SOUNDING PLATFORMS
Used by the Canadian Hydrographic Service

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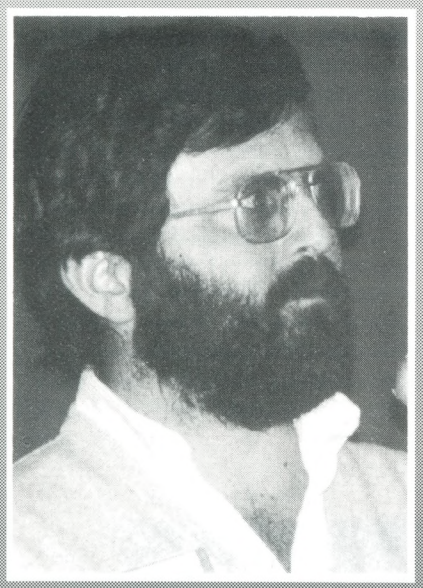

Introduction

The mandate of the Canadian Hydrographic Service (CHS) can be divided in two; the field side which conducts bathymetric, tide and current surveys, and the office side which prepares and distributes navigational charts. These activities promote and facilitate the safe use of Canada's navigable waters. On the field side the bathymetric, or sounding operations, occupy the majority of our time and resources allotted to our field survey divisions.

Hydrography has been practised formally for about 400 years and it is commonly considered that Captain Cook was the first Hydrographer. In central Canada hydrographic surveys were done under the direction of such notable British Admiralty hydrographers as Admiral Henry Wolsey Bayfield and Captain William Fitzwilliam Owen, whose names are not part of the nomenclature of Ontario. CHS was formed out of the British Admiralty over 100 years ago as a result of the sinking of the steamer Asia in 1882. The 150 persons lost on the Asia, combined with a long list of smaller marine casualties, convinced the new Dominion that a Canadian Hydrographic Service was needed.

To run the service an ambitious young "man of the Admiralty" was seconded. In 1883 Staff Commander John George Boulton was made Canada's first Hydrographer and continued the work of Bayfield and Owen in the Great Lakes and Georgina Bay.

The advanced skills developed by the Admiralty in astronomy, geometry, mathematics, engineering and surveying were for the most part taken into the field by Hydrographers. Much of the Ontario township fabric laid out after the American War of Independence and the determination of the position of the Canada United States border was done by surveyors trained by the British Navy. These men were extremely well educated in the sciences at a time when the ability to read and write was extremely rare.

The skill which separated hydrographers from all other professions and ranks was the skill which is still the essence of hydrography. The essence of hydrography is the ability to answer the question: Where am I and how deep is it?

Over the last 400 years, the technologies which have affected hydrographic surveying have been many. The introduction of the echo sounder and electronic positioning in the 1950s and 1960s and the introduction to computer based systems in the 1970s and 1980s are examples of technologies impacting currently on the way hydrography is being done. However, it remains to be seen if the modern technologies make the lasting impact that the introduction of technologies like precise Harrison chronometer, the sextant, the conversion from sail to steam and the introduction of the internal combustion engine have to sounding operation. This paper will deal with some of the ways in which the CHS field operations have and are now trying to answer the question: Where am I and how deep is it?

The majority of soundings are taken from ships or launches, it is after all one of the best forms of transportation on the water. But because of developments largely in the last quarter of this century the term sounding vessel became too limiting, hydrographers now use aircraft, submarines and satellites along with their fleet, thus the term sounding platform.

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This paper will trace the development of sounding platforms from row boats to airborne systems and in the process touch on the methods of positioning and sounding used in each case.

The Platforms

Cook's first ship the HMS Pembroke was a 1250 ton warship which carried 64 guns. A fact which is very important because Cook's first assignment was to sound the approaches to Quebec for the assault on the city and the defeat of Montcalm. In 1759 Cook reported that the Traverse, an area south of Ile D'-Orleans down stream of Quebec city was surveyed and buoyed. Now it was possible for ships to sail right to Quebec city. The British assault on Quebec started on June 25, 1959. Cook's log entry shows:

> "at 11:00 a.m. a signal for all boats, manned and armed, in order to go lay the Traverse as buoys for the ships to come up".

The British fleet moved up to Quebec for what was to become the seige of Quebec and the end of French rule in North America. The fleet which carried Wolfe's army consisted of nine ships of the line, thirteen frigates and one hundred and nineteen transports and they all passed the Traverse without mishap. Cook's hydrography resulting in the defeat of Quebec was noticed. He was made a King's surveyor and assigned to the Grenville, a 68 ton schooner with a crew of seven. While on the Grenville, Cook, surveyed much of Newfoundland. But, Cook was a real hot shot and was to make his name on his third voyage. For the trip he was assigned two ships, the 100 foot coal carrier called the Resolution and the 80 foot Bloodhound which he renamed Discovery. From these ships he would survey from 45 N to 65 N on the west coast of the new world, what we now call British Columbia. The year was 1777.

In 1890 a sounding machine was developed. It was a winch which released a 40 lb. weight forward of the ship and retrieved it from the stern. With this machine soundings of up to 24 fathoms could be taken at a speed of about 5 knots. Bolton described it this way.

> "Where the depth does not exceed about 24 fathoms the ship steams steadily on at 5-1/2 knots. The sounding machine with a lead of 25 to 40 lbs. weight attached to it, is hauled out by a traveller, on a wire rope, to the bow of the vessel. It is detached from the traveller by a tripping line when the cast is wanted. The line travels through the hand of a man aft and at a depth of over twenty fathoms the lead would be fifty or sixty feet astern of the vessel before striking the bottom. An experienced and attentive sounder easily notices the slacking up on the line, which is then brought to the stream winch and hove up ... The interval between the soundings is regulated by an ordinary timepiece with a second hand."

Later developments would see the Somerville sounding gear which cast the lead well forward of the ship and the Lucas sounding machine which used a thin wire so that speeds could be increased to 7 knots.

Leadlines and sounding wire were the state of the art in 1884 when the first Canadian Hydrographic ship, the Bayfield was commissioned. The Bayfield was actually a twenty year old American tug which was purchased for $15,000 and refitted for an additional $4,000. She was involved in establishing control in Lake Huron until 1886 when she was refitted again and two small boats were added at a cost $5,000. She now carried a compliment of 23 crew and 3 hydrographers. The Bayfield surveyed the Great Lakes for the next 16 years until she was retired in 1902.

The Bayfield was replaced by the Bayfield II, who like her namesake was another converted tug. The Bayfield II was originally the Lord Stanley, a twelve year old tug refitted in Toronto and scheduled to replace the Bayfield in 1901. But she was damaged in Toronto after the refit and did not see service until 1903. The Bayfield II retired after 32 years of service on the Great Lakes and is most noted for the survey of Superior Shoal in the main shipping channel of Lake Superior in 1930.

In 1905, the Canadian Government took full responsibility for hydrography and charting of the entire country. This master stroke of bureaucratic genius neglected one small detail, there were no hydrographic ships on either coast of Canada. In the fall of 1905 William J. Stewart chief of the Hydrographic Survey requested that the Government have two ships built, one for each coast. In 1908 the first ship designed especially for the CHS was launched. The Lillooet was built in Esquimalt at a cost $150,000. She was 175 feet with gross tonnage of 575. She was able to accommodate 6 hydrographers, carry five small boats and had a crew of forty. The Lillooet would be the only hydrographic ship on the west coast for the next 24 years. On the east coast the Cartier was commissioned in 1910 and, while constructed in England, she was a virtual sister ship of the Lillooet. She remained in service until 1945 which included secondment to the navy for war time patrol duty.

In 1913, "Canada's Grand Old Ship" the Acadia arrived. Built at a cost of $330,000 she is a beautiful, graceful ship and was the pride of the CHS fleet for 55 years. The Acadia retired in 1969 and is now docked at the Maritime Museum of the Atlantic in Halifax, where she is maintained in her splendour and open to the public. The Acadia was build in the Edwardian style and exhibits a quiet splendour no longer seen on ships. The senior hydrographer's mess was as posh as a fine restaurant with china, silver flatware and serving pieces, linen, crystal embossed with the ships crest and a call button at each chair to summon the steward. CHS Acadia was retired by the time I joined the Hydrographic Service in the 1970s, but many of the older

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hydrographers who trained spent many seasons on her. The Acadia by their accounts was a floating hotel, coal burning steam power made her extremely quiet, the accommodation for the hydrographic staff and the service provided was nothing short of first class. She was a pretty ship kept that way by her crew, and a good sea boat. But, the comment which always comes up is that she was always warm and there was always lots of hot water. This is not surprising since she was driven by steam boilers, but if you were working in the Canadian Arctic or in some cold damp cove in Newfoundland it is an outstanding feature.

In 1932, the Wm. J. Stewart arrived at Victoria to replace the aging Lillooet. The Willy J., as she was called, was built in the same stature and style as the Acadia, 228 foot long and 1295 gross tons. The largest survey ship of her day, her complement was 68 including eight hydrographers, eight officers and 52 crew. She was the only CHS ship to not be seconded to the Navy during the second world war and during this period she would be the first CHS ship to carry female crew, seven cooks, stewards, and launders. The Stewart was decommissioned in 1975.

In the years following the second world war, there was a high demand for new charting activities and a surplus of warships. The result of this overstock and expansion of CHS activities, coupled with the fact that the Acadia and the Stewart were starting to show their age and scars from misadventures while surveying, was that numerous surplus warships were seconded to CHS.

On the west coast the Parry and the Ebkoli; 87 foot coastal patrol boats, were acquired and used for coastal, tidal and current surveys. The Marabell (YMS-91) a surplus USN mine sweeper, bought by Doctor Ballard of pet food fame and converted to a yacht, was purchased in 1953. These three boats remained in service until 1969.

On the east coast, the two RCN Algerina class minesweepers were acquired and refitted.

In the years after the war there were two factors which affected the CHS fleet. The first was the demand for charts exploded CHS's response by to try to acquire more ships to mount more surveys. However, the post-war demand for new merchant ships was so high that finding a yard to build a hydrographic vessel was next to impossible. The impasse was broken by CHS by chartering Newfoundland sealing ships. These ships had several logistical advantages, they were available during the survey season because the sealing season was in late winter, they were ice reinforced and they came with crews and captains who had Arctic experience. But, they were a far cry from the floating hotels of the Acadia and the Stewart. At the end of the sealing season the ships would sail to the nearest Newfoundland yard where a hastily constructed drafting room was fitted in the holds and the sealers quarters were converted for the hydrographer. Although the ships were given a thorough scrub down both topside and interior the stench of seal flesh was still noticeable even at the end of the field season. In total five sealers were contracted, the Terra Nova, Theta, Theron, Algerina and the North Star IV. These sturdy, smelly ships surveyed the Arctic and sub-Arctic into the early 1970s. The North Star IV being an exception, she sank while surveying after running aground on a shoal in James Bay which now bear her name.

The emphasis on Arctic surveying continued and CHS commissioned the Baffin, a new major survey vessel in 1956. The Baffin is 285 feet long and has a 3,700 ton displacement with an ice reinforced hull and was totally designed to support hydrographic surveying. She carries several deep ocean winches and has a landing pad and hanger for her on board helicopter. She is a survey ship par excellence however, she is the last of her kind. By the 1960's hydrography would be done in conjunction with oceanographic studies and the Baffin, like other great survey ships world wide would be refitted to take up the dual roles of hydrographic and oceanographic.

The newest ship in the CHS fleet is under construction and is a radical new design called SWATH. Small Waterplane Area Twin Hulled vessel has a revolutionary hull design. She resembles a beamy catamaran above the water surface. The difference is below the surface. Below the water twin submarine-shaped pontoons with trim fins run barely submerged and parallel to one another at the outer side and the length of the vessel. The pontoons connect to the accommodation deck by vertical struts which contain the machinery decks. These struts have a relatively slim profile at the waters surface and are the only part of the vessel exposed to water surface. This means that the boat is supported above the water on the pontoons which are below the surface action of the water. The result is a vessel with a very stable and smooth ride. The SWATH boat is small: 65 feet long; 32 feet in beam; displace 73 tons; draft about 8 feet and has the surprisingly low cost of between 2 and 3 million dollars.

Today the only vessels which remain purely hydrographic are the survey launches. Cook's launches were simply the ships boats or gigs. The typical gigs of Cook's day were wood 22 feet long and 7 feet wide. Their rigging would have been spritsail, but the main method of propulsion would have been 4 or 6 oars attached to burly seaman. The boat was positioned by sextant and depth taken by lead line. Sounding technique would change little until the 1930s and the invention of the echo sounder, and positioning by sextant would continue until the 1950s when first radio positioning systems were used.

Leadline sounding operations are best described by a quote from an 1890 lecture by Commander Boulton.

> "The officer takes away in his small boat a small sheet of the points on the portion of the shore he is to sound... He also takes a sextant, station pointers, protractor, tracing paper and pencils, not forgetting his pipe and baccy if a smoker".

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Depths were taken by lowering a 14 lb. lead weight over the side on a measured wire and calling out the depth when it touched bottom. It was gruelling work. An experienced leadsman could take depth to about 6 fathoms 36 feet without stopping the boat or ship. But, deeper than this presented problems. A quote from R.J. Fraser Dominion Hydrographer for 1948 to 1952 described the sounding of superior shoal in the early 1900 this way.

> "On Lake Superior the water was very deep close inshore - too close for safe ship sounding. When a gig was stopped for a sounding - and because of the possibility of pinnacle rocks (the stops were frequent) - sometimes ten or twelve minutes would be consumed in letting the lead reach the bottom and then hauling it up again. The surveyor had time to check his notes, fill his pipe and if the day were warm, almost fall asleep. The oarsmen lazed idly. The one who worked hard was the leadsman."

By 1910, two 30 foot gasoline powered launches, the Nelson and the Budge, were used in the field. The Nelson nicknamed the Sea Louse and Budge nicknamed the Never Budge were stationed on each coast. By their nicknames you may have guessed that they were undependable. It was not until 1913 that power launches were approved for use on surveys. The technology improved and by the start of the war most large survey ships were equipped with 30 foot power sounding launches. In 1941, a hydrographer named H.L. Leadman noticed that these launches were too small and underpowered.

He wrote:

> "during the summer I noticed that there were a great many sunny days when our 27 foot launches were driven to shelter and the day was a total loss as far as sounding was considered. They could not stand up to the fresh summer breeze. In replacing these launches as they were out it would be highly advisable to use a much larger craft. I would suggest one about 40 to 45 feet long, under four feet in draft, one of easy running and fairly light construction. In view of our Cape Breton experience and others, it would have two engines of about 40 HP each."

Sounding would never be the same.

Leadman's wish came true the next year the Anderson, a boat very similar to his description, was put into service and it remained the standard for many years. In more recent years the evolution of launch has been very rapid. This evolution is a result of the introduction of the echo sounder, electronic positioning systems and on board computer systems. Launches designed for sextant and leadline survey were open to allow the casting of the lead and the observation of the sextants; no electrical power was required or supplied. The introduction of the echo sounder required that there be a dry place to mount and operate the sounder and that there be a source of power. The leadsman now became the sounder man and he moved from the bow in the spray to a dry and usually stuffy cabin.

The echo sounder was introduced in 1929 and its ability to take continuous sounding profiles was recognized as having real benefits in the ability of hydrographers to portray the bottom. Electronic navigation systems came along after the second world war. But, it was not until the early 1960s that they had developed to the state where they were accurate enough to be used on large scale surveys. Large scale surveys were done with sextants and echo sounder, in launches developed to support this type of surveying. Modern launches developed in two distinct directions which reflect the different marine environment in which they were to work. The launches used on the inland waters evolved to small light weight boats which could be easily trailered and maintained without a mother ship. They tend to be planing or high speed hulls with large twin engines. The launches used on the coasts evolved into large, heavy displacement hulls, which can be lowered from a ship daily. They tend to be built for comfort not speed.

For the most part the high speed launches used on inland waters are modified pleasure boats or motor cruiser. Initially they were made of wood, cedar strip as were most boats up to the 1960s. Manufactured by companies like GREW, and MASON, they were propelled by engine from companies like JOHNSON and EVINRUDE.

In 1960, Central Branch of CHS was faced with the task of re-charting the entire lower St. Lawrence River at a large scale. But the fleet of wooden boats were all suffering from old age. CHS caught wind of a Scandinavian boat built especially for hydrographic surveying. The Botveds where sturdy little 28 foot runabouts laid out with two front seats and a canvas top. They were powered by twin VOLVO inboard and drafted less than a metre with the legs up. They were fast, solid and well laid out for sextant work. As the technology of electronic positioning improved, minor interior modifications were made and a solid top was added to these fine little boats. They would take all the abuse that CHS could throw at them for almost 20 years. It was not wear and tear that pushed the Botveds out of service. It was the need for space and electrical power for the computers and electronic gear required for modern surveys.

Launches used on the coasts changed surprisingly little from the first canoe shaped power launch. They were initially made of 2 or 3 inch thick Nova Scotia fir known for its strength, had a covered top and were steered from an open cockpit at the stern. The last generation of these boats would see fibreglass replace the wood. But, there would be no improvement in speed and they would be nicknamed Plastic Pigs.

Currently there are three basic launch styles in use in the Hydrographic Service in Central and

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Arctic Region. The large sounding launch is a 28 foot deep vee planing hull vessel called a Hourston. The cabin is enclosed and spacious enough to allow the semi permanent mounting of the survey and data logging equipment. Electrical power is supplied from the engines and converted to 120 volts through an inverter. These launches come in twin or single inboard configuration. Hourstons are Canadian made work boats. They are also used as patrol boats by the RCMP, Hamilton Harbour Police and other law enforcement agencies. For survey work in closer quarters small launches are used. The Mckee Crafts are a 18 foot flat bottomed open runabouts with a walk through to the bow, powered by 90 hp. outboards. The Mckees are used to do harbour surveys and in areas where there is a high probability or running aground or crumpling a propeller. They are small enough to manhandle off a shoal and the outboard allows a quick propeller change.

If anything the Mckees are a little bit too small and fully outfitted and crewed there is not much room to spare. Power is supplied to the survey gear from two 12 volt batteries but currently these boats are being fitted with small gas generators.

For Arctic, Sub Arctic and offshore surveys, Nelson launches are used. No relation to the first launch, the Nelsons are British designed modified lifesaving hulls. They are 38 feet long displacement hulls, and are especially fitted for working from a ship in Arctic and sub-Arctic conditions. The drive shaft comes in single and twin engine configuration, the engines are large marine diesels and electrical power is supplied directly by a diesel generator.

In addition to launches and ships CHS has used, (with various degrees of success) helicopters, airplanes, tracked vehicles and remote controlled submarines as sounding platforms. These platforms are used in the Arctic for through the ice sounding. Sounding is done on the ice because in most of Canada's Arctic the open water season is so short and ice conditions so unpredictable that sounding in the early spring, while there is 100% ice cover is the only option.

Helicopters are used in two ways to sound through the ice. Over the last 15 years CHS in conjunction with the Polar Continental Shelf Project has conducted helicopter spot soundings surveys in high Arctic. To do this hydrographic positioning systems and survey sounders are fitted in Bell 206 type helicopters. The sounder transducer is connected to a long cable and carried inside the helicopter's cabin.

To survey, the hydrographer and pilot take a list of pre-selected sounding positions out in the beginning of the day. The helicopter flies to the spot and lands. The hydrographer gets out of the helicopter scrapes away the snow and pours a little bit of oil on the ice, places the transponder on the oil spot, turns on the sounder and plays with the dials until a sounding is obtained. The oil provides an acoustic couple to the ice. The sounder is turned off, the transducer retrieved and the helicopter flies to the next spot. A modification to this technique was to mount the transducer on a spike and lower it to the ice with a ram hard mounted to the helicopter. The ram was controlled from inside the helicopter. This method was somewhat less than successful because the ram, which was a modified automobile power steering system was unreliable at Arctic temperatures. The idea may be tried again in the future because apart from the temperature problem the ram was a technical success.

Spot sounding whether taken by leadline and row boat or helicopter and sounders are still a poor substitute for sounding profiles. To address this problem a research project calls TIBS, a Through the Ice Bathymetry System was developed. TIBS is a modification of the electro magnetic systems used in the resource exploration industry. TIBS is tethered below a helicopter and flown over the ice. The EM readings taken are converted to depths. The TIB system is still under development and will undergo its final field trials in Tuktoyatuk this April.

The system shows great promise in providing continuous profiles of ice covered sea bottoms very quickly, the helicopter can fly at about 90 knots. In areas of relatively flat ice spots sounding by oil spot or ram has been done from a tracked vehicle. The platform is a Bombie; a two tracked vehicle similar to the one that ploughs the snow on city side walks. The sounding operations are the same as the helicopter spot operation.

Fixed wing sounding is done from a DC 3, and a lidar profiler. The lidar system uses a Larsen laser with a scanning mirror to profile wide areas. The system measures the slope range to the water surface and to the bottom. On board processing then corrects the slant ranges and the depth is the difference between the range to the surface and the range to the bottom. The Larsen system has been transferred to Terra Surveys Ltd. They currently contract this service to the private and public clients internationally.

The Larsen, was developed over a number of years. It first used inertial systems to position the aircraft and to provide "control" for the laser data. But last year the aircraft was positioned by differential GPS techniques. Two GPS receivers were used both with data links. One was set up on a known control point near the survey area the other was in the aircraft. The differential data was sent to the aircraft via the data links and provided real time positioning and navigation.

The Larsen is a laser (light) system and it is limited by ice cover and water clarity. The system has been used successfully in the Gulf of St. Lawrence, the western Arctic, and may be used on the eastern shore of Lake Huron this summer. The Larsen, like all airborne surveys has a high hourly cost but the rate of collecting data is extremely high and surprisingly flexible. Last year in the western Arctic the survey area was completely surveyed even though it was partly ice covered. With the GPS and the aircraft the operator was able to take advantage of the shifting ice due to wind and survey areas as they became open.

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Another type of sounding platform which CHS is experimenting with is the unmanned submarine. They come in two forms, tethered and remote controlled.

The tethered version is called MARS; a small craft lowered through a hole in the ice where it sounded an area with a radius the length of its umbilical cord. It was an interesting concept which performed below expectation in the field.

The remote controlled submarine DOLPHIN Deep Ocean Logging Platform with Hydrographic Instrumentation and Navigation is more successful and has helped put Canada on the leading edge of unmanned submarine technology. The DOLPHIN is a torpedo shaped craft which rides slightly below the surface to avoid the surface wave action. It is powered by a conventionally gasoline or diesel engine. Air and exhaust are vented through a snorkel. The craft is designed to function in waters too shallow for a ship or in a "school" running parallel to the mother ship. The DOLPHIN carries a conventional echo sounder and can be outfitted with a number of positioning systems. The bathymetry collected is stored on the craft and also sent to the mother ship via the telemetry link used to remotely control the submarine.

The DOLPHIN has proved itself as a sounding platform and shown that it can be a useful tool in ship based survey operations. It has been plagued with one technical problem which has presented it from moving from the development stage to production. Retrieving it in a rolling sea is next to impossible. However there is a project under construction at this time to address this problem. We may be able to land a DOLPHIN yet.

Although the reasons have changed from military colonial expansion to the production of recreational and resource charts the CHS is still trying to answer the question: Where am I and how deep is it?

Our methods have gone from leadlines to lasers and from row boats to aircraft. We are capable of collecting more data in a few minutes than was collected in an entire year 100 years ago. The CHS is still doing what it does best and doing the only things it is allowed to by its mandate producing navigation charts for the safe efficient use of Canada's navigable waters.

Credits and References

All quotes are taken from The Chartmakers a history of nautical surveying in Canada. This book written by Stanley Pillmore and R.W. Sandilands was written to commemorate the 100 Anniversary of the Canadian Hydrographic Service and is dedicated to the men and women of the CHS.

Photographic Slides were borrowed from the slide collection of the Canadian Hydrographic Service, Central and Arctic Region.

Fillmore, Stanley, Sandilands, R.W. The Chartmakers
Toronto: N.C. Press Limited, 1983

Foster, Michael, Marino, Carol. The Polar Shelf
Toronto: N.C. Press Limited, 1986

SWATH Vessels, Swath Ocean Systems, Inc.
Chula Vista, California, 1988

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ANNOUNCEMENT

The next meeting of the 20th Congress of the International Federation of Surveyors, F.I.G., will be held in Melbourne, Australia, March 3 - 15, 1994.

Details will be available shortly.