



KONGSBERG

HAIN Reference

The new DP Reference using INS technology



www.kongsberg.com

HAIN – Hydroacoustic Aided Inertial Navigation

No one disputes the statement “A Dynamic Positioning (DP) system can never become better than its references” for holding the vessel automatically in wanted position.

The HAIN Reference system uses the latest technology for providing the best and most reliable underwater DP reference. By its unique feature of combining both acoustic and inertial technologies HAIN Reference will ensure highest quality position data and update rate.

We maximize performance by providing The Full Picture

Our mission

We shall earn the respect and recognition for our dedication to provide innovative and reliable marine electronics that ensure optimal operation at sea. By utilising and integrating our technology, experience and competencies in positioning, hydroacoustics, communication, control, navigation, simulation, and automation, we aim to give our customers The Full Picture. The Full Picture yields professional solutions and global services that make a difference enabling you to stay ahead of the competition.

Our philosophy

Our success depends on the success of our customers. Actively listening to our customers and truly understanding their needs, and then translating these needs into successful products and solutions is central to achieving our goal. Our people are the key to our success and we empower them to achieve. Working together in a global network of knowledge, guided by our values, engenders innovation and world class performance. Every day we have to think a little differently, because every client is unique. We aspire to translate the imagination and dedication of our staff into successful technologies and solutions. Our commitment is to add value to your operations by providing you with The Full Picture.

What is HAIN Reference?

An Inertial Measurement Unit (IMU) measures its own movement. This IMU is the core component in an Inertial Navigation System (INS) which processes data from the IMU sensor in a computer. The position measurements from an INS are very accurate over a short time frame, but the position data will drift more and more over time. The IMU is therefore not suitable as a DP reference sensor on its own, but it is one out of two main components in a HAIN Reference system.

The IMU data is processed together with position data from an underwater Hydroacoustic Position Reference system in a computer that then will output the unique combined data characterized in HAIN. The vessel position, velocity, heading and attitude are updated at 300 Hz, based on the readings from the IMU, and corrected every time a new acoustic position is measured.

HAIN Reference can therefore be seen as an add-on to the acoustic reference system. It improves the robustness, quality and reliability of the acoustic reference system dramatically and gives you the best and most reliable acoustic reference system available.

Why HAIN Reference?

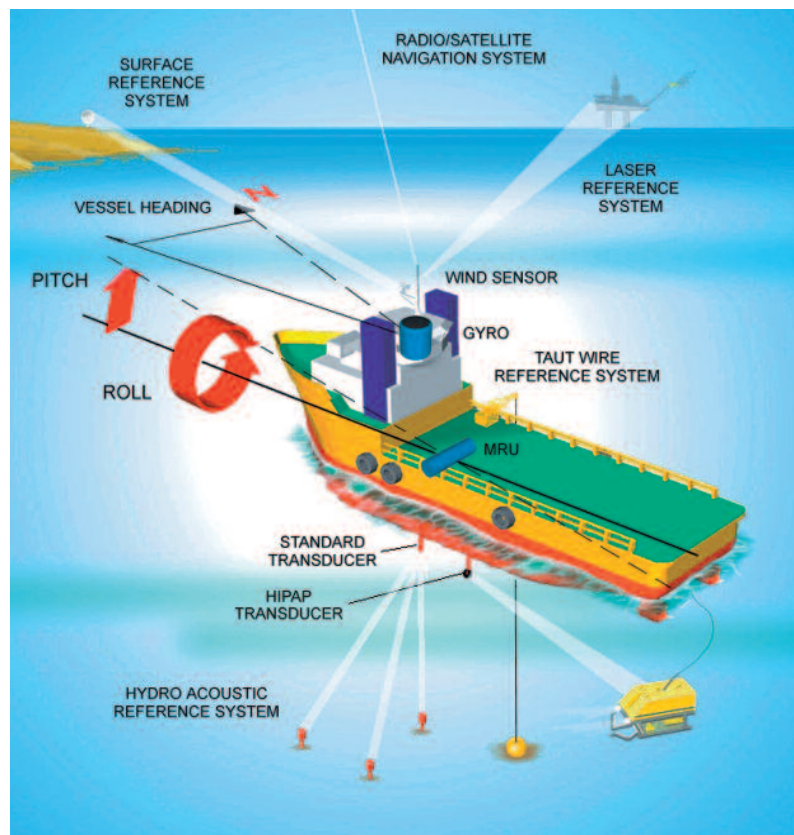
HAIN Reference system has the following main advantages:

- It maintains the High update rate (1 second) output to the DP regardless of water depth
- It filters out the acoustic position noise
- It will provide the DP with position data even minutes after losing the acoustic signals

The deeper water, the more valuable is the HAIN Reference investment.

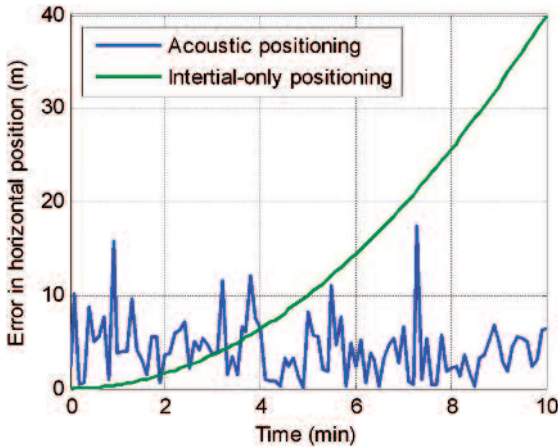
However, experiences from drilling rigs have even in shallow waters also shown great value in position stability.

The user will be able to work longer in heavy weather and to have a more dependable reference system.



HAIN Reference – Technology & Principles

Complementary technologies in position noise and drift



Acoustic positioning provides:

- Relatively high and evenly distributed noise
- No drift in the position

Inertial positioning provides:

- Very low short term noise
- Relatively large drift in the position

HAIN positioning provides:

- Very low short term noise
- No drift in the position

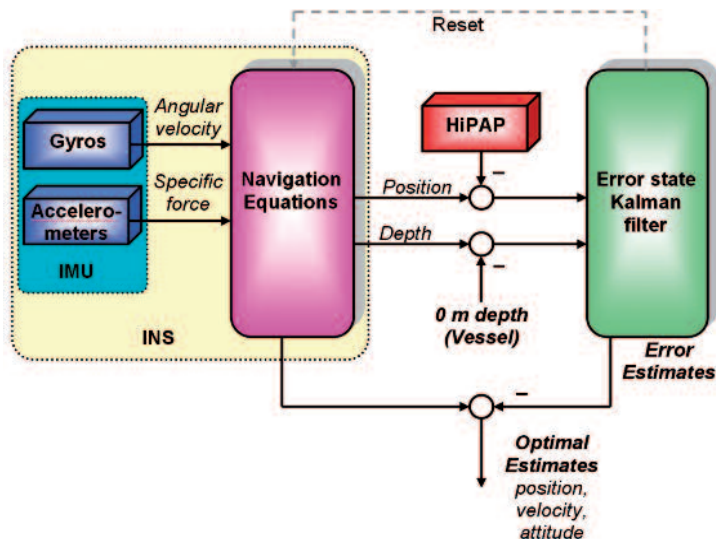
HAIN - THE IDEAL COMBINATION

Inertial Measurement Unit – IMU

The IMU contains three accelerometers and three gyros that measure the vessel's accelerations and rotation in all three axes very accurately.

High Precision Acoustic Positioning – HiPAP

The acoustic system provides horizontal position for HAIN. Both Super Short Base Line (SSBL) and Long Base Line (LBL) positioning principles can be used.



HAIN Reference processing

HAIN integrates the IMU measurements to provide velocities, position and attitude in all three axes. The positions are compared with the acoustic positions and deviations are sent to a Kalman Filter for optimal performance. To avoid drift in the vertical direction an artificial 0 depth measurement is used. The Kalman Filter optimally estimates errors in the measurements and velocity, attitude, and position. This limits the position drift that is inherent in inertial navigation systems.

HAIN Reference System overview

Inertial Measurement Unit – IMU

The IMU contains three accelerometers and three gyros that measure the vessel's accelerations and rotation in all three axes very accurately.

HAIN Computer

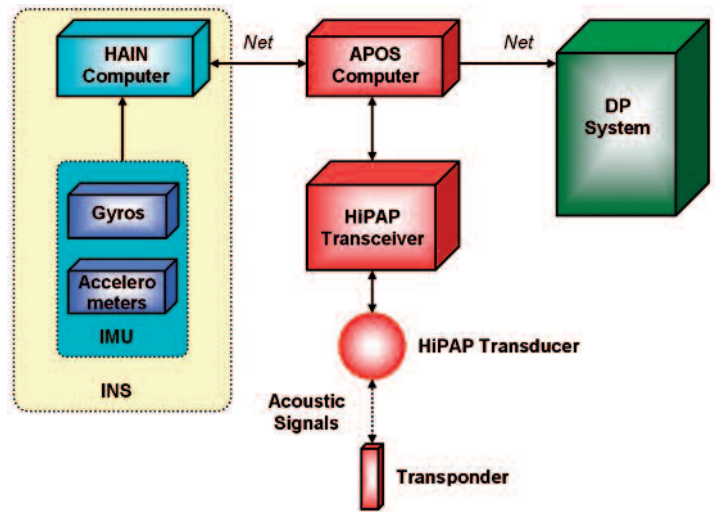
The HAIN Reference computer executes the navigation algorithms.

Acoustic Position Operator Station - APOS

APOS holds a complete operator interface to supervise and configure HAIN and shows HAIN's status and position output together with the aiding acoustic positions.

HiPAP – High Precision Acoustic Positioning

The acoustic positioning (HiPAP) could be either SSBL or LBL. The acoustic system provides horizontal position for HAIN.



Installation and commissioning

HAIN Reference is very easy to install onboard any vessel fitted with a HiPAP or HPR system.

The HAIN system consists of only two units which easily can be installed anywhere onboard. The installation kit consisting of a HAIN computer and the IMU with Power box includes also a new "HAIN button" in DP console and software in the DP.

All operations are performed in HiPAP Operator Station, APOS.

HAIN will be treated as any other reference system in the DP.

The DP will see HAIN Reference as an improved HiPAP.

IMU



HAIN computer



Easy calibration

Lever arms values (3D) from the IMU to the vessel reference point must be measured and implemented in software during commissioning. The verification procedure of the HAIN interface to the DP takes approximately 4 hours. The rig must be able to move on DP (+/- 20 meters movements), and at least two SSBL transponders must be used for positioning.

HAIN Reference – Benefits

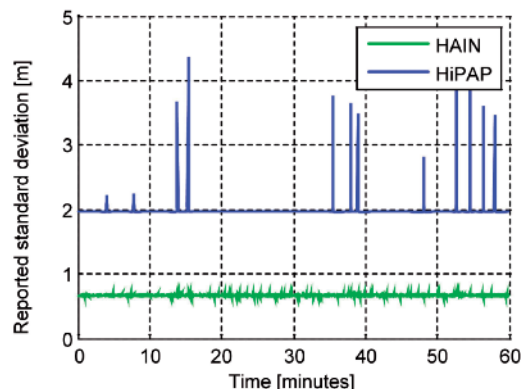
- Improves hydroacoustic positioning accuracy
- Improves the output update rate to 1 Hz regardless of water depth
- Increases the hydroacoustic system's operational depth as a valuable reference to DP
- Enables operation in SSBL mode to a greater depth before changing to LBL mode
- Longer transponder battery lifetime by increasing the transponder interrogation time
- Increased robustness by advanced filtering and suppression of acoustic position jumps
- Increased safety by continued quality position output
- High quality gyrocompass and attitude sensor (standalone feature in HAIN Reference)



Deepwater drillship West Navigator, © Seadrill

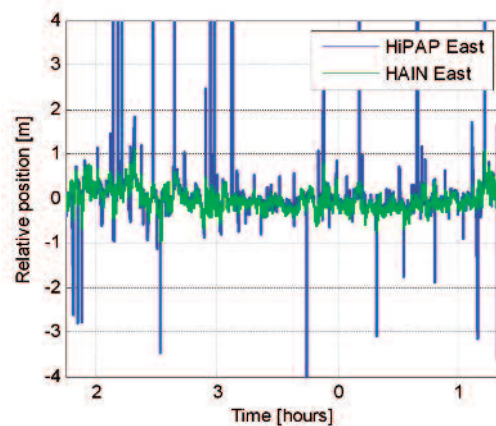
Real data samples – HAIN improves SSBL

HAIN Reference improves the standard deviation substantially. Data from a semi-submersible drilling rig using Super Short Base Line (SSBL) acoustic positioning in 1000 meters depth is shown in the figure.



Real data samples – HAIN improves LBL

HAIN Reference operates well with Long Base Line (LBL) acoustic positioning in 2400 meters depth in the Gulf of Mexico. The easting relative position is shown in the figure. HAIN Reference is much more stable and without the large position jumps displayed by the LBL.

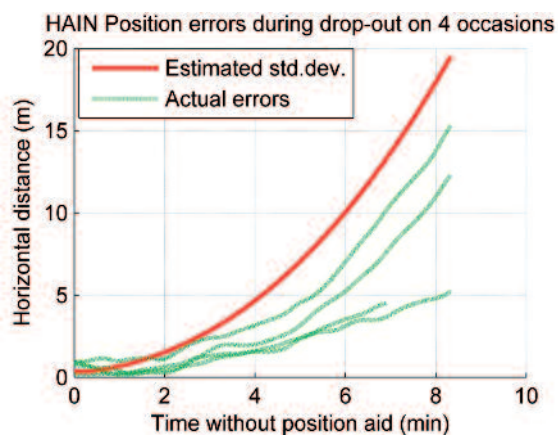


Performance during Acoustic Dropout

The graph shows the quality of the HAIN Reference position drifts versus estimated standard deviation. It also shows the results of the actual drift over time when HAIN Reference lost its position aiding for a period.

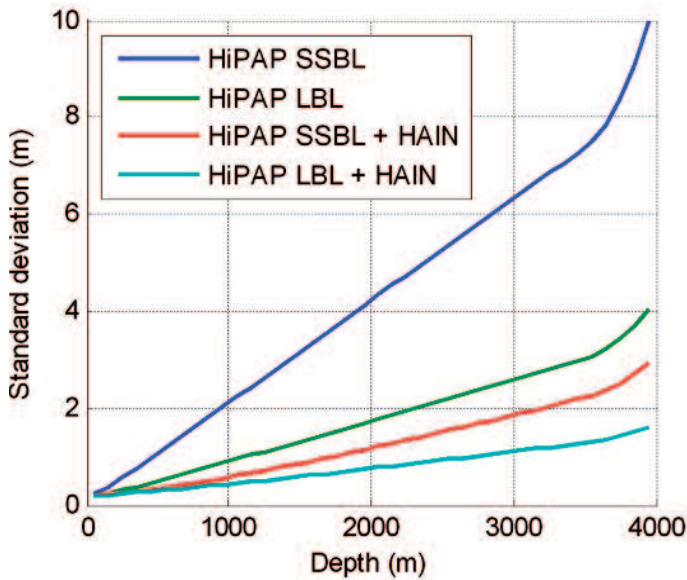
The data are from a semi-submersible drilling rig running HAIN Reference in the Gulf of Mexico in approximately 2400 meters depth, with LBL as position aid for HAIN Reference.

The four error curves are actual measured drift offs and vary due to differences in IMU measurements over time.



Improvements and DP Weighting

Graph shows typical HiPAP SSBL and LBL standard deviations as a function of depths with and without HAIN Reference.



SSBL angle accuracies of 0.12° in x and y axis are improved more than 3 times when using HAIN Reference system.

LBL position accuracies are improved by 2-3 times when using HAIN Reference system.

The non linear curves of the graphs are due to reduced S/N ratio in deeper waters.

HAIN REFERENCE IMPROVES THE HYDROACOUSTIC POSITIONING INPUT TO DP

Any reference system with accuracy (standard deviation) less than 1 meter and with an update rate of minimum 1 second is allocated equal weight in the DP system. The GPS (Global Positioning System) is of such nature.

In an example where HiPAP (or HPR) operating in 1000 meter water depth, the table below shows typical data without and with HAIN Reference.

Reference System:	HiPAP SSBL	HiPAP LBL	GPS
Standard deviation	2.0 meters	1.0 meter	0.5 meter
Update rate	1.5 seconds	2.5 seconds	1.0 second
Standard deviation with HAIN	< 1.0 meter	< 0.5 meter	0.5 meter
Update rate with HAIN	1.0 second	1.0 second	1.0 second

HAIN REFERENCE AIDED BY SSBL OR LBL WILL BE GIVEN THE SAME WEIGHTING AS GPS

HAIN Reference specifications

Specifications IMU rack

Dimensions (L x W x H) 406 x 183 x 200 mm
 Weight in air 6.3 Kg
 Material rack Aluminum
 Approval CE approved

Power
 Power requirements (50-60 Hz) 90 - 264 VAC
 Nominal power 10 W
 Frequency 50 - 60 Hz

IMU
 Dynamic range – Gyro $\pm 450 \text{ }^\circ/\text{s}$
 Dynamic range – Accelerometers $\pm 60 \text{ g}$

Attitude and Heading dynamic accuracy
 Roll/Pitch 0.01 degrees
 Heave 0.10 meter
 Heading 0.025 deg *sec (lat)

Environmental conditions
 Degree of protection IP 40
 Operating temperature -15 to 55 $^\circ\text{C}$
 Storage temperature -20 to 70 $^\circ\text{C}$

Storage / Operating humidity 95% / 85% relative

Vibration
 Range 5 - 150Hz
 Excitation level 5-13.2Hz +/- 1.5mm, 13.2 - 150Hz 1g

Specifications HAIN Reference computer

Dimensions (L x W x H) 425 x 445 x 185 mm
 Weight 17 kg
 Mounting Desktop / rack
 Material Steel and Aluminum
 Approval CE approved
 Capacity data logging > 80GB

Power
 Power requirements (50-60 Hz) 180-264 / 90-132 VAC
 Nominal power 200 W
 Max inrush current 20Amp AC
 Frequency 50 - 60 Hz

Environmental conditions
 Degree of protection IP 22
 Operating temperature 0 to + 55 deg C
 Storage temperature - 30 to + 70 deg C
 Storage / Operating humidity 95% / 85% relative

Vibration
 Range 5 - 100Hz
 Excitation level 5-13.2Hz +/- 1.5mm, 13.2 - 100Hz 1g

Customer feedback

"The use of HAIN Reference has significantly increased positioning reliability and accuracy compared to use of SSBL/LBL without HAIN Reference. No doubt the HAIN Reference installation was a correct decision and a good investment."

*Frode Hjortdahl
Offshore Installation Manager
Leiv Eiriksson, Ocean Rig*



Other user's feedback

"HAIN seems to carry more weight than the other systems. This is especially noticeable when we have unfavorable conditions for acoustics (supply vessels alongside, dumping of cuttings etc.)"

"As we have experienced the HAIN Reference, it is very useful and helps us getting a much more stable reference system. This gives us a better use of SSBL and LBL. As showed on the print out from the DP, it increases the accuracy and give us a higher weighting of the reference system"

"In summary, we agree that the HAIN Reference system is a good investment and becoming a valuable aid to accurate position keeping"

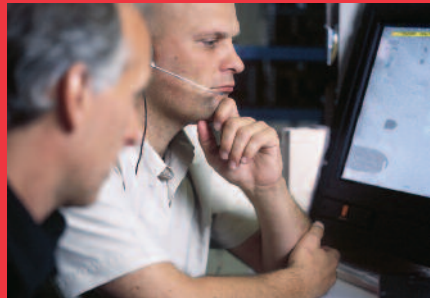
We are always there, wherever you need us

KONGSBERG customer services organisation is designed to provide high-quality, global support, whenever and wherever it is needed. We are committed to providing easy access to support and service, and to responding promptly to your needs. Support and service activities are supervised from our headquarters in Norway, with service and support centres at strategic locations around the globe – where you are and the action is.

As part of our commitment to total customer satisfaction, we offer a wide variety of services to meet individual customers' operational needs. KONGSBERG support 24 is a solution designed to give round-the-clock support. For mission-critical operations, Kongsberg support 24 can be extended to include remote monitoring. We can adapt the level of support needs by offering service agreements, on-site spare part stocks and quick on-site response arrangements.

Global and local support

We provide global support from local service and support facilities at strategic locations world wide. Service and support work is carried out under the supervision of your personal account manager, who will ensure that you receive high-quality service and support where and when you need it. Your account manager will ensure continuity and work closely with your personnel to improve and optimise system availability and performance. Under the direction of your account manager, and with a local inventory of spare parts, our well-qualified field service engineers will be able to help you quickly and effectively.



Solid competence reduces cost

We have always recognised the importance of supporting our products and systems with professional training.

A wide range of courses are therefore offered to ensure that you achieve the goal of full system utilisation with safe and efficient operation.

Upgrading that pays

Product and system upgrades can improve your vessel's operations and reduce your overall maintenance costs. We will ensure that existing products and systems can be extended or upgraded based on standard upgrade kits.



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