New French DGPS maritime service powered by EDAS

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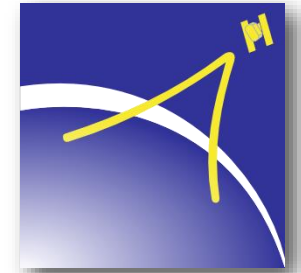EGNOS Workshop, 24-25 September 2019, Rome, Italy

Outline

- Alberding GmbH and CEREMA

- Background

- Modernised French DGPS service

- Initial performance results

- Conclusions and service operator feedback

Alberding GmbH

- German GNSS software and hardware development company

- Founded in 1994

- Based in Wildau (near Berlin)

- 14 employees (12 engineers)

- Independent from GNSS receiver manufacturers

Alberding range of services (portfolio)

Adaptable **software**, **sensors**, **systems** and **services**
for automated applications of precise (mm-cm) satellite-based
positioning, monitoring and data transmission

Agriculture/Forestry

Construction/Mining

Geo-monitoring

GIS/Surveying

Traffic/Transportation

Maritime/IWW Navigation

Beacon.net + Beacon Site Control

Alberding Beacon.net

- Central data processing

- Scalable, modular DGNSS software

- GNSS data input, VRS and EGNOS-VRS processing, integrity monitoring (PBM, FFM), data transmission (RTCM, AIS #17, VDES, Ntrip)

- Combination of DGNSS/RTK and waterway information
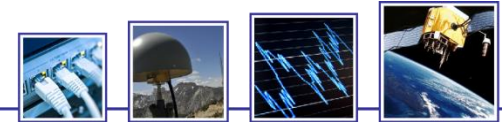
- R-Mode support

Alberding Beacon Site Control

- Decentralised processing – local backup

- EGNOS-VRS correction generation

- Pre-Broadcast Integrity Monitoring
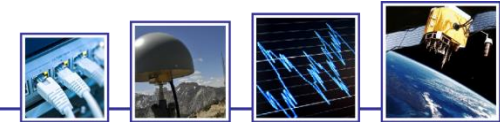
- Correction selection for transmission
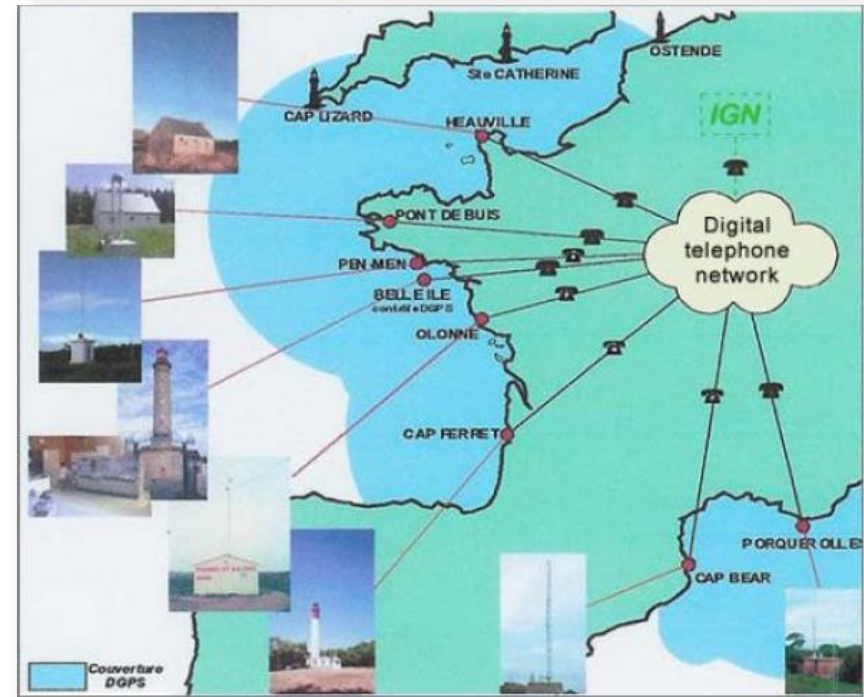
DGPS service in France - stakeholders

- **Central administration**
  French Maritime Authorities (DAM) manage policy and budget at the national level
  The AtoN office of the DAM maritime safety department is responsible for the DGPS stations

- **8 decentralised administrations**
  (DIRM & DM) manage the operation and maintenance of the AtoNs

- **CEREMA** (public administrative institution) navigation and positioning systems division supports DAM by providing scientific and technical expertise

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Cerema

Legacy French DGPS network

- 7 beacon DGPS stations

- No redundancy at the stations

- No Pre-Broadcast Monitoring

- Central control station at Belle-île (Far Field Monitoring)

- Old low rate WAN

- No changes since the 90's

- Obsolete equipment

- Availability decreasing

Role of CEREMA in the project

- CEREMA was requested by DAM to

    - Analyse the legacy DGPS system

    - Propose a cost effective solution to modernise the service

    - Conduct a Proof of Concept on that solution including a prototype, tests and result analysis at laboratory scale & field scale

    - Specify requirements for the modernisation of the service

    - Support AtoN operators to deploy the modernised service

- Test campaigns and preliminary studies

    - Successful test campaigns in 2016-2018

    - Cost-Benefit Analyses conducted by CEREMA and GSA

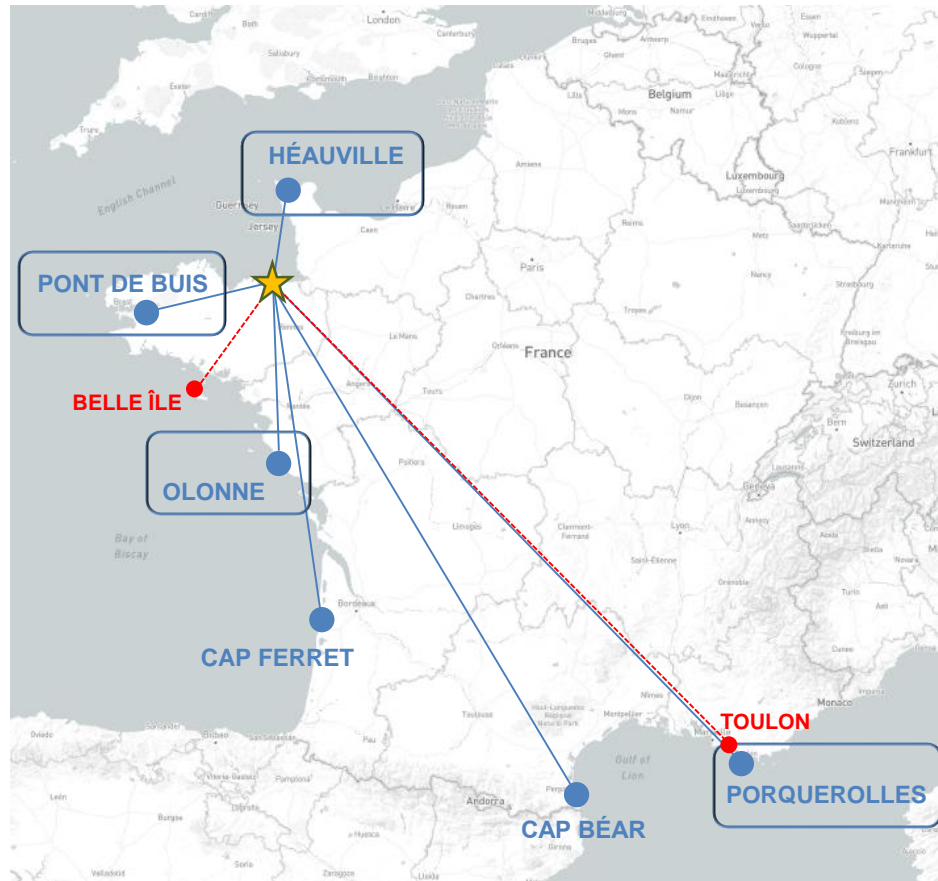   ➡ **Centralised EGNOS-based architecture selected**

EGNOS benefits

- Free of charge service

- Redundancy of signal sources (SiS and EDAS)

- EGNOS-based VRS:
  corrections generated remotely for locations
  with no physical reference stations
  (centralised architecture)

- Reduction of onsite infrastructure

- Quality of corrections not affected by local issues
  that could impact the beacon site (e.g. multipath,
  interference)

- Transparent for end users and compatible with
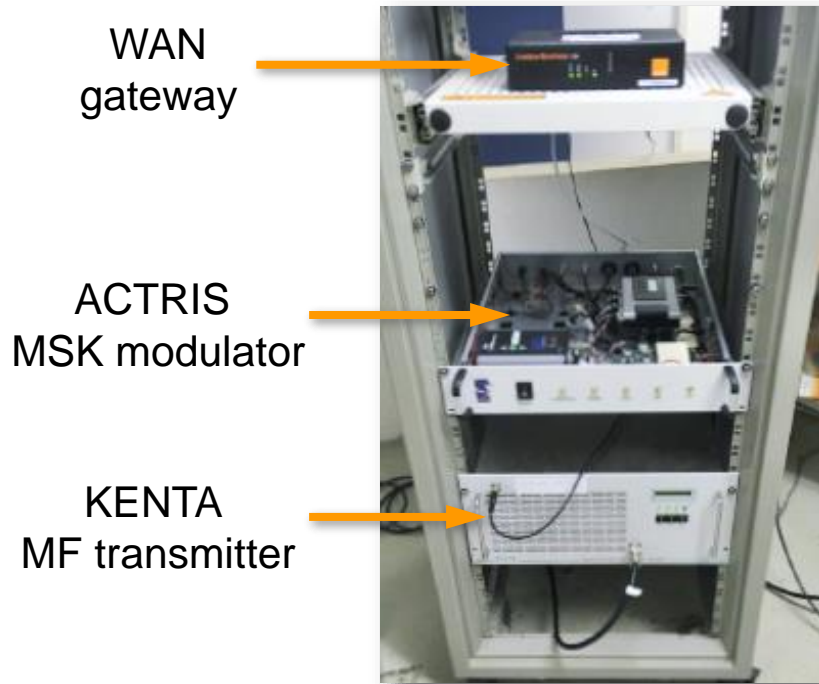 deployed user equipment

Modernised French DGPS network

- Official commissioning of the first French IALA beacon station transmitting EGNOS-based VRS corrections: 1 March 2019 (Olonne)

- 3 more stations equipped in 2019

- All 6 stations will be commissioned by the end of 2020

EGNOS-VRS	PBM Station (Monitoring)		FFM Station (Rover)	
	Location	Baseline	Location	Baseline
IALA HEAU Héauville	PBM HEAU	0 km	FFM BELL 1 Belle Île	274 km
IALA PNDB Pont de Buis	PBM PNDB	0 km	FFM BELL 2 Belle Île	127 km
IALA SABL Olonne	PBM SABL	0 km	FFM BELL 3 Belle Île	139 km
IALA PORQ Porquerolles	PBM PORQ	0 km	FFM TOUL Toulon	27 km

- 🔵 IALA Beacon
- 🔴 Far Field Monitor
- ⭐ Central Server
- ----- WAN – new governmental communication lines

Modernised facilities

WAN
gateway

ACTRIS
MSK modulator
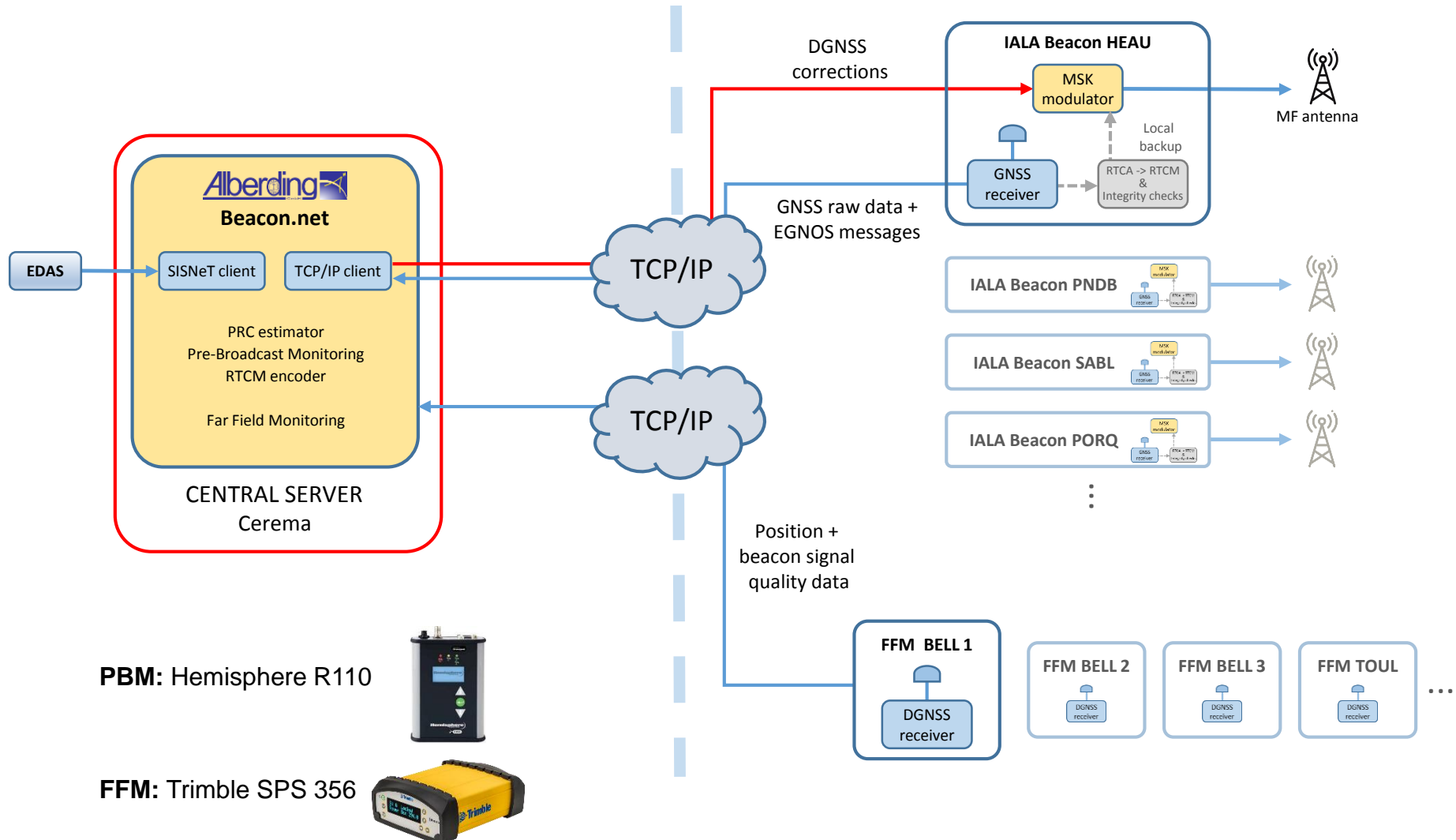
KENTA
MF transmitter

**Modernised DGPS rack
at transmission site**

**Modernised transmitting antenna
IALA Beacon BEAR**

New system architecture

Central data processing

Central Server (Linux)

Alberding Beacon.net sw

Web Interface
- Configuration
- Visualisation
- Alarming

HTTP(S) — Operating staff

EDAS SISNeT — RTCA data

GNSS Rx — GNSS raw data + EGNOS SiS RTCA data

Data input, plausibility check

EGNOS-VRS correction generation RTCA → RTCM

DGNSS corrections for EGNOS PRNs 123 & 136

Pre-Broadcast Monitoring

Far Field Monitoring

NMEA — Far Field Monitor station

DGNSS corrections for EGNOS PRNs 123 & 136 with integrity information

Data formatting, switched output

RTCM MT 9/3 — IALA Beacon
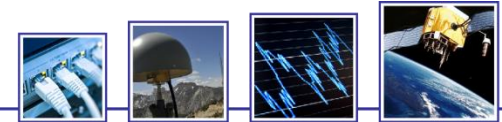
EGNOS Backup

MF 100 bps

Alberding GmbH

Redundant setup

- **RTCA source: EDAS SISNeT with EGNOS SiS backup**
  software takes any available RTCA input

- **EGNOS-VRS corrections generated for PRNs 123 & 136**
  software automatically selects one of them for output based on availability, health status and user-defined priority

- **Pre-broadcast integrity monitoring with 2 monitoring stations**
  software automatically selects monitoring station based on availability (not used in the current French setup)

- **EGNOS SiS based local backup at the IALA beacon**
  EGNOS-VRS corrections generated and checked locally if no connection to data centre (not used in the current French setup)

Maritime performance requirements

	Accuracy (95%)	Time to Alarm	Continuity (15 min)	Availability	Update Interval
Harbour entrances, harbour approaches and coastal waters	≤ 10 m	< 10 s	≥ 99.97%	> 99.8%	≤ 2 s

IMO Resolution A.1046 (27)

Initial performance results

Time frame: 2 Jun 2019 – 25 Aug 2019

	HEAU	PNDB	SABL	PORQ	Requirement IMO Res. A. 1046
Availability before integrity check	99.97%	99.97%	99.97%	99.97%	
Availability of healthy corrections	98.56%	99.89%	99.92%	99.93%	> 99.8%
Accuracy (mean)	0.85 m	0.88 m	0.45 m	0.57 m	
Accuracy (95%)	1.51 m	1.40 m	0.98 m	1.08 m	≤ 10 m
Continuity before integrity check	98.37%	98.37%	98.38%	98.39%	
Continuity of healthy corrections	97.57%	97.19%	98.08%	98.06%	≥ 99.97%

Availability and continuity: service level, measured at the central server
                                with 1 s temporal resolution
Accuracy: system level, measured at the FFM station
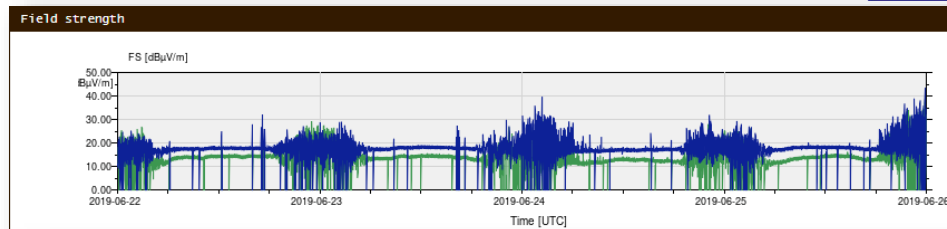
Remarks to performance results

- **HEAU-VRS availability affected by**

  - 28 h communications outage to IALA Beacon station HEAU on 1-2 July.
    - → add local backup at the transmission sites
    - → use redundant communication lines
    - → use redundant PBM with 2 monitoring stations

- **Accuracy performance affected by**

  - Biased FFM station coordinates. New coordinates introduced on 18 July causing a position error reduction of ~ 0.5 m. → determine station coordinates with cm accuracy

- **Continuity performance affected by**

  - Monitoring station data gaps → use redundant PBM with 2 monitoring stations
  - Many short (< 1 min) data gaps in the correction output due to overloaded server computer → add more computing power to central server
  - Several 'unhealthy' integrity events → increase position error PBM threshold to 10 m
    → use high quality GNSS equipment and ensure clear sky view at the monitoring stations

- **Integrity events in the pseudorange domain**

  - Very few events (0.06% of all epochs)
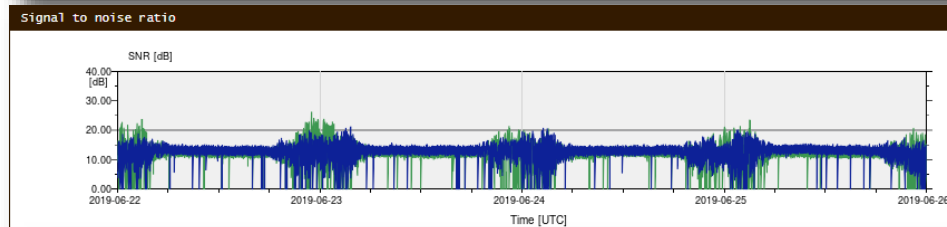 - Individual low elev. satellites excluded due to high PRC residuals
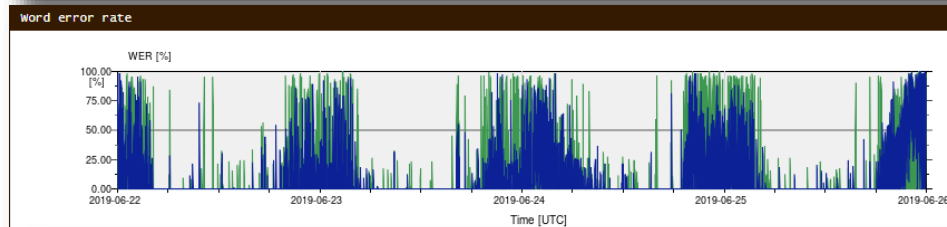
Radiobeacon skywave interference
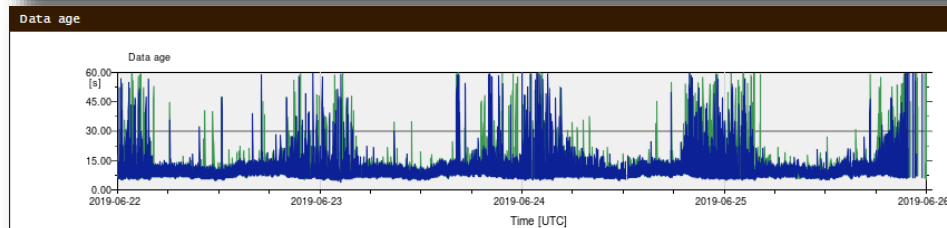
Field Strength

Field strength

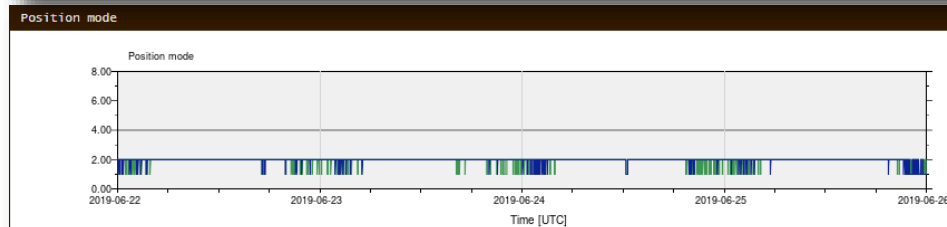**Signal to Noise Ratio**

Signal to noise ratio

Word Error Rate

Word error rate

FFM HEAU BELL (274 km)
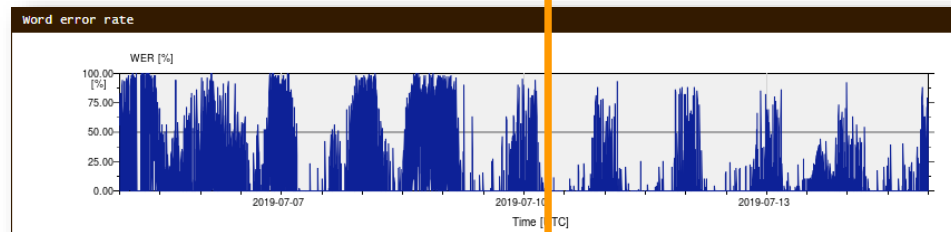**FFM PNDB BELL (127 km)**

Data Age

Data age

Position Quality

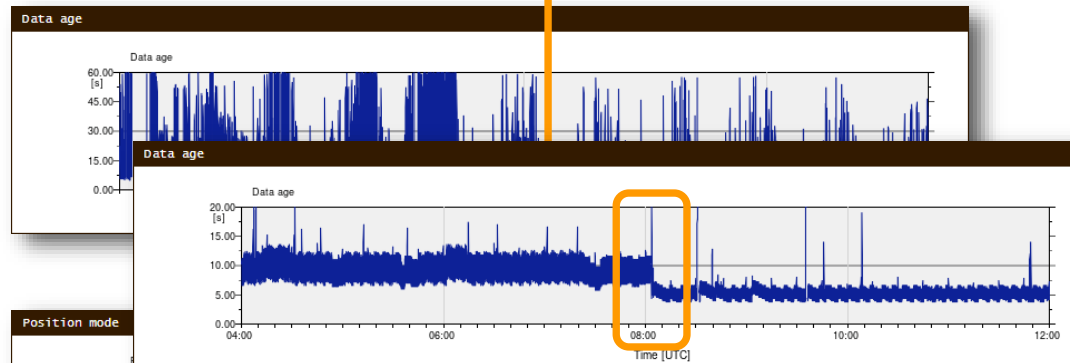Position mode

RTCM Type 1 → Type 9/3

Type 9 messages are useful for slow data links that are susceptible to interference
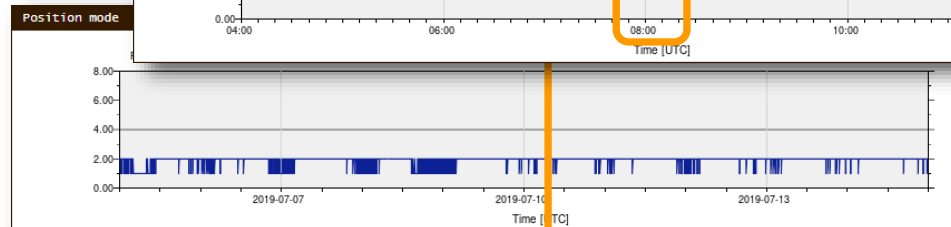
Word Error Rate

Data Age

Position Quality

Conclusions and recommendations

- The legacy French DGPS system is currently being replaced by a new centralised EGNOS/EDAS-based DGPS service

- **Significant cost savings** of the EGNOS/EDAS-based solution with respect to a traditional DGPS setup (at least 50%)

- Very good initial operational performance results indicate

  - Significantly increased service availability compared to the old system. **Availability performance meets the IMO requirements.**

  - **Accuracy performance** fulfils expectations and clearly **meets the IMO requirements.**

  - Continuity performance is affected by overloaded server computer, monitoring station outages and not optimal integrity settings.

    → **made recommendations to improve continuity performance**

  - Integrity performance proved the high quality of EGNOS-based VRS corrections

CEREMA R&D and operating feedback

- EGNOS correction transmission via IALA beacons is still a rather new concept and not too many off the shelve products exist.

- Requirements need to be carefully specified in that case.

- Cost savings can be made if working with smaller companies instead of the big equipment manufacturers. Consequently, we need to work with hardware companies that are sometimes not DGNSS specialists.

- During the testing and early operations phase we experienced some interruptions in our service both due to software and hardware failures that had to be improved with the providers.

- A local backup at the transmission sites would be very interesting to complement the EGNOS-based centralised approach. It is not clear yet if this backup should also be EGNOS-based or traditional DGPS.

- Remote control & monitoring of all on site equipment is very important.

Thank you for your attention!

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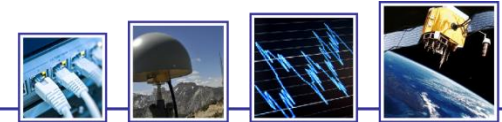Cerema Eau Mer Fleuves Division
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Reserve slides

French PBM integrity settings

Integrity parameter	PBM threshold
Max PRC	60 m
Max RRC	0.6 m/s
Max PRC Residual	10 m
Max RRC Residual	0.5 m/s
Max (Horizontal) Position Error	5 m
Max PRC Residual Delay	5 s
Max RRC Residual Delay	5 s
Max Position Error Delay	5 s