Positions fixed in the North Sea navigation battle

Traditionally the control of maritime navigational aids in and around British waters has been monopolised by Decca. But new technologies are making the lucrative North Sea navigational market more competitive—and are forcing Decca to take defensive action

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The control and use of radio navigational aids in UK offshore waters is in dispute following last month's announcement by ITT and Redifon of a joint venture to promote a Loran C type navigational system. Superficially, the venture challenges the supremacy of Decca which, since the Second World War, has ruled the navigational air waves around Britain. But only a few days after the ITT/Redifon announcement, Decca carried out the first operational tests of a Loran C based system called Pulse 8.

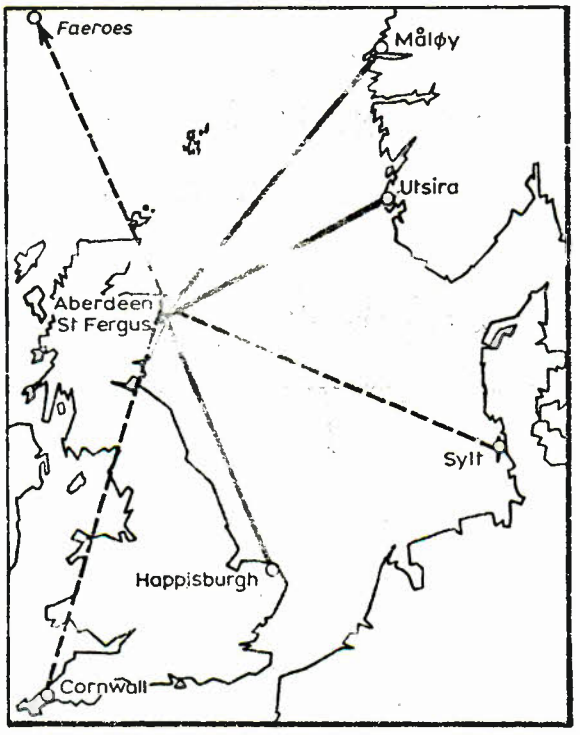
The initial Decca tests were on a station at St Fergus near Aberdeen, which will be the "master" in Decca's four-station Pulse 8 chain. A second station in Norfolk is almost complete and two others are being built in Norway. From October, Pulse 8, granted a Home Office licence some three months ago, will give offshore operators and surveyors in the northern North Sea a position fixing system more continuously accurate than they had before (see box on next page).

ITT/Redifon's counterbid is designed to augment existing Loran C coverage which is unsatisfactory below about 61°N (some 20 km north of the Shetlands). The chain of shore stations for this system would incorporate two existing stations, one in the Faeroes, the other at Sylt in Germany. But it would also require two new UK transmitting stations near Aberdeen and in Cornwall (see map). ITT hopes to sell these two stations to the British government for £2 million: a strategy it is following in other parts of the world.

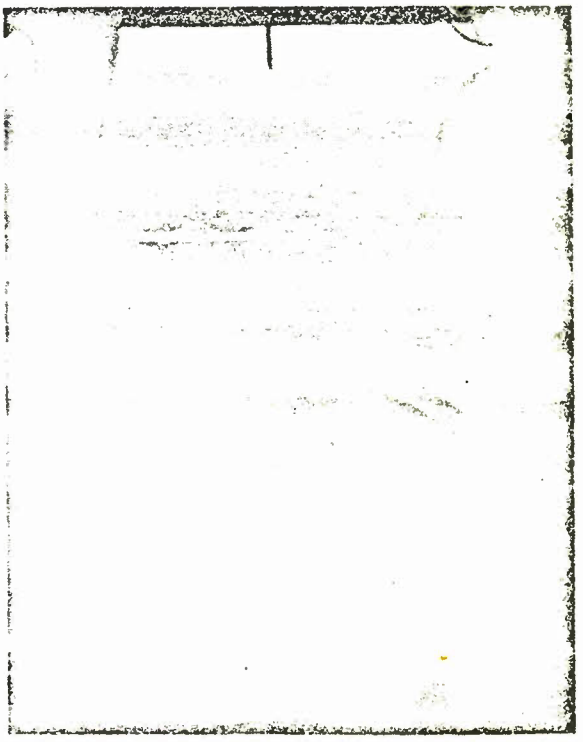
Both ITT and Decca systems use the same basic Loran C format (see box), transmitting on 100 kHz. But, according to Decca, the Pulse 8 chain is intended only for surveyors and position fixing in the North Sea—not routine navigational tasks. ITT/Redifon's Loran C primarily would be a general navigational aid. Both systems could, in theory, operate side by side. But simultaneous operation might at times lead to interference and could be an unnecessary waste of time and resources.

Current radio navigation systems cover all UK offshore waters, but with a fluctuating degree of repeatability. Repeatability is the accuracy with which a vessel can return to a given location, whereas accuracy is the correctness of a position with reference to shore-based coordinates. For example, a persistent and irritating error in the accuracy of fixing in the northernmost North Sea waters was recently traced to an error of eight metres in the position of the Shetlands on nautical charts. However, this error did not affect the degree of repeatability that Decca position fixing equipment was able to achieve in this area.

The two existing radio navigational systems are Decca Navigator, dating back to the Second World War, and Decca Hi-Fix, a more recent system installed to provide greater accuracy for North Sea survey work by using



The map shows recent North Sea navigation systems. Solid lines indicate Pulse 8 chain stations and dotted lines, the proposed Loran C chain. The shaded area shows the coverage of the Hi-fix chain



Putting drillings on the correct spot is an expensive business. The rig shown here is the semi-submersible Sea Quest drilling for B.P.

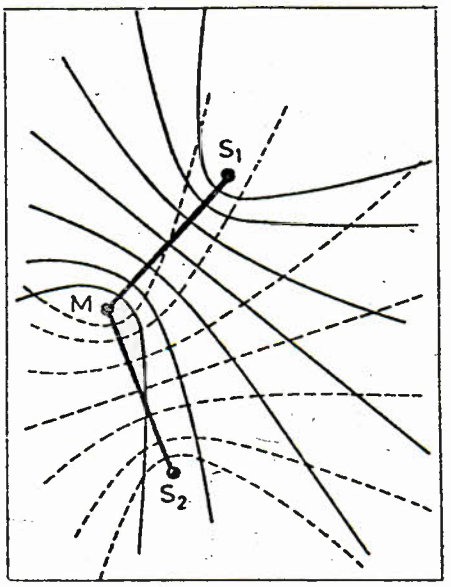
Crossed hyperbolae fix the spot

Systems like Loran C and Pulse 8 enable ships and aircraft to fix their positions on the Earth's surface through onboard analysis of signals broadcast by at least two—and usually three—shore transmitters. Simple geometry indicates that, if you know the distance (range) to two known points, then your position is at one of the two intersections of two circles drawn round these points. Cruder navigational data will normally enable you to resolve which intersection actually represents your position.

However, most radio navigation systems normally provide hyperbolic coordinate systems. This is not the ideal type—the hyperbolae rapidly start intersecting at small angles, which degrades the accuracy of a fix. But hyperbolic coordinates are the simplest to generate.

The key to radio navigation is usually the measurement of the time (or phase) difference between two signals from separate transmitters, received on the mobile platform. Lines of constant time difference which, mathematically, are hyperbolae are then plotted on to maritime or aeronautical charts.

Why measure time differences given the resulting poorer lattice? Unless extremely accurate time standards are available at both receiver and transmitter, then no useful measurement of transmission time can be made, and so the range (from the transmitter) cannot be accurately measured. If, however, time standards



Hyberbolic coordinates derived from a constant time difference between signals from master (M) and slave (S1, S2) shore stations

are available (usually caesium or rubidium clocks), then a more accurate fix can be made using the "range-range" method.

Both Loran C and Pulse 8 transmit on 100kHz, sending out groups of 8 pulses, from "master" and "slave" stations. Each group of pulses lasts eight milliseconds (ms), except the Loran C master which takes a further 2 ms to transmit special system control information. The master will transmit a group of pulses, followed by up to four slaves at predetermined intervals. The process is repeated between 10 and 50 times a second.

Each pulse in a group may start with a positive or a negative half-cycle—this is known as the phase-coding of the group and is used to distinguish different systems and transmitters.

The navigation receiver has circuits which lock on to each group in turn—both deriving the necessary phase difference, and ensuring that unwanted stations are screened out. But the entire pulse is never used—in Loran C, only the third cycle is needed. This is to avoid contamination of the signal by skywaves, reflections of the original signal from the ionosphere, which arrive at a later point in time. Skywaves never arrive before the third cycle, so that cycle is always interference free.

Pulse 8 is claimed to have a slightly improved repeatability, principally because its range is restricted to 320-480 km instead of 1600 km or more of Loran C. The virtual absence of skywaves at this range allows the Pulse 8 receiver to sample a later cycle in the pulse—when, owing to the shape of the pulse, the signal is greater. Thus, signal-to-noise ratio will be improved—and, consequently, so will the repeatability. But the improvement is slight, since other important factors (chain configuration, transmitter power, and propagation) are unaltered.

a higher frequency (2 MHz or 150 m wavelength) than Navigator which operates at a frequency of 100 kHz (3 km wavelength). Neither system incorporates much protection against interference from reflections of the original signal from the ionosphere. Because of diurnal variations in the ionosphere, these reflections, called skywaves, are worse at night than during the day. And because of seasonal variations in day length, skywave interference is a more serious problem in the winter. These problems create the risk of fixing error if no other navigational information is available.

Recently, for example, a drilling rig was found to be 10 km out of position in UK block 2/5—an entire "zone" of the Decca Navigator chart. An error of this magnitude is abnormal and was apparently caused by three operators on three accompanying ships making simultaneous errors. But even smaller errors can be tremendously costly given the huge charges for drill rigs and other vessels involved in North Sea operations. More commonly, a "lane" (there are 20 lanes in a zone on a Decca Navigator chart) is lost because of skywave interference when the vessel carrying the position fixing equipment has to steam overnight to reach its station.

To date, no other permanent navigational systems have been licensed in the UK North Sea waters. All operators, except NATO navies, have to rent ship-board equipment from Decca to take fixes. Not surprisingly in this near monopoly situation, complaints about equipment standards and leasing arrangements are not uncommon. Trawlermen complain that they cannot take advantage of government capital equipment subsidies to fishing fleets because Decca refuses to sell receivers. Offshore operators, too, would prefer more than one supplier.

Since several important fisheries are at the extreme range of land-based Navigator chains, some fishing fleets are increasingly turning to Loran C in these areas. Although no Admiralty Loran C charts are published, the White Fish Authority has recently published a series covering Icelandic and other deep sea fishing grounds. Naturally those fleets that use Loran C would like to see it extended into UK offshore waters.

Satellites spot the way

Because of the skywave problem associated with existing navigational systems, an increasing number of offshore operators are turning to satellite navigation systems for position fixing. Six orbiting US Navy satellites can locate any point on the Earth's surface to an accuracy of around 50 metres. But by taking 30 fixes over a day or so, the error reduces to

about five metres. A major disadvantage, however, is that fixes can be obtained only once an hour or so. Thus "satnav" on its own is insufficient for anything but a verification of a fix. But if combined with an input of a vessel's velocity relative to the sea-bed, dead reckoning can provide a continuous plot of position. This input can be gained by measuring the doppler shift of a sonar return from the sea-bed or by digitising the output of a Hi-Fix or Navigator system.

Position fixing needed for a pipeline or geological survey is carried out by the survey ships themselves. Until 1973, drilling rigs, pipelaying barges, and production platforms that needed a fix hired specialist vessels (usually from Decca) to accompany the barge or rig. The vessel fixes the position to which the rig or barge is to move, and lays a buoy pattern to indicate where the rig should travel and where anchors should be dropped. Once the rig is in position, the specialist ship takes a bundle of fixes to verify that the rig is, in fact, on station.

But specialist companies offering satnav services are beginning to gouge out a section of this market for themselves—one estimate is that a third of the 300 rig movements this year will be serviced by satnav. Another advantage of satnav is cheapness. A specialist vessel accompanying a rig can cost £2500 a day. Satnav operators flying in their equipment to the rig itself charge about this amount for the whole service. This threat to Decca's dominance of the North Sea position fixing market may be one reason for the development of Pulse 8.

Sea of discontent

As well as the ITT/Redifon proposal for the North Sea, AFOS (Anglo-French Offshore Surveys) has also applied for a licence to operate a North Sea position fixing chain called Toran. Like Hi-Fix, this operates in the 2 MHz maritime band. The AFOS application is still "meandering through" Home Office procedures. AFOS is, however, hopeful about an application to operate the same system in the Celtic Sea. Here it is competing against Decca's application to run a Pulse 8 chain.

But it was Decca's announcement of its application for a North Sea Pulse 8 chain that exposed tense commercial rivalries. In a letter to *Electronics Weekly* (13 November, 1974), Redifon claimed that Pulse 8 would create "unacceptable interference" to hundreds of Loran C receivers in British deep sea trawlers and suggested that Pulse 8 would be "the basis of [another Decca] monopoly".

Redifon's real interest in Loran C was not disclosed at that time, but the claim of "interference" was hotly denied by Decca. In fact, the claim could well be substantiated—but not for the reasons given by Redifon. Older Loran C receivers carried on many vessels are merely modified Loran A designs, of which the US Coast Guard, which runs the Loran system, strongly disapproves. These older receivers do not automatically lock on to the coded pulses transmitted by the shore stations. Instead a navigator has manually to adjust pulse patterns on an oscilloscope. Extra pulses from Pulse 8 transmitters might confuse the navigator to such an extent that he might find it impossible to use a Loran C signal.

Pulse 8's major selling point is its resistance to skywave interference, although Decca also claims that the engineering standards and reliability of its transmitters are superior to Loran C. Nevertheless, Hi-Fix is a more accurate system than Pulse 8. Decca hopes that Pulse 8's interference resistance will be needed to sustain bad weather and winter operations. Pulse 8 can gain fixes of roughly the same quality regardless of the time of day or season. In contrast, Hi-Fix's greater susceptibility to skywave interference renders it liable to the risk of a lane slippage.

Decca claims that Pulse 8 is solely an improved position fixing system for surveyors in the North Sea. But Decca has taken unusual steps in Pulse 8 design, suggesting that this might be only a part of the story. The phase coding of Pulse 8 signals (see box) has been deliberately made different from the Loran C format, purely for "proprietary" reasons. The phase coding is, moreover, secret. Thus existing Loran C receivers, of whatever origin, will not be able to lock on to the Pulse 8 chain—even well inside the admittedly reduced range of Pulse 8 transmitters. If Pulse 8 is intended solely for the position fixing market, and not as a general navigation aid, this tactic (making existing Loran C receivers incompatible) seems unnecessarily defensive. If however Decca intends to extend Pulse 8 to become a general navigational aid at some future date, the foot-in-the-door strategy—of gaining acceptance of Pulse 8 first as a position fixing system—makes sense. Then ships wanting to take advantage of Loran C type coverage in the North Sea would have to equip with Pulse 8/Loran C (and therefore Decca) equipment. The near monopoly would continue unperturbed.

ITT/Redifon's venture is likely to be strongly, if tacitly, supported by the US government, because Loran C is now a vital US national and military navigational system. But the signs in the UK are not good for ITT/Redifon.

A previous application for a UK Loran C chain was refused at prime minister level. A government standing committee on navigational aids sits under the auspices of the Department of Trade. A spokesman for the department stonily commented that the ITT/Redifon Loran C proposal was "not on the agenda at all" and that no further meetings about it had been arranged. However, ITT/Redifon plan to start lobbying support by the beginning of September.

Theoretically, there is no reason why both Pulse 8 and Loran C should not operate simultaneously. Modern receivers could certainly distinguish signals from the two, although this might not always be the case since Loran C transmissions are 400 times as powerful as Pulse 8. But the chances of the UK government forking out £2 million for an American system to supplement Decca's efforts are only slightly greater than those of a snowball in hell.