

HRG

THE NAVIGATION REVOLUTION



STILL IN A FOG ? GO HRG!

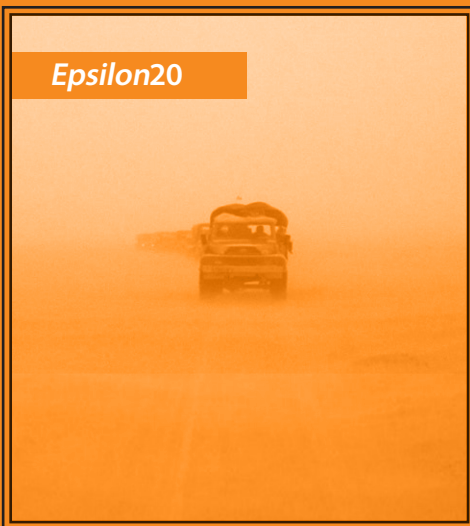
Sagem's growing family of innovative HRG-based navigation systems :

BlueNaute™



BlueNaute™ is a shipborne inertial system delivering high reliability and performance in a compact package. Maintenance-free over its entire lifetime, *BlueNaute™* is easy to use and minimizes total cost of ownership for all types of ships, from tankers and container ships, to ocean liners and offshore support vessels, as well as super-yachts.

Epsilon20



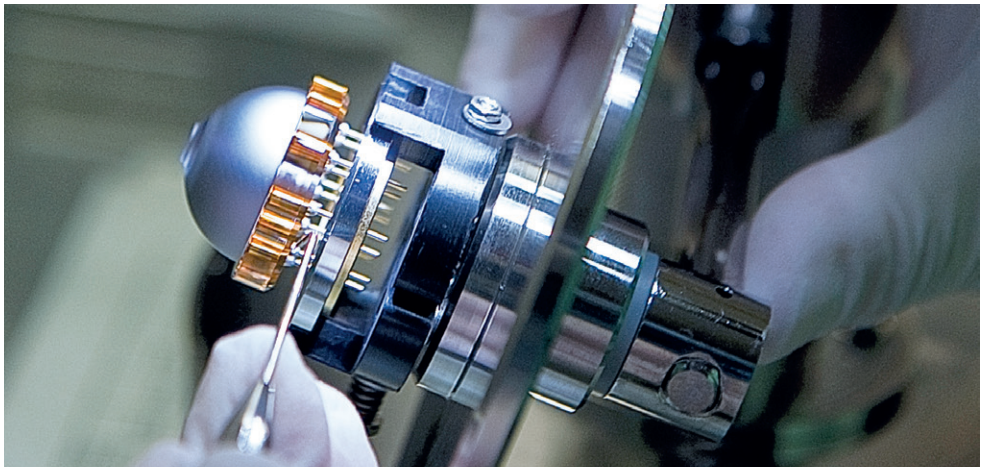
Epsilon is a high-performance land navigation system that provides accurate position and attitude readings even when GPS is not working. Thanks to its innovative alignment method, *Epsilon* delivers accurate data faster than any other inertial navigation system. It is easily integrated in any type of vehicle, and features a straightforward design for satcom-on-the-move.

PROVEN EXPERTISE

IN ALL INERTIAL NAVIGATION TECHNOLOGIES

■ Sagem is undoubtedly the only company today that offers proven expertise in all inertial technologies: mechanical, optical and vibrating gyroscopes and accelerometers for all applications, whether on land, in the air, or at sea. Capitalizing on this unique expertise, Sagem can always give customers the most appropriate sensor for their specific application.

■ The latest inertial solution from Sagem is the hemispherical resonator gyro, or HRG. This breakthrough technology offers outstanding reliability and robustness in a compact package. Small, light and energy-efficient, these sensors, such as Sagem's Regys 20, were first used in satellites. Today, Sagem has developed proprietary production processes to make HRG-based systems affordable for commercial navigation and positioning applications.



The advantages of inertial navigation

> An inertial navigation system is a high-precision system capable of independently calculating the position and attitude of all types of vehicles, including aircraft, land vehicles, ships, submarines, etc. It uses a set of inertial sensors, generally three gyros and three accelerometers, providing raw data which is "crushed" using sophisticated Kalman filters (a type of algorithm).

HRG: A BREAKTHROUGH IN 21ST CENTURY NAVIGATION

■ The hemispherical resonator gyro (HRG) contains only a few basic parts and has a simple design, making it extremely reliable. Sagem's patented HRG uses the inertial characteristics of the plane of vibration of a wave resonating inside a miniature hemisphere that is mechanically isolated from the outside world. Because of this sturdy construction, it undergoes almost no mechanical wear and therefore, unlike mechanical gyros, has a virtually unlimited lifespan. This is why HRGs were first used for space applications. It is the only technology that has never failed in space, having logged more than 18 million hours in operation without the slightest incident.

■ The HRG is the only technology that is both "maintenance-free" and ultra-reliable. Although its high performance and extreme reliability are universally recognized, this technology still had to become affordable enough for use in a civilian gyrocompass. This challenge was met by Safran through major technical innovations and substantial industrial investments.

■ Safran has created a world-class production facility for inertial navigation systems and equipment, dubbed Coriolis, to support its growth in this critical market and further enhance its production capabilities for gyroscopic sensors. Located at the Sagem plant in Montluçon, one of the largest employers in the Auvergne region of south-central France, the Coriolis facility represents an investment of €50 million. It encompasses the production of high-tech inertial systems and sensors – ring laser gyros (RLG) and hemispherical resonator gyros (HRG) – for both civil and military applications.



INERTIAL NAVIGATION: 80 YEARS OF EXPERTISE

■ Sagem is the world's third leading manufacturer of inertial systems. Drawing on 80 years of experience in gyroscopes, it has developed expertise in all major inertial technologies. Sagem has forged its unrivaled expertise in inertial navigation by providing systems for a number of different civil and military platforms, on land, at sea and in the air. Below are a few selected highlights from Sagem's long history.

1961: Sagem's first inertial navigation system makes first flight on a Nord 2501 airplane at the Brétigny flight test center (France).

1965: successful launch of the Diamant launcher, equipped with a Sagem E27 flight control unit.

1970: development of the M28 inertial navigation system for submarines. A few years later, the system will be used on France's first nuclear submarines.

1974: production startup of the new GSM 20 gyros and ASM 20 accelerometers, intended in particular for surface-to-air and air-to-air missiles.

1988: a world first, as Sagem provides two Uliss 52 inertial systems for the Mirage 2000 N bomber; the airplane's navigation coordinates are periodically recalculated using the Tercor terrain correlation technique developed by Sagem.

1996: Sagem selected to supply the Saphir navigation system for the European helicopter NH90.

2005: start of production on the inertial guidance system for the AASM smart, modular air-to-ground weapon, based on HRG technology.

2008: at the Eurosatory defense trade show, Sagem presents the Sigma 30 PNU, a new position and navigation unit for artillery.

2009: first flight of the Airbus A400M, equipped with a high-precision laser gyro navigation system from Sagem, and the only plane to receive dual civil/military certification.

2012: • Sagem's Sigma 40 marine navigation systems exceed 8 million hours of operation.

• Introduction of BlueNaute™, the first shipborne inertial reference system using new-generation HRG technology.

2013: launch of *Epsilon*, a new family of inertial navigation systems for land applications.



Le Redoutable nuclear submarine



NH90 Helicopter



Caesar gun



Airbus A400M



Commercial shipping

KEY MISSIONS, KEY TECHNOLOGIES, KEY TALENTS

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