

## Innovative Liferaft

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**ABSTRACT:** The paper presents the latest results of research carried out within R&D project on new solutions of liferaft construction. CFD simulations of liferaft performance are presented.

### 1 INTRODUCTION

Liferafts are the lifesaving appliances used on all types of vessels. Their main advantages are low weight, low space demands and availability in cases of sudden disasters. In these cases the life raft, automatically launched from 4-5 m depth, by the hydrostatic release system, is the only chance to survive for people in the water (Gerigk M., 2004).

For the dozens of years operational characteristics of liferafts did not change a lot. The main improvements were: introduction of lighter materials, insulated floor, insulated canopy for better thermal protection of survivors and different designs of boarding platforms for easier entry from the water (Abramowicz-Gerigk&Burciu, 2012; Abramowicz-Gerigk&Burciu, 2014).

The general objectives in liferaft design are still the economic issues - low cost and wide availability of service. Not very high operational demands are related to the rules of the International Life Saving Appliances Code (LSA), Convention for Safety of Life at Sea (SOLAS, 2008; IMO Resolution MSC. 48(66), 1996) and European Union standards (EU Directive of Marine Equipment 96/98/EC, 1996). The results of the field tests give satisfying results as they are carried out in good weather conditions.

The success of SAR action at sea is dependent on time of search and rescue operations. The time to search, detection and rescue the survivors should be shorter than time to survive. Time of search action –  $T_R$  is the sum of three components (Burciu Z., Grabski Fr., 2011):

$$T_R = T_1 + T_2 + T_3 \quad (1)$$

where:

- $T_1$  - time to reach the theatre,
- $T_2$  - time of the search in the determined area to the moment of the search object detection,
- $T_3$  - time to give the effective aid.

The detection methods used during SAR action are visual observations, radar and thermal imaging.

The research conducted in real sea conditions, have shown that the main difficulties in search and detection of liferafts are related to the liferaft shape, construction material, colour of the canopy, colour of the outside part of the floor and operational characteristics.

- The most important problems recognised in the liferaft operation are as follows:
- difficult entry into the liferaft from the water even if boarding platform is available,

- not sufficient protection from hypothermia, due to the water inside the liferaft,
- difficult or impossible detection by radar, due to small radar reflective surface, which reduces the probability of detection,
- insufficient stability in heavy weather conditions.

## 2 LIFERAFT DETECTION

The improved liferaft detection can significantly decrease time to search. The instruments used by SAR services can detect search objects using daylight cameras, thermal imaging and radiolocation. The improvement can be achieved by increasing the liferaft signatures in all ranges of detection: the visible (VIS and NIR), LIR (thermal IR) and radar. Use of modern materials, structural elements and technologies enables to increase the thermal signature and increase reflection of the liferaft radar signal.

### 2.1 Detection using thermovision

The temperature relative to the background is an essential parameter in the search using the thermal imaging. The improved detection of liferafts in thermal imaging can be obtained by the use of worm materials on the whole surface of the canopy or application of worm elements only strengthening the thermal signature. The example of the thermal illumination histogram of the material sample tested for the application on the liferaft canopy is presented in figure 1.

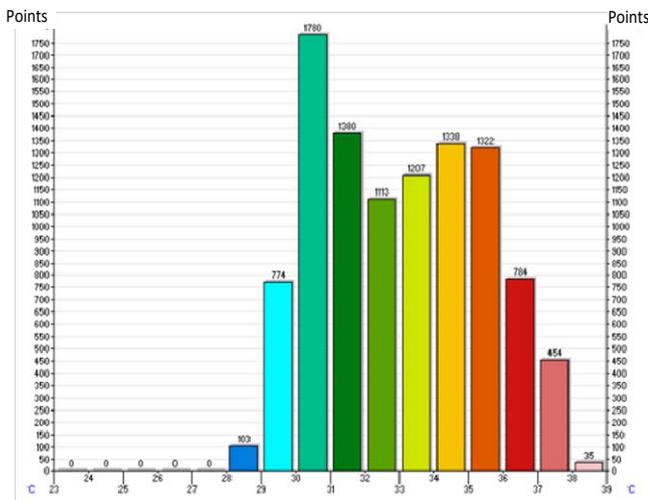


Figure 1 Thermal illumination histogram of a canopy material - sample no 10 after 3 minutes for 12 V.

### 2.2 Radar detection

The traditional liferafts are made of rubber or coated fabric, which are very good dielectrics. This is the reason they are almost invisible on the screen of the navigational radars.

There are several types of passive radar reflectors used to increase the liferaft reflective characteristics. The reflectors are unfolded automatically after the liferaft is launched or they should be manually installed on top of the canopy. In heavy weather conditions the

process of installation can be very difficult or even impossible. The chance of the liferaft detection is therefore dependent mainly on the applied or not applied radar reflector, proper radar installation and its effective reflection area (Technical report, 2014).

The effectiveness of radar reflectors used on liferafts is limited due to their low position above the water surface about 1.5 m, note less than m (LSA, 2013) The detection also depends on disturbances caused by waves.

The liferaft echo and disturbances from waves can make the liferaft invisible in the navigational radar display (fig. 2).

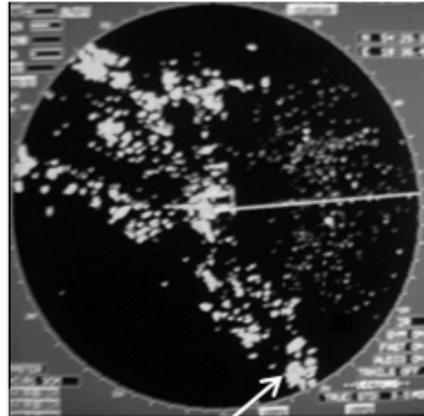


Figure 2. Radar echo of a liferaft and disturbances from waves presented in the navigational radar display (Technical report, 2014, Szklarski A.)

The maximum range of the radar detection very seldom exceeds the distance of 0.5 - 0.6 Nm (Nautical mile). At the sea state 8 the intensive disturbances from the waves make the liferaft invisible.

The increase of radar detection probability can be obtained in two ways:

- using the improved radar reflector mounted directly on the liferaft canopy or on a small mast, preferably pneumatic,
- adding the reflective outer shell on the canopy or making the whole canopy of the reflective fabric.

The radar signatures for different reflective materials in dependence on the distance from the liferaft are presented in figure 3.

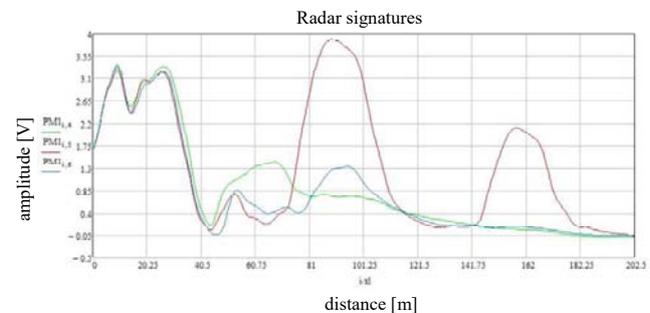


Figure 3. Diagram of radar signatures (Technical report, 2014)

The 2D and 3D images of radar reflectivity of a reflective material sample are presented in figures 4 and 5.

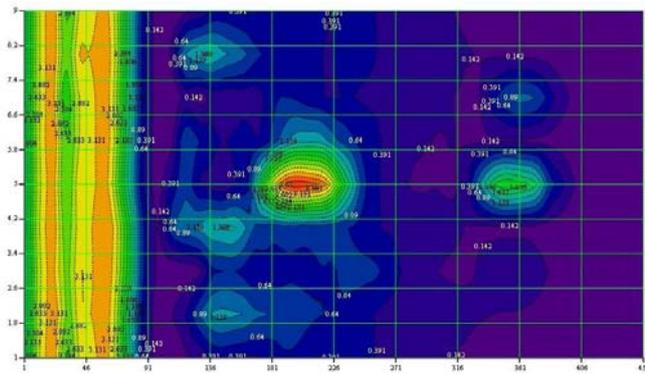


Figure 4. 2D radar reflectivity of a reflective material sample (Technical report, 2014)

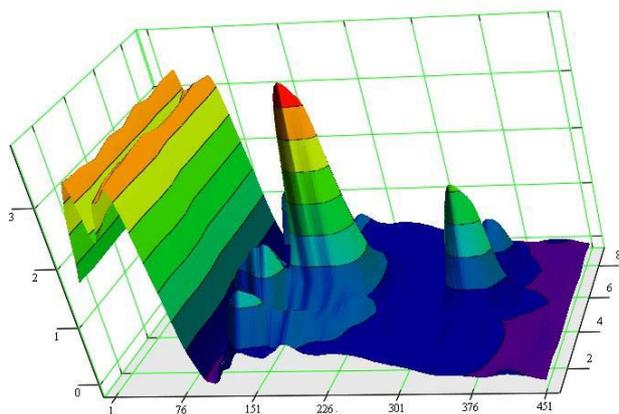


Figure 5. 3D radar reflectivity of a reflective material sample (Technical report, 2014)

### 3 LIFE RAFT STABILITY

The first model of a liferaft proposed by Gdynia Maritime University (fig. 6) was designed in compliance with the LSA code. According to the rules the total mass of a liferaft, its container and equipment shall be not greater than 185 kg.

The mass of the proposed liferaft in full load condition includes 8 persons 82,5 kg each - 660 kg, and mass of liferaft with equipment 100 kg. The total weight of the liferaft with survivors on board is 760 kg. Component weights (m) and areas of related surfaces of the liferaft model (P) are presented in figure 7.

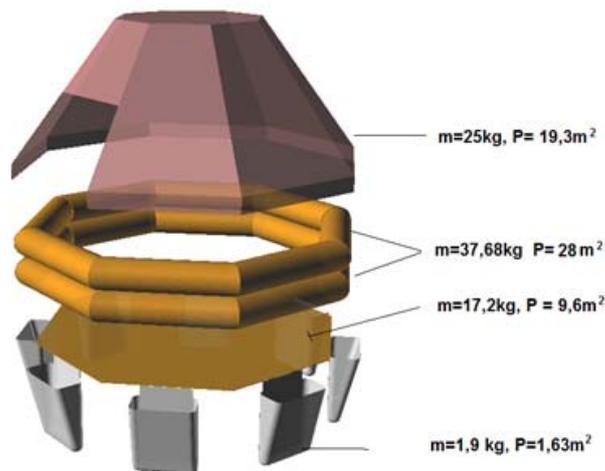


Figure 7. Component weights of the liferaft model ((Technical report, 2014)

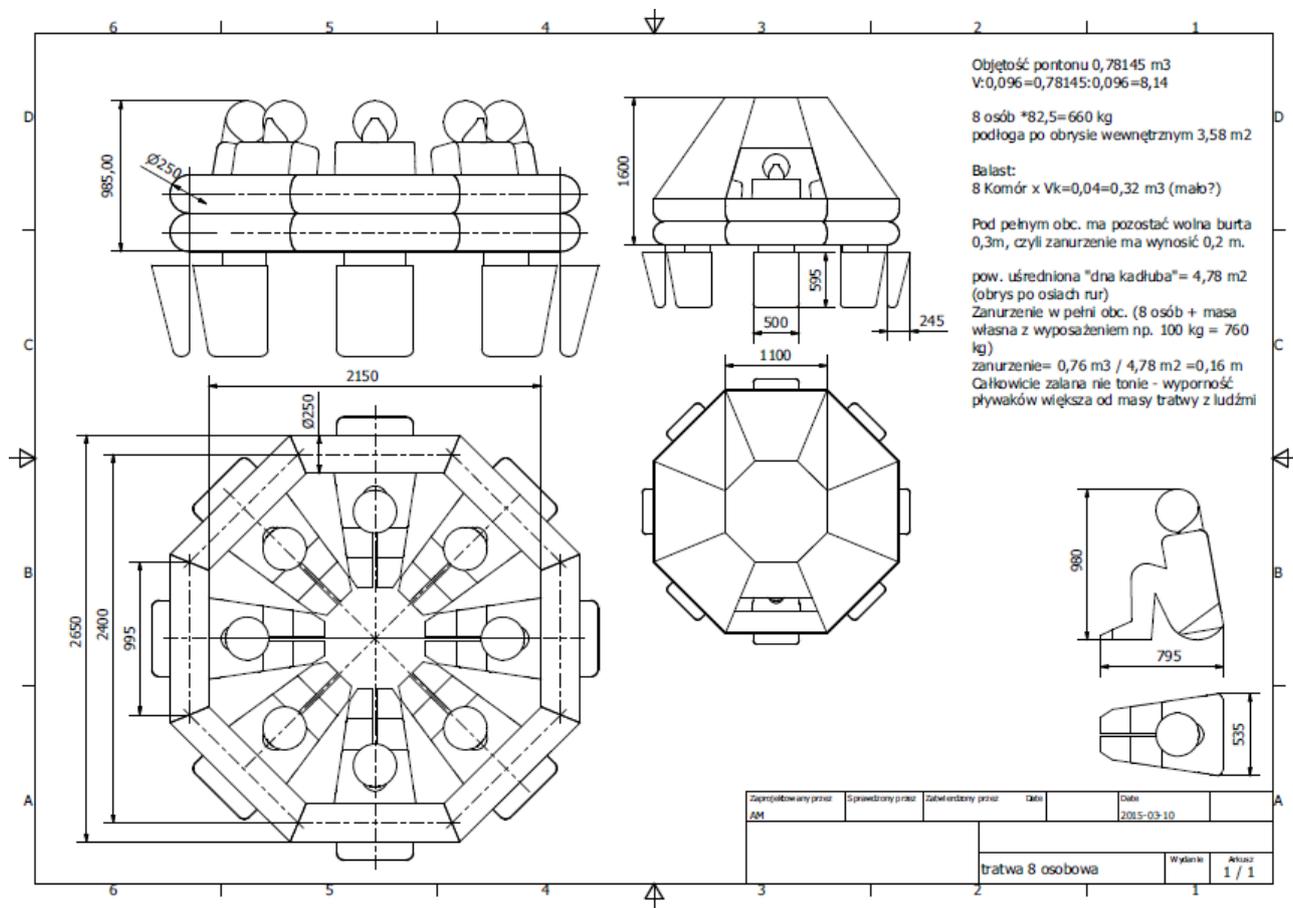


Figure 6. Basic parameters of the proposed liferaft (Technical report, 2014)

The stability calculations were performed assuming that then liferaft is a solid body. The centre of gravity was determined in coordination system presented in figure 8:  $X_g=0,025$  m,  $Y_g=0$  m,  $Z_g=0,32$  m, ( $z_g$  - measured from the bottom of life raft).

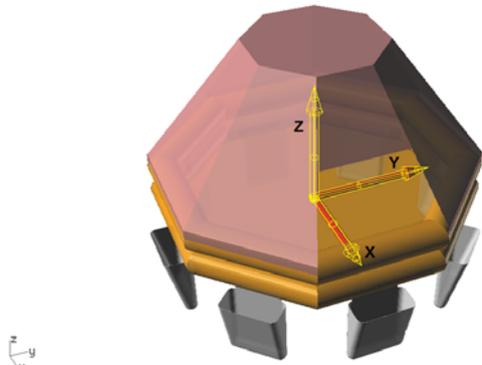


Figure 8. Model of the 8 persons liferaft (Technical report, 2014)

The range of drafts used for the calculation of hydrostatic data is presented in figure 9.

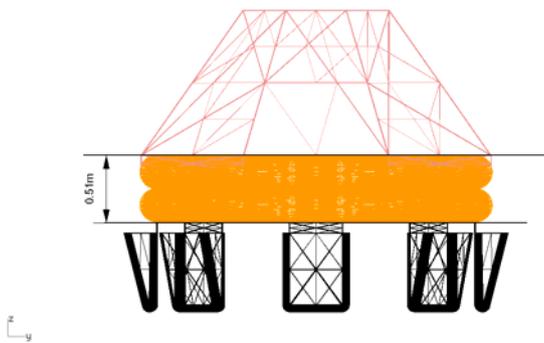


Figure 9. Range of drafts used in calculations (Technical report, 2014)

The hydrostatic data calculated for the liferaft are presented in table 1, where:  $T$  [m] – draft,  $V$  [m<sup>3</sup>] – volume of underwater part,  $D$  [t] – buoyancy,  $VCB$  [mm] – vertical centre of buoyancy  $Z_g$ ,  $A_w$  [m<sup>2</sup>] – waterline area,  $M_j$  [tm/m] – moment to trim per 1 m, buoyancy increase per 1 cm draft increase.

The static stability curves of a liferaft are presented in figure 10. There were three assumed loading conditions analysed with three different positions of the centre of gravity:

- 2 persons are lying down on the floor, the rest is sitting around in the liferaft:  $z_g=0.4$  m,
- all survivors are sitting symmetrically around in the liferaft:  $z_g=0.5$  m,
- 2 persons are standing, the rest is sitting around in the liferaft:  $z_g=0.8$  m.

Table 1. Hydrostatic data for liferaft - draft range from 0 m to 0.5 m.

T [m]	V [m <sup>3</sup> ]	D [t]	VCB [mm]	$A_w$ [m <sup>2</sup> ]	$M_j$ [tm/m]	TPC [t/cm]
0.000	0.018	18.400	0.000	5.500	0.900	0.055
0.027	0.170	174.647	0.015	5.567	0.974	0.056
0.054	0.327	335.690	0.024	6.070	1.102	0.061
0.081	0.494	507.025	0.039	6.345	1.167	0.063
0.107	0.667	684.008	0.050	6.490	1.197	0.065
0.134	0.842	863.617	0.069	6.541	1.202	0.065
0.161	1.017	1043.201	0.080	6.488	1.179	0.065
0.188	1.189	1220.125	0.088	6.342	1.131	0.063
0.215	1.356	1391.334	0.093	6.064	1.047	0.061
0.242	1.513	1552.166	0.107	5.555	0.898	0.056
0.268	1.651	1694.216	0.120	5.300	0.811	0.053
0.295	1.804	1850.361	0.133	5.949	0.966	0.059
0.322	1.968	2019.065	0.148	6.276	1.031	0.063
0.349	2.139	2194.669	0.163	6.457	1.056	0.065
0.376	2.314	2373.730	0.178	6.531	1.051	0.065
0.403	2.490	2554.027	0.193	6.540	1.030	0.065
0.429	2.664	2732.734	0.207	6.423	0.971	0.064
0.456	2.833	2906.743	0.222	6.193	0.872	0.062
0.483	2.995	3072.160	0.235	5.778	0.717	0.058
0.510	3.042	3121.208	0.239	5.680	0.698	0.057

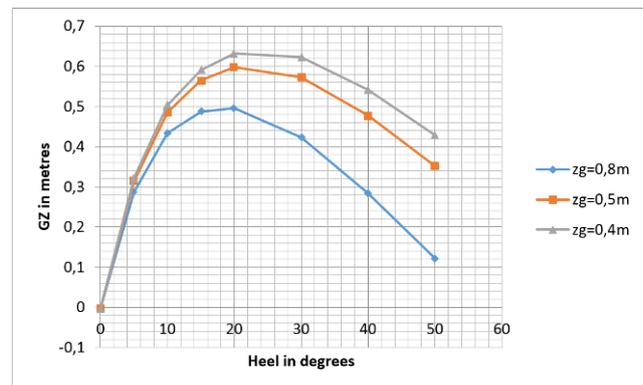


Figure 10. Stability curves for different positions of liferaft centre of gravity (Technical report, 2014)

#### 4 CONCLUSIONS

Operational reliability of a life raft is a characteristic informing whether it fulfils live saving functions in given hydro-meteorological conditions. To minimize the danger of capsizing in strong wind and waves, in partially occupied liferafts, the survivors should always occupy the windward side. In real life the occupation is random, therefore in the presented study the equal distribution of survivors and the level static trim were assumed. (Abramowicz-Gerigk&Burciu, 2014). The presented preliminary design should be followed by the numerical calculations of hydrodynamic and aerodynamic reaction forces in wind and waves, towing and recovery from the water characteristics (Burciu et al., 2001; Marchenko, 1999; Raman-Nair et al., 2008; <http://data.tc.gc>, 2012) to optimize the shapes of buoyancy chambers, ballast pockets and canopy.

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