Study on One Mile SART

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ABSTRACT: From a point that should be improved further in present SART (Search and Rescue Radar Transponder), the size, the number, and the cost were enumerated. Some types of SART developed to solve them in Japan are introduced in this paper. That is automatically operating SART, circular polarization SART and so on. In the process, it was clarified that circular polarization is effective. In addition, One Mile SART using circular polarization was mentioned. It is SART miniaturized instead of limiting the function, because all crews and passengers can always carry the small and light SART. The parts were made for trial purposes and the performance was confirmed.

1 INTRODUCTION

After it is completely equipped with GMDSS (Global Maritime Distress and Safety System) by the SOLAS (the Safety of Life at Sea) agreement by IMO (International Maritime Organization), the accident ship came to be rescued effectively. At the same time, however, some problems and points that should be improved are understood. In this paper, SART of GMDSS was examined.

The main problems in use are thought the size and the number of installations. To solve them, a necessary performance requirement was limited and the miniaturization was tried.

2 PRESENT SART

2.1 *Externals specification and cost*

SART was developed to detect and to do homing for the lifeboat with the radar of the search ship. It is provided to one of GMDSS as equipment goods of the ship and the lifeboat. Though the height of the main body is about 30–40 cm, when using it, it installs in the ceiling of the lifeboat or in the stick of the attachment, and 1m or more in height above sea level is secured. Weight is about 1–4 kg. A price on the market is about 900 US$, and it costs 500 US$ the battery kit that should be exchange every 3–4 years.

2.2 *Performance requirement*

The main of the performance requirements provided by the SOLAS agreement is listed in Table 1.

Table 1. The main performance requirement for present SART

Temperature range (in operation)	–20 –+55 Celsius degree
Operation time	After stand-by 96 hours, continuous response for 8 hours
Height of antenna above sea level	1m or more
Reception sensitivity	below –50 dBm
Radiation electric power	400mW (+26dBm) or more
frequency	9200–9500 MHz
polarization	horizontal
Weight	1– 4 kg

3 IMPOROVED SART

At first of the SOLAS agreement enforcement concerning GMDSS, SART was one (Passenger boat etc. are 2) in each ship. It is fewer than the number of crew and passenger or the number of lifeboats. This is thought to be a result of considering an economic side very much. When actually leaving from the mother ship, it is necessary to carry SART. It is, however, not easy to go to installation place and board the lifeboat by carrying it in the dark night

or at rough sea. There is a possibility of dropping it to the sea, too. In Japan, the development and study are done to solve these problems. Three kinds of SART, that is, life raft installation type, dropping type, life jacket installation type are developed and the result is achieved.

3.1 *Life raft equipment type SART*

It is a type to install SART in the ceiling part of an automatic restoration life raft beforehand. It is not an obstacle even if the life raft is usually folded and put it in the container. When the container is dropped to the sea and the life raft expands, the switch of SART is automatically pulled out and operation begins. Figure 1 shows the photograph of the life raft equipment SART.

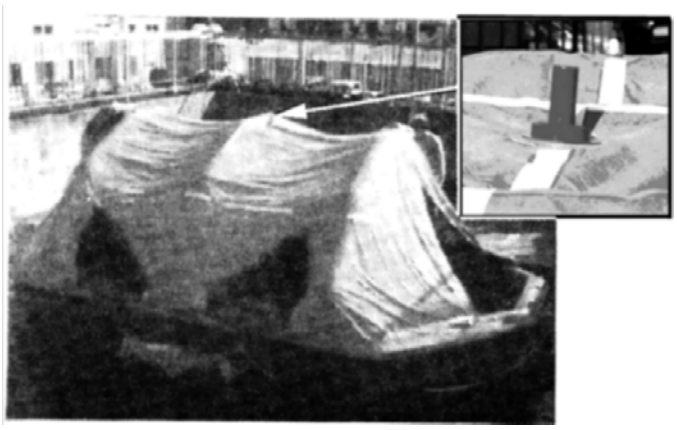

Fig. 1. Life raft equipment SART

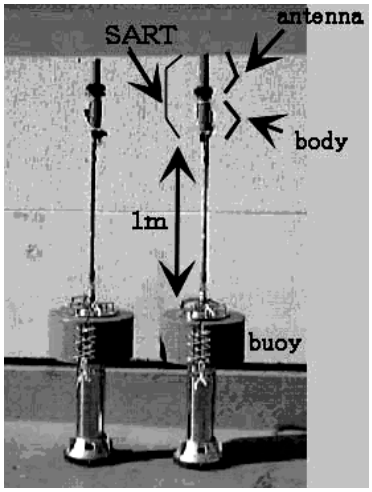

Fig. 2. Dropping type SART

3.2 *Dropping type SART*

It is SART of the type in which the fold stick of about 2m in total length previously installed only the antenna. It is folded compactly, and the stick expands automatically when drop it, the floating body expands, and SART also begins operating. The main body of SART and battery are installed from the center of the stick a little below with the floating body. The weight is attached on the opposite side of the stick, and the height of about 1.5m is maintained on the sea surface. The photograph is shown in Figure 2. This is installed to the buoy for the examination.

3.3 *Life jacket installation type SART*

Life jacket installation type SART (called life jacket SART in this paper) was developed using circular polarization antenna based on the obtained result by above 3.1 and 3.2. One example is shown in Figure 3. In this type, the case where person falls in water is assumed. Therefore, some contents in Table 1 are over specification for usual condition of life jacket installation SART. The suitable specification is shown in Table 2.

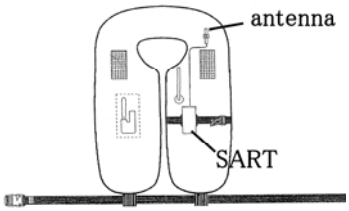

Fig. 3. Life jacket SART

Temperature range (in operation)	-1 ÷ +55 Celsius degree
Operation time	After stand-by 24 hours, continuous response for 4 hours
Height of antenna above sea level	20cm or more
Reception sensitivity	below -50 dBm
Radiation electric power	400mW (+26dBm) or more
frequency	9200-9500 MHz
polarization	Circular
weight	180g

Table 2. The Specification of the life jacket SART

Fig. 4. SART for life jacket installation

When these are decided, the situation of the occurrences of the shipwreck in the near shore waters and the accident of falling in the sea are researched, furthermore, the relation between temperature of seawater and time that person who fall in the sea can live, was considered. The main change point is a use temperature and continuous operation time. Though the height of the antenna is not especially decided, the shoulder or the top of helmet of man who floats on the sea wearing the life jacket are assumed.

As the result, the use of a small general-purpose battery became possible, and the main body became the size of 8 mm videocassette tape. The prototype is shown in Figure 4.

4 COMPARISON BETWEEN PRESENT SART AND CIRCULAR POLARIZATION SART

When these had been designed, in the process of examining the miniaturization of the antenna and the connection of the main body of SART and the antenna about the simplification, it has been understood that the use of circular polarization has advantage. The antenna of SART is provided the horizontal polarization according to ship's radar. SART, however, doesn't necessarily keep the polarization, because big wave motion is generated at sea. It is thought that there is attenuation based on the rotation of the polarization by the reflection on the surface of big wave. Therefore, the difference in the effect is almost nothing between the horizontal polarization and the circular polarization in rough wave.

The polarization plane rotates in the circular polarization. Therefore, because null that originates in interference by the direct wave and the reflection wave becomes small, it is possible to receive it with stability. Moreover, differing height pattern becomes an effect, and the effective range expands.

In the examination in the water tank and the sea, circular polarization often gave strong receiving signal for the horizontal polarization.

Figure 5 shows the one example when sea state is calm. The lower line (SART→radar) in the graph is theoretical value of horizontal polarization and the block dots are received signal from circular polarization SART. The value that is stronger than the theoretical value of horizontal polarization is indicated, and it is also understood that detection distance has expanded as a experimental result.

In the use of circular polarization, the antenna can be miniaturized. Furthermore, there is an advantage with an easy separation of the distance of the main body and the antenna because of connect possible by the semi- rigid cable. It means the antenna can be miniaturized and the design has flexibility for installation.

Figure 6 shows the result when sea state is rough.

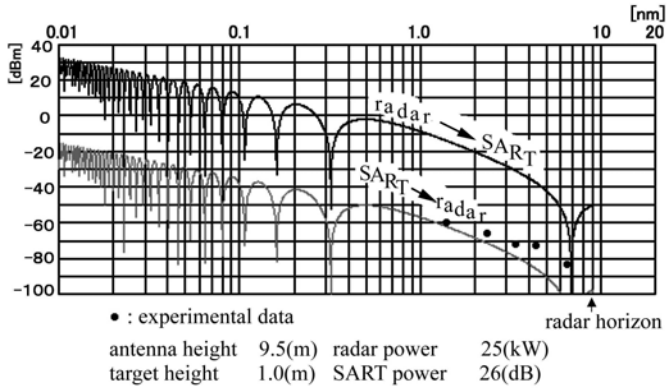

Fig. 5. Theoretical value of horizontal polarization and observed value of circular polarization

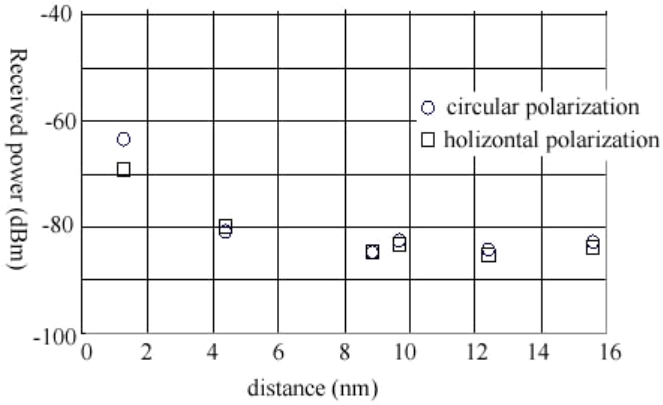

Fig. 6. Signal strength that radar received from SART in wave height 2 – 3 m

The maximum value of the SART signal of circular polarization and that of horizontal polarization in each observation point were compared, and the difference is -0.8 to +5.6 dB. The value numerically increases, when the signal of circular polarization is stronger. Therefore, the signal of circular polarization is stronger than or equivalent to the horizontal polarization

Because of the difference of heights is not constant at each observation point, each observation data cannot be compared in same height pattern, however, it was confirmed that SART of circular polarization was no inferior comparing with horizontal polarization.

5 ONE MILE SART

Furthermore, the authors aimed at the development of less expensive and smaller SART based on these results. To reduce the size to always carry it, and to reduce the cost for all crews and passengers it is our ideal purpose. SART consists an antenna, a battery, an oscillation module, a control module and the case. It made the limitation of the effective range to about one mile to reduce the battery so that the battery might occupy most of weight. One mile is

about 1/10 compared with SOLAS agreement SART. It is, however, difficult to find person who floats on the surface of the sea even by the distance of only hundreds of meters with the unassisted eye. It is thought that the effect of reflecting in radar is large even if the distance is only as much as one mile. This SART is called One Mile SART in this paper.

5.1 *Specification*

The specification at which One Mile SART aims shows in Table 3.

Table 3. The Specification of One Mile SART

Temperature range (in operation)	-1 - +30 Celsius degree
Operation time	After stand-by 24 hours, continuous response for 4 hours
Height of antenna above sea level	20cm or more
Reception sensitivity	below -40 dBm
Radiation electric power	10mW (+10dBm) or more
frequency	9410 MHz ±30MHz
polarization	Circular
weight	Less than 100g

Because it was assumption that the survivor in the sea was putting SART, the category temperature range was assumed to be almost -1 - +30 Celsius degree from the water temperature where person was able to live and the body temperature.
The effective receive sensitivity and the effect radiation electric power relate closely to the battery capacity and weight, and they should be made a minimum requirement. The theoretical value for effective radiation electric power 10mW and the height of the antenna 20 cm is shown in Figure 7 forthe examination. The radar height is 6.5 m as a the examination. The radar height is 6.5 m as a small patrol vessel or small fishing boat. When the minimum receive sensitivity of a radar for the search is assumed to be -80 dBm, it is understood to be able to secure the distance one mile. The effective receive sensitivity can be secured enough. When effective range is 1nm, transmission power is enough in 10mW.

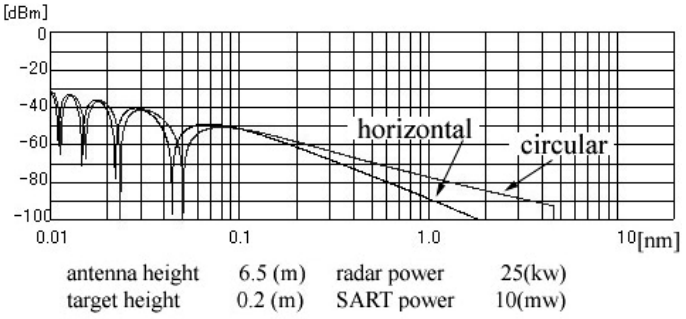

Fig. 7. The theoretical value of One Mile SART

The battery is consumed by the range of frequency and the circuit becomes complex, too. Because most of the radar actually used with the ship was a catalog value 9410MHz ±30MHz, the frequency limited to only having the minimum content of the range here.

About weight, it aimed at the level of the cellular phone or the penlight as extent that did not become obstructive even if it always carried, it aimed at 100g or less.

5.2 *Examination of each component*

SART consists of the antenna, the oscillation module, the control circuit, the battery and the case separately, as mentioned. The result of review of each element to achieve the above-mentioned specification will be presented. Total weight is brought together, it becomes less than 100 g.

6 CONCLUSIONS

To solve problem of present SART, new SART developed in Japan was introduced. In addition, the examination that aimed at SART that each one was able to carry at any time was done, and the performance of the minimum requirement was maintained and miniaturized. The performance was confirmed and the weight became less than 100 g.

The authors will be going to put the improvement and integration to practical use achieving it in addition in the future, and to achieve a prompt salvage.

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