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Lighthouse

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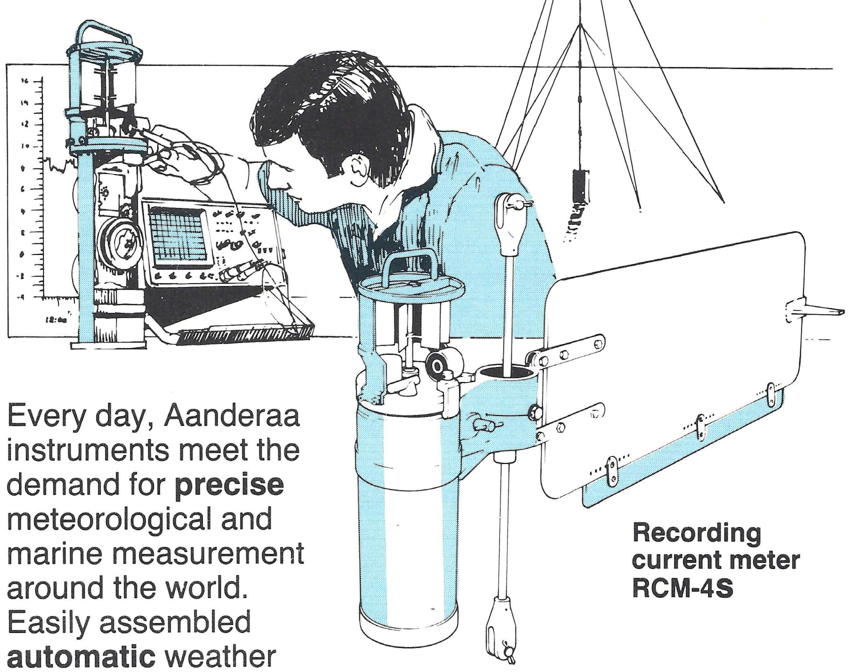

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LIGHTHOUSE

NOVEMBER, 1986

JOURNAL OF THE CANADIAN HYDROGRAPHIC ASSOCIATION

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Editor's Notes

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Looking back over the years, one cannot help but take pride in the tremendous progress made by LIGHTHOUSE since its inception, in 1969, as an in-house newsletter of the Canadian Hydrographic Association. This achievement has only been made possible by the dogged perseverance of my predecessors and the continuing cooperation of the CHA membership.

In the 33 editions of LIGHTHOUSE published so far, a great variety of subjects and issues have been discussed, and these have ranged from purely technical subjects to philosophical treatise on science and technology interspersed with a coverage of major events in the world hydrographic community.

It is befitting, therefore, that we shall be publishing in the next issue a cumulative index of all articles that have appeared in LIGHTHOUSE.

HYDROGRAPHIC SOCIETY

The Hydrographic Society, based in London, has now formed an Australasian Branch to complement the national branches already existing in Denmark, the Netherlands, U.K. and the U.S.

The new branch will serve the interests of members in Australia and New Zealand. The elected officers are Commodore A.H. Cooper (Chairman), formerly of the Royal Australian Navy and past president of the Hydrographic Society, and Mr. George Goldstein as Secretary. The Branch's administrative headquarters are based at the Australian Maritime College in Tasmania.

TRANSPORT CANADA —
Expert Systems in Transportation

Transport Canada has completed a study in the use of Expert Systems in Transportation with the publication of two reports, "Expert Systems: their Application in the Canadian Transportation Sector" and "Proceedings of the Workshop on the Application of Expert Systems to Transportation". The former is a 374-page report which contains a layman's guide to expert systems, an analysis of the application of these systems to transportation, an 'encyclopedia' of available tools for implementing the systems, and an inventory of Canadian capability in this field of activity.

Incidentally, Expert Systems have been defined as a branch of Artificial Intelligence which deals with the part of computer science concerned with designing intelligent computer systems, i.e., systems that exhibit characteristics that humans would consider intelligent if performed by a human.

The proceedings record the discussions held during a workshop in Montreal, September 1985, where about 40 senior government, industry, university and computer science representatives met to study the implications of the emerging technology on transportation in Canada. Some most interesting and significant conclusions have emerged from this study and the two reports provide a wealth of information on possible application areas, including vehicle control, navigation, cargo monitoring, specialized communications, etc., affecting all modes of transportation.

Transport Canada intends to make these documents available to managers in transportation, government, universities and industry on request to: Mel. Walker, Transport Canada, Research and Development, 28G, Tower "C", Place de Ville, Ottawa, K1A 0N5.

Captain Vancouver Branch

We apologize for the oversight in failing to include in the April issue of LIGHTHOUSE a suitable announcement pertaining to the formation of the Captain Vancouver Branch. Our belated congratulations and very best wishes for your future success.

Back Issues of LIGHTHOUSE

Back issues of Lighthouse, Editions 24 through 32, are available at a price of $10.00 (Can.) per copy. Please write to the Editor.

President's Message

1986 was a good year for our Association. A successful workshop was held in Lake Louise in May in conjunction with the Canadian Petroleum Association. Many futuristic ideas were discussed including data bases and new techniques in hydrographic surveying. The next CHA workshop is to be hosted by the Ottawa Branch in the Spring of 1988.

The problems associated with LIGHTHOUSE have now been overcome and I am sure the high quality of our journal will continue to be maintained in the years to come.

Our membership continues to grow and at the present rate of increase we will soon have 500 members. The new membership certificates have been distributed to all Branches and pocket card versions and ties are now available. The second edition of the Brochure has been printed and the portion related to application for membership in the brochure replaces the old application form.

We are still hopeful of obtaining a grant from the Canadian Hydrographic Service. This grant, if received, could be used by our Association for:

- the promotion of survey information and its commercialization;
- the extension of cooperation between federal and private sector interests;
- the study of the effectiveness of mechanisms to obtain input to program priorities;
- making recommendations on the overall efficiency of the national hydrography program.

As this is the last year of my term of office, the National Executive decided that profiles of members running for President should be published in LIGHTHOUSE. This allows all members to know the candidates. I urge you to vote for the candidate of your choice in your respective Branches. The new President will take office at the Annual Meeting in Burlington, February 1987.

In closing, I wish to thank all Branches for their support throughout the year.

Best wishes to all members,

J. Bruce
President, CHA

A Permanent Gauging System for Arctic Application

by
D.A. St. Jacques
Canadian Hydrographic Service
Central and Arctic Region

Introduction

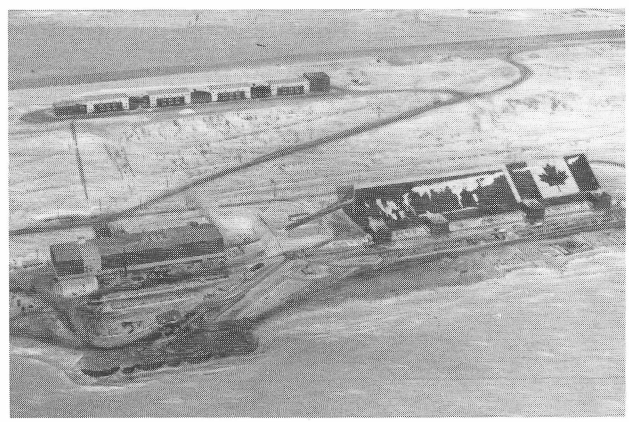
In recent years, the Canadian Hydrographic Service has stepped up its efforts to obtain high quality tidal observations in the Canadian High Arctic. Initially these efforts were directed towards collecting short-term records with submersible, self-recording, portable gauges. However, more recently the need for long-term tidal measurements has been identified. This need prompted the design of a permanent tide gauge for arctic application.

A permanent tide gauge for the Arctic must operate under a number of constraints not normally encountered at more southerly latitudes. Not only must the gauge survive extremely low temperatures and the pressure of ridging shore-ice, but it must also operate virtually unattended for long periods and have low power requirements. It soon became apparent that a single design for the entire Arctic was unrealistic and that gauge design must to some extent be tailored to the site. As a result, the approach was to develop a concept that would be the most versatile and adapt that concept to a specific gauging site. The conventional stilling well, float and counterweight system was not considered for this application because of the problems associated with keeping the well and intakes from freezing and the requirement for a vertical face for installation. Gas-purge systems had been used in the Arctic previously with some degree of success but had failed when the capillary tubing was destroyed by ridging shore-ice. Submerged pressure sensors with atmospheric pressure compensation had received little use in the Arctic but would experience the same problem with the vented cable at the ice-water interface. A gas-purge system with a reinforced sensing mechanism was chosen because of its proven ability and its potential to operate at most locations.

The Polaris Mine on Little Cornwallis Island was selected at the test site (Plate 1). The gauge was designed by Whitman, Benn and Associates Ltd., Consulting Engineers of Halifax, Nova Scotia according to specifications provided by the Canadian Hydrographic Service. In the summer of 1985, Tower Arctic of Montreal were contracted to fabricate and install the gauge. This report describes the system components and provides a progress report on the first year's operation.

System Design

The gauge is designed to measure the hydrostatic head over a sensing orifice with a conventional nitrogen, gas-purge system (Figure 1). The sensing orifice is located at the bottom of a protective structure which is located several metres below chart datum and fixed to the vertical face of the loading platform at the Polaris Mine. The orifice is coupled to a differential pressure sensor via a nitrogen bubbler hose. Estimates of the hydrostatic head are recorded in a data collection platform (DCP) and subsequently transmitted via ARGOS satellite for post processing. The pressure sensor and DCP are located in a heated enclosure located approximately 100 m from the sensing structure.



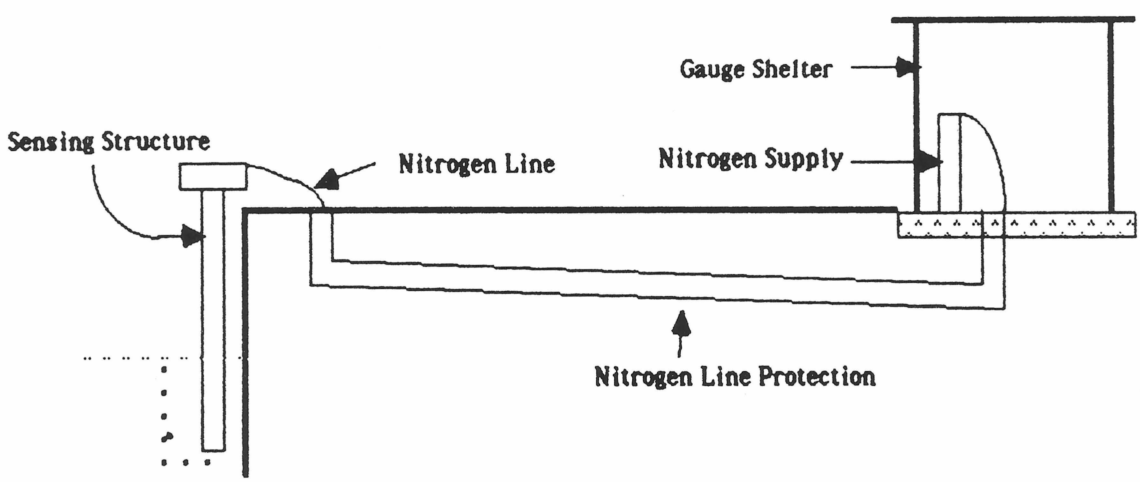


Figure 1. Arctic Permanent Gauging Station

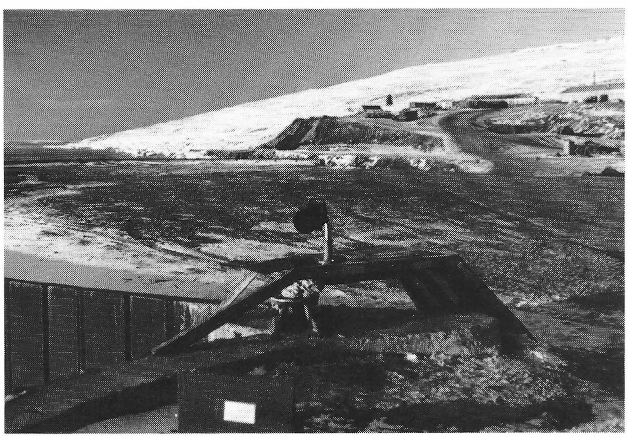
Sensing Structure

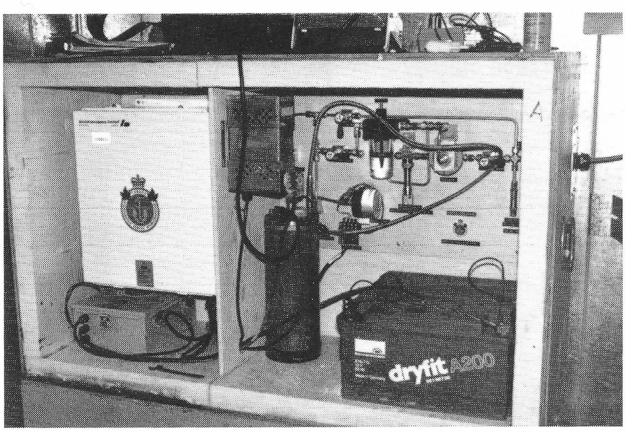
The sensing structure consists of a bronze sensing orifice, a stainless steel bubbler hose, a stainless steel support assembly and a protective housing. The sensing orifice is manufactured from cast bronze to reduce marine fouling and is attached to the bottom of the support structure.

The support structure consists of a 2 in. diameter stainless steel support tube with top and bottom cover plates. The support tube was fabricated in four sections and outfitted with quick release Camlock couplings to facilitate quick assembly/disassembly. A 1/2 in. diameter, flexible stainless steel hose runs from the sensing orifice through the support tube to the top cover plate and is used to deliver nitrogen to the sensing orifice. The hose is attached with swaglock fittings. The sensing orifice, bubbler hose and support tube fit inside an 8 in. diameter protective housing and are designed to be removed for annual inspection and maintenance. Spacers are used inside the protective housing to provide lateral stability for the support structure.

The protective housing is located at the intersection of two sheet piling cells on the loading structure (Plate 2). A "V" shaped fairing covers the exposed side of the protective housing and is filled with concrete to increase the crushing resistance of the protective housing. The protective housing and "V" fairing are permanent installations (Figure 2).

A 3 in. diameter pipe was installed behind the protective housing to serve as a method of conducting gauge comparisons during the summer months.





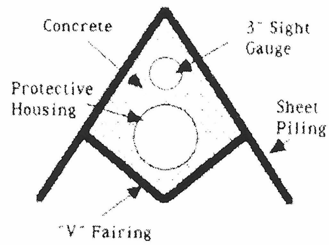


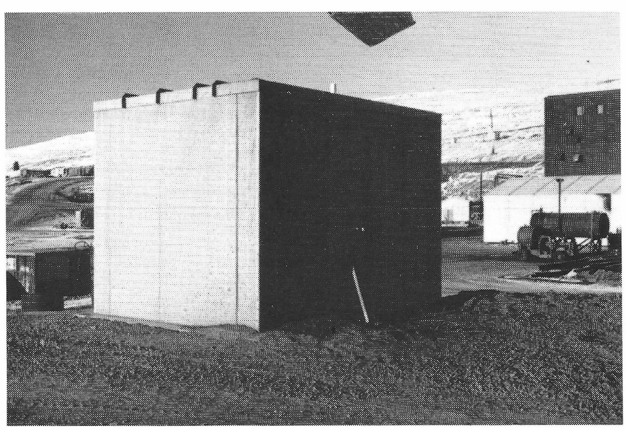
Figure 2. Top View of Sensing Structure

Gas-purge System

Nitrogen is supplied to the bubbler orifice at a rate of approximately 100 bubbles/minute. The back pressure which is equivalent to the hydrostatic head is measured by a SetraCeram Model 271 differential pressure sensor with a 0 - 13.8 metre range with a resolution of 0.01 metres. The pressure sensor is also vented to the atmosphere. The voltage output of the pressure sensor is logged on a Bristol Aerospace DCP at 15 minute intervals and transmitted to the ARGOS satellite approximately 20 times per day. For the prototype system installed at Little Cornwallis Island, an Aanderra WLR-5 submersible tide gauge was also interfaced to the pressure line as a backup recorder. The pressure sensors, nitrogen supply and the DCP are located in a heated enclosure near the wharf face (Plates 3 and 4). Power for the heat and battery charger is supplied by Polaris Mine.

Results

Approximately a year's data has been collected since the gauge began operation on September 29, 1985. The analysis of the results reveals a continuous series of problems with the operation of the gauge. During the period from October, 1985 to January, 1986 the tidal signal was present in the data but the mean pressure of the time series progressively increased from approximately 1.5 m to 8.0 m above gauge zero. In addition, a number of spikes began appearing in the data. Figure 3 shows the progressive increase in mean pressure and the spikes that occurred during December. From January to March, 1986, the mean pressure leveled off and began to slowly decrease while the tidal signal became more and more contaminated with spurious data. Ron Solvason and Rick Sandilands of the Tides, Currents and Water Levels Section in Burlington developed the hypothesis that the increase in hydrostatic pressure was the result of an improper installation of the sensing structure. They felt that the 1/2 in.



stainless steel hose that connects the orifice with the top of the sensing structure had not been installed. As a result, the 2 in. support structure had filled with sea water and the gas-purge system was slowly displacing the entrained water with nitrogen. This hypothesis proved to be true but the bubbler hose could not be installed until the warmer weather in August.

In March, the tidal signal disappeared from the record and the pressure continued its gradual decline. During a site visit in March, the pressure transducer and the DCP were replaced but the problems with the data persisted. A subsequent visit in May uncovered a grounding problem which, when corrected, removed the spikes from the data.

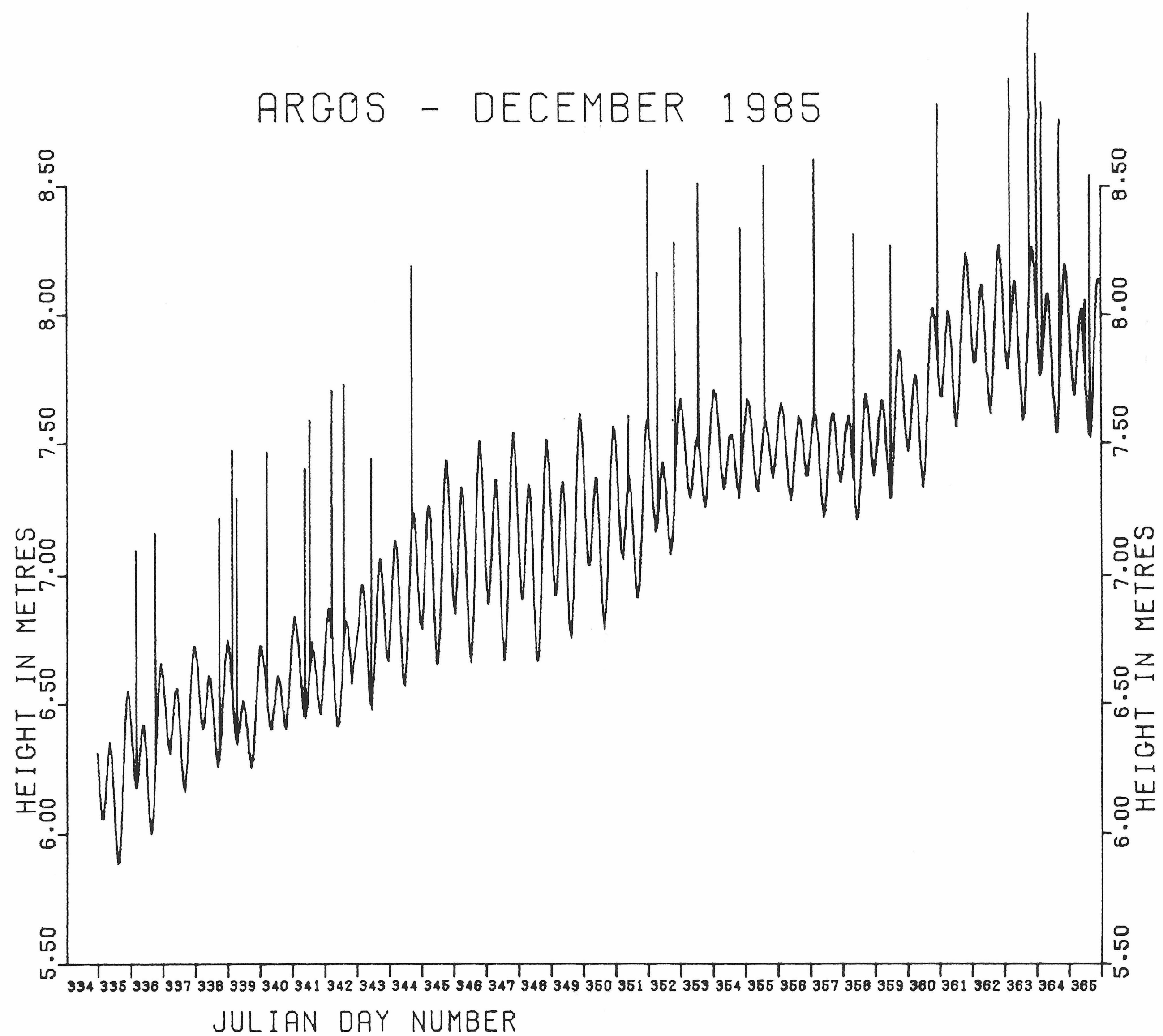
From April until August, the tidal signal was absent and the pressure stabilized at around 5.0 m above gauge zero. The missing tidal signal suggests that the orifice was blocked or the pressure transducer was not operating properly. The first attempt to remove the support structure in August proved unsuccessful because the support structure was still frozen to the protective housing. Indeed, the 3 in. sight gauge pipe was also frozen. This lends support to the contention that the 2 in. support structure may have been frozen as well. The ice in the system was melted, the support structure removed, the 1/2 in. bubbler hose attached to the orifice and the system was reassembled.

Summary

This prototype arctic gauging system has been plagued with problems which occurred as a result of an improper installation of the sensing mechanism. By not installing the 1/2 in. bubbler hose, the system was forced to flush a 2 in. diameter pipe that was not designed to be air tight. This no doubt resulted in leaks in the system and may have led to a blockage of the pipe by ice. The design decision to allow the protective housing to flood was a poor decision because the ice that formed inside the housing did not thaw during the summer and prevented the easy removal of the sensing structure for maintenance. Nevertheless, the Tides, Currents and Water Levels Section feels that the design concept is sound and looks forward to its successful operation during the coming year.

Acknowledgements

I wish to acknowledge the staff of the Tides, Currents and Water Levels Section for their contributions to this project; Ron Solvason and Danny Mahaffy for installation of the pressure sensor and the DCP, Bob Johns for fabricating the pressure sensor and DCP unit, Rick Sandilands for processing and analyzing the ARGOS data, and Ron, Bob, Rick and Mike Donegan for trouble-shooting the system.



RÉSUMÉ
Présentation et évaluation de la précision du Polarfix de Krupp-Atlas

par
Richard Sanfaçon
Service Hydrographique du Canada
Région du Québec

ABSTRACT

In this report the author provides an evaluation of the POLARFIX system. A general description of the equipment is folllowed by calibration procedures and a summary of the evaluation tests conducted in Quebec City. Using the results of the dynamic tests, the author calculates the accuracies achieved in distances, angles and positional measurements. The results are presented by means of error ellipses, graphs and histograms. A comparison is made with the manufacurer's specification.

Finally, practical conclusions are drawn from the field evaluations.

Dans ce rapport, nous présenterons l'appareil; nous proposerons des procédures d'étalonnage; nous décrirons sommairement les tests d'évaluatyion faits à Québec dont nous utiliserons les résultats des test dynamiques pour calculer la précision sur les distances, les angles et les positions. Représentée sous forme d'ellipses d'erreur, de graphiques et d'histogrammes, la précision du système sera comparée à celle fournie par la compagnie. Enfin, nous évaluerons le rendement sur le terrain (aspect pratique).

Installation in Blanc-Sablon / L'installation à Blanc-Sablon

The Polarfix / Le Polarfix

Combined with Trisponder the Polarfix in use in Blanc-Sablon / Combiné au Trisponder Le Polarfix en fonctionnement à Blanc-Sablon.

INTRODUCTION

Les systèmes de positionnement offerts pour réaliser des levés à grande échelle et à courte distance n'ont pas encore satisfait complètement les besoins en précision des usagers. Bien sûr, il y a eu la révolution des systèmes de positionnement électronique, dans les années 1950, qui ont supplanté peu à peu les sextants. Les problèmes inhérents à l'utilisation de deux ou plusieurs balises émettrices ont conduit à la fusion de deux systèmes soit le théodolite et la balise à micro-ondes. Ce dernier système encore très populaire élimine les problèmes de géométrie puisque les lignes de position (LOPs) se croisent toujours à angle droit. Toutefois, ce système nécessite la présence d'un opérateur à la station afin de suivre le véhicule de levé; de plus, il ne peut fournir de positionnement continu. C'est ici qu'entre en jeu le Polarfix de Krupp-Atlas. Ce système de positionnement angle-distance utilise la télémétrie et le laser. Il ne nécessite pas nécessairement d'opérateur à la station puisqu'une fois orienté sur sa cible, il la suit et transmet les données au véhicule. Enfin, la précision promise par le manufacturier est très intéressante et la région du Québec après avoir évalué l'appareil s'en est procuré un en 1985.

Voyons donc brièvement la description de l'instrument.

DESCRIPTION DE L'APPAREIL

Les éléments du système sont séparés en deux groupes.

Sur le point (sur la rive)

— La tête chercheuse ou station "traquante" montée sur un trépied et qui a pour fonction de mesurer les angles et les distances.

— L'unité de contrôle branchée à la tête chercheuse par un câble et contenant le microprocesseur et le sous-système de télémétrie.

à bord du véhicule (à bord)

— Une couronne de prismes (réflecteur) qui retourne le signal à la tête chercheuse.

— L'antenne de télémétrie pour les communications avec l'unité de contrôle.

— Le "téléface", qu agit comme un récepteur/transmetteur radio, est muni d'un large affichage et d'une sortie pour l'équipement d'ordinateur.

— Le terminal (clavier Texas 700) pour envoyer des commandes à l'unité de contrôle. Il est possible de brancher un ordinateur, qui en plus d'accomplir cette fonction, permettra d'emmagasiner des données (data logger).

FONCTIONNEMENT DE L'APPAREIL

Les "LOPs" pour les angles et les distances sont obtenues grâce à un **faisceau laser** de $\lambda = 904$ nm dans la bande infrarouge (3 x 10^{13} Hz à 3 x 10^{14} Hz). Le faisceau est très mince horizontalement (quelques cm à 1 000 m) et plus large verticalement (5 m à 1 000 m). La mesure des angles se fait par un arbre encodé. La mesure des distances s'obtient par le calcul du temps nécessaire à l'onde pour parcourir le voyage aller-retour sur les réflecteurs.

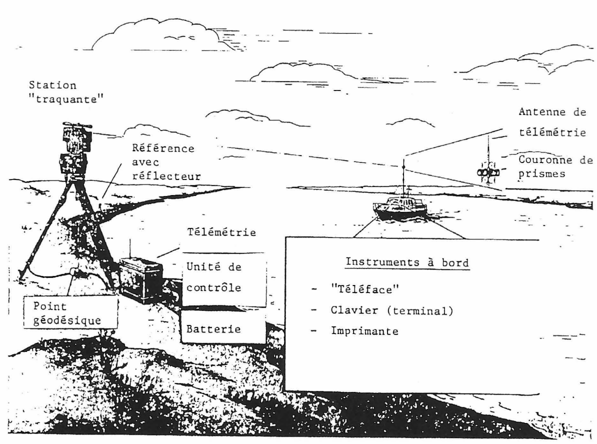
On réussit la **traque horizontale** en envoyant des impulsions laser à l'avant et à l'arrière du faisceau laser principal. Ces impulsions frappent les prismes avant ou après le faisceau principal et ainsi fournissent l'information sur la vitesse et la direction du déplacement du véhicule. Ces informations sont interprétées par les moteurs de la station "traquante" comme des commandes sur l'orientation à suivre.

La **traque verticale** automatique ne suit pas le même principe. En effet, à cause du faisceau vertical qui est large, la traque dans cet axe est moins critique et elle s'effectue indirectement par un calcul de l'angle vertical dépendant de la distance et du delta h entre le mobile et la station (voir figure 1).

Ce système de traque permet donc à la tête chercheuse de suivre l'embarcation dans toutes les directions peu importe que le mouvement soit vertical, diagonal (vagues) ou horizontal (déplacement).

Notons ici cependant qu'il peut arriver que la tête chercheuse perde la cible lorsque la distance diminue et que le véhicule s'élève (ex.: gravir une pente à l'aide d'un véhicule sur roue). Ceci est dû au fait que la différence d'élévation entre la station traquante et le mobile est normalement assez constante (mis à part le facteur marée). Alors, une diminution de distance pour un même delta h oblige le Polarfix à augmenter la pente du rayon laser d'où perte de la cible. Le même phénomène peut être observé lorsque le mobile s'éloigne et qu'il descend une pente. Ajoutons que le tout est inversé si le delta h est négatif (voir figure 1). Il est évident que ce problème ne se produira pas sur l'eau si on a eu soin de signaler au Polarfix un changement de delta h correspondant à un changement de niveau d'eau assez important.

APERÇU DES INSTALLATIONS
ET IDENTIFICATION
DES COMPOSANTES



KRUPP ATLAS ELEKTRONIK

Le Polarfix est également muni d'un mode de recherche lorsqu'il y a perte de la cible. Ce mode de recherche est expliqué en appendice.

Si l'embase du Polarfix ne comporte pas de fil optique, il faut utiliser un trépied muni d'un fil à plomb pour bien installer l'appareil sur le point.

La référence pour la mesure des angles peut être passive (sans réflecteur, ex.: clocher d'église, tours, etc ...) ou active (points connus munis d'un réflecteur).

Une fois cette référence entrée, on aligne la tête chercheuse sur les prismes du véhicule. La station est maintenant prête pour la traque automatique. Il est à noter qu'une calibration externe pour la distance peut être effectuée de temps à autre sur une base connue (voir procédures d'étalonnage). Cependant, une calibration interne est réalisée automatiquement sur simple commande au clavier.

Le contrôle de la station est maintenant laissé totalement à l'opération du "téléface" soit l'hydrographe. Ce contrôle s'exerce au moyen de commandes envoyées à la station "traquante" qui répond par des actions correspondantes.

Le logiciel permet le branchement d'ordinateur externe pour emmagasiner des données; il effectue certains filtrages et prédiction de données et affiche le "monitoring" (résultat des commandes).

Notons enfin que le système peut travailler à une distance de quelques mètres à 5000 mètres.

PROCÉDURES D'ÉTALONNAGE

Comme pour tout système de positionnement, il est important avant d'entreprendre un travail, de vérifier l'étalonnage ("calibration") du Polarfix.

Une fois que l'on a choisi le point géodésique où sera installé l'appareil, on monte un théodolite sur ce point et on choisit une référence (point, tour, clocher, etc ...) par rapport auquel seront mesurés précisément les angles sur deux autres stations visées (point, tour, clocher, coin de quai, etc ...).

Ensuite, à l'aide d'un géodimètre précis (ex.: Di-20 de Wild), on mesure deux distances précises et représentatives de la zone de travail. Une de ces distances peut être celle entre la référence et la station; et l'autre peut être une marque sur le quai. L'avantage d'un tel choix s'évalue en termes d'économie de temps. En effet, lors de la prise de la visée de référence (active) le matin, on obtient en même temps une vérification de la mesure de distance. De même, un point sur le quai permet à l'embarcation d'avoir une vérification rapide et indépendante (pas d'opérateur station "traquante", pas de commandes) en utilisant les prismes de l'embarcation. Avant de débuter, il ne nous reste qu'à vérifier un autre angle et le tour est joué; nous avons effectivement vérifié deux angles et deux distances.

Cependant, s'il y a une erreur dans la lecture de la distance, il est possible de corriger la mesure à l'aide d'un potentiomètre à l'intérieur de l'unité de contrôle. En principe, l'erreur sur la distance sera toujours une erreur systématique, c'est-à-dire que peu importe la distance, l'erreur sera toujours la même en trop long ou en trop court.

> Ex.: si au lieu de 100 m, on lit 100.5 mm de même au lieu de 2000 m, nous lirons 2000.5 m.

Il n'y a pas de possiblité de corriger une mesure d'angles et, selon le manufacturier, ce n'est pas nécessaire. Toutefois, il est suggéré d'utiliser une référence active de plus souvent possible afin d'éviter l'erreur de collimation qui pourrait exister entre l'axe de la lunette et l'axe du laser.

Enfin, mentionnons que dans certains cas, il peut être avantageux d'installer au milieu de la zone de travail une bouée dont la position sera établie à partir de 2 points connus.

I faut également ajouter qu'il est important de bien centrer et bien niveller le Polarfix au-dessus du point géodésique.

DESCRIPTION DES TESTS

Des tests ont été effectués en mars et avril 1985 aux environs de Québec. Les test étaient divisés en trois parties et en ce sens, on a respecté les lignes directives contenues dans le document "Standard Test Procedures" no 39-1-5 publié par le Bureau hydrographique international en collaboration avec la Fédération internationale des géomètres.

Test en bureau

Ils avaient pour but de se familiariser avec le système, d'"interfacer" le système et d'apprendre les capacités de l'appareil.

Test statistiques

L'objectif était d'obtenir une idée de la stabilité des distances et des angles en fonction du temps pour divers azimuths, diverses distances, et sous différentes conditions (température, réflecteurs et différents voltages).

Test dynamiques

Ces test nous intéressent plus particulièrement parce qu'ils représentent plus fidèlement le comportement attendu sur le terrain, dans la vraie vie quoi! Les effets de mouvement du véhicule sur le système sont ainsi pris en considération. Le système considéré comme un tout, on peut alors déterminer la précision, la fiabilité et la "répétitivité" (repeatability) des données. Ces tests ont été affectués à vitesse constante tout comme en décélération et en accélération.

Dans l'étude Hally et Journeault, on nous présente 2 graphes, résumant les tests dynamiques. Un de ces graphes présente l'écart de fermeture en distance en fonction de la distance et l'autre montre l'écart de fermeture en angle en fonction de la distance.

Notre travail consiste donc à synthétiser l'information contenue dans ces deux graphes afin de fournir une erreur à un écart-type sur les distances et les angles. Ensuite, nous combinerons ces 2 erreurs pour trouver l'erreur en position que nous illustrerons par différentes ellipses.

ÉVALUATION DE LA PRÉCISION

Calcul des écarts-types

L'étude de Hally et Journeault concluait que la précision de l'appareil ne donnait pas les résultats avancés par la compagnie, sans toutefois spécifier davantage.

En tant qu'utilisateur potentiel, en tant qu'hydrographe, nous cherchons à savoir quelle est vraiment cette erreur et conséquemment, à quelle grandeur d'échelle de levé nous pouvons travailler pour rencontrer les normes minimales (1 mm à l'échelle).

Pour calculer l'écart-type sur les angles, nous utitisons les différences de mesure entre de Polarfix et le théodolite Wild T-2, la valeur de ce dernier étant considérée comme juste.

De même, l'écart type sur les distances est obtenu à partir des différences entre la mesure au Polarfix et la mesure au géodimètre Wild Di-20 (cette dernière étant considérée comme juste).

Le tableau 1 illustre le genre de données utilisées pour les calculs. Il s'agit de 4 mesures prises au point 2250 en se dirigeant vers la station "traquante".

Tableau 1

POINT VISÉ	ANGLE HORIZONTAL (°) Polarfix	T-2	Δ	DISTANCE (m.) Polarfix	Di-20	Δ
2250	0.929	0.929	0	2 246.41	2 246.28	0.13
	0.917	0.929	-0.012	2 246.37	2 246.28	0.09
	0.937	0.929	0.008	2 246.74	2 246.28	0.46
	0.941	0.929	0.012	2 246.73	2 246.28	0.45

Il y a eu 11 points visés en tout; pour chaque point, 4 mesures furent prises en se dirigeant vers la station "traquante" et 3 mesures prises en s'éloignant. Ce qui nous donne un échantillion théorique de 132 mesures. En pratique, l'échantillion est un peu moins grand puisqu'à certains passages, on a eu droit à des "miss".

Nous avons considéré contre echantillion comme assez petit et en conséquence, nous avons utilisé la formule de l'écart-type pour un échantillion aléatoire:

$$S = \sqrt{\frac{\Sigma (x_i - m)^2}{n - 1}}$$

Puis l'écart-type moyen utilisé:

$$\overline{S} = \sqrt{\frac{\Sigma S_i^2}{n}}$$

Voir donc un tableau des écart-types sur les angles et les distances pour chaque point visé.

Tableau 2

POINT VISÉ	ÉCARTS-TYPES Angles (deg.)	Distances (m)
3 000	---	0.65
2 750	0.026	1.58
2 500	0.025	1.36
2 250	0.024	0.58
2 000	0.024	1.07
1 750	0.029	1.12
1 500	0.025	0.92
1 250	0.031	0.28
1 000	0.008	0.55
750	0.054	0.65
500	0.048	1.02

Résultat:

Angles	**Distances**
$\overline{S} = 0.032$ deg.	$\overline{S} = 0.96$ m

Remarque sur les angles

- Considérant que les tests ont été faits pour des distances de 500 à 3 000 m, on remarque que l'amplitude de l'écart-type sur la mesure des angles est assez constante pour les mesures comprises entre 1 000 et 3 000 m.
- À moins de 1 000 m, on remarque que l'amplitude des écarts-types est environ le double des autres valeurs moyennes, donc l'erreur sur l'angle est plus grande.

Remarque sur les distances

- La valeur des écarts-types sur les distances varie d'environ 0.5 m à 1.5 m, peu importe la distance contrairement aux angles.

Conséquemment le ratio pour la distance: $\frac{\textbf{plus grand S}}{\text{plus petit S}} \simeq \frac{3}{1}$

Alors que pour les angles: $\frac{\textbf{plus grand S}}{\text{plus petit S}} \simeq \frac{7}{1}$

Suite à ces remarques, on s'aperçoit qu'à la suite de plusieurs autres tests, on pourrait peut-être dégager des constantes qui pourraient nous amener à suggérer des conditions d'utilisation lesquelles contribueraient à augmenter la précision du travail.

Par exemple, on a noté que la zone de 1 500 à 3 000 m est susceptible de fournir une plus grande précision et constance dans la mesure des angles.

D'autres conclusions similaires pourraient conduire à la définition d'un aire à rendement maximum.

Ellipses d'erreur

La précision attribuée au système est différente pour chaque organisme.

Tableau 3

PRÉCISION DU SYSTÈME EN MODE DYNAMIQUE

	Dist. (m)	**Angle (deg.)**	**Position**
Manuel d'instruction (Valeur à 1 S)	+/- 0.5	+/- 0.025	* +/- 0.66 m à 1 km * +/- 1.40 m à 3 km * +/- 2.24 m à 5 km
Essais par le "German Water Authority"	0.1 +/- 0.1 m/km	+/- 0.01	+/- 0.26 m à 1 km +/- 0.64 m à 3 km +/- 1.04 m à 5 km
Notre étude (Valeur à 1 S)	+/- 0.96 m	+/- 0.32	+/- 1.11 m à 1 km +/- 1.93 m à 3 km +/- 2.95 m à 5 km
Notre étude (Valeur à 2 S)	+/- 1.92 m	+/- 0.064	+/- 2.22 m à 1 km +/- 3.86 m à 3 km +/- 5.91 m à 5 km

* Valeurs que nous avons calculées (elles n'étaient pas fournies dans le manuel).

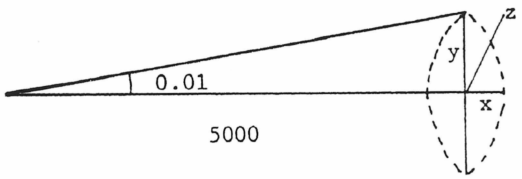
Il est intéressant de constater que notre erreur en angle est assez similaire à celle fournit dans le manuel d'instruction. Cependant, l'erreur en distance présente une différence un peu plus grande.

Si on compare notre erreur en position à celle du "German Water Authority", la différence est directement attibuable aux différences des valeurs angles et distances dans la formule.

Le "German Water Authority" a probablement utilisé une formule où l'on tente de séparer l'erreur systématique de l'erreur aléatoire dans la distance. Puis à cette formule, ils ont ajouté un certain facteur p.p.m.

Ex.: 0.1 m — Erreur systématique; +/- 0.1 m/km — Erreur aléatoire

Ex.:



Soit: $x = \sqrt{(0.1)^2 + (\pm 0.5)^2}$, $y =$ Tan (0.01 x 5 000 $\Big\}$ $z = \sqrt{x^2 + y^2}$

Dans notre cas, l'erreur aléatoire est incluse dans l'erreur systématique. En effet, nous avons remarqué une distribution assez uniforme autour de la valeur juste peu importe la distance d'où la difficluté de discerner une erreur en fonction de la distance.

La forme et la direction des ellipses d'erreur varient en fonction de la distance.

En effet, à courte distance, l'erreur sur l'angle sera plus petite que l'erreur sur la distance d'où une ellipse à la ligne de visée. À distance moyenne, l'erreur sur l'angle deviendra égale à l'erreur sur la distance (cercle d'erreur) et enfin à plus grande distance, la direction de l'ellipse sera perpendiculaire à la ligne de visée (voir figure 2).

On peut voir que l'erreur de position est surtout fonction de la distance. La précision sur l'angle demeure la même mais à grande distance, elle se traduit par un plus grand déplacement. C'est donc la précision obtenue à la plus grande distance de notre zone de travail qui gouvernera l'échelle à laquelle on peut travailler pour obtenir une position qui, sur toute la surface, respectera les normes de 1 mm à l'échelle (voir figure 3).

La figure 3 montre la progression exponentielle de l'erreur en fonction de la distance. Aussi, on peut trouver, à partir de ce graphique, la distance maximale de travail pour respecter la précision sur les positions.

Ex.: À l'échelle 1:2 000, précision requise = +/- 2 m

Sur la courbe de notre étude (1 S), à cette précision requise correspond une distance d'environ 3.5 km.

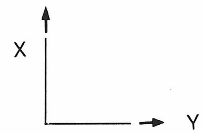
Si on cherche une précision de 1 mm à l'échelle, on peut construire l'histogramme de la figure 4.

ÉVALUATION RENDEMENT TERRAIN

Nous avons utilisé l'appareil pour une courte période à Blanc-Sablon en octobre 1985.

Remarques

- Les caisses pour transporter l'appareil sont lourdes et il est préférable d'être 2 personnes pour les transporter.
- Conséquemment, le choix du site est important. Il doit être facile d'accès et on doit vérifier qu'il n'existe pas d'obstacles dans la ligne de visée de la zone de travail prévue.
- Il est aussi conseillé de placer, près de l'appareil, une pancarte signalant le danger. Il est recommandé de ne pas regarder directement le canon du laser à des distances de moins de 80 mètres. Il faut également être prudent si on utilise des jumelles.
- Lors du branchement de la source de puissance, il faut être vigilant puisque le câble bleu est le négatif.
- Il faut également prendre note que X = Northing et Y = Easting sur cet appareil.



- L'appareil s'est bien comporté sous la pluie et la brume.
- Une fois familiarisés avec l'appareil, il nous a été possible d'utiliser avec efficacité le Polarfix sans autre opérateur que celui à bord de l'embarcation.

Points négatifs

- La précision ne semble pas rencontrer tout à fait ce que prédit le manufacturier (surtout en ce qui concerne les distances).
- En aucun endroit, on nous signale que la distance mesurée est la distance en pente.
- Les caisses sont lourdes.
- La lunette sans "focus" cause beaucoup de parallaxe et peut être source d'erreur si on utilise une référence passive.
- Le coût de l'appareil $100 K US pour deux LOPs et seulement un utilisateur.
- Il devrait y avoir une touche permettant de relire rapidement la référence.
- Il n'y a pas d'option pour la sortie des angles en D.M.S. au lieux de D.D.

Points positifs

- La télémétrie fonctionne bien.
- La traque automatique fonctionne bien (voir appendice 1).
- Il est facile d'utilisation et d'installation.
- Positionnement continu à bord du mobile.
- L'aire maximum de levé autour d'un point est défini seulement par la limite d'opération du laser en distances.
- Ne nécessite pas de calcul de géométrie de réseau et le déploiement d'équipement que cela entraîne.

CONCLUSION

Même si le Polarfix n'atteint pas la précision promise par le manufacturier, nous avons été agréablement surpris par ses performances-terrain (nous avons même réussi une des journées les plus productives en terme de kilométrage à Blanc-Sablon).

Il serait intéressant de poursuivre d'autres tests dynamiques dans un proche avenir afin de vérifier de nouveau l'écart sur les distances.

Pour l'instant, dépendant de l'échelle du levé, cet appareil peut nous rendre de fiers services et nous sommes enthousiasmés à l'idée de l'utiliser de nouveau en production la saison prochaine.

- À partir de la position A, il faut que le véhicule occupe la position B et non la position C pour que Δh_1 reste le même.
- Un trop grand changement de Δh peut occasionner la perte de la cible d'où perte de signal.
- Un Δh initial négatif occasionnera un processus de traque inverse pour le Polarfix, c'est-à-dire que si la distance diminue, l'angle de traque par rapport à l'horizontale augmentera.

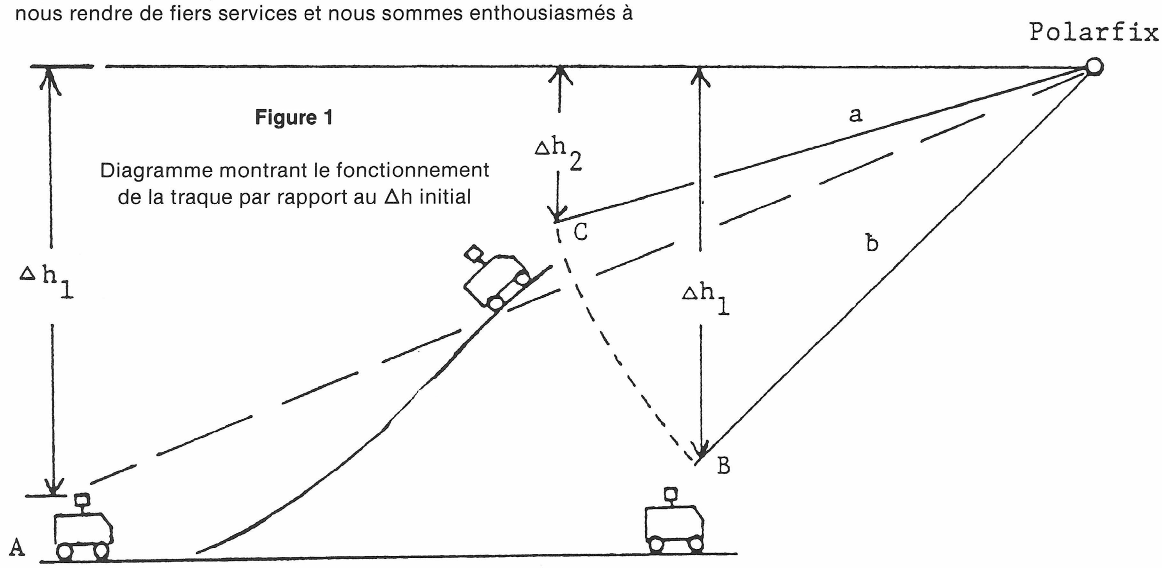


Figure 1

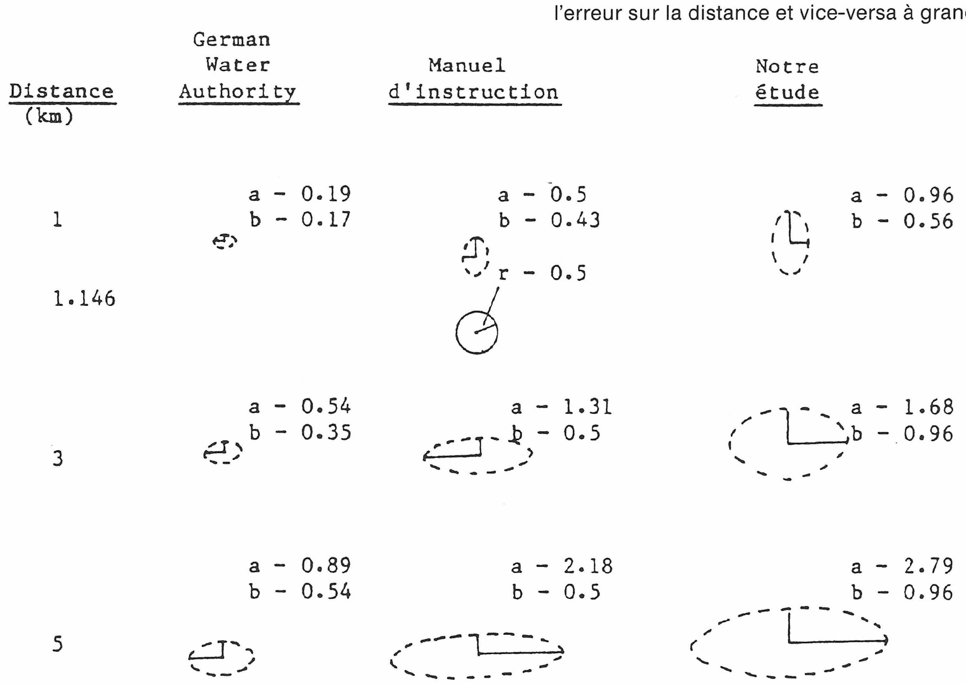
Diagramme montrant le fonctionnement de la traque par rapport au Δh initial

Figure 2

Ellipses d'erreur

- La forme et la direction de l'ellipse varient en fonction de la distance.

À courte distance, l'erreur sur l'angle est moins grande que l'erreur sur la distance et vice-versa à grande distance.



a = demi-grand axe (m)
b = demi-petit axe (m)

Figure 3

Graphique de la précision des positions
en fonction de la distance

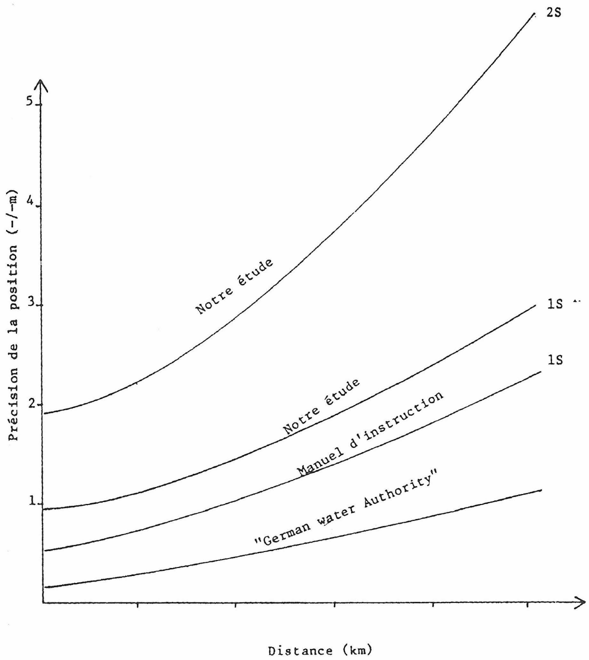
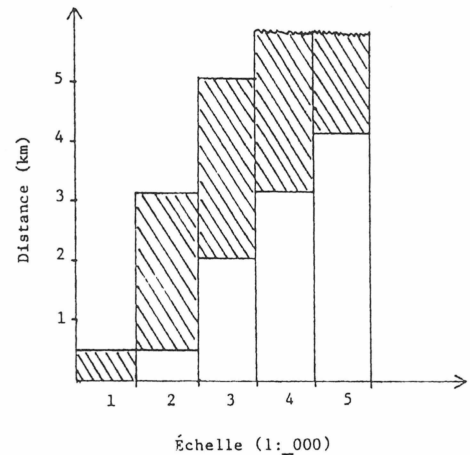


Figure 4

Histogramme des distances maximales de travail
en fonction de l'échelle pour respecter
la norme de position (1 mm à l'échelle)



Échelle	**Distance maximale (m)**	
	1 S	2 S
1:1000	500	Impossible
1:2000	3 140	500
1:3000	5 090	2 060
1:4000	6 950	3 140
1:5000	8 785	4 130

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APPENDICE

Mode de recherche du Polarfix après perte de la cible

Si la cible a été perdue, le Polarfix continu de suivre dans le même sens à la même vitesse azimuthale moyenne pendant 10 secondes.

S'il ne nous a pas retrouvé, il retourne à la position où il nous a perdu et recherche dans une fenêtre de 200 m x 200 m centrée sur cette position.

Si c'est sans succès, il commence alors un balayage horizontal. Il accomplit d'abord un petit azimuth centré sur le point où la cible a été perdue, et avec l'inclinaison qui était en vigueur lors de la perte du signal. La surface du secteur de recherche est augmentée peu à peu.

(La vitesse de rotation de la tête chercheuse dépend de la distance qui existait avant la perte du signal. Si la distance était petite, la vitesse sera grande et vice-versa. On aura toujours une vitesse tangentielle de recherche à la position de la cible d'environ 25 m/sec. (90 km/heure)).

Le plus grand secteur est +/-90° mesuré de par at d'autres de la ligne centrale.

Par la suite, la recherche se poursuit en modifiant l'angle d'inclinaison et en répétant le balayage horizontal. L'angle vertical changera dans la direction qui s'appliquerait si la cible s'était rapprochée de la station "traquante" (dépendant du delta h entre la station "traquante" et la cible).

Notons enfin que le Polarfix assume que la cible se trouve entre 50 m et 10 000 m. De plus, la ligne centrale du secteur de recherche doit être à au moins 30 degrés du blocage mécanique de l'appareil (voir la flèche orange sur l'appareil).

GPS — Current Capabilities and Prospects for Multi-purpose Offshore Surveying

by
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This paper was presented at the FIG-XVIII International Congress, Toronto, June 1986.

SUMMARY

The current and future capabilities of the Global Positioning System (GPS), in terms of parameters such as accuracy, satellite availability, user equipment, etc., are discussed, with emphasis on static and kinematic marine applications. The advantages and disadvantages of the PPS (Precise Positioning Service) and SPS (Standard Positioning Service) in both single and differential positioning mode are analysed as a function of accuracy and cost effectiveness. The advantages of, and problems associated with, the use of phase measurements for precise static and kinematic positioning are discussed. Results of experiments undertaken by Nortech Surveys (Canada) Inc., who has been using the system for the past five years, are reported to illustrate the current capabilities of the system for offshore applications, ranging from offshore platform subsidence monitoring, to shipborne Loran-C calibration, and airborne LIDAR bathymetry.

RÉSUMÉ

Les possibilités courantes et futures du GPS sont discutées en fonction de paramètres tels que précision, visibilité des satellites, instrumentation, etc... Une attention particulière est portée aux applications statiques et cinématiques en mer. Les avantages et désavantages du PPS (Service de Positionnement Précis) et du SPS (Service de Positionnement Standard) sont analysés en fonction de leur précision et rendement. Les aspects positifs et négatifs reliés à l'utilisation des mesures de phase pour le positionnement statique et cinématique de précision sont présentés. Les résultats de tests entrepris par Nortech Surveys (Canada) Inc., laquelle utilise le système depuis cinq ans, sont cités afin de démontrer les possibilités courantes du GPS pour applications marines; tels tests incluent la détection des mouvements verticaux de structures fixes en mer, la calibration du Loran-C par navire, et les mesures bathymétriques aéroportées au LIDAR.

INTRODUCTION

The characteristics of the satellite-borne GPS radionavigation system are well documented in literature (e.g., The Institute of Navigation, 1980, 1984). Despite the numerous delays which have occurred in launching all the satellites required for a worldwide, 24 hour per day, utilization of the system, the expectations have grown steadily and are still on the rise. This is partly due to successful experiments which have been conducted with GPS during the past few years. Indeed, much progress has taken place since the FIG XVII International Congress held in Sofia, 1983, when the first civilian portable GPS receiver, namely the TI4100, had just become available (Lachapelle et al 1983). During the past three years, new types of receivers have become available (Wells & Tranquilla 1986). The development of differential pseudo-range kinematic positioning methodologies has lead to higher accuracies and higher accuracy reliabilities than possible with single point positioning. GPS has gradually found its way into a variety of offshore applications. The use of carrier phase measurements has resulted in spectacular precise static differential positioning results. The availability of both P and C/A codes (PPS and SPS respectively) has resulted in important comparative results and a better understanding of the effect of the ionosphere on GPS positioning. The utilization of phase measurements for kinematic positioning is expected to further increase the accuracy during the next few years.

SPS, PPS, SINGLE POINT AND DIFFERENTIAL POSITIONING

The Standard Positioning Service (SPS) is based on the one frequency C/A code and will provide a 2d rms accuracy of 100 m, if the code is degraded according to the U.S. DoD plans (Scull 1986). At present, the C/A code yields static or kinematic single point accuracy of the order of 20 to 30 m under good satellite geometry. The Precise Positioning Service (PPS) is based on the dual frequency P code and yields a corresponding accuracy of the order of 10 to 20 m. The current DoD intention is to deny access to PPS once the satellite constellation is completed in the late 1980s, except for limited applications (Ibidem). However, PPS is currently available and advantageous for a variety of applications. A major advantage of the PPS is the removal of the effect of the ionosphere through the use of the two frequencies. The effect of the ionosphere on a single range measurement can easily reach 30 m. If the satellite geometry is poor, this can result in position errors exceeding 100 m in single point positioning mode. Since satellite geometry is currently good for a limited period only, the use of SPS in single point positioning mode is seldom utilized when accuracy requirements are more stringent than the 25 m threshold. For the same reason, the use of PPS has resulted in satisfactory single point positioning accuracies for a variety of applications, ranging from seismic surveys to rig positioning. In this respect, Nortech has conducted successful missions with TI4100 receivers in various parts of the world during the past three years. In the two-dimensional mode, the current constellation of seven satellites provides up to 12 hours of coverage per day in many parts of the world. In areas where the deployment of shore-based radionavigation systems constitutes logistical complexities and relatively high costs, PPS single point positioning offers an attractive alternative. In many instances, no other system can yield the same level of accuracy in any case. The only major drawback of PPS single point positioning at this time is the limited satellite coverage which is a function of the geographical area, time of the day and day of the year.

Differential positioning techniques can be applied to both the static and kinematic cases. Differential kinematic positioning is used to increase the accuracy and accuracy reliability. In the marine case, an onshore static monitoring station is used to obtain differential corrections which are transmitted in real time or post-mission mode to the kinematic station offshore. These differential corrections consist typically of pseudo-range corrections which are due to satellite ephemeris, clock errors and ionospheric effects. These error sources are by far the most important. Satellite ephemeris and clock errors will generally cause position errors of the order of 10 to 20 m. The PPS in single point positioning mode is limited by this error source. This is why the differential technique is also used with the PPS. The ionosphere will contribute another 5 to 20 m if the SPS is used. The differential technique allows for a constant monitoring of the health of the satellites tracked; this is very important to maintain a high accuracy reliability. Accuracy reliability is an area of special concern to the Canadian Hydrographic Service for its charting program. CHS is thus developing, in cooperation with Nortech, highly reliable differential methodologies for this purpose.

Static positioning is usally based on the use of carrier phase measurements, which yield accuracies of the order of one to a few parts per million (ppm) in differential mode. The use of this methodology for the monitoring of offshore structure subsidence is discussed later on in this paper. The use of pseudo-range measurements for differential static positioning is sometimes advantageous for applications such as rig positioning. In such a case, instantaneous single point positioning is used to navigate the rig to the selected site and differential pseudo-range positioning can thereafter rapidly yield the final rig position with the accuracy required. Differential kinematic positioning has been based, up to now, almost exclusively on the use of pseudo-range measurements. GPS kinematic pseudo-range positioning tasks have been successfully conducted on land, and in the shipborne and airborne mode (see following sections for details). The implementation of telemetry links for real time transmission of differential corrections has been slow, due to the lack of real time requirements for accuracies better than 25 m. The use of carrier phase data for differential kinematic positioning is currently being investigated, and will likely yield very significant accuracy improvements.

The use of the SPS in differential kinematic mode has yielded adequate results which, in terms of accuracy, are about the same or better than the use of PPS in single point mode (e.g., Lachapelle et al 1984a,b). For instance, Nortech has satisfactorily completed marine positioning projects with the Trimble 4000A in SPS differential pseudo-range mode during 1985. The differential SPS technique is likely to be the standard offshore surveying methodology for kinematic positioning once the PPS is no longer available, and SPS is degraded. The degradation of SPS is unlikely to prevent full recovery of accuracy in the differential mode for baselines of upto at least a few hundred km. At present, the choice between the single point or the differential technique for kinematic positioning depends on similar parameters as those listed earlier for the choice between GPS and conventional radionavigation systems. These parameters will, in turn, affect costs accordingly. In this respect, the higher cost of a single PPS receiver as compared to two SPS receivers is often more than offset by the higher operational cost incurred with the use of two SPS receivers in differential mode.

MARINE KINEMATIC POSITIONING — PROSPECTS AND LIMITATIONS

The accuracies quoted in the previous section for the SPS and PPS in single point mode also apply to low kinematic marine positioning provided that an adequate receiver is used. Such a receiver will be either a relatively fast switching sequential instrument or, preferably, a multiplex type receiver such as the TI4100, or a full multi-channel receiver such as the Trimble 4000A. In addition, the data rate will have to be compatible with the dynamics of the vessel; other wise, a degradation of accuracy will occur unless the receiver is aided by external sensors. This was the case, for instance, with the STI4050 slow switching receiver used by Sheltech/Nortech from 1980 to 1983 (Lachapelle et al 1983).

The single point positioning accuracies quoted in the previous section for the PPS, namely 10 to 20 m, have been routinely achieved by TI4100 users in marine kinematic mode during the past three years (e.g. Lachapelle et al 1984a). At this time, the TI4100 is the only PPS receiver commercially available. Single point positioning results obtained with the SPS have also been satisfactory. For instance, single point positioning accuracies achieved with the Trimble 4000A (Ashjaee & Helkey 1984) are of the same order of magnitude than those obtained with the PPS. However, the accuracy reliability decreases considerably in SPS single point positioning mode. An important factor in this respect is the effect of the ionosphere which will be particularly severe under poor satellite geometry. The magnitude of ionospheric effects is primarily a function of solar activity which is currently near a minimum. One would normally expect the accuracy of the undergraded SPS to decrease gradually until the early 1990s when the effect of the ionosphere is expected to be maximum. This degradation will not be uniform; while mid-latitude regions will be mildly affected, polar regions will be the hardest hit, and SPS single point positioning errors caused by the ionosphere could easily reach 50 m unless adequate ionospheric models are used. The testing of existing models and development of improved models is an area requiring extensive research and development.

The single point positioning accuracies quoted above are based on either pseudo-range measurements only, or combined pseudo-range and phase measurements as in the case of the TI4100 internal solution. The absolute accuracy does not depend on whether phase measurements are used or not, because the satellite ephemeris and clock errors are dominant in the single point positioning mode. However, the use of phase measurements improves the relative accuracy between successive epochs, and this can be important for a variety of marine positioning tasks such as seismic surveys. For instance, decimetre level accuracies have been obtained by Ashjaee (1985) when combining Trimble 4000A pseudo-range and phase observations.

Marine differential positioning based on pseudo-range measurements has been performed successfully by several institutions. Typical accuracies range from 5 to 10 m for baselines of up to several hundred km (e.g., Lachapelle et al 1984a). The accuracy achievable is strongly dependent upon the satellite geometry. During 1984, Nortech conducted PPS differential positioning operations for the Canadian Hydrographic Service in the Gulf of St. Lawrence and offshore Newfoundland for the calibration of Loran-C (Hagglund et al 1985). An accuracy of 25 m was obtained for over three and half hours per day with an estimated reliability of 95%. Many other operational PPS and SPS differential marine positioning tasks were conducted by Nortech in Canada and the North Sea for petroleum applications such as rig relocations and seismic surveys.

Efforts are currently directed at combining phase and pseudo-range measurements to increase the accuracy achievable in differential pseudo-range mode. The many tests carried out during the past year using land static and land dynamic data show that, in principle, sub-metre accuracies are possible (e.g., Remondi 1985, Kleusberg 1985, Lachapelle et al 1986). In practice, complex problems are to be solved before accuracies better than 5 m can be achieved under normal marine operating conditions.

A major problem is ship's dynamics, which is a function of parameters such as sea state, height of antenna above water, etc. Under relatively difficult conditions, a receiver may frequently lose phase lock and this will render phase measurements practically useless unless GPS is aided by an external sensor such as an inertial navigation system. However, the cost and complexities of such an integrated system would not be effective for most marine operations. Also, for phase measurements to be truly useful, a multiplex or multi-channel type receiver tracking simultaneously at least three to four satellites and measuring integrated phase continuously needs to be used. Until recently, the TI4100 receiver was the only commercial instrument which was available for this purpose. However, several multi-channel SPS receivers which can fulfill these requirements have recently become available (e.g., Trimble 4000S, Magnavox T-Set) or will be within one year (e.g., Norstar 1000 being developed by Norstar Instruments Ltd., a subsidiary of Nortech Surveys). Early experiments jointly conducted by Nortech and the Canadian Hydrographic Service with the TI4100 equipped with Phase I tracking software revealed frequent losses of phase lock, presumably due to ship's dynamics. The tests were carried out off Canada's East Coast under a wide range of weather conditions. The antenna height above water varied between 15 and 40 m, depending on the type of vessel used. More recent marine tests conducted for other purposes by Nortech with TI4100 receivers equipped with Phase II tracking software have shown improved phase measurement performances.

If accuracies better than a few metres are to be achieved for differential kinematic marine positioning, three-dimensional positioning solutions will have to be estimated since the vertical movement of the vessel alone contributes several metres. A receiver simultaneously tracking at least four satellites will be required. However, a receiver which could track more satellites, say 5 to 7, would be preferable in order to increase the redundancy. This would result in a higher reliabilitiy and a more effective method to detect cycle slips and losses of phase lock. A system will also have to be developed to accurately relate the position of the GPS antenna with that of the sensor being positioned and located elsewhere in the vessel. On a relatively small vessel, such as a survey launch, this may not be necessary if an accuracy of the order of 2 to 3 m is sought, in which case a two dimensional position solution may be satisfactory.

Other problems which will have to be dealt with for high accuracy marine kinematic positioning are the removal of multipath effects, the accurate positioning of the vessel with respect to shore at the beginning of an observation period, losses of phase lock on all satellites simultaneously, etc. During the testing of new techniques, the vessel itself will have to be positioned accurately by independent means for comparison purposes. In an experiment to be conducted jointly by Nortech and the Canadian Hydrographic Service next October, an Atlas Krupp Polarfix system will be used to positon the vessel and survey launch to be tested. In this experiment, TI4100 and Trimble 4000S receivers will be utilized.

The nature of the problems discussed above shows that marine sub-metre positioning will not be easily achieved. However, given the research activities taking place in this area, a gradual accuracy improvement from the current 10 m is more than likely to be achieved during the next two years.

THE AIRBORNE CASE — HIGH KINEMATIC POSITIONING

Two types of aircraft are of interest for marine GPS applications, namely fixed wing and helicopter. Fixed wing aircraft applications range from LIDAR bathymetry (e.g., O'Connor and Casey 1986) to aeromagnetic surveys (e.g., Holtz et al 1986). Helicopter borne operations are usually limited to onshore and near shore applications, such as buoy positioning.

An important requirement for airborne GPS positioning is the availability of suitable users equipment which can track satellites in a fast switching sequential mode or, preferably, in a multiplex or multi-channel mode. The data output rate has to be compatible with the dynamics of the aircraft. The selection and mounting of a GPS antenna on any type of aircraft is a problem which can absorb significant amounts of funds and time. A site which reduces multipath and blade interference as well as masking effects from wings and fins is required. The choice is often limited to a few or one location, especially on helicopters. The installation requires permanent modifications to the aircraft. Government approvals for such modifications are often based on stringent requirements for obvious safety reasons.

The single point and differential positioning accuracies quoted in the previous section for PPS and SPS in marine kinematic mode also apply to the airborne mode provided that suitable equipment is utilized. Fixed wing aircraft GPS positioning using TI4100 receivers in single point and differential pseudo-range mode was tested jointly by Nortech Surveys and the Canadian Hydrographic Service in late 1983 (Lachapelle et al 1984b). The experiment was carried out using a DC3 aircraft at velocities of up to 300 km/h. The differential baseline extended up to 100 km. The GPS derived positions were compared against Del Norte Trisponder derived horizontal positions and LIDAR derived vertical positions. These positions were accurate to within 1 to 2 m. The results, in term of accuracy, were satisfactory. Single point PPS accuracies were of the order of 10 to 15 m in latitude and longitude and 20 to 25 m in height. Differential positioning accuracies of 5 m in latitude and longitude and 10 m in height were obtained.

During the summer of 1985, Nortech supplied an integrated GPS/Loran-C navigation system for a 130,000 line km aeromagnetic survey conducted by Geoterrex Ltd. and Kenting Earth Sciences Ltd. off Newfoundland's East Coast (Holtz et al 1986). The SPS differential pseudo-range positioning mode was used together with Trimble 4000A receivers. Heights were constrained using radar and/or pressure altimetry data and accuracies better than 100 m were obtained for over 12 hours per day. When more than two satellites were available, the differential accuracy was superior to 35 m.

Many fixed wing aircraft applications call for very high positioning accuracies, i.e., at the sub-metre level. As discussed in the previous section, the combination of pseudo-range and phase measurements will, in principle, yield this level of accuracy. However, in view of the difficulties associated with the recovery of cycle slips and losses of phase lock, it is doubtful that sub-metre accuracy is achievable for routine airborne operations with unaided GPS. The integration of GPS with external sensors will be required. Interesting background work has already been carried out by various organizations on the possibility of using GPS integrated with an inertial navigation system (e.g., Wong et al 1985, Goldfarb & Schwarz 1985). Few, if any, high accuracy airborne tests of this type have yet been conducted by the civilian sector. However, many experiments are being proposed. For instance, Hardwick et al (1986) propose to integrate GPS with an accurate pressure altimeter, airborne gravimeter and, optionally, an external inertial navigation system. In this project, to be conducted jointly by Nortech Surveys, the National Research Council of Canada and the Department of Energy, Mines, and Resources, the GPS portion of the system will consist of two TI4100 receivers operating in differential mode. Both pseudo-range and phase observations will be used in the data integration process. The accuracy requirement is the most stringent for the vertical component, where sub-metre accuracy is sought. This type of experiment will contribute to improve the accuracies achievable for fixed wing aircraft positioning. It is not unrealistic to predict that a one metre accuracy level will be available for operational projects within one to three years.

Helicopter positioning with GPS can be used for a variety of marine and onshore applications, ranging from buoy positioning to laser profiling (e.g., Engler & Hagglund 1983). A major problem with helicopter positioning is the selection of an appropriate site for the GPS antenna. If the antenna is installed under the main rotor, signal interference will inevitably cause frequent losses of the GPS signal. Depending of the type of helicopter used, it may be possible to install the antenna on the top of the main rotor's shaft, above the rotor. This type of helicopter is usually large and relatively expensive to operate. On smaller types of helicopters, such as the Bell 206B, the upper extremity of the vertical tail fin is well suited for a GPS antenna due to its location above the vertical tail rotor of the helicopter.

During the period 1984-85, Nortech modified, under contract for the Canadian Hydrographic Service, a Bell 206B vertical tail fin. Tests were conducted in December 1984 for the Canadian Coast Guard along the southeast coast of Nova Scotia. Selected buoys and lighthouses were positioned by hovering the helicopter over the sites. TI4100 receivers in differential pseudo-range mode were utilized. The receiver onboard the helicopter was equipped with Phase I tracking software. Frequent losses of the GPS signal occurred. However, enough pseudo-range measurements were recorded at each site for a good assessment of the accuracy achievable. In differential mode, horizontal accuracies of the order of 10 m were obtained which was satisfactory for the purpose. In June 1985, additional helicopter tests were conducted in western Canada with TI4100 receivers equipped with Phase II tracking software. No loss of signal occurred and the phase data appeared to be of a usable quality. The experiment was successful and positively proved the concept of GPS helicopter positioning. The next step is obviously to integrate pseudo-range and phase data to increase accuracy to a metre or sub-metre level. Related potential applications are extensive.

MONITORING OFFSHORE STRUCTURE SUBSIDENCE WITH GPS

The use of GPS for monitoring the settlement of offshore structures constitutes another challenging application. During the past year, the petroleum industry has shown increasing interest in GPS for this purpose and the progress is very encouraging (e.g., Collins 1986, McLintock 1986).

The challenge is to determine the height difference between platforms and selected references with an accuracy of 1 ppm over distances of the order of 25 km and 0.1 to 0.5 ppm over distances of the order of 100 to 200 km. Several problems have to be surmounted. The finite accuracy of satellite ephemerides and clocks is currently estimated at the 1 ppm level (Krakiwsky et al 1985). The effect of the ionosphere is also at the 1 ppm level (Lachapelle & Cannon 1986). That of the troposphere is estimated at the 0.5 ppm level. Multipath effects on an offshore platform are likely to increase the phase measurement noise level significantly. The satellite geometry is not currently well suited for accurate height determination in many parts of the world.

However, efforts are being directed at solving these problems. The use of dual frequency data will remove the effect of the ionosphere to a large extent (e.g., Lachapelle & Cannon 1986). The use of more than one reference station may contribute to decrease the effects of satellite ephemeris and clock errors. Proper antenna shielding will reduce multipath effects. Experiments under different weather conditions will assist in determining optimal methods to minimize the effect of the troposphere.

Considering the overall progress made with precise GPS positioning during the past two years (e.g., NOAA 1985), the prospects for obtaining the accuracies required for offshore structure monitoring are positive. Accuracies of 1 ppm are achieved routinely with several types of instrumentation and methodologies. The next step will be to confirm that this accuracy level is not only short term repeatability but absolute accuracy achievable in the long term.

CONCLUSIONS

The versatility and capabilities of GPS to solve a wide range of offshore surveying problems in a cost effective manner are well established. Cost effectiveness will improve considerably as the full constellation becomes available. Accuracies currently achievable already match or surpass those achievable with any other system. However, the full accuracy potential of GPS is not yet achieved. The use of phase measurements is expected to lead to important improvements in shipborne and airborne positioning. The problems to be resolved are complex and important challenges lie ahead.

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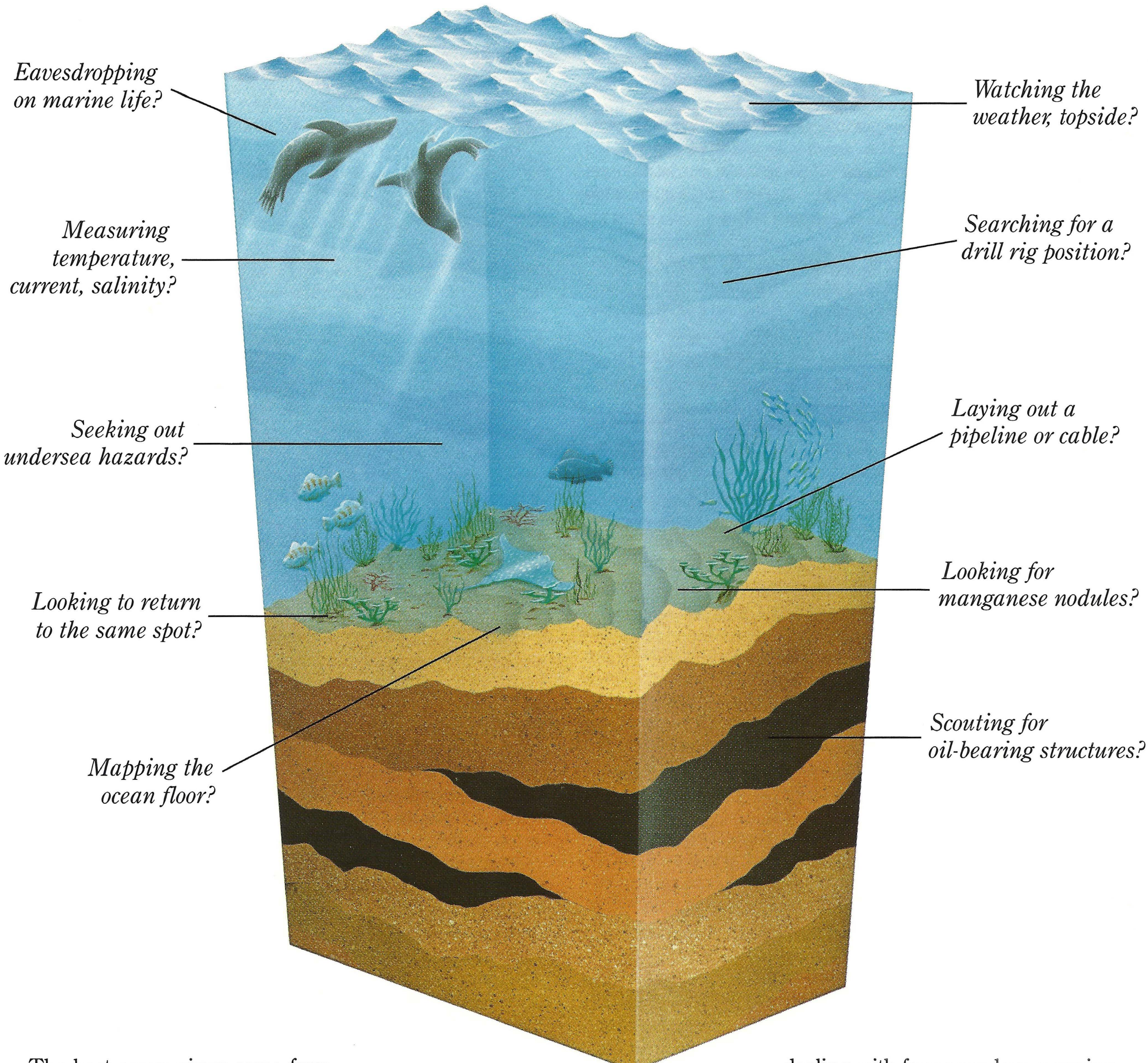

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Multibeam Echo Sounder — SIMRAD EM100

by
Freddy Pohner
SIMRAD SUBSEA A/S
Norway

Summary

The EM100 multibeam echo sounder system was developed by SIMRAD SUBSEA A/S of Horten, Norway, with production commencing Spring 86. The EM100 is designed mainly for high resolution seabed mapping at water depths to 500 meters. The system development was supported by Statoil and the Norwegian Hydrographic Office.

The system operates at a frequency of 95 kHz, giving a maximum slant range of 550 meters. The transducer, which can be hoisted into the ship's hull, is composed of 96 rectangular transducer elements, mounted on a single compact 40cm long x 80cm wide cylinder segment.

The signals are electronically beamformed by SIMRAD SUBSEA's digital bitslice technology to form 32 separate beams. Each beam is 3 degrees in the fore and aft direction, and 2 or 25 degrees in the athwartship direction. The fan of beams can be stabilized for ship motions, the swath width on the bottom extending for up to 1.7 times the water depth.

Athwartship and fore and aft profiles of water depth are presented graphically on the operators display. Operation is simplified by use of self explanatory operation menus and single joystick control.

The EM100 sounder system can transfer its measurement values to external data systems for recording, or it can store measurements on a digital cassette unit with a capacity of 11.5 Mbytes, corresponding to 5-15 hours of operation.

A realtime contour mapping subsystem can be offered with the EM100. With this facility it is possible to produce contour maps in real time or from tape recorded data, with map scale from 1:100 to 1:10000, and contour interval selectable down to 0.5 meter. If the ship's course and position data is supplied to the system, the resultant map can be produced in UTM projection, for one survey line at a time.

A great effort has been made to optimize the accuracy. Because During sea trials, RMS measurement errors less than 0.5% of water depth were achieved for all 32 beams. Errors caused by imperfections in gyro compass V.R.U. and heave measurements will add to this.

The system compensates the measurement for nonlinear sound transmission paths caused by variations in round velocity with water depth.

During seatrials, RMS measurement errors less than 0.5% of water depth were achieved for all 32 beams. Errors caused by imperfections in gyro compass V.R.U. and heave measurements will add to this.

Introduction

The EM100 is a multibeam echosounding system designed mainly for high resolution seabed mapping at water depths to 500 meters. It was developed by SIMRAD Subsea A/S, of Horten, Norway, over a period of 4 years. The product development project was supported by Statoil and the Norwegian Hydrographic Office assisted during sea trials.

The working principle of the EM100 is illustrated in Fig. 1. The system operates at a frequency of 95 kHz, giving a maximum slant range of 550 meters. The transducer assembly is comprised of 96 ceramic transducer elements mounted together to form a cylinder segment, which can be hoisted into the ship's hull. A single pulse is transmitted to cover 3 degrees in the fore and aft direction and 80 degrees in the athwartships direction. During reception of reflected energy, the 96 transducer signals are processed digitally to form 32 beams, each beam being 2.5 x 3 degrees.

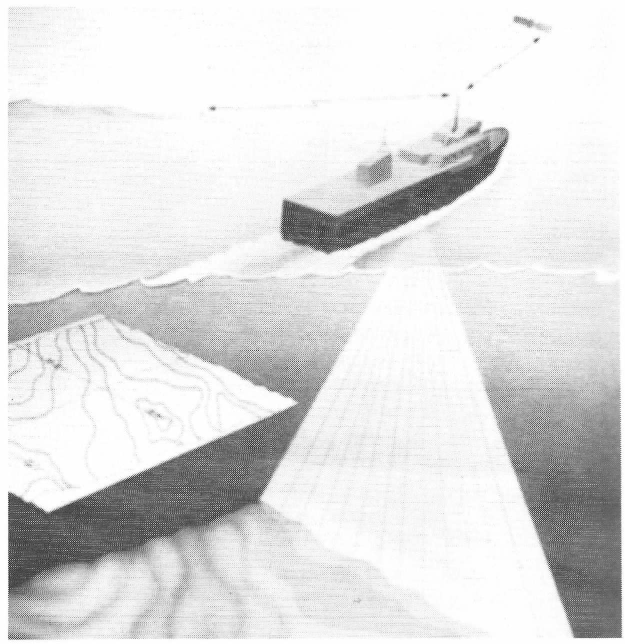


Figure 1

By measurement of the distance to the sea floor for each beam, combined with control and measurement of each beam's direction relative to the true vertical, the system will continuously calculate the depth and athwartships coordinate value for the intersection point between each beam and the sea bottom (see Fig. 2).

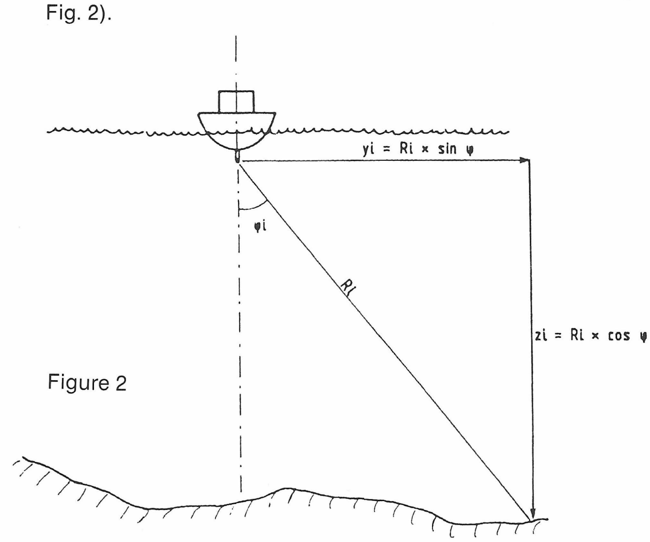


Figure 2

The system is capable of covering a swath with a width of up to 1.7 times the water depth, the maximum vessel speed being 10 knots.

The data collection is supplemented by rational handling of data quality control, storage of bathymetric data on digital magnetic tape cassettes, and computerized production of contoured maps in a postprocessing phase.

Mapping Costs and Quality

The single largest cost factor for sea floor mapping is the cost of operating the survey vessel(s). The cost per survey hour depends mainly on the cost of the vessel itself, its instrumentation systems, fuel and crew.

The aim of the designers of this system has been to reduce the number of survey hours whilst maintaining a high standard of accuracy.

Table 1 is a comparison of the steaming distance for a one nautical mile square area using 3 alternative survey methods:

A. The EM100 used with 30% area overlap between neighbouring sounding lines

B. High resolution single-beam echo sounder with, 25 meter distance between survey lines (Conventional detailed survey)

C. Survey with single beam echo sounder and sounding line spacing equal to the water depth (Conventional coarse survey)

Table 1 Comparison of steaming distances

	WATER DEPTH		
	50 meters	100 meters	300 meters
A. EM100	31nm	15nm	5nm
B. Conventional detailed survey	74nm	74nm	74nm
C. Conventional coarse survey	37nm	18nm	6nm

Table 2 is a comparison of the largest distance between neighbouring points being sounded by each of the methods.

Table 2 Maximum distance between sounding points

	WATER DEPTH		
	50 meters	100 meters	300 meters
A. EM100	2.5m	5m	15m
B. Conventional detailed survey	25m	25m	25m
C. Conventional coarse survey	50m	100m	300m

It will be apparent from these two tables that the system provides a more detailed area coverage with a less steaming distance.

System Design

The EM100 design is illustrated in Figure 3. The special transducer assembly is mounted in a hull unit which can be retracted into the hull when not in use. When in operation, the transducer is lowered almost 1 meter below the hull for signal transmission. The transducer signals are connected to the preamplifier cabinet by coaxial cables. Amplified signals are fed to the transceiver cabinet, in which the signal processing takes place. The signals are A/D converted, the beam-formation is performed by 2 parallel bitslice processors. Detection and estimation of the bottom echo time delay for each beam is then carried out. After calculation of athwartship coordinates and depth, the data set for each ping is transferred to the operator's workstation in serial form.

Compensating for Vessel Movements

By use of a Vertical Reference Unit (V.R.U.), it is possible to eliminate the effects of vessel movement. Pitching is counteracted by mechanically turning the transducer so that the radiation pattern is kept vertical.

The effects of roll are eliminated electronically during the beamformation process. In this way the beam is stabilized for changes of 2 rotation angles. The third angle of rotation is measured by the gyro compass, and the measured value is attached to a dataset for each ping to be used during the postprocessing/map production phase.

Heave measurements are used in the calculations, so that the final results are heave-compensated values for depth.

Compensating for Sound Velocity Variations

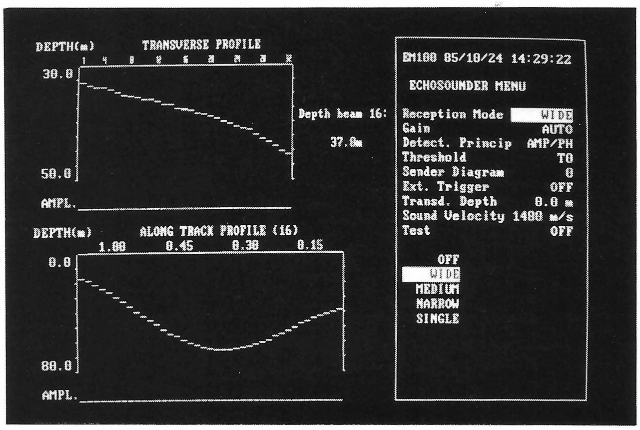
The sound velocity in water varies considerably with temperature and salinity, roughly from 1400m/s to 1500m/s. For a conventional echo sounder the depth is calculated as

$$\text{depth} = \text{time}/(\text{mean sound velocity}).$$

When transmitting sound through water at a slant angle, further problems arise. If the sound velocity varies with depth, the transmission path of the beam will deviate from a straight line. To maintain the best possible accuracy for all beams, the EM100 will compensate the measurements for variations of mean sound velocity, causing changes in arrival times, as well as nonlinear transmission paths. The compensation is based upon the measurement of the sound velocity profiles. The equipment used for making this measurement is connected to the EM100. It will calculate the correction for each beam and for all depths. The actual compensation is performed in real time, for each ping.

Data Recording

The echo sounding system does not produce conventional echograms. In any case, 32 simultaneous echograms would be a very impractical end result, requiring extensive post survey analysis. Instead, the output is a block of digital depth data on a serial data channel. The data may be stored on a digital tape cassette, or transferred to some external data system for storage. The amount of data produced by the echo sounding system is in the order of 1Mbyte per hour. Accurate syncronization of position and depth data can be achieved by transferring position data to the EM100 for each position fix. In this case the data output channel will also comprise position data blocks, all data blocks being marked and referred to the common clock with a 1/100 second resolution. By this procedure it is possible during postprocessing to calculate


DEPTH(m) TRANSVERSE PROFILE
30.0
50.0
AMPL.
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37.8m
DEPTH(m) ALONG TRACK PROFILE (16)
1.00 0.45 0.30 0.15
0.0
80.0
AMPL.
EM100 85/10/24 14:29:22
ECHOSOUNDER MENU
Reception Mode WIDE
Gain AUTO
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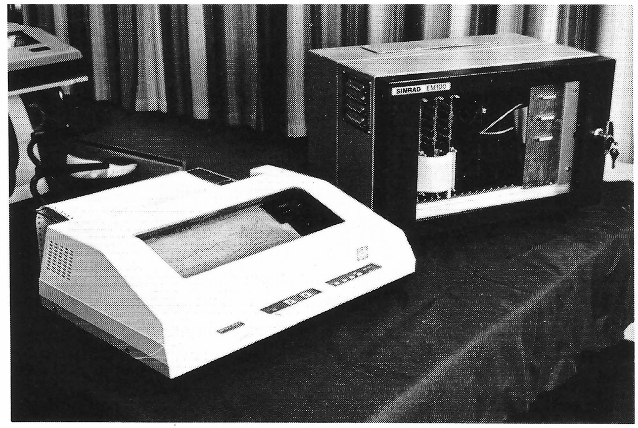

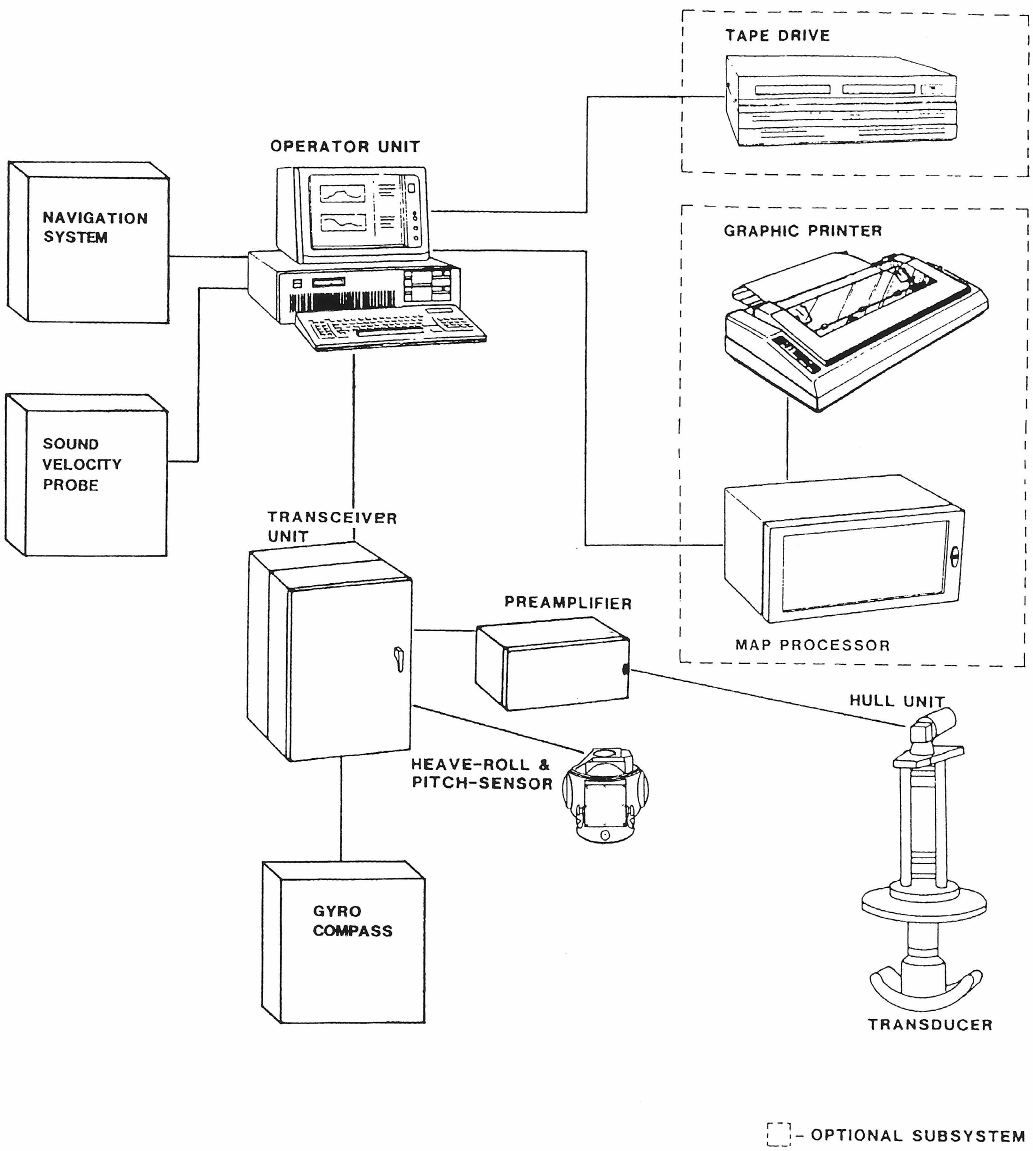
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PREAMPLIFIER
MAP PROCESSOR
HULL UNIT
HEAVE-ROLL & PITCH-SENSOR
GYRO COMPASS
TRANSDUCER
- OPTIONAL SUBSYSTEM

Figure 3

the best vessel position estimate at the exact time of each sounding.

Real Time Contour Map

The real time mapping processor is a separate, powerful data system utilizing 3 Intel 8086/8087 microprocessors. Properly interfaced to the output data stream, this system is capable of producing a contour map in real time. The map will cover the swath being surveyed at the time. A fast graphical printer is used to output the results. The width of the map will be limited to 1.7 times the water depth, whilst there is no limit on the length of the map. If positioning data is tranferred to the EM100, the map will have UTM position reference marks, and will then be a correctly scaled representation of the sea floor topography. The scale can be selected, from 1:100 to 1:10000. The smallest contour interval that can be selected is 0.5 meter. Alternative forms of presentation comprise a "water fall" mode, giving a 3 dimensional impression of the sea floor.

Quality Control

Real time quality control of the results is accomplished by:

— inspection of the realtime contour map. This map will indicate areas where bottom detection was incomplete and will continuously indicate the number of beams with poor bottom detection.

— inspection of the operators display. The athwartships depth profile is displayed for each sounding. Directly underneath this is a display line indicating the signal strength for each beam. Fore-and-aft depth profile for the last time period, up to 5 minutes, is displayed for one selected beam.

Quality control during postprocessing is feasible. In addition to the depth and position data, vessel movements and parameter changes are available. It is the normal practice in surveying to have some overlap between neighbouring swaths with redundancy of data in the overlap zone. This is useful for assessing the accuracy achieved and for actually producing a better map in the end.

Map Production

The real time map processor is not suited for production of final maps, mainly because it only processes data from one survey line, and does not address the problem of intergrating data from several survey lines into one area map.

There are, however, suitable data systems available for this purpose. IRAP, produced by SYSSCAN/KV, is one example. Data samples from the EM100 are used as input to a digital terrain model. When all available data has been used for calculating depth values at the grid points of the terrain model, subprograms for filtering and map drawing take over. Computerized data postprocessing is the only practical way to do high resolution mapping from swath covering sensors of the EM100 type, for areas of some size. Field testing of this map production system with the EM100 will be performed in the near future.

Results

Figures 6 and 7 show two different ways of displaying the same data. Both figures have been produced by the real time mapping subsystem of the EM100. The survey pertains to the wreck of the German warship "Blucher", which was sunk on the 9th of April 1940 in Drobak Sound near Oslo. The survey vessel used was M/K SIMRAD. The presentations are the results of a single survey line, at a course of 340 degrees, speed 3 knots. The actual collection of data took less than 5 minutes. The direction of advance is downwards on the maps. From the contour map (Fig. 6) it can be seen that the wreck is resting on its port side, with the stern towards Oslo. Close to the bow one can see a clearly marked pit (it is known that the ship sank bow first). The bow is resting at about 73 meters depth, while 93 meters is recorded at the stern.

The actual shape of the hull is more clearly seen in Figure 7, a waterfall presentation. It is possible to see the straight lines of the hull, a reduction of the full volume aft of the superstructure, and a clearly visible hole in the bottom.

Figure 8 shows the results of a survey of Frebergsviken in Oslofjorden, south of Holmestrand. The map has been produced from real time contours. Maps from 8 survey lines, at scale 1:1000, have been combined manually by putting corresponding UTM position marks from neighbouring charts on top of each other. The contours have then been transferred to one single film. The same area has been surveyed by NSKV by use of a single beam sounder (SIMRAD EA 200) with 10-meter survey line spacing, totalling 83 survey lines. The two surveys are in agreement with one another. By making use of a data processing system with digital terrain modelling for the postprocessing of results, the data in the overlap zones will be used to better advantage. This work will be undertaken shortly.

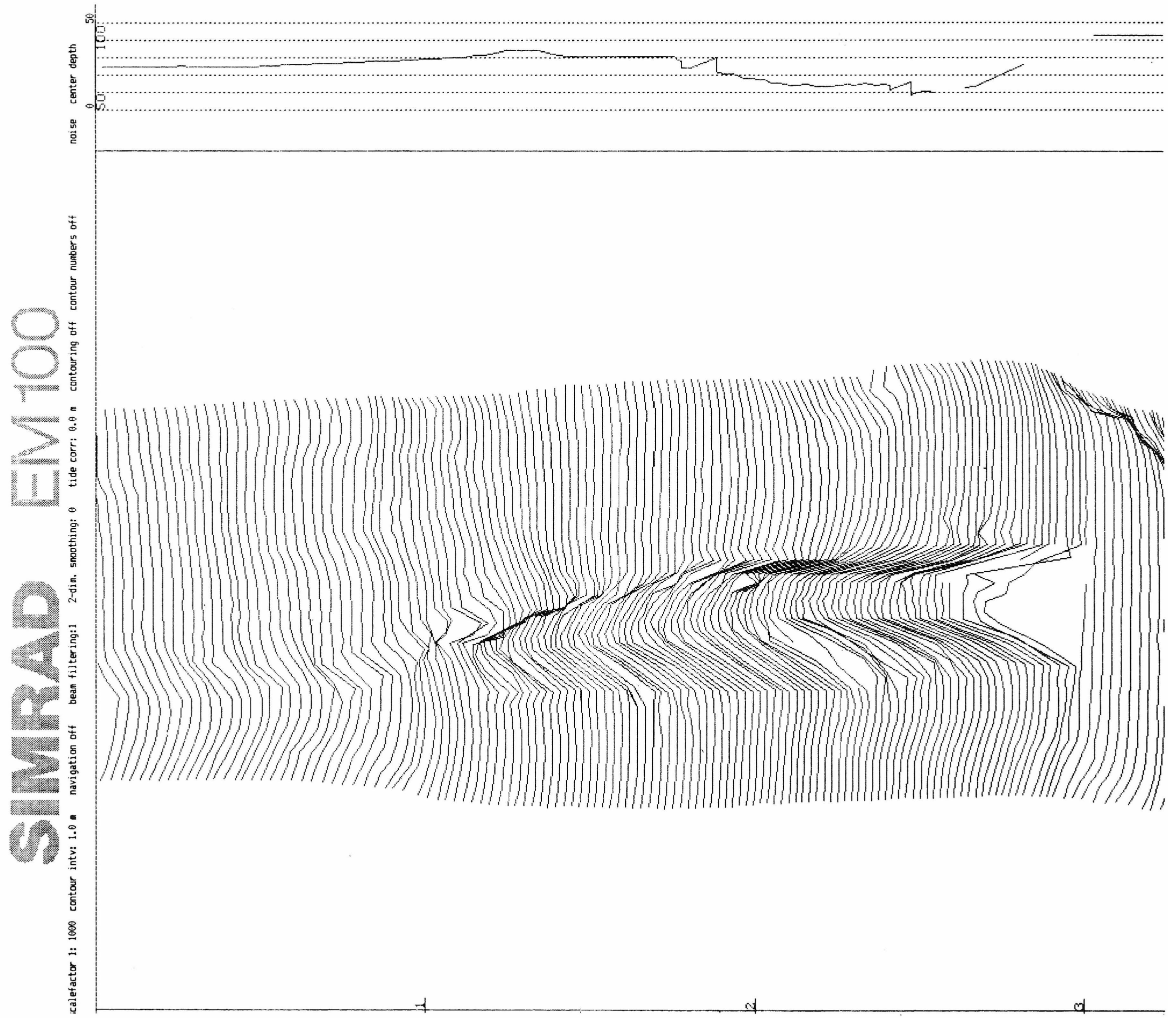
Conclusion

Swath covering sensor systems seem to have been developed to a point where it begins to make sense to use them for reasons of efficiency, survey quality and overall economy. Postprocessing is also benefitting from technical advances, and from the availability of data processing systems with proven terrain modelling software. It is now therefore possible to make use of the new digital sensor systems without the need for time-consuming and costly development projects.

The EM100 has been tested in waters off the west coast of Norway. The equipment was installed on board the survey vessel S/V GEOFJORD and an area 1.75 x 2.25 km, with a complex seabed topography, and depths ranging from 130 to 320 metres was surveyed. The sounding lines, being approximately 125 metres apart, were run first in a north-south direction. The same area was then covered with east-west profiles. The total steaming time was 4 hours.

The 3-D map at Fig. 9 has been generated from a digital terrain model of the area. The standard deviation in depth in the wide reception mode i.e. with a beamwidth of 80° at a depth of 320 metres was of an order of less than 0.2% (approx. 0.5m).

The main objective of the trials was to test the accuracy, reliability and efficiency of the system in areas of very rugged seabed topography and the results show that the EM100 is a highly effective and accurate tool for bathymetric surveys of the continental shelf. Furthermore, the system achieves its objectives in a cost effective manner.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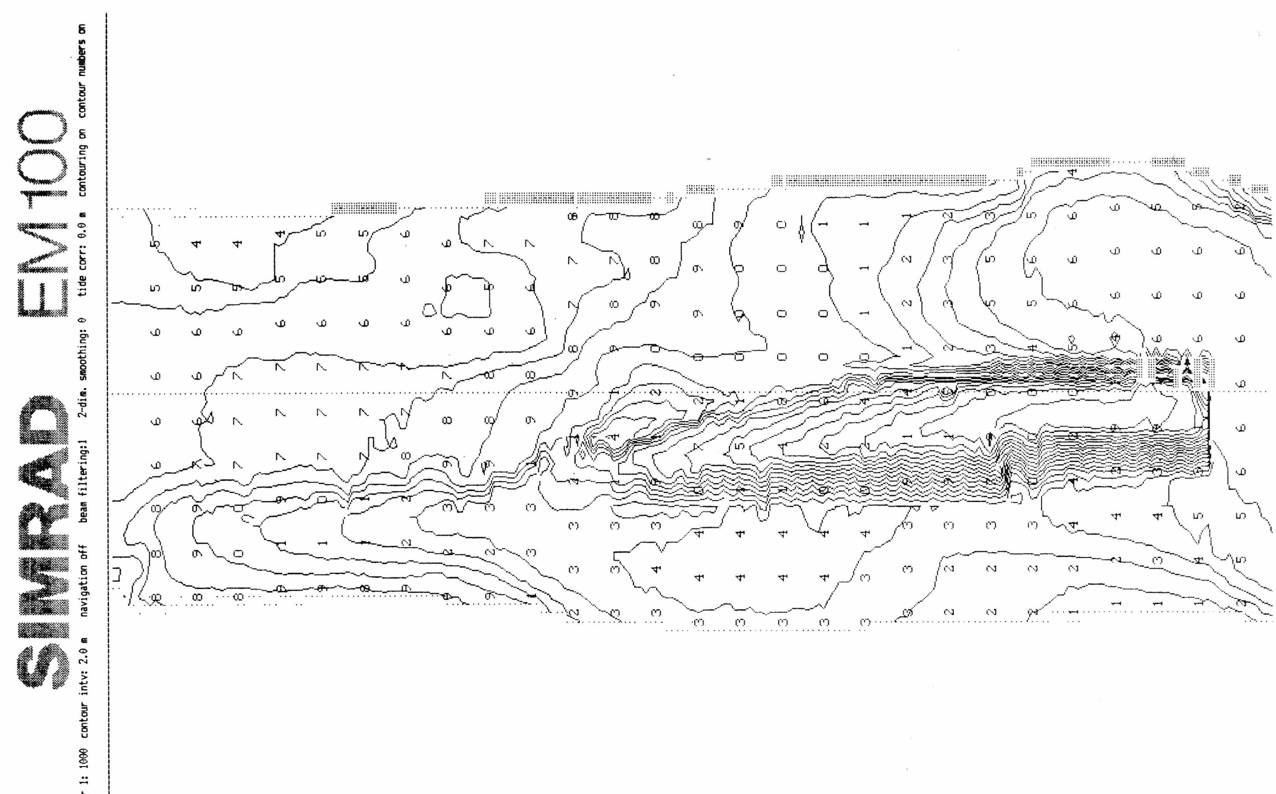
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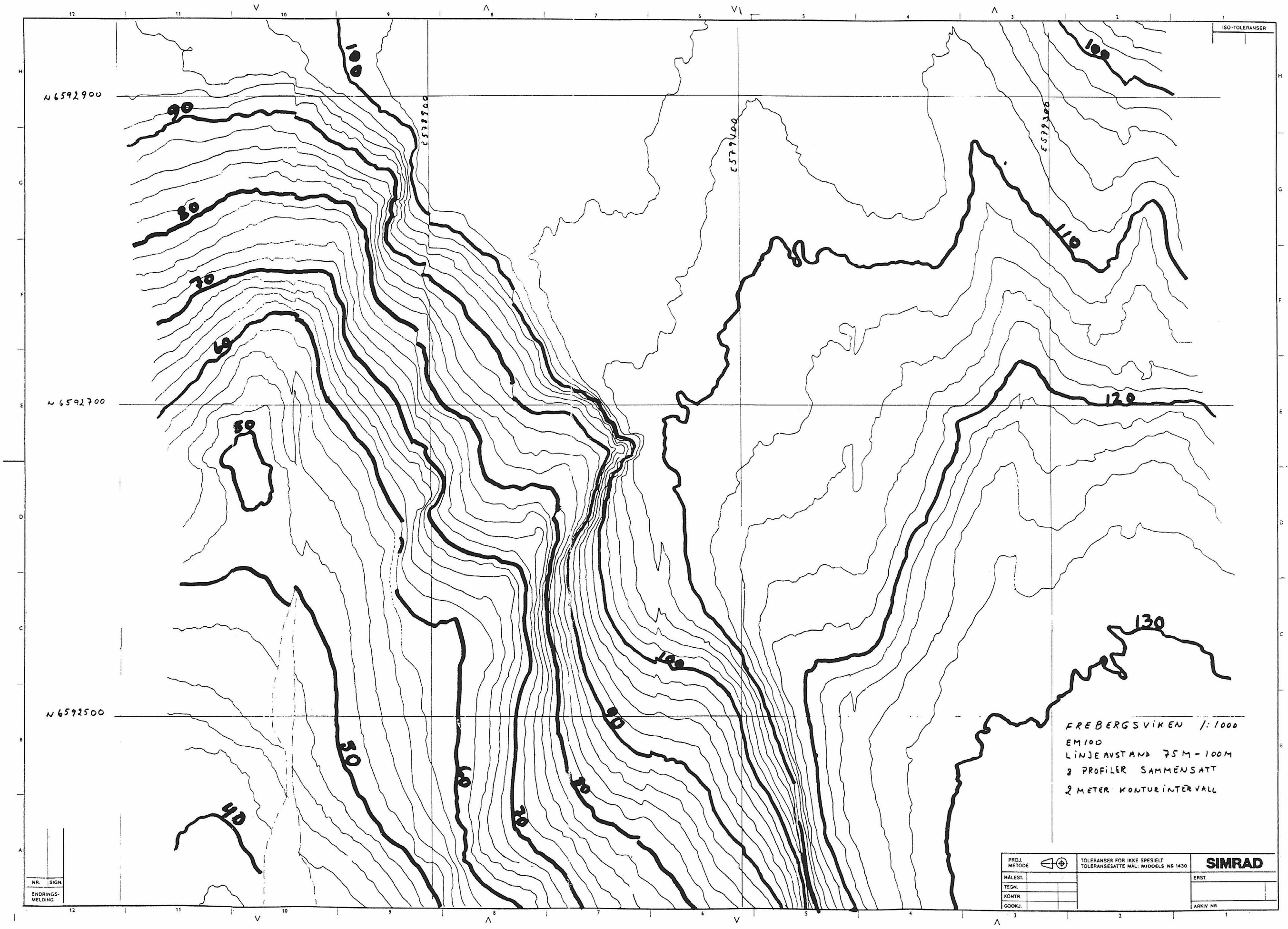
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ISO-TOLERANSER

Fig. 8

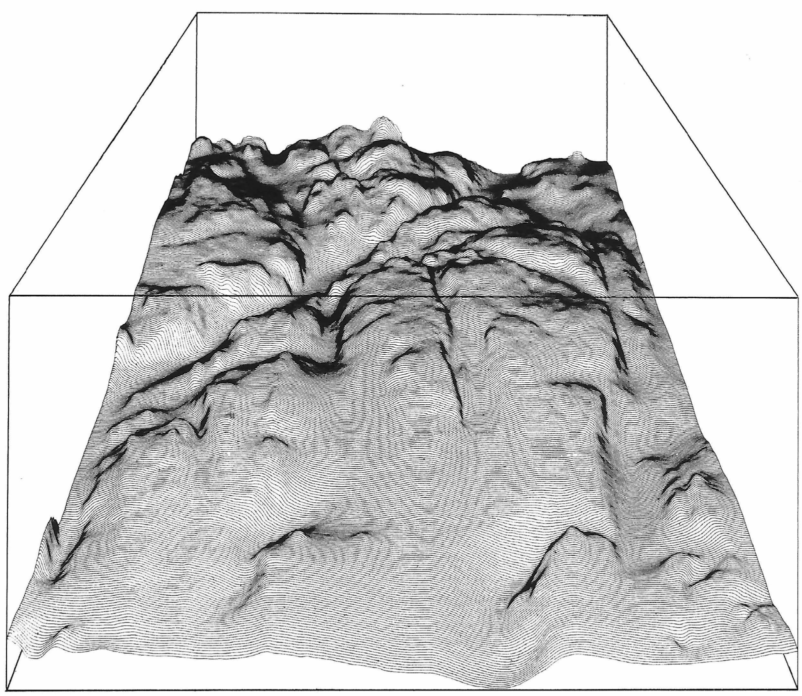
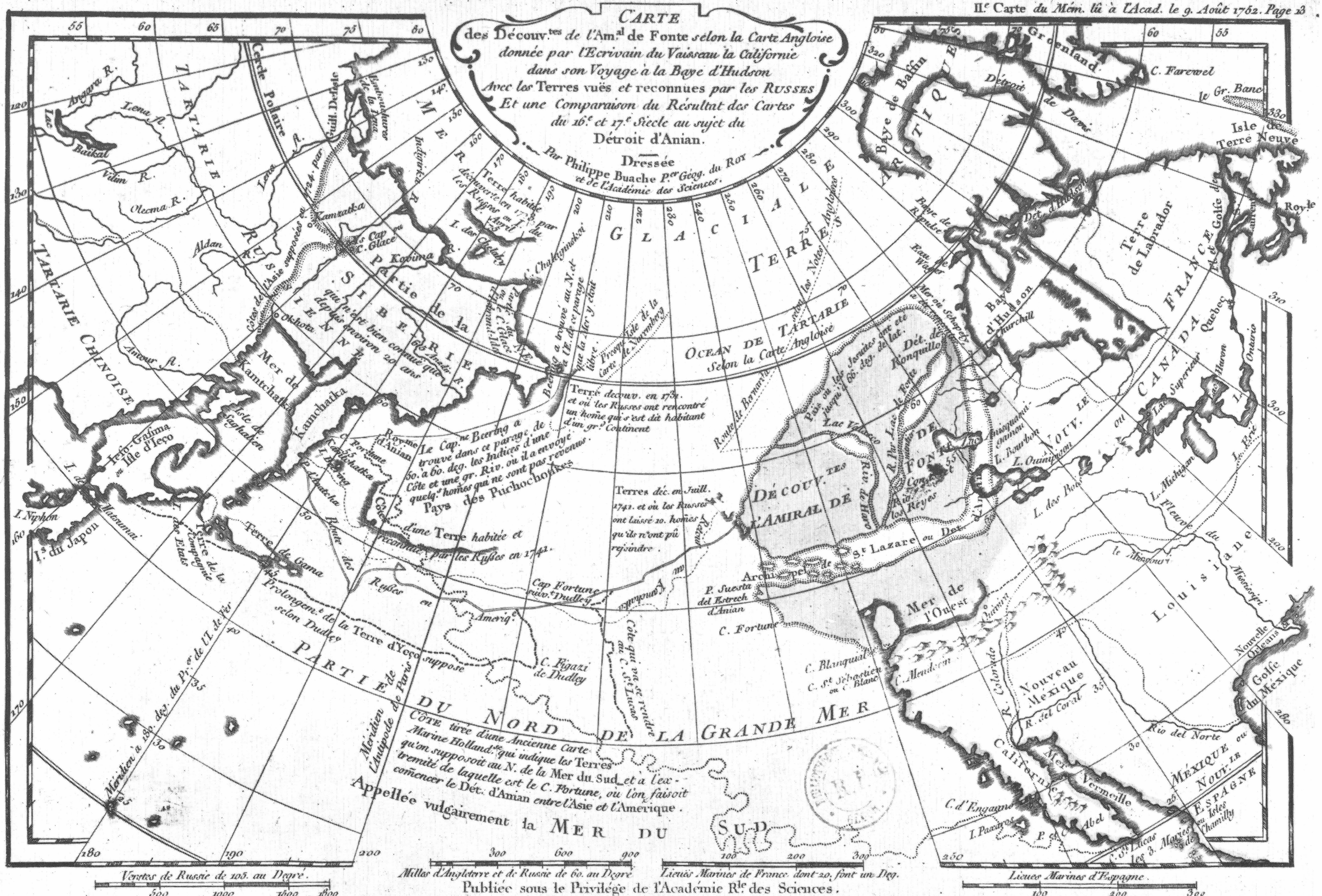


Fig. 9



1 — Carte de Ph. BUACHE, publiée en 1752, montrant les parages Nord-Ouest de l'Amérique du Nord.

Two Hundred Years Ago (1786) La Perouse Explored the Coasts of North America From Alaska to California

Il y a deux cents ans (1786), LAPEROUSE explorait les côtes d'amérique du nord entre l'Alaska et la Californie

par
L'Ingénieur général de l'Armement BOURGOIN
Directeur du Service Hydrographique
et Océanographique de la Marine, France

Economic and Political Background

As a result of the treaty of Versailles of 1783, which marked the end of the American war of independence as well as the end of hostilities between France and England, it was considered appropriate and timely to undertake a major scientific and humanitarian expedition. Such a voyage would serve to reveal a peaceful and enlightened France. Cook's expeditions, especially his third voyage, had fascinated the political and scientific establishment which was now eager to prove that France could resume its tradition of exploration. In addition, the main scientific goals of La Perouse's expedition would serve France both politically and economically.

At the time that King Louis XVI ordered La Perouse, born Jean Francois de Galaup, to "pay particular attention to those parts (of North America) not explored by Captain Cook or those whose account had not been given by the Russian and Spanish sailors" and to "search carefully for some river or enclosed bay which would give access to Hudson Bay via some inland lake" the belief in a mythical westward waterway leading to China across North America was still strong. Jacques Cartier, Champlain, Jolliet, Cavalier de La Salle, de la Verendrye as well as Chateaubriand in 1791 were all believers in that magical passage to the "land of wonders", supplier of spices and precious metals, as described at the end of the 13th century by Marco Polo. The North American leg of La Perouse's expedition was of particular interest. It showed that the Anglo-Franco political and economic rivalry was being kept alive through scientific exploration. It may perhaps even be possible to connect the £20,000 offered in 1745 by the British Government for the discovery of a westward passage and the offer of a similar amount through an act of the British parliament, in 1714, for improving the method of longitude determination at sea; these two problems being more closely linked than it may seem. In case the famous waterway could not be discovered, more modest commercial goals had been unofficially assigned to La Perouse.

Hydrography and the Fur Trade

Accounts of Cook's last voyage, published in 1784, revealed the large monetary gains made by his crew from the trade of otter pelts. The pelts, which were obtained in Nootka, were traded in China at a huge profit. In the years following Cook's death, 1787 to 1788, many British sailors became involved in the fur trade — sailors such as Dixon and Portlock who were shipmates of Vancouver on the DISCOVERY, as well as Barkley, John Meares and James Colnett. Some of these men were excellent cartographers and have left behind local toponymes bearing their names. Claret de Fleurieu, director of harbours and arsenals, who was also the adjunct inspector of the map office, was introduced to the fur trade by the Dutch merchant Bolts who was fully aware of the

Le contexte économique et politique.

Le traité de Versailles, en 1783, ayant mis fin à la guerre d'Indépendance des États-Unis et aux hostilités entre la France et l'Angleterre, les circonstances étaient très favorables pour entrprendre un grand voyage d'exploration dont le programme scientifique et humanitaire était de nature à promouvoir l'image d'une France pacifique et éclairée. Les hautes sphères politiques et scientifiques avaient été fascinées par COOK et notamment par son 3è voyage et souhaitaient vivement apporter la preuve que la France pouvait prendre sa relève. Par ailleurs, les objectifs scientifiques principaux de l'expédition de LAPEROUSE allaient de pair avec des objectifs politiques et commerciaux.

Le roi LOUIS XVI, en ordonnant à LAPEROUSE de "s'attacher particulièrement à reconnaître les parties (de l'Amérique du Nord) qui n'ont pas été vues par le Capitaine COOK, et sur lesqueslles les relations des navigateurs russes et espagnols ne fournissent aucune notion" et de "chercher avec le plus grand soin si, dans les parties qui ne sont pas encore connues, il ne se trouverait pas quelque rivière, quelque golfe reserré, qui pût ouvrir, par les lacs de l'intérieur, une communication avec quelque partie de la baie d'Hudson", continuait d'obéir au mythe de la route maritime de l'Ouest pour gagner la Chine à travers le continent américain. Jacques CARTIER, CHAMPLAIN, JOLLIET, CAVELIER DE LA SALLE, de la VÉRENDRYE, et encore CHÂTEAUBRIAND en 1791 crurent à cette fabuleuse solution pour atteindre le "pays des merveilles", source des épices et des métaux précieux, qu'avait décrit MARCO POLO à la fin du 13è siècle. Dans l'ensemble de l'expédition de LAPEROUSE, l'épisode nord américain revêtait donc une importance particulière. Il mettait clairement en évidence que la rivalité franco-anglaise, en se déplaçant sur le terrain de l'exploration scientifique, continuait de traduire une compétition politique et économique. On peut d'ailleurs faire un curieux rapprochement entre les 20 000 livres offertes par le gourvernement britannique en 1745 pour la découverte de cette liaison maritime et la même somme offerte par un acte du parlement britannique en 1714 pour une méthode d'amélioration de la détermination des longitudes à la mer; les deux problèmes étaient liés entre eux plus étroitement qu'on ne pouvait le croire. À défaut de la découverte de la communication maritime entre l'Atlantique et le Pacifique, des objectifs commerciaux plus modestes étaient discrètement désignés à LAPEROUSE.

L'hydrographie et le commerce des fourrures.

La relation du dernier voyage de COOK, publiée en 1784, révéla au public que lorsque ses navires gagnèrent la Chine, après sa mort la vente des peaux de loutre qu'il s'était procurées à Nootka apporta des bénéfices considérables. Dans les années qui suivirent (1787-1788), le nom de nombreux marins britanniques resta good fortune attending Cook's crew. The idea was simple — firstly, common goods were traded with the indians for fur pelts; secondly, the furs were traded in Canton for "Asian goods". One may well imagine that a prime objective of la Perouses's expedition to the north west coasts of America was the trade in pelts. The objective, however, was not to risk the Navy's reputation in an unproven commercial venture but to carry out what would now-a-days be termed an export market feasibility study with all the inherent political and diplomatical precautions. The trade between Canton and Nootka never did materialize for France. Spain having learnt from accounts of Cook's third expedition that the Russians were based on the north west coast, decided to take possession of Nootka in 1789. This act was not, however, taken lightly by England. The British intervention resulted in the "Nootka Convention" signed in Madrid in October of 1790. The Convention gave equal commercial rights to both Britain and Spain for ventures in America. In 1791 Britain felt it necessary to assert her rights by sending the frigate DISCOVERY under Captain Vancouver to accurately chart the north-western coast of North America from latitude 30° to 60° North. Vancouver successfully completed this massive task during the summers of 1792, 1793 and 1794. He charted the coast of British Columbia (from latitude 49° 54′ N., to Cap Douglas or more precisely from Cap Lookout to Cap Decision) starting from the waters surrounding the island bearing his name, he sounded in the Juan de Fuca Strait, Puget Sound, the Strait of Georgia, Johnstone Strait and Queen Charlotte Sound. His superb work also had a successful political outcome since it resulted in the departure of the Spanish from the area by 1792.

Coastal Reconnaissance

La Perouse was given, as a major goal, the accurate charting of the known coasts using the most recent astronomical positioning techniques. The work of mariners and astronomers was, therefore, of greater importance than that of any other scientists taking part in the expedition. Thanks to the leadership of Choiseul, the naval officers of the day were given a thorough nautical and scientific education. In 1752 the newly created Naval Academy, which took over the teaching of hydrography from the Jesuits, was attracting the most brilliant students. Fleuriot de Langle, Captain of the ASTROLABE, was an accomplished sailor, as demonstrated on the ASTREE during the Hudson Bay expedition. He was also a man of science as shown by his collaboration with La Coudraye in the Pancouke Encyclopedia. His passion for navigation was genuine and he was also very skillful at maritime observations and calculations. Louis Monge and Dagelet, the two astronomers associated with the expedition, had been selected from amongst the most brilliant in their day. However, Monge, the ASTROLABE's astronomer, had to leave the expedition at Teneriffe due to health problems. Dagelet, selected by Borda on a recommendation by the astronomer Lalande, was at that time the youngest member of the French Academy.

Great care was also used in the selection of information and navigation equipment. The best sources and instruments makers were consulted: reflecting circles from the shop of Lenoir, the "Peru Standard", a quadrant from the Naval Academy, a transit telescope, 5 watches, 2 weight clocks (numbers 18 and 19), 2 small torsion clocks from Berthoud the official navy supplier, 2 azimuth compasses, 2 theodolites, 4 compasses, 3 sextants, 2 barometers, 4 thermometers, all from the best English suppliers. The Board of Longitude made available the two mariner's compasses used by Cook during his first expedition. Astronomical and navigational literature was also plentiful. It included among other things Mayer's tables, the Nautical Almanac for the years 1786 to 1790, La Caille and Lalande's astronomical treatise and Berthoud's treatise on maritime clocks.

lié à ce commerce. Tels ceux de DIXON et PORTLOCK, compagnons de VANCOUVER sur le "Discovery", et des marchands de peau, BARKLEY, John MEARES et James COLNETT. Certains d'entre eux s'illustrèrent dans les levés et ils laissèrent tous leur nom à des toponymes locaux. CLARET de FLEURIEU, Directeur des ports et arsenaux et Inspecteur adjoint du Dépôt de Cartes et Plans, eut l'attention attirée sur le commerce des fourrures par un certain BOLTS, homme d'affaire d'origine hollandaise qui avait eu vent probablement des bénéfices réalisés par l'équipage de COOK. Le schéma commercial était simple: dans un premier troc des marchandises de première nécessité étaient échangées avec les indiens contre des fourrures; dans un deuxième temps, ces fourrures seraient échangées à Canton contre des "marchandises d'Asie". Il y a tout lieux de penser que la traite des pelleteries était un des objectifs essentiels de la mission de LAPEROUSE sur les côtes nord-ouest de l'Amérique du Nord. Par contre il ne s'agissait pas d'engager la réputation de la Marine dans une opération commerciale dont on ignorait encore si elle serait couronnée de succès; non, il était question seulement de ce que nous appelons aujourd'hui une étude de marché à l'exportation, avec tout ce que cela comporte de précautions poitiques et diplomatiques. Elle n'eut pas de lendemain en ce qui concerne la France, mais les Espagnols ayant appris par le récit du 3è voyage de COOK que les Russes s'étaient installés en Amérique du Nord-Ouest prirent officiellement possession de Nootka, en 1789. L'émotion fut vive en Angleterre et l'intervention britannique aboutit à la "Convention de Nootka", signée à Madrid en octobre 1790, qui donnait des droits égaux à la Grande-Bretagne et à l'Espagne pour les entreprises commerciales en Amérique.

Cependant, les Britanniques jugèrent bon d'affirmer leur présence sur le terrain en envoyant in 1791 le Capitaine de frégate VANCOUVER, commandant du nouveau "Discovery", pour effectuer un levé précis de la côte nord-ouest d'Amérique du Nord entre les parallèles 30° et 60° Nord. VANCOUVER s'acquitta de cette énorme tâche pendant les étés 1792, 1793, 1794. Il fit un levé complet des côtes de la Colombie Britannique (du point de latitude 49° 54′ N au Cap Douglas et plus précisément en ce qui concerne directement du Cap Lookout au Cap Decision) en commençant par les eaux qui entouraient l'île qui porte son nom, en sondant le détroit du Juan de Fuca, le Puget Sound, le détroit de Georgie, le Johnstone Strait et le Queen Charlotte Sound. Son remarquable travail alla de pair avec un grand succès politique, puisque les Espagnols s'étaient retirés de ces eaux dès 1792.

Méthodes de reconnaissance des côtes.

Les instructions données à LAPEROUSE fixaient comme une priorité majeure la détermination avec la plus grande précision possible des côtes reconnues, en ayant recours aux progrès les plus récents faits dans la détermination astronomique des positions.

La tâche assignée aux marins et aux astronomes apparaît comme essentielle et dans la pratique leurs responsabilités et l'importance attachée à leurs travaux passent avant celles des autres savants de l'expédition. Du côté des officiers de marine, et sous l'impulsion de CHOISEUL, les "grades de la marine" reçoivent à cette époque une formation scientifique et nautique plus approfondie. La création de l'Académie de Marine, en 1752, a d'ailleurs pris la relève des Jésuites dans l'enseignement de l'hydrographie et suscite un engouement parmi les plus brillants marins, devenus aussi des savants. FLEURIOT de LANGLE, le commandant de l'"Astrolabe", et un excellent marin, comme il l'a prouvé en commandant l'"Astrée" lors de l'expédition à la baie d'Hudson, mais aussi un scientifique averti, qui a collaboré avec LA COUDRAYE à l'Encyclopédie de Pancouke. Il a une vraie pasison pour la navigation et il est rompu aux observations et calculs à la mer. Les astronomes de l'expédition, Louis MONGE et DAGELET, sont

2 — Titre d'une carte anglaise, publiée en 1777, illustrée d'une scène de commerce de fourrure de loutre.

It is of interest to understand how these facilities were utilized. Trans-oceanic navigation at that time was done mainly by dead reckoning along with latitude corrections obtained from celestial observations, usually the sun. Dead reckoning used with determination of speed and heading made it possible to determine the distance covered in 24 hours, known to British sailors as the "day's work". The speed could be estimated by the topman by counting the number of knots on the log line slipping between his fingers during a period of thirty seconds as estimated from a pulverized egg shell hour-glass. A spacing of 1/120 of a mile between the log line's knots would conveniently give the speed directly in knots. Even though the procedure may appear simple, one must keep in mind that at that time no standard of length had been established with respect to the earth's radius. In France, until the official adoption of the metric system in 1801 the standard length was the "Chatelet standard" (1.95m) by which the cloth merchants were required to calibrate their rulers. Picard's evaluation of the Paris-Amiens meridional arc during the years 1669 to 1671 helped to accurately define, as far as mariners were concerned, the sexagesimal minute. Until 1780, however, educated naval officers and hydrographers were attributing to the log line a length ranging from 42 to 45 feet as opposed to its official length of 47 feet and 6 inches. It is true that the systematic shorter length of the log was meant to take into account errors introduced by water friction on the vessel as well as hour-glass errors. Moreover, the shorter length gave an exaggerated covered distance and consequently provided a safety margin useful to avoid navigational dangers. The vessel heading was measured using a compass. The mariner's compass was used for the vessel's heading and the azimuth compass was used to measure azimuths from which the angle subtended between the vessel heading and some meridian could be estimated. A source of error was introduced by neglecting the deviation of the compass induced by metallic structures onboard the vessel. Helmsmen could only steer within a few degrees in any case. La Perouse used conventional navigation techniques. However, he used them carefully, especially as regard to the standard of length — after all did he not have on board the "Peru Standard" utilized by La Condamine to measure a meridional arc in Peru (1735-1744)? As well, La Perouse, like Cook before him, used modern astronomical techniques to improve his dead reckoning. Techniques for the determination of latitude such as astronomical observation of altitude were already in use for many years and Bouguer had introduced the circummeridian method in 1753 when publishing his "Treatise on Navigation". The determination of longitudes was more problematic, for it was first used by mariners and astronomers only 15 years earlier. Determination of longitudes was the major naval

choisis parmi les plus brillants de l'époque. Malheureusement, MONGE, affecté à l'"Astrolabe", est débarqué à Teneriffe pour raison de santé. DAGELET, choisi par BORDA lui-même sur le conseil de l'astronome LALANDE, est le plus jeune Académicien du moment.

Le plus grand soin aussi a été apporté au rassemblement de la documentation et de l'instrumentation de navigation. Les meilleurs sources et fabricants sont mis à contribution: des cercles à reflextions de l'atelier de LENOIR; la toise du Pérou, de l'Académie des sciences; un quart de cercle de l'Académie de Marine; une lunette méridienne; 5 montres, 2 horloges à poids (N° 18 et 19), 2 petites horloges à ressort, de BERTHOUD, fournisseur attitré et exclusif de la Marine; 2 compas azimutaux, 2 théodolites, 4 compas de route, 3 sextants, 2 baromètres, 4 thermomètres, achetés chez les meilleurs fournisseurs anglais. Le Board of Longitudes prêta même les 2 boussoles d'inclinaison qui avaient servi lors du premier voyage de COOK. Les documents astronomiques de navigation ne manquent pas non plus. On comptait parmi eux les Tables de MAYER, le Nautical Almanac pour les années 1786-90, les traités d'astronomie de LA CAILLE et de LALANDE, le traité des horloges marines de BETHOUD.

Mais comment furent utilisés tous ces moyens? c'est ce à quoi nous allons nous efforcer de répondre. Les grandes navigations transocéaniques se faisaient à l'estime, rectifiée par des déterminations de la latitude au moyen de la mesure de la hauteur d'un astre (le soleil le plus souvent) lors de son passage au méridien. L'estime permettait, en effet, à partir de la mesure de la vitesse et du cap, d'évaluer la route parcourue en 24 heures, ce que les marins anglais appelaient le "travail de la journée". Le gabier comptait le nombre de noeuds de la ligne de loch qui filait entre ses mains, le temps qui s'écoule, en 30 secondes, la coquille d'oeuf pulvérisée contenue dans le sablier. Si l'espacement entre deux noeuds successifs était de 1/120 de mille, on obtenait directement la vitesse en noeuds. La simplicité de l'opération ne doit pas faire perdre de vue qu'elle posait l'important problème des unités de mesure de longueur et de leur rattachement à la valeur du rayon terreste. En France, jusqu'à l'adoption officielle du système métrique, en 1801, l'unité de mesure était matérialisée par la "toise du Chatelet" (1,95 m) où les drapiers étaient tenus de comparer leurs règles de mesure. La mesure par PICARD de l'arc de méridien Paris-Amiens en 1669-1671, précisa de façon suffisante our les navigateurs la valeur de la minute sexagésimale. Pourtant, jusque vers les années 1780, les officiers de marine instruits et les hydrographes dénoncent des valeurs de la ligne de loch comprises entre 42 et 45 pieds alors que la valeur jugée exacte est de 47 pieds 6 pouces. Il est vrai que les valeurs systématiquement minimisées de l'unité de mesure voulaient tenir compte de l'"eau morte" que le navire entraînait avec lui, et de l'usure des sabliers; elles permettaient aussi, en exagérant en moyenne les distances parcourues, d'anticiper les atterrissages et leur danger. Le cap du navire était mesuré au compas. Le compas de route servait à gouverner tandis que le compas de variation servait à l'observation des azimuts, d'où on déduisait la valeur de l'angle entre l'aiguille et le méridien. L'ignorance de l'influence des masses métalliques à bord des navires ne permettait pas de tenir compte rigoureusement de la déviation; d'ailleurs les timoniers gouvernaient d'après les "aires de vent" c'est à dire à quelques degrés près. Tout en ayant recours aux méthodes traditionnelles pour sa navigation à l'estime, LAPEROUSE y apporta le plus grand soin, en particulier en utilisant des unités de longueur exactes pour la mesure des distances. N'avait-il pas, à son bord, l'étalon de longueur, la "toise du Pérou" qui avait servi à LA CONDAMINE pour la mesure d'un arc de méridien au Pérou (1735-1744)? Mais surtout LAPEROUSE comme COOK eut recours aux récentes méthodes d'astronomie nautique pour corriger son estime. La mesure de la latitude par des hauteurs méridiennes du soleil ou d'étoiles était accessible depuis longtemps scientific task of the 18th century, ever since the 1714 and successively better rewards offered by the British parliament for the determination of longitude accurate to half a degree after 42 days at sea (the average time needed to cross the Indian or Atlantic oceans). The principle to be used was simple and well known, i.e., the longitude difference between two points is equal to the difference between local times of the same two points. The local time at a specific location could be obtained from astronomical observations. The problem, however, was to obtain the local time for the reference meridian for the same instant. Nowadays, the problem is solved by radio transmission of reference time signals. During the 18th century two techniques were simultaneously developed. One of the techniques — the clock method — was based on keeping track of the reference (Paris or Greenwich) local time by using a precise clock. The other technique — the lunar method — was to measure the position of the moon against a stellar background and to compare the position so obtained to that predicted for the reference meridian at the same instant, i.e., local time for the reference meridian. The lunar method made use of the apparent eastward lunar motion of half a degree per hour or one complete revolution in approximately one month. Both methods required ephemeris, the application of corrections for refraction and parallax, and the use of precise marine angular determination instruments. As well, the factor of 30 between the apparent motions, against a stellar background, of the sun and that of the moon produces an accuracy degradation of the same order in longitude determination as compared to the determination of the celestial body-moon distance. In practice three observations were required: the celestial body-moon (or sun) distance and the altitude determinations of the moon and celestial body (or sun) respectively.

Based on Clairault's method (1750) the Gottingen astronomer Tobie Mayer compiled, in 1753, tables for the moon's motion which made possible longitude determination to better than one degree. Also, in 1767 Maskelyne using an improvement on La Caille's (1765) method compiled tables for the "Nautical Almanac" for longitude calculation based on distances between the moon and the sun as well as other selected celestial bodies. A longitude calulation could be completed in half an hour; Greenwich was used as the reference meridian from the time of the insertion of Meskalyne's tables into the Nautical Almanac, in 1774, until 1788. Unfortunately, Mayer's tables did not preserve their accuracy for long, for lunar secular acceleration was not taken into account at the time of compilation. Accurate lunar tables did not become available until 1786, the year of the discovery of secular acceleration by Laplace. La Perouse made use of the Nautical Almanac for the years 1786 to 1790.

Measurement of angles at sea, whether they relate to angular distances between celestial bodies, to their altitudes or to angular distances between prominent features on shore form the basis for any nautical instrument, In the days of La Perouse, mariners were using the Davis Quadrant, a wooden instrument designed in 1594. Its average precision was only of one tenth of a degree, but it was less expensive than the more modern octant or sextant. It became possible in the mid eighteenth century to measure angles at sea with a precision of one sexagesimal minute using Hadley's quadrant. Based on the principle of double reflection, the instrument was insensitive to the vessel's motion. The successive adoption of octants, sextants and some modified forms of reflection circles was due, to a great part, to improvements relating to size, angular coverage, graduation and mirror construction. With the adoption of more precise instruments, it became necessary to apply various corrections such as those relating to instrumental errors, curvature of the earth, refraction, sun's semi-diameter and parallax.

Clock making techniques in France and in England were greatly improved around 1770. In France, Ferdinand Berthoud became

déjà, et BOUGUER avait étendu l'usage de la méthode par des observations circumméridiennes depuis 1735 (année de publication de son "Traité de la Navigation"). Mais il en allait autrement de la longitude dont les marins et les astronomes avaient triomphé il y avait moins de 15 ans. La détermination de la longitude avait été l'obsession majeure du monde savant s'occupant de la navigation au 18è siècle, depuis que l'Acte du Parlement britannique avait lancé, en 1714 son appel d'offre avec des prix de valeurs croissantes our une précision allant jusqu'au demi degré après une traversée de 42 jours (durée moyenne des traversées de l'Atlantique ou de l'Océan Indien). Le principe de la mesure était simple et connu depuis longtemps: la différence de longitudes entre deux points est égale à la différence des heures locales mesurées simultanément à ces deux points. Or il est facile de déterminer une heure locale en mesurant la hauteur d'un astre connu et en résolvant un triangle sphérique; mais comment savoir quelle était l'heure locale au méridien origine au même instant? Aujourd'hui on résoud le problème en écoutant les dignaux horaires. Au 18è siècle, deux méthodes furent mises en oeuvre parallèlement. L'une consistait à emporter avec soi le temps du méridien origine (Paris ou Greenwich) grâce à un "garde-temps"; c'est la méthode du chronomètre. L'autre consistait à mesurer la position de la lune sur un fond d'étoiles et la comparer à celle prédite à la même heure locale au méridien origine; c'est la méthode des distances lunaires. En somme, on utilisait le caractère errant de la lune, qui se déplace sur fond d'étoiles d'ouest vers l'est de 0°5 environ par heure et accomplit donc une révolution complète en à peu près un mois. Dans les deux cas, il fallait disposer d'éphémérides donnant les coordonnées des astres (et de la lune dans la deuxième méthode), corriger les mesures des effets de la réfraction et de la parallaxe, et disposer d'instruments précis de mesures angulaires à la mer. On se rend compte en outre que le facteur 30 entre les déplacements relatifs du soleil et de la lune sur fond d'étoiles entraîne une dégradation du même ordre dans la précision de la longitude comparée à celle de la mesure de la distance astre-lune. Dans la pratique, les observations à la mer comprenaient trois mesures: Celle de la distance angulaire lune-astre (ou soleil), et celles des hauteurs respectives de la lune et de l'astre (ou du soleil).

En utilisant la méthode de CLAIRAULT (1750), l'astronome Tobie MAYER, de Göttingen, dressa en 1753 des tables des mouvements de la lune qui permettaient d'atteindre une précision meilleure que le degré de longitude. Le perfectionnement de la méthode introduit par LA CAILLE en 1765 profita à PASKELYNE, qui dressa, dès 1767 dans le "Nautical Almanac", des tables pour calculer la longitude à partir des distances lunaires au soleil et à un certain nombre d'étoiles. Le calcul de la longitude prenait une demi-heure; le méridien de Greenwich était pris pour origine, ce que fit la Connaissance des temps jusqu'en 1788, après avoir inséré les tables de MASKELYNE en 1774. Malheureusement, l'exactitude des tables de MAYER ne devait pas se maintenir longtemps car il avait négligé l'accélération séculaire du mouvement moyen de la lune qui fut découvert par LAPLACE en 1786. Alors seulement fut maîtrisée la prédiction de cet astre errant. LAPEROUSE avait emporté le Nautical Almanac pur les années 1786 à 1790.

La mesure des angles à la mer, qu'elle concerne des distances angulaires entre astres (lune, soleil, étoiles), des hauteurs d'astres au-dessus de l'horizon, ou éventuellement des écarts angulaires entre des points remarquables à la côte, est à la base de l'instrumentation nautique. À l'époque de LAPEROUSE, les marins faisaient usage du Quartier de DAVIS, un instrument en bois, inventé en 1594, dont la précision moyenne était de dixième de degré, mais qui avait l'avantage de coùter moins cher que les modernes octants ou sextants. Cependant la mesure des angles à la mer avec la précision de la minute sexagésimale était accessible dès le milieu du 18è siècle, après l'invention en 1731, par HADLEY, de son fameux quadrant. Basée sur le principe de la the Royal Navy's exclusive supplier of marine clocks. Berthoud was also the Inspector of marine clocks. He made the five clocks used by La Perouse. Either method of longitude determination could be employed to achieve an average remarkable precision of 15 sexagesimal minutes. The lunar method, as previously stated, suffered from an angular measurement degradation by a factor of thirty. However, the technique produced absolute determination of longitude. The clock method precision was a reflection of the clock's precision. Both methods were of comparable accuracies. The lunar method, however, was preferred for absolute longitude determination and the clock method for relative determination between two known points, as used by La Perouse.

Cartographic Documentation

Exploratory expeditions preceding La Perouse's voyage were few and incomplete. Sir Francis Drake gave up his search for a passage across North America in 1579 after reaching Cap Flattery. In 1592, the Spanish viceroy of Mexico sent Juan de Fuca to explore the area surrounding the strait that now bears his name. In 1774, the viceroy of Mexico sent another Spanish naval officer, Juan Perez, to explore the coast south of Alaska. His mission was political, for it aimed at preventing any Russian claims to the surrounding territory. Juan Perez did reconnaissance work around Queen Charlotte Island and Vancouver Island. Following the American Declaration of Independence in 1776, Spanish, British and American vessels became more numerous around the northwest coast of America. In 1778 during his third expedition, James Cook, Captain of HMS RESOLUTION, spent a month at Nootka Sound before reaching the coasts of Alaska. His ship was accompanied by HMS DISCOVERY commanded by Captain Charles Clerke. On board HMS DISCOVERY was a young lieutenant by the name of George Vancouver.

In 1772 Bellin was succeeded by Jean-Nicolas Buache de la Neuville as adjoint director of the Map and Chart Office. It is Buache who selected the cartographic documentation needed for La Perouse's expedition. His selection was accomplished with great care and reflected the information obtained from the above mentioned expeditions. He was assisted in his task by his cousin Beautemps-Beaupre. Although he was the nephew of Philippe Buache, also the King's geographer, he disagreed with his uncle on the existence of a western sea. His cartographic documentation was based on the well documented Spanish expeditions as well as Cook's voyage. La Perouse's cartographic documentation was quite voluminous. It came from numerous and often unconnected sources. In fact La Perouse's mission was partly to acquire continuous hydrographic information for the 1500 miles coastal section connecting Alaska (60° N) to California (35° N).

Reconnaissance of the Coasts of North America

Taking into account the various tasks to be accomplished as well as the seasonal meteorological constraints, La Perouse had at his disposal only 2 to 3 months to perform the reconnaissance of the western coast of North America, search for a possible route to Hudson Bay as well as to build a foundation for a future fur trade. He expressed a global and realistic view of his mission when he noted that "the true coastal orientation, the determination of latitudes and longitudes of landmarks will ensure to our work a usefulness that will be appreciated by all mariners". Those were the tasks to which he devoted the better part of his time between June 23, 1786, when he arrived at Mount Saint Elias, and September 14, when he reached Monterey. La Perouse had established a careful schedule for his mission. Taking into account displacements between sites, meteorological conditions of a monsoon sea and the delays caused by a summer reconnaissance off the coasts of Asia Minor, Japan and the Chukchi Peninsula, he had estimated reaching Monterey between September

double réflexion, la mise en coïncidence de deux points était insensible aux mouvements de plateforme. Le passage de l'octant au sextant, et sous une forme légèrement différente au cercle à réflexion, n'était qu'une affaire d'adaptations portant sur les dimensions, la couverture angulaire, la graduation des limbes et la construction des miroirs. Avec les progrès de l'instrumentation, il était devenu nécessaire de tenir compte de corrections variées: instrumentales, dépression de l'horizon, réfraction, demi-diamètre pour le soleil, parallaxe.

La technique des chronomètres, en France comme en Angleterre, connut un développement intense vers les années 1770. En France, Ferdianand BERTHOUD obtint le privilège exclusif de la fourniture des horloges marines aux vaisseaux du roi, avec le titre d'Inspecteur des horloges marines. Il avait fabriqué les 5 horloges remises à LAPEROUSE. La méthode basée sur les distances lunaires et celle basée sur les chronomètres rivalisèrent de précision pour déterminer les longitudes à 15' près en moyenne, ce qui était un progrès considérable. La première comme nous l'avons vu plus haut souffrait d'une dégradation d'un facteur 30 dans les mesures angulaires, mais elle était absolue. La seconde était tributaire des irrégularités de marche des chronomètres. Au total la précision des deux méthodes était comparable, mais la première se recommandait pour des déterminations absolues et la seconde pour des interpolations entre deux points connus et c'est bien comme cela que LAPEROUSE en fit usage.

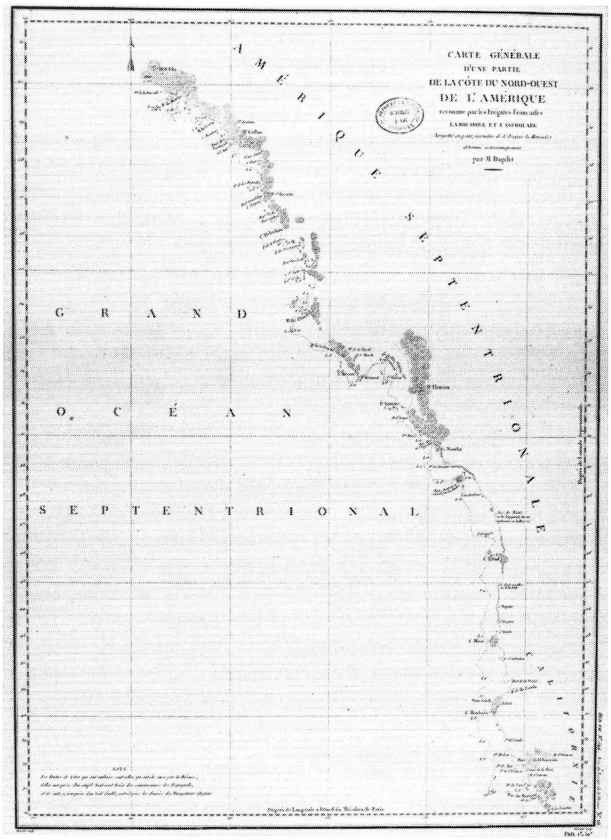
La documentation cartographique.

Les reconnaissances qui avaient précédé la mission de LAPEROUSE avaient été peu nombreuses et sommaires. Sir Francis DRAKE avait abandonné la recherche d'un passage au nord de l'Amérique lorsqu'il atteignit le Sud du cap Flattery en 1579. En 1592, le vice-roi espagnol du Mexique envoya Juan de FUCA dans les parages du détroit qui porte son nom. En 1774, le vice-roi du Mexique, envoya un officier de marine espagnol, Juan PEREZ, explorer la côte au sud de la limite actuelle de l'Alaska, dans le but politique de prévenir des revendications russes. Juan PEREZ exécuta des levés de reconnaissance dans la zone des îles de Reine Charlotte et de l'île de Vancouver. Après la déclaration d'indépendance des États-Unis en 1776, la présence de marins espagnols, britanniques et américains se renforça dans ces parages. James COOK, commandant le HMS "Resolution", passa un mois en 1778 à Nootka Sound, lors de son 3è et dernier voyage, avant de se rendre directement sur les côtes de l'Alaska. Il était accompagné du capitaine de frégate Charles CLERKE, commandant le HMS "Discovery", à bord duquel se trouvait un jeune enseigne du nom de George VANCOUVER.

Jean-Nicolas BUACHE de la NEUVILLE succéda en 1772 à BELLIN comme directeur adjoint du Dépôt des Cartes et Plans. C'est lui qui fut chargé de rassembler la documentation cartographique pour l'expédition de LAPEROUSE, ce qu'il fit avec le plus grand soin en s'appuyant sur les sources évoquées ci-dessus. Il fit appel à son cousin BEAUTEMPS-BEAUPRE pour la mise en forme de cette documentation. Géographe du roi, comme son oncle Philippe BUACHE, il eut la prudence de ne pas le suivre dans son hypothèse d'une mer de l'ouest, et de s'en tenir aux certitudes cartographiques qui se dégageaient de levés espagnols et du voyage de COOK. Les sources cartographiques de LAPEROUSE n'étaient pas négligeables mais elles étaient d'origines diverses et non reliées géographiquement entre elles. LAPEROUSE avait pour mission d'obtenir une information hydrographique continue le long d'un vaste périmètre côtier s'étalant de l'Alaska (60° N) à la Californie (35° N) sur 1 500 milles.

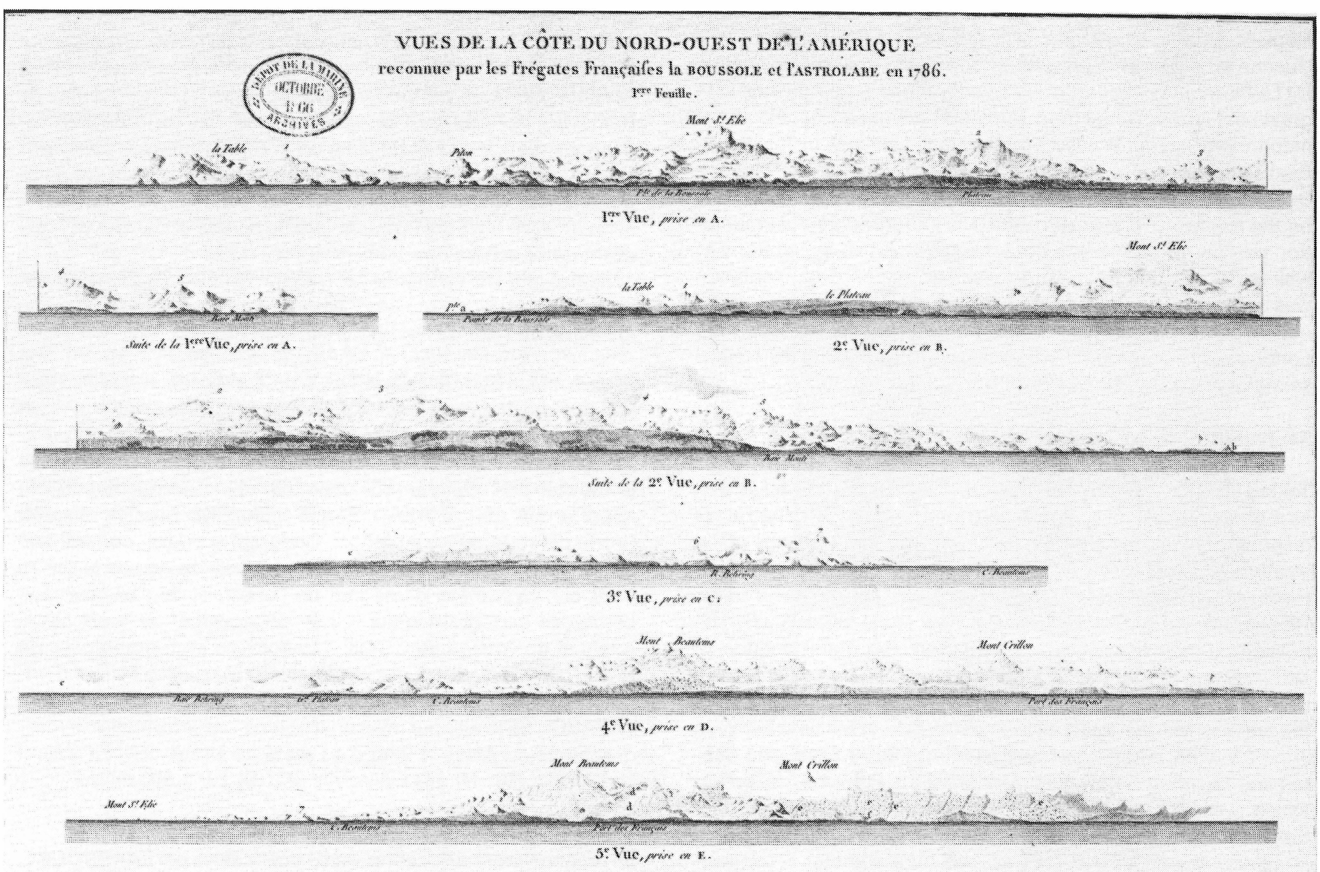
La reconnaissance des côtes nord-américaines par LAPEROUSE.

Compte tenu de son plan de campagne et des contraintes météro-



4 — Carte générale de la côte N-W de l'Amérique du Nord extraite de l'Atlas du Voyage de LAPEROUSE (Planche 16).

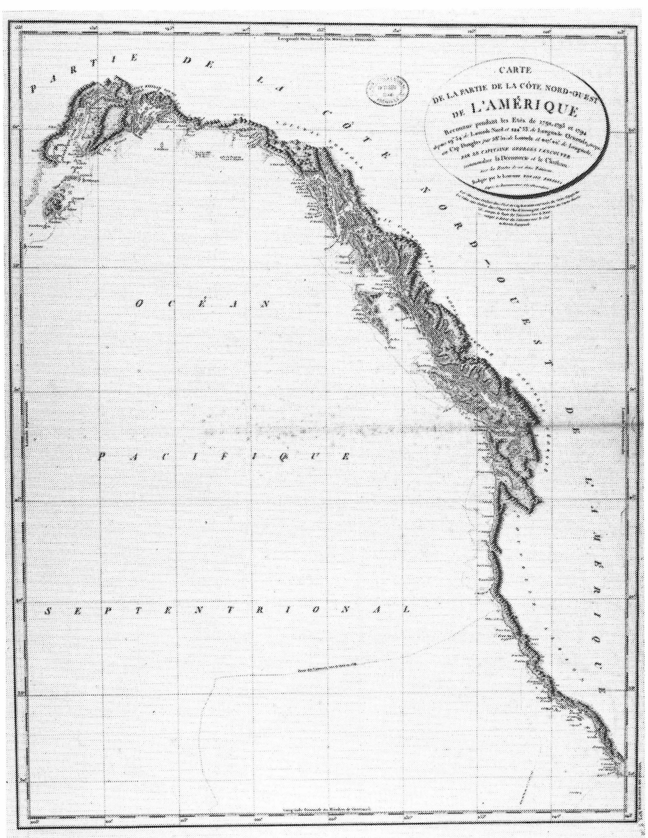
logiques saisonnières, LAPEROUSE ne disposait que de 2 à 3 mois pour reconnaître cette fraction du littoral nord américain, chercher les voies d'eau éventuelles vers la Baie d'Hudson et jeter les bases d'un commerce de fourrures. Il avait une vue globale très réaliste de sa mission en affirmant dans son journal: "la vraie direction de la côte, la détermination en latitude et en longitude des points le plus remarquables, assureront à notre travail une utilité qui ne sera méconnue d'aucun marin". C'est grosso modo, ce à quoi il s'appliqua entre le 23 juin 1786, en atterrissant sur le Mont Saint-Elias et le 14 septembre, jour de son arrivée devant Monterey. LAPEROUSE avait fait un compte à rebours prenant en considération les transits, les conditions météorologiques dans un océan à mousson et le délai de reconnaissance des côtes de Tartarie, du Japon et du Kamtchatka, qu'il voulait visiter pendant l'été; sa conclusion était qu'il fallait se présenter à Monterey entre le 10 et le 15 septembre, ce qu'il fit. Les conditions météorologiques qu'il rencontra sont conformes à celles décrites dans nos modernes instructions nautiques: des brouillards d'advection assez fréquents, causés par des vents d'ouest soufflant au-dessus des secteurs côtiers d'eau froide, plus denses et persistants dans les chenaux intérieurs et les "sounds", mais se dissipant souvent au cours de la journée. La visibilité était un critère essentiel pour la réussite des opérations. Elle conditionnait les observations astronomiques qui jalonnèrent le cabotage de l'Astrolabe et de la Boussole à une douzaine de milles de la côte en moyenne et permirent de dresser le canevas des routes. Pendant une navigation d'une cinquantaine de jours on put observer des distances lune-soleil, des méridiennes ou des hauteurs d'astre un jour sur deux environ. Une bonne visibilité était aussi indispensable à la détermination approximative du trait de côte, au relèvement des caps et des sommets remarquables de l'arrière-pays. Comme BEAUTEMPS-BEAUPRE le fit un peu plus tard, mais sans recours systématique au cercle à réflexion, LAPEROUSE fit appel



3 — Vues de côtes extraites de l'Atlas du Voyage de LAPEROUSE (Planche 18).

10th and 15th — he was there on the 14th. The meteorological conditions he had to face were similar to those prevailing nowadays: frequent fog patches caused by westerly winds blowing over the cold coastal regions. Fog was denser inside sounds and channels but would dissipate during day time. Visibility was an essential criterion to the success of the mission, for it restricted the pilotage of the ASTROLABE and the BUSSOLE and restricted astronomical observations and the charting of the route, to about twelve miles from the coast. During a fifty day period it was only possible to measure the moon-sun distance and the altitude of celestial bodies one day out of every two. A good visibility was also essential for the determination of the coastal outline and the detection of capes and inland summits. La Perouse, and Beautemps-Beaupre later on, made use as much as possible of visual verification of the coast in order to chart the foreshore. Without taking into account all the details such as the numerous archipelagos, channels and sounds of which La Perouse was fully aware, he concluded not without doubt, that the likelihood of finding an intra-continental waterway was practically nil.

It was not until Vancouver conducted a detailed survey of the area explored by La Perouse that the idea of an oriental bound waterway could finally be discounted. In his mission report Vancouver correctly stated that he was proud that his accurate reconnaissance of the north-west coasts of America would finally dissipate any remaining doubts about a possible north-west passage. He also noted that it should not be believed any longer that it would be possible for a vessel to reach the inner part of America from the Pacific ocean along the coastal section that he had explored.



5 — Carte extraite de l'Atlas du Voyage de VANCOUVER (Planche 3).

dans toute la mesure du possible aux vues de côtes pour dresser la carte du littoral. Au total, sans entrer dans le détail d'une cartographie complexe du semis d'îles qui borde cette côte, des chenaux intérieurs et des sounds, dont il eut cependant bien conscience, LAPEROUSE en prenant quelque risque de se tromper, eut la conviction qu'il n'y avait aucune chance de trouver une large voie de pénétration fluvio-maritime du continent nord-américain dans ces parages.

Il fallut attendre les travaux de VANCOUVER, comme nous l'avons vu plus haut, pour qu'un levé détaillé de la zone reconnue par LAPEROUSE, ne laisse plus aucun doute sur l'hypothétique voie de pénétration. Dans son rapport de mission, VANCOUVER écrivit à juste titre: "Je me flatte que notre reconnaissance très précise de la côte nord-ouest de l'Amérique dissipera tous les doutes et écartera toutes les fausses opinions concernant un passage par le nord-ouest; qu'on croira plus qu'il y ait une communication pour des vaisseaux entre la mer Pacifique du nord et l'intérieur du continent de l'Amérique, dans l'étendue que nous avons parcourue".

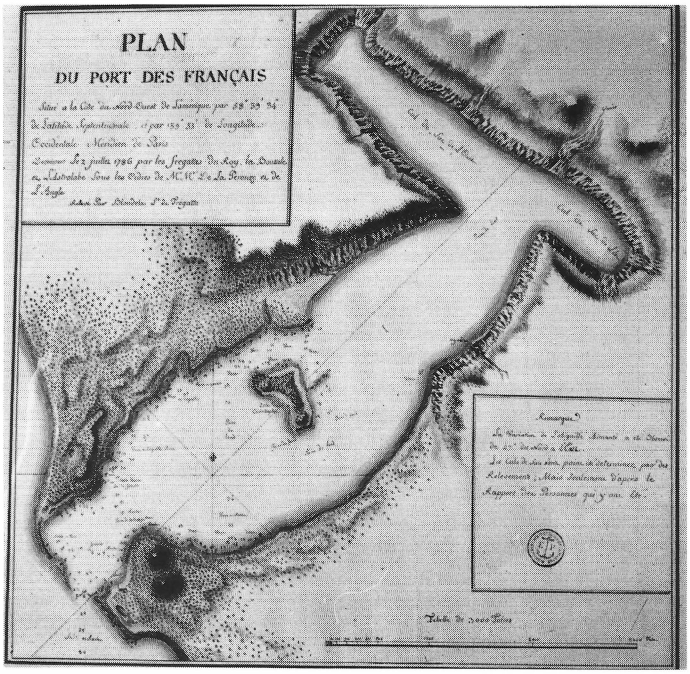
L'escale tragique au Port des Français (LITUYA BAY).

Peu de jours après avoir atterri sur la côte nord américaine devant le Mont St. Elias, les navires de LAPEROUSE se présentèrent le matin du 3 juillet 1786 devant la passe de la baie du Port des Français (Lituya Bay). L'occasion parut bonne pour explorer la baie et ses possibles raminifications, pour approcher les indiens qui manifestement chassaient la loutre et surtout pour profiter d'un plan d'eau calme pour "changer presque entièrement notre arrimage, afin d'en arracher six canons placés à fond de cale, et sans lesquels il était imprudent de naviguer dans les mers de la Chine, fréquemment infestées de pirates". Marlgré la reconnaissance faite sans difficulté en canot la veille, l'entrée dans la baie, contrariée par une saute de vent et le courant, fut délicate au point que LAPEROUSE écrivit dans son journal: "Depuis trente ans que je navigue, il ne m'est pas arrivé de voir deux vaisseaux aussi près de se perdre". Il faut préciser que la passe d'entrée n'était large que de 320 mètres et parcourue par un violent courant en dehors des étales. Les travaux commencèrent sans difficultés particulières par une reconnaissance du fond de la baie, car comme le déclara LAPEROUSE non sans quelque naïveté "c'était au fond de cette baie que nous espérions trouver des canaux par lesquels nous pourrions pénétrer dans l'intérieur de l'Amérique. Nous suposions qu'elle devait aboutir à une grande rivière dont le cours pouvait se trouver entre deux montagnes, et que cette rivière prenaint sa source dans un de grands lacs au nord du Canada". Il fallut naturellement déchanter, et nous lisons un peu plus loin dans son journal: "nous retournâmes tous à bord, ayant achevé en quelques heures notre voyage dans l'intérieur de l'Amérique".

Le levé terrestre de la baie fut exécuté selon les méthodes régulières par les ingénieurs BERNIZET et MONNERON après que le lieutenant de frégate BLONDELA eut mesuré une base. La détermination d'un point astronomique fut faite à proximité d'un petit campement sur un îlot qui devait prendre le nom de l'île de cénotaphe. Enfin LAPEROUSE ordonna de "placer" les sondes sur la carte terrestre qui venait d'être dressée. Le travail fut confié à des officiers de marine le 13 juillet, sur instructions écrites de LAPEROUSE, qui avait mis en garde de façon explicite et par écrit le responsable de l'opératon, M. d'ESCURES, son premier lieutenant, contre la violence des courants dans la passe d'entrée et le danger des brisants jusqu'à l'étale qui devait se produire vers 8 h 30. Trois embarcations furent mises à l'eau vers 6 heures du matin: une biscayenne de la Boussole (LAPEROUSE), commandée par d'ESCURES, une biscayenne de l'Astrolabe (de LANGLE), commandée par de MARCHAINVILLE, un canot de la Boussole, commandé par le lieutenant de vaisseau BOUTIN. Les

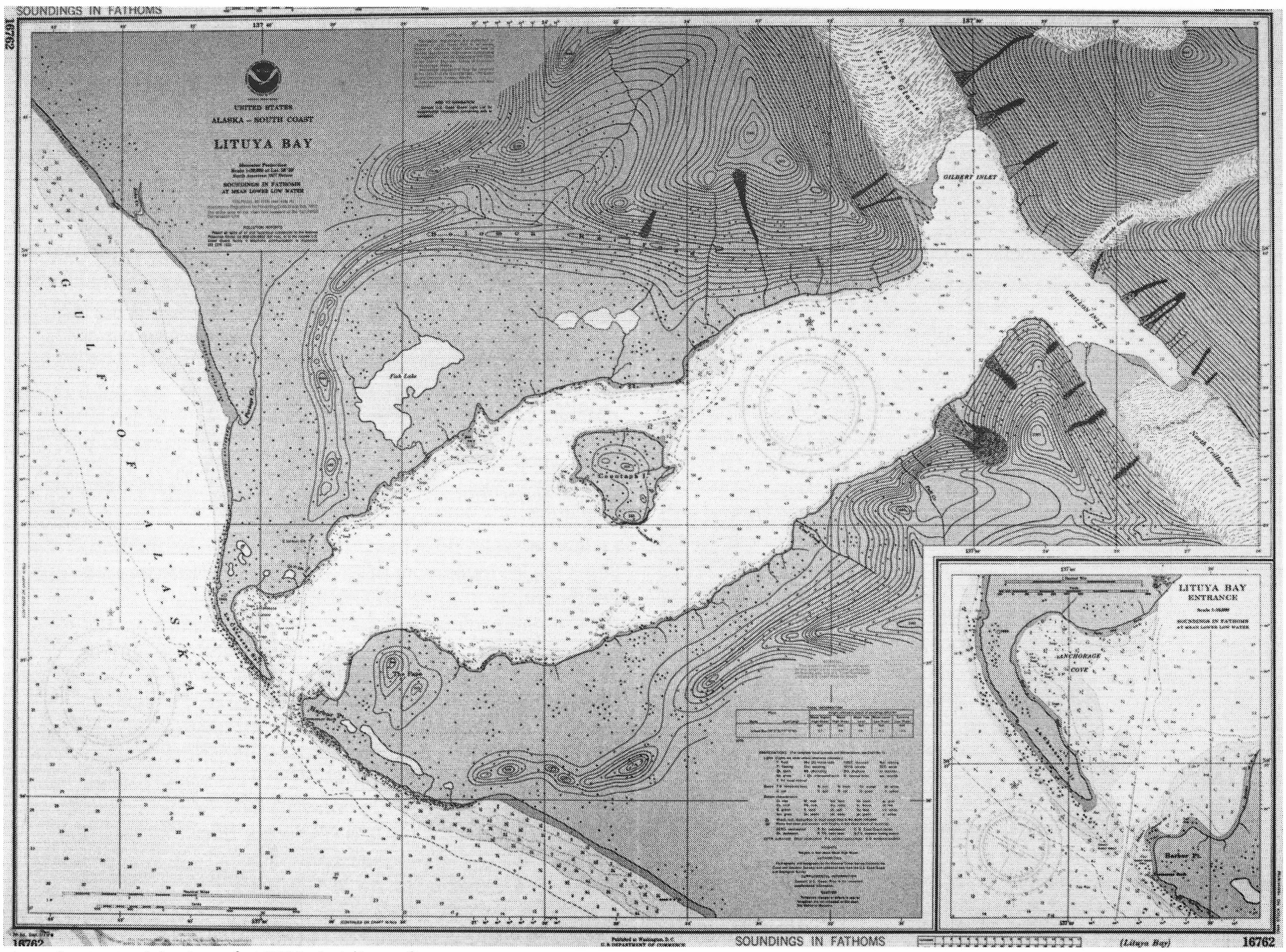
The Tragic Lituya Bay Anchorage

Soon after reaching the coast of North America near Mount Saint Elias, La Perouse's vessels arrived at the entrance to Lituya Bay on the morning of July 3rd 1786. The time seemed appropriate to explore the bay and its possible inner channels, to make contact with the natives who were hunting otters and to take the opportunity of the calm water to "reorganize his vessel and remove from the hold the six cannon without which it may be unwise to sail the China Seas, which were often visited by pirates". Regardless of the previous night's canoe reconnaissance, the bay, which was subject to varying winds and currents, had proven difficult to enter. La Perouse noted in the ship's log: "Of all thirty years that I have been sailing, it is the first time that I have come close to witnessing the wrecking of two vessels." It should be emphasized that the entrance to the bay was only 320 meters wide and subject to strong currents at all times other than slack water. The work proceeded without much difficulty beginning with a reconnaissance of the far shore of the bay, since as noted by a slightly naive La Perouse "it was on the far shore of that bay that we were hoping to find a waterway to the inner continent. We assumed that the bay should connect to some major river running between the mountains, and that the river should drain from one of the great lakes of northern Canada." It was, of course, necessary to sing a different tune, and a further log entry stated that "they all returned to the vessels having completed within a few hours their trip inside America."



7 — Plan du "Port des Français", par Blondéla.

The land survey was completed by the engineers Bernizet and Monneron in a conventional manner according to a baseline established by the frigate lieutenant Blondela. Astronomic



8 — Carte américaine n° 16762 de Lituya Bay.

determination of latitude and longitude for a point located on an island, later known as Cenotaph Island, was obtained. La Perouse then gave order to "locate" the soundings on the newly prepared map. That mission was given on July 13 to the naval officers. Mr. d'Escures and his first lieutenant were given written instruction by La Perouse. As part of the instruction there were explicit warnings against the danger of the fast current at the entrance to the bay as well as the danger of breakers until slack water around eight thirty. Three craft were launched around six o'clock that morning: one biscayenne from the BOUSSOLE with d'Escures, one biscayenne from the ASTROLABE with Marchainville and one canoe from the BOUSSOLE with Boutin. The mission of the three craft was to sound three parallel lines across the entrance to the bay. The craft had reached their working positions by 7:15 a.m. The ebb first pushed the BOUSSOLE's biscayenne away from the bay. The craft then overturned in the rough sea. The other biscayenne was a victim of similar fate as it attempted to rescue the crew. Only the canoe remained afloat, partly a consequence of its easier handling and the prudence of its crew. Six officers and fifteen crew members lost their lives that morning.

It is today possible to confirm the information on the tides and currents for the day of the tragedy. In his instructions La Perouse had estimated that slack water would occur around eight thirty and Boutin noted in his report of the accident, that in effect the "tides had been active until 8:45 a.m.". On the other hand, based on the Schwiderski's tidal atlas, the American Tidal Current Tables for the years 1974 and 1975 and the "Services Hydrographique et Oceanique de la Marine", (SHOM) Tide Tables for Major Harbours, it is possible to compile the following table:

LITUYA BAT (entrance) JULY 13, 1786
LOCAL TIME

MAXIMUM EBB	LOW WATER	SLACK WATER	MAXIMUM CURRENT	HIGH WATER
5 h 50	7 h 58	8 h 52.5	12 h 05	14 h 27
6.0 knots	- 0.55 m	0 knots	6.6 knots	2.87 m

By reaching the entrance of the bay one and a half hours before slack water the craft had to face a current of approximately 4 knots. If the Captains had respected La Perouse's instructions, the tragedy could have been avoided. Nautical instructions for British and American mariners warn coxswains of small craft against the very real danger of breakers occuring in conjunction with the ebb tide and a southwesterly swell. They advise mariners not familiar with the area to reach the entrance to the bay at slack water. The maximum currents, as stated in British instructions, can reach eight knots on the ebb and 12 knots during the flood. The ebb flows to sea like a river narrowed over several miles and creates a phenomenon characteristic of a bay. La Perouse was well aware of that danger; it had also been noticed that "indians were especially afraid of the entrance to the bay and would never venture in it outside of slack water. It was clear, he noted, that when the indian craft were located near the entrance to the bay, the chief or at least the tallest indian would stand up with his arm pointed toward the sun seemingly invoking its mercy while the other indians would be rowing with great vigour".

Conclusion

At first impression it appears that La Perouse's North American expedition was a failure. Of course some results had been accomplished such as the preliminary sketches of the still largely unknown coasts; the strengthening of the arguments in favour of the non-existence of a waterway leading to the inside of the continent; the confirmation of the viability of a fur trade; increased scientific knowledge relating to wildlife and mineral-

trois embarcations devaient sonder la passes dans le sens de la largeur et en formtion parallèle. Elles se présentèrent devant la passe vers 7 h 15. Le courant de jusant entraîna d'abord la biscayenne de la Boussole vers l'extérieur de la baie, qui soumise à l'action opposée de la houle chavira la première dans la mer hachée constituée par la barre. La biscayenne de l'Astrolabe, qui s'était généreusement portée à son secours, chavira à son tour dans les mêmes conditions. Seul le canot de la Boussole, plus prudent dans sa manoeuvre et sans doute aussi plus manoeuvrant, échappa au désastre. Six officiers et quinze membres de l'équipage périrent dans le naufrage des deux biscayennes.

Il nous est possible aujourd'hui de confirmer les informations concernant la marée et les courants le four du naufrage. Dans ses instructions écrites LAPEROUSE pensait que l'étale aurait leur vers 8 h 30m et BOUTIN dans son rapport des évènements note que "la marée a porté au large jusque vers 8 h 45m". En réalité, selon l'atlas marégraphique de SCHWIDERSKI, les "Tidal Current Tables" américaines de 1974 et 1975 et la "Table des marées des grands ports du monde" du SHOM, on peut dresser le tableau suivant:

LITUYA BAY (entrée) — 13 juillet 1786
Heures locales

Maximum jusant	Basses mer	Étale du jusant	Maximum flot	Pleine mer
5 H 50^{m}	7 H 58	8 H 52,5^{m}	12 H 05^{m}	14 h 27
6,0 noeuds	-0,55^{m}	0 noeud	6,6 noeuds	2,87^{m}

En se présentant dans la passe d'entrée 1 H 30^{m} environ avant l'étale de basses mer, les biscayennes ont rencontré un courant de l'ordre de 4 noeuds (d'après la règle des douzièmes). Le respect des instructions de LAPEROUSE aurait évité le drame. Les instructions nautiques américaines et anglaises mettent en garde de la façon la plus formelle les navigateurs à bord de petites unités contre le danger mortel des lames déferlantes lors du jusant en présence de houle du sud-ouest. Il est recommandé aux navigateurs non familiers des lieux de se présenter devant l'entrée de la baie à l'étale de courant. Les courants maximum atteignent, selon les instructions anglaises 8 noeuds en morte eau et 12 noeuds en vive eau. Le jusant s'écoule en more comme un fleuve étroit sur plusieurs milles et constitue un phénomène remarquable signalant la baie. LAPEROUSE était bien conscient du danger; il avait notamment remarqué que les "Indiens paraissaient beaucoup redouter la passe, et ne s'y hasardaient jamais qu'à la mer étale du flot ou du jusant: nous apercevions distinctement, dit-il, que lorsqu'ils étaient entre les deux pointes, le chef, ou du moins l'Indien le plus considérable, se levait, tendait les bras vers le soleil, et paraissait lui adresser des prières, pendant que les autres pagayaient avec la plus grande force".

Conclusion.

Jugé en lui-même, le bilan de la phase nord-américaine de l'expédition de LAPEROUSE n'est pas entièrement positif. Certes, on a dégrossi le tracé d'un littoral en grande partie inconnu, renforcé l'hypothèse de l'absence d'une grande voie fluvio-maritime de pénétration vers l'intérieur, confirmé le potentiel en fourrures de la région visitée, collecté des observations et des échantillons du monde naturel, minéral et vivant, et pris quelques contacts humains. Mais à côté de cela, des erreurs et des échecs sont à mentionner. Y avait-il lieu de croire que la première baie rencontrée après l'atterrissage serait la bonne? le point de départ d'une voie d'accès vers l'intérieur? le mouillage idéal d'une flotte de commerce? le point de rencontre des chasseurs d'Amérique du Nord? Non, Lituya Bay (Port de Français) était une souricière.

ogy as well as the establishment of a better relationship with the local inhabitants. These successes, however, were plagued by miscalculations and failures. Why was the first encountered bay selected as the most promising site for the existence of a possible waterway; the best location to harbour a commercial flotilla, as well as the best location to make contact with North American hunters? Far from being the ideal location, Lituya Bay was in fact a death trap. The entrance to the bay was a real danger as the death of 21 sailors proved. Its depths were less than desirable. Also frequent cross winds made access to the bay difficult. The surrounding mountains should have removed all hope for the existence of an intercontinental waterway. Out of the three months timetable for coastal exploration, forty percent of the time was actually spent anchored (including 27 days in Lituya Bay). The task of finding an inner waterway was never fully completed even though the sketches of the coast were fairly accurate, given its complexity. Encounters with the nomad hunters had raised some problems to be resolved for the fur trade to be successful. In no way, however, could these encounters be regarded as a feasibility study. In the final analysis of La Perouse's expedition, however, the very circumstances in which it took place should be taken into account. His prestigious expedition with all its encompassing ambitions was the last of its kind. The ones that followed would be of a much more limited geographical extent such as Baudin's Australian expedition and that of Dumont d'Urville, or they would be of a more limited scope such as Freycinet's geophysical expedition or Vancouver's hydrographic mission. The success of such a limited expedition is more likely and also easier to judge. This was the case with Vancouver's expedition which entailed a difficult political and hydrographic task but was completed successfully.

In trying to summarize La Perouse's expedition it would be wise to try to understand some of the events by taking into account their human aspects. For example, it may be difficult nowadays to imagine the French Navy as it existed at the end of the 18th century. Lack of discipline was a very likely problem. The Lituya Bay tragedy could have been avoided if La Perouse's instructions had been explicitly followed. Similarly it would not be fair to hold La Perouse fully responsible for the aftermath of having to follow the King's orders regarding the fair-treatment of native people. La Perouse was ordered that force should be used only as a last resort. The ill-treatment of native people during the Spanish conquest, of course, was still fresh in the minds of 18th century sailors, but so were the recent deaths of Marion-Dufresne in New Zealand, Cook in the Hawaiian Islands and the ill treatment of Wallis in Tahiti. The events at Lituya Bay did not, however, have any tragic consequences. But, one may wonder about the wisdom of letting natives disarm the officers and to allow them to steal the astronomical observation records without meting out any punishment. Human dignity, as understood around the civilized world, should not have tolerated such behaviour. The universality and logic of philosophical theories lost some of their strength when confronted with reality. It is not known whether La Perouse's conduct was a reflection of the ideologies of his time. La Perouse was certainly a generous man with a mind open toward progress. As a warrior, explorer and skillful sailor, however, it appears that La Perouse often disagreed with the contemporary ideologies, which, it is true, were mostly enunciated by intellectuals who, as opposed to La Perouse, never had to apply them to the real world.

In conclusion, based on the scientific rigour of the observations, especially those relating to navigation, obtained during the North American leg of La Perouse's expedition, it may be stated that the expedition contributed greatly to global exploration. His contribution took place at the same time, not altogether without connection, as another breakthrough in occidental thinking. La Perouse like his most enlightened contemporaries was certainly

L'entrée de la baie était mortellement dangereuse et elle coûta la vie à 21 hommes; le plan d'eau, détestable, avec des sauts de vents inacceptables compte tenu des conditions de sortie. La chaîne de montagne toute proche n'aurait de laisser aucun espoir à une voie de pénétration! Sur les trois mois que dura l'exploration des côtes nord-américaines, 40% furent consommés en escales (dont 27 jours à Ports des Français) alors que le programme était très tendu. L'objectif concernant la voie de pénétration fluviomaritime ne put être atteint avec une complète certitude, même si la reconnaissance donnait une bonne physionomie d'ensemble d'un littoral, il est vrai, particulièrement complexe. Les contacts avec les chasseurs nomades avaient permis de se faire une idée des problèmes à aborder dans le cadre d'un commerce de fourrures, mais ne constituaient pas une véritable étude de marché. Il faut cependant corriger ce jugement concernant LAPEROUSE, car il avait d'importantes circonstance atténuantes. Son expédition de prestige, universelle par ses ambitions thématiques et géographiqes, est la dernière du genre. Celles qui suiveront seront géographiquement limitées, comme celle de BAUDIN en Australie et de DUMONT d'URVILLE, ou réduites à un thème, la géophysique par exemple comme celle de FREYCINET, ou l'hydrographie dans une zone limitée comme celle de VANCOUVER dans les mêmes eaux que LAPEROUSE en Amérique du Nord. Or il est plus facile du juger une opération aux objectifs limités et surtout plus probable de la mener à bien. Ce fut le cas de VANCOUVER qui joua une partie politique délicate avec succès tout en accomplissant une remarquable tâche hydrographique.

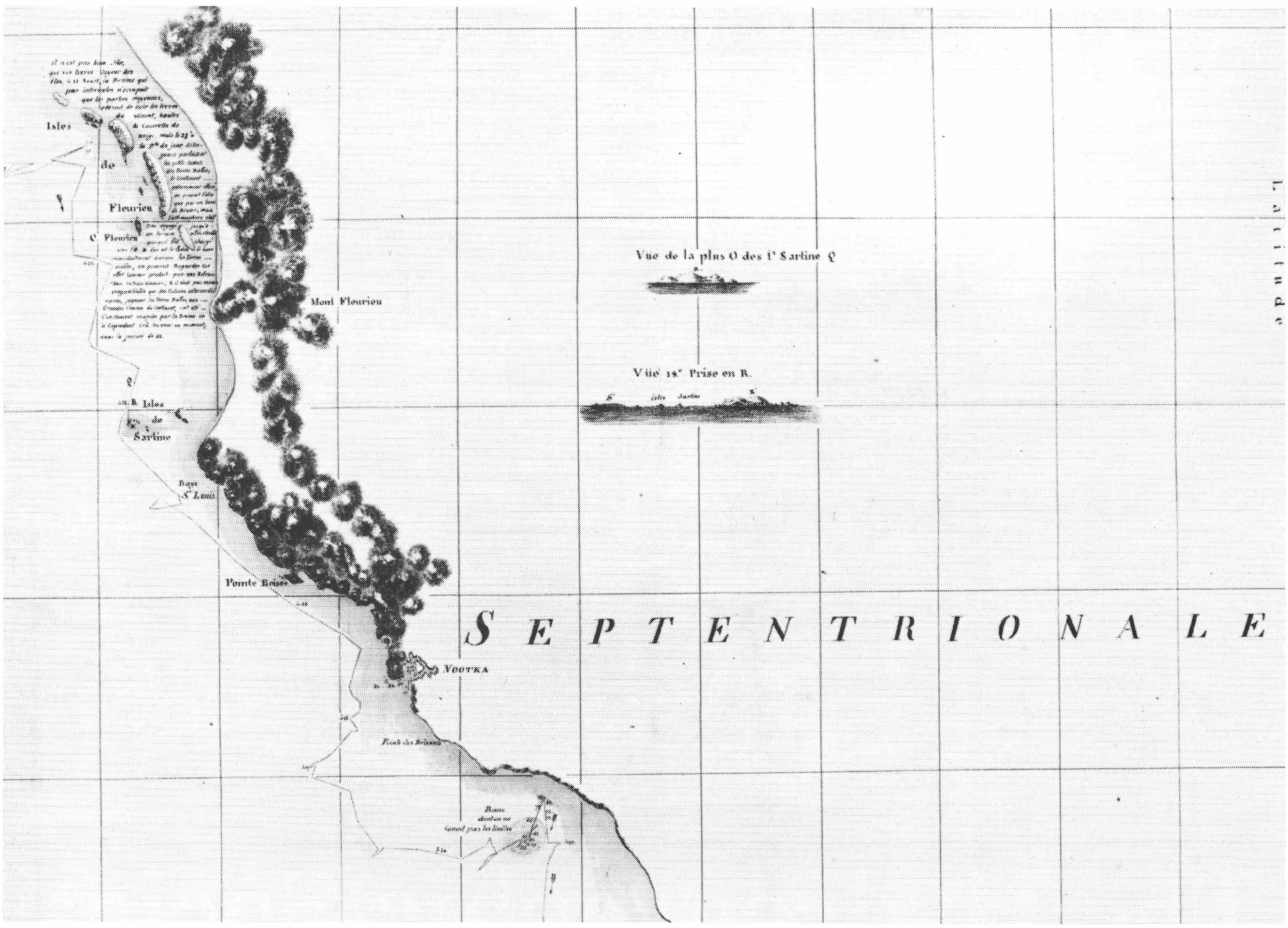
Mais la phase nord-américaine du voyage de LAPEROUSE appelle notre attention sur d'autres points qui risquent de prêter à confusion si l'on veut apprécier la personnalité de LAPEROUSE. Nous avons du mal à imaginer aujourd'hui la Marine française de la fin du 18è siècle, dont la discipline n'était sans doute pas le point fort. Ainsi, la tragédie du Port des Français aurait été évitée si les ordres écrits de LAPEROUSE avaient été respectés. De la même manière, il serait injuste de faire supporter directement à LAPEROUSE les conséquences des consignes de bienveillance concernant les indigènes qu'il avait reçues du Roi. Il avait reçu l'ordre de ne recourir à la force qu'en cas de nécessité absolue. Bien sûr, les navigateurs du 18è siècle avaient encore présent à l'esprit les abus de la conquête espagnole, mais ils se souvenaient aussi d'évènements récents qui avaient coûté la vie à MARION-DUFRESNE en Nouvelle-Zélande, à COOK aux îles Hawaï, et mis en danger WALLIS à Tahiti. À Port des Français, le comportement vis à vis ds indigènes n'eut pas de conséquences dramatiques mais était-il normal que des officiers se soient laissés dépouiller de leurs armes et de leurs uniformes et que l'on ait toléré le vol des carnets d'observations astronomiques? La dignité humaine, bien comprise sous toutes les latitudes, exigeait un autre comportement. Ainsi, l'universilité et la logique des Philosophes pâlissent sur le terrain. Et la question se trouve posée de savoir si LAPEROUSE partageait les idées de son temps et si tout jusqu'à quel point. En tant qu'homme généreux et esprit ouvert au progrès, la réponse est sûrement positive. Mais en tant que chef de guerre, explorateur et marin averti il est non moins certain qu'il a éprouvé et condamné les abus et les contradictions véhiculées en son temps par des penseurs qui n'avaient pas, comme lui, de lourdes responsabilités opérationnelles.

En conclusion, et même en se limitant à l'épisode nord-américain, on peut affirmer que par la rigueur scientifique de ses observations, et notamment celles concernant la navigation, l'expédition de LAPEROUSE est située à un tournant majeur de l'exploration du globe. Ce tournant arrive en même temps, — et ce n'est pas l'effet du hasard —, qu'un autre grand tournant de la pensée occidentale. LAPEROUSE a certainement partagé le sentiment de ses contemporains les plus éclairés d'appartenir à une civilisation dont l'avance imposait des devoirs humanitaires envers les moins favorisés. Mais les tragiques revers qui ont jalonné son well aware of the moral obligations of more advanced societies toward those less fortunate. The difficulties encountered during his expedition, however, taught him that there exists a margin of safety between theory and practice when it comes to collective psychology.

Great sailor and navigator — without much doubt Cook's equal — La Perouse, like many of his contemporaries, was also a man characterized by his hunger for knowledge and understanding. With the globe as a laboratory La Perouse was able to objectively, and sometimes at a high cost, implement theories elaborated by philosophers by the side of their fireplaces.

expédition lui ont enseigné les écarts entre la théorie et la pratique en matière de psychologie collective et les limites qu'il est dangereux de dépasser.

Grand marin et grand navigateur, — sans doute à l'égal de COOK —, il fut aussi pleinement un homme de son temps par sa soif de découvrir et de comprendre; avec l'univers pour laboratoire, il expérimenta objectivement et parfois à ses dépens les théories des philosophes élaborées au coin du feu.



6 — Extrait d'une minute de LAPEROUSE.

CHA/CHS News

Atlantic Branch

The new Atlantic Branch Executive is as follows:

Vice-President	Steve Grant
Secretary-Treasurer	Kirk MacDonald
Executive	Ed Lischenski
	Charlie O'Reilly
	Mike Lamplugh
	Richard Palmer

Personal News

Congratulations to Ron Melbourne and Patsy Meisner on their marriage.

Our best wishes to the following families and their new additions:

Mike and Sheila Lamplugh	— a girl, Jillian
Herman and Judy Varma	— a boy, Robin-James
Alan and Valerie Smith	— a boy, Alexander
Paul and Joanne McCarthy	— a girl

The region would like to extend a warm welcome to our newest members, Graham Rankine and Dave Thornhill.

Our condolences go out to the following families who lost a family member during the last year: Smith, Ryan, Stead, Mehlman, Comeau, Doiron and Cunningham.

CHS Atlantic was sorry to see June Senay leaving but we all wish her well in her new job with Eastcan Ltd.

Awards

Malcom Jay won two first prizes for his Rolls and Pies and a second prize for his Bread at the Atlantic Winter Fair. His special pumpkin pie was auctioned off and bought by IGA Atlantic for $340.00. The money was donated to the I.W. Killam Hospital for Children in Halifax.

Events

A dinner and evening cruise in Halifax harbour aboard the sailing ship Polaris was organized by Linda MacDonald at the start of the summer and was very well attended. Two attempts at day cruises and picnics on MacNabb's Island in Halifax Harbour had to be cancelled due to bad weather.

Sports

The CHA street hockey hooligans are beginning to gear up for the winter season.

Training

Charlie O'Reilly and Chris Rozon successfully completed the CHS Step II course last fall and Kirk MacDonald successfully completed the Step I course last spring.

Central Branch

The CHS field parties have returned from another enjoyable summer of collecting data. Word from private sector cohorts though is that work is still in progress.

Our "future" ranks of Hydrographer's are growing with the additions to the families of:

Phil and Kelly Elliott	— a boy, Marcus
Brent and Evelyn Beale	— a boy, Adam
Norah and Dave Prince	— a boy, Neil

Members of our Branch who attended the workshop in Lake Louise obviously enjoyed themselves. Reports in have Boyd Thorson not wanting to come back east.

The CLS exam results are in, with Bob Langford able to put CLS post namus, and Geof Thompson and Dave Pugh pending on their thesis only. Others who wrote are anxiously awaiting Feb. '87 for more fun and excitement.

Central Branch members are currently "gearing up" for the '87 conference "completing the picture — the search continues", by polishing up on wrist and elbow exercises at noon.

We hope to see many of our counterparts at the conference which will of course be the best yet.

Pacific Branch

The CHA Pacific Branch continues to be active with executive meetings being held on the second Monday of each month. Except for August of this year, executives in Pacific Branch have adhered to this schedule. Items under discussion include:

1. Coordinate "86" where survey-related associations and societies will meet in Burnaby on October 11, 1986, to present their individual associations' philosophies and discuss their relationships. Our representative for this Saturday meeting will be Fred Stephenson. Some of the participating associations are: Applied Science Technologists and Technicians of B.C., ASPRS, Canadian Cartographic Association, and the Corporation of B.C.L.S.

2. C.I.S. public awareness program where open houses will be held across Canada during the year. Pacific Branch has volunteered their cooperation.

3. The election of the new national president and Pacific Branch's nomination of B.M. Lusk for this office.

4. Continued involvement of this branch in the creation of a new membership certificate and national brochure.

5. Advertising: Mr. P. LaCroix, of INTERACT/QUESTER TANGENT and a member of our executive, is presently including a short paragraph on our association in scientific journals where his company is advertising. This advertising will be free to CHA.

Our first general meeting of the fall will be held in October where we will appoint a nomination committee for our annual branch elections, which will be held in December. At this meeting we will also discuss seminars for the winter season and generally inform our membership at large of our continuing activities.

Conferences

On May 28, in the IOS auditorium, reports from recent conferences were presented:

CHA Annual Meeting, Colloquium IV
Lake Louise, Alberta — Mike Woods

Hydro USA '86
Norfolk, Va. — John Watt

Oceanology International
Brighton, U.K. — P. LaCroix

Scripps Institute
La Jolla, Ca. — Jim Galloway

Colloquium IV, probably of most interest to our members, was held in scenic Lake Louise. The colloquium was jointly sponsored by the Prairie Schooner Branch of CHA and the Canadian Petroleum Association. The quality of the papers presented was good, as conferences go, and proceedings will be published shortly. Pacific Branch members attending were Messrs. Chapeskie, Crowther, LaCroix, O'Connor, Watt and Woods.

FIG, the major International Surveyors Conference and Meeting, was held from June 2 to June 12. Approximately 2,000 attended, including Messrs. O'Connor and Sandilands for CHA Pacific.

Future Conferences

The next Canadian Hydrographic Conference, to be jointly sponsored by CHA and CHS, will be held in Burlington, Ontario, February 17-19, 1987. It is our hope, with the help of CHS, Pacific, to support this conference. However, the availability of funds at that time will determine the numbers.

Lighthouse

Edition 33 arrived in Victoria on June 2, and has been distributed to all members.

Hydrographic Related Publications

Branch members are reminded that the Library at the Institute of Ocean Sciences contains many hydrographic-related publications. Examples of these holdings are complete sets of the *Hydrographic Journal* (1972-to date) and *Cartographica* (1980-to date) as well as most issues of the *Canadian Surveyor* (1958-to date).

New publications are being added regularly and members are encouraged to provide Sharon Thomson with information on any useful books or reports not presently in the Library.

Branch members who do not work at IOS can use the Library during normal working hours, but cannot remove books from the Library. They can, however, photocopy at a cost of 10¢ per page.

News From Industry

As a service to our members in the private sector and in the interests of expanding a general awareness of hydrographic and related activities, we asked local industry to provide brief reports.

The following reports were prepared by Ian Campbell, Paul LaCroix and Rick Quinn.

1. **Coast Pilot Ltd.**

Coast Pilot Ltd. reports a busy schedule with a variety of challenging hydrographic tasks in the private sector. An interesting break from their normal summer activities.

They have just completed a job in Salt Spring Island that involved sounding an area for a proposed marina development. Their new aluminum launch once again proved ideal for harbour and inshore work.

Designed and built to their specifications by a firm in Duncan for surveys of Kitimat and Stewart in 1985, its capability and general features have now been proven. The firm in Duncan has therefore added the design to its inventory and has included this model in their catalogue. The boat, equipped with trailer, makes mobilization fast and easy and is fitted with a transducer well and positioning system mounts.

The crew of Coast Pilot left on June 16 by air for the Northwest Territories where they are providing support to Terra Surveys Ltd. for a survey on the Mackenzie River.

2. **Quester Tangent Corp.**

The contingent of CHA members associated with Quester Tangent Corporation continue to aggressively pursue the task of evolving and marketing ISAH to ensure its acceptance as a world leading hydrographic instrument. Our field, in a marketing sense, continues to expand as we secure representatives and respond to solicited proposals on all continents.

Our current efforts include:

- Ongoing development to put ISAH in the control seat of the LARSEN system.
- Manufacture of four ISAHs to fulfill an order received last week from the Quebec Region of CHS.
- Working closely with CHS Pacific to ensure that ISAH performs by meeting the stringent requirements of the coastal survey off Tofino.
- Interfacing a Trimble GPS receiver into the Real-Time Navigation software.
- Actively pursuing identified potential for the ISAH system in Australia, India, Brazil, Singapore, Malaysia, and the U.K.

3. **Terra Surveys Ltd.**

With the summer field season upon us, the hydrographic staff at Terra Surveys is busily gearing up for various projects. Brian Clarke, will soon be arriving in Hay River, N.W.T., to begin the hydrographic survey of the first 280 km. of the Mackenzie River. Two specially designed survey launches, equipped with jet drives, will be used. A floating barge camp will serve as operations base, with provisions for a large workshop, computer and office space for data processing and a spacious accommodation for personnel.

Jim Vosburgh will be testing the '86 version of the LARSEN 500 scanning laser system in Lake Huron before taking it back to Cambridge Bay. Ice conditions permitting, Jim will continue hydrographic coverage in the western Arctic along the southern route of the Northwest Passage. Field data from this year's program will be simultaneously shipped to Terra Surveys Sidney office for data processing and analysis.

Some new responsibilities for CHS Pacific

As we in the Canadian Hydrographic Service move more towards contract surveys, a different breed of government hydrographer has emerged.

This year Pacific Region is monitoring four separate field contracts. The first is a recently completed photogrametric contract of the North Coast of Vancouver Island. McElhanney Group of Vancouver recently submitted five coastline sheets at 1:10,000 and 1:30,000 of Bull Harbour and the north coast. These sheets will assist the CHS in charting the north coast during the next few years.

The second contract, and one closely related to the first, is the contract for hydrographic surveys, again with McElhanney of Vancouver, for a survey of Bull Harbour and the north coast of Vancouver Island from Goletas Channel to Shuttleworth Bight. This survey is scheduled to begin in mid-July and will be based at the Coast Guard Station in Bull Harbour.

Terra Surveys of Sidney has been awarded our third contract, having won out over seven other companies in their bid for the job. This contract will consist of surveying and producing six charts of the Mackenzie River. These surveys are scheduled to begin on June 20, and start at the mouth of the river at Great Slave Lake and continue, using the new chart format, to Jean Marie River. Accommodations for the Terra surveyors will be supplied by Northern Transportation Company aboard their camp barge which will be moved as the survey progresses north.

The last contract will be conducted by a consortium of companies and government agencies and will consist of LIDAR surveys in the southern northwest passage. Based at Cambridge Bay, the Canadian Centre for Remote Sensing's D.C.3 aircraft will fly sounding lines in Requisite Channel, Simpson Strait and James Ross Strait during August of this year. The LIDAR system was built by the Toronto company, OPTECH, and one of their technicians will accompany the party to Cambridge Bay. Terra Surveys is the operator of the system and will be supplying the Canadian Hydrographic Service with 1:25,000 field sheets of the data gathered in this important area.

These four surveys are being monitored by B. Lusk of the Pacific region of the Canadian Hydrographic Service and will afford him the opportunity of seeing the 'private sector' at work. Good lusk (luck) to you all.

Ongoing CHS Pacific Activities

Despite an ongoing, impending and rumored management and administrative reorganization at the Institute of Ocean Sciences and in the Department of Fisheries and Oceans, normal summer activities for CHS Pacific are in full swing. Surveys are as follows:

"L. PACIFICA", Vern Crowley in charge, is operating on the West Coast of Vancouver Island in Tofino Inlet. His survey will conclude on October 10.

"RICHARDSON", George Eaton as H.I.C., has completed surveys in Kyoquot and Cumshewa Inlet. He returned to IOS on September 15.

"JOHN P. TULLY", departed for surveys in the Beaufort Sea in early July. In charge is Mike Woods with Alex Raymond as 2 i/c. The season was very successful and the ship returned to IOS the first week of October.

One highlight from Charts Branch was the printing and issue of Chart 3312, a new format cruising atlas of the Jervis Inlet-Desolation Sound Areas.

Personal News

- Congratulations to George Schlagintweit and Neil Sutherland for successful completion of Hydro I. George topped the class.
- Condolences to Carol Nowak on the recent death of her father.
- Pacific Branch has 56 paid-up members for the 1986 year.
- Congratulations to M. Ward who was married on September 6, 1986.
- M. Woods obtained his C.L.S. Commission.
- Rob Hare wrote and passed five of his C.L.S. exams last spring. His thesis remains to be completed.
- The annual IOS summer golf tournament was held at Prospect Lake Golf Club. There was a very good turnout.
- One of our executives, Mike Bolton broke his leg while taking tennis lessons and has been recuperating for the past four months.

Prairie Schooner Branch

The 1986 Prairie Schooner Branch CHA executive is:

Vice-President	Hugh Stewart
Secretary-Treasurer	John Hasson
Executive	Bob Ireland
	Colling Langford
	John Schleppe
	Ken Simpson
	Dave Thomson

Another summer of arctic and prairie hydrographic surveying has passed and many of our members are still reeling from the blow that low oil prices have struck to the survey industry.

Offshore Oil Exploration in the arctic and the east coast has diminished this summer and the arctic season wound up several months earlier than usual.

Many of our members have been laid off and have either gone back to school or are seeking employment elsewhere. It is regrettable to see this talent leave the survey industry.

Branch News:

The CPA/CHS Colloquium IV, "Land, Sea and Space — Today's Survey Challenge" was held at the Chateau Lake Louise, Alberta, on April 22-25, 1986. Topics ranged from the Electronic Chart and swatch systems to the survey needs of the petroleum industry. Extra curricular activities included a western breakfast, ski-race and watching the Calgary Flames beat the St. Louis Blues.

In the spring of 1986 the PSB designed CHA ties which are selling very well, we are currently designing lapel pins which should be available in 1987.

Industry News:

- Canmar was active in the Arctic this summer with their Explorer I and II drillships and the SSDC.
- Beaudril was active in the Arctic with the Kulluk and Molipaq drilling units.
- Nortech continued their GPS research this summer for the CHS and performed rig moves for Shell.
- Cansite spent the summer in Madagascar performing offshore positioning for Sonics.
- McElhanney and Cansite teamed up together to do Gulf's offshore surveys in the Arctic this year.
- Cansite mobilized a 2 MHz hyperfix chain in the Canadian Beaufort for Dome.
- McElhanney provided acoustic positioning services to Dome during the summer of 1986 in Canada and Alaska.
- CES provided offshore positioning services to Esso and Gulf in the Arctic this summer.

- RACAL provided microfix to Dome for channel navigation during 1986.
- During the fall, McElhanney is providing offshore positioning services to Sonica in Morocco.
- Challenger did some sub-contracting offshore California this summer.
- OSPS performed several sonar surveys for Gulf/Beaudril.

Personal News

- Brian Ross obtained his CLS Commission.
- Phil Bates returned to school to obtain an Electrical Engineering degree.
- New additions:
  Stewart — a boy
  Schleppe — a boy
  Troy — a girl
- John Adams is now manager of McElhanney's technical services branch.
- Congratulations to H. Janes on his new position with W.D. Usher, Canada, where he will be involved in G.P.S. navigation.
- Best wishes to Ken Thompson on his retirement from SHELL.
- Dave Parkhill has moved to New Brunswick and we wish him luck for the future.
- Murdock McAllister has moved to Moncton, New Brunswick, and is with the Department of Public Works.
- John Pointon has been promoted to manager of RACAL operations, China. His many admirers in Calgary miss him!
- Gary Charbonneau has moved back to Ontario and is looking for a suitable position. We wish him, Sharon and their daughter Tess, the very best of luck.
- Bruce Calderbank has been teaching at the University of Calgary and is sitting for the technical examinations. We wish him success in all his efforts.
- Congratulations to Howard and Roberta on their new son Stephen Robert Goldby.
- Bob Ireland has been in Madagascar where he has obviously been very active — for where have those 35 lbs gone?
- Best wishes to Tony Parker who is our representative in the United States.
- Nico Bier's family moved to Rotterdam whilst he was away in the Beaufort Sea. We hope that he will find his new home to his liking.
- A merry X'mas to all CHA members.

Région du Québec

Le S.H.C. région du Québec a déménagé, le 2 septembre dernier, dans des locaux temporaires à Rimouski en attendant sa relocalisation définitive à l'Institut Maurice-Lamontagne à Sainte-Flavie. De même, la nouvelle adresse postale de l'A.C.H. section du Québec est maintenant au,

180 de la Cathédrale
C.P. 1447
Rimouski
Québec
G5L 8M3

Le S.H.C. région du Québec, a fait une demande officielle auprès de M. Steve MacPhee (directeur général du S.H.C.) pour que la conférence S.H.C./A.C.H. se tienne à Rimouski en 1989.

L'association a soumis 9 projets le 17 octobre dernier dans le cadre des Programmes de Développement de l'Emploi Ces projets s'ils sont acceptés permettront l'embauche de personnel pour oeuvrer dans les secteurs de la cartographie, de la numérisation, du développement et des communications.

Le nombre de membre de l'association s'est accru de 42% depuis avril dernier pour un totasl de 70 membres.

Félicitation à Marc Journault qui a gagné le poste d'agent de cartographie automatisée du S.H.C.

Deux nouveaux hydrographes ont été engagés par le S.H.C. Bienvenue à Claude Côté et Roger Côté.

Bienvenue à Geneviève Robichaud qui a gagné un poste de cartographe.

Deux cartographes et deux hydrographes nous ont quittés suite au déménagement de nos bureaux à l'Institut Maurice-Lamontagne. Il s'agit de:

Guylaine Tessier
Diane de Montigny
Claude Perron
Paul-Emile Bergeron

Bonne chance à vous tous dans vos nouvelles carrières.

Ottawa Branch

There have been more than a few changes at the Ottawa Brach:

- **Sid Van Dyck,** a former vice-president of the Branch, has left the CHS to accept a position with the Department of National Defense here in Ottawa.
- **Gerry Jasky** is now a cartographer with the Department of Energy, Mines and Resources, still at Booth Street.
- **Jon Swayze** is no longer with the CHS; he has returned to school at Algonquin College here in Ottawa.
- **John Hanrahan** has retired after 37 years as a marine cartographer with the CHS.
- **Charlie Doakes** has left the CHS.
- **Gil Lance** who was working on data base development at CHS is now working for another federal government department in Ottawa.
- **Lynn Preston** is now working for the Mississippi Valley Conservation Authority.

We were sorry to see so many members of our Branch leave us. We wish them the best of luck and hope that they will still keep in touch.

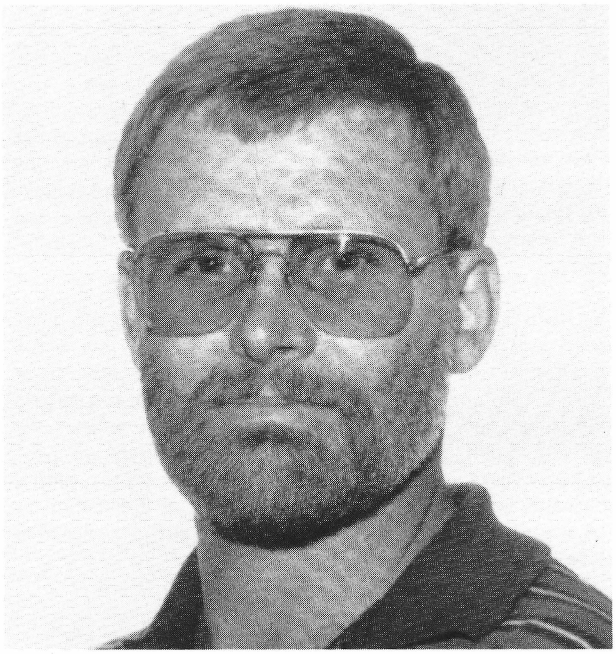
Ottawa Branch is sad to announce the deaths of **Mr. Dalton McCauley** and **Mr. Steve Titus**, two former employees of the CHS who were well known by many CHS members.

Rolly Hamilton, who retired not six months ago, is now back in harness working on a contract for CIDA, helping to establish a marine cartography unit for the Royal Malaysian Navy.

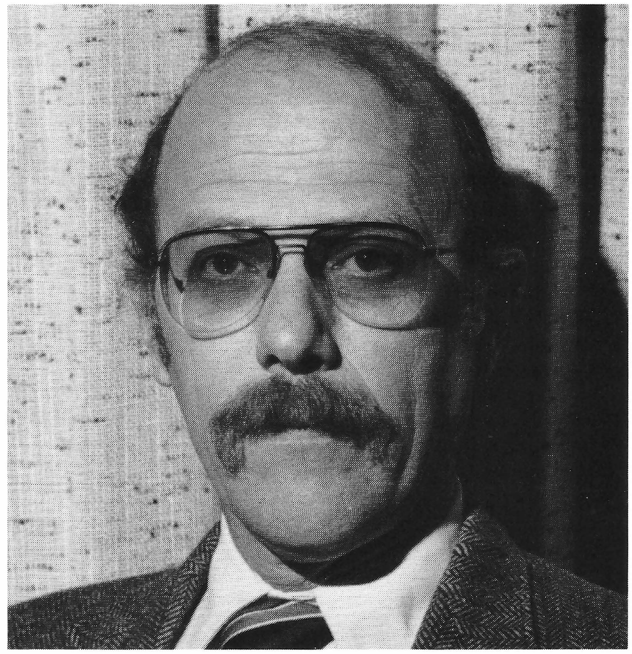
Ottawa Brach wishes to thank Prairie Schooner Branch for the successful Banff Workshop. It's too bad that only four of our members could be there but we hope to have a much larger contingent at Burlington in February next year.

Profiles of Candidates for President

The Editor is pleased to publish the profiles
of two candidates for President of
the Canadian Hydrographic Association.



Kenneth R. Clifford, P.Eng., C.L.S.



Barry M. Lusk

CHA INVOLVEMENT

I have been actively involved in the Prairie Schooner Branch of the Canadian Hydrographic Association since its formation in 1983. While attending both executive and general branch meetings, I have contributed to many of the activities organized by this young and energetic branch, as well as providing guidance to the executive on several key issues. Also, as a member of the national association, I have taken a keen interest in the recent constitutional amendments, name changes and in Colloquium IV.

WORK EXPERIENCE

I have been involved in the offshore industry since 1969. During this period I have worked on numerous projects both domestic and international, primarily in the Survey and Hydrographic fields. These projects have required positive direction from both technical and administrative perspectives and consisted of: resource studies, offshore positioning, hydrography and engineering.

Technical Manager Eastcan Group since 1986
Director/Partner NoLark Resources Inc. since 1985
President Broken Circle Land & Cattle Co. Ltd. since 1980
Director Canadian Engineering 1982-1984
President Broken Circle Resources Inc. since 1980
Partner/Director Renald Carriere & Associates 1980-1983
Chief Hydrographer 1976-1979
Operations Manager Offshore Positioning Co. 1975-1976

ACADEMIC QUALIFICATIONS

Public School Kitscoty, Alberta Class of 1965
NAIT Survey Technology Class of 1968
UNB Survey Engineering 1974

One of the most significant events taking place within the Canadian Hydrographic Association in 1987 is the triennial election of a National President. At no time in our twenty-year history has the election of a new President been more important. In January of 1987 you must choose a President who is prepared and qualified to lead the seven branches in a firm and dedicated manner. I believe that the correct choice will confirm our continued existence. We are now poised on the threshold of success and only with appropriate leadership in the national office and in the branches will we be prepared and capable of realizing the opportunities that presently exist. We must be prepared. We must show dedication. We must choose a President who is prepared to lead. The choice will be yours in January. Please consider it carefully.

Lighthouse, the journal of hydrography in Canada, has the potential to attract many more members and advertisers from around the world. We must be prepared and organized in order to offer these new members a well-managed association. We are no longer an extension of the Canadian Hydrographic Service, but an important cross section of the hydrographic community in Canada. This community consists of government agencies, large and small companies involved in hydrography, and exploration concerns interested in bathymetric data.

The interrelationship between all these groups is extremely important to our success. We must elect strong leaders from within CHA who are prepared to accept and foster these national and international interests.

In consideration of the above, I offer myself as a candidate for National President of the Canadian Hydrographic Association. I have been a member of CHA since its inception in 1966 and was the first National Secretary Treasurer. My involvement in the Pacific Branch has been equally long. I have been the Vice-President of the Pacific Branch for the past three years and on

STATEMENT

Promote more inter-branch dialogue and improved co-operation between government and private industry members. I hope to accomplish this by means of frequent attendances at branch meetings, and participating in CIS joint meetings which will be facilitated by my professional work arrangements.

To increase the membership of the Canadian Hydrographic Association by encouraging professionals in related disciplines to become involved in CHA activities.

To strengthen the position and ensure the future of Canadian Hydrographers by promoting international recognition and certification and encouraging education and technical development.

To further the general public awareness of Hydrographers, Offshore Surveyors and Cartographers.

more than one occasion during previous years. Under my direction, the Pacific Branch assisted in the creation of the Captain Vancouver Branch, designed the 1986 version of the membership certificate, designed and printed the newest CHA brochure, hosted the 1984 CHA/CHS workshop, and hosted numerous luncheon seminars. I was a member of the committee for Colloquium IV at Lake Louise, Alberta, and a participant in many other functions which I believe strengthened the CHA nationally.

I have been employed by the Canadian Hydrographic Service and been based in Pacific Region for the past twenty-six years. This year my assignment is to be the survey authority for contract surveys and therefore I am working closely with many companies in the private sector of hydrography. Last year I was the Hydrographer-in-charge of CSS Tully which carried out surveys in the Beaufort Sea. As you can see I am actively engaged in and at the forefront of hydrography in the most practical sense in Canada.

It has been suggested that our next National President should be chosen from candidates presently employed in the private sector. The rationale seemed to be "a change of pace" or "another perspective". After consideration, I have decided that these criteria alone are not enough to justify the election of our President. We must look to him for strong and appropriate leadership over the next three years and employment in the private sector will not necessarily guarantee this. My experience, my dedication to CHA, my interests and my proven record makes me the sensible choice.

News from Industry

Navitronics — New Hydrographic Survey Computer

1. The new COMFLEX-1010 computer from NAVITRONICS has been developed for use in hydrographic surveying systems. The computer is compatible with IBM PCs and has been designed to provide fast operation on board a vessel. Features include:

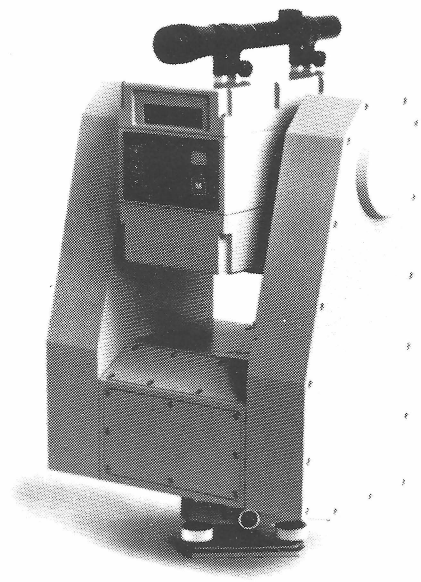
   - colour video and RGB output for traditional colour monitors
   - dual RS-232C serial inputs and outputs
   - centronics output for printers
   - dual 5-1/4" floppy disk drive, or optional dual 3-1/2" floppy disk drive
   - optional in the COMFLEX-1020 is an integrated 20M byte Winchester disk or, in the 1030, a tape storage drive
   - 10" rack compatible with 24V DC power supply

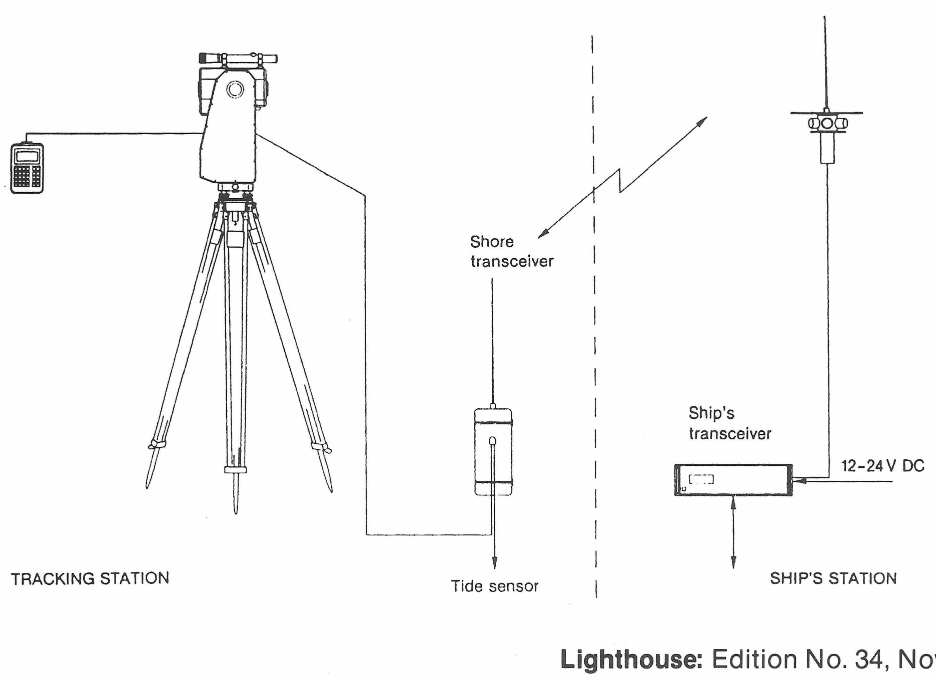
   The HYFLEX-1000, recently introduced, in many ways complements this computer as an interface capable of synchronizing different external signals and routing the resulting data to the computer.

2. NAVITRONICS also announces the introduction of a new short-range positioning system designated the NAVITRACK-1000 and based on laser optronics. The system consists of a land-based tracking unit with a UHF radio link for transmission of range and bearing data to the survey vessel. The tracking unit can be remotely controlled from the vessel through the radio link which also facilitates the monitoring of the shore instrumentation.

   On board the vessel is a reflector unit with prisms, a data transceiver and a display unit. A small hand-held terminal permits entry of starting data and subsequent operation.

   The unit automatically tracks a moving vessel and, in case of signal loss, it goes into a search mode until lock is restored. The range of the system is 5,000 metres with an angular coverage of 340 degrees and a vertical tracking angle of ±45 degrees with reference to the horizon.



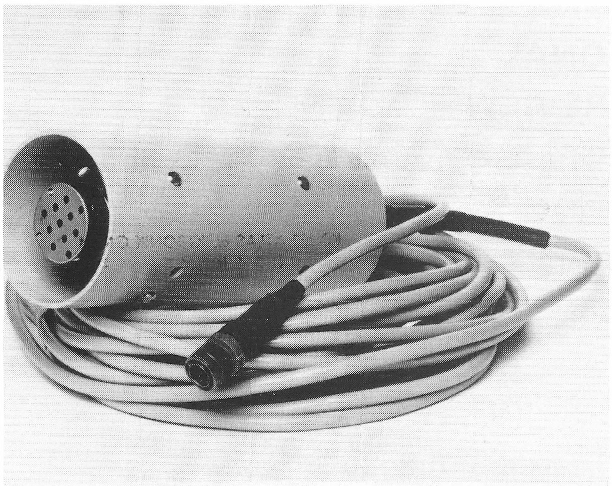


Krupp Atlas — Level Meter for POLARFIX

Krupp Atlas Electronik has now extended the capability of its POLARFIX laser range-azimuth positioning system with the introduction of an add-on meter for continuous automatic determination of water levels.

The PLM 1170 consists of a pressure sensor with a pre-stressed measurement membrane connected to an inductive acquisition system. Water pressure is converted to distance travelled. The meter is capable of measuring down to depths of 6 metres.

Readers will note that we carry an evaluation of the POLARFIX system in this issue of LIGHTHOUSE.



Targa Bubble Memory Cartridge System

Targa Electronic Systems Inc., Ottawa, announce the availability of 1 Megabyte bubble memory for Hewlett-Packard products which have a HPIB interface. The Targa cartridge Data Recorder permits users of H.P. data loggers, small computers and analytical equipment, to have a data storage facility in reliable and convenient removable format with upto 1MP capacity.

The Data Recorders are benchtop or rack-mount units with a variety of power supply options.

Bubble memory devices provide rugged data storage facilities, particularly in environments where dust, rough handling, temperature extremes, humidity and shock may be encountered.

Geovision Corporation

Geovision Corporation of Ottawa specializes in the development of support software and integrated systems for mapping and charting application which includes compilation and production of topographic, hydrographic, land ownership, natural resources, municipal and other maps. The Corporation's products and services pertain to automated mapping/geographic based information systems, the autochart (digital hydrographic charting) and specialized advanced mapping systems.

Amphibious Survey Craft

An interesting concept in surveying has emerged as a consequence of certain special requirements in Germany for sounding in small rivers and restricted channels. An amphibious craft, the "Amphi-Ranger 2800SR", was designed and fitted out with survey instrumentation suitable for the task of sounding the narrow channels with increased accuracy in depth measurement, as well as positioning — an additional task being the identification of mud and sediments by the use of different transducer frequencies.

The 5-metre long craft is of aluminum construction and is fitted with a four wheel drive and a retractable propeller for propulsion in water. It has a maximum speed on land of 140 km/h and 9 knots in water. The craft is fitted with a Polarfix positioning system and the echo-sounding and data acquisition systems have been supplied by NAVITRONICS.

Trials conducted in Germany indicate that the Amphi-Ranger has excellent stability, handling and manoeuverability in water. As the echo-sounder is located forward of the craft, it can be used also for navigation and is most useful for manoeuvering along river banks. Depending upon the size and nature of the survey section, 800 to 1,000 metres can be surveyed in one day.

The WHERE machine. The Motorola Eagle™ GPS Receiver.

Where you've been. Where you are. Where you're going. Plus, velocity and altitude. Core receiver data supplied to your integrated navigation system with superior accuracy and timing. For surface or airborne navigation. The Eagle GPS receiver features 4-channel simultaneous L-1 band with course acquisition (C/A) code operation, embedded differential software, selective satellite acquisition, and post-processing differential capability. For more details on the WHERE with Eagle GPS receivers call 416/499-1441 or write Motorola Limited, 492 McNicoll Avenue, North York, Ontario M2H 2E1.

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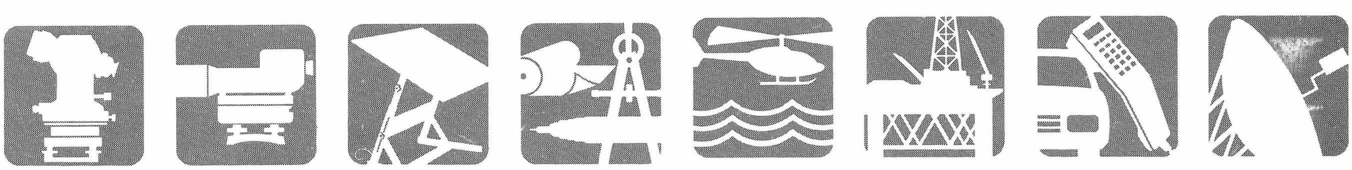
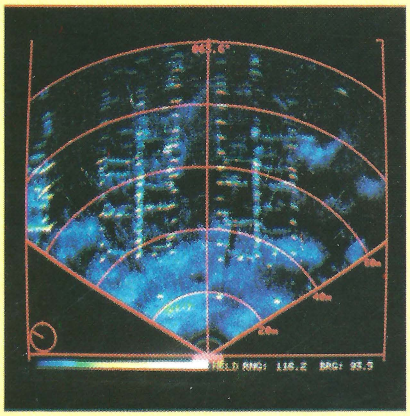


NO OTHER SONAR COMES CLOSE.

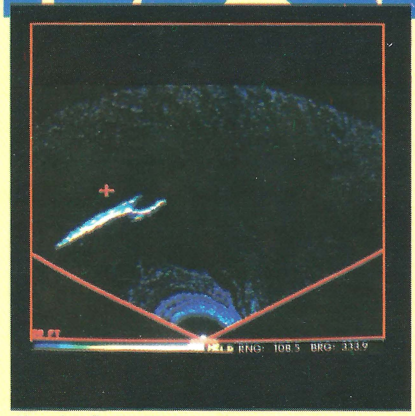
You need the best imaging sonar available. This is it — the 971. A colour imaging, multi-purpose miniature sonar. Best because it displays the widest range of signal levels. Because each of its 128 distinct colours represents a precise sound level. Because it has the highest definition — ¼ million pixels — to show the finest details. And because the colours and high definition produce breathtaking images.



Marina with pilings in Sector Mode.

As shown here, the colours represent about one tenth of the actual brilliance of the monitor screen. The sonar also displays a dynamic sequence of images, enhancing your interpretation.

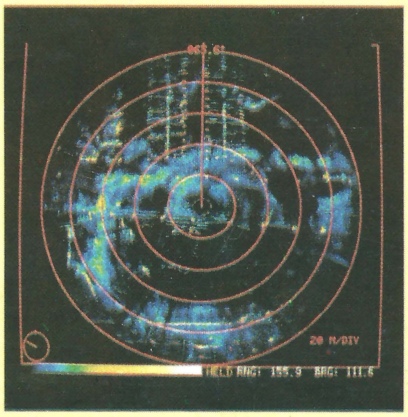
With the 971, you can 'see' as far as 500 metres. Compare that to a few metres with your eye or TV. Add the feature of five operating modes/display formats and you have an unrivalled versatility. For instance, the narrow sonar beam of the Sector Scan will detect even the smallest hazards and the display will reveal them. Perfectly. Switch to the unique Perspective Mode for Pilotage and a sound image of the outside world is presented with stunning realism. You 'fly' into the scene guided by the perspective grid.



Aircraft in Sector Mode.

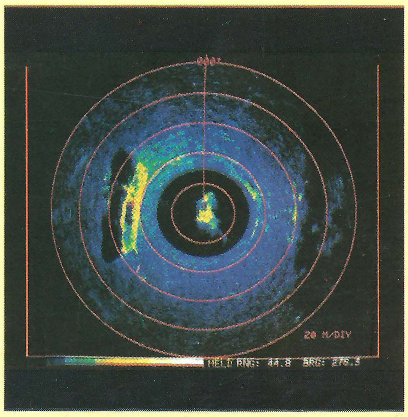
Switch to the Polar Scan Mode for General Surveillance. If a job calls for monitoring and controlling traffic at an oil rig, this mode will guide divers and vehicles directly to a rendezvous or work station. Constant monitoring can be achieved with an NTSC or PAL converter and a standard video recorder. And playback utility is enhanced by the on-screen data, which lets you record date, time, depth...

Marina with pilings in Polar Mode.



Side-Scan is well known, but the 971's high definition colour display adds a completely new dimension. Surfaces are recognized by their signal strength, as shown by their colour. And targets which you miss with a regular sonar's limited on-screen range show clearly on the 971.

This much performance would normally require a rack full of equipment. Not so with the 971. The on-board processor is compact, the Sonar Head is small and yet light enough to fit any ROV. Or to pass through drill strings, casings and sea chests.



Large shipwreck in Polar Mode.

Performance, versatility, size, value. Now you know.

No other sonar comes close.

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