RECOMMENDATION ITU-R M.628-3*

TECHNICAL CHARACTERISTICS FOR SEARCH AND RESCUE RADAR TRANSPONDERS

(Questions ITU-R 28/8 and ITU-R 45/8)

(1986-1990-1992-1994)

The ITU Radiocommunication Assembly,

considering

a) that Regulations III/6.2.2 and IV/7.1.3 of the 1988 Amendments to the International Convention for the Safety of Life at Sea (SOLAS), 1974 require the carriage of radar transponders operating in the 9 GHz frequency band for locating the ship when it is in distress at sea or its survival craft;

b) that such radar transponders may also be used by ships not subject to the 1974 SOLAS Convention; some of these radar transponders may be installed with a float-free release and activation arrangement or with a float-free Emergency Position Indicating Radio Beacon (EPIRB) or float-free satellite EPIRB;

c) that Regulations V/12(g) and (h) of the 1988 Amendments to the 1974 SOLAS Convention prescribe the requirement that passenger ships irrespective of size and cargo ships of 300 tons gross tonnage and upwards carry a radar installation or if they are of 10 000 tons gross tonnage and upwards, two radar installations; from 1 February 1995, the radar installation or at least one of the radar installations shall be capable of operating in the 9 GHz frequency band;

d) that the International Maritime Organization (IMO) has adopted a Recommendation on performance standards for survival craft radar transponders for use in search and rescue operations (Resolution A.697(17));

e) that location is part of the basic requirements for the GMDSS;

f) that a locating system would be more effective if the radar transponder was in conformity with internationally agreed technical and operating characteristics,

recommends

1. that the technical characteristics of search and rescue radar transponders (SART) operating in the frequency range 9 200-9 500 MHz should be in accordance with Annex 1;

2. that the maximum detection range of a SART having technical characteristics in accordance with Annex 1 by a radar conforming with IMO Resolution A.477(XII) should be assessed using its measured technical characteristics in conjunction with the theoretical method given in Annex 2.

Note 1 – The propagation losses of a SART signal caused by a survival craft and its occupants are explained in Annex 3.

ANNEX 1

Minimum technical characteristics for search and rescue radar transponders operating over the band 9 200-9 500 MHz

1. Frequency: 9 200-9 500 MHz.

2. Polarization: horizontal.

3. Sweep rate: 5 μs per 200 MHz, nominal.

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* The Director, Radiocommunication Bureau, is requested to bring this Recommendation to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Electrotechnical Commission (IEC) and the International Association of Lighthouse Authorities (IALA).

4. The response signal should consist of 12 sweeps.

5. Form of sweep: sawtooth, forward sweep time: 7.5 μs ± 1 μs,
return sweep time: 0.4 μs ± 0.1 μs.
The response should commence with a return sweep.

6. Pulse emission: 100 μs nominal.

7. e.i.r.p.: not less than 400 mW (equivalent to +26 dBm).

8. Effective receiver sensitivity: better than –50 dBm (equivalent to 0.1 mW/m^2) (see Note 1).

9. Duration of operation: 96 h in stand-by condition followed by 8 h of transponder transmissions while being continuously interrogated with a pulse repetition frequency of 1 kHz.

10. Temperature range: ambient: –20° C to +55° C,
stowage: –30° C to +65° C.

11. Recovery time following excitation: 10 μs or less.

12. Effective antenna height: ≥ 1 m (see Note 2).

13. Delay between receipt of radar signal and start of transmission: 0.5 μs or less.

14. Antenna vertical beamwidth: at least ± 12.5° relative to the radar transponders' horizontal plane.

15. Antenna azimuthal beamwidth: omnidirectional within ± 2 dB.

Note 1 – Effective receiver sensitivity includes antenna gain.

– Effective receiver sensitivity of better than –50 dBm applies to interrogating radar pulses (medium and long) of > 400 ns.

– Effective receiver sensitivity of better than –37 dBm applies to interrogating radar pulses (short) of ≤ 100 ns.

– The receiver should be capable of correct operation when subjected to the radiated field (28 dB(W/m^2)) emitted from a shipborne radar complying with IMO Resolution A.477(XII) at any distance > 20 m.

Note 2 – This effective antenna height is applicable for equipment required by Regulations III/6.2.2 and IV/7.1.3 of the 1988 Amendments to the 1974 SOLAS Convention.

ANNEX 2

The maximum detection range of a SART of given or measured e.i.r.p. and effective receiver sensitivity when deployed with a radar conforming with IMO Resolution A.477(XII) may be assessed using Fig. 1.

The essential parameters of the radar are:

– transmitter power 25 kW,

– antenna gain 30 dBi,

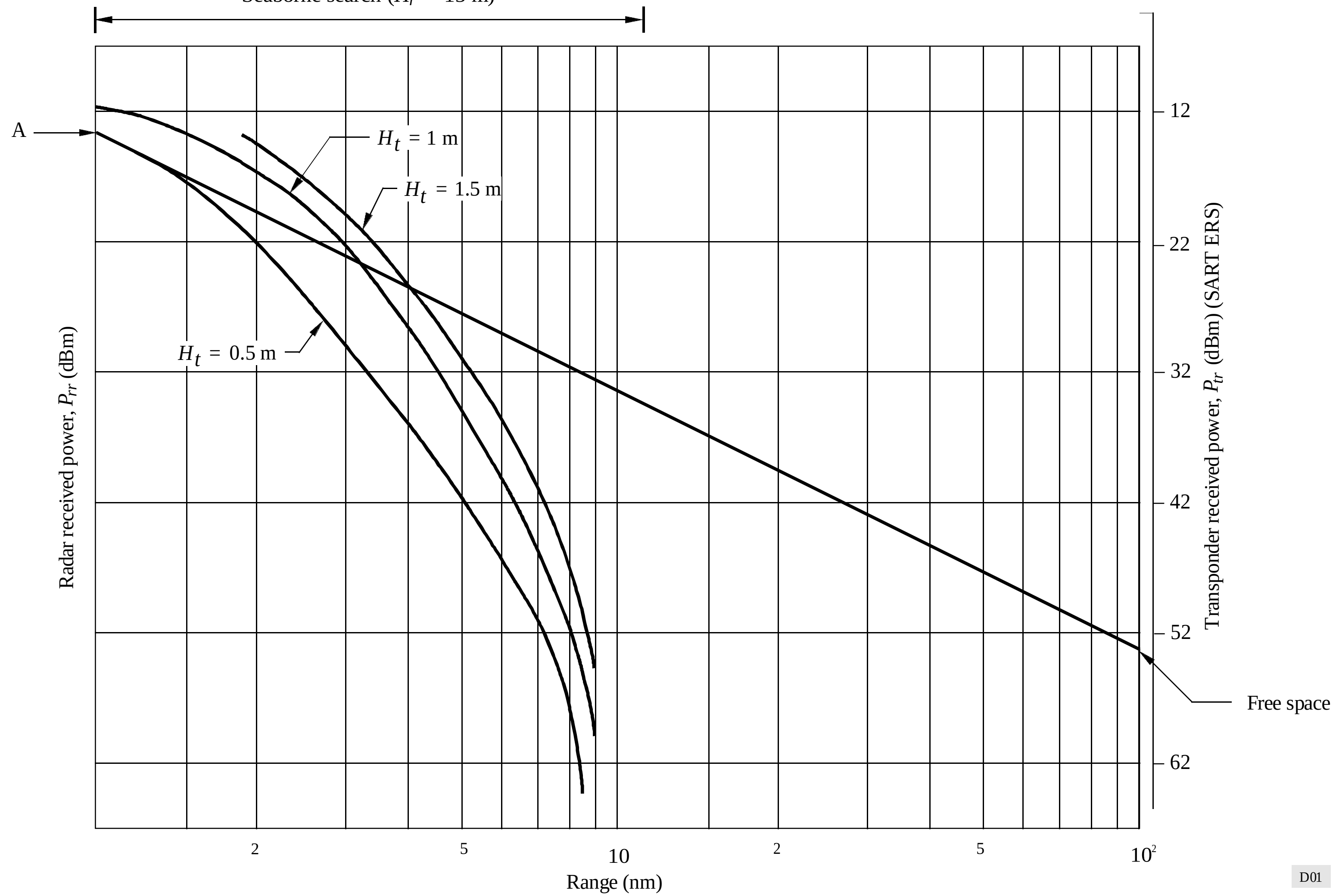
– antenna height 15 m,

– receiver sensitivity –94 dBm.

Figure. 1 shows the propagation curves for SARTs of height 0.5 m, 1 m and 1.5 m in a fairly calm sea (wave height 0.3 m). For rougher seas, the sea reflection coefficient is reduced and the propagation curves move back towards the free space line depending on atmospheric refraction. For an SART of 1 m height, the maximum detection range is at least 5 nm.

FIGURE 1

Propagation curves for measurement of SART maximum detection range



The method of using Fig. 1 is as follows:

– calculate the radar received power (P_r) at range 1 nm using the formula:

P_r = SART e.i.r.p. × radar antenna gain × $(\lambda/4\,\pi\,R)^2$
that is P_r (dBm) = SART e.i.r.p. (dBm) –87 dB;

– set the calculated P_r against point A on the radar received power scale and complete the scale (10 dB per division);

– set the SART effective receiver sensitivity (ERS) on the transponder received power scale and read the intercept with the appropriate propagation curve at that level to obtain the radar to SART maximum detection range;

– take the –94 dBm level on the radar received power scale and read the intercept with the appropriate propagation curve at that level to obtain the SART to radar maximum detection range.

The smaller of the two maximum detection ranges so obtained is the required assessment of SART maximum detection range, which should be at least 5 nm as required by IMO Resolution A.697(17).

ANNEX 3

Effects of antenna height and obstruction of the signal path by a survival craft and its occupants on the detection range of SARTs

1. Introduction

This Annex discusses the effects on the propagation path of SART signals, taking into account the height of the SART antenna above the surface of the sea and also the attenuation caused by the materials of the survival craft and its occupants.

2. Effects of SART antenna height on detection range

This Recommendation requires that the height of the installed SART antenna should be at least 1 m above the sea surface in order to obtain the five nautical mile detection range required by IMO Resolution A.697(17). Practical tests have confirmed this performance. Tests on a sample of six SARTs from different manufacturers gave detection ranges between 8.2 nm and 9.2 nm with an antenna height of 1 m.

2.1 Tests have also shown the importance of maintaining a SART antenna height of at least 1 m. The following results were obtained with a SART in a survival craft:

– SART lying flat on the floor: range 1.8 nm

– SART standing upright on the floor: range 2.5 nm

– SART floating in the water: range 2.0 nm

3. Effects of survival craft on SART signal

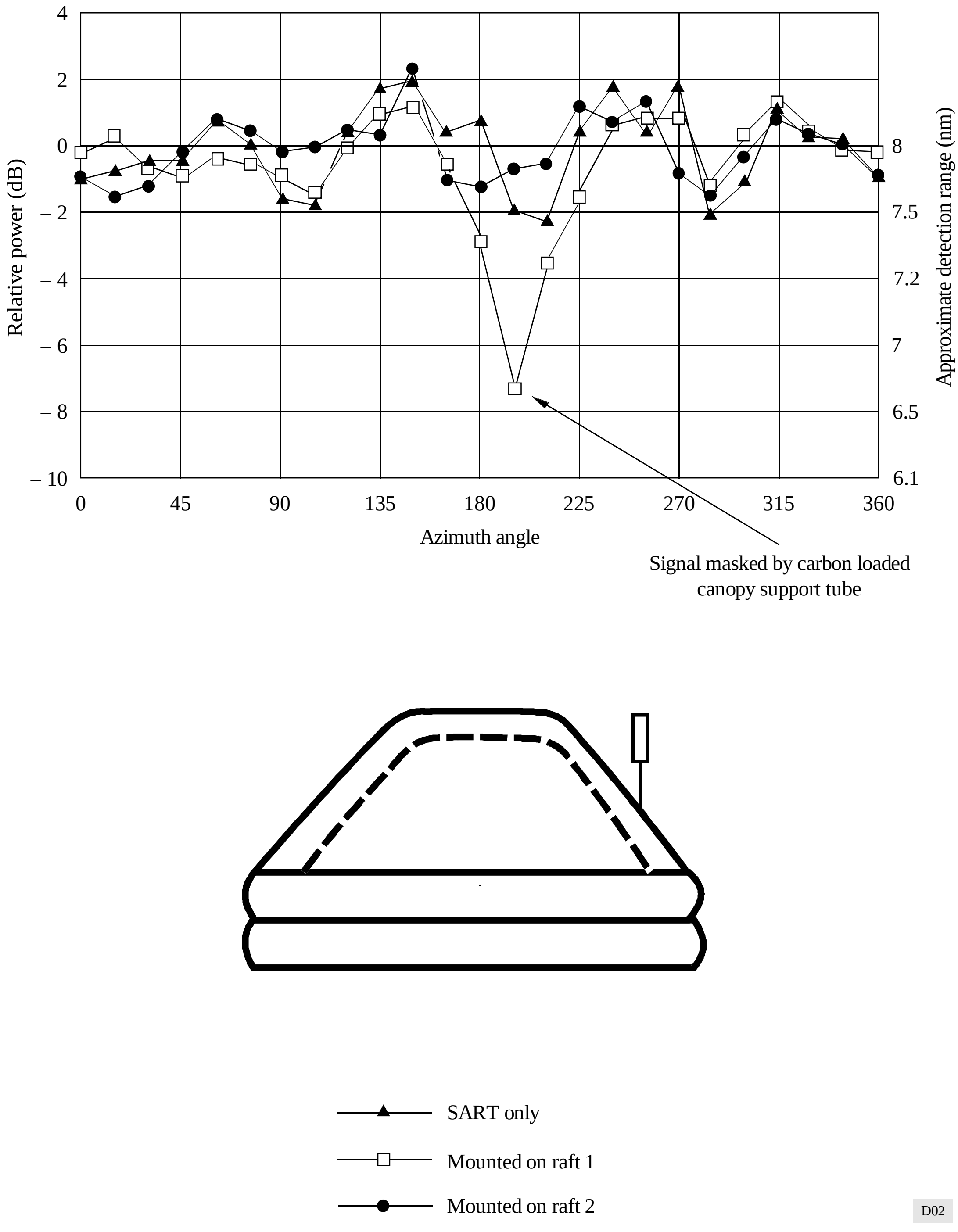
Tests have been made with a SART mounted on a survival craft to give a 1 m antenna height, in order to determine whether the body of the survival craft and its occupants may cause an obstruction.

3.1 Figures 2-4 give the results of these tests carried out on two different models of an eight-man SOLAS life-raft. In each case, the SART was placed at the centre of a turntable in an open field site, and was triggered with a pulsed radar signal. Each set of measurements was conducted with and without the life-raft and "survivors" present, keeping the SART at the centre of the turntable.

3.2 Figure 2 shows the results obtained from a SART mounted on a telescopic pole fitted to the life-raft's antenna mounting. In this case, the SART antenna was level with the canopy support tube of the raft. One of the rafts had little effect on the SART signal, whereas the other (which has carbon in the material of the support tube) caused a dip in the signal through an angle of about 30°.

FIGURE 2

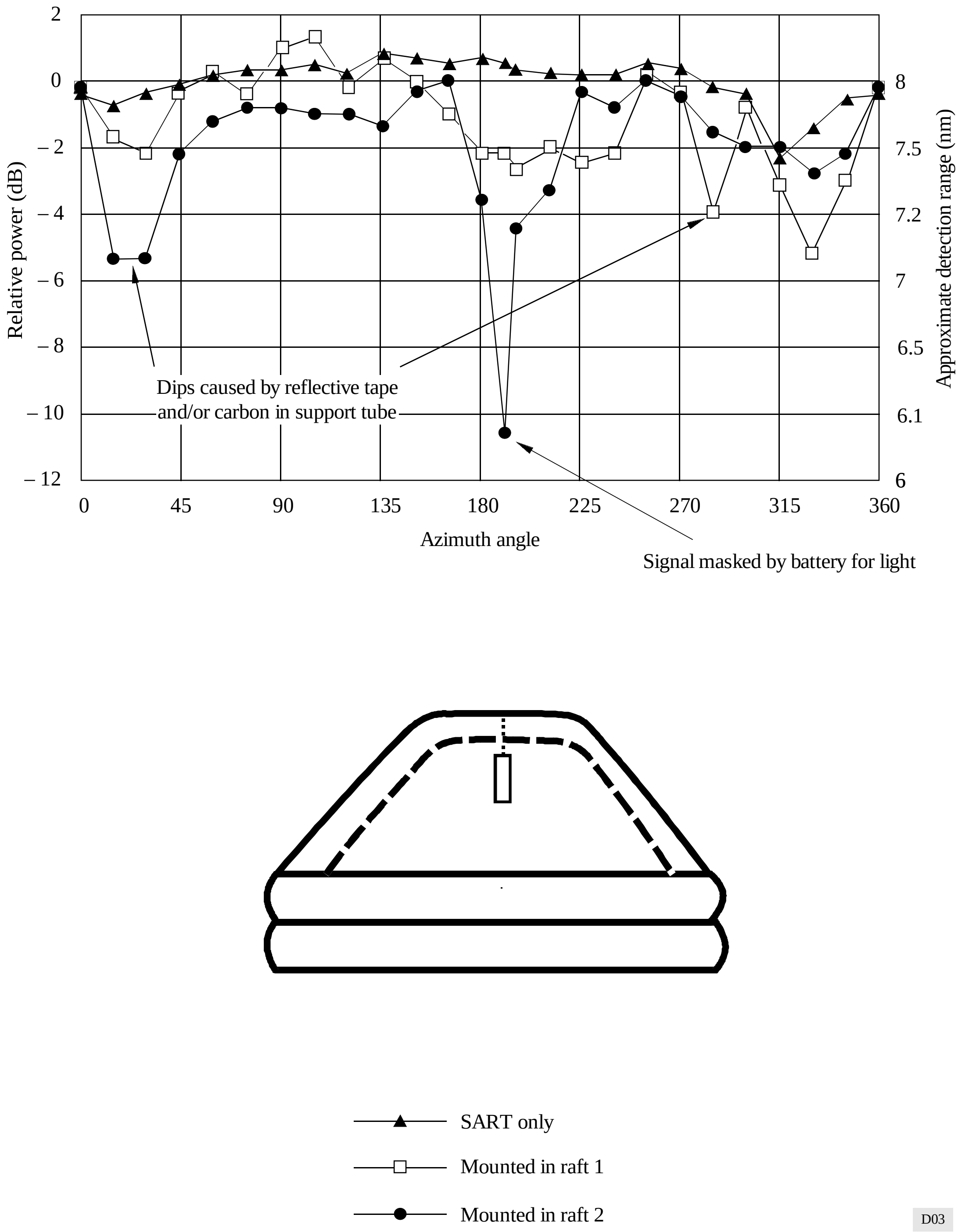
Pole mounted SART



3.3 Figure 3 shows the results obtained with the same rafts, but with a SART designed to hang from the support tube, inside the canopy of the raft. A smaller loss of signal was noted due to the carbon loaded tubes, as the signal was only passing through the vertical sections. Dips were also noted, however, due to the presence of retro-reflective tape on the outside of the life-raft canopies. On one raft, there was a severe reduction in signal over a very small angle, due to the proximity of a Lithium battery pack mounted on the canopy for powering the life-raft location light.

FIGURE 3

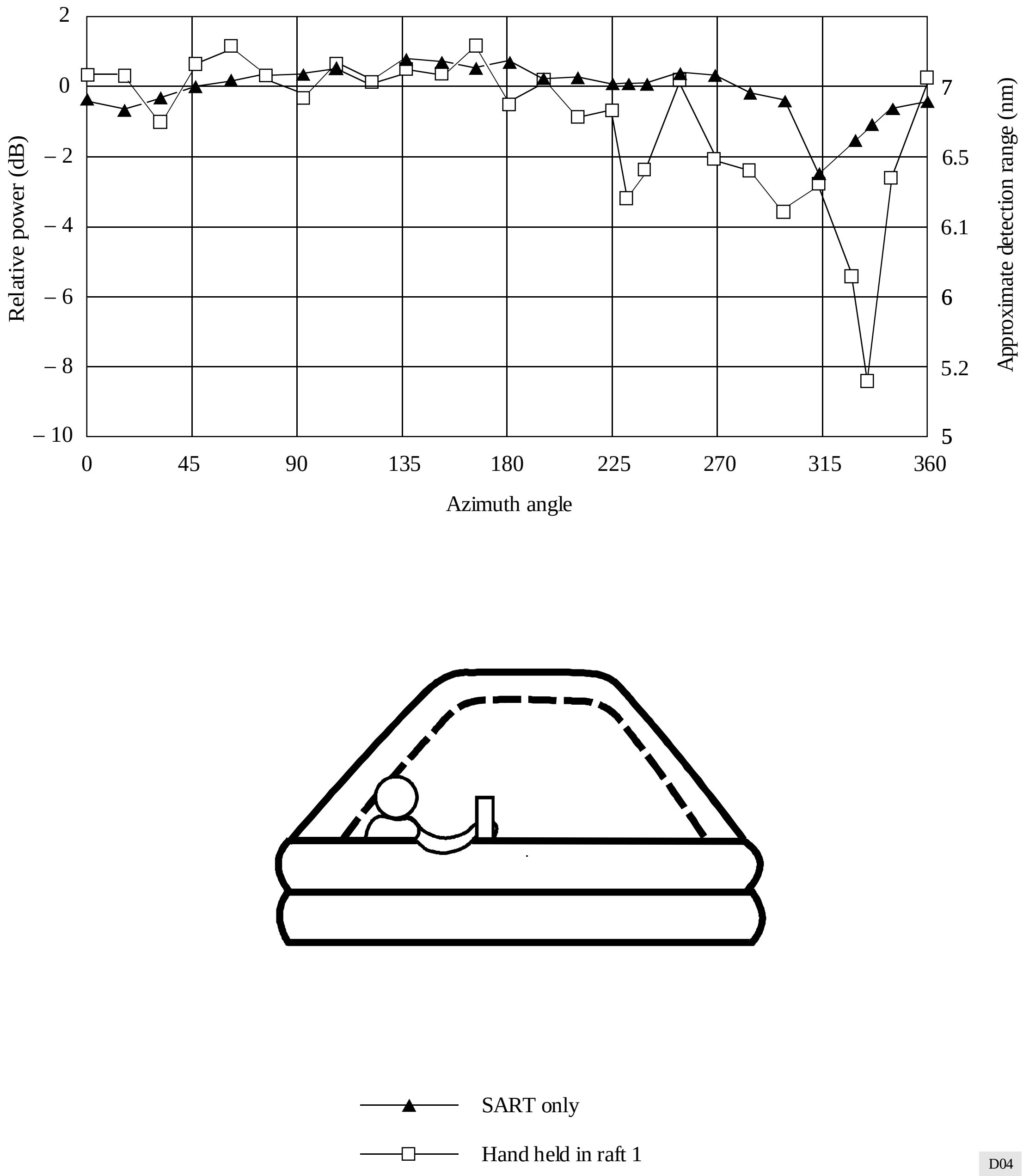
SART hung inside raft



3.4 Figure 4 shows the blanking effect caused by a survivor holding the SART at arm's length. In this case however the SART height was only 0.5 m.

FIGURE 4

Hand-held SART



3.5 On each figure approximate detection ranges are given. These are derived theoretically assuming an 8 nm detection range for a 1 m height SART and a 7 nm range for 0.5 m height.

3.6 It can be seen from the figures that best performance was obtained with the pole mounted SART where the reduction in detection range due to the survival craft was generally no more than 0.5 nm. In all cases there was reduced performance over narrow sectors of 1.5-2.0 nm but in practice with the survival craft moving in the sea this will not be a serious operational problem. The reduction shown in Fig. 4 caused by a person, will not be significant in practice as a person seated in a survival craft is lower in height than 1 m.

3.7 The above results were obtained with the survival craft dry as it was on a test site. Table 1 gives the propagation loss for the canopy and air tube cloths used in a number of different manufacturers' survival crafts. The last two entries give the loss when the materials are sprayed with sea water. It can be seen that in the worst case the additional loss for wet material was 3.35 dB which equates to a reduction in detected range of about a further 0.5 nm.

TABLE 1

Transmission loss through canopy of life-raft (measurement results)

Test	Sample	Thickness (mm)	Weight (kg/m^2)	Transmission loss (dB) vs. slant of canopy			
				Slant			
				θ = 0°	θ = 30°	θ = 45°	θ = 60°
1	Canopy cloth of company A	0.18	0.22	0	–0.1	–0.2	0
2	Air tube cloth of company A	0.53	0.7	–0.05	–0.05	–0.3	–0.2
3	Canopy cloth of company B	0.25	0.27	0	–0.1	–0.15	–0.05
4	Air tube cloth of company B	0.57	0.67	0	–0.4	–0.4	–0.45
5	Canopy cloth of company C	0.26	0.3	–0.2	–0.5	–0.3	–0.4
6	Air tube cloth of company C	0.54	0.67	–0.6	–1.4	–1.9	–2.4
7	Spraying salt water (4.8% NaCl) over "1"	–	–	–0.35	–0.55	–0.95	–1.1
8	Spraying salt water (4.8% NaCl) over "3"	–	–	–1.3	–1.9	–2.6	–3.4

Measurement freqency: 9.4 GHz
Sample size: 600 × 800 mm

4. Conclusions

The tests indicated that properly mounted SARTs will achieve the detection range required by IMO, even allowing for the blanketing effects of the survival craft. There is no necessity to mount the SART more than 1 m above the sea particularly if the extra height is likely to lead to difficulties by survivors in achieving the mounting, but in future improved antenna mountings may be feasible giving additional detection range.

4.1 The tests did not consider the effect on SART performance of a radar reflector but it would be expected that this would seriously degrade the SART response. Survivors are advised not to deploy a SART and a radar reflector on the same survival craft because the reflector may obscure the SART.