DESIGN AND TESTS OF THE OGS LOW-COST CODE DRIFTER

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Approved by: ……………………………

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1. Introduction

Near-surface drifters are used worldwide to monitor marine currents. The modified CODE (Coastal Ocean Dynamics Experiment; Davis, 1985) drifters are drifter designs mainly adopted by the oceanographers for the study of ocean currents in the first-meter below the surface. These drifters can provide data for more than a year (they update their location every hour) and are considered disposable since they are sealed and their batteries cannot be replaced.

Since 2007, OGS has been involved in coastal and dispersion experiments (MREA07, MREA08, LIDEX10, MILONGA (Poulain et al., 2012), TOSCA (Gerin et al., 2012b and 2013), MEDESS4MS (Gerin et al., 2014)) in which the drifter trajectory has to be determined with precision and with high frequency. Several modifications of the standard CODE drifter have been realized at OGS in order to meet new requirements. The structure of the drifter was always replicated as similar as possible to the modified CODE design, while the electronic was significantly changed introducing a module with a GPS receiver and GPRS transmission (Brunetti and Zuppelli, 2011). This module was integrated with the original CODE drifter structure or was revised and integrated in a new structure (Gerin et al., 2012a) or was incorporated in a prototype drifter equipped with current meter and current profiler (Gerin and Poulain, 2011). The cost to produce these drifters was similar to the price of CODE drifters available on the market. Recently OGS developed a new CODE drifter at a substantially reduced cost, named the “OGS low-cost CODE” drifter. This report presents the realization phases of this drifter and the results of some tests carried out at sea. The computation of the buoyancy and of the center of gravity is also presented.

2. Technical characteristics of the CODE drifter

The CODE drifter consists of a negatively buoyant 1-m vertical tube from which 4 vertical cloth planes extend radially. Four foam balls attached on the upper extremities provide net positive buoyancy and maintain the antenna out of the water.

Comparisons with current meter data (Davis, 1985) showed that the CODE drifters follow the current of the first meter below the surface to within 3 cm/s, even during strong wind episodes. More recently, Poulain et al. (2009) compared CODE drifter data with the

European Centre for Medium-Range Weather Forecasts wind products and proved that the drag effect of the wind on the emerged part of the drifter is responsible for wind-driven velocities of about 1% of the wind speeds in the Mediterranean Sea.

3. Localization system

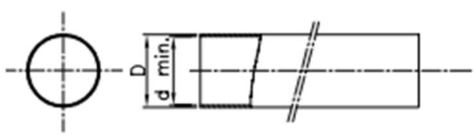
The fundamental component of the drifter is the system that localizes the instrument and then transmit the data on land. Several models are available on the market and they can be GPS/GSM or GPS/Iridium (or similar) module. The SPOT Gen3 is a low cost GPS/Globalstar location device with Lithium batteries. It was chosen as it appeared ideal to be installed on a drifter. It weighs only 114 g and has a small size (height 8.72 cm, width 6.5 cm and thickness 2.54 cm). It can be used in tracking mode meaning that it can be switched on and its position can be sent to the satellite at a set period (up to 5 minutes). Furthermore, it is quite cheap (around 179€ plus another 175€ for 1-year data transmission).

4. Material for the realization of the OGS low-cost CODE drifter

The OGS low-cost drifter was realized with material of easy availability in the sector of the residential electrical components (about 30 €). In particular, the drifter is made up of:

- 1 medium rigid conduit RK15 (Gewiss), length 110 cm, diameter 40 mm (Fig. 1);
- 5 medium rigid conduit RK15 (Gewiss), length 50 cm, diameter 20 mm (Fig. 1);

RK15/IRL - MEDIUM RIGID CONDUIT



Code 2m	Code 3m	conduit Ø (mm)	D		d. min
DX 25 216 DX 27 216	DX 25 316 DX 27 316	16	16	0 -0.3	13
DX 25 220 DX 27 220	DX 25 320 DX 27 320	20	20	0 -0.3	16.9
DX 25 225 DX 27 225	DX 25 325 DX 27 325	25	25	0 -0.4	21.4
DX 25 232 DX 27 232	DX 25 332 DX 27 332	32	32	0 -0.4	27.8
	DX 25 340 DX 27 340	40	40	0 -0.4	35.4
	DX 25 350 DX 27 350	50	50	0 -0.5	44.3
	DX 25 363 DX 27 363	63	63	0 -0.6	55

Fig. 1. Gewiss medium rigid conduit characteristics.

- 9 conduit-box union elements (Gewiss or THW or similar), internal diameter 20 mm (Fig. 2);

Fig. 2. Conduit-box union.

- 2 junction boxes, 4 cable entries, round, diameter 80 mm (Fig. 3);

Fig. 3. Junction box.

- 1 junction box, 0 cable entry, square, 115x115x60 mm, IP67 or higher;
- 1 conduit reducer from 40 mm to 20 mm diameter, made with a lathe (Fig. 4);

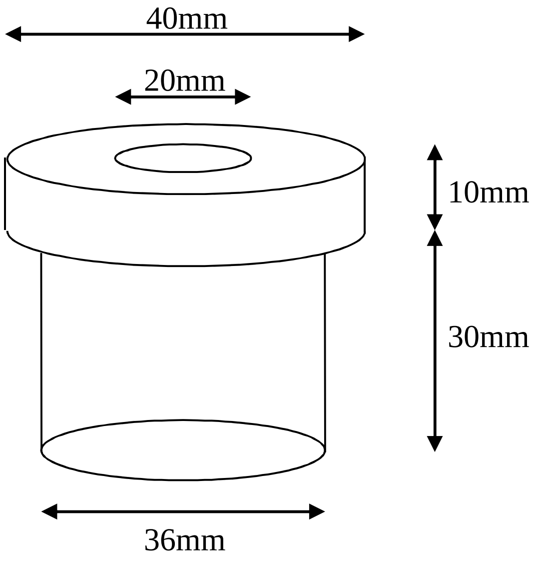


Fig. 4. Conduit diameter reducer.

- 4 pieces of 75 cm of elastic cord, diameter 8 mm;
- 8 dock washer, internal diameter 8 mm, external diameter 25 mm.

5. Realization of the OGS low-cost CODE drifter

The bottom part and the cover of the round junction box was drilled to create a 40 mm diameter hole in order to fix the box on the 40 mm conduit (40 mm from the border of the conduit; bottom part of the drifter). The 4 holes of the round junction box had to be enlarged to receive the conduit-box union element and the conduit was drilled perpendicularly to hold the threaded part of the union element. All these parts were mounted together with sealant as shown in Fig. 5.

Fig. 5. Installation of the round junction box on the conduit (bottom part of the drifter).

A foam annulus was added on the drifter structure to provide extra buoyancy (Fig. 6). The same operations were repeated on the upper part of the drifter. The distance between the center of the perpendicular holes of the two round junction boxes is 98.5 cm.

A washer was inserted in the elastic cord and a knot was made at its extremity (Fig. 7).

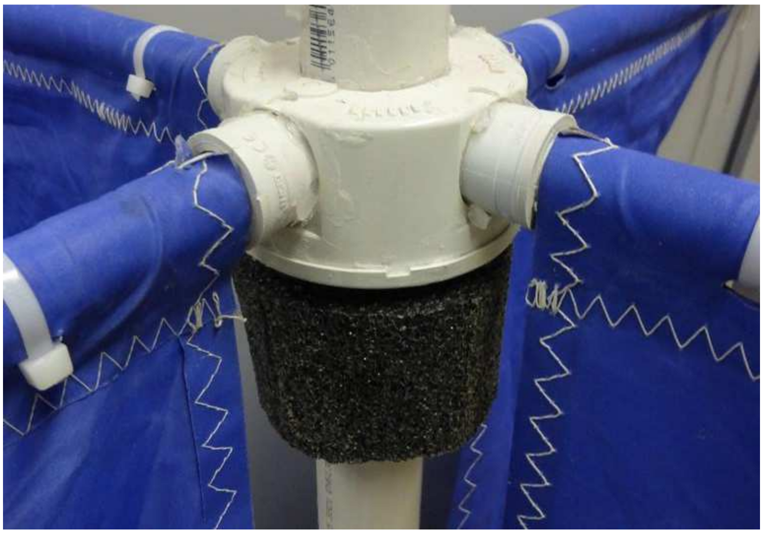


Fig. 6. Foam annulus (in black) providing extra buoyancy to the drifter.

Fig. 7. Knot at one extremity of the elastic cord.

The cord was then passed through the 20 mm diameter conduit (long 50 cm; “arms” of the drifter), then through the round junction box and the union elements fixed on the 40 mm diameter conduit (Fig. 8).

Fig. 8. Mounting the “arms” of the drifter.

At this point the elastic cord had to be stretched and passed through the opposite drifter “arm” (the piece of the 20 mm diameter conduit) and through the second washer. Maintaining the cord stretched, a knot was made at the other extremity of the cord.

The conduit reducer was fixed on the antenna mast (the piece of 20 mm diameter conduit) with sealant and then on the drifter structure (the 40 mm diameter conduit) using 2 metal screws (Figs. 9 and 10)

Fig. 9. Conduit reducer fixed on the antenna mast.

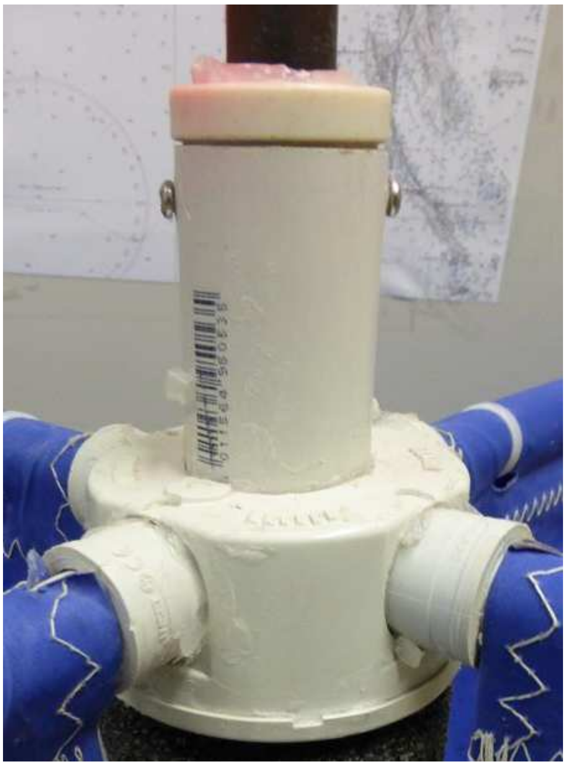


Fig. 10. Conduit reducer installed on the drifter structure.

The antenna was then completed by installing the square junction box on top of the antenna mast by using the last conduit-box union element, sealant and metal screws (Fig. 11).

Fig. 11. Upper part of drifter antenna.

The 4 vertical cloth planes and the 4 floating foam balls were taken from an old CODE drifters, but they can be easily produced. The planes were fixed on the drifter with some zip ties after inserted the "arms" of the drifter in the eyelet of the planes. The floating balls were attached to the drifter simply by tying up the line already attached to the balls to the elastic cord between the washer and the knot (Fig. 12). The tubular main structure of the drifter is not sealed and once the drifter is in the water it is flooded. No additional weights were added to the drifter. Tests demonstrate that the drifter returns in its regular position even if it is turned upside-down. Additionally, the foam annulus makes the drifter positively-buoyant (with almost all the antenna underwater) even in case of loss of the 4 floating foam balls. The drifter assembled and ready to be deployed can be seen in Fig. 13, while Fig. 14 compares the OGS low-cost CODE drifter with an original modified CODE drifter (see also schematic diagrams with dimensions in Figs. 15 and 16). Furthermore, the computation of the drag area ratio (Sybrandy et al., 2009) resulted almost the same for the two drifters (Tables 1 and 2).

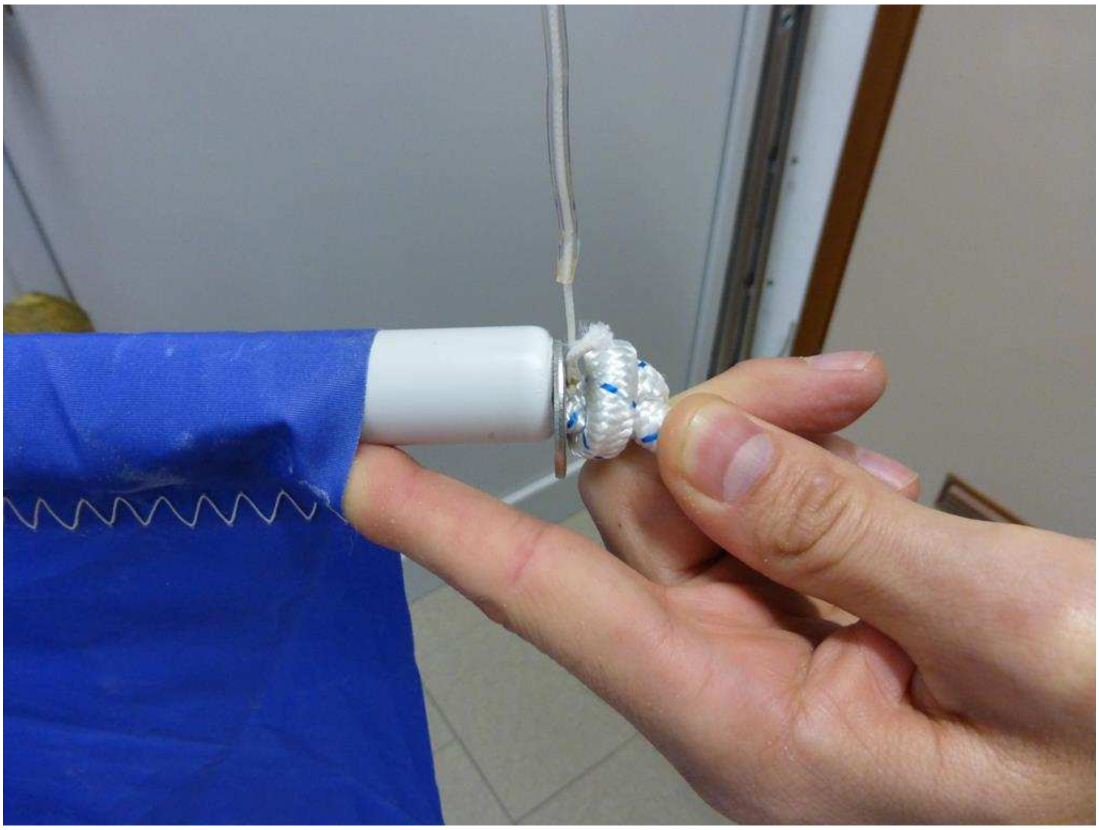


Fig. 12. Attaching the line of the floating foam ball to the "arm" of the drifter.

Fig. 13. The drifter fully assembled.

Fig. 14. The OGS low-cost CODE drifter (on the right) and an original modified CODE drifter (on the left).

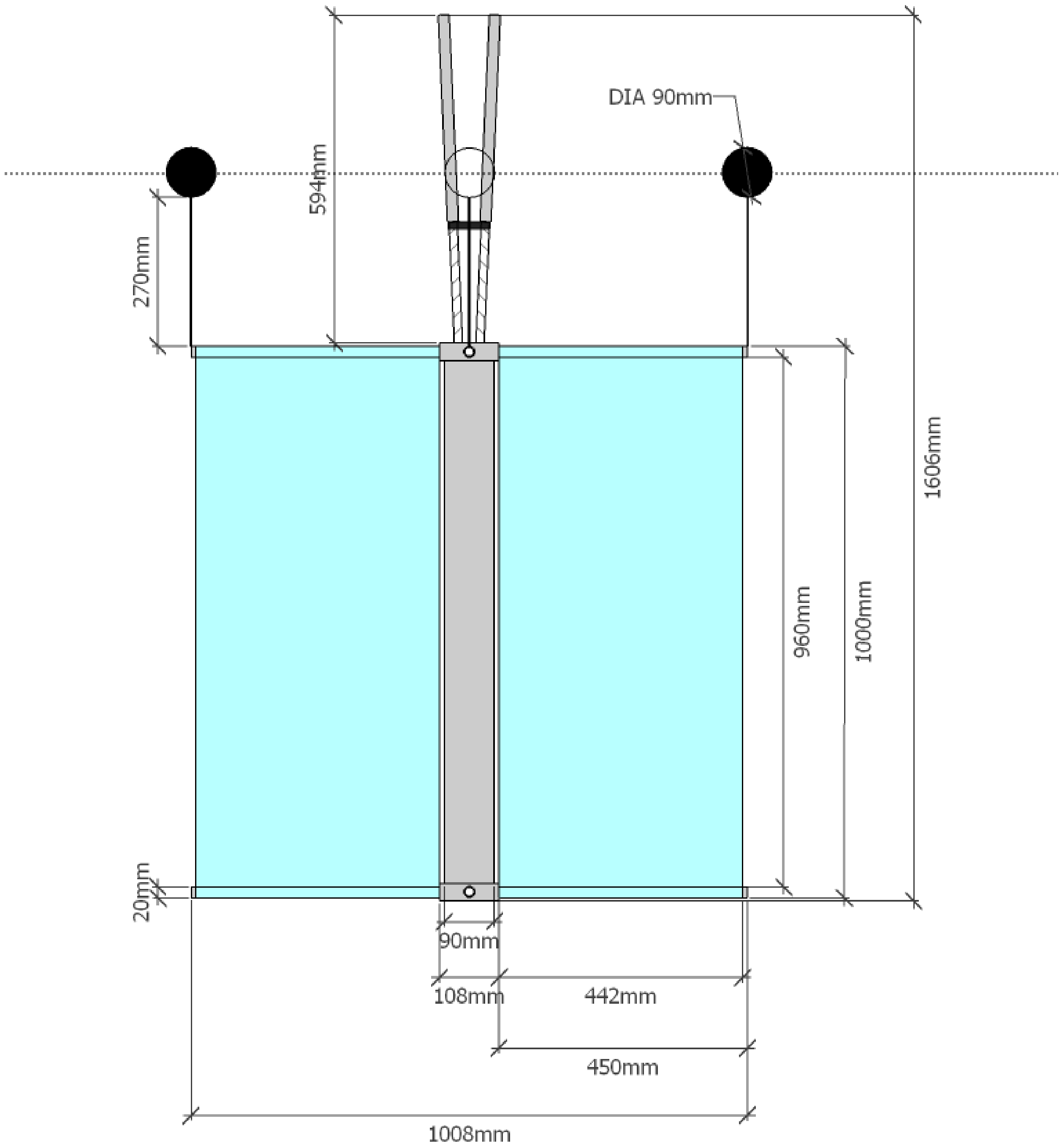


Fig. 15. Schematic diagram of the original modified CODE drifter with dimension in mm.

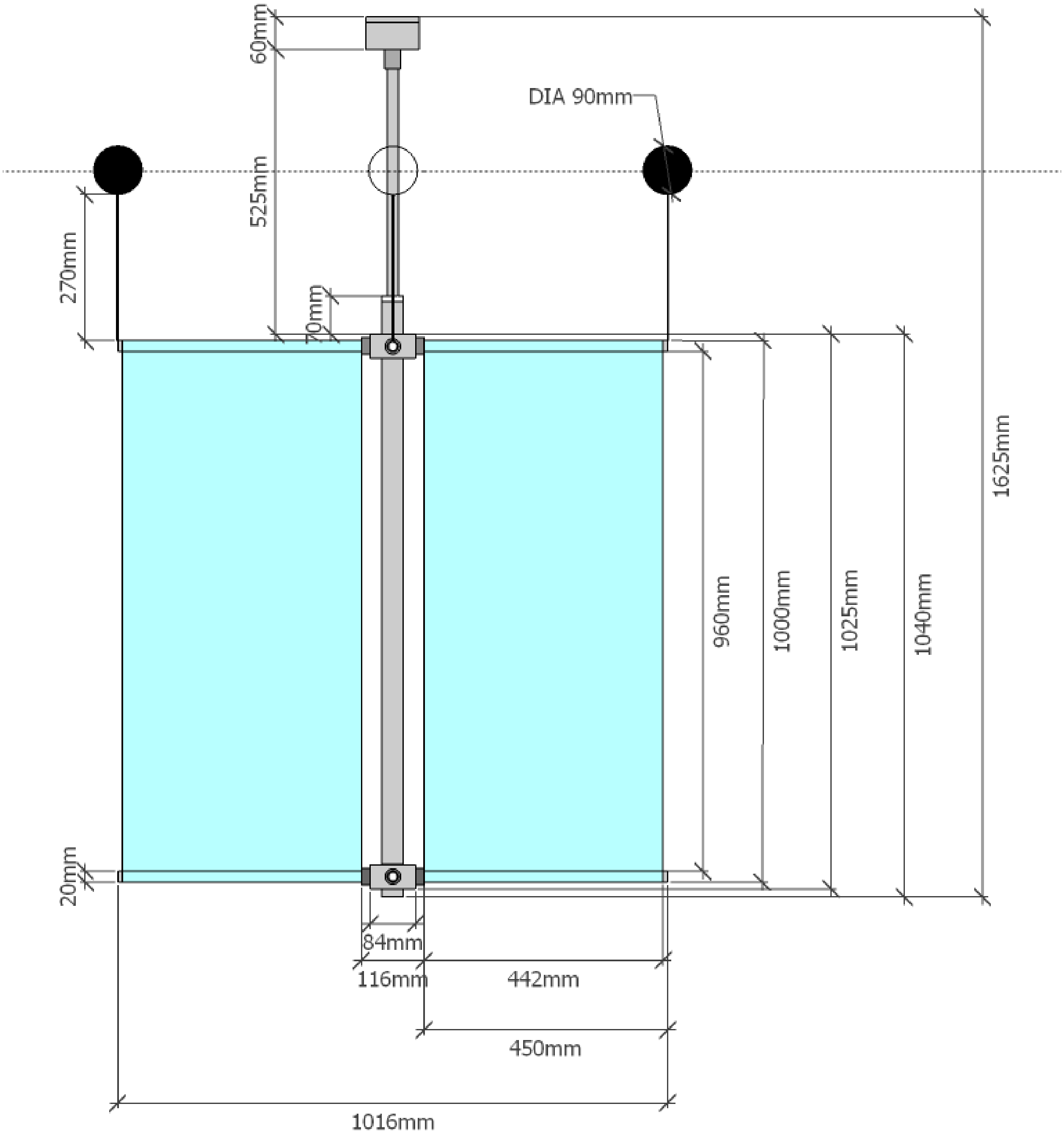


Fig. 16. Schematic diagram of the OGS low-cost CODE drifter with dimension in mm.

drifter	element	shape	num elem	size1	size2/diam	coeff	area	drag area
original modified CODE	antenna	long cylinder	2	595	17	1.4	20230	28322
	"arms slot"	cylinder	2	108	32	1.15	6912	7949
	body	cylinder	1	948	90	1.15	85320	98118
	"arm"	long cylinder	4	450	22	1.4	39600	55440
	"sail"	parallelepiped	2	1000	450	1.15	900000	1035000
	ball	sphere	3		90	0.47	19076	8965
	line	long cylinder	3	270	4	0.82	3240	2657
OGS low-cost CODE	antenna	long cylinder	1	450	20	1.4	9000	12600
	box	parallelepiped	1	98	60	1.15	5880	6762
	joining element	cylinder	1	50	35	1.15	1750	2013
	"arms" slot	cylinder	2	84	45	1.15	7560	8694
	body	cylinder	1	865	40	1.15	34600	39790
	anulus	cylinder	1	56	84	1.15	4704	5410
	body not centered at 1m	cylinder	1	95	40	1.15	3800	4370
	"arm"	long cylinder	4	450	21	1.4	37800	52920
	"sail"	parallelepiped	2	1000	450	1.15	900000	1035000
	ball	sphere	3		90	0.47	19076	8965
	line	long cylinder	3	270	4	0.82	3240	2657

Tab. 1 Drag area computations (values in mm or mm^2).

original modified CODE	underwater elements	1196507
	surface elements	39944
	drag area ratio	30.0
OGS low-cost CODE	underwater elements	1141814
	surface elements	37367
	drag area ratio	30.6

Tab. 2 Drag area ratio computations (values in mm^2 or dimensionless).

6. Tests at sea

The OGS low-cost CODE drifters were used in an experiment in the Gulf of Trieste (28 and 29 September 2015) with moderate sea conditions (Figs. 17 and 18).

Three OGS low-cost CODE drifters were deployed together with the OGS prototype CODE drifter equipped with current meter and current profiler and with three STRING drifters (Fig. 18). The OGS low-cost drifters followed the prototype CODE drifter in a cyclonic motion (Fig. 19), while the STRING drifters depicted a larger diameter arc.

Fig. 17. Deployment of the OGS low-cost CODE drifter.

Fig. 18. The OGS low-cost CODE drifter (on the left), the OGS prototype CODE drifter equipped with current meter and current profiler (center) and a STRING drifter (on the right).

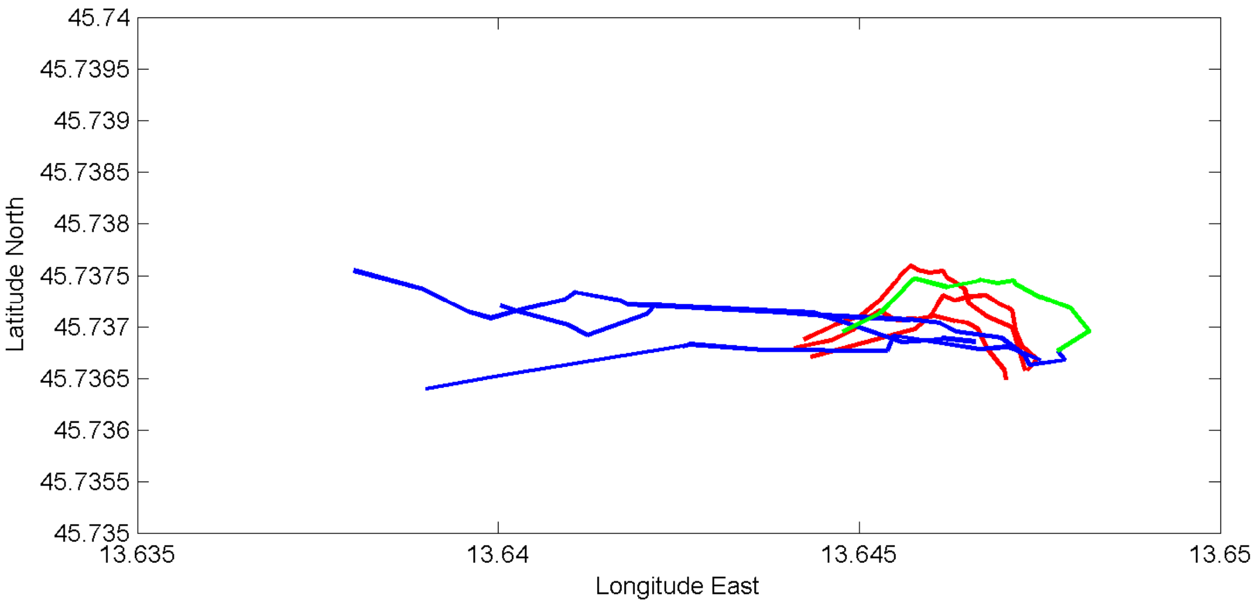


Fig. 19. Trajectories of the drifters during 28 September 2015 (red = OGS low-cost CODE; green = prototype CODE; blue = STRING drifters); starting points are to the right.

No transmission problem occurred, meaning that the length of the antenna was adequate and could eventually be reduced. The drifters took about 30 seconds to lay vertically and maybe resulted slightly tilted in the water under these sea/wind conditions, therefore an additional weight in the bottom part of the drifter structure is recommended.

Previous experiments have demonstrated that the prototype CODE drifter equipped with current meter and current profiler follows the water currents as accurately as the original modified CODE drifter (see Gerin and Poulain, 2011 and Gerin et al., 2012b, 2013, 2014). Unfortunately, no original modified CODE drifter were deployed during the experiment, anyway, the OGS low-cost drifters follow the prototype CODE drifter and not the STRING drifters. Additional tests together with some original modified CODE drifters are desirable.

7. Buoyancy and center of gravity computations

The buoyancy of the original modified CODE and of the OGS low-drifter was computed considering the hydrostatic forces acting on all the elements of the drifters (defined as buoyancy) and the gravity. When the computation is made without considering the contribution of the four floating balls, the result shows that the OGS low-cost CODE drifter weights in water more than the original modified CODE (resulting force equal to -3.39 and -2.83 N, respectively), indeed, when deployed in water, the floating balls of the first drifter are immerged by about 5% more with respect to the other drifter. All the computations can be found in Tables 3 and 4 in Appendix A.

The center of gravity of the original modified CODE and of the OGS low-drifter was also estimated (Figs. 20 and 21). The center of gravity of the original modified CODE drifter is at about the middle of the main tube of the instrument, while the center of gravity of the OGS low-cost drifter is at about 1/3 of the main tube (closer to the sea surface).

Fig. 20. Center of gravity of the original modified CODE drifter.

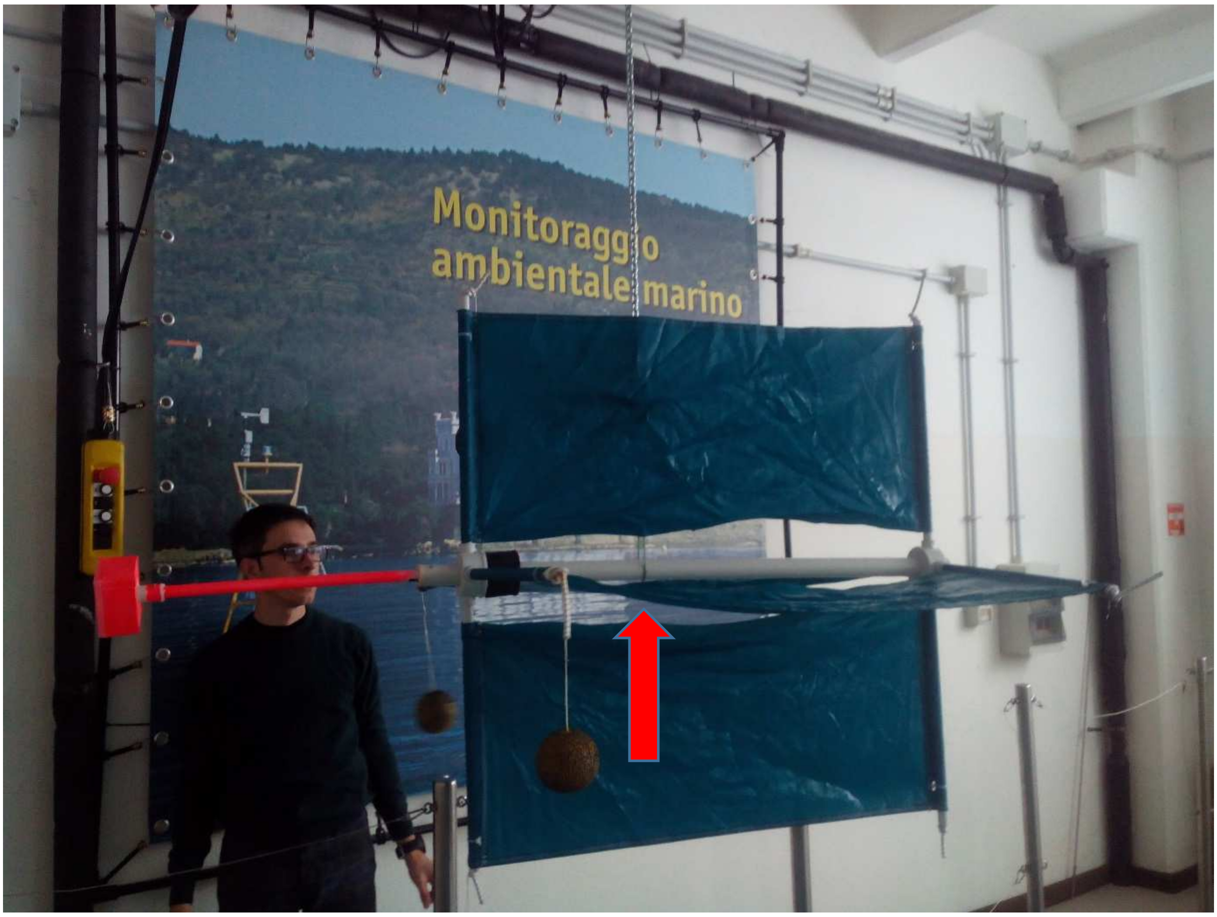


Fig. 21. Center of gravity of the OGS low-cost CODE drifter.

An additional weight of about 930 g is necessary in order to obtain the same center of gravity of the original modified CODE drifter (Fig. 22). The weight can be easily added to the OGS low-cost CODE drifter, but the buoyancy elements must be redesigned in order increase the hydrostatic force acting on the instrument and to guarantee almost the same resulting force of the original modified CODE drifter. One possibility (see Table 5 in Appendix B) is to seal the main tube of the drifter and to increase the size of the “arms” slot (the additional floating annulus can be eliminated).

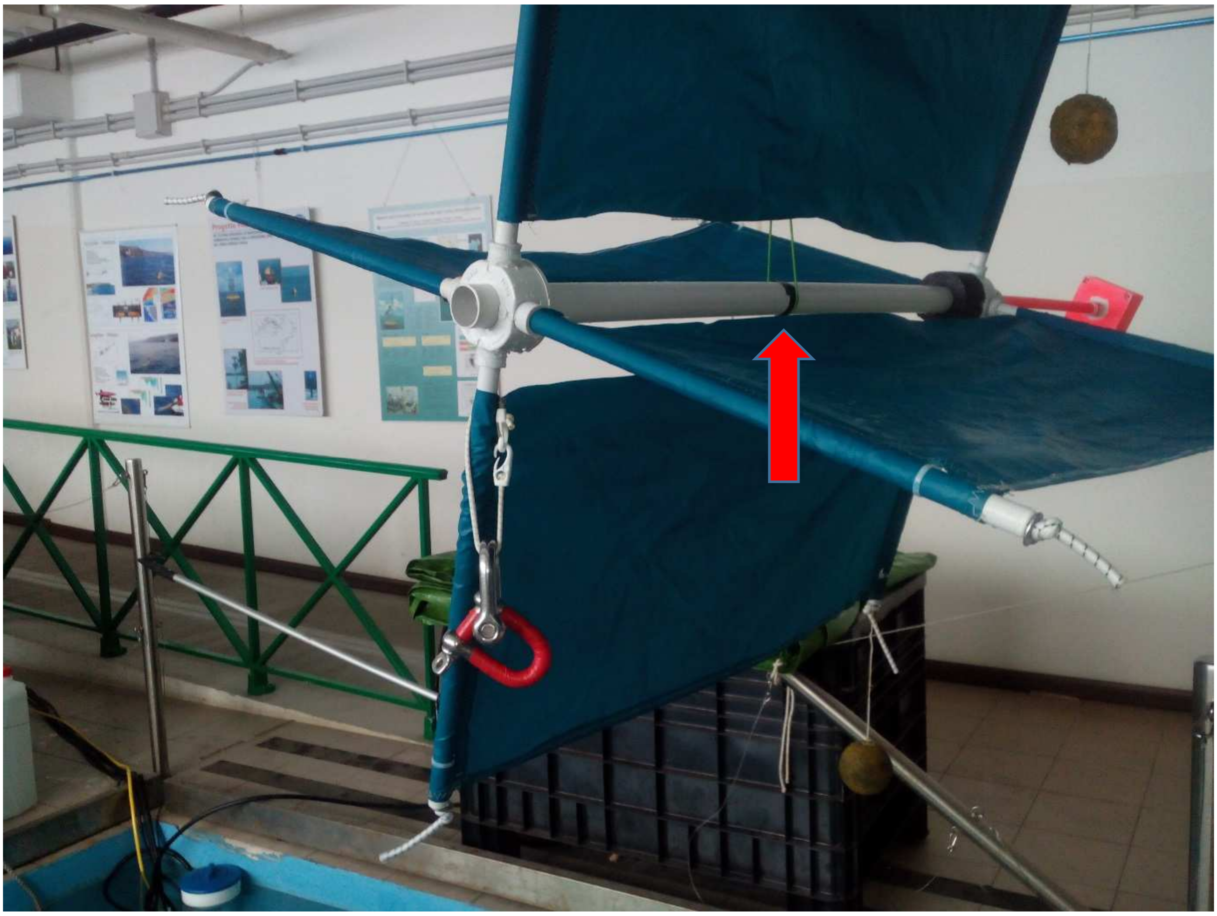


Fig. 22. Center of gravity of the OGS low-cost CODE drifter with the additional weight.

8. Conclusions

The OGS low-cost CODE drifter has to be slightly modified in order to correspond to the characteristics of the original modified CODE drifter, while remaining lighter in air and much easier to handle and deploy at sea. Anyway, a lighter instrument reacts differently to any water motion perturbations of its normal status with respect to a heavier instrument. This is due to the inertia of the instrument. Therefore, in order to obtain a low-cost instrument which correspond almost exactly to the original modified CODE drifter, also the weight of the instrument must be replicated, maintaining unaltered the buoyancy and the center of gravity. This can be easily done by increasing the diameter of the main tube and carefully placing the additional weight inside the structure (new computations in Tables 6 in Appendix C).

9. Acknowledgements

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11. Appendix A

water density	1000	kg/m3			
not considering the balls buoyancy			**with the balls buoyancy**		
antenna diameter	21	mm	ball diameter	90	mm
h submerged antenna	70	mm	ball volume	0.00038151	mm3
volume	2.4233E-05	mm3			
			submerged ball	0.45	%
antenna spiral diameter	15	mm			
h antenna spiral	220	mm			
volume	3.88575E-05	mm3	hydrostatic force	6.91859458	N
"arms" slot diameter	108	mm			
h "arms" slot	32	mm			
volume	0.000293	mm3			
tube diameter	90	mm			
h tube	948	mm			
volume	0.006027858	mm3			
"arm" diameter	22	mm			
h "arm"	450	mm			
volume	0.000170973	mm3			
"arm" int diameter	13	mm			
volume	5.96993E-05	mm3			
elastic cord diameter	8	mm			
volume	0.000022608	mm3			
total volume "arm"	0.000133882	mm3			
tot vol drifter - "arms"	0.006740038	mm3			
tot vol drifter	0.007811092	mm3			
hydrostatic force	76.62681507	N			
drifter weight	8.1	kg			
gravity force	79.461	N			
resulting force	-2.834184929	N	resulting force	4.08440965	N

Tab. 3 Forces acting on the original modified CODE drifter.

water density	1000	kg/m^3			
not considering the balls buoyancy			**with the balls buoyancy**		
antenna diameter	20	mm	ball diameter	90	mm
h submerged antenna	230	mm	ball volume	0.00038151	mm^3
volume	0.00007222	mm^3			
			submerged ball	0.5	%
"arms" slot joining elem diam	29	mm			
h "arms" slot joining elem	19	mm			
volume	1.25435E-05	mm^3	hydrostatic force	7.68732731	N
"arms" slot diameter	84	mm			
h "arms" slot	45	mm			
volume	0.000249253	mm^3			
anulus diameter	84	mm			
h anulus	56	mm			
volume	0.000310182	mm^3			
tube diameter	40	mm			
h tube	960	mm			
volume	0.00120576	mm^3			
tube internal diameter	36	mm			
volume	0.000935971	mm^3			
total volume tube	0.000269789	mm^3			
"arm" diameter	21	mm			
h "arm"	450	mm			
volume	0.000155783	mm^3			
"arm" int diameter	16	mm			
volume	0.000090432	mm^3			
elastic cord diameter	8	mm			
volume	0.000022608	mm^3			
total volume "arm"	8.79593E-05	mm^3			
tot vol drifter - "arms"	0.001251045	mm^3			
tot vol drifter	0.001954719	mm^3			
hydrostatic force	19.17579417	N			
drifter weight	2.3	kg			
gravity force	22.563	N			
resulting force	-3.38720583	N	resulting force	4.30012148	N

Tab. 4 Forces acting on the OGS low-cost CODE drifter.

12. Appendix B

water density	1000	kg/m^3			
not considering the balls buoyancy			**with the balls buoyancy**		
antenna diameter	20	mm	ball diameter	90	mm
h submerged antenna	230	mm	ball volume	0.0003815	mm^3
volume	0.00007222	mm^3			
			submerged ball	0.45	%
"arms" slot joining elem diam	29	mm			
h "arms" slot joining elem	0	mm			
volume	0	mm^3	hydrostatic force	6.9185946	N
"arms" slot diameter	105	mm			
h "arms" slot	63	mm			
volume	0.000545241	mm^3			
tube diameter	40	mm			
h tube	1016	mm			
volume	0.001276096	mm^3			
tube internal diameter	0	mm			
volume	0	mm^3			
total volume tube	0.001276096	mm^3			
"arm" diameter	21	mm			
h "arm"	450	mm			
volume	0.000155783	mm^3			
"arm" int diameter	16	mm			
volume	0.000090432	mm^3			
elastic cord diameter	8	mm			
volume	0.000022608	mm^3			
total volume "arm"	6.53513E-05	mm^3			
tot vol drifter - "arms"	0.002438799	mm^3			
tot vol drifter	0.002961609	mm^3			
hydrostatic force	29.05338184	N			
drifter weight	3.25	kg			
gravity force	31.8825	N			
resulting force	-2.82911816	N	resulting force	4.0894764	N

Tab. 5 Forces acting on the OGS low-cost CODE drifter with the adding weight.

13. Appendix C

water density	1000	kg/m^3			
not considering the balls buoyancy			**with the balls buoyancy**		
antenna diameter	20	mm	ball diameter	90	mm
h submerged antenna	170	mm	ball volume	0.0003815	mm^3
volume	0.00005338	mm^3			
			submerged ball	0.45	%
antenna slot diameter	59	mm			
h antenna slot	60	mm			
volume	0.000163955	mm^3	hydrostatic force	6.9185946	N
"arms" slot diameter	108	mm			
h "arms" slot	57	mm			
volume	0.000521906	mm^3			
tube diameter	90	mm			
h tube	948	mm			
volume	0.006027858	mm^3			
"arm" diameter	21	mm			
h "arm"	450	mm			
volume	0.000155783	mm^3			
"arm" int diameter	16	mm			
volume	0.000090432	mm^3			
elastic cord diameter	8	mm			
volume	0.000022608	mm^3			
total volume "arm"	6.53513E-05	mm^3			
tot vol drifter - "arms"	0.007289004	mm^3			
tot vol drifter	0.007811814	mm^3			
hydrostatic force	76.63389985	N			
drifter weight	8.1	kg			
gravity force	79.461	N			
resulting force	-2.82710015	N	resulting force	4.0914944	N

Tab. 6 Forces acting on the OGS low-cost CODE drifter with the same weight of the original modified CODE drifter and the increased main tube diameter.