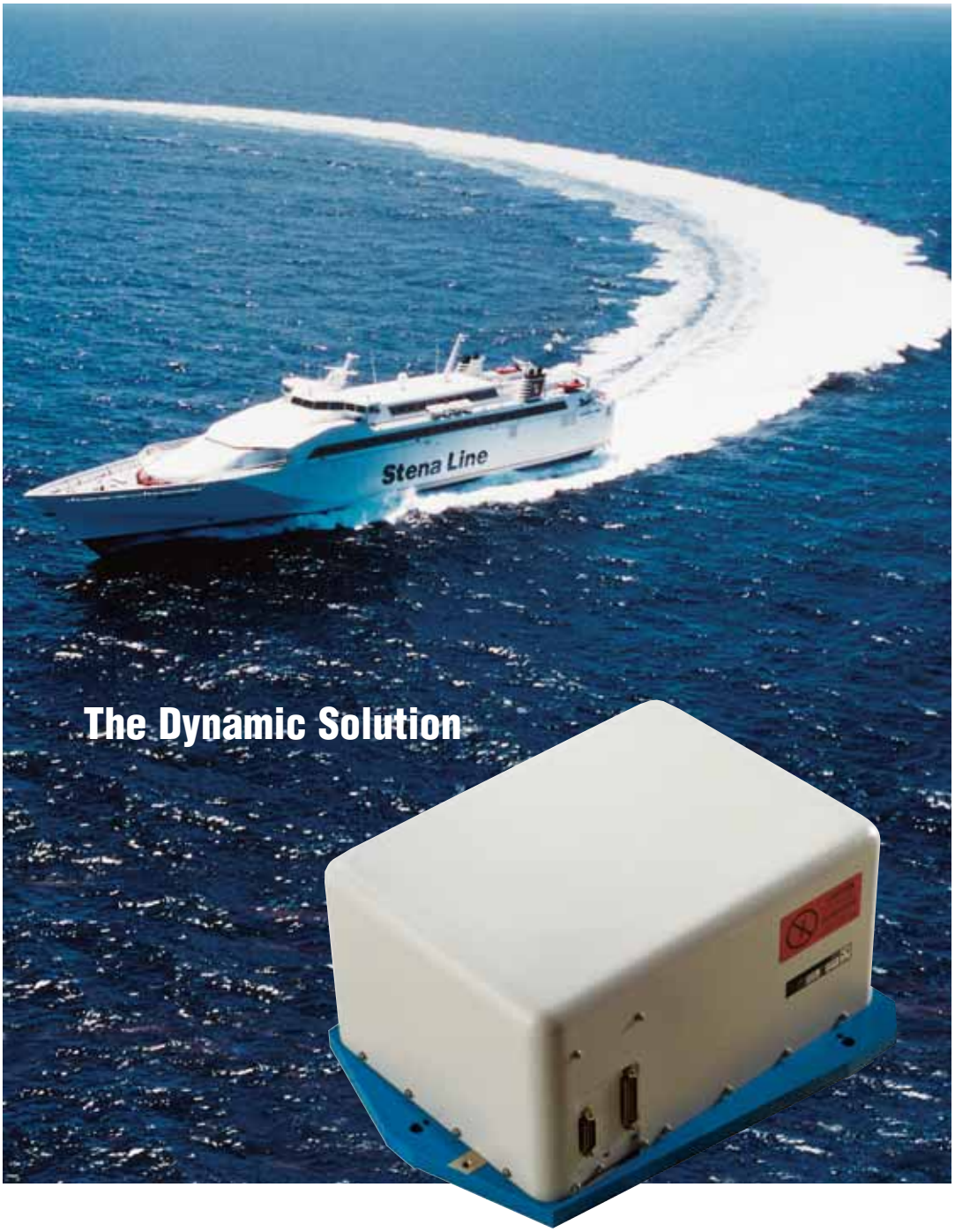
NORTHROP GRUMMAN

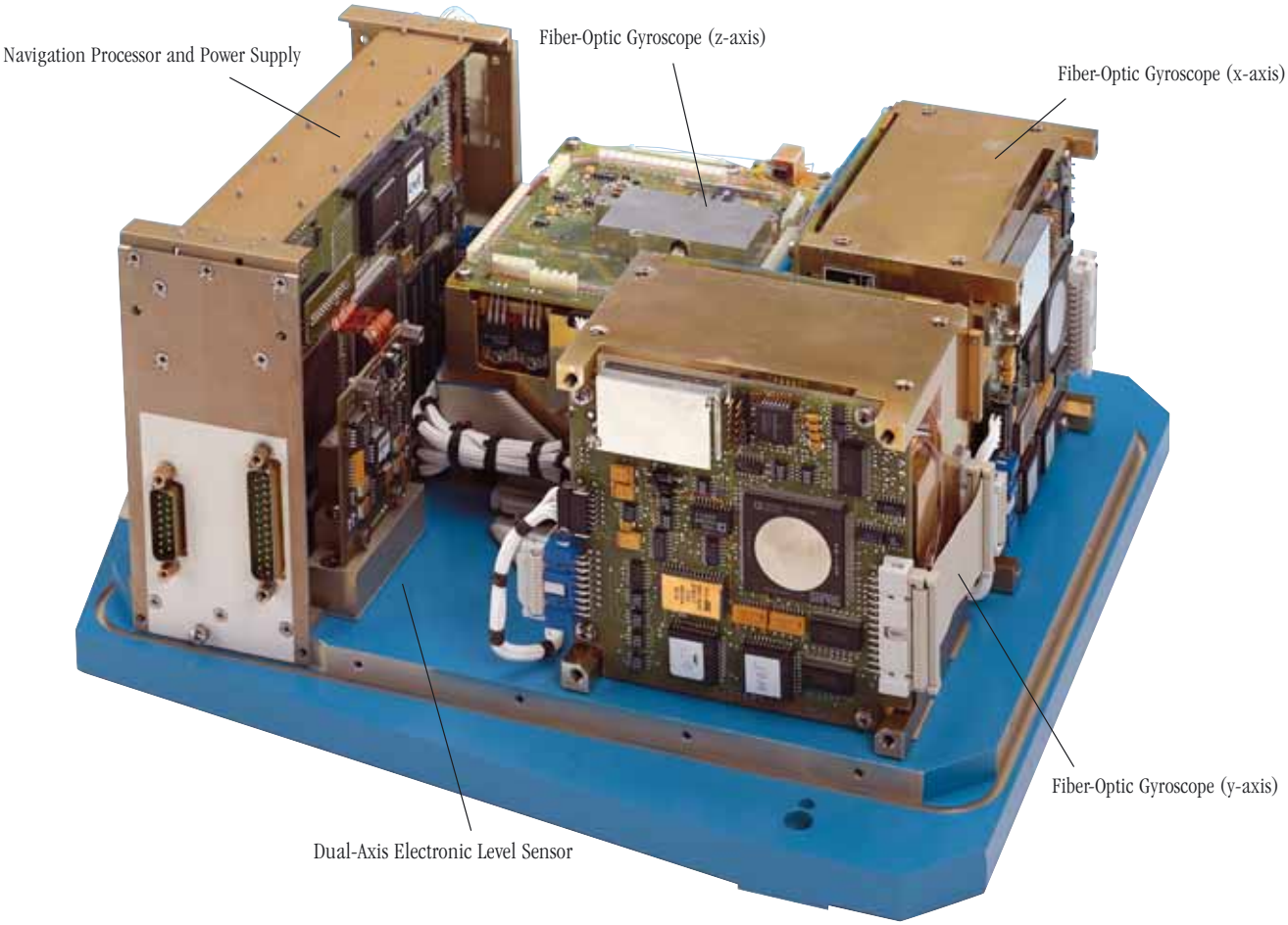
NAVIGAT 2100

Fiber-Optic Gyrocompass and Attitude Reference system



Sperry Marine

FIBER-OPTIC GYROCOMPASS AND ATTITUDE REFERENCE



Fiber-Optic Gyrocompass and Attitude Reference Sensor Unit

(Shown without cover)

Title page:
PEGASUS ONE built by Fincantieri for O.B.I.

The NAVIGAT 2100 Fiber-Optic Gyrocompass is the first solid-state, fully electronic digital gyrocompass system for marine application in strapdown technology designed for integrated bridges and advanced high-speed vessels.

The fundamental principle of the fiber-optic gyrocompass is the invariance of the speed of light and the so-called Sagnac effect. Here, a fiber-optic coil is used as a very sensitive rate sensor which is capable of measuring the speed of rotation of the earth. A combination of three such fiber-optic coils (gyroscopes) and a dual-axis electronic level sensor is able to determine the direction of true north. From the three rate of turn signals and the information from the electronic level sensor a complex Kalman filter computes the direction of the rotation of the earth from which geographical north is derived.

Designed in strapdown technology, the fiber-optic gyrocompass is attached directly to the vessel, eliminating the use of a gimbal system. This arrangement supplies heading information and also roll, pitch and rate of turn about all three axes.

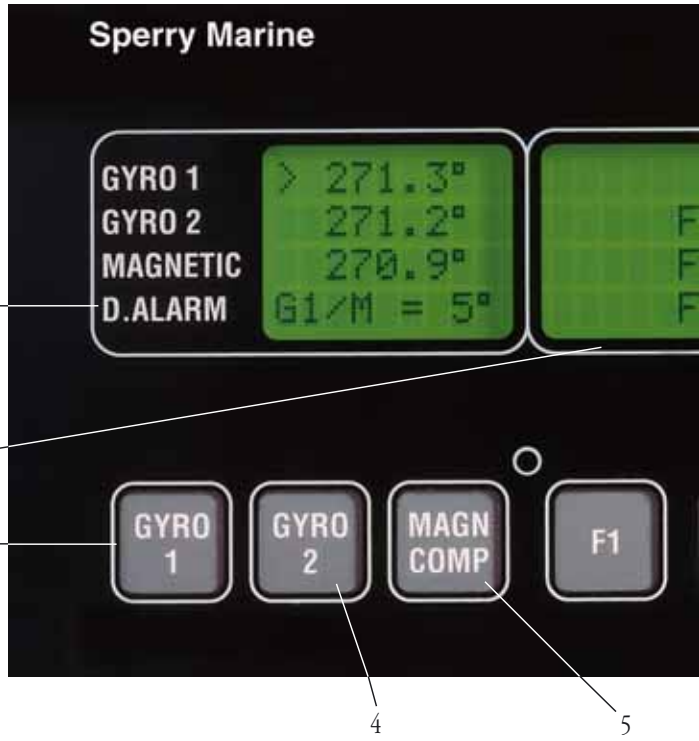
The fiber-optic gyrocompass can also be used as a sensor for stabilizer systems not only on merchant marine vessels but also on hydrofoils and catamarans. The extremely short settling time of only 30 minutes will be of great advantage for fast ferries.

The very high dynamic accuracy coupled with the absence of north speed error will much increase the safety of all vessels, particularly so that of high-speed craft at high latitudes during frequent maneuvers at high speed.

The fiber-optic gyrocompass is a complete solid-state design with no rotating or other

moving parts. It has very high reliability (MTBF) and no maintenance requirements during its service life.

In addition to the sensor unit, a basic NAVIGAT 2100 system comprises a control and display unit, and an interface and power supply unit. Analogue and digital display units and other peripheral equipment are supplied with output data through serial interfaces. It is also possible to add to the system a second gyrocompass (of the conventional type as a back-up for example) and a transmitting magnetic compass system (flux gate).



The Sagnac Effect

In a circular light path with the radius R, a light wave enters the ring at P (figure 1). Here, the light wave is split into two waves which travel in opposite directions, clockwise, counterclockwise, through the ring. Since the light path is assumed as being ideal, it is therefore identical for both light waves traveling in opposite directions. Consequently both light waves will arrive back at the point of entry P simultaneously. Here the waves rejoin and leave the ring.

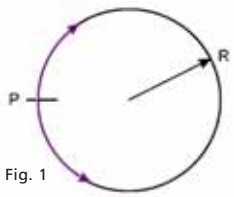


Fig. 1

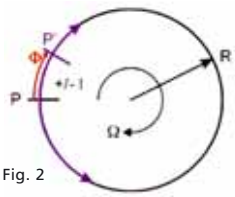


Fig. 2

The transit time of each wave through the ring can be measured with a very sensitive detector. What happens when the light path rotates when the light waves are traveling through the ring? Assume that the light path rotates clockwise. The entry and exit point P will move towards the wave traveling counterclockwise and away from the clockwise wave. One wave will travel over a longer distance to reach the exit point P, the other wave over a shorter distance. The light path with a radius of R has a circumference of $L = 2\pi R$. The transit time for the path L is:

$$T = L/c$$

where c is the speed of light. During the transit time T the light path rotates at a rate of Ω and through an angle $\Phi = \Omega T$. The shortening of one light path (figure 2) can be calculated with $I = R\,\Phi$ as:

$$L_{-} = L - I$$

The increase in the other light path is:

$$L_{+} = L + I$$

The total difference in path length is:

$$\Delta L = L_{+} - L_{-} = 2I = 2R\,\Phi$$

If the difference is divided by the wave length of the light wave, the difference in units of wave length is obtained. Considering that a wave length γ is equivalent to a phase angle of 2π, the path difference can be expressed as a phase shift between the two light waves:

$$\Phi_s = 2\pi\Delta L/\gamma$$

This phase shift is also called Sagnac phase. To sum up: the rotation of two light waves traveling in opposite directions results in a phase shift. If the aforementioned relationships are combined, they result in the following equation for the link between Sagnac phase and rotation rate:

$$\Phi_s = \frac{4\pi RL}{\gamma c}\Omega$$

Significant Features

- No moving parts.
- Solid-state technology.
- No maintenance during service life.
- High dynamic accuracy.
- Short settling time.
- Heading, roll, pitch and rate sensor.
- Meets all IMO recommendations including high-speed code.
- High mean time between failure (MTBF).
- Compact, low-weight design.
- Low power consumption.
- Data transmission via serial interface.
- NMEA 0183 FAST output.
- RS 422 SUPER FAST output.
- Second gyrocompass and magnetic compass input.
- All repeater compasses self-aligning via serial interface.
- Additional analogue outputs for all rate of turn signals.
- Compass monitor and heading selector function to NAUT-AW.
- Automatic emergency power changeover to GMDSS.
- Independent, short-circuit proof repeater outputs.
- Built-in test equipment.
- Basic system comprises only three units:

Sensor Unit, Control and Display Unit and Interface and Power Supply Unit.

- Type approved to the High-Speed Craft Code in accordance with the EC Council Directive 96/98/EC.
- The Rate-of-Turn output is type approved to the High-Speed Craft Code and in accordance with the EC Council Directive 96/98/EC and also fulfills IMO Resolution A.526(3)

Controls and Displays

1 Liquid crystal heading display with LED background illumination. Indicates in 4 lines of each 9 characters the headings of GYRO 1, GYRO 2 and the MAGNETIC compass, and also the preset heading Difference ALARM threshold. The difference in heading alarm is selectable between: GYRO 1 and GYRO 2, or GYRO 1 and MAGNETIC compass, or GYRO 2 and MAGNETIC compass. The alarm threshold range is from 1° to 35° in increments of 1°.

2 Main liquid crystal display with 112 characters in 4 lines and LED background illumination. Provides the user with all necessary operational data and speed, latitude, longitude, roll and pitch angles, rate of turn about all three axes (x, y, z).

3 Selects GYRO 1 as heading information source (selection only in a manual steering mode).

4 Selects GYRO 2 as heading information source (selection only in a manual steering mode).

5 Selects magnetic compass as heading information source (selection only in a manual steering mode).

6 Function keys. In combination with the main display, the function keys provide the user with a menu-controlled, high-level operation dialogue.

7 The cursor keys simplify the selection of menu pages and the editing of operational data.

8 Key pad with 16 logically arranged sealed-foil keys for the input of operational data, selection of menu pages, alarm reset, test function and illumination control.

Award Winning Technology

The 1997 Seatrade Award for Innovation was won by the NAVIGAT 2100 Fiber-Optic Gyrocompass.

SYSTEM CONFIGURATION

NAVIGAT 2100 Basic System

Control and Display Unit

Senor Unit

RS 422

24 VDC Power Supply

Interface and Power Supply Unit

Power Supply max. 250 VA — 115/230 VAC, 18-36 VDC

12 off NMEA 0183 (TTL) — Heading outputs to analogue and digital repeaters, radar and navigation systems

Optional

Position NMEA 0183
Position NMEA 0183

Electronic Compass NMEA 0183

Magnetic Compass with Flux gate sine/cosine

HDLC acc. to ISO 3309 (optional)

Speed — 200 pulses/nm, RS 422 or NMEA 0183, RS 422 or NMEA 0183

Status

Rudder 1, analogue
Rudder 2, analogue

NMEA 0183 (TTL) HDG, ROT, Roll, Pitch, X/Y-Rate, Speed, Pos.
NMEA 0183 (TTL) HDG, ROT, Roll, Pitch, X/Y-Rate, Speed, Pos.
NMEA 0183 (RS 422) HDG, ROT, Roll, Pitch, X/Y-Rate, Speed, Pos.
NMEA 0183 (RS 422) HDG, ROT, Roll, Pitch, X/Y-Rate, Speed, Pos.
NMEA 0183 (RS 422) FAST HDG, ROT, Roll, Pitch
NMEA 0183 (RS 422) SUPER FAST HDG, ROT, Roll, Pitch, X/Y-Rate
6 Steps/1° Heading Output (24 VDC/0,25 A)
6 Steps/1° Heading Output (24 VDC/0,25 A)
Analogue Output (±10 V) X-Rate
Analogue Output (±10 V) Y-Rate
Analogue Output (±10 V) Rate of Turn
Analogue Output (4-20 mA) X-Rate
NAVIPRINT
Alarms
Status

Accessory Equipment

Universal Digital Repeater
Weight: 650 g

Bearing repeater compass with 360° card in a stand with azimuth device PV 23
Total weight: 16.1 kg

Bearing repeater compass with 360° card in a bulwark console
Weight: 10.3 kg

Prismatic azimuth device PV 23
Weight: 1 kg

Jupiter Magnetic Compass

NAVIPRINT
Navigation Data Printer
Weight: 8 kg

Bulkhead repeater compass with 360° card
Weight: 2.9 kg

Console repeater compass with 360° card
Weight: 1.5 kg

Steering repeater compass for console mounting with 360° and 10° compass cards Weight: 1.5 kg

Sperry Marine

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ACCURACY (under all conditions)

Heading	≤0.7° secant latitude
Roll/pitch angle	≤0.5°
Rate of turn	≤0.4°/minute
x/y rate	≤0.4°/minute

Secant latitude = 1/cosine latitude

RANGE

Heading	0° to 360°
Roll & pitch (optional)	±45° (±180° with reduced accuracy)
Rates (X, Y, Z)	±80°/sec.

SETTLING TIME

Static conditions	≤30 minutes
Sea conditions	≤45 minutes
Rate of turn	≤4 minutes

ENVIRONMENTAL CONDITIONS

In accordance with EN 60945 (IEC 945+A1)

Ambient temperature	
Operation	-15°C to +55°C
Storage	-35°C to +70°C

SIGNAL OUTPUTS

NMEA (TTL) heading output	12 repeaters
NMEA (TTL)	2 all data
NMEA (RS 422)	2 all data
NMEA (RS 422) FAST	1 HDG, ROT, ROLL, PITCH
NMEA (RS 422) SUPER FAST	1 all data
6 steps/degree	2 heading outputs (24 VDC/0.25 A each)
Analogue ±10 V	3 rate signals
Analogue 4 to 20 mA	1 rate signal
HDLC	1 all data, bidirectional (optional)

SIGNAL INPUTS

Position	NMEA 0183
Speed	NMEA 0183/200 pulse/nm (max. 100 kts)
Second gyrocompass	NMEA 0183
Magnetic compass heading	NMEA 0183 or sine/cosine signal

POWER REQUIREMENTS

115/230 VAC 50/60 Hz and/or 24 VDC (18 V-36 V)
Includes automatic switchover to 24 V emergency power supply in accordance with GMDSS Rules for INMARSAT/SES Terminals.

POWER CONSUMPTION

Startup and operation (DC)	45 W
Each repeater compass	7 W

CURRENT CONSUMPTION

115 VAC	450 mA
230 VAC	225 mA
24 VDC	1.9 A

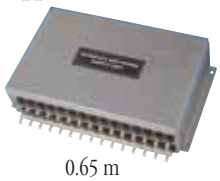
DIMENSIONS

Sensor Unit

Width	292 mm
Depth	340 mm
Height	170 mm
Weight	11.5 kg
Magnetic clearance to	
standard magnetic compass	0.80 m
steering magnetic compass	0.65 m
Reduced magnetic clearance to	
standard magnetic compass	0.50 m
steering magnetic compass	0.40 m
Protection grade	IP23

The Sensor Unit is supplied with two prefabricated interconnection cables.

Interface and Power Supply Unit



Width	524 mm
Depth	341 mm
Height	123 mm
Weight	15 kg
Magnetic clearance to	
standard magnetic compass	0.65 m
steering magnetic compass	0.50 m
Reduced magnetic clearance to	
standard magnetic compass	0.40 m
steering magnetic compass	0.30 m
Protection grade	IP23

Control and Display Unit

Width	288 mm
Height	96 mm
Depth	55 mm
Weight	0.7 kg
Magnetic clearance to	
standard magnetic compass	0.40 m
steering magnetic compass	0.30 m
Reduced magnetic clearance to	
standard magnetic compass	0.30 m
steering magnetic compass	0.30 m
Protection grade (installed)	IP23

Sperry Marine, with worldwide headquarters in Charlottesville, VA, and major engineering and support offices in Melville, NY, New Malden, England, and Hamburg, Germany, is part of the Northrop Grumman **Electronic Systems** sector.

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