Underwater acoustic identification of hospital ships

by Philippe Eberlin

At the Twenty-fifth International Conference of the Red Cross (Geneva, 1986) the ICRC presented its report on the identification of medical transports, including the action taken to implement Resolution VIII of the previous International Conference. The report stressed that in a naval conflict the protection of medical transports at sea largely depended on the technical means of identification available.

By adopting its Resolution III entitled "Identification of medical transports", the Twenty-fifth Conference recognized the need for continuous efforts to ensure that the means used to signal and identify medical personnel, units and transports keep pace with technical advances.

The development and testing of equipment for the underwater acoustic identification of hospital ships are described in the following article.

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I. Introduction

The subject of underwater acoustic identification of hospital ships was first raised almost 75 years ago during the First World War. At the Tenth International Conference of the Red Cross in 1921, the Netherlands Red Cross reported that:

"Thanks to the good offices of the Dutch Government, a reciprocal agreement was reached on 2 July 1917 between the British and German Governments under which a certain number of prisoners of war would be interned in the Netherlands; the transport of these prisoners, both civilian and military, would henceforth be combined with the exchange of invalid soldiers and medical staff. To ensure that

the ships tranporting them were not torpedoed, the German Government wanted them to consist of at least two paddle-steamers sailing in convoy, because only the noise made by paddle-wheels can be recognized by submarines over great distances. The Zélande *and the* Koningin Regentes *of the Zélande company were chosen and with them the* Sindoro *of Rotterdamsche Lloyd. They were marked with the distinctive emblems specified for hospital ships under the 1907 Convention and were converted to transport 900 sick, wounded or mentally ill people. Normally it would have been possible to make the voyage to the English port of Boston in 19 hours but, because of the danger involved, the voyages took longer."*

At the time, the protection of hospital ships was governed by the Xth Hague Convention of 10 October 1907 for the Adaptation to Maritime Warfare of the Principles of the Geneva Convention of 1906. This Convention provided only for the visual identification and localization of hospital ships, in spite of the fact that radio communications—wireless telegraphy (WT)—had been used aboard ships since the turn of the century. In 1906, the International Radiotelegraph Conference adopted the Radio Regulations which, among other things, established the universal distress signal SOS. This new signal replaced the CQD distresss signal used prior to the 1906 Conference but still sent out, along with the SOS, by the TITANIC when it sank in 1912.

Article 8 of the Xth Hague Convention of 1907 allowed WT to be used aboard hospital ships but did not lay down any rule for their radiocommunications in wartime or impose any restriction on the use thereof. In 1915, the hospital ship OPHELIA was involved in a naval incident related to the transmission of messages in secret code. The experts consulted by the ICRC in 1937 for the planned revision of the Xth Hague Convention of 1907 were probably influenced by this incident in drafting their texts.

Their proposed ban on the use by hospital ships of secret codes for wireless or other means of communication was adopted. It is now contained in Article 34 of the Second Geneva Convention of 1949 which, under Art. 58 of this new "maritime" Convention, replaced the Xth Hague Convention of 1907.

Apart from this provision placing restrictions on radio communications, the 1949 Diplomatic Conference did not embrace the proposals which the experts had made on the use of technical means of identifying and locating hospital ships. Such means were mentioned in the final paragraph of the new maritime (Second) Convention's draft Art. 40, which provided for both underwater acoustic and radar identification:

"As soon as technically possible, all hospital ships shall be provided with radar and underwater sound apparatus, to permit their identification by the detecting apparatus of belligerents and neutrals..."

Long discussions took place on these technical matters at the 1949 Conference. In its report to the plenary meeting, Committee I, which had the task of studying them, stated that:

"As regards marking, the Committee dealt mainly with those on medical aircraft and hospital ships.

There was general agreement that in the present conditions of aerial warfare, the red cross on a white ground no longer constituted an easily recognizable emblem and therefore no longer afforded effective protection. Aircraft at present speeds can be recognized only by their general shape; moreover, the most distinctive signs are quite unrecognizable at night and a fortiori *by wireless controlled projectiles.*

A new conception was therefore embodied in the Conventions; belligerents are required to agree between themselves on the routes to be followed by military aircraft, and also the altitude and times of flight. Aircraft will only be entitled to respect in so far as there has been previous agreement on these points.

The Committee was unable to agree to a condition of a similar kind applicable to hospital ships, as it feared that in notifying the enemy of the course they were to follow, this would give valuable information regarding the safety of navigation in certain maritime zones. Be this as it may, there was unanimous agreement that the best means of ensuring protection is to inform the enemy of the exact position of the formation requiring protection. There is no question, therefore, of camouflage; on the contrary everything will be done to facilitate recognition. Further, the recommendation, in the Maritime Convention, that belligerents shall only employ vessels of over 2,000 tons gross as hospital ships on the high seas is to be interpreted in this sense, since the greater visibility of vessels of that size tends to increase security."

The experts in 1949 did study the question of technical means of marking and identification for medical aircraft and hospital ships, but this resulted in nothing more than the suggestion that the parties to a conflict should reach separate agreements on how to proceed. The experts did not go into detail about the technical means to be used.

For the use of radiocommunications, the 1949 Conference adopted Resolutions 6 and 7 which are annexed to the four Geneva Conventions. The preamble to Resolution 6 explains the limtis to the Conference's work in the technical field:

"...the present Conference has not been able to raise the question of the technical study of means of communication between hospital ships, on the one hand, and warships and military aircraft on the other, since that study went beyond its terms of reference..."[1].

As regards other technical means of identification—underwater acoustic and radar—the final paragraph of Art. 43 of the Second 1949 Convention recommends their use without actually specifying them. The Conference wished to provide the possibility of preparing for the use of such devices, which at least took into account the concerns of the ICRC.

II. Underwater acoustics and acoustic signatures

Acoustics is the scientific study of sound, and underwater acoustics studies, in particular, the propagation of sound waves under water. Sound waves, which are produced by a vibrating body—quartz, ceramic, a bronze bell, etc.—travel through water at a speed of 1,500 metres per second. The speed of sound through water was measured for the first time in 1827 by two scientifists, Jean-Daniel Colladon and Charles Sturm, who were studying the use of underwater sound signals in Lake Geneva. Their work was published by the Geneva Physics and Natural History Society, established in 1790.

Unlike electromagnetic waves which can travel through a vacuum because they are produced by the vibration of an electromagnetic field, the propagation of sound waves requires a material substance—air, water, metal, etc. Thus, while sound cannot travel through a vacuum, radio, radar and light can travel unhindered.

The spectrum of electromagnetic fequencies is considered to be a natural resource, the joint property of all humanity. The International Telecommunication Union (ITU) was created to manage this resource on the basis of the International Telecommunication Convention. Nothing like it exits at present for acoustic, infrasound, sound or ultrasound waves. For underwater acoustic purposes, civilian and military transmitters and receivers can therefore use whichever wavelengths they prefer to obtain the desired result.

[1] See *Geneva Conventions of August 12, 1949*, Resolution 6, and *Commentary on the Additional Protocols of 8 June 1977 to the Geneva Conventions of 12 August 1949*. ICRC, Martinus Nijhoff Publishers, Geneva, 1986, p. 318, par. 1144-1145.

Beneath its surface, the sea is a noisy environment and this background noise can make it difficult to receive an acoustic signal. The signal can be disrupted or even blocked by changes in water temperature as the signal travels. Other factors—variations in depth, salinity and the nature of the seabed—also affect the propagation of sound under water. For example, in some parts of the Baltic and North Sea, both of which are relatively shallow, acoustic propagation is a very complex process, especially in winter. In addition to such conditions hindering sound propagation, and the various sources of underwater background noise, there is also the noise produced by surface vessels and submarines. These are becoming less and less noisy in an attempt to evade acoustic detection; nuclearpowered submarines can attain very high speeds (in the order of 30 knots)[2] at a depth of several hundred metres, but still produce very little noise for such a large craft.

When a ship sails, noise is produced by its bow cutting through the water, the propeller turning, its main and auxiliary engines, etc. The combination of these noises constitutes the ship's "acoustic signature". Each ship theoretically has its own unique acoustic signature, a sonic fingerprint as it were, serving as a passive means of identification. However, shipowners of various nationalities sometimes combine in a joint venture to order several ships of identical design from the same shipyard and thereby reduce construction costs. As a result, several ships sailing under different flags can have identical characteristics and thus acoustic signatures which are so similar as to be very easily confused.

Moreover, a ship's acoustic signature is not immutable. When a ship's load changes, so does its draught; this changes the acoustic signature as do the ship's age and any damage or modifications made to it, especially to the propeller. Some experts believe that the acoustic signature should be measured and recorded every six months to make reliable identification possible. The recording is made with hydrophones—special microphones for receiving sound under water. A hydrophone converts the sound into electrical oscillations which can be displayed as vertical lines on a screen or printed on a graph. It is then possible to "read" the acoustic signature and, theoretically, to identify it by comparison with a pre-recorded specimen signature.

Given the complexity of an acoustic signature and its propagation, only specialists with sophisticated equipment can make a reliable identification. The specimen signature is prerecorded by having the ship

[2] 1 knot = 1 nautical mile (1,852 metres) per hour.

sail across an "acoustic range" where an array of hydrophones has been installed on the seabed. The recording could also be made by a submarine with an array of hydrophones installed on its hull.

Modern navies have the specialized equipment and personnel necessary to provide their ships at all times with up-to-date recordings of acoustic signatures. However, recording the signature of a civilian ship can be very difficult, even impossible, if that ship sails under the flag of a State which does not have a navy or the necessary technology.

The question arises whether, in the event of armed conflict, the acoustic signatures of hospital ships and ships converted into hospital ships on the one hand, and neutral ships chartered by the ICRC on the other, could be recorded periodically and communicated to the belligerents and neutral parties. As there is nothing regulating the recording methods, nor any international standards for acoustic signatures, it would be impossible in practical terms to record acoustic signatures simultaneously among the belligerents and neutral parties.

Finally, when submarines are on station, it would be out of the question to send them recordings of the acoustic signatures of ships converted into hospital ships or neutral ships chartered by the International Red Cross. The acoustic signature is therefore, very probably, a sort of IFF "identification friend or foe" system, that is, passive and reserved for the identification of "friendly" warships but unusable by neutral ships or hospital ships.

III. Systems for active underwater acoustic identification

Experience during the Second World War and subsequent armed conflicts has demonstrated the need for hospital ships and neutral ships to have a reliable system of underwater acoustic identification. The idea of an active underwater identification system took shape in the years preceding the 1970 ICRC meeting of technical experts, convened in preparation for the 1974-77 Diplomatic Conference which was to create the Protocols additional to the Geneva Conventions of 1949. This idea was supported by the Swiss Transport Office, the authority responsible for Swiss maritime transport in wartime, and by the ICRC, which is concerned with the safety of hospital ships and other vessels protected by the Geneva Conventions.

Three ships sailing under the Swiss flag were equipped with the first active identification system. They were:

the REGINA—a cargo ship of 1,100 DWT[3]
the RHÔNE—a chemical tanker of 3,600 DWT
the CERVIN—a chemical tanker of 6,900 DWT.

The system comprised an electronic control unit connected to a fixed acoustic transmitter, composed of four transducers, emitting the ship's callsign in Morse code. The callsign was preceded by the prefix NNN. The transmission was automatically repeated either continuously or at set intervals. The transmitter, housed in a watertight box, was located in a water-ballast in the double bottom of the ship's hull, where there was an opening through which the transducers came into contact with the sea.

A ship's callsign, which is used for all communications, is a group of letters assigned to it under the ITU Radio Regulations. The callsign gives the ship's nationality and a group of letters from which its individual identity can be derived by matching them against lists published by the ITU.

The tests carried out on this system aboard the three ships showed that it worked, though it was not possible to have its range confirmed by monitoring stations or submarines.

TESTS ON THE ACOUSTIC IDENTIFICATION SYSTEM INSTALLED IN THE HULL

Period	Ships	Morse signal	Frequencies	Geographical areas
18.08.79 to 27.08.86	REGINA	NNN HBDR	5-5.1 kHz	North Sea Atlantic Pacific
Report: met various warships; no monitoring report; normal transmission of signal.				
29.09.80 to 16.07.87	RHÔNE	NNN HBDO	5-5.1 kHz	Mediterranean Atlantic Baltic
Report: transmission verified by hydrophone arrays installed on seabed; submarine surfaced close to *Rhône* in the Baltic; no monitoring report; normal transmission of signal.				

[3] DWT = deadweight tonnage.

19.05.82 to 18.09.87	CERVIN	NNN HBFJ	5-5.1 kHz	North Sea Atlantic Baltic Mediterranean

Report: no monitoring report; normal transmission of signal.

Generally speaking, the monitoring of underwater signals is classified. For civilians wishing to monitor non-military underwater signals, not only are one or several hydrophones and a recording device required, but also a vessel to go out to the open sea and check the range and the acoustic radiation. Difficulties arose, however, and this project had to be abandoned. Since a fixed transmitter could be installed in a ship's hull only when the ship was in dry dock, installation proved to be too slow and costly. So another solution was sought.

IV. The TRAINE system—a towed acoustic transmitter

The search for a solution led to construction by a specialized firm of an acoustic transmitter installed in a "fish" and towed behind the ship, using a single transducer to transmit a Morse signal consisting of a prefix followed by the ship's callsign. The electronic control unit uses microprocessors which make it small enough to be carried like a suitcase. The TRAINE system has the following advantages:

— modest price;

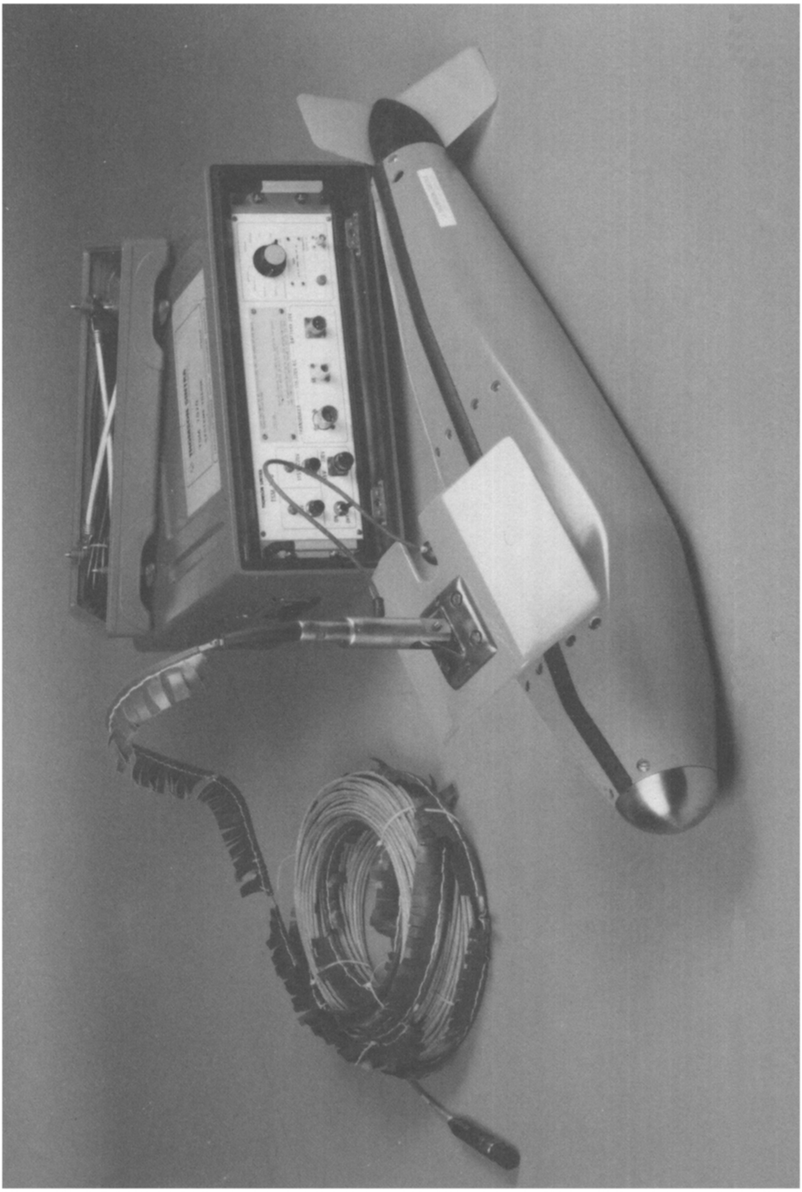
— size and weight such that it can be handled by one or two persons;

— to install it, no equipment other than the ship's already existing towing, hoisting and mooring equipment is needed;

— the tranmission interval can be set;

— it can be towed at an economic speed of 14 knots.

The ICRC and the Swiss Transport Office in Berne arranged for the TRAINE system to be tested on board the Swiss ships FRIBOURG and GÉNÉRAL GUISAN in the North Sea and the Atlantic. However, as in the case of tests carried out on the transmitter fixed in the ship's hull, no reception report was received from the various navies informed of the TRAINE system tests.



The TRAINE system for the underwater acoustic identification of hospital ships (the "fish" containing the acoustic transmitter, the cable which tows it and controls its transmission, and the electronic control unit).

Photo: Thomson Sintra Activités sous-marines.

The *Poolster* (16,800 GT) of the Royal Netherlands Navy and placed by the Netherlands government at the ICRC's disposal to conduct tests on the TRAINE system for the ICRC.

Photo: Royal Netherlands Navy.

In addition, with the help of the Federal German Ministry of Transport, the TRAINE system was installed in a Federal German naval vessel and tested with a submarine in August 1987 off the coast of Norway. The Norwegian Sea rarely presents favourable conditions for sound propagation. This limited the range of the sound produced by the ship as well as the YYY TEST signal emitted by the TRAINE system. The submarine received the signal at distances of up to 8.5 nautical miles. The signal's sound level and the signal radiation pattern matched the specifications for the TRAINE system. Technicians who monitored the tests were able to give useful advice on using the system.

The acoustic identification of hospital ships had already been raised at the Twenty-fifth International Conference of the Red Cross (Geneva, 1986). The government delegation from the Netherlands informed the ICRC that the Netherlands wished to contribute to the ICRC's efforts in this area and was therefore willing to have the Royal Netherlands Navy (RNLN) carry out tests free of charge on the TRAINE system, using a submarine to monitor the signal propagation.

These tests were carried out from 23 October to 6 November 1987 between Plymouth and Barcelona, with the TRAINE system installed on board the Royal Netherlands Navy supply ship POOLSTER. The signal transmitted consisted of the prefix YYY, reserved for hospital ships under Chapter XIV of the International Maritime Organization's Code of Signals. This was followed by the word TEST. The signal was transmitted continuously in Morse code.

In an area near Cartagena, off the coast of southern Spain, where temperature variations in the water make for less than ideal acoustic propagation, the range of the underwater acoustic signal was well above 25 nautical miles, sometimes going beyond 35 miles. The main points of the RNLN report on the tests are given below. Thanks to the excellent co-operation of the Netherlands authorities and the skilled assistance of the POOLSTER's Commander M. C. Bakker and his officers, detailed results were obtained which demonstrated that active underwater acoustic identification is possible.

TESTS CARRIED OUT ON THE TRAINE SYSTEM—
TOWED ACOUSTIC IDENTIFICATION TRANSMITTER

Period	Ships	Morse signal	Frequencies	Geographical areas
12.11.84 to 09.07.86	FRIBOURG 3,500 DWT	NNN HBFF	5-5.1 kHz	North Sea Norwegian Sea Baltic Atlantic
Report: no monitoring report; technical incidents when starting up the system, normal transmission of signal; 100 m cable too short in heavy weather.				
28.08.86 to 16.09.86	GÉNÉRAL GUISAN 55,000 DWT	NNN HBFS	5-5.1 kHz	North Sea South Atlantic
Report: no monitoring report; met warships; on 06.09.86, "Traine" fish damaged after striking submerged object (transducer recovered intact).				
22.08.87 to 24.08.87	WALTER V. LEBEDUR	YYY TEST	5-5.1 kHz	Norwegian Sea
Report: monitoring report from submarine: signal received up to 8.5 nautical miles. Unfavourable propagation profile.				
23.10.87 to 06.11.87	HNLMS POOLSTER 10,000 DWT	YYY TEST	5-5.1 kHz	Atlantic Mediterranean
Report: monitoring report from submarine: signal received at a distance of over 25 miles (see following extract from Royal Netherlands Navy report); used 300 m cable which was damaged while ship was moving at 20 knots (transmitter intact).				

EXTRACT FROM REPORT ON TESTING TSM 7070 TRAINE SYSTEM
ISSUED BY THE MINISTRY OF DEFENCE—
ROYAL NETHERLANDS NAVY—MARCH 1988.
TRIALS CARRIED OUT O/B HNLMS POOLSTER

Results

1. Acoustic effectiveness of Traine signal

- Proved discernable at a distance of at least 25 NM (nautical miles).
- Bearing of the signal was obtainable at the same distance.

- Was detected before the ship's noise.
- Readability proved reasonable during all runs.

  NOTE: Due to the great speed of the transmissions the separation between points and bars could only be deciphered by *trained* Morse operators. In order to enhance the readability of the Morse signals, the speed of the transmissions should be lowered such as to allow less qualified operators to perform the job.
- With a detection range of at least 25 NM, it is recommended to increase the repetition time (interval) of the transmitted message because it is expected that the radial velocity of the approaching vessels can be greater than or equal to 25 NM/hour.

2. *Mechanical handling characteristics*

- *Inboard handling*
  - TRAINE proved easy to handle inboard although several adaptations had to be made to facilitate operations.
  - Several electronic indications need readjustments to improve easy monitoring of the functioning of the fish.
- *Towing characteristics*
  - The fish tends to break out of the water at speeds greater than 12 kts when 100 metres of cable is streamed. With 260 metres of cable streamed the fish tends to break out at 15 kts speed.
  - It is recommended to use a heavier type of cable. Also a longer cable should be used.
  - The attachment of the towing point needs reconsideration.
- *Paying out and hauling in*

  It is recommended to use markings on the towing cable each 50 metres.
- *Mechanical strength of body and cable*

  Generally the towed body is of too weak a construction for continuous use. Also the fish should be more streamlined.

IV. Conclusion

The problem of protection for hospital ships and neutral vessels in times of armed conflict goes beyond the actual technical development of modern means of identification. It is also up to naval experts to help find solutions for it, for their observations and experience on board surface vessels and submarines can show exactly where the problem lies.

The final paragraph of Article 43 of the Second Geneva Convention of 1949 states that "parties to the conflict shall at all times endeavour to conclude mutual agreements, in order to use the most modern methods available to facilitate the identification of hospital ships".

By promoting the TRAINE system, the ICRC and the Swiss Confederation (Switzerland is the depository State for the Geneva Conventions) have demonstrated that it is possible in peacetime to find more modern and effective means of protection for non-belligerent ships and hospital ships.

Philippe Eberlin

The author, **Philippe Eberlin**, served as an officer on neutral merchant vessels during the Second World War, then as an ICRC delegate on board a ship chartered to carry relief supplies. In 1945, and until the end of the war, he accompanied relief convoys to the combat zone in eastern Germany. He has since carried out several missions on ships and aircraft chartered by the ICRC in the Far East, the Middle East and Africa, and on board ships on the Mekong in connection with relief operations in the region and in the South China Sea to combat piracy and bring assistance to Boat People. He was an ICRC delegate on board Argentine and British hospital ships during the South Atlantic conflict.

He has written several articles for the *International Review of the Red Cross* on the marking and identification of medical transports. He is also the author of the Commentary on the Regulations Concerning Identification, Annex I to Protocol I, and has written on the subject of arms limitation and the rules applicable to maritime warfare. He himself invented the underwater acoustic identification system. Although he has now retired from the ICRC, he still takes active part in matters concerning safety at sea.