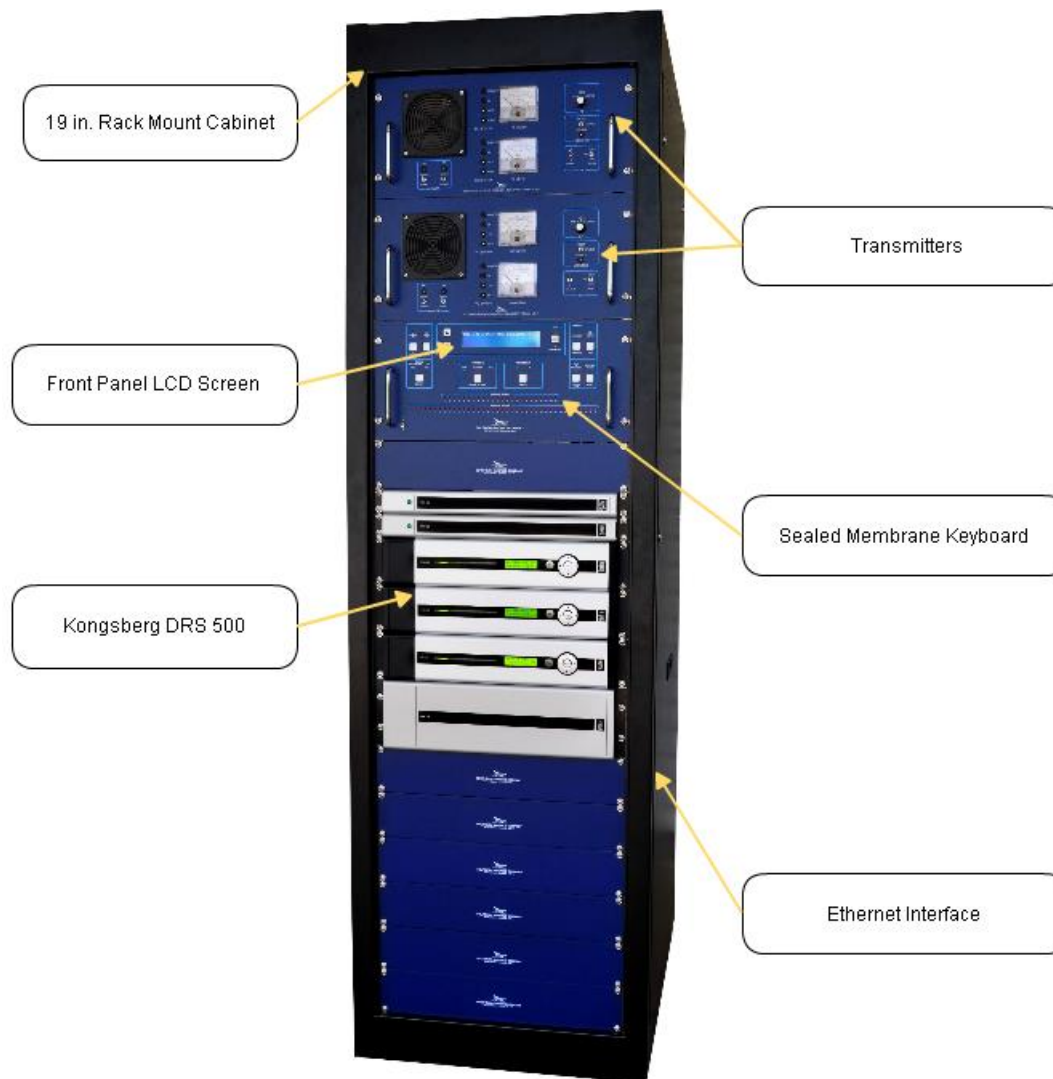
- ✓ DRS 500, Reference station
- ✓ IMS 500, Integrity Monitoring
- ✓ APC 500, Power Control Unit
- ✓ MSK 500, Minimum Shift Keying (MSK) modulator
- ✓ Keyboard and display and KVM switch
- ✓ Using Southern Avionics (SAC) MF radio systems

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



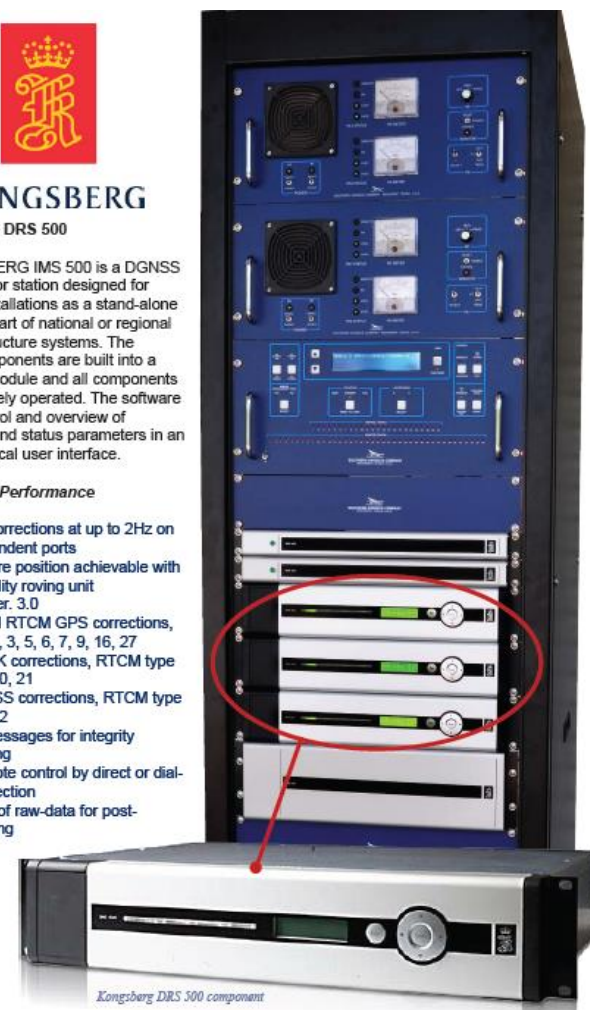
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KONGSBERG DRS 500

The KONGSBERG IMS 500 is a DGNSS integrity monitor station designed for permanent installations as a stand-alone system or as part of national or regional GNSS infrastructure systems. The electronic components are built into a 19-inch rack module and all components are fully remotely operated. The software offers full control and overview of configuration and status parameters in an intuitive graphical user interface.

Features and Performance

- RTCM corrections at up to 2Hz on 4 independent ports
- Sub-metre position achievable with high quality roving unit
- RTCM ver. 3.0
- Standard RTCM GPS corrections, type 1, 2, 3, 5, 6, 7, 9, 16, 27
- GPS RTK corrections, RTCM type 18, 19, 20, 21
- GLONASS corrections, RTCM type 31 and 32
- RSIM messages for integrity monitoring
- Full remote control by direct or dial-up connection
- Storage of raw-data for post-processing

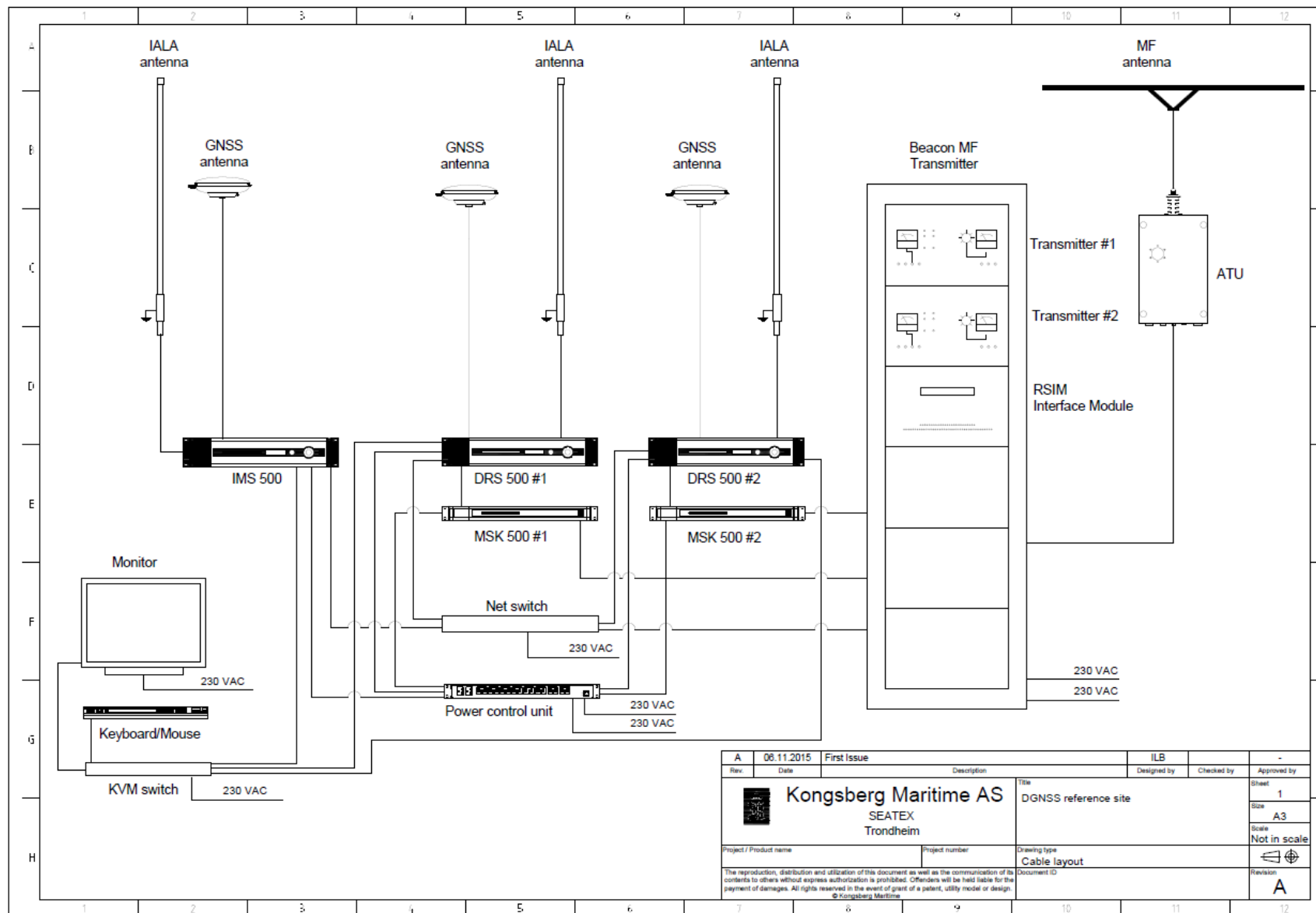


Kongsberg DRS 500 component

Architecture example – Reference Site



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Central Monitor

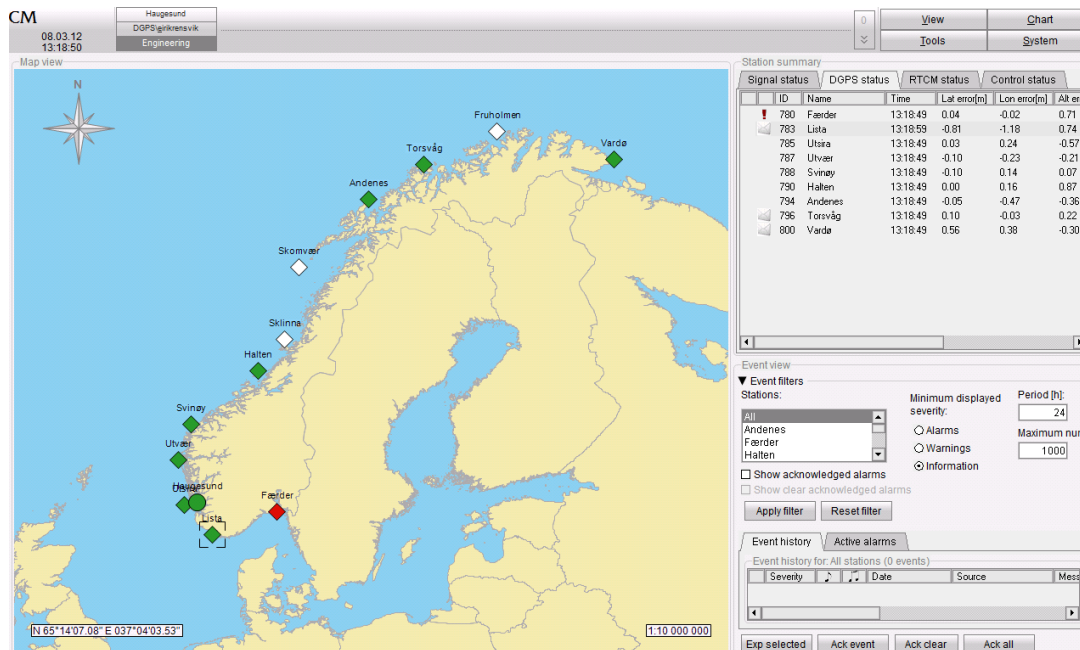
- The Central Monitor (CM) is an application developed to provide a complete solution for the utilization of the DGNSS reference station and integrity monitor.
- CM offers full remote control and overview over configuration and status parameters for an unlimited number of DGNSS reference stations and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

- Tailored for real time operation and service with special focus on:

- ✓ Status and system integrity
- ✓ Efficient operation and remote maintenance
- ✓ User friendliness

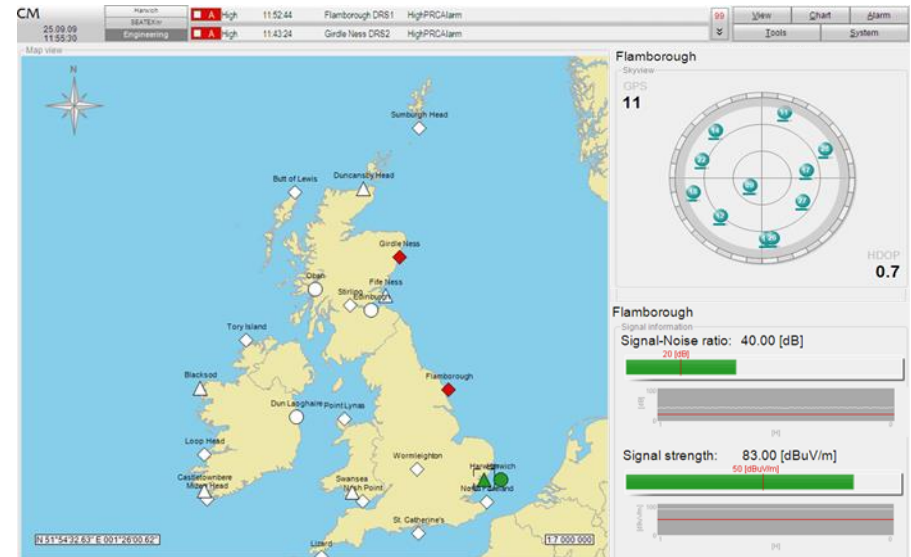
- User interface developed in close co-operation with end users

- 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

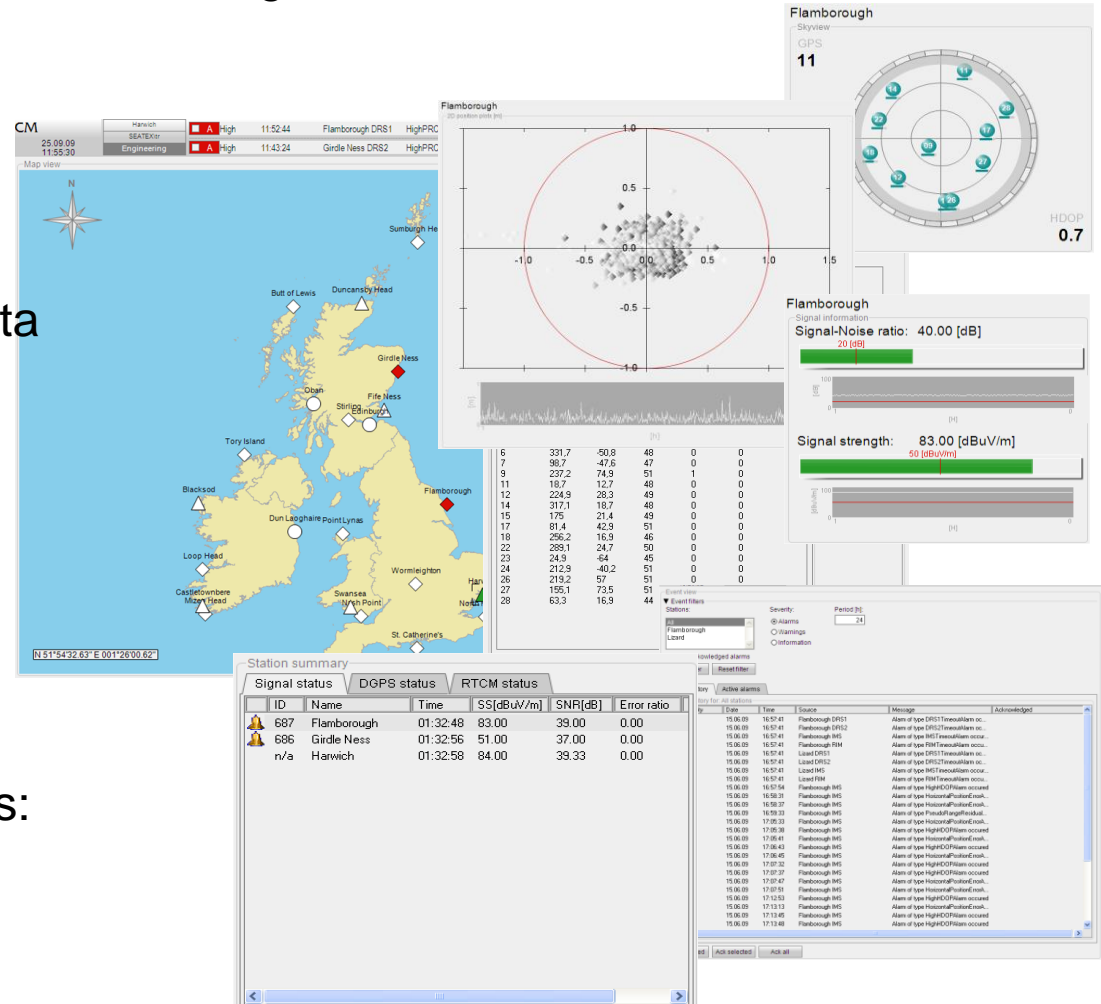
- GNSS integrity checking and monitoring
- System components monitoring (e.g. Mimic diagram)
- Radio transmission quality monitoring
- System performance status monitoring
- Early warning if performance is outside thresholds
- Alarm system
- Alarms and RSIM data stored in central DB. Raw data stored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



Views

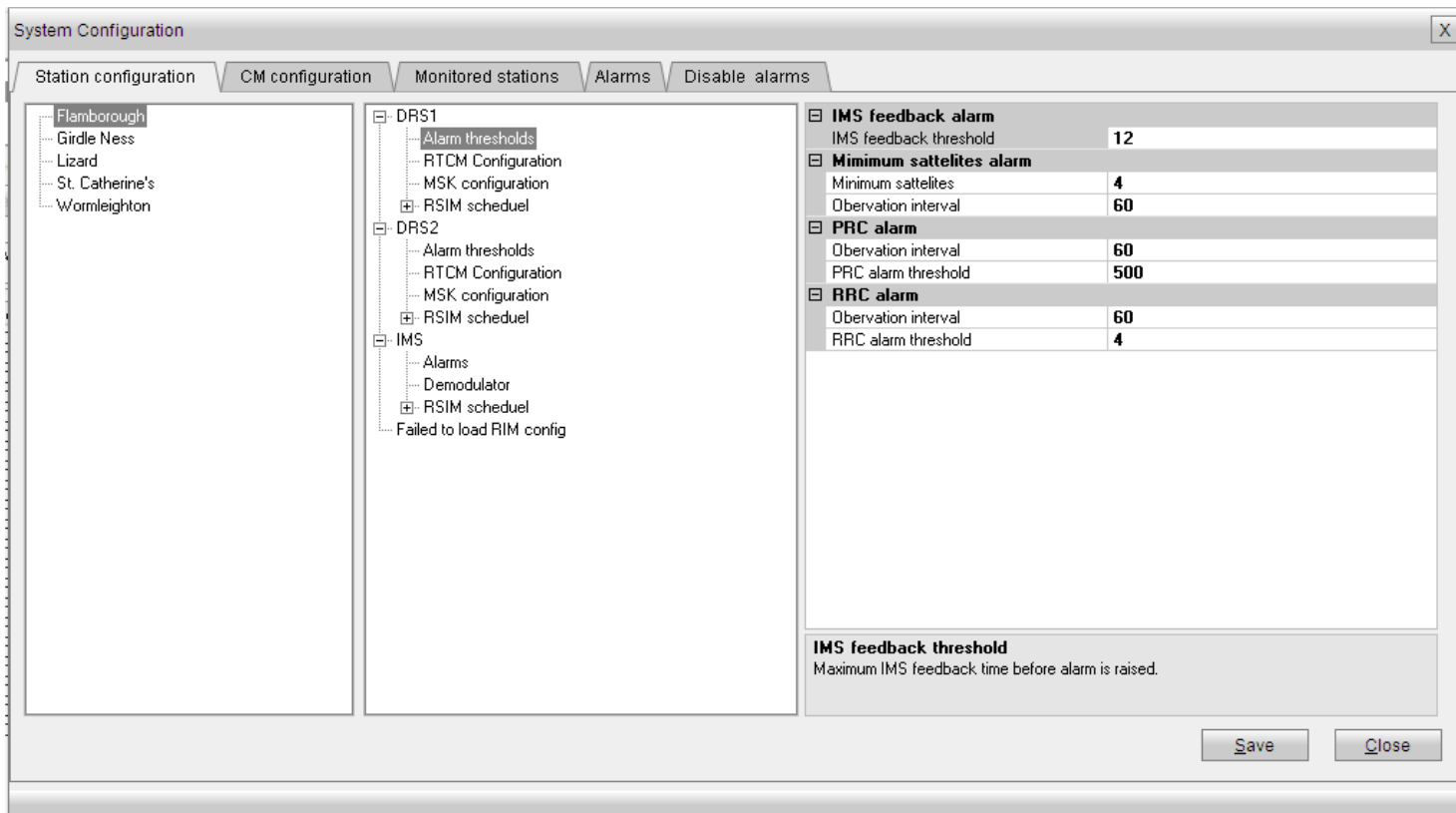
The operator may select between the following views:

- 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.



The screenshot shows the 'System Configuration' window with the 'Alarms' tab selected. The left pane shows a tree view of configurations for 'Flamborough', 'Girdle Ness', 'Lizard', 'St. Catherine's', and 'Wormleighton'. The middle pane shows the configuration for 'DRS1', 'DRS2', and 'IMS'. The right pane shows the alarm settings for 'IMS feedback alarm', 'Minimum satellites alarm', 'PRC alarm', and 'RRC alarm'.

Alarm Type	Parameter	Value
IMS feedback alarm	IMS feedback threshold	12
	Minimum satellites alarm	4
PRC alarm	Observation interval	60
	PRC alarm threshold	500
RRC alarm	Observation interval	60
	RRC alarm threshold	4

IMS feedback threshold
Maximum IMS feedback time before alarm is raised.

Save Close

Web reporting tool

Monthly report

Select year

2013

Sample mode

☒ Instantaneous

☐ Hourly mean

Select station(s)

All

Makis

Select month

February

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	<input checked="" type="checkbox"/>	Zero signal strength	
Makis	27/02/2013	15:42:06	27/02/2013	15:55:15	789	<input checked="" type="checkbox"/>	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

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