MARINE SERVICES

Compagnie Générale de Géophysique

PIONEERS IN GEOPHYSICS

CGG, which has its head office in Massy, France, is a public service company founded in 1931 to study the earth's surface and subsurface worldwide, using all the geophysical techniques available today (seismic, gravity, magnetic, electric, electromagnetic, etc.).

Ranked among the four leaders dominating the world market, CGG employs over 60 land crews, four fixed-wing aircraft and five ocean-going vessels. The company's activities are focused on an international logistical network of more than 50 offices, agencies and subsidiaries, complemented by a group of data processing centres.

Today, CGG's Marine Division represents approximately 10% of Group turnover. To remain fully adapted to the needs of its clients, the fleet is present in the main zones of production - North Sea, Mediterranean, Africa and South East Asia. All five ocean-going vessels are equipped either to carry out cost-effective 2D and non-exclusive surveys or the extensive and technology-intensive multi-streamer 3D surveys which are increasingly the standard requirement for surveying reservoirs.

The structure of the division keeps it in permanent contact with the surveys being carried out at any particular time, and breaks down into:

- an operations and marketing department
- CGG Norge (Norwegian subsidiary)
- an equipment department
- an R & D department
- a non-exclusive survey department

Operations and Marketing

The Marine Division's main marketing team is based in Massy but CGG is also established in other locations around the world to reinforce contacts with clients, with Singapore covering surveys in South East Asia, London covering the British North Sea and Oslo the Norwegian North Sea.

Equipment

The equipment department is responsible for import/export, supplies, maintenance, repairs etc. Representatives from this department are based in Massy, Oslo and Singapore and remain on call around the clock.

R&D

The marine R&D department makes a substantial contribution to the innovative efforts of CGG's Marine Division, consistently improving both accuracy and quality. Highly qualified engineers and technicians are responsible for seismic data acquisition, radionavigation, or quality control.

Non-exclusive surveys

CGG's marine non-exclusive surveys department offers a complementary set of products and services:

- **North Sea non-exclusive data** acquired at a rate of roughly 5,000 km per year since 1986 in UK and Norwegian waters in preparation for licensing rounds.

- **international surveys** operated as joint-ventures with State companies. Examples include surveys carried out offshore Angola, Egypt, and Indonesia, as promotion for new zones, offering regional surveys for evaluation of basin potential.

- **brokerage of proprietary data**, with a catalog of over 100,000 km of worldwide marine data, acquired between 1972 and 1984 and owned by French Companies and the French Petroleum Institute. Seismic data acquired in the Barents sea and the Okhotsk sea are also offered in collaboration with CGG's partners, with initial packages of 20,000 km each available from the end of 1991 and further detailed packages planned for later release.

Offshore non-exclusive data available in North Sea, Mediterranean and African waters.

TECHNOLOGY

CGG's experience

CGG's ocean-going vessels have been exploring the oceans of the world for over thirty years. Since 1957, when CGG carried out the very first marine seismic operation in New Caledonia, the company has continued to innovate with new techniques and has fitted out a total of 35 boats to form its fleet at different times.

Technological milestones which have contributed to CGG's leading position:

1973 First 3D multistreamer survey.
1974 First application of the Syledis system to a marine seismic survey, in the Congo.
1975 Geophysical Integrated Navigation system, GIN[1], forerunner of the current GIN 3 and its future successor.
1982 Twin vessel techniques to acquire data under fixed obstacles at sea.
1986 Integrated Positioning Concept for multistreamer acquisition.
1990 Source Quality Control and synchronizer.

The CGG Group's wholly-owned manufacturing subsidiaries, Sercel (electronics) and AMG (electromechanics) have supplied CGG and the rest of the industry with a complete range of seismic acquisition systems (Sercel recording systems and AMG analog and digital streamers). Sercel has also designed and manufactured a series of positioning systems that are known and used throughout the world: Syledis®, Geoloc, GPS satellite receivers.

CGG's applied technology

CGG's wide experience in marine surveys guarantees a complete range of state-of-the-art techniques for 2D and 3D surveys.

After defining acquisition parameters with the client for each survey, CGG runs simulation programs to optimize survey management, before initiating the actual survey. As a further guarantee, a full range of quality control and quality assurance tools are available on board the vessel.

The GIN 3 integrated navigation and quality control system handles all positioning data from the sources, streamers, and tail buoys, producing quick-look plots on board and a complete navigation tape for use during data processing. Current development projects include a workstation which complements the GIN 3 to provide detailed analysis of navigation data acquisition.

Four of CGG's five vessels operate a digital data acquisition system using industry-standard technology. Quality control is ensured by the Micromax field processing system, while a specific Marine Source synchronizer monitors and controls airgun and sleeve airgun and source arrays.

The full set of acquisition and QC equipment is adaptable to all types of marine surveys in particular multi-streamer/multi-source operations and multi-vessel acquisition.

(1) CGG trademark
® Sercel trademark

The M/V Stormy during operations in the North Sea with four short streamers.

CGG has a fleet of five ocean-going vessels, two of which specialize in exclusive and non exclusive 2D surveys while the remaining three, fitted with the latest technology, are devoted to 3D surveys.

The 3D fleet

CGG's 3D vessels range in length from 72.5 m to 94 m, and offer the most sophisticated technology, maximizing flexibility and geographical availability. All of them are equipped with two sources and multistreamers.

They are also fitted with the GIN 3 integrated navigator, a Syntrak 480 recorder, with the new marine source synchronizer and with optional 3D monitoring, gravimeter and magnetometer equipment. In addition, all the vessels offer the patented CGG tail buoy positioning system using Syledis SB5 and/or GPS receivers (Sercel NR103 or NR 105), and Simrad hydroacoustic positioning (EA500).

The M/V Rig Master.

The M/V CGG Mistral.

- **M/V CGG Mistral** entered service in the Spring of 1991 as the new flagship of the CGG fleet. This vessel is fitted with a sleeve airgun source, and three AMG 480-trace digital cables. The Mistral sails under the French flag.
- **M/V Stormy** operates an airgun source and up to two 480-trace or four short digital streamer cables from its extended booms. The Stormy is registered in Liberia.
- **M/V Rig Master** operates an airgun source and twin 480-trace digital cables. This vessel is registered in Norway.

The M/V Stormy.

The 2D fleet

CGG has signed several contracts and agreements with various organizations in the USSR. Two of these agreements relate to operating of the vessels, M/V CGG Sirocco and M/V CGG Zephyr, which have joined the CGG fleet.

These two vessels have been completely refitted by CGG to offer a cost-effective solution for 2D surveys.

- **M/V CGG Sirocco** offers a sleeve airgun source, a 144-trace analog streamer, a Litton LRS 100 source synchronizer and a Sercel SN 358 DMX recorder (240 channels).
  CGG Sirocco is fitted with GIN 3, a GPS receiver (Sercel NR 103), a Syledis receiver (Sercel SB5) and Perkin Elmer and Versatec Quality Control tools. The Ramesses Quality Control system (Odegaard) is available on request.
  This vessel is operated jointly with the Murmansk Trust.
- **M/V CGG Zephyr** offers an airgun source, a 240-trace digital streamer and recording system and an I/O type AIRCON III synchronizer.
  For radionavigation, the vessel is fitted with GIN 3, a GPS receiver (Sercel NR 105), and a Syledis receiver (Sercel SB5).
  This vessel is operated jointly with the Sakhalin Trust.

The M/V CGG Zephyr.

Cooperation with Russia

In 1990, agreements were signed with geophysical organizations in Murmansk and Sakhalin with respect to the joint operation of two of their vessels:

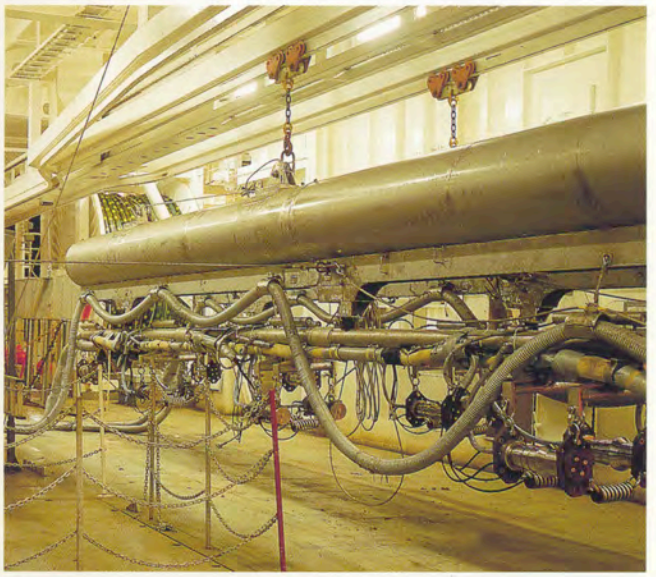
- *M/V CGG Sirocco operates in the North Sea, Africa and the Mediterranean. The vessel entered service in May 1991, commencing with extensive non-exclusive surveys in the North Sea.*
- *M/V CGG Zephyr concentrates its activity around South East Asia. After entering service in April 1991, the Zephyr shot a large quantity of exclusive data in Vietnam.*

Both vessels sail under the Panamanian flag. With these bilateral cooperation agreements, CGG increased the potential of its Marine Division both quickly and cost-effectively.

The M/V CGG Sirocco.

Sources

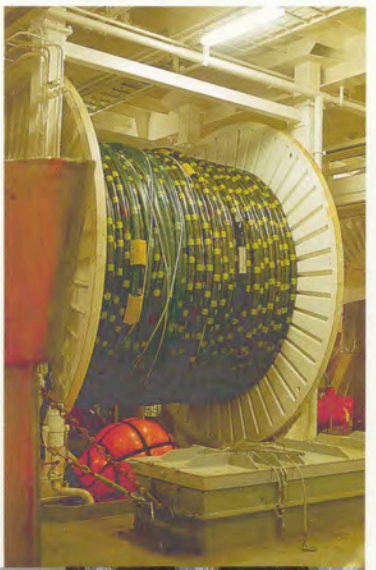
All vessels in the CGG fleet are fitted with either the airgun or sleeve airgun[1], to meet the requirements of today's market.



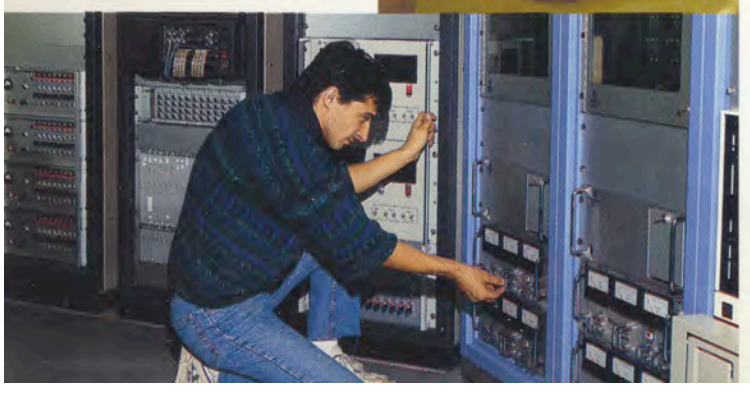
Sleeve airgun on board M/V CGG Mistral.

Acquisition systems

Four of the five vessels in the CGG fleet are equipped with digital streamers, three with the industry-standard Syntrak system.



Syntrak acquisition system on board M/V CGG Mistral.



Quality control

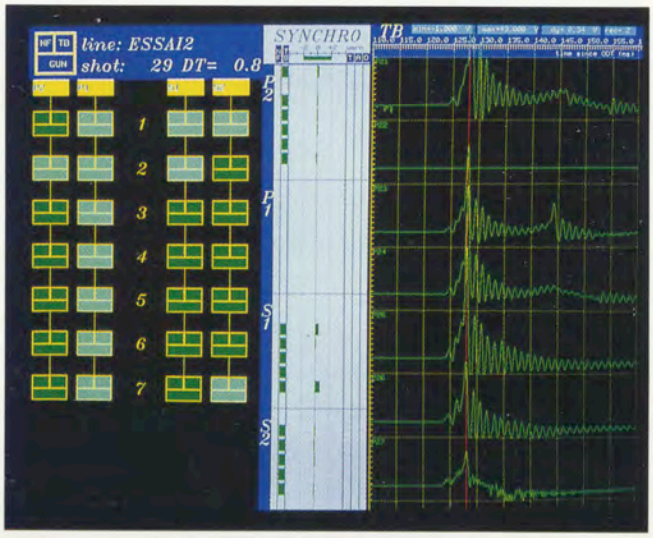
As 3D marine surveys become ever more complex, and the demand for accuracy grows, stringent quality control procedures are becoming increasingly necessary. To meet this demand, CGG has developed a complete and continuous quality control process covering the entire sequence from the first shot to delivery of the final data.

The marine source synchronizer, developed jointly with the IFP (French Petroleum Institute), significantly improves acoustic quality for airgun or watergun shots. In addition to ensuring a precise triggering sequence, this system provides a source quality control function: signal analysis, detection of mis-timed shots and misfires, monitoring of guns and receivers for preventive maintenance.

This instrument has been used on the CGG vessel M/V Stormy in the North Sea and is also installed on the M/V CGG Mistral and the M/V CGG Rig Master. It will be installed gradually on the other vessels in the CGG fleet, and elsewhere.

Once the profile has been established, CGG uses the on board Micromax[2] system to establish a simplified sequence for processing data in order to control their quality. Micromax provides real-time monitoring with raw data visualized on screen. Micromax is fully interactive; results enable the seismic crew to optimize acquisition parameters.

The Micromax on-board quality control system.



Marine source synchronizer screen display showing time break signatures for a subarray.

NAVIGATION - POSITIONING

CGG's GIN 3 system handles the large volumes of data involved in providing comprehensive positioning for all the elements in a geophysical survey (vessel, source subarrays, seismic traces, streamer heads and tails) while covering the full range of real-time monitoring and quality control functions required on board a seismic vessel in single or twin vessel surveys.

Quality control of the main survey parameters is also provided on screen in real time and on printouts at the end of each line.

All navigation and QC data are **recorded** on magnetic tape or cartridge and a special record is made of initialization parameters.

The multi-function **Real-Time Binning** (RTB) tool defines up to 64 ranges of shooting distances with bin coverage maintained in real time for all them.

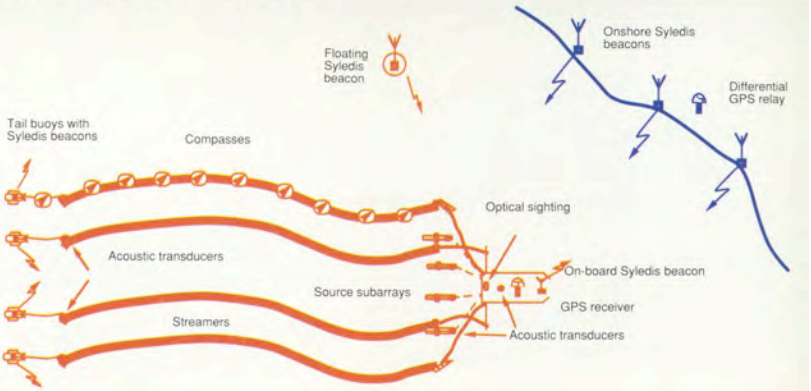
GIN 3 system on board M/V CGG Mistral.

Tail buoy

The tailbuoy utilized by CGG integrates a Syledis radiopositioning beacon which gives the position of the streamer tail in real time with the same degree of accuracy as the vessel.

Recent developments integrated into the tail buoy system include four new sensors linked to the vessel over a telemetry link:

- An acoustic transponder, suspended below the float, positions the final sections of the streamer.
- A magnetometer can be towed behind the buoy.
- A GPS satellite receiver, communicating in differential mode with a ground station, can position the tail buoys independently of the Syledis radiopositioning system.
- A receiver built into the buoy monitors the available electrical current and the propeller driving the power alternator.



Satellite positioning

Transit and GPS modes are available. GIN 3 handles the configuration data (antenna offsets, vessel speeds for Transit, computation mode for GPS) and offers direct control of GPS functions (choice of receivers, threshold selection, datum shift selection).

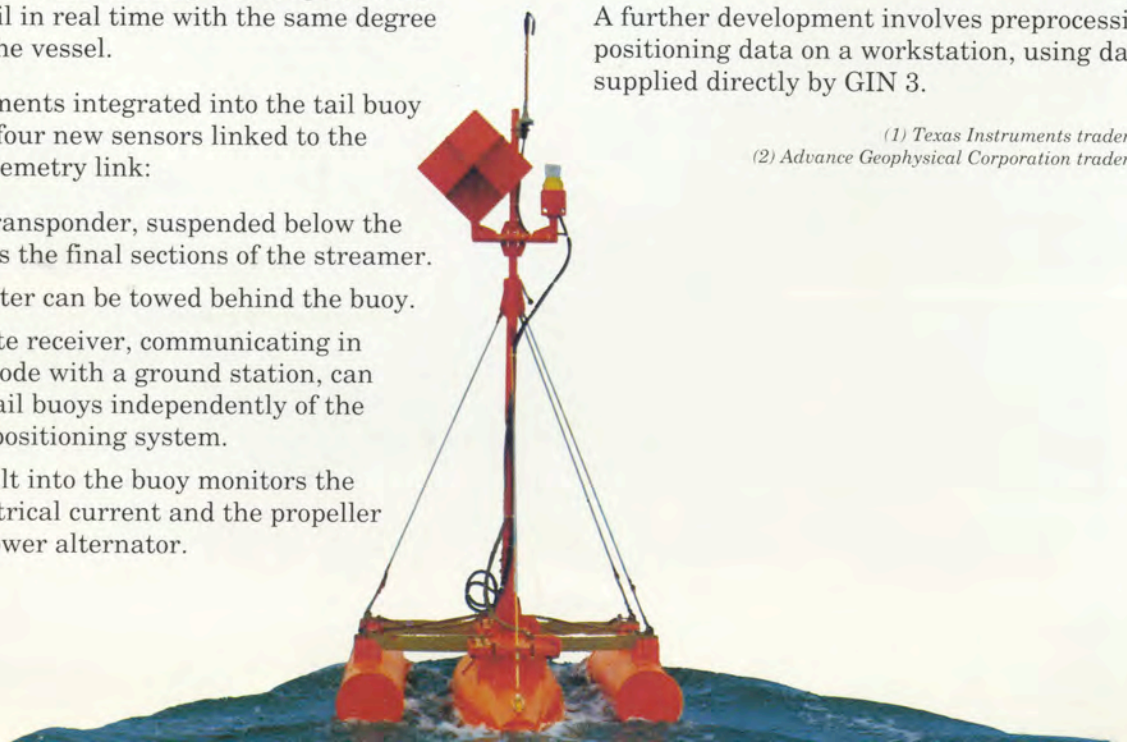
Acoustic positioning

GIN 3 handles both short base and ultra short base acoustic transponder systems, with up to eight transponders on the sources and streamer heads or up to 50 distances from transducers located on the sources, the first and last sections of the streamers, and under the tail buoys.

Current developments envisage upgrading of the GIN system to manage any possible combination of multi-streamer, multi-source and multi-vessel acquisition systems; to handle non-conventional 3D acquisition methods including, for example, circular seismic; to improve Real-Time Binning functions with enhanced definition and to operate with tapes in all international formats including UKOOA P290 and P286. This new GIN would use existing sensors including the relative GPS system.

A further development involves preprocessing positioning data on a workstation, using data supplied directly by GIN 3.

(1) Texas Instruments trademark
(2) Advance Geophysical Corporation trademark



QUALITY - SAFETY

Quality Assurance

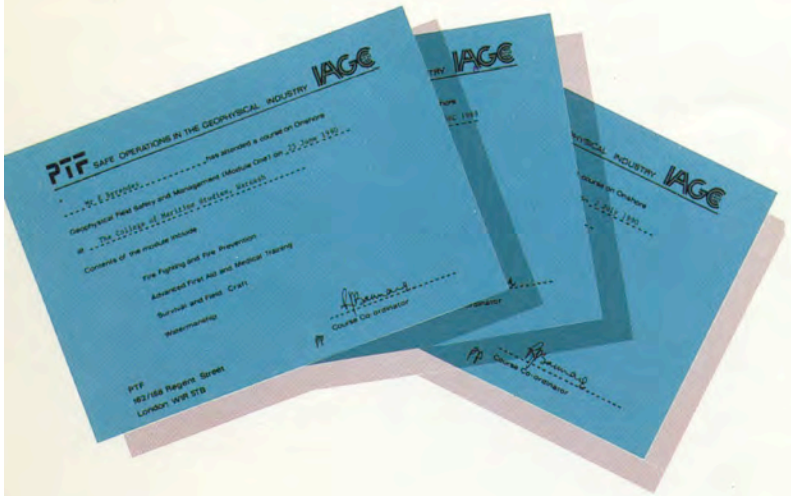
Quality is defined as all the features and characteristics of a service or product which make it able to satisfy a given need.

CGG attaches increasing importance to Quality Assurance as the group's overriding aim is to give complete satisfaction to clients by the service it performs.

The system of Quality Assurance procedures in force in the Marine division ensures that each crew remains in permanent contact with a center which can inform it of any incident that may occur. Quality Assurance procedure documents include:

- organization of a marine crew
- content and end-user of geophysical products
- dispatch of seismic magnetic tapes for data processing.

International crew training courses are followed systematically by CGG personnel in the context of the Company's quality and safety policies.



Safety

For many years now, CGG has focused on one particular objective which it regards as an ongoing priority: ensuring and improving the safety of its personnel. This notion of safety covers two aspects:

- equipment used on board, whether specifically safety-oriented or not
- safety management governing safety regulations for staff in all working situations.

To foster this safety consciousness, CGG lays great emphasis on training and information:

- All permanent crews follow a basic safety training course at the PTF or PETANS training centres in England where they are taught the general principles of safety and accident prevention in the workplace. This training continues in practice on board CGG's vessels as every auxiliary helper is placed under the responsibility of a more experienced crewmember who checks that he operates the equipment correctly so as to avoid accidents during operations.
- Information is communicated regularly on the subject of safety, including hygiene, health and the environment.

Each crew has CGG's safety regulations on board in addition to memos giving details of specific procedures relating to vessel evacuation, first aid and hygiene etc.

To ensure that the safety aspect of operations is adhered to on each survey, CGG offers a safety clause in every contract signed with its clients. By doing so, it demonstrates the extent to which it considers accident prevention to be one of the major elements of cooperation between contractor and client.

Front cover photo:
The M/V CGG Mistral.

Main Offices

1, rue Léon Migaux
91341 Massy Cedex
France
Tel.: (33-1) 64 47 30 00
Fax: (33-1) 64 47 39 70

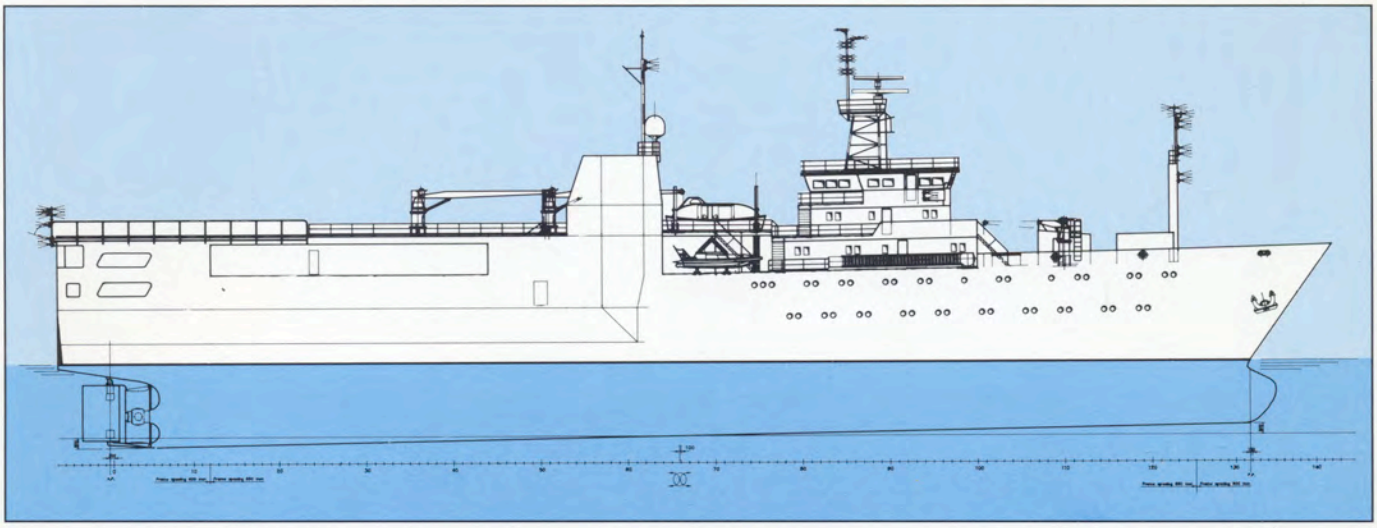
Baarsrudveien 2
N-3478 Naersnes
Norway
Tel.: (47-3) 28 27 50
Fax: (47-3) 28 06 65

2500 Wilcrest, Suite 200
Houston, Tx 77042
U.S.A.
Tel.: (1-713) 784 0740
Fax: (1-713) 266 9754

CGG House, 4 Dukes Green Avenue
Feltham - Middlesex TW14 0LR
U.K.
Tel.: (44-81) 899 2400
Fax: (44-81) 899 2500

Unit 11-09 Parkway Parade
80 Marine Parade Road
Singapore 1544
Tel.: (65) 440 93 88
Fax: (65) 440 92 28

THE M/V CGG MISTRAL



VESSEL SPECIFICATIONS

Owner	SA L. DREYFUS
Home port	Port aux Français
Flag	French
Registration no.	t.b.d.
Builder - Year	Baatservice Norway - 1991
Class	BV.1.3/3, Helideck AUT
Radio call sign	t.b.d.
Marisat No.	t.b.d.

Main characteristics

Length, beam, max. draught	94 m x 15,6 m x 6 m
Tonnage - Gr./Net	3500/900 tons
Main engine	Bergen diesel BRM 8MCR 3000 kW
Propeller	Ulstein variable pitch + nozzle
Auxiliaries	3 x 1500 KVA (440/50) Bergen diesel KRG 8
Stern thruster	1 x 300 KW
Bow thruster (azimuth)	1 x 400 KW Brunvoll
Max. speed	15 knots
Tank capacities:	
- Fuel oil (heavy)	830 m^3
- Diesel oil	111 m^3
- Fresh water	120 m^3
- Water ballast	70 m^3
- Evaporator	2 x 10 t/day
Radio:	
- SSB (No. - power)	1 x 800 W Sailor
- VHF (No. - channels)	2 x Sailor RT 2047 RT 2048
Radar (No. - range) + ARPA	1 x JRC 3CM 1 x JRC 10CM
Satellite communications	1 x JRC JUE 45A
Satcom fax	TBK FAX 1431
Gyrocompass	1 x Sperry MK 37
Autopilot	1 x Robertson MK II
Echo sounder	JRC JFE 570S
Accommodation capacity	41 total
Air conditioning	

GEOPHYSICAL EQUIPMENT

Source	Sleeve Airgun 4 LMF air compressors each 30.1 m^3/min (1100 cfm) Options: - long array - wide array - dual source
Streamer cable	3 AMG digital cables Max. 480 traces & 6000 m 3 streamer winches
Recorder	Syntrak 480 - 3 STC tape transports (6250 bpi) and cassette recorder

Options

- 3D monitoring equipment
- Gravimeter
- Magnetometer
- Micromax
- Tail buoy positioning(1) using Syledis(2) SB5 receivers
- Simrad hydroacoustic positioning system HPR 388

RADIONAVIGATION

Integrated navigator	GIN* 3
Satellite receiver	Magnavox MX 1107R
GPS receiver	Sercel TR5S
Syledis receiver	SB5 beacons
Doppler Loch	Magnavox MX 610B
Depth recorder	Simrad EA500
Electromagnetic loch	Sagem LHS
Gyrocompass	Sperry MK37
Loran C	Decca DL91

* *CGG trademark*
(1) *CGG patent*
(2) *Sercel trademark*

Printed in France by R. LUTHRINGER

THE S/V RIG MASTER

VESSEL SPECIFICATIONS

Owner	K/S A/S RIG SEISMIC II
Home port	Monrovia (Liberia)
Flag	Liberian
Registration no.	8427
Builder - Year	Flekkefjord Slipp & Maskinfabrikk, Flekkefjord, Norway - 1983
Class	DnV, 1A1, EO, Ice C, Helideck, Worldwide, AUT
Radio call sign	ELIV 4
Marisat No.	124 01 65

Main characteristics

Length, beam, max. draught	72.5m x 13.8m x 6m
Tonnage - Gr./Net	1528.8/360 tons
Main engine	BERGEN Diesel KVBM 12 2640 HP - 825 rpm
Propeller	1 variable pitch
Auxiliaries	4 x 536 kVA AC motor generators & 1 shaft generator 1000 kVA - 440 V - 60 Hz
Bow thruster	2 Brunvoll SPX 600 HP
Max. speed	12 knots
Tank capacities:	
- Ballast	408 m^3
- Fuel oil	475 m^3
- Fresh water	95 m^3
- Evaporator	10 t/day
Radio:	
- SSB (No. - power)	1 x 800 W Sailor
- VHF (No. - channels)	2 x Sailor RT 143
Radar (No. - range)	2 x Raytheon - 48 nautical miles
Marisat	JRC (Telephone - Telex)
Satellite navigator	Furuno
Gyrocompass	Robertson
Autopilot	Robertson
Depth recorder	Simrad
Accommodation capacity in addition to crew	12 x 1 + 11 x 2
Air conditioning	

GEOPHYSICAL EQUIPMENT

Source	Airgun 5 LMF air compressors: 3 x 29.45 m^3/min(1040cfm) 2 x 22.60 m^3/min(798cfm) Options: - long array - wide array - dual source
Streamer cable	AMG analog cables Max. 480 traces & 4800 m Option: 2 x 240 x 12.5m 2 streamer winches
Recorder	Sercel SN 358 DMX (two units) - 254 channels each - 3 STC tape transports (6250 bpi)

Options

- 3D monitoring equipment
- Gravimeter
- Magnetometer
- Micromax
- Tail buoy positioning(1) using Syledis SB5(2) receivers
- Simrad hydroacoustic positioning system HPR 300/309

RADIONAVIGATION

Integrated navigator	GIN* 3
Satellite receiver	Magnavox MX 1107 R
GPS receiver	Sercel TR5S
Syledis receiver	SB5 beacons
Doppler Loch	Magnavox MX 610 B
Depth recorder	Simrad EA 500
Electromagnetic loch	Sagem LHS
Gyrocompass	Sperry MK 37

(1) CGG patent
(2) Sercel trademark
** CGG trademark*

Printed in France by R. LUTHRINGER

THE S/V AKADEMIK NEMCHINOV

VESSEL SPECIFICATIONS

Owner ..... USSR OIL MINISTRY
Home port ..... Murmansk
Flag ..... USSR
Registration no. ..... 1S M 42023
Builder - Year ..... Varskego Shipyard
Poland - 1988
Class ..... KM * UL 1 A2
Radio call sign ..... UETM
Marisat No. 140 15 46

Main characteristics

Length, beam, max. draught . 81.85m x 14.8m x 5m
Tonnage - Gr./Net ..... 3631/2833 tons
Main engine ..... ZGODA-SULZER Diesel
4260 HP - 500 RPM
Propeller ..... 1 variable pitch
Auxiliaries ..... 2 x 740 HP
+ 2 shaft generators
Total 2308 KW
Bow thruster ..... 220 KW
Max. speed ..... 14.3 knots
Tank capacities:
- Fuel oil ..... 750 m^3
- Fresh water ..... 109 m^3
- Evaporator ..... 10 t/day
Radio:
- SSB (No. - power) ..... 1 MOUSSON - 2250 W
- VHF (No. - channels) ..... 1 REYD-1 - 24 channels
Radar (No. - range) ..... 2 NAYADA 5 - 64 n.miles
Satellite communications ..... 1 VOLNA-S
Gyrocompass ..... 1 VEGA - 1 PLAT
Autopilot ..... 1 VEGA
Depth recorder ..... DESSO-25 - NEL-M3B
Accommodation capacity
in addition to crew 62
Air conditioning

GEOPHYSICAL EQUIPMENT

Source ..... Airgun
4 EL COMP EK 30A
compressors
each 12.5 m^3/min
1 JUNKER 5 FKMS Diesel
8.1 m^3/min

Synchronizer ..... REFTEK 43 - 32 channels

Streamer cable ..... AMG 120 traces

Recorder ..... SERCEL SN 358 DMX
- 120 channels
- 3 STC tape transports
(6250 bpi)

Options

- Gravimeter
- Magnetometer
- Quality control: PERKIN ELMER and VERSATEC

RADIONAVIGATION

Integrated navigator ..... GIN* 3
Satellite receiver ..... MAGNAVOX 1107
GPS receiver ..... SERCEL TR5S - GPS 8400
Syledis(1) receiver ..... SB5 beacon
Doppler Loch ..... ATLAS
Depth recorder ..... ATLAS DESO 20
Electromagnetic loch ..... IEL 2M
Gyrocompass ..... VEGA
Loran C ..... MICROLOGIC 3000

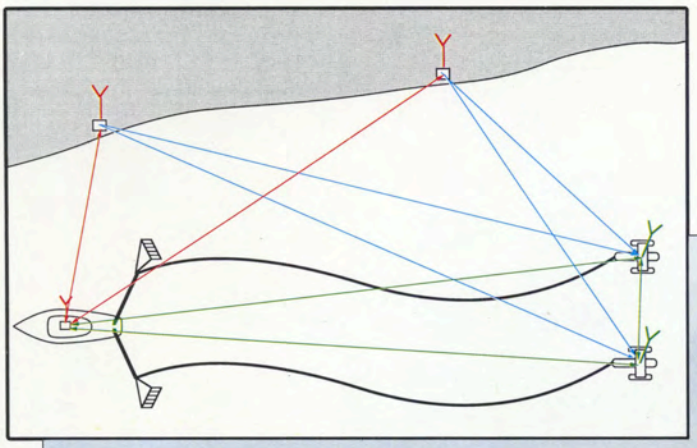
** CGG trademark*
(1) Sercel trademark

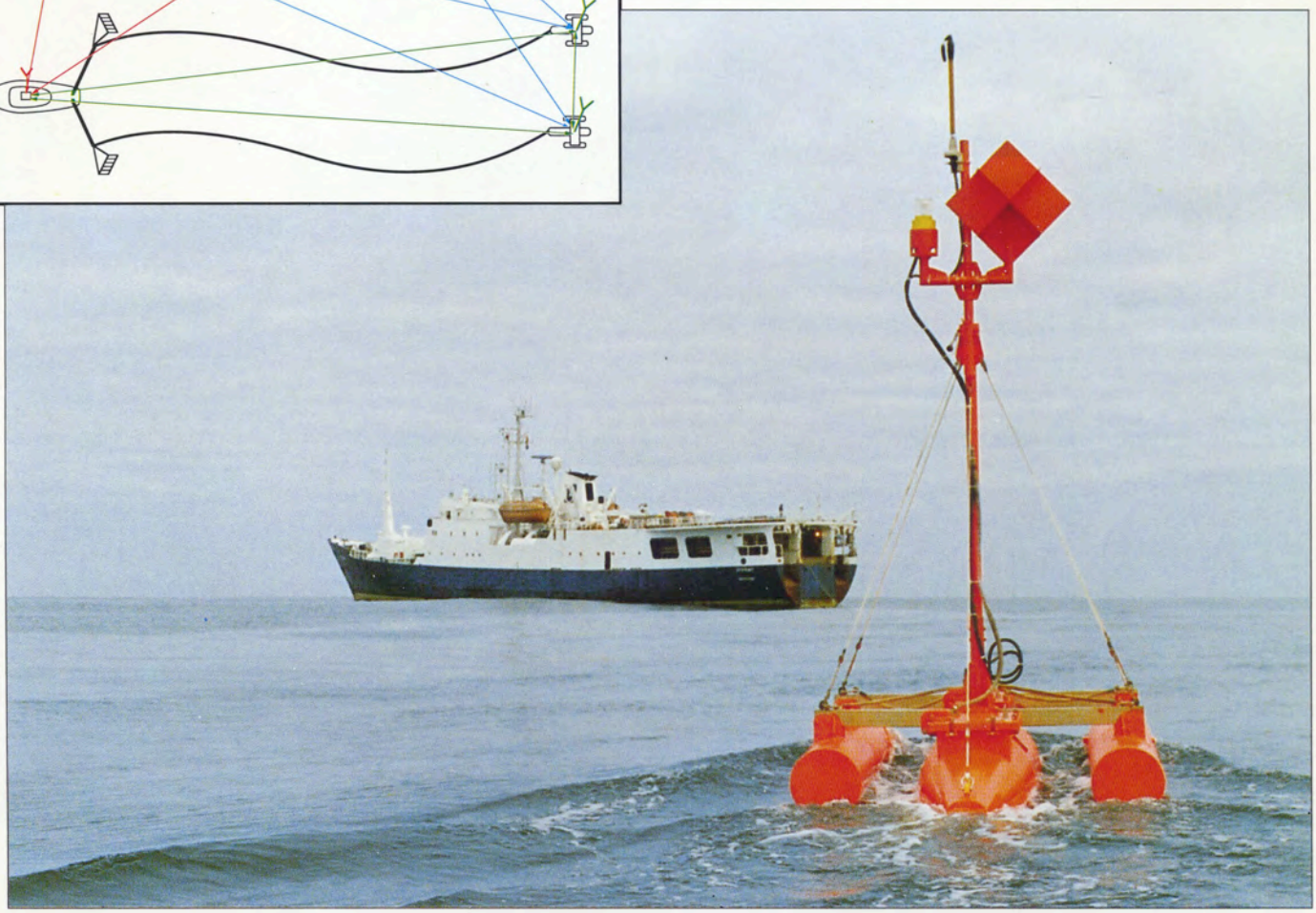
Technical series no. 588-90-10

Printed in France by R. LUTHRINGER

Radionavigation services

STREAMER TAIL BUOY





Real-time absolute positioning of the end of the streamer cable

Since 1986, Syledis radiolocation techniques have been applied systematically by CGG to provide absolute positioning of streamer tail buoys at all times, with accuracy similar to that for the position of the vessel, i.e. 3 to 5 meters. The specially designed tail buoys contain built-in Syledis SB5 beacons which transmit to the vessel all the data required to establish their position.

This technique[1] and the corresponding equipment are now established as a reference in the industry, generally for dual cable surveys and increasingly for single streamer operations. Operations over several tens of thousands of kilometers have proven system reliability with respect both to the radiopositioning system and the buoy itself, the structure and electrical components of which are specifically designed for the most severe marine environments.

[1] *CGG patent*

TECHNICAL SPECIFICATIONS

Buoys are delivered complete with launching and towing systems and facilities for handling on board the vessel. Safety devices built into the design of the tail buoy include deflectors, electrical safety protection, etc.

Floats

The floats are manufactured from light marine alloy and filled with polyurethane foam, for light weight and stability. Floats undergo leaktightness testing during manufacturing and are protected against corrosion.

Compartments

The trimaran tail buoy consists of a center float comprising three leaktight compartments:
- Syledis® SB5 beacon
- marine generator
- high performance battery

Mast

The mast is folding and removable. The upper part of the mast supports:
- a radar reflector
- an antenna
- a flashing light

On-board positioning system

- integrated in the GIN'3 navigation system on board CGG vessels
- special system available for tail buoy hiring services, as specified below.

Features

Omnidirectional antenna
Leaktight flashing light
Marine generator
Syledis® SB5 beacon
Nickel cadmium battery
Battery charge status included in Syledis® signal for transmission to vessel.

Dimensions

Overall length: 3.01 m
Overall width: 1.65 m
Overall height with antenna: 4.15 m
Height with mast folded (with deflector): 2.95 m
Height without mast: 1.445 m
Net weight: 313 kg.

Packing dimensions

Length: 2.94 m
Width: 1.7 m
Height: 1.65 m
Gross weight with palette: 460 kg.

® Sercel registered trademark
** CGG trademark*

TAIL BUOY SERVICES

Complete sets of two or three tail buoys are available for hire at all times, complete with the on-board computerized real-time positioning system. Packaging is specially designed for air freight. Assistance from CGG technicians is available for system installation and, over a modem link, for trouble-shooting.

On-board positioning system

- HP 9000-330 computer
- Color graphic screen
- Double disc drive
- Printer
- CGG tracking software
- Connection to any on-board navigation system by RS 232 or GPIB line

For further information, please contact:

CGG - Radionavigation Department
1, rue Léon Migaux
91341 Massy Cedex
France

Tel.: (33-1) 64 47 36 82/3
Fax.: (33-1) 64 47 39 00
Telex: 602442 F

PRINTED IN FRANCE BY R. LUTHRINGER

NAVIGATION PROCESSING AND MAPPING

INTRODUCTION

Recent technical advances in 3D marine acquisition have placed new emphasis on several criteria relating to the processing of large volumes of navigation data. In particular, the search for ever greater quality and accuracy has caused a huge increase in navigation data volumes. Meanwhile the parallel demands for increased cost-efficiency and the faster turnaround times required to be compatible with the decision-making programs of large oil companies have made further demands on technology.

CGG's response to these demands has been multiple:

- new software has been written
- interactive stand-alone workstations have been implemented
- new quality control procedures have been set in place.

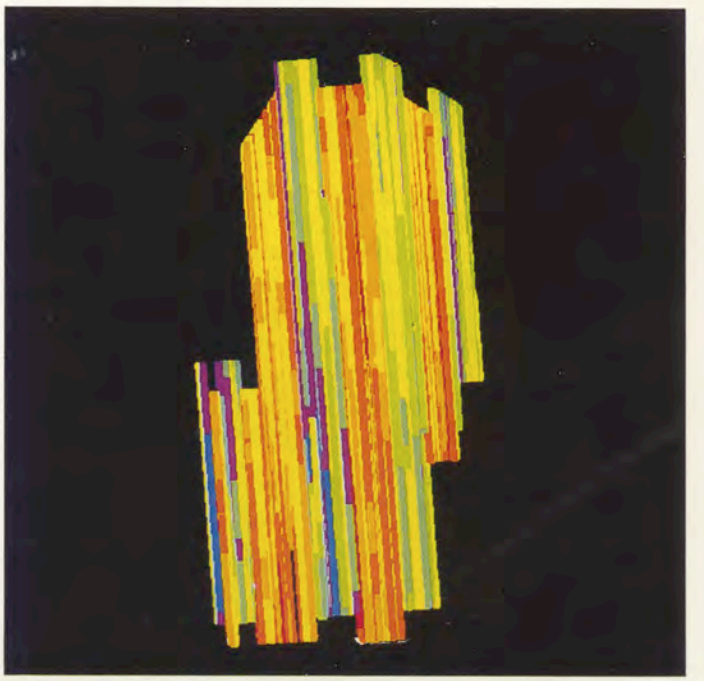
All these features are included in the on-board navigation processing workstation implemented by CGG on its entire marine fleet. However a large proportion of the world seismic fleet does not have this kind of sophisticated technology available on its vessels, and CGG is able to propose the same quality of service with the specialist in-house navigation group which contributed to developing the on-board system.

The potential applications of this service are multi-fold:

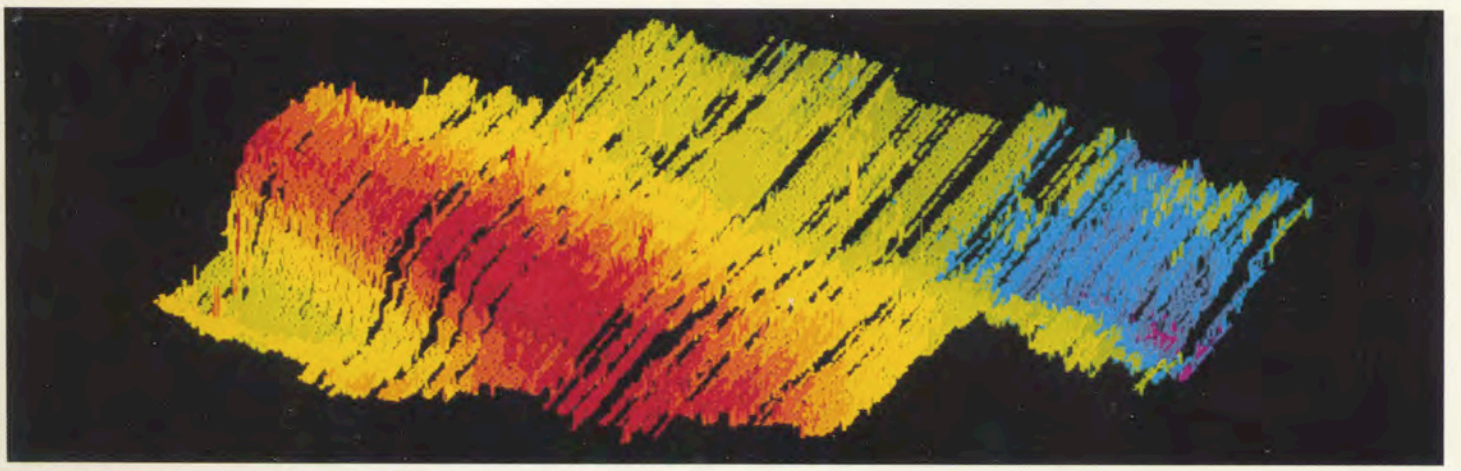
- reprocessing of navigation data from old surveys with today's accuracy
- processing of data acquired by any other contractor in UKOOA P2/86 format or field format
- quality assessment of post-processed data in UKOOA P1/90 format
- thorough inspection by comparison of sample processing with post-processed data.

Clients benefit from the experience of a team based in one of the industry's largest data processing centers, implementing the most sophisticated tools available to marine navigators.

Particular benefits include the complementary know-how of a large seismic contractor, the expert problem-solving assistance available on site for special projects or complex problems, and the wealth of sophisticated peripheral equipment available in a main center for specific tasks such as digitizing, plotting large maps, reformatting, etc.



Cable drift.



Water depths over a 3D survey, before tidal corrections.

NAVIGATION PROCESSING PRINCIPLES

Navigation post-processing is required principally because current real-time navigation systems are unable to perform detailed processing on the several hundred parameters for each shot point which are received from sensors. These data (radio, optical, acoustic, magnetic, etc.) must first be analyzed, sorted and corrected, and such operations can only be carried out in off-line mode.

A preliminary and basic step in the processing sequence is to collect and check all the non-variable parameters of the survey (station coordinates, antenna offsets, etc.) which are then stored in an initialization data base.

The actual processing sequence then takes place in three steps:

- optimization of the data
- merging of data of the same type in order to obtain intermediate positions
- merging of all intermediate results in order to obtain final positions for sources and traces.

This sequence is a logical result of the specialized processing applied to each type of data. As a complimentary approach, groups of lines are processed in chronological order so as to benefit from a statistical selmection of the most suitable parameters for use at a certain period. These principles then guarantee quality and fast turnaround.

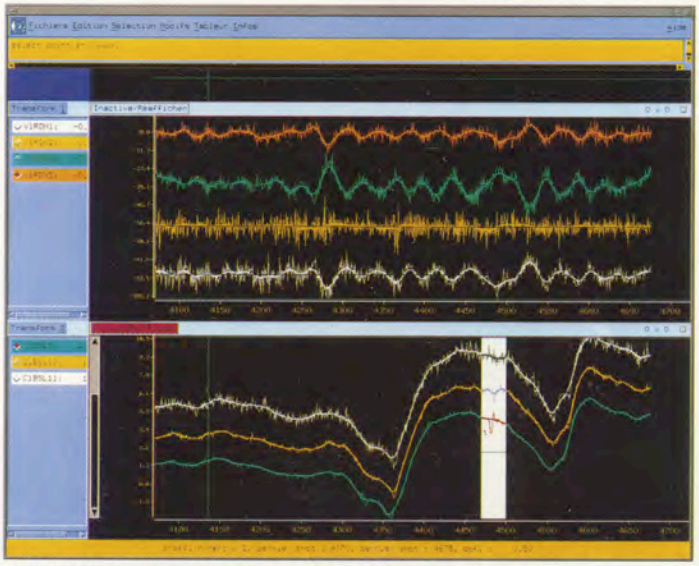
PROCESSING SEQUENCE

Phase 1: Data optimization

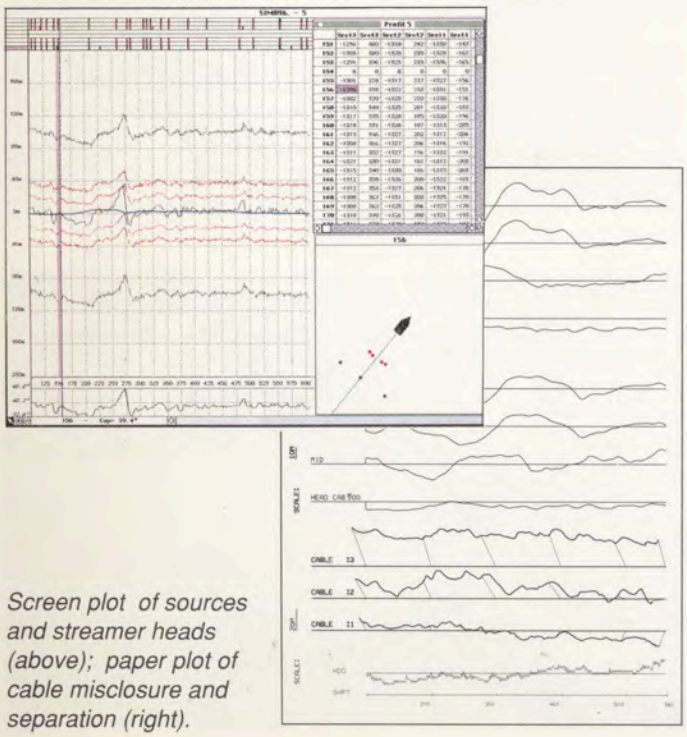
This phase is mainly carried out by filters with adjustable parameters which eliminate noise while respecting the signal dynamic. GEOVECTEUR® modules provide detailed plots giving a reliable representation of the filtered signal superimposed on the raw signal. The fast and powerful interactive graphic editing tool EDILOC reduces the time required for selecting filtering parameters to a matter of minutes and facilitates the reformatting of poor quality data.

Phase 2: Intermediate merging

Each specialized module in the processing sequence for one certain type of data uses the filtered signals to compute a result (position of the antenna on the vessel, or on a streamer head or tail buoy; systematic calibration of all compasses, pre-positioning of the source or streamer head). Results are presented as a paper or screen plot for fast and reliable QC. As backup QC, a statistical file is constantly updated.



EDILOC display of radio ranges and compass values.



Screen plot of sources and streamer heads (above); paper plot of cable misclosure and separation (right).

Phase 3: Final merging

In this phase the intermediate results established in Phase 2 are combined in order to compute the final positions of the sources and traces. This mainly involves adjusting the head and tail networks, and rotating the streamers on known positions. The need for system redundancy becomes particularly obvious at this stage if a high degree of confidence is to be accorded to the results.

Once again, the modules easily produce plots (distance between streamers at different points, angular and longitudinal closure, etc.) and update statistical files.

The final product - positions of sources and traces - is supplied to the client in the form of tapes in UKOOA P1/90 format and to the seismic processing center. In CGG centers, navigation data files are transmitted directly to the supercomputers with no further time required for transportation or for tape read/write operations.

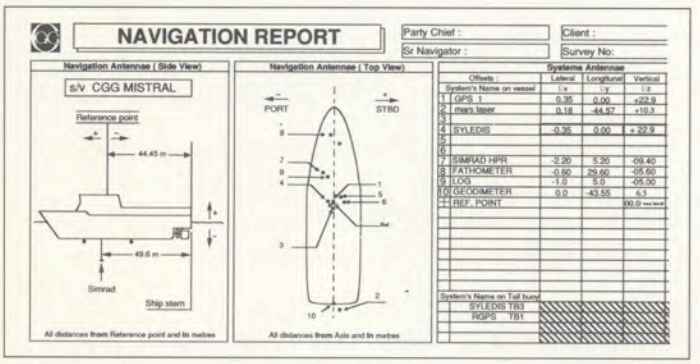
QUALITY CONTROL

QC during navigation data processing is integrated into a set of procedures that are rigorously applied at CGG. QC covers all aspects of processing, including inspection of field documents and reports, dialog with the organization responsible for the data acquisition and/or the client, monitoring turnaround times, and checking the final documents sent to the seismic processing phase.

The two main QC phases concern the general parameters and processing results for each line.

Phase 1: General parameters

A check is made that all the geodetic, radio stations, and other parameters are present and correctly applied. Any possible ambiguities concerning the date and time of parameter changes are also corrected.



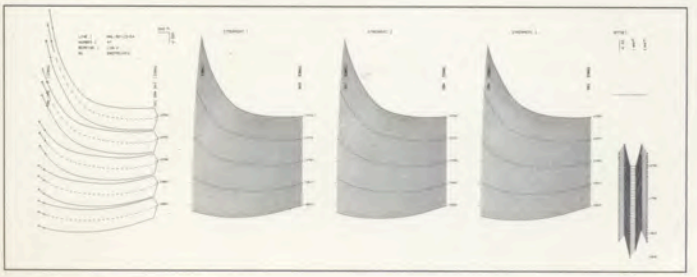
Initial check on acquisition parameters.

Phase 2: Examination of the results

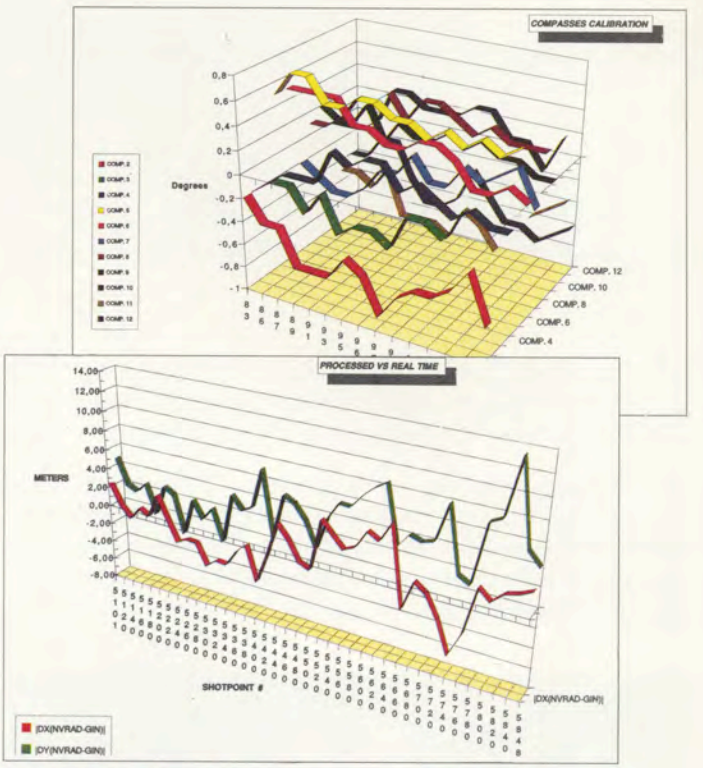
Three different cross-checks are made:

- for each line, quality criteria are examined, such as residuals for radio points, deviation after network adjustment, closure after rotation of the streamers, etc.
- the same criteria are examined over a period of time (trend analysis) and any anomalies observed are explained
- the final processed data are systematically compared with the raw data from a redundant system; for example the distance between streamers at the midpoint computed from the compass data are compared with the acoustic data at the same position.

Plots and graphic presentations generated by Geovecteur® modules provide rapid quality evaluation. Clients are supplied with a report containing this set of documents and a set of recommendations with a view to improving the quality of future surveys.



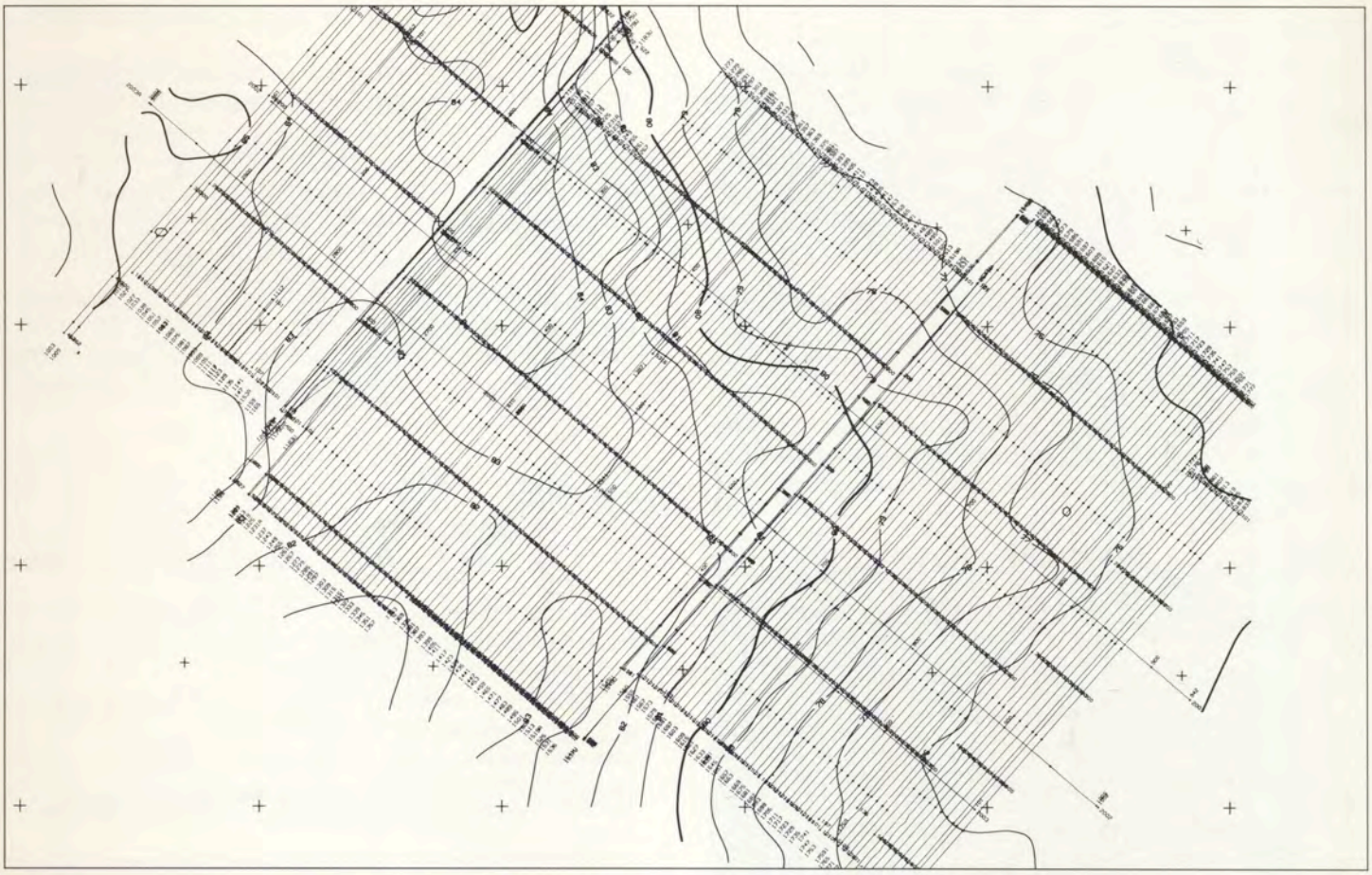
Plot of cable shapes.



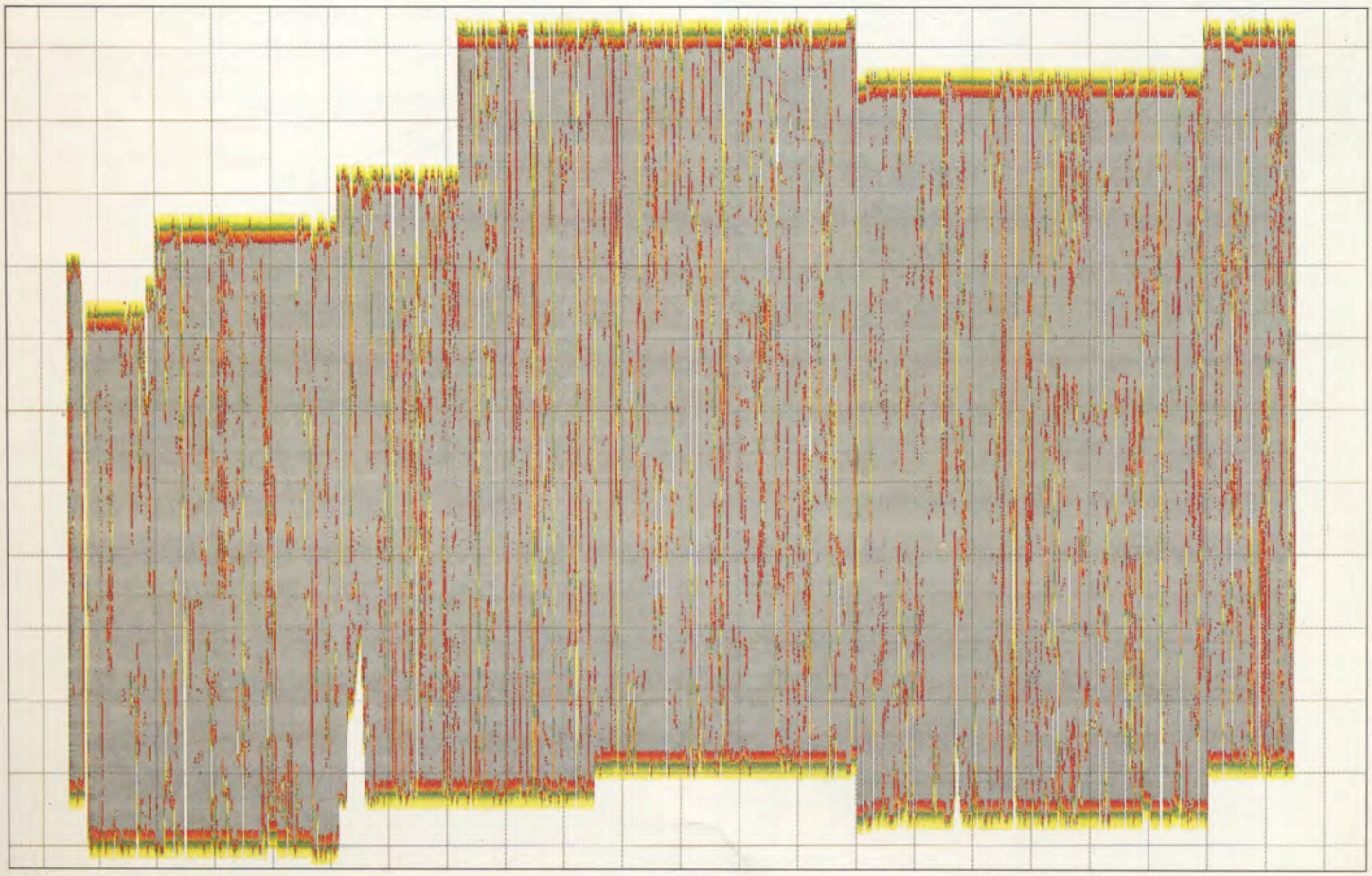
OTHER NAVIGATION PROCESSING SERVICES

- Enhancement of existing data: lists and maps can be digitized, even when quality has seriously deteriorated, with a final result in the form of UKOOA tapes
- Mapping: location maps, bathymetry, line crossings
- Geodetic transfers, pre-computation of lines, computation of offset position
- Data base of non-exclusive surveys
- Archiving on micro-fiche

Water depths plot.



Water depth map with iso-values.



Near trace stack fold map.

PRINTED IN FRANCE BY R. LUTHRINGER

CGG Massy - S. Medina/H. Loriot
1 rue Léon Migaux
91341 MASSY Cedex
France