Joint European Research Infrastructure network for Coastal Observatories

D4.5 –Running costs of coastal observatories

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1. Document description

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2. Executive Summary

Long term sustained marine observing systems are required to help understand and predict changes in the world's seas and oceans. The cost of setting up and operating such systems can be significant. This report examines the costs associated with setting up and running fixed platforms, Ferrybox systems, gliders and calibration laboratories, compiled using questionnaire replies returned from JERICO partners. The costs for gliders (section 4.3) are taken directly from Tintoré et al., 2013 (Annexe 2) which were complied through a joint exercise with GROOM.

There was a large variability in costs between laboratories reflecting the different types of platforms and parameters being measured. Initial investment costs are greater for glider fleets (€222,545 in 2011) and Ferrybox systems (€110,298) than for fixed platforms (€86,526). Ongoing total annual running costs for a glider fleet (€184,014 excluding investment in 2011) and fixed platforms (€139,358) exceed those of Ferrybox systems (€90,529). This analysis of costs has shown that a large proportion of the total annual running costs (27%) of fixed platforms is associated with boat charter. Collaborative working such as under the Eurofleets project (http://www.eurofleets.eu/np4/63) may give the opportunity to reduce these costs and maximise efficiency.

3. *Introduction*

Long term sustained marine observing systems are required to help understand and predict changes in the world's seas and oceans. The cost of setting up and operating such systems can be significant including scheduled and unforeseen expenses including routine operation, repair and replacement of equipment, personnel costs and accidents. Observing systems within Europe have been funded through a variety of national and EU programmes. These have frequently been programmes which fund observatories for fixed periods of time rather than providing funding for sustained observations. An analysis of the running costs of observing systems would enable better informed decisions about their sustainability to be made. The complexity of these systems varies in both the types of parameters measured (physical, chemical, biological) and the nature of the platform (towers, pylons, moorings, research vessels, ships of opportunity, gliders). JERICO provides an opportunity to describe in an analytical form the expenses emanating from the operation of each different system (fixed platforms, Ferrybox, gliders) and calibration laboratories. This will be a valuable tool as it will enable the operators to compare, adjust, improve and exchange practices with the ultimate goal of minimising costs and maximising the scientific value of the infrastructure.

Information for this report was gathered using a questionnaire (Annexe 1) which was designed in February 2012 at the Rome JERICO workshop and modified in discussions with GROOM participants. A joint JERICO/GROOM – EGO Glider Workshop was held on 22-23 May 2012 in Mallorca during which costs for operating a glider fleet were assessed by each participating institution. The costs for gliders (section 4.3) are taken directly from Tintoré et al., 2013 (Annexe 2) which were complied through this joint exercise.

4. Main Report

The questionnaire (Annexe 1) was sent to all JERICO task 4.3 participants. The questionnaire asked for costs associated with initial investment, routine and emergency operations and personnel for fixed platforms, Ferrybox systems and calibration laboratories. Details were provided for fourteen different fixed platforms, eight Ferrybox systems, ten glider fleets and three calibration laboratories. The complexity of platforms varied between institutes both in terms of the types of structures used (e.g. tethered moorings, pylons, masts) and the parameters measured (e.g. waves, temperature and salinity, biogeochemical sensors including CO_2). Therefore there was a wide range in the costs of running the different platforms, which is shown in the figures presented in this report. The level of detail provided in the completed questionnaires depended on how different institutes track costs. Institutes were asked to provide costs for their platforms for both routine operations and emergency operations (e.g. costs associated with replacement of a mooring which had been hit).

Summary of replies	
Number of in situ platforms	14
Number of Ferrybox platforms	8
Number of glider fleets	10
Number of calibration laboratories	3

Table 4.1 *Summary of completed questionnaires*

The replies were grouped together in categories, which closely match those of the glider analysis (Tintore et al., 2013, Annexe 2) for ease of comparison, with annual operation costs summarised under variable and fixed costs. As the number of platforms per institute varies greatly, costs have been calculated per platform to allow comparison, although recognising that some efficiency in costs can be obtained when operating more than one platform. The costs associated with fixed platforms, Ferrybox systems and calibration laboratories are presented in the following sections.

4.1. Analysis of costs for fixed platforms

The different platforms described under fixed platforms include tethered moorings, pylons and towers. Examples of the different platforms are shown in Figure 4.1.

Figure 4.1 *Examples of the fixed platforms operated by (a) HCMR;(b-c) Puertos del Estado; (d) HZG, (e) CNR*

4.1.1. Summary of costs related to Investments

The average initial investment per fixed platform is €86,526 (Table 4.2) although there is a very wide range in the investment made. The initial investment is dominated by the capital purchase of the system (Table 4.3). The average annual routine running cost is €95,826 and the average annual total running cost (routine plus emergency) for operating fixed platforms is €139,358 due to the additional variable and personnel costs associated with responding to emergencies (Table 4.2). Personnel costs (€68,615) account for 49% of the total annual running cost with variable costs (€55,952) and fixed costs (€14,791) accounting for 40% and 11% respectively. The personnel costs equate to an annual average of 114 days for total operations (i.e. routine plus emergency).

	Average initial investment (€)	Average routine cost (€)	Average total cost including emergencies (€)
Investment per platform	86,526		
Operations per year - variable		52,407	55,952
Operations per year - fixed		14,319	14,791
Personnel costs		29,100	68,615
Total	**86,526**	**95,826**	**139,358**

Table 4.2 *Summary of initial investment and annual running costs per fixed platform*

	Mean (€)	As % of mean
purchase of mooring	2,329	3%
purchase of sensors	12,607	15%
purchase of buoy infrastructure (e.g. pressure chamber)	0	0%
purchase of buoy equipment (e.g. tools, R&D, launch)	319	0%
purchase of safety equipment	229	0%
Initial set up costs (Capital)	71,042	82%
Total	**86,526**	**100%**

Table 4.3 *A breakdown of the investment associated with running fixed platforms*

4.1.1. Summary of costs related to Operations

More than half (67%) of the €55,952 annual total variable operations costs are from the cost of boat hire (Table 4,4, Figure 4.2). Consumables and repair, replacement and calibration of sensors are 23% of the annual variable costs with small contributions (1% - 4%) from the other categories (Table 4.4, Figure 4.2). The fixed costs are split almost equally between rents, data centre costs, insurance and devaluation (Table 4.4.4, Figure 4.3).

	Annual routine operations			Annual total operations		
	Total	**Mean (€)**	**As % of mean**	**Total**	**Mean (€)**	**As % of mean**
Variable operations						
consumables (cables, anchors, batteries, chemicals etc.)	88,259	6,304	12%	91,604	6,543	12%
telecommunication costs	31,525	2,252	4%	31,525	2,252	4%
spare parts	14,483	1,035	2%	15,850	1,132	2%
repair of sensors and buoy devices	12,686	906	2%	15,561	1,112	2%
replacement of sensors and buoy devices	27,721	1,980	4%	30,388	2,171	4%
large overhaul costs (where not already included in other categories)	7,282	520	1%	7,416	530	1%
operational centre consumables	6,150	439	1%	7,150	511	1%
calibration costs	41,676	2,977	6%	41,926	2,995	5%
boat hire (trips*days*daily cost)	488,017	34,858	67%	522,406	37,315	67%
transportation of equipment	15,904	1,136	2%	19,498	1,393	2%
Total	**733,704**	**52,407**	**100%**	**783,324**	**55,952**	**100%**
Fixed operations						
rents	48,500	3,464	24%	48,850	3,489	24%
waste disposal/service charges from institute	147	11	0%	147	11	0%
data centre costs	46,175	3,298	23%	52,425	3,745	25%
insurance	49,598	3,543	25%	49,598	3,543	24%
devaluation total (platform infrastructure, sensors, equipment)	56,049	4,004	28%	56,049	4,004	27%
Total	**200,469**	**14,319**	**100%**	**207,069**	**14,791**	**100%**
Grand Total	**934,173**	**66,727**		**990,393**	**70,742**	

Table 4.4 *A breakdown of the annual routine and total operations costs associated with running fixed platforms*

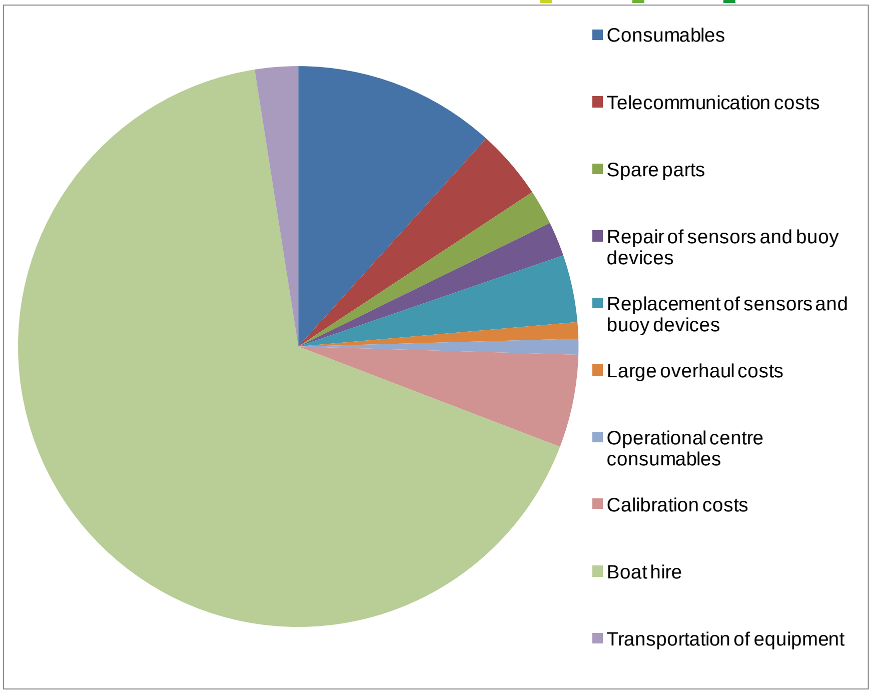

Figure 4.2 *A breakdown of the annual total variable costs associated with running fixed platforms*

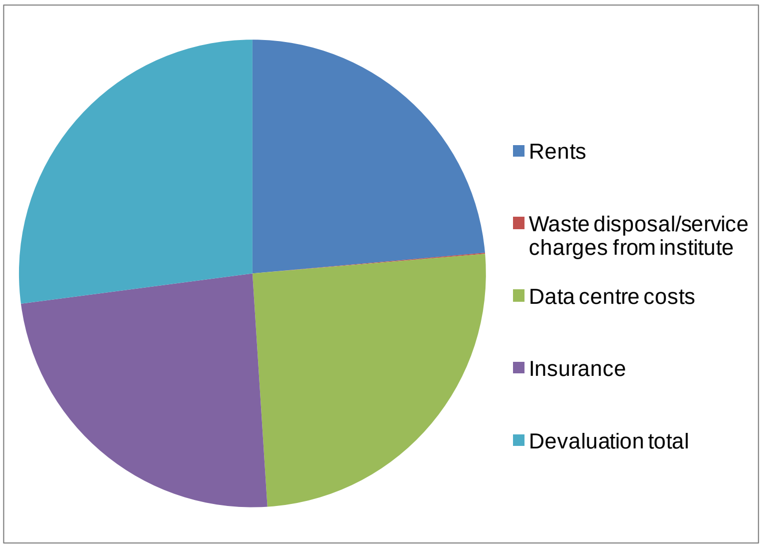

Figure 4.3 *A breakdown of the annual total fixed costs associated with running fixed platforms*

4.1.1. Summary of costs related to Personnel

Personnel costs (€68,615) account for 49% of the total annual running costs of €139,358 for fixed platforms (Table 4.2). The majority of the additional costs associated with emergency operations are due to increases in personnel costs (Table 4.2). Engineer and technician costs account for over half of the annual routine and total operations costs (Table 4.5).

	Annual routine operations			Annual total operations		
	Total	**Mean (€)**	**As % of mean**	**Total**	**Mean (€)**	**As % of mean**
Head engineer	154,150	11,011	38%	156,028	22,290	32%
Assistant engineer	22,587	1,613	6%	23,114	4,623	7%
Technician	72,805	5,200	18%	83,786	10,473	15%
Operational Centre data manager	50,489	3,606	12%	56,114	7,014	10%
Scientific assistant	29,779	2,127	7%	35,404	7,081	10%
Scientist in charge	35,983	2,570	9%	40,858	6,810	10%
Personnel	26,732	1,909	7%	37,541	7,508	11%
Personnel Travel	11,118	794	3%	13,688	1,521	2%
Personnel Training	3,763	269	1%	3,888	1,296	2%
Total	**407405**	**29,100**	**100%**	**450,420**	**68,615**	**100%**

Table 4.5 *A breakdown of the annual routine and total personnel costs associated with running fixed platforms*

4.2. Analysis of costs for Ferrybox systems

The different systems described under Ferryboxes include commercial systems and custom-made systems installed on ships of opportunity and research vessels. Examples of the different systems are shown in Figure 4.4.

Figure 4.4 *Examples of the Ferrybox systems operated by (a) HCMR; (b) NOC; (c) HZG, (d) SMHI*

4.2.1. Summary of costs related to Investments

The average initial investment per Ferrybox is €110,298 (Table 4.6) although there is a very wide range in the investment made. The cost of purchasing the system and other capital costs dominate the initial investment (Table 4.7). The average annual routine running cost is €84,729 and the average annual total cost (routine plus emergency) for operating a Ferrybox system is €90,529 due to the additional variable and personnel costs associated with responding to emergencies (Table 4.6). The amount of money spent on non-routine operations is much smaller for Ferrybox systems than for fixed platforms. Personnel costs (€49,565) account for 55% of the total running costs with variable costs (€21,027) and fixed costs (€19,937) accounting for 23% and 22% respectively (Table 4.6). The personnel costs equate to an annual average of 125 days for total operations.

	Average initial investment (€)	Average routine cost (€)	Average total cost including emergencies (€)
Investment per laboratory	110,298		
Operations per year - variable		17,214	21,027
Operations per year - fixed		19,937	19,937
Personnel costs		47,578	49,565
Total	**110,298**	**84,729**	**90,529**

Table 4.6 *Summary of initial investment and annual running costs per Ferrybox system.*

	Mean (€)	As % of mean
purchase of Ferrybox	53,365	48
purchase of sensors	20,069	18
purchase of Ferrybox infrastructure (e.g. pressure chamber)	4,166	4
purchase of Ferrybox equipment (e.g. tools, R&D, launch)	4,548	4
purchase of safety equipment	125	0
Initial set up costs (Capital)	28,025	26
Total	**110,298**	**100**

Table 4.7 *A breakdown of the investment associated with running Ferrybox systems*

4.2.1. Summary of costs related to Operations

Consumables, repair, replacement and calibration of sensors, spare parts account for 73% of the variable operating costs of a Ferrybox system (Table 4.8, Figure 4.5). Fixed operational costs are dominated by data centre and devaluation (Table 4.8, Figure 4.6).

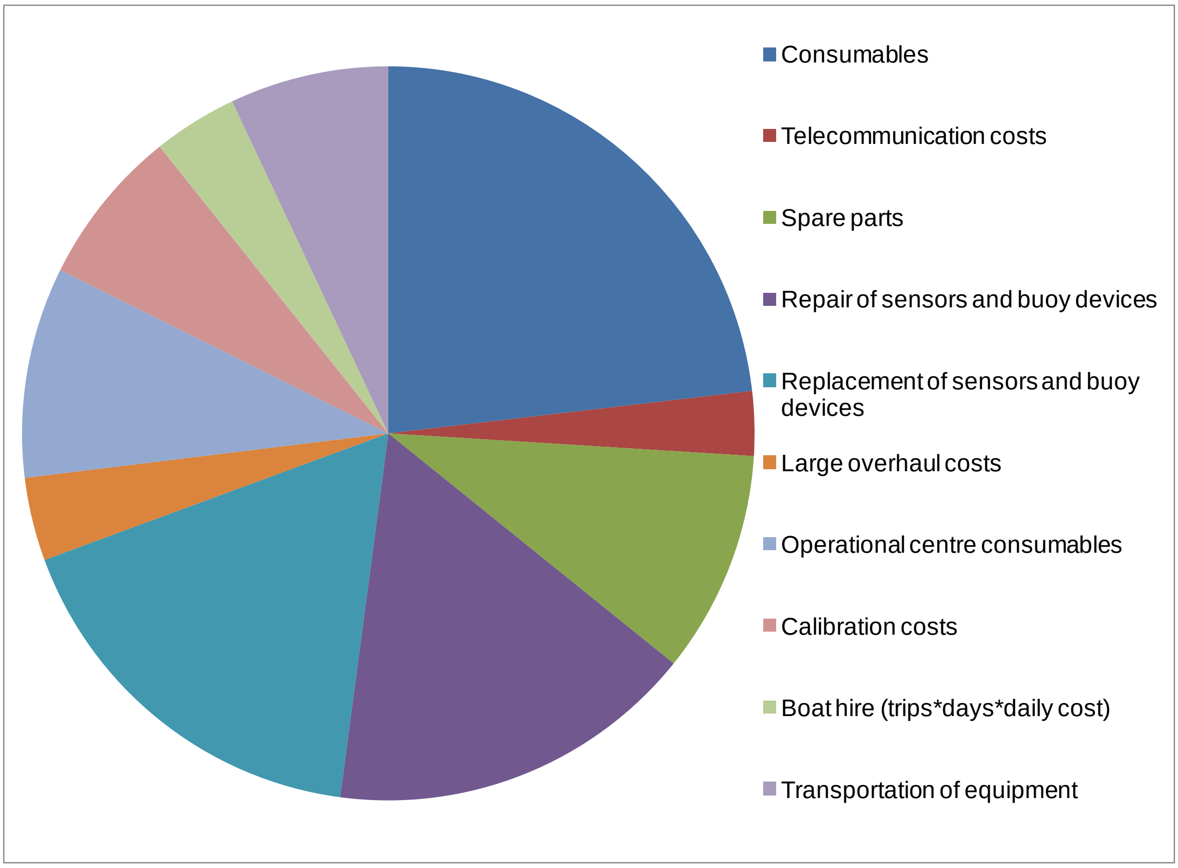

Figure 4.5 *A breakdown of the variable costs associated with running Ferrybox systems*

	Annual routine operations			Annual total operations		
	Total	Mean (€)	As % of mean	Total	Mean (€)	As % of mean
Variable operations						
consumables (cables, anchors, batteries, chemicals etc.)	18,941	2,368	14%	38,941	4,868	23%
telecommunication costs	4,776	597	3%	4,776	597	3%
spare parts	16,500	2,063	12%	16,500	2,063	10%
repair of sensors and Ferrybox devices	21,250	2,656	15%	27,415	3,427	16%
replacement of sensors and Ferrybox devices	24,750	3,094	18%	29,088	3,636	17%
large overhaul costs (where not already included in other categories)	6,176	772	4%	6,176	772	4%
operational centre consumables	15,625	1,953	11%	15,625	1,953	9%
calibration costs	11,671	1,459	8%	11,671	1,459	7%
boat hire	6,250	781	5%	6,250	781	4%
transportation of equipment	11,773	1,472	9%	11,773	1,472	7%
Total	**137,712**	**17,214**	**100%**	**153,845**	**21,027**	**100%**
Fixed operations						
rents	0	0	0%	0	0	0%
waste disposal/service charges from institute	118	15	0%	118	15	0%
data centre costs	72,780	9,098	46%	72,780	9,098	46%
insurance	12,500	1,563	8%	12,500	1,563	8%
routine maintenance contract	12,500	1,563	8%	12,500	1,563	8%
devaluation total (platform infrastructure, sensors, equipment)	61,597	7,700	39%	61,597	7,700	39%
Total	**159,495**	**19,937**	**100%**	**159,495**	**19,937**	**100%**
Grand Total	**297,207**	**37,151**		**313,340**	**40,964**	

Table 4.8 *The annual routine and total operations costs associated with running Ferrybox systems*

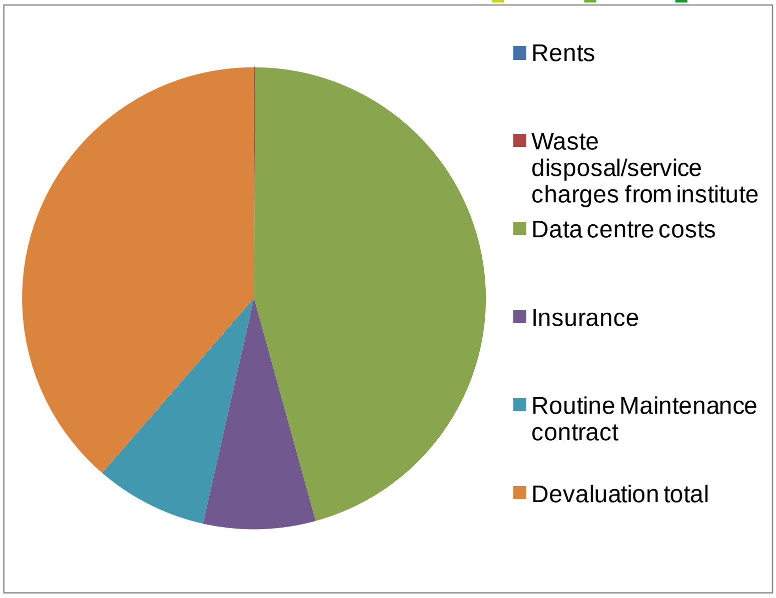

Figure 4.6 *A breakdown of the fixed costs associated with running Ferrybox systems*

4.2.1. Summary of costs related to Personnel

Personnel costs (€49,565) account for 55% of the total annual running costs of €90,529 for Ferrybox systems (Table 4.9). Engineer and technician costs account for over half of the annual routine and total operations costs (Table 4.9).

	Annual routine operations			Annual total operations		
	Total	**Mean (€)**	**As % of mean**	**Total**	**Mean (€)**	**As % of mean**
Head engineer	67,775	8,472	18%	67,775	8,472	17%
Assistant engineer	76,100	9,513	20%	76,100	9,513	19%
Technician	71,681	8,960	19%	86,479	10,810	22%
Operational Centre data manager	52,466	6,558	14%	52,466	6,558	13%
Scientific assistant	50,000	6,250	13%	50,000	6,250	13%
Scientist in charge	35,225	4,403	9%	35,225	4,403	9%
Personnel Travel	18,691	2,336	5%	19,787	2,473	5%
Personnel Training	8,688	1,086	2%	8,688	1,086	2%
Total	**380,626**	**47,578**	**100%**	**385,910**	**49,565**	**100%**

Table 4.9 *A breakdown of the annual routine and total personnel costs associated with running Ferrybox systems*

4.3. Analysis of costs for glider fleets

This section is based on the response to the JERICO Glider Questionnaire from 11[1] of the 12 active glider laboratories in Europe. The questionnaire asked about the investment, operational and personnel costs associated with running the glider facilities in 2011, to provide an overview of the costs of running the glider observatories. However it should be recognized that depending on the funding available investment in gliders and glider operations will vary from year to year. In addition, the cost of operations can vary depending on the type of mission, for example for coastal vs. open ocean, multi glider vs. single glider, monitoring vs. specific experiment and Mediterranean vs. Arctic operations. The costs outlined below however may provide some initial insight into the order of magnitude of costs associated with running a glider facility across Europe.

4.3.1. Summary of costs related to Investments

[1] UoC, DT-INSU, GEOMAR, HZG, AWI, IMEDEA/SOCIB, PLOCAN, NOCS, SAMS, UEA, and CMRE

The questionnaire asked about the investment in gliders and glider related equipment and infrastructure during 2011. Below is a table of the mean investment across the 11 active glider laboratories.

The mean investment in gliders is approximately equivalent to 1.5 gliders per glider lab, most of the investment was in the purchase of gliders (93%), with 7% in sensors and 4% in infrastructure. Seven of the 12 labs invested in gliders and 6 in sensors during 2011. Two labs made large investments in gliders, accounting for 58% of the total investment (2,317,994€) across the 11 glider labs.

Investment	Mean €
Purchase of gliders	195,091
Purchase of sensors	13,817
Glider infrastructure (e.g. pressure chamber)	8,591
Glider equipment (e.g. tools, R&D, launch)	4,641
Safety equipment	405
Total	222,545

Table 4.10 *- Mean investments (€) in 2011 (approx.), excluding VAT (€) -*

4.3.2. Summary of costs related to Operations

The operational costs associated with running a glider lab were divided into fixed and variable costs, and 10 of the 12 active glider labs responded to this section of the survey[2]. Below is a summary table of the total and mean operational costs across the glider labs. The fixed costs rent, waste disposal, data centre, and insurance were not accounted for by most of the glider labs (with 1, 1, 3 and 1 answers respectively).

[2] UoC, DT-INSU, GEOMAR, HZG, AWI, IMEDEA/SOCIB, PLOCAN, NOCS, SAMS and UEA

OPERATIONS	Total Europe	Mean	As % of mean costs
Variable Operations			
batteries	234,788	23,479	41%
consumables other (e.g. cables)	11,336	1,134	2%
iridium	121,457	12,146	21%
communications other (Argos, mobile)	4,960	496	1%
spare parts for repair or upgrade etc.	56,303	5,630	10%
calibration (outsourced)	31,380	3,138	6%
vessel costs (e.g. hire, fuel)	27,632	2,763	5%
transportation of equipment	79,773	7,977	14%
Subtotal	567,629	56,763	100%
Fixed Operations			
rent buildings	5,600	560	13%
waste disposal/service from institute	500	50	0%
data centre costs	27,210	2,721	63%
insurance (gliders)	10,000	1,000	23%
Subtotal	43,310	4,331	100%
Total Variable and Fixed Operations	610,939	61,094	

Table 4.11 *- Operational costs 2011 (approx), excluding VAT (€)*

For the variable costs, batteries and iridium account for approximately 60% of the mean costs, 41% and 21% respectively, transportation of equipment accounts for 14%. The mean annual cost operations was approximately 61,000€, however and the variable costs accounted for 93% of the total operational costs.

4.3.3. Summary of costs related to Personnel and Depreciation

The mean cost of personnel in 2011 was approximately 80,000€, with approximately 40% on permanent personnel, travel accounted for 8% of the spend and training 2%.

PERSONNEL	Total Europe	Mean	As % of mean costs
personnel permanent	304,647	30,465	37%
personnel contracted	208,489	20,849	26%
personnel indirect (estimate)	216,731	21,673	27%
travel personnel	66,932	6,693	8%
training personnel	17,500	1,750	2%
Total Personnel	814,299	81,430	100%

Table 4.12 *- Personnel costs 2011 (approx.), excluding VAT (€) -*

Two of the 10 respondents accounted for depreciation of the gliders and equipment, with a mean depreciation cost of approximately 41,000€.

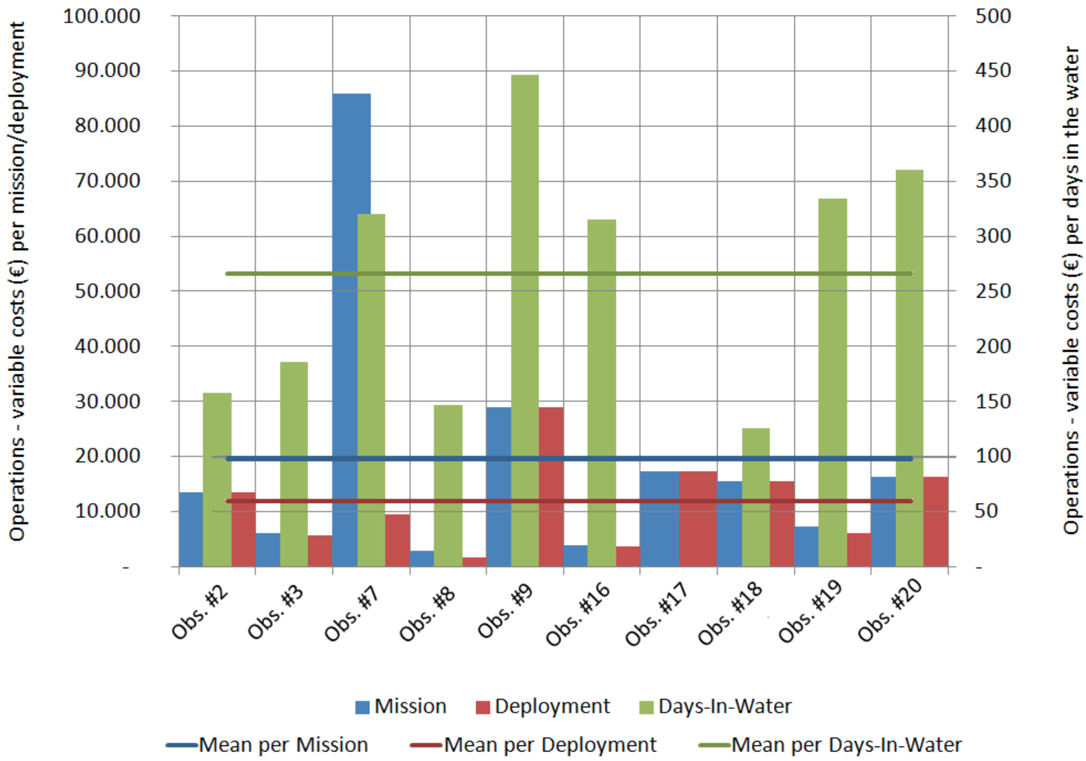

Figure 4.7 *- Variable costs for each respondent and mean values (as a function of missions, deployments and Days-in-Water)*

4.3.4. General Summary

As glider laboratories vary in number of personnel, gliders and mission, for example smaller labs have 2 gliders and the largest 14 gliders, the personnel and variable costs are divided by mission, deployment and number of days in the water to provide a view of the costs as viewed per glider operation across the various glider labs and mean values. There is a large range in the variable costs per mission, deployment and days in the water, as noted in the introduction this can be due to many factors associated with the type or style of glider operations. These numbers are represented in Figure 4.7 (Variable costs) and Figure 4.8 (Personnel costs). Table 4.13 quantifies the means represented in these figures whereas Table 4.14 summarizes table of total costs for glider operations across Europe in 2011. For comparison with fixed platforms and Ferrybox systems, excluding mean investment made in 2011 (€222,545), the mean total running cost for a glider fleet in 2011 was €184,014 (Table 4.14). Of this, 44% was associated with personnel costs.

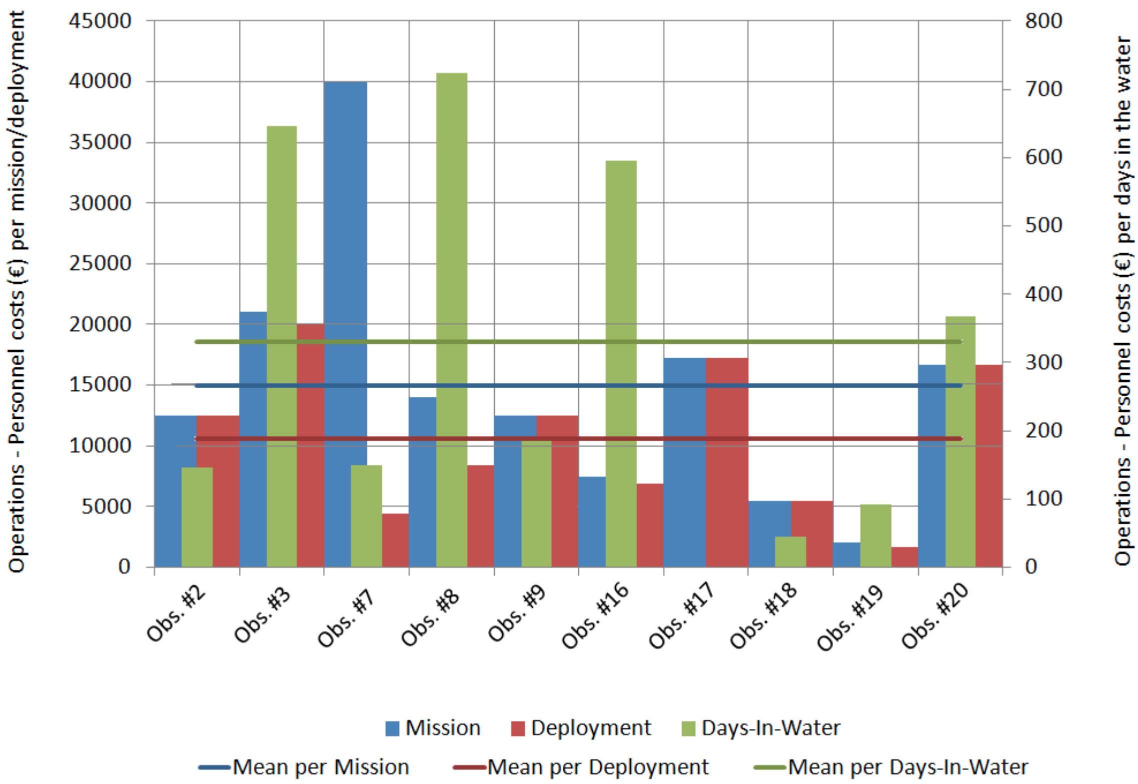

Figure 4.8 - Personnel costs for each respondent and mean values (as a function of missions, deployments and Days-in-Water)

Variable costs by:	Mean
Mission	19,752
Deployment	11,824
Days in the water	266
Personnel costs by:	
Mission	14,880
Deployment	10,573
Days in the water	329

Table 4.13 *- Mean variable costs and personnel costs as a function of missions, deployments and days in the water for 2011 (€)*

TOTALS	Total Europe	Mean	As % of mean costs
Total Investment	2,317,994	222,545	54%
Total Variable and Fixed Operations	610,939	61,094	35%
Total Personnel	814,299	81,430	20%
Depreciation (gliders, sensors, equipment)	414,896	41,490	10%
TOTAL Annual (investment, operations, personnel and depreciation)	4,158,128	415,813	100%

Table 4.14 *- Summary table of total costs for glider operations across Europe in 2011 (€)*

Across Europe, three countries, France, Spain and the UK, made similar and higher levels of investment/spending in gliders and glider operations (see Table 4.15). Germany invested approximately 50% less and Cyprus 90% less, the figures for Italian investment/spending are unknown. Norway is now developing their glider observatory and Poland and Greece both have interest and/or intend to commence operations.

Summary of spending per country	Investment	Operations (variable and fixed costs)	Personnel	Total (inc. depreciation)
FRANCE	230,494	138,019	537,968	1,092,858
GERMANY	274,000	152,400	107,000	533,400
SPAIN	601,500	933,000	183,100	1,333,000
UK	852,500	110,540	65,450	1,078,990
CYPRUS	28,000	26,880	25,000	119,880
ITALY	130,000	no data	no data	no data
NORWAY	no data	no data	no data	no data
POLAND	no gliders	no gliders	no gliders	no gliders
GREECE	no gliders	no gliders	no gliders	no gliders

Table 4.15 *- Summary of the total spending per country, in glider investment, operations and personnel for 2011 (€)*

4.4. Analysis of costs for calibration laboratories

Costs were provided for the operation of three calibration laboratories, with a wide range in the costs given.

4.4.1. Summary of costs related to Investments

The average initial investment was €118,333 (minimum €5,000, maximum €340,000) (Table 4.16).

	Average initial investment (€)	Average total cost including emergencies (€)
Investment per laboratory	118,333	
Operations per year - variable		29,667
Operations per year - fixed		18,333
Personnel costs		64,697
Total	**118,333**	**112,697**

Table 4.16 *Summary of initial investment and annual running costs per calibration laboratory.*

4.4.1. Summary of costs related to Operations

	Total	Mean (€)	As % of mean
variable operations			
maintenance	14,500	4,833	16%
consumables	14,500	4,833	16%
transportation of equipment	1,500	500	2%
spare parts	1,000	333	1%
repair of reference sensors	5,000	1,667	6%
replacement of reference sensors	52,000	17,333	58%
telecommunication costs	500	167	1%
Total	**89,000**	**29,667**	**100%**
fixed operations			
insurance			
electricity/water	500	167	1%
Rents	0	0	0%
data centre costs	0	0	0%
waste disposal	0	0	0%
devaluation	56,000	18,667	99%
Total	**56,500**	**18,833**	**100%**
Grand Total	**145,500**	**48,500**	

Table 4.17 *A breakdown of the fixed and variable costs associated with running a calibration laboratory*

Variable costs and fixed costs account for 26% and 16% respectively of the total annual running costs (Table 4.17).

4.4.1. Summary of costs related to Personnel

Personnel costs account for 57% of the annual running cost of a calibration laboratory, with the majority of the cost associated with technicians (Table 4.18).

	Total	Mean (€)	As % of mean
Head engineer	900	300	0%
Assistant engineer	12,900	4,300	7%
Technician	172,290	57,430	89%
Scientific assistant	1,000	333	1%
Personnel Travel	7,000	2,333	4%
Total	**194,090**	**64,697**	**100%**

Table 4.18 *A breakdown of the total personnel costs associated with running a calibration laboratory*

5. Summary

The average initial investment and annual running costs for fixed platforms, Ferrybox systems and calibration laboratories in Europe have been considered in this report based on the results of a questionnaire. There was a large variability in costs between laboratories reflecting the different types of platforms and parameters being measured. However, the figures presented here give an indication as to the level of investment required and annual running costs for fixed platforms, Ferrybox systems and calibration laboratories. Initial investment costs are greater for glider fleets (€222,545 in 2011) and Ferrybox systems (€110,298) than for fixed platforms (€86,526). Ongoing total annual running costs for a glider fleet (€184,014 excluding investment in 2011) and fixed platforms (€139,358) exceed those of Ferrybox systems (€90,529). Personnel costs account for 44%, 49% and 55% respectively of the total annual running cost of a glider fleet (€81,430), fixed platforms (€68,615) and Ferrybox systems (€49,565). This analysis of costs has shown that a large proportion (27%) of the total annual running cost of fixed platforms is associated with boat charter (€37,315). Collaborative working such as under the Eurofleets project (http://www.eurofleets.eu/np4/63) may give the opportunity to reduce these costs and maximise efficiency.

Annexes and References

References

Tintore, J., Testor, P., Smeed, D., Beguery, L., Pouliquen, S., Heslop, E., Martinez-Ledesma, M., Cusi, S., Torner, M., Ruiz, S., Merckelbach, L., Knight, P., 2013. Report on current status of glider observatories within Europe, in: Farcy, P. (Ed.). JERICO.

Annexe 1 Questionnaire used to compile costs presented in this report

PLATFORM - FIXED BUOYS			
ANNUAL COSTS	**Routine Maintenance**	**Emergency Maintenance**	**Total Costs**
Boat hire (trips*days*daily cost)			
Consumables (cables, anchors, batteries, chemicals etc.)			
Personnel Travel			
Personnel Training			
Transportation of equipment			
Spare parts			
Repair of sensors and buoy devices			
Replacement of sensors and buoy devices			
Large overhaul costs (where not already included in			
Insurance			
Telecommunication costs			
Operational centre consumables			
Calibration costs			
Rents			
Initial set up costs (Capital?)			
Data centre costs			
Waste disposal/service charges from institute			
Personnel (need days as well as total cost to compare			
Head engineer			
Assistant engineer			
Technician			
Operational Centre data manager			
Scientific assistant			
Scientist in charge			
devaluation total (platform infrastructure, sensors,			
purchase of mooring			
purchase of sensors			
purchase of buoy infrastructure (e.g. pressure chamber)			
purchase of buoy equipment (e.g. tools, R&D, launch)			
purchase of safety equipment			
Number of buoys			
Total number of deployed mooring days			

PLATFORM - Ferrybox			
ANNUAL COSTS	**Routine Maintenance**	**Emergency Maintenance**	**Total Costs**
Boat hire (trips*days*daily cost)			
Consumables (batteries, chemicals etc)			
Personnel Travel			
Personnel Training			
Transportation of equipment			
Spare parts			
Repair of sensors and other devices			
Replacement of sensors and other devices			
Large overhaul costs (where not already included in			
Insurance			
Telecommunication costs			
Operational centre consumables			
Calibration costs			
Rents			
Initial set up costs			
Data centre costs			
Waste disposal/service charges from institute			
Routine Maintenance contract			
Personnel (need days as well as total cost to compare			
Head engineer			
Assistant engineer			
Technician			
Operational Centre data manager			
Scientific assistant			
Scientist in charge			
devaluation total (platform infrastructure, sensors,			
purchase of FerryBox			
purchase of sensors			
purchase of Ferrybox infrastructure (e.g. pressure			
purchase of Ferrybox equipment (e.g. tools, R&D,			
purchase of safety equipment			
Number of FerryBoxes			
Total number of FerryBox days			

PLATFORM - GLIDERS			
ANNUAL COSTS	Routine Maintenance	Emergency Maintenance	Total Costs
Boat hire (trips*days*daily cost)			
Consumables - batteries			
Consumables (cables, chemicals etc) exluding batteries			
Personnel Travel			
Personnel Training			
Transportation of equipment			
Spare parts for repair etc			
Repair of sensors and glider devices			
Replacement of sensors and glider devices			
Large overhaul costs (where not already included in other categories)			
Insurance			
Iridium costs			
Telecommunication costs other (Argos, mobile)			
Operational centre consumables			
Calibration costs			
Rents			
Initial set up costs			
Data centre costs			
Waste disposal/service charges from institute			
Personnel (need days as well as total cost to compare man hours required between institutes)			
Head engineer			
Assistant engineer			
Technician			
Operational Centre data manager			
Scientific assistant			
Scientist in charge			
devaluation total (gliders, sensors, equipment)			
purchase of gliders			
purchase of sensors			
purchase of glider infrastructure (e.g. pressure chamber)			
purchase of glider equipment (e.g. tools, R&D, launch)			
purchase of safety equipment			
Number of gliders			
Total number of deployed glider days			

CALIBRATION LABS			
ANNUAL COSTS	**Routine Maintenance**	**Emergency Maintenance**	**Total Costs**
Maintenance			
Consumables			
Personnel Travel			
Transportation of equipment			
Spare parts			
Repair of reference sensors			
Replacement of reference sensor			
Insurance			
Telecommunication costs			
Electricity / Water Costs			
Rents			
Initial set up costs			
Data centre costs			
Waste disposal/service charges from institute			
Personnel (need days as well as total cost to compare			
Head engineer			
Assistant engineer			
Technician			
Scientific assistant			
Devaluation 10-15% (equipment usually lasts 7-8 years)			

Annexe 2 Tintore et al., 2013. Report on current status of glider observatories within Europe, in: Farcy, P. (Ed.). JERICO

Joint European Research Infrastructure network for Coastal Observatories

SEVENTH FRAMEWORK PROGRAMME

Report on current status of glider observatories within Europe D#3.2

Grant Agreement n°: 262584

Project Acronym: JERICO

Project Title: Towards a Joint European Research Infrastructure network for Coastal Observatories

Coordination: P. Farcy, IFREMER,

jerico@ifremer.fr, www.jerico-fp7.eu:

Authors: Tintoré, J.; Testor P.; D. Smeed; L. Beguery, S. Pouliquen; E. Heslop M. Martínez-Ledesma; S. Cusí; M. Torner; S. Ruiz, L. Merckelbach, P. Knight.

Involved Institutions: CSIC, INSU/CNRS, HZG, IFREMER, NERC
Version and Date: v1.8, 30 May 2013

Table of Contents

1. Document description

REFERENCES

Annex 1 to the Contract: Description of Work (DoW) version XX

Document information	
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Revision	*8th (version 1.8)*
Revision Date	*30/may/2013*
Author	*Jerico WP3 Team*
Security	

History			
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V1.0	Aug/2012-	Questionnaire results processing	CSIC
V1.1	Oct/2012	First draft report	CSIC
V1.2	Dec/2012	Iteration and revision	CSIC
V1.3	Feb/2013	2nd revision	CSIC
V1.4	April/2013	New texts, statistics and figures corrected (all answers – including costs- received and included)	CSIC/CNRS
V1.5	May/2013	First version of report circulated to European partners	CSIC
V1.6.1-V1.6.3	May/2013	Versions iterated and revised partners	Partners
V1.7	May/2013	Version created after integrating most of partner's suggestions and comments	CSIC/
V1.8	May/2013	Final version ready to be delivered	CSIC

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Consortium beneficiaries	X			
Third parties				
Associated Partners				

2. Executive Summary

The present document stands as the deliverable report for Task 3.2, relative to Glider platforms, as part of the work package 3, titled "Harmonizing Technological Aspects", of the JERICO EC funded project number 262584.

The aim of this report is to describe the state of the art of glider activities in Europe as developed in the frame of JERICO project, with participation of glider experts both from JERICO project and also from other European laboratories, by this creating a first European Review on glider activities in Europe.

The report is based on the information collected from an extensive questionnaire that was prepared by the JERICO glider team (see Annex II) during 2011-2012, the discussions that took place in the glider meeting in Mallorca in May 2012 (see Annex IV) and the discussions and iterations that continued after the meeting and during 2013.

The report is structured in four main sections:

- Introduction to European Glider Observatories: in terms of staff, glider fleet, sensors and vehicles available.
- Operational activity analysis: overview of missions undertaken in 2010 and 2011 (zones of presence, typology and driving objectives); key findings obtained with gliders; and how these missions were supported in terms of (a) planning, (b) prevention, (c) piloting and (d) scientific calibration, amongst others.
- Data management strategies: review of the current situation followed by three representative examples of processing systems and discussion including a specific proposal for glider data management in Europe;
- Compilation of costs related to the glider activity: quantification of the personnel; the operations; the investments derived from the purchase of gliders and related goods (in coordination with WP4).

This Review of Current Status of Glider Observatories in Europe is therefore a starting point, showing the present status of the glider activities in Europe, the costs of operations as well as the existing gaps and needs. Gliders are presently key elements of both, sustained monitoring activities, with for example permanent endurance lines in key control points in Europe, and also of specific process oriented studies on key unresolved questions of worldwide scientific interest (e.g., water masses formation, upper ocean mixing, meso and submesoscale eddies, etc.). We therefore show that, in line with the general international trend, gliders are key elements of the new European Strategy on new Marine Infrastructures and Observing systems, serving science, technology and society needs, in line with key priorities of Horizon 2020 and Blue Growth EU Strategies.

3. Introduction

New monitoring technologies are key components of recent observing systems being progressively implemented in many coastal areas of the world oceans. As a result, new capabilities to characterise the ocean state and its variability at small scales exists today in many cases in quasi-real time.

Gliders are a key example of these new technologies. They are small, autonomous, buoyancy-driven vehicles designed to sample the oceans and coastal oceans regions. They allow the autonomous and sustained collection of conductivity-temperature-depth (CTD) and biogeochemical measurements (e.g. fluorescence, oxygen and turbidity), at a higher spatial resolution and lower cost than conventional methods. At present, commercially available gliders can operate between the ocean surface and 1000 m depth (shallow units to 200 m), but further research is ongoing to develop a prototype able to dive to 6000 m depth.

By modifying their buoyancy and making use of small fins, gliders sample the water column describing a zigzag trajectory between the surface and deep levels, with a horizontal speed of 25 to 40 cm s–1. At every surfacing point gliders transmit data to a land station through bi-directional Iridium satellite communication, normally every 6 hours. At the surface gliders behaviour can be modified (e.g. sampling frequency, up/down data acquisition and depth of inflexions) and the missions' waypoints can be changed. Autonomy at sea ranges from months to weeks, depending on the type of batteries (lithium or alkaline) and the glider mission configuration.

Gliders (soon to become fleets of gliders) are being progressively implemented in coastal to open ocean regions allowing repeated high resolution monitoring of specific areas showing the dynamical relevance of new features, such as for example sub-mesoscale eddies that are characterized by strong horizontal gradients and intense vertical motions. These eddies, that could not be routinely monitored before, can interact with the underlying mean flows, blocking the general circulation in key ocean regions; or they can give rise to enhanced upper ocean biogeochemical exchanges modifying the ecosystem response at a scale that was not previously observable on a routine basis. Gliders have been also instrumental in recent years in understanding water masses formation and spreading, as well as in characterizing upper ocean mixing and air-sea exchanges in extreme events. These are just some examples of the contribution of new technologies to address and better understand state of the art oceanic questions of worldwide scientific relevance in a climate change context. But gliders are also key in addressing society related objectives, in particular in relation to the implementation of the European Marine Strategy Directive (MSFD), the marine pillar of the EU Integrated Maritime Policy.

Gliders are being implemented in ocean observing systems around Europe and are already contributing to our knowledge on ocean circulation and ocean variability. Gliders are also driving important technology developments and are finally also contributing to respond to specific society needs.

4. Main Report

4.1. Review of glider observatories in Europe

The first glider deployments in Europe occurred around 2005 and marked the beginnings of a community that has been increasing in members, fleet sizes, areas of action and scientific productivity. Although the groups included in this European glider community emerged individually and based on their own scientific needs and objectives, there has, since the beginning, been an effort towards cooperation and networking between the groups in the framework of EGO (recognized by the ESF as the COST Action Es0904) that continues ever since. Nowadays there exist several European wide initiatives to share glider knowledge, develop best practices, extend glider operations across the scientific community and provide to scientists and engineers transnational freely access to glider infrastructures that do not exist in their own countries.

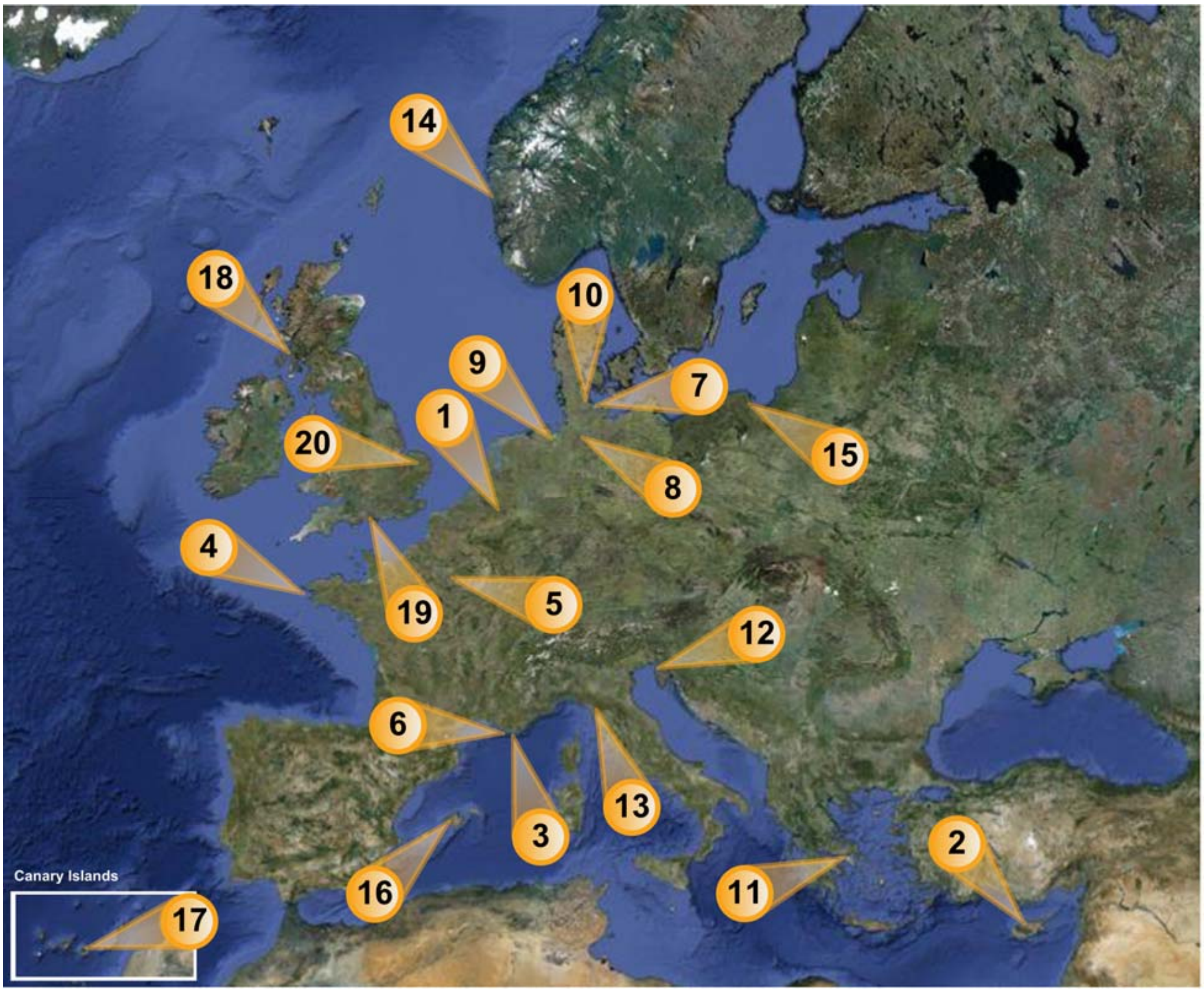


Figure 4.1 *- Territorial distribution of the European glider groups. Pushpins mark the location of each surveyed observatory, while the table below provides the key to the numbered institutions-*

In this section we show that there is homogeneity but also a significant degree of heterogeneity amongst the European glider observatories, that is directly linked to the inherent differences in geographical, human, technical, social and funding factors. Additionally, this section contains information compiled from the extended JERICO/GROOM/EGO online survey and provides details on the European Glider Groups (also called Institutions or Observatories), including location and contact information, human resources, types of gliders, physical and biogeochemical sensors and a 2012 snapshot of the material and logistic resources dedicated (fully or partially) to support glider operations.

4.1.1. Glider observatories and laboratories

Glider laboratories in Europe have different origins and background. Accordingly, we find a wide variety of glider teams, with different skills, assigned tasks, and operating in different locations around the world. The map presented above (Figure 4.1) offers a general overview of the location of the main glider laboratories in Europe and the following chart (Table 4.1) lists the institutions by number, providing correspondence between the locations pointed out in the map and the more detailed directory included in Annex I that shows major key points for each laboratory.

Nationality	Map	Acronym/Logo	Location
Belgium	1	vito	Antwerp (Flanders)
Cyprus	2	CYPRUS Oceanography Centre	Nicosia
France	3	CNRS INSU	La Seyne sur Mer, Paris, Villefranche sur Mer
		UPMC / ENSTA Bretagne	Paris, Villefranche sur Mer
	5	Ifremer	Issy-les-Moulineaux (Paris), Brest, La Seyne sur Mer
		IRD	Marseille, Toulouse
Germany	7	GEOMAR	Kiel (Schleswig-Holstein)
	8	Helmholtz-Zentrum Geesthacht	Schleswig-Holstein (Geesthacht)
		AWI Alfred-Wegener-Institut für Polar- und Meeresforschung	Bremerhaven (Bremen)
		BWB	Eckernförde (Schleswig-Holstein)
Greece	11	hcmr	Anavyssos (East Attica)
Italy	12	OGS	Sgonico (Trieste)

			NATO OTAN S&T CMRE	La Spezia (Spezia)
Norway	14		Universitas Bergensis	Bergen
Poland	15		IO	Sopot (Eastern Pomerania)
Spain	16		SOCIB Balearic Islands Coastal Observing and Forecasting System / IMEDEA	Palma / Esporles (Mallorca)
			PLOCAN consorcio	Telde (Gran Canaria)
UK	18		SAMS	Oban (Argyll and Bute)
	19		National Oceanography Centre NATURAL ENVIRONMENT RESEARCH COUNCIL	Southampton
	20		UEA University of East Anglia	Norwick (Norfolk)

Table 4.1 *- Equivalency char for the location map shown in the Figure 4.1*

As shown in the directory in Annex I, the composition of the human glider teams is quite varied, ranging from small groups in which the same role interacts in all the phases of the glider operation, to bigger ones in which members exhibit a higher degree of specialization. More data would be needed to determine if the composition of the groups is variable through years and to better establish and understand the constraints applying to the formation of the teams (i.e. funding). Table 4.2 contains statistical figures on the statistics of human resources of European glider teams. For a better understanding, the following definitions apply when analysing Table 4.2:

- *Man-Power (M-P)*: Percentage of the annual working time of one team member (i.e. M-P of 2.5 indicates two and half full-time workers per annum)
- *Full/Part-Time People*: Number of physical persons working with glider groups, either dedicated either full time or part time

	Man-Power per Role				
	PostDoc	Glider Operator	Glider Technic.	Scientist Staff	PhD Students
TOTAL[1]	5.75 *(8.5%)*	21.75 *(32.2%)*	13.15 *(19.5%)*	19.40 *(28.8%)*	7.40 *(11%)*
Average	0.8	1.6	0.9	1.3	1.2
Max	2.0	4.0	2.0	5.0	3.0
Min	0.3	0.1	0.1	0.2	0.2
STD	0.6	1.3	0.7	1.2	1.4

[1] Percentatges calculated comparing each SubTotal by Rank in chart ("Man-Power per Role") with the Man-Power Total in chart ("European Team Sizes")

	European Team Sizes		
	Man-Power	Full-Time People	Part-Time People
TOTAL	67.45	53	37
Average	4.0	4.4	3.1
Max	11.0	10.0	7.0
Min	0.5	1.0	1.0
STD	2.9	2.6	1.5

	Human Resources per Glider	
	Man-Power / Glider	People / Glider
Average	1.3	1.8
Max	3.7	4.0
Min	0.2	0.4
STD	1.2	1.2

Table 4.2 *- Basic statistics on the numbers and composition of the European glider teams -*

The first conclusion from Table 4.2 is that the European glider teams exhibit quite significant heterogeneity in team composition and size. Second, specialized roles (operators & technicians) are the most numerous with the exception of the scientific staff although a significant portion of them could correspond to scientists performing as operators and/or technicians due to a lack of these roles in their teams and the fact that scientific staff are numerous and the gliders are owned to perform science, which is encouraging for them.

Actually, there are six groups in which the scientific staff represents at least a 50% of the human capital of the team. Third, it is interesting to note that part-time personnel represent 70% of the total, this could have several reasons including not all institutions/countries have a central dedicated glider facility (i.e. France and UK) and the general economic situation favouring part-time employment. This high percentage is maybe understandable, although not necessarily very positive since gliders are very demanding in terms of dedication due to the complex and varied tasks associated to their operation.

Finally, weighting the human resources of each team by the number of gliders managed it appears that just over 1 man-year is required per glider (1.3 on average), which translates with part-time positions to approximately 2 people per glider (1.8 in average). Nevertheless, analysis revealed that a 70% of the groups rely in less than 1 person with full daily dedication to glider related tasks. Please refer to Figures 4.2 and 4.3 for detailed graphical information on this topic.

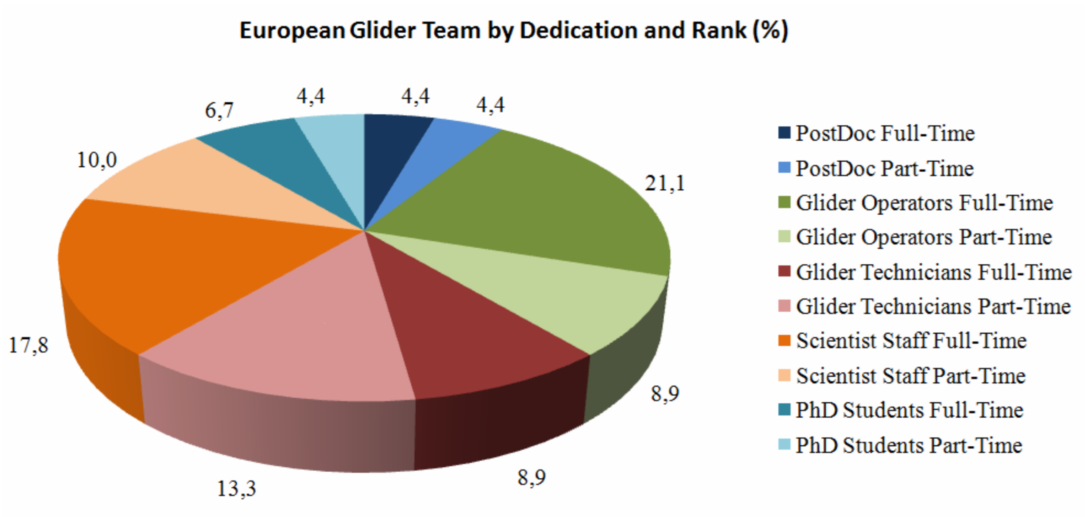


Figure 4.2 *- Percentage split between roles of the European glider users (as a % of total users) with a further split into fulltime (dark tone) and part-time (light tone) roles*

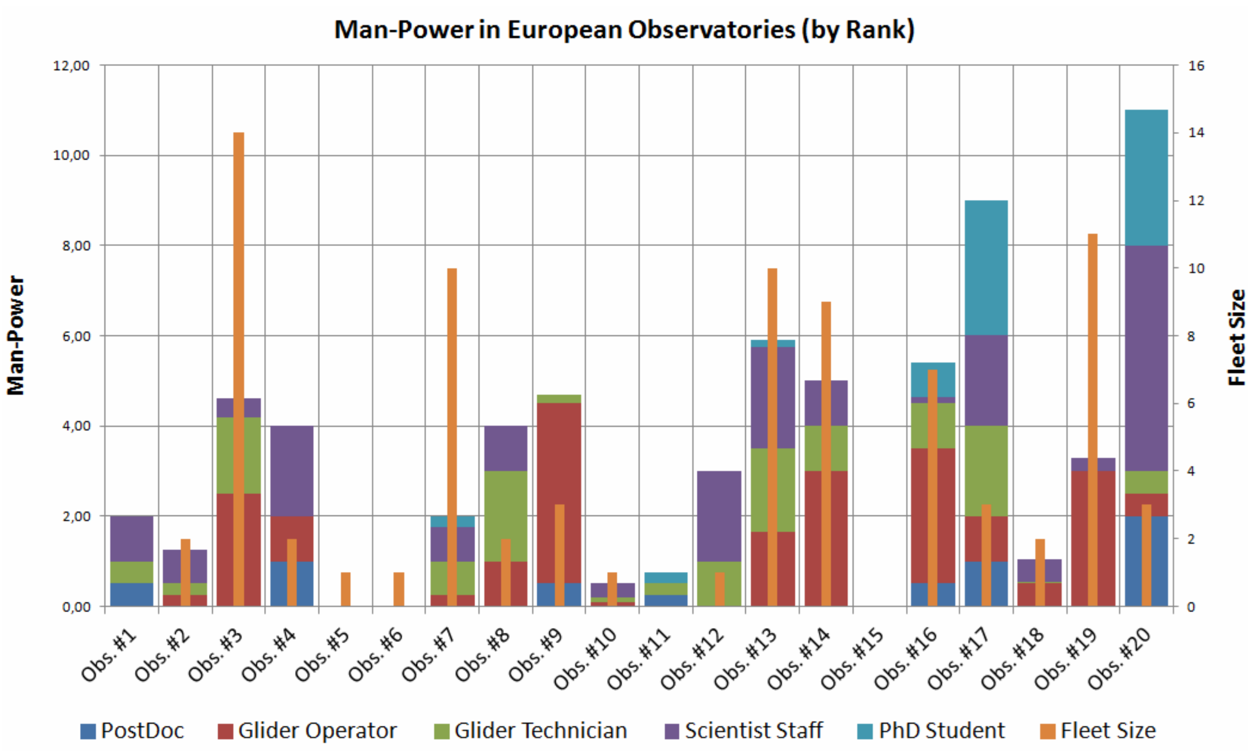


Figure 4.3 *- Man-Power available to each European observatory compared to its individual fleet size-*

4.1.2. European fleet of gliders

a) Gliders

A detailed and complete state-of-the-art evaluation is out of the scope of this report; however, there are some interesting highlights about the electric gliders which are commercially available nowadays. There are four providers of glider technology: (1) Teledyne Webb Research with the Slocum, (2) University of Washington's (3rd party licensed) SeaGlider, (3) BlueFin with the Spray, and more recently joined by (4) ACSA with the SeaExplorer (although this glider has yet to establish operational activities at sea).

Between the various glider designs available there are basic and common features, which are implemented and particularized in different ways by each manufacturer as a response to their different strategies for product development and client services. For those not familiar with gliders, a summary of these features is provided below:

- Advancement: movement in the horizontal plane is achieved from displacement in the vertical axis converted via a pair of side wings and a controlled variation of the angle of attack

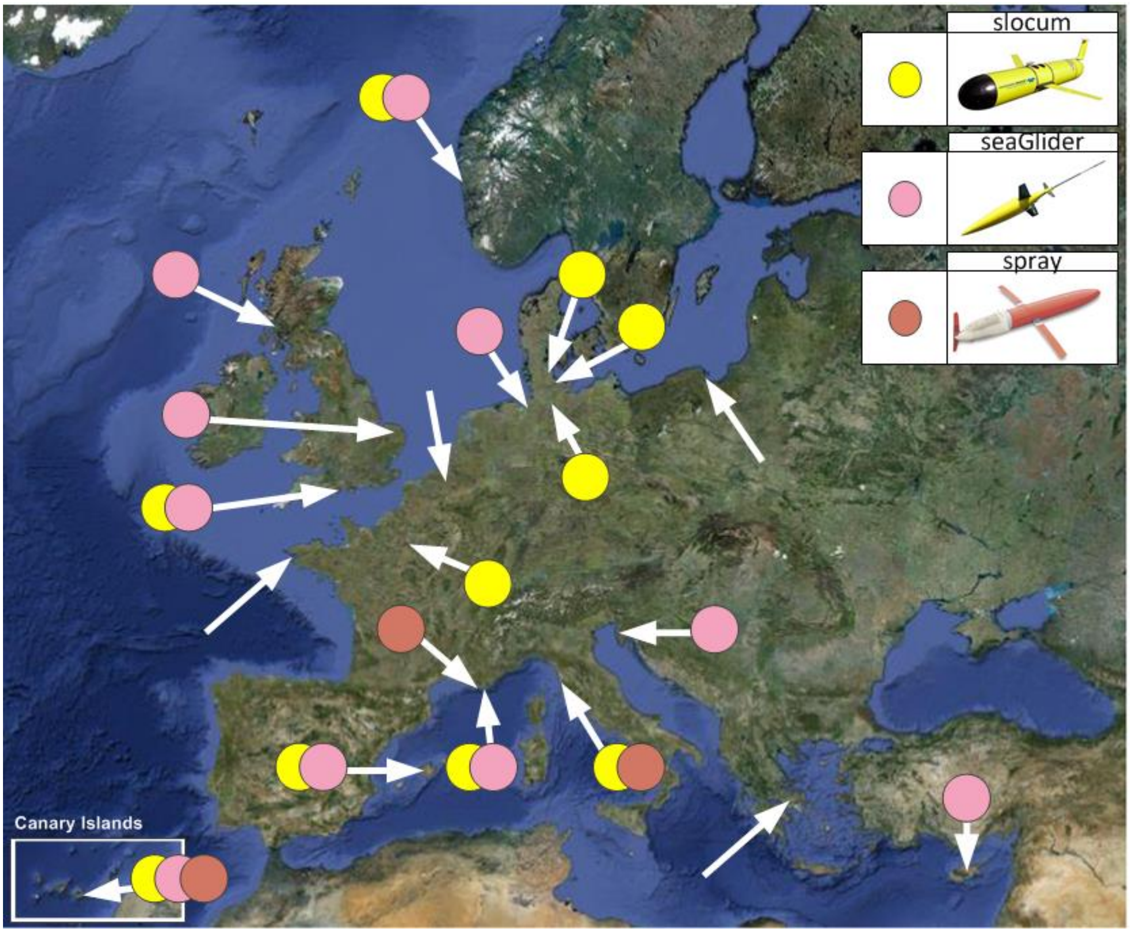


***Figure 4.4** - European fleet distribution by location, model and number of gliders available and being operated. Empty arrows point out glider observatories with none of the models-*

- Thrust: is provided by a variable hydraulic pump capable of reducing the volume of the vehicle to dive and increasing it to climb in the water column. There is one version (Slocum 200m) that uses a mechanical piston for shallow water flight.
- Equilibrium: Mass shifters are used to alter the equilibrium of the vehicle. One moving along the longitudinal axis of the machine changes its pitch and hence the angle of attack. A second rotates in reference to this same axis acting as the steering system. The first is common to all assemblies, whereas the second is replaced by a mechanical fin in the Slocum models
- Communication: The communication channel preferred by all manufacturers is the Iridium global satellite network; however, the on-board set of communication interfaces vary amongst them as do the protocols to exchange information and the commands between the vehicle and the control station. Also, all gliders can have the possibility to use a secondary uni-directional satellite communication system (ARGOS) as an alternative backup system to locate and recovery the glider in case of failure.
- The rest of the systems (electronics, hull, fairings, sensors, processing units, battery packs and voltages,...) differs in one degree or another following a different philosophy and objectives

Consequently, although the basic operation of gliders can be viewed as similar, when it comes to specific aspects of application and performance there is considerable variety between glider models and glider missions.

The European glider fleet is basically heterogeneous. Some labs use a single glider model only while others work with the two predominant types (Slocum and SeaGlider). Only a few laboratories operate all three types. A map indicating the gliders found in each laboratory is presented in Figure 4.4.

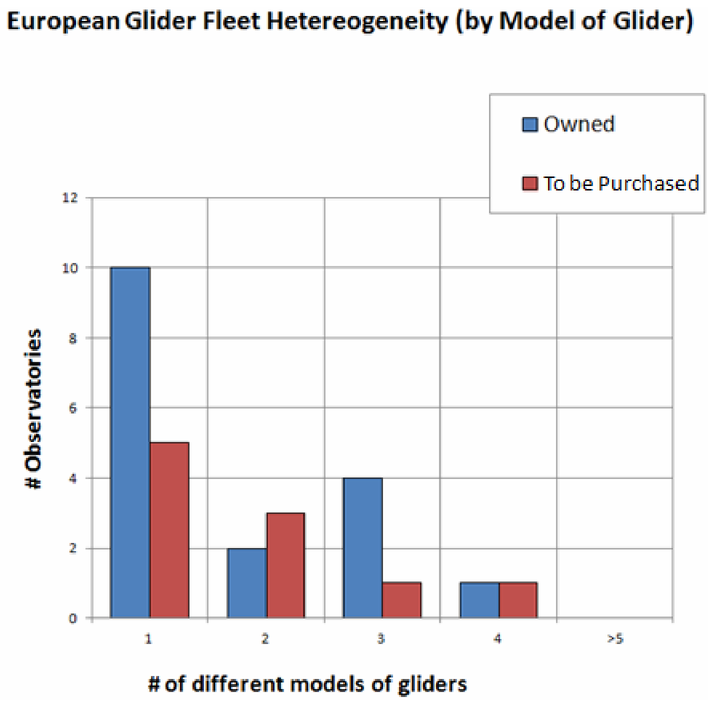
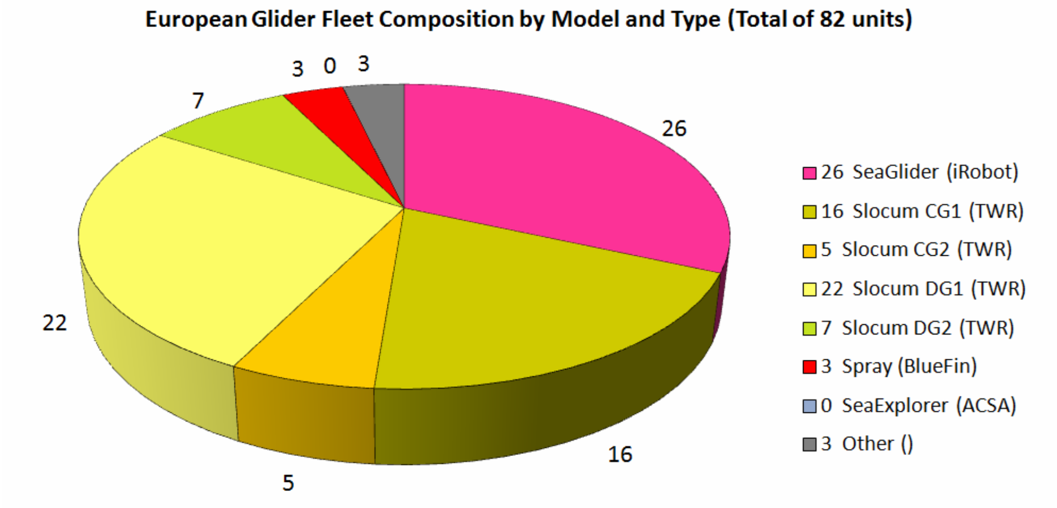


***Figure 4.5** - Histogram representing the distribution of heterogeneity amongst the European fleets in terms of glider models commercially available (Blue) and the same distribution in regard of the gliders which are intended to be purchased in the near future -*

Obtained results reveal a tendency to use and operate the same model of glider. As it can be seen in Figure 4.5, the majority of the groups (50%) prefer to operate the same piece of hardware although, as it has been stated at the beginning of this subsection 4.1.2, all the models share the same basis in functionality and operability. This could likely be due to the fact the achievement of a solid KnowHow on glider management is not trivial as it requires serious investments in equipment, time, personnel and other resources. However, larger and more experienced groups might use their solid bases to complete their fleets with other models, which exhibit different capabilities, as an intent to take advantage of the differences for different objectives.

Additionally, the model of glider that a group purchases can be highly dependent on the past experience of the scientific leaders (work done involving gliders during PhD, Post-Docs,...) and/or recommendations from colleagues and collaborators.



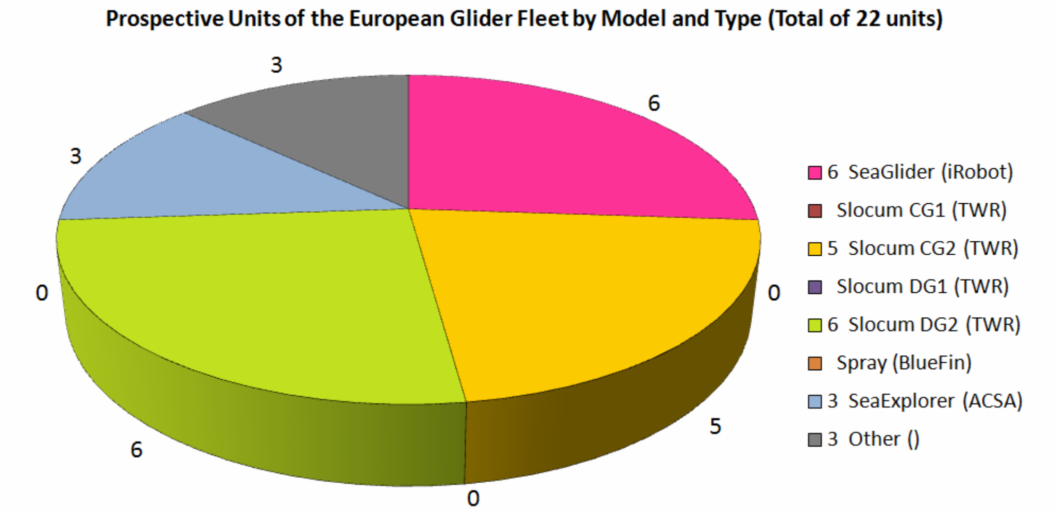


Figure 4.6 *- Current composition of the European glider fleets by commercially available models of gliders (Up) and the models which are considered in the plans of future purchase of gliders (Down) -*

With respect to purchase intentions, note that the majority is not considering the acquisition of new units and, amongst those that do, the major part contemplates no more than two models.

In addition to that, it can be said that the Slocum and SeaGlider models are, by far, the most common platforms, each of them representing a slightly different philosophy of operation and management. The Slocum glider is the model that has been commercially available for a longer period of time (since 2004; year in which the first European Slocum was delivered to a German group) and it is consecutively the most used model by European glider fleets as shown in Figure 4.6.

Figure 4.6 presents the portion of presence for each model and the perspectives of purchase. At the time of writing of this report, the first generation of the Slocum models (CG1 -Coastal Glider 1st Generation- & DG1 -Deep Glider 1st Generation- in Figure 4.6) are no longer commercially available, although the manufacturer still refurbishes and updates broken components, therefore, no intention of purchase is valid for these models. Figure 4.7 presents the ratio between owned 1st and 2nd Generation. In terms of preferences on the different models available for purchase, it seems evident that groups will not take risks in buying a new unit. That is, Slocum is at the head of the purchase list (Figure 4.6) mostly because users are apparently satisfied and want to continue with well known models (Figure 4.4). Numbers in Table 4.3 indicate the European fleet could grow up to a 28% in the following years.

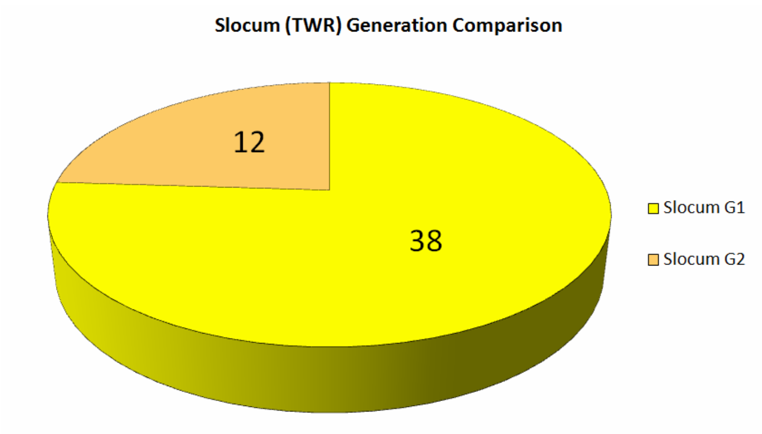


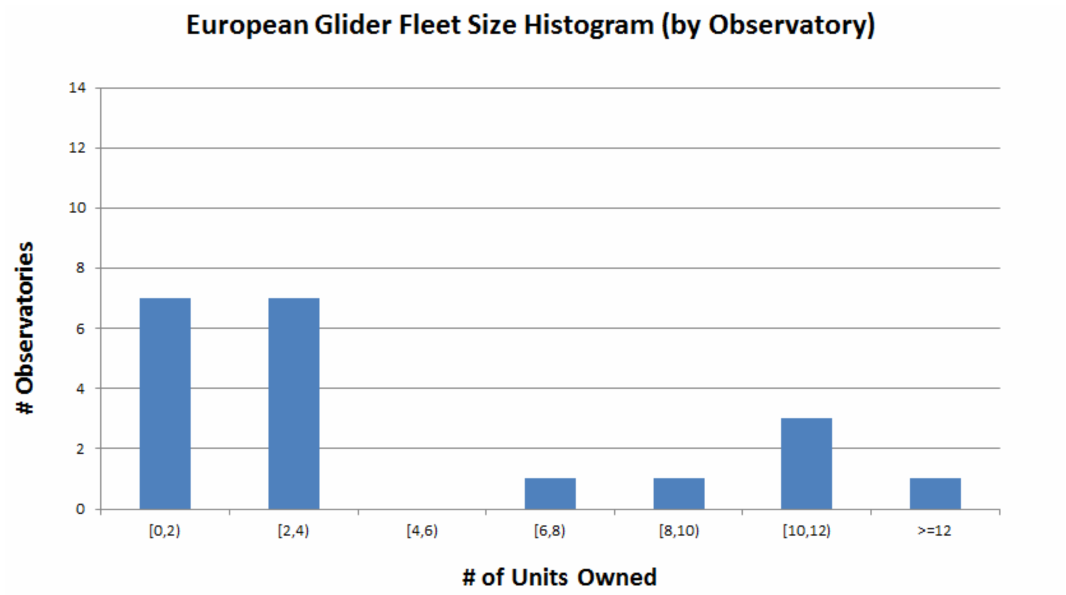
Figure 4.7 *- Comparison of the 1st (G1) generation Slocum fleet in Europe versus the 2nd (G2) -*

A more detailed analysis reveals that SeaGlider(SG)-only users would continue exclusively with SG while multi-model groups are willing to acquire the same amount of both (SG and Slocum). This could be an indicator of the perception, of scientists and technicians, that these two models are a mature technology that can fulfill their requirements (or at least be the best available approach).

	Owned	Planned Purchases
Total	82	23
Avg	4.10	1.15
Max	14	6
Min	1	1
STD	4.34	1.59

Table 4.3 *- Statistical figures related to the size of the European glider fleets -*

The existing European glider fleet has reached an overall size of 82 units, but individual fleets exhibit a very dissimilar size amongst them. Leaving aside the decision-making processes which yielded each group to configure their own, three main factors appear to affect the number of vehicles of a specific fleet: (1) economical, (2) strategic and (3) productive.



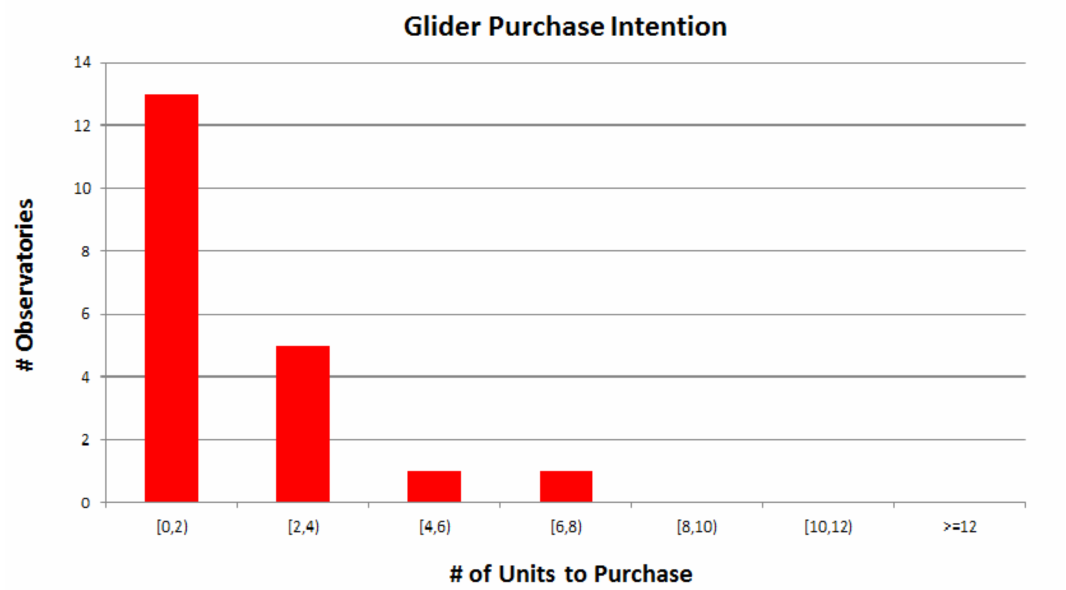


Figure 4.8 *- Histograms representing the distribution of the fleet sizes amongst the European glider groups (Up) and the distribution of the number of units to be purchased (Down) –*

According to that, most of the fleets stay below 6 units while only some, probably the most experienced and productive in terms of mission performance, have formed a larger package of vehicles. However, most likely related to the second of the factors listed in the previous paragraph (2), there is another type of groups, very experienced, that have configured a relatively small fleet. This last approach is interesting considering the relatively low investment in glider purchasing, compared to larger fleets, although it might imply a higher risk of ending with an inoperative fleet in the case of serious mechanical failures. It is probably the chosen strategy for those groups performing occasional rather than sustained observational tracks.

Figure 4.8 presents more information about fleet sizes (current and forthcoming). In the first place, and for obvious reasons related to the mentioned constraints, smaller fleets are predominant. Nevertheless, since some countries have centralized the management and operation of all the units purchased, while others have not, representing Figure 4.8 in terms of nationalities (instead of fleet sizes) could show a more even distribution (see Figure 4.9).

Finally, the reader will note that the majority of the groups are not planning to acquire new units with the exception of two observatories that are considering the purchase of four and six units respectively.

We see therefore a tendency for small fleet enlargements. Specifically, Figure 4.8 indicates that most groups are not planning to purchase more units and only very few indicated intentions to increase their fleet with one or two units. The most ambitious plans correspond to groups under construction and/or to others with very optimistic/ambitious prospective relying on forthcoming incomes and projects. This tendency can be due to (1) the relatively high costs of glider acquisition and operation and (2) the fact that the construction of these gliders fleets was made on past research projects. In fact, most of these gliders are re-used without the proper financing to allow the renewal of the fleets. It is clearly an illustration of the difficulty of the bigger groups to consolidate, while willing to be cost-effective with a large pool of instruments, and a lack of proper financing in general.

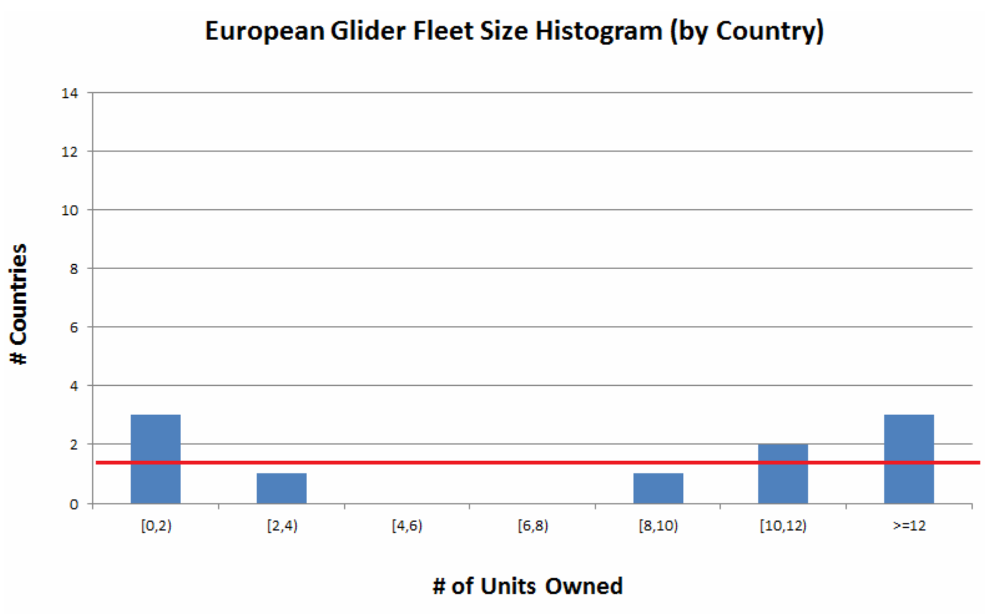


Figure 4.9 *- Histograms representing the distribution of the fleet sizes amongst the European glider groups (Up) and the distribution of the number of units to be purchased (Down) –*

b) Scientific sensors on-board gliders

Gliders can be defined, in a very general approach, as the combination of two main blocks: (1) the platform itself which assures navigation and (2) the scientific payload carrying the scientific sensors to actually execute the sampling activity. Once the review of the current state of the glider fleet in terms of platform has been presented, in this section we present and discuss the sensors available.

The separation of both inventories responds to the fact that, for the majority of the glider models, it is technically possible to exchange sensors between units of the same manufacturer. Therefore, establishing a detailed list of the available sensors would be extremely beneficial in terms of both stock control and also contributing to construct a trans-national sensor cooperation and exchange.

Considering the set of sensors available for each model, as well as the insertion degree of them in the oceanographic community (which reflects these are very well known amongst researchers and technicians), a review of sensors to carry onboard a glider will not be included here (since it can be easily accessed from the web of manufacturers).

Nevertheless, it is worth to mention that there is a very common payload configuration amongst the different models available consisting of: (1) Pumped/Unpumped CTD, (2) Dissolved Oxygen Sensor and (3) Fluorometry/Turbidity/CDOM. More information on this type of sensors can be found at the manufacturer's (SeaBird®, Aanderaa®, Wet Labs®,...) websites. The European survey has shown that most of the gliders being operated nowadays use the mentioned set as payload sensors. Figure 4.10 shows the fraction that each one of these well-accepted sensors represents inside the overall fleet.

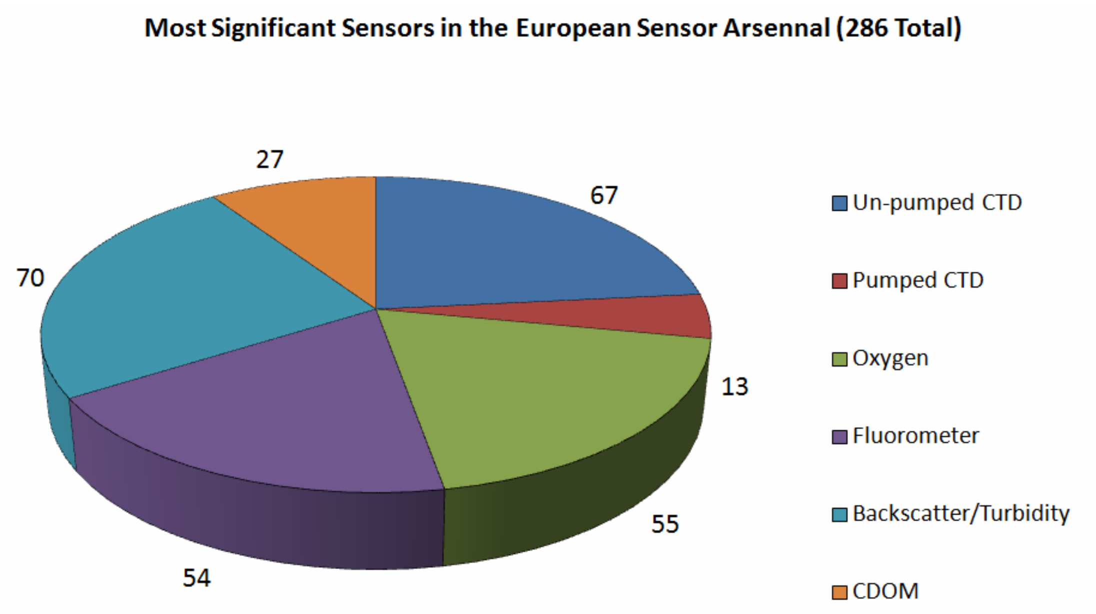


Figure 4.10 *- Configuration of the European sensor arsenal by type of the most common sensors. These sensors are the ones typically included in the default science bay configurations of new gliders-*

Observing that graph the following evidences emerge:

- Un-pumped CTD is the dominant against the pumped glider version by SeaBird. In fact, all the CTDs of the European fleet were done by this leading manufacturer. Since SeaGliders and G1 Slocums (both Coastal and Deep) carry that un-pumped version, the presence of the pumped one is only testimonial at present, although it is expected to grow along with the increase in the number of G2 Slocums (since they typically carry that model on-board) and Sea Gliders with extended payload. The predominant model is cp41p.
- Dissolved Oxygen Sensors (Optodes) are also very popular and, at an 85%, provided by Nordic manufacturer AADI. SeaBird also provided a few Optodes to SeaGlider users. WetLabs models vary between 3830,3835,5013 and 4330
- Fluorometers, Backscatters/Turbidity and CDOM are embedded in the same ECO PUCK series device done by Wet Labs. While the first two are generally used, only a half of the users decided to customize their Puck with a CDOM sensor.

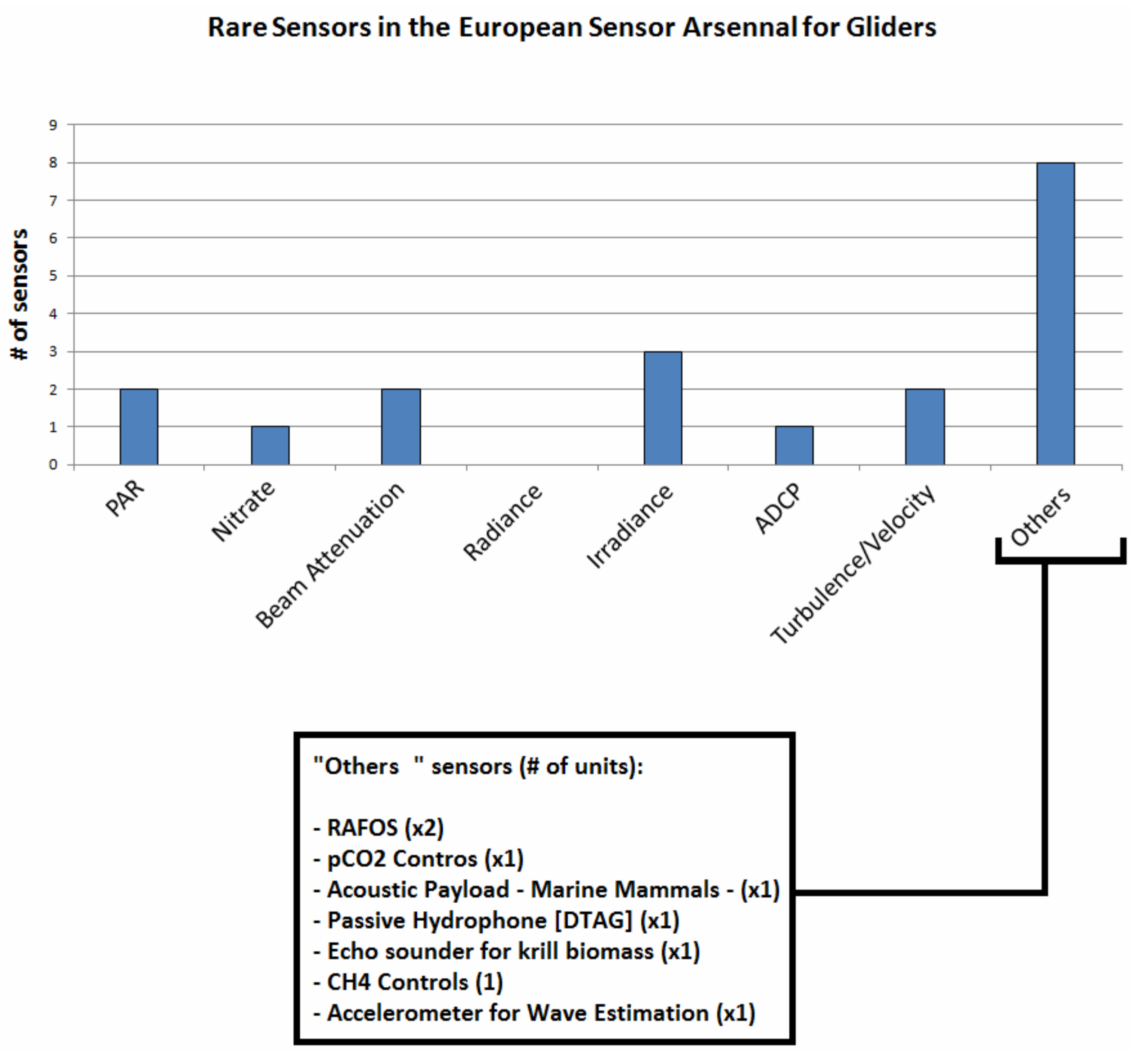


***Figure 4.11** - Quantification of the number of not common sensors within the European sensor arsenal -*

Alternatively, there are groups interested in very particular applications and accordingly they have acquired very specific sensors for such purposes. Of course, manufacturers usually offer the possibility to integrate a wide range of sensors, although the cost of these improvements can imply a difficult implementation and increased operational costs. Therefore, the amount of these uncommon sensors is very low in comparison to those listed in Figure 4.10. Additionally, there are pioneer groups implementing in-house sensors for custom payloads. Logically, this capability is reserved to very advanced groups relying on strong experience, critical mass and important funding.

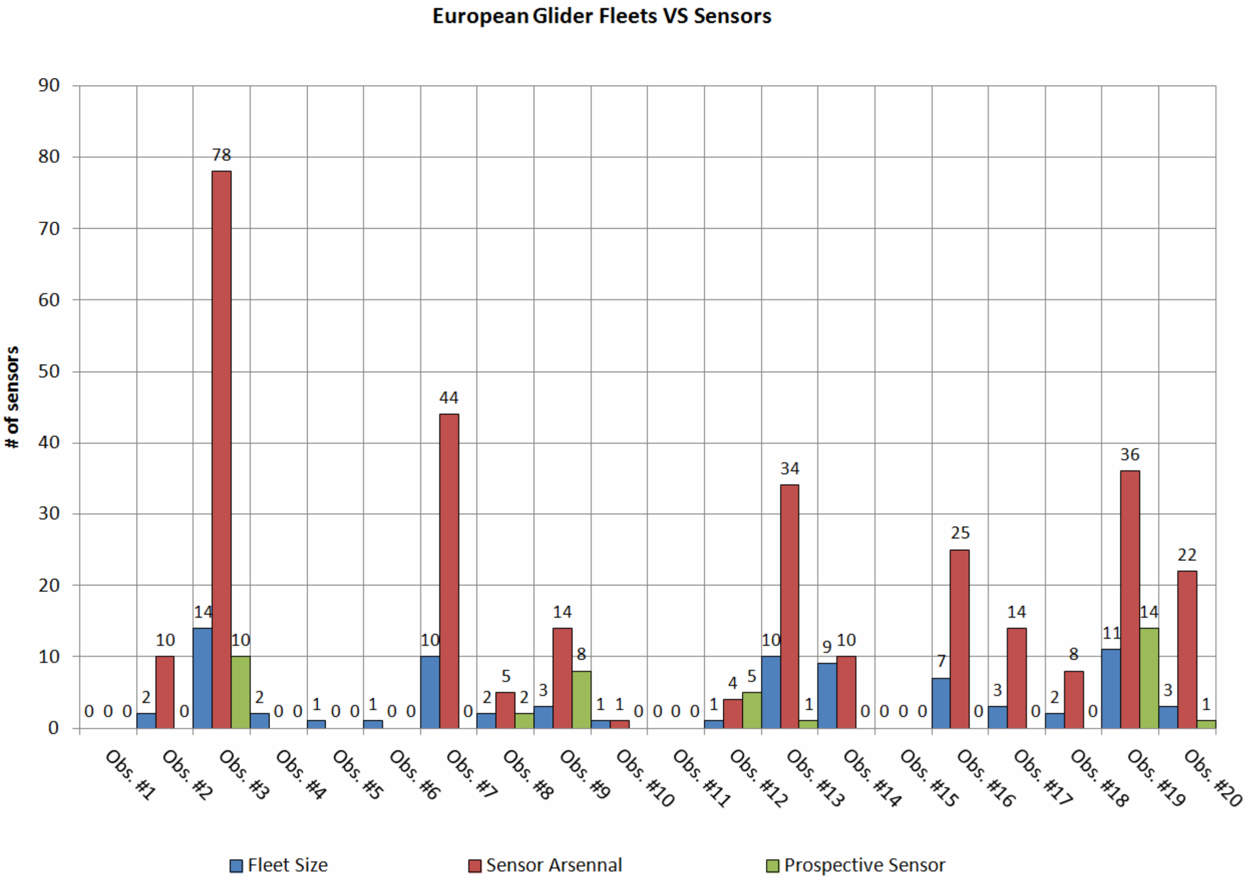


Figure 4.12 *- Individual sensor arsenal per each surveyed glider group (Red) and intention of purchase/development (Green). Fleet size is also included (Blue) -*

Gliders are relatively closed systems which make quite difficult to develop, implement and integrate custom sensors in them. Sometimes the most efficient way is to ask the manufacturer to do the integration. Figure 4.11 provides more information on that minority. Additionally, it has to be kept in mind that payloads are exchangeable within Slocum units. Therefore, since the fact that some groups have purchased spare science bays, the overall number of sensors does not correspond to the number of full vehicles. As shown in Figure 4.12, there are groups with a sensor-to-vehicle ratio much higher than others. It all depends on the number of Slocum units and, for those, the number of spare science bays since Sea Glider-only users do not have the possibility to exchange sensors themselves. The most important aspects related to the scientific instrumentation on-board a glider are related to (1) finding the better cost-effective sampling configuration, (2) controlling/determining their error of measurement (i.e. heading in the electronic compass) and, in parallel, (3) performing a strict and rigorous maintenance and calibration.

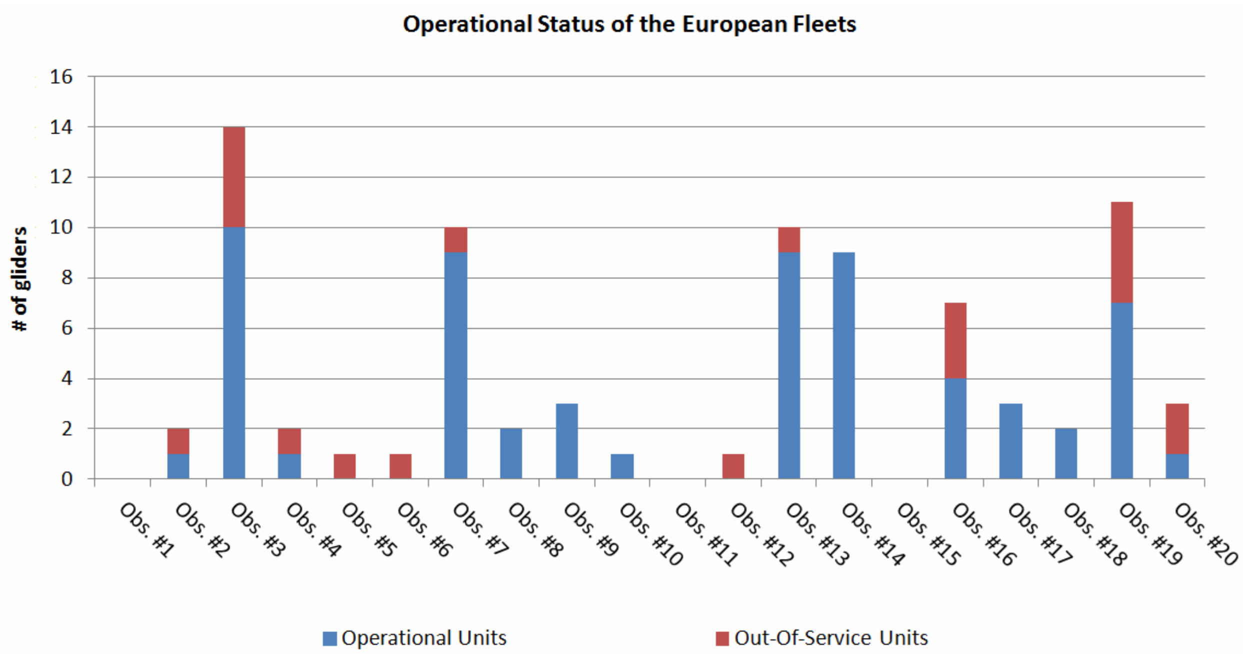


Figure 4.13 *- Punctual operational status review (Blue stands for the operational and Red for the out-of-service of the European fleets during the period of the survey fulfilment -*

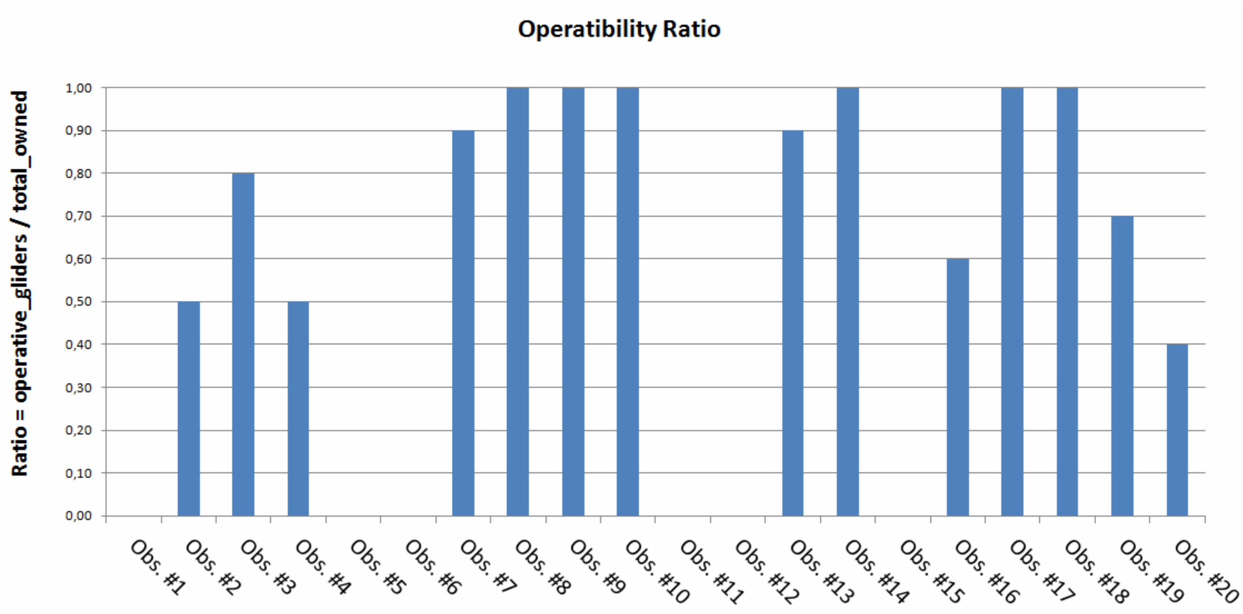


Figure 4.14 *- Plotting of the ratio between the operative gliders and the total owned (82 units) -*

To conclude the present review of the glider fleets and the sensors on-board them, a snapshot of the operational status of each fleet (in 2012, at the moment each groups filled the survey) is provided and can be seen in Figure 4.13. From a general point of view, there is no tendency or pattern of operational ratio. It seems to be related to the general heterogeneity between European observatories already presented and discussed above. In average a 60% of the fleet is ready, however, the standard deviation warns that this figure is uncommon.

It is very important to remark that these results should only be considered as an example of the glider fleet status at a specific time. The influence of the ambiguity in the definition of 'Operational' prevents us from extracting further conclusions. Moreover, it is very common in the glider management to experience a false estimation of the fleet's operability; especially involving units stored on the shelf for medium/long periods of time. Some users would even mark a glider as operative only if it is successfully deployed and obtaining scientific samples.

Analysing (Figures 4.13 and 4.14) by groups, three key points rise amongst the others: (1st) large fleets (more than seven units) exhibit an average of 2.17 out-of-service gliders. In concordance to the ambiguity mentioned earlier in this paragraph, these are the most active in terms of deployments per year. Additionally, (2nd) SeaGlider-only users exhibit very high ratios of operability and, finally, (3rd) fleets of active glider groups having a 100% of operability are not bigger than 3 units in size. As the fleet size surpasses that number, problems begin to show up. Table 4.4 summarizes basic statistical figures on this aspect.

	Operative	Out-of-Service	Owned	Operatibility Ratio
Total	62	20	82	-
Avg	3.10	1.00	4.10	0.57
Max	10	4	14	1
Min	0	0	1	0.4
STD	3.60	1.05	4.34	0.59

Table 4.4 *- Statistical figures related to the operatibility of the European glider fleets –*

4.1.3. Physical Infrastructure

Different facilities are used to support the overall activity of a glider group although some are more needed than others. Specifically, those providing the means and equipment related to (a) the preparation/maintenance of the vehicles, (b) their storage, (c) nearby on-field operations and (d) piloting/control at shore are more likely to be deployed in-house rather than outsourcing them.

Nevertheless, the choices of logistics provisioning is very wide and highly dependent on various factors ranging from the geographical dispersion (of personnel, gliders, buildings,...) to the available resources (mainly funding) or the expected usage demand based on the programmed deployments/missions/days-in-water. Considering that, the glider teams were requested to answer on the following types of infrastructures (shown in Figure 4.15):

- Ballasting Facilities: used to modify the weight of the glider and its distribution. Hence, adjusting the glider density to the target waters where it will be deployed in a relatively short time period. This activity is less intense for some glider models (Sea Glider) than for others (Slocum).

- Repair/Preparation Laboratories: used to perform general maintenance and sporadic repairs (if this ability is available). The complexity of this infrastructure depends on the degree of mechanical and electronic skills of the glider staff. It may include workshops, electronics laboratories and clean rooms amongst others.
- Pressure Testing: used to test gliders under pressure in a controlled environment which allows observation and data logging. This is one of those facilities which are not very frequent since they represent quite an investment and since there are multiple procedures to gradually test at sea the robustness of the glider against external pressure. However, the capability of doing so in the lab increases the reliability of operations and significantly reduces at sea operations tests.
- Calibration Facilities: used to keep scientific sensors up and calibrated. Also not a restrictive exigency since glider and, more specifically, sensor manufacturers offer such services. (Additional information can be found in JERICO's Deliverable 4.1)
- Other(s): Meant to cover infrastructures within categories as Communications, IT, Data Management and Electronic Distribution, Public Relations, etc...

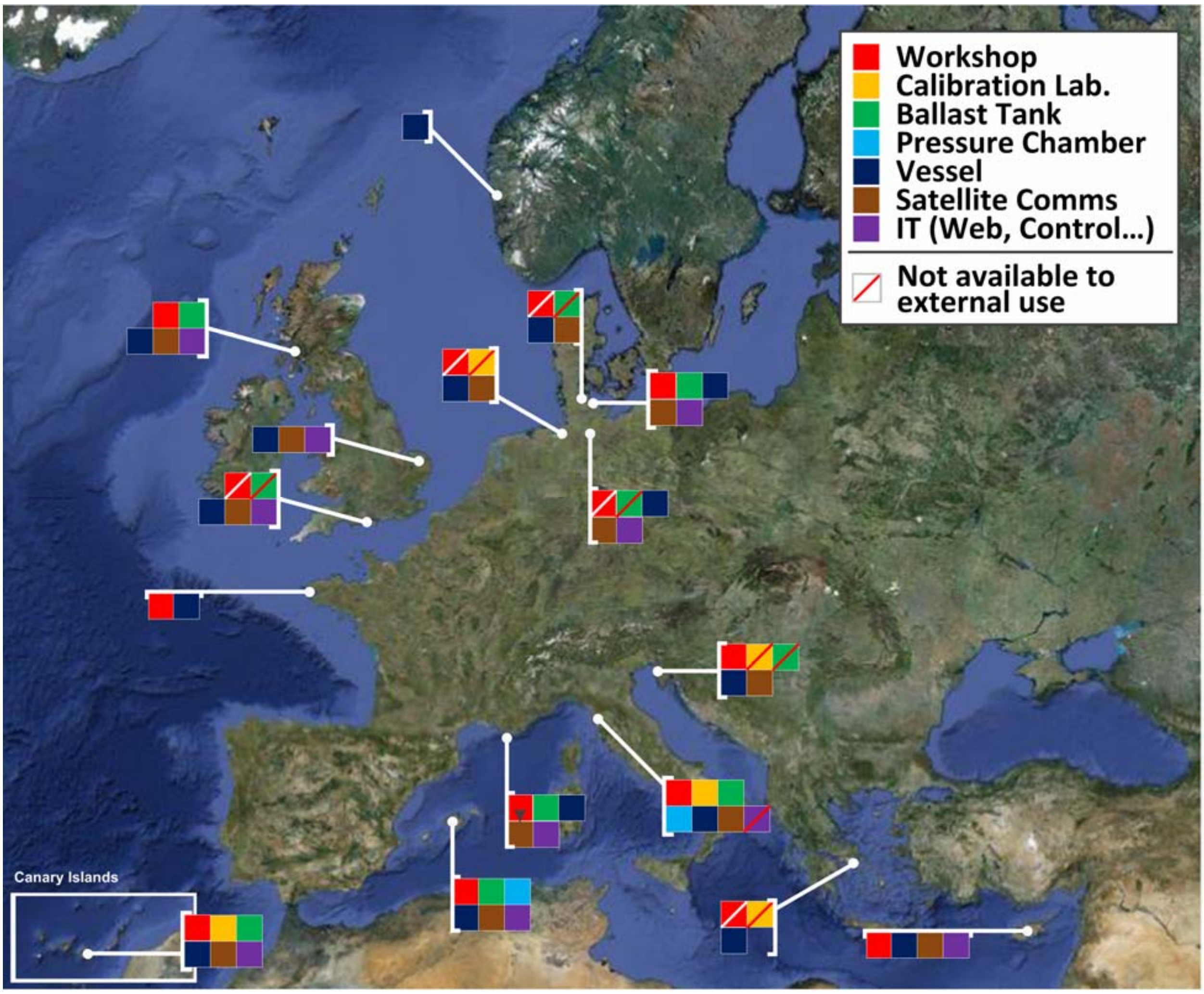


***Figure 4.15** - Territorial distribution of the European glider infrastructures. Each color stands for an existing facility and those marked with an overlapping side bar are not available to be used by an external glider groups -*

Note: items listed above have not been evaluated or characterized in terms of technical specifications or costs (for running, implementing and acquiring them) since the variation in sizes, qualities, performance levels and requirements is so high that such information is out of the scope of the present report.

The principal conclusion of the survey is that glider teams have in-house access to the basic functionalities regarding the stages of preparation, short-reach deployment/recovery and mission control. Additionally, there are some groups which have invested in less frequent infrastructures such as, for instance, calibration laboratories.

The distribution shown in Figure 4.15 could serve as a basis onto which to build a transnational network of glider ports where European partners could take advantage of other's services. For example, a group willing to test a unit in a pressure chamber could contact the group from the Balearic Islands and have them performing the test and sending back both the unit and the results. In particular, repair and preparation labs, as well as ballasting facilities, are the most implemented nowadays. The elevated number of Slocum units has probably contributed to this situation since that model explicitly requires both infrastructures.

Emerging and yet-to-be-created groups will need to implement those as well and, consequently; preparation and ballasting are also the facilities with a higher intention of future deployment.

On the contrary, pressure testing and calibration rooms are the least frequent due to their elevated implementation and running costs. Anyway, the four calibration labs stand as an already high number considering the overall number of groups. Those which currently own these infrastructures will very likely provide service to other platforms besides gliders as well. For those that don't, it is probably more economical, considering the number of gliders in their fleet, to send the sensors for calibration (every 1 or 2 years) instead of making the important investment in setting up their own calibration laboratory. However, the fact that most of the sensors require to be shipped back to the USA (often still mounted on the gliders or on the science bays) is certainly changing this. This implies the equipment is not available for long periods of time and this is definitely not optimal.

Finally, note that almost 50% of the facilities are available for external use; ratio which should be considered with caution due to the ambiguity of the concept as there are many degrees of availability and replies might not had been given following a consensus. (See Table 4.5 and Figure 4.16 for additional information and Figure 4.17 to read the most valuable comments to complete it).

	Ballasting			Repair/Prep.			Pressure			Calibration			Other(s)		
	Already Have	Plan to Have	Externally Available	Already Have	Plan to Have	Externally Available	Already Have	Plan to Have	Externally Available	Already Have	Plan to Have	Externally Available	Already Have	Plan to Have	Externally Available
YES	10	3	6	15	4	8	2	0	2	4	2	2	3	0	0
NO	7	10	10	2	5	7	15	16	11	13	11	11	2	2	3
No Answer	3	7	4	3	11	5	3	4	7	3	7	7	15	18	17

Table 4.5 *- Chart containing the resume of the answers to the survey related to the current and intended ownership of the main glider infrastructures as well as the predisposition for external usage -*

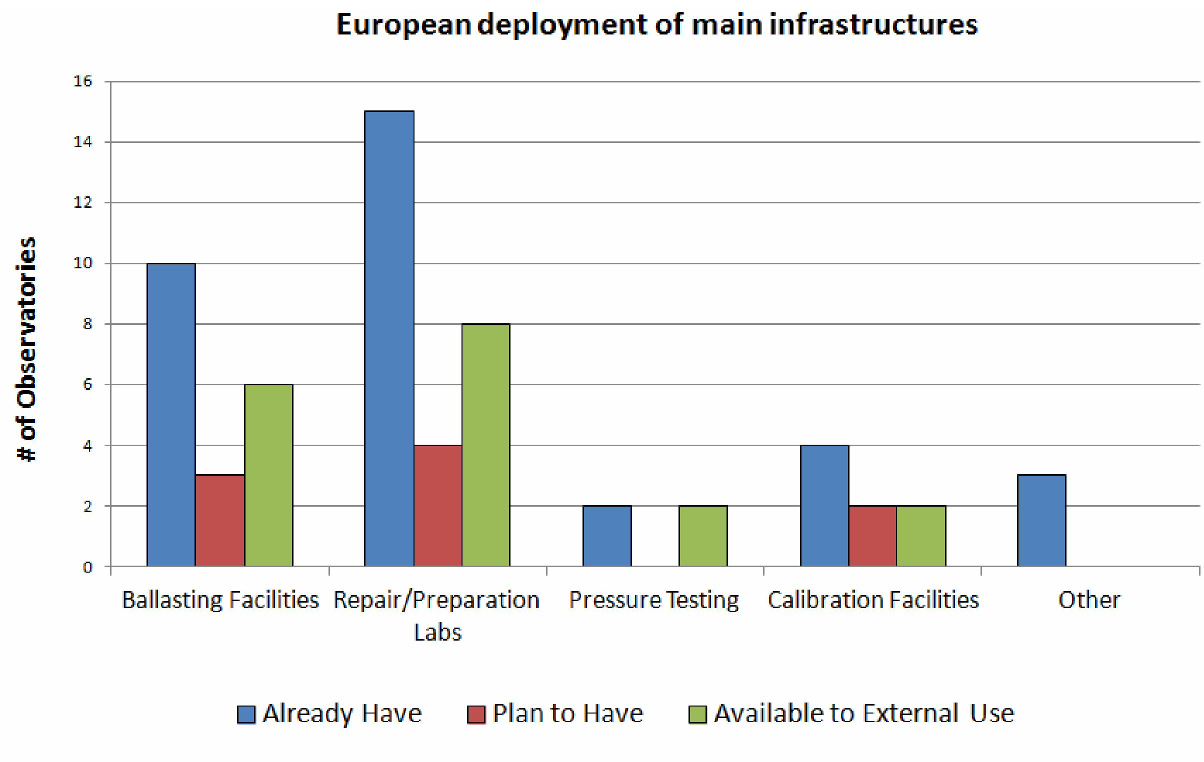


Figure 4.16 *- Plotting of the number of the main infrastructures deployed by the surveyed European glider groups -*

	Most significant comments
Ballasting	"30 m^{3}" (dedicated to ballasting procedures)
	"GRP tank of 5 m^{3}"
	"Freshwater tank/crane, sufficiently large/special cases only"
	"3x2" [meter supposedly]
	"2,65 m^{3}" (idem)
	"salt water tank 2.5x1.5m "
	"50 m^{2}" (idem)
	"4,2 m^{3}" (idem)
Repair/Prep.	"4mx6mx3m / basic workspace"
	"shared lab/workshop for oceanographic equipment "
	"general lab"
	"25x25m/ Glider, Electronic, and Mechanical labs"
	"200 m^{2}" (dedicated to preparation procedures)
Pressure Test	"Full glider"
	"400x2000mm / pressure vessel"
Calibration	"15 m^{3}" (not owned yet but planned)
	"Oceanographic and optics"
Other	"80 m^{2}, control room"

Figure 4.17 *- Most significant comments inserted, as free text, by surveyed European glider groups -*

Vehicles such as vessels and boats are a different type of infrastructure which is essential to deploy a glider. There is a wide range of possibilities (ownership, renting, collaboration agreement...). Groups owning and/or controlling some kind of vessel themselves represent a very reduced group (a total of four), while the preferred form of receiving such a service seem to be the usage of (1) ships owned by institutions of which the groups is dependent and/or part of (i.e. research vessel shared by all departments within a research institute) and (2) ships hired/leased/ceded by partners and/or collaborators with or without a monetary cost.

These two situations are represented in Green ("Have Available") and Purple ("Use Regularly") in Figure 4.18 respectively. Also, there is a high disparity in the intentions of usage of vessels to deploy gliders. Glider teams are interested by the use of a wide range of sea access, from big survey research vessels to manoeuvrable RIBS (Rubber Inflatable Boats). To conclude, note that very few groups consider launching the gliders from the coast which is not surprising since gliders do not perform well in very shallow waters (<30 meters of depth).

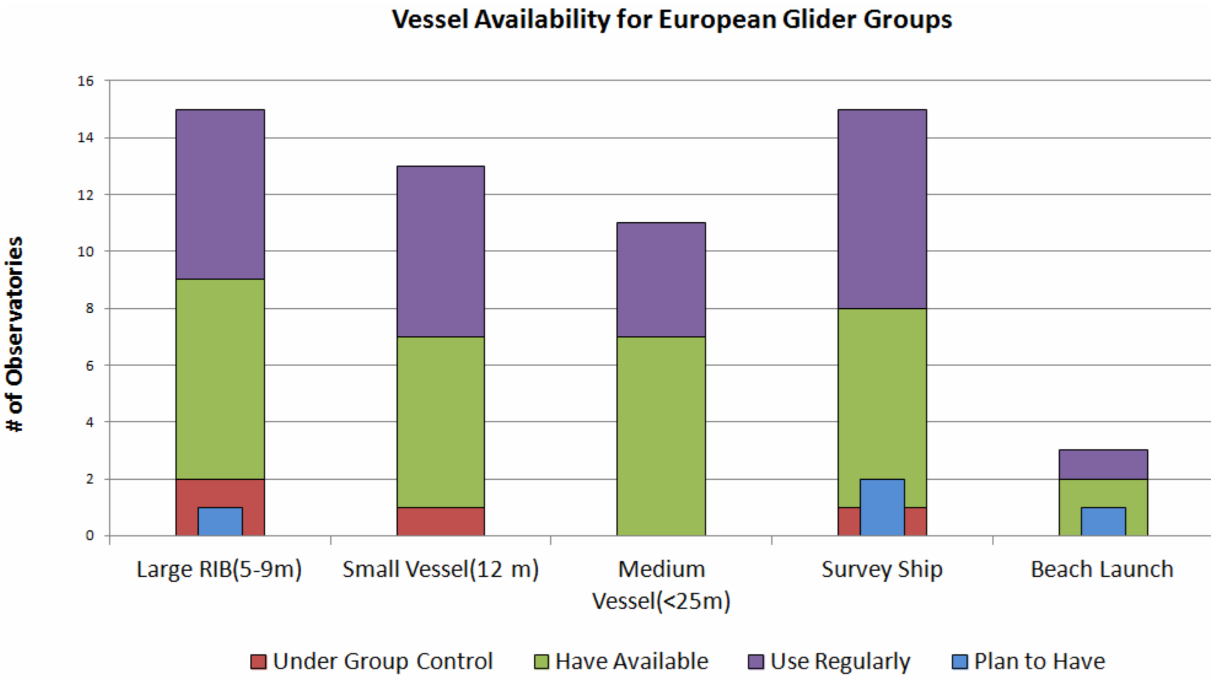


***Figure 4.18** - Fleet of vessels suitable for glider operations, discriminated by size, in disposition to be used by the Euro-groups -*

Additionally to the facilities providing sea access, the European groups had been inquired about the communications channel and technology used to interact with their units (for remote control and near-Real-Time data reception); elements which could be included in the IT/Mission-Control facility. This is another example of facility of which its usage is mandatory. The IT infrastructure is basically formed, from a very general point of view, by (a) the Iridium service contract, (b) with 56K modems (Dial-Up) or internet access (RUDICS or sbd messages), (c) a telecommunication network and (d) computers and servers running proprietary applications, acting as control stations, to interact with the glider firmware run onboard. Although a detailed description is out of the scope of this report, reader must take into account that:

- *Dial-Up connection*: uses the PSTN (Public Switched Telephone Network) from the Iridium Ground Station to the 56K Modem connected, via serial, port to the control station.

- *RUDICS connection*: uses the Internet network to deliver data, received at the Iridium Ground Station directly, through the Internet, to the control station computer in the form of TCP/IP packages.

Main conclusions from the survey indicate that a vast number of the European glider teams relies on RUDICS to keep their primary gateway online and connected to their fleet whereas the secondary, used as a backup, is mainly implemented using the Dial-Up connection (RUDICS SIM cards are exclusively allowed to call to the computerized control station associated to their fleet group whereas a DIAL-UP call can be established to stations owned by other groups). Figure 4.19 shows these percentages. An explanation to the first could be that RUDICS helps to reduce the communications costs and improves the stability of the Iridium connections if the access to the Internet is assured. To overcome that limitation, and also because of the first connection type available and implemented were Dial-Up, backup lines are based on Dial-Up which is less dependent on foreign network control such as a university Internet access, for instance. Finally, it is interesting to see (Figure 4.20) that 22% of the groups have already moved to RUDICS completely and none keep working with Dial-Up connections exclusively. An alternative, which is used in countries and locations where land-lines are not sufficiently trustable, consists in configuring an Iridium handheld device to receive the call directly from the glider so data is not lowered to the ground level and the control station can be deployed anywhere with a good enough sky sight.

Another important glider IT facility is shown in Section 4 of the present report: the Data Center. This facility processes, visualize, verify and export the engineering and scientific data generated by the glider.

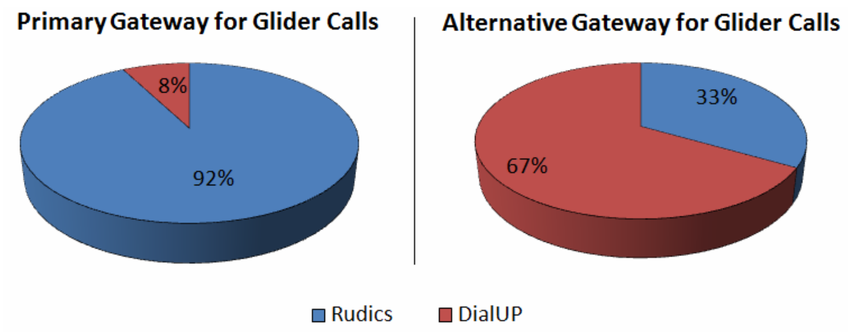


Figure 4.19 *- Percentages of Dial-Up and RUDICS connection usage amongst primary and secondary (backup) gateways for European glider calls -*

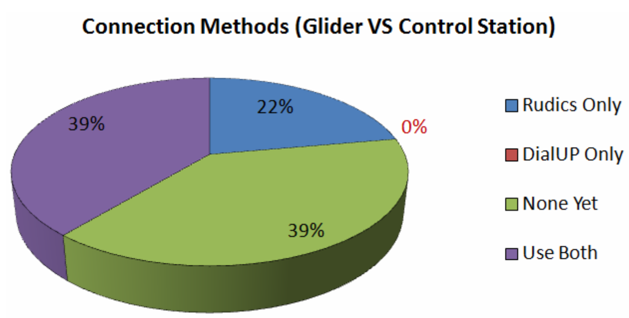


Figure 4.20 *- Percentages of exclusivity regarding the usage of Dial-Up and RUDICS connections amongst European glider mission-control facilities*

4.2. Review of glider operations in Europe

4.2.1. Missions in years 2010 and 2011

The data obtained from the survey show that gliders are used in multiple scenarios and in many different types of missions. Every observatory has different ways of using gliders in line with their scientific, technological or societal objectives. However, similar working patterns exist, even if differences in the number of missions, deployments and number of days at sea (amongst others) can be observed.

The following definitions should be kept in mind:

- *Mission*: refers to an on-field activity undertaken by a glider group, or by a collaborating force, driven by specific objectives under applying geographical and temporal constraints. (i.e. 30 day mission in Gulf of Lion to collect hydrographical data).
- *Deployment*: refers to the action of launching a particular glider in the water, piloting it during a variable amount of miles and days and finally retrieving it. Considering that, multiple deployments can occur (concurrently and/or sequentially) during the development of a mission.
- *Days-In-Water*: refers to the sum of the duration of all deployments within a certain period of time or a certain activity (mission, campaign,...).

The results from the survey indicate that the activity carried out by each one of the groups during 2010 and 2011 is quite stable. Some groups have a consolidated activity while others are under construction and did not deploy any glider. It is important to note that this period is not long enough to extract any inter-annual variation.

The European glider productivity is summarised in Table 4.6. It is important to note that this productivity is very similar between years although the heterogeneity of missions experienced a slightly increase in 2011. The Ratio between Deployments and Missions indicate a low number of missions with multiple glider deployments (more than one glider deployed simultaneously), and missions in which a glider was deployed more than once (due to failure or simple strategy). This rate can be also verified in Figure 4.31. Figures related to Days-in-water indicate an enlarged autonomy provided by the usage of lithium batteries and, additionally, reveal that groups make investments to have gliders in the water during almost a third of the year. It is important to remark that the number of Missions, Deployments and the achieved Days-in-water are significantly influenced by the number of gliders available to each group, its material and personal resources, its scientific and operational drivers and the geographical distribution of its working zones.

	Missions			
	total	*max*	*mean*	*STD*
2010	51	13	3	3.54
2011	64	19	3	5.01
	Deployments			
	total	*max*	*mean*	*STD*
2010	83	24	4	6.34

2011	88	20	4	6.25
	Days-In-Water			
	total	*max*	*median*	*STD*
2010	2068	531	103	146.68
2011	1904	619	95	147.01

Table 4.6 *- Productivity, in terms of missions, deployments and days in water, of the surveyed European glider groups -*

Figure 4.21 shows the missions heterogeneity amongst the European groups. While only 5 groups maintained the same number of missions during 2010 and 2011 (discarding inactive groups), 6 groups increased their missions and 8 groups reduced their activity. Observatory #16 shows the biggest increase. Furthermore, comparing missions and deployments, we can see that both variables are similar in absolute terms and in inter-annual variation (with the exception of 2 groups which performed much more deployments than missions). This indicates that most of the groups deploy a single glider during each mission. Additionally, Observatory #7 represents an exception since it exhibits a strong inter-annual reduction of missions while increases the number of deployments. Unfortunately, there is not enough data to glimpse an explanation.

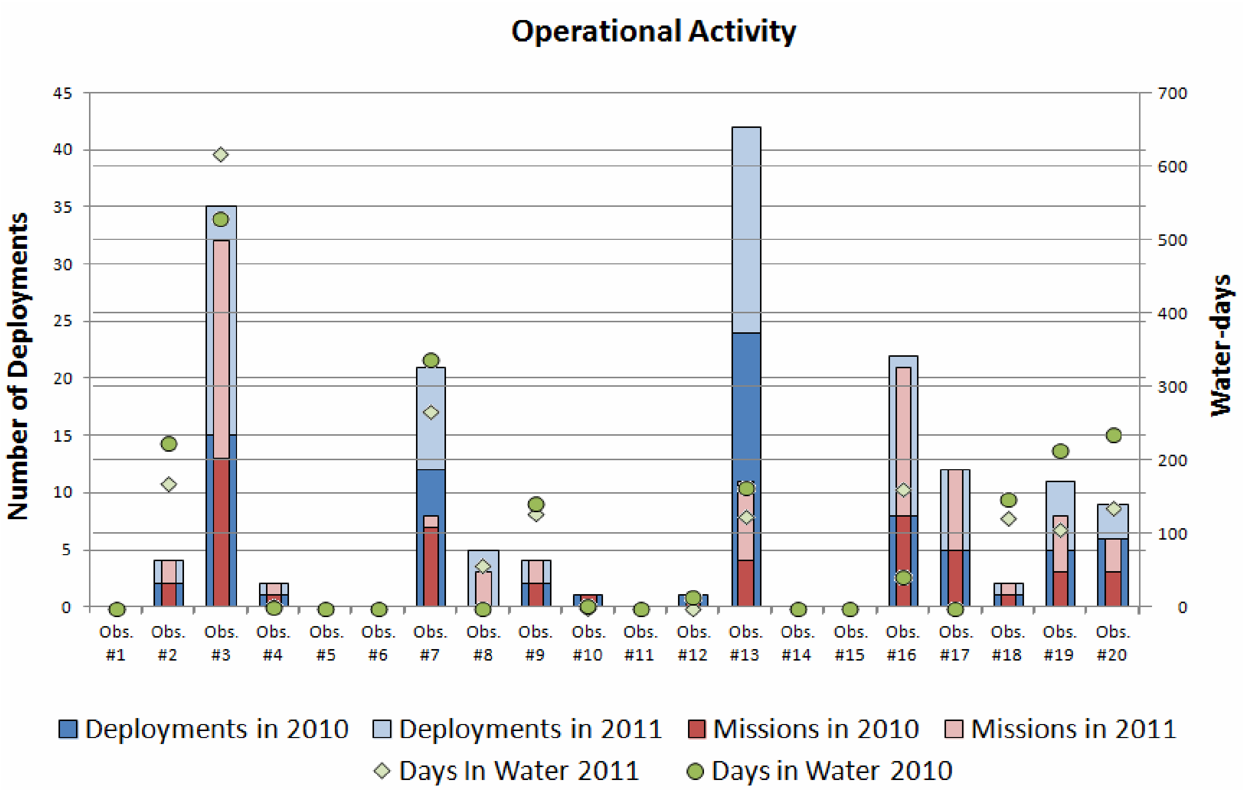


Figure 4.21 *- Plotting of the absolute number of deployments (Blue) and missions (Red) for each surveyed glider group, of years 2010 (Dark tone) and 2011 (Light tone) -*

Comparing the different fleet sizes of each observatory (Green bar in Figure 4.22) with the number of missions shown in Figure 4.21 we can note:

- 2 groups (#10 and #12) ceased operations in 2011
- One group (#8) operated only in 2011
- Observatory #7 performed a relative low number of missions when compared with the Top-6 groups in fleet size. Observatory #13 performed a lot of deployments but not many days at sea.
- The most active group is also the one managing the biggest fleet
- There is a case (Observatory #19) of a very significant fleet in size, with much more moderate figures
- The fifth fleet in size did not perform any mission during 2010 and 2011 (probably because that group purchased their gliders in 2011-2012 and/or were dedicated to the setup of supporting facilities for their glider activity)

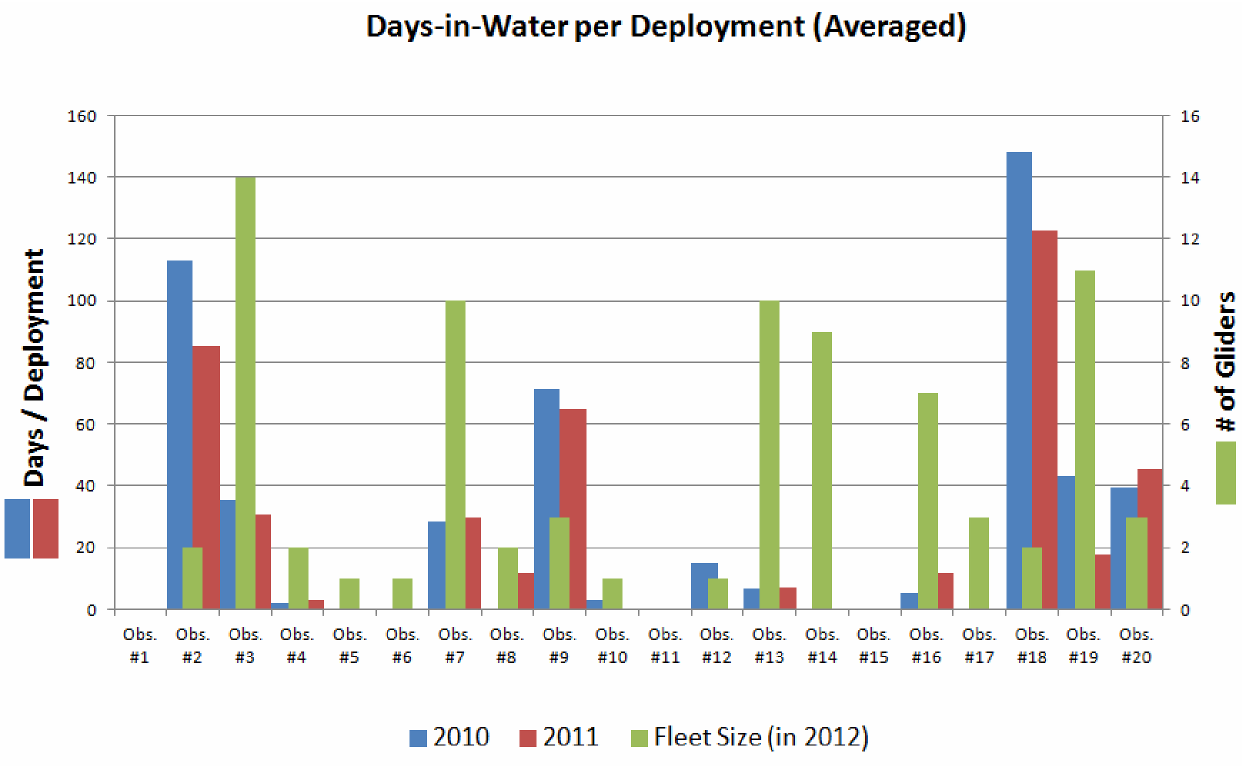


Figure 4.22 *- Plotting of the average Days-In-Water per Deployment, for each surveyed glider group, of years 2010 (blue) and 2011 (red). Green bar quantifies the number of gliders each groups owned during 2012 -*

Figure 4.22 shows the average duration of the deployments carried out by the different glider groups (considering the previous definition of Days-in-Water). This figure shows that the three groups with the longest deployment duration manage reduced fleets and also perform a low number of single-glider missions per year. These groups probably work with models incorporating lithium batteries that provide autonomy higher than 60 days per deployment. For those cases, the inter-annual tendency was slightly negative. Also, the four biggest fleets show moderate Days-in-Water per Mission ratios while maintaining the number of missions performed. This is probably due to limiting factors or strategic plans such as (1) the avoidance of overloading the piloting team, (2) a navigation in shallow (200-400m) or very shallow (<200m) water mostly, (3) working in areas within a relatively easy reach and/or (4) have a majority of "low endurance" gliders (heavily equipped with sensors for instance); amongst others. The rest of the cases correspond to those groups that performed short deployments (<10 days). One of those cases (Obs.#16) corresponds to the most active groups in terms of deployments. This could indicate that this observatory was dedicated to short testing/training missions.

Figure 4.23 shows the average duration of the missions performed during years 2010 and 2011. The ratio Mission VS Deployment sets the difference between this figure (Days-in-water per Mission) and Figure 3.1b (Days-in-water per Deployment). Therefore, groups that performed the longest single-glider missions show the same results in both figures. The same characteristic also applies to inactive groups and to those which performed short missions and exhibited an unaltered inter-annual variation. In opposition, multi-glider users increase their value since the duration of each deployment is added to represent the duration of a few missions (this is the case of Observatory #7). Finally, some groups exhibit relevant differences between ratios Days/Deployments and Days/Missions, such as an inversion of the inter-annual variation, because significant differences of Days-in-Water and/or missions executed between years.

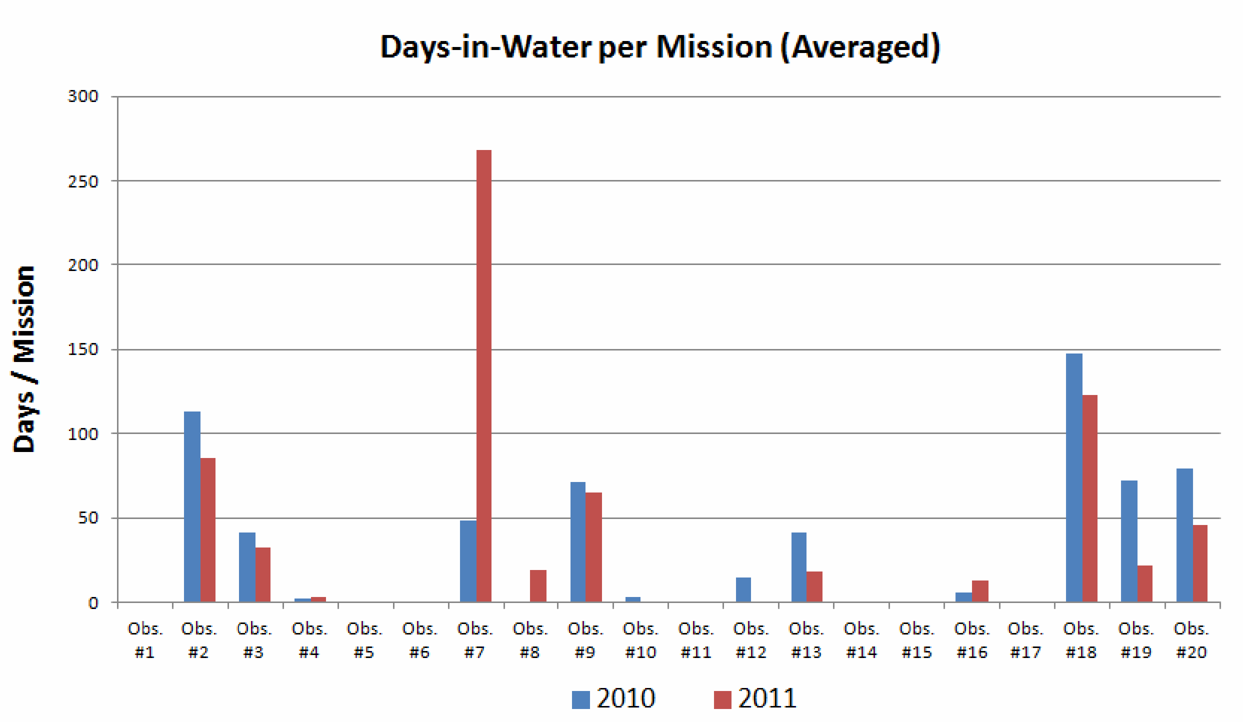


Figure 4.23 *- Plotting of the average Days-In-Water per Mission, for each surveyed glider group, of years 2010 (blue) and 2011 (red) -*

The relation between the number of days a glider is working in a mission and the probability of failures (mechanical failure, external collision/interference, bio-fouling accumulation, and others), and also the information regarding problematic events occurred during the development of that activity in 2010 and 2011 have been also studied in detail. Table 4.7 summarizes the events of failure and loss suffered by gliders deployed in this period. It is very important to note that the overall number of missions affected by glider failures remained constant at about 27-28% which is a relatively high number. The activity and size of the fleets also remained approximately constant, but the number of lost units doubled. This number is fortunately still less than 5% of the number of deployments in 2011 (or the size of the European fleet)

Year	Total of Deployements	European Fleet Size	Failed	Lost
2010	83	88	23	2
2011	88	86	24	4

Table 4.7 *- Totals of failures and losses of gliders during the missions carried out in 2010 and 2011 by the surveyed European glider groups. Contextual information is given: deployments and European fleet size*

The heterogeneity of the capabilities and interests of the surveyed European groups also results in a varied contribution to these absolute figures with respect to unsuccessful events of glider failure and loss. Figure 4.25 shows the specific numbers for each one of these groups. As it may occur with other information exposed in this report, the lack of success has different relevance depending on the context of each glider observatory, especially on its operational productivity. Consequently, the reader is encouraged to complement the visualization of Figure 4.25 with that of Figure 4.21 which leads to interesting conclusions such as:

- (1st) Failure rate is not only proportional to the fleet size (with exceptions - Obs.#17 -) but to the number of deployments (which is not always the same as the number of missions).
- (2nd) Groups which achieved more Days-in-Water per deployment (Obs #2, 9 & 18) were also the ones performing less missions and deployments. This is related to (a) facing fewer risks associated to deployment/recovery vessel operations and (b) having longer 'dry periods' to maintain and prepare vehicles.
- (3rd) Number of failures increased in line with the inter-annual variation of the glider activity. However, it is important to differentiate between those groups that suffered a high number of failures but also kept its productivity high and those which failures seemed to prevent them from continuing with the operations.

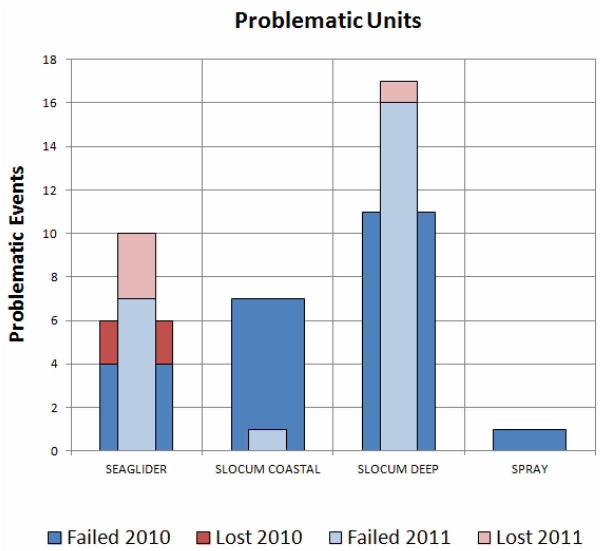


Figure 4.25 *- Plotting of the absolute number of problematic events (failures in Blue and losses in Red) for the most commonly used glider models. All this for years 2010 (Dark tone) and 2011 (Light tone)-*

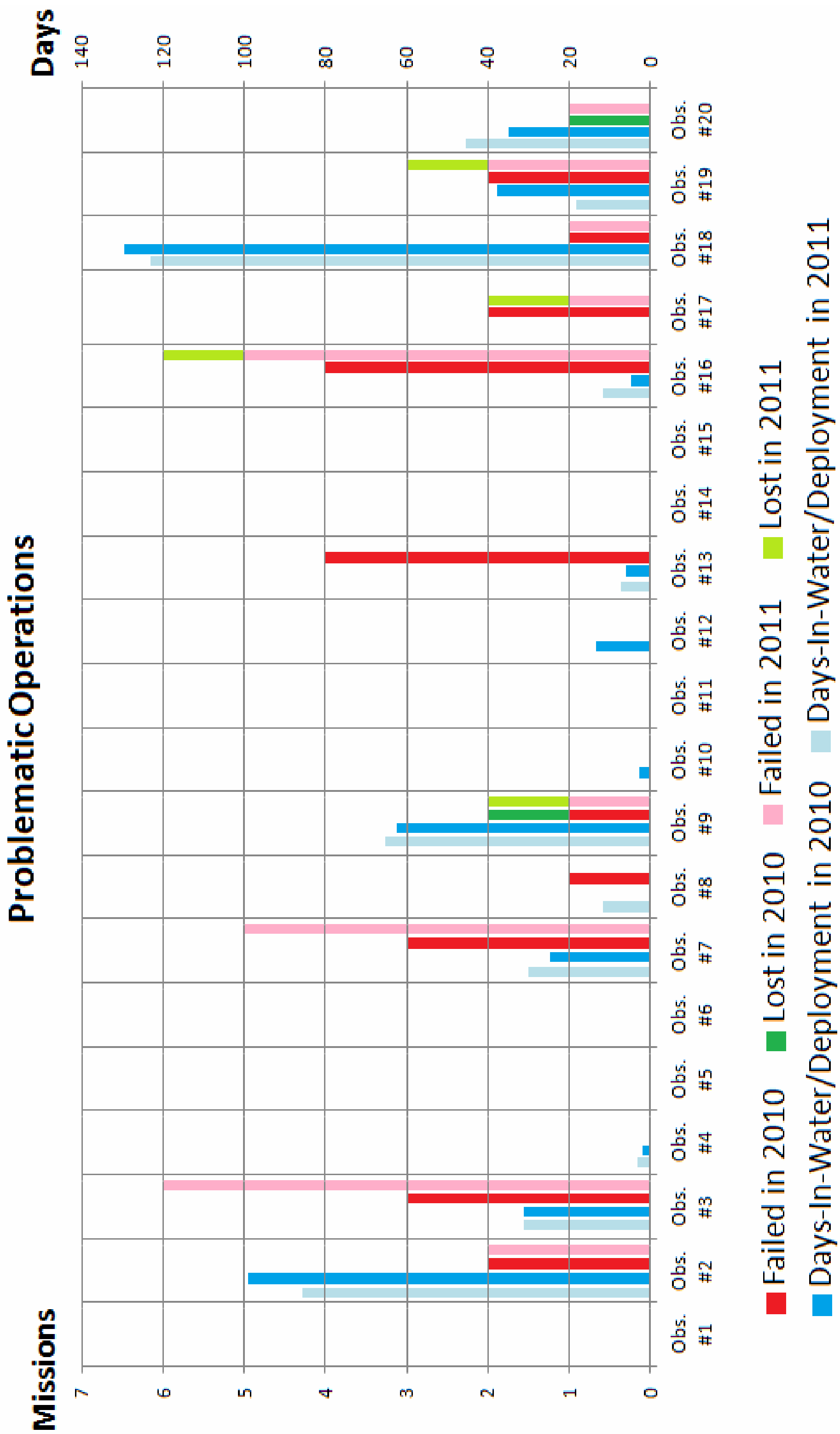


Figure 4.25 *- Plotting of missions ended in glider failure (Red) and loss (Green) for each surveyed glider observatory. Additionally, to contextualize this data, averaged duration (Blue), in days, per deployment and observatory is also given. All this for years 2010 (Dark tone) and 2011 (Light tone)-*

- (4th) there are some relevant cases to be discussed such as the following:
  - Only one group suffered losses in both years
  - Observatory #17 experienced problems while having not achieved any day-in-water
  - There are active groups that ended one year suffering neither failures nor losses. Amongst these, Observatory #13 is especially significant. This might be a sign that the procedures for preparations, deployments and recoveries got a significant improvement or that gliders could be repaired up to their nominal capabilities and stabilized (there are failures that are hard to diagnose, like recurrent leaks, and require to carry out several tests at sea – deployments – before they are solved)
  - Some groups had a moderate performance during both, or only one of the years of study but did not suffer problems at all. Any of these groups carried out more than 1 mission per year

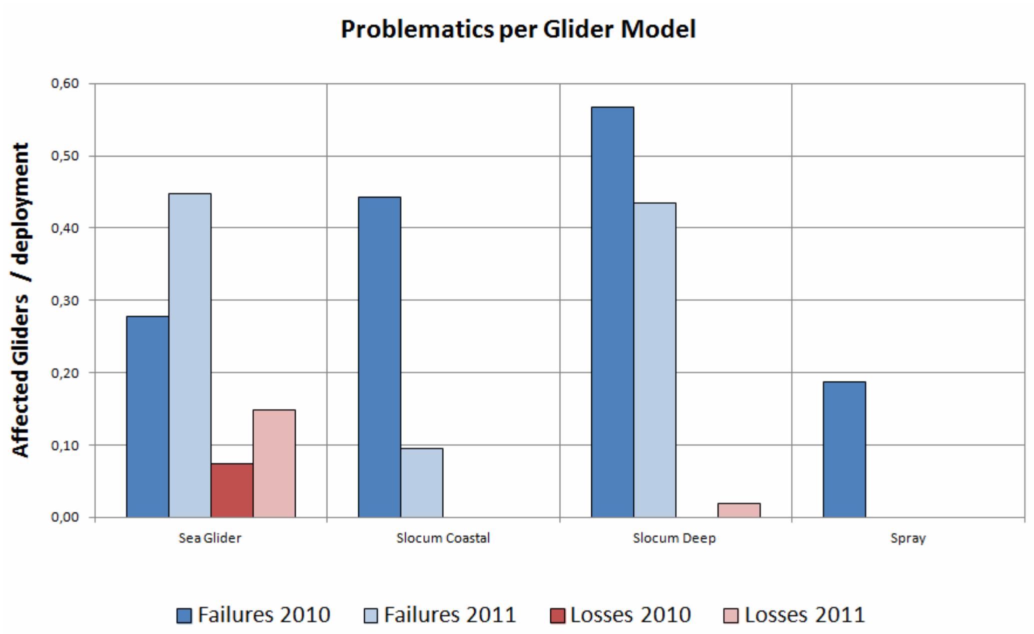


Figure 4.26 *- Plotting of the probabilistic number of gliders, for the most commonly used glider models, affected by failures (Blue) and losses (Red) for years 2010 (Dark tone) and 2011 (Red tones)-*

It is possible to present the previous data on the failure rate from the model of glider point of view. As it occurs with any piece of machinery, structural and mechanical differences, different designs or different manufacturing processes may confer more or less robustness and reliability between competing models. In fact, there is not really enough data to extract conclusions on the reliability of each glider model and version. Figure 4.24 shows the number of problematic events and loss of gliders that occurred during 2010 and 2011. It is important to note from the previous observations that, first, Slocum models registered the biggest number of failures although only one unit was lost in the two-year period under study in opposition to the three units of Sea Glider lost. Slocums gliders are maintained by the user (opening and closing, ballasting, battery replacement procedures are common) but they have implemented additional emergency systems. On the other hand, Sea Glider units are refurbished by the manufacturer following a certified procedure but operate with lithium batteries that appear to be more difficult to predict in terms of capacity and duration. The Sea Glider shows slightly better performances than the Deep Slocum but suffered more losses and failures in 2011 than in 2010 (maybe due to the ageing of the platforms or different procedures for the refurbishment were set up by the manufacturer) while the Slocum seem to improve. Finally, the coastal version of Slocum glider and Spray had a very low number of failures and no losses during 2011 but the number of deployment of these models is very low.

Results from the survey can be weighted with contextual information to provide a wider perception of the glider's performance. The contribution of each model to the European fleet is very important when presenting the results on glider failures (the previous section shows the different gliders models owned by each observatory). The most active groups in terms of deployments per year (Obs. #3, #7, #13 & #16) use Slocum gliders, while those with very long and not frequent single-glider missions (Obs. #2, #9 & #18) operate only Sea Glider. It can be seen in Figure 4.26 the weighting of glider problems (shown in Figure 4.24) versus the number of deployments. While the number of losses is not affected, the number of failures is redistributed and reveals that Slocum gliders hold the highest chance of failure during a deployment and the lowest number of losses. More precise data of the usage of each model should be considered to ensure a performance improvement.

To identify the causes for the most recurrent mission failure, the different glider groups responded to different questions in the survey. The results are shown in the following figures. (See Table 4.8 and Figure 4.27).

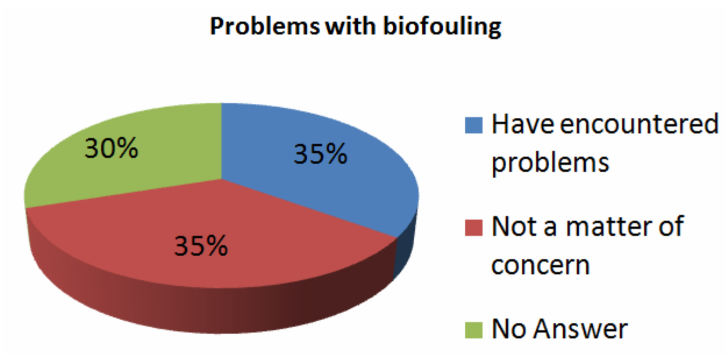
Having discriminated the results by model of glider, it is possible to conclude that there is one model which suffers of having a battery source and a communication system that do not appear to be robust enough, while another model is susceptible to water leaks through its hull junctions and wall-through connectors. These seem to be the major challenges that manufacturers will have to face rapidly to increase the reliability of gliders.

Observatory	SeaGlider	Slocum Coastal	Slocum Deep	Spray
#1				
#2	Communication failure ; Early battery failure			
#3	Early battery failure		Internal water leak	
#4				
#5				
#6				
#7		FLNTU Sensor water leak; Air bladder water leak	FLNTU sensor water leak; Air bladder water leak	
#8		In-Preparation Water Leak		
#9	Communication failure; Early battery failure			
#10		Ballast pump failure		
#11				

#12				
#13		Water leak; Communication failure; Other device failure (Digifin, Compass)	Early battery failure; Broken tail while deploying	Excessive air presence in hydraulic system
#14				
#15				
#16		Water leak; Defective O-rings Air bladder air leak; Other device failure (Digifin, Compass)	Water leak; Defective O-rings Air bladder air leak; Other device failure (Digifin, Compass)	
#17	Communication Failure		Internal water leak	
#18	Early battery failure			
#19	Communication failure	Connector failure	Internal water leak; Early battery failure	
#20	Software failure			

Table 4.8 *- Answers (discriminated by glider model) from surveyed glider groups in regard to the commonly faced mission failures –*

It is also important to note that one third of the surveyed users have experienced problems with biofouling growth (Figure 4.27). There are no clear and effective ways to counter act this issue which becomes very relevant in organically rich waters and when the use of lithium batteries enlarge the mission duration beyond the 40 days in water.



Biofouling Counter-Measures
"None tried yet. It just seems glider is slower and more difficult to maneuver near the 4-5th month"
"Gooseneck barnacles: tried chili power (not effective); tried non-metal antifouling paint (not effective); tried teflon tape on seams (not effective)"
" Recover the glider and clean asap - obvious- (if possible) and to cover the critical parts with an antifouling special tape"
"nothing tried yet"
"continued deep diving for deep slocums and seagliders"
" Cleaning (after the fact)"

Figure 4.27 *- (Left) Percentages associated to the answers given by surveyed groups in regard to biofouling growth on deployed gliders and (Right) some answers from the groups which have encountered problems with biofouling (blue in apple pie chart) -*

a) Areas of interest for European glider missions

It is possible to extract the following highlights from the location of the missions (see Figure 4.28) developed during 2010 and 2011:

- Gliders are used in local environments mostly: Groups perform deployments in zones that are reachable within 1 day of navigation (700 Km approx.). In terms of emergency handling and general logistics, operating a glider in a remote zone can seriously increase the risk of loss. Additionally, it is more likely that stakeholders are more interested in regional environments rather than transnational developments.
- Working zones are distributed around two latitudes: 30ºN and 60ºN.
- There are several groups that operate far away from the European coasts. These teams have either international-based glider ports and/or undertake long multiplatform missions with big research vessels

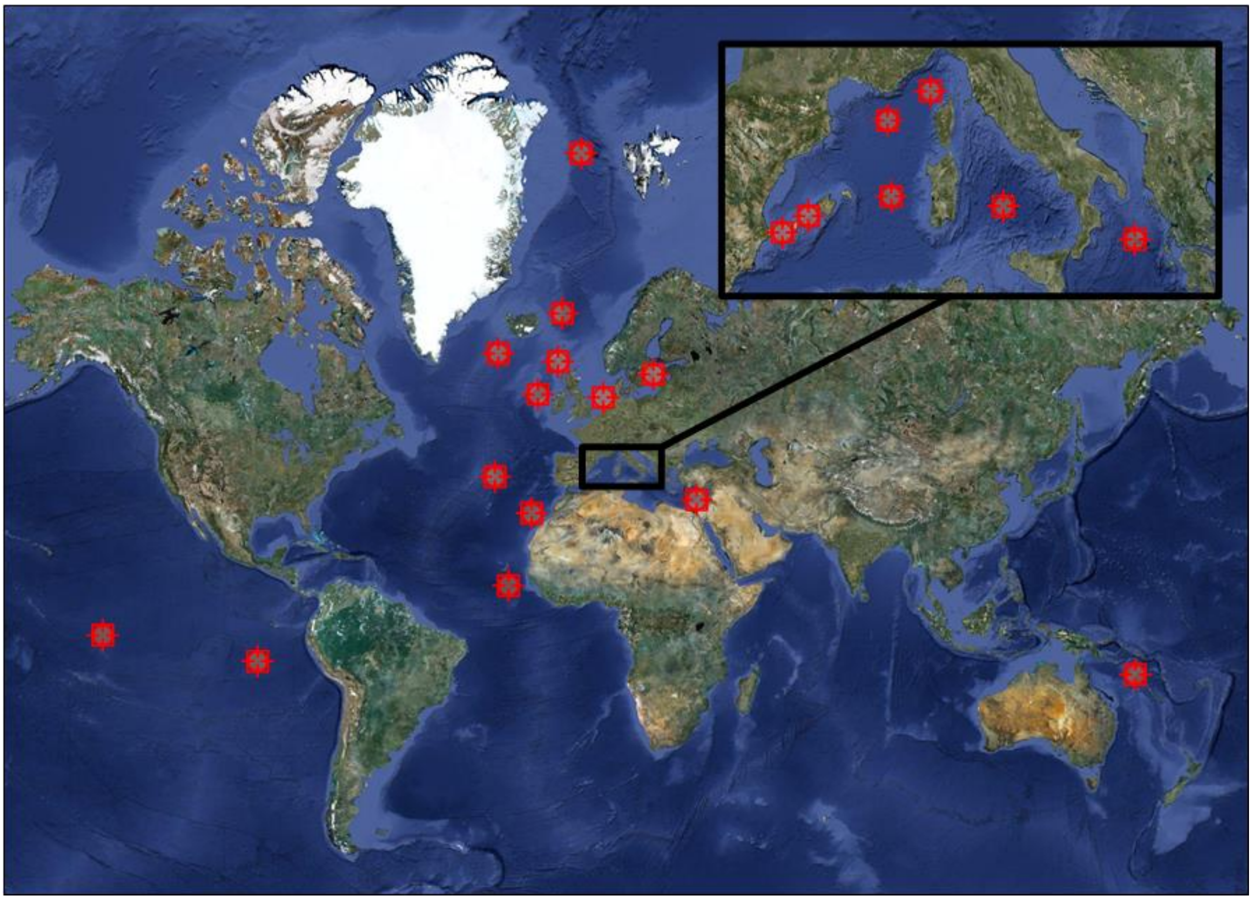


Figure 4.28 *- Zones of operation of European glider groups considered in this report. For a matter of simplicity, all those locations included within a 1000 Km wide region, with its epicentre on the most relevant of each group, have been considered part of the same positioning icon ( )*

b) European glider missions typology

The definition and execution of the missions are products directly derived from the available resources (number of gliders, R/V, personnel for 24h surveillance, capability of outsourcing,...) and how they are managed according to the different objectives. In the following paragraphs, an overviewed characterization of missions quantified in section 4.2.1 is provided.

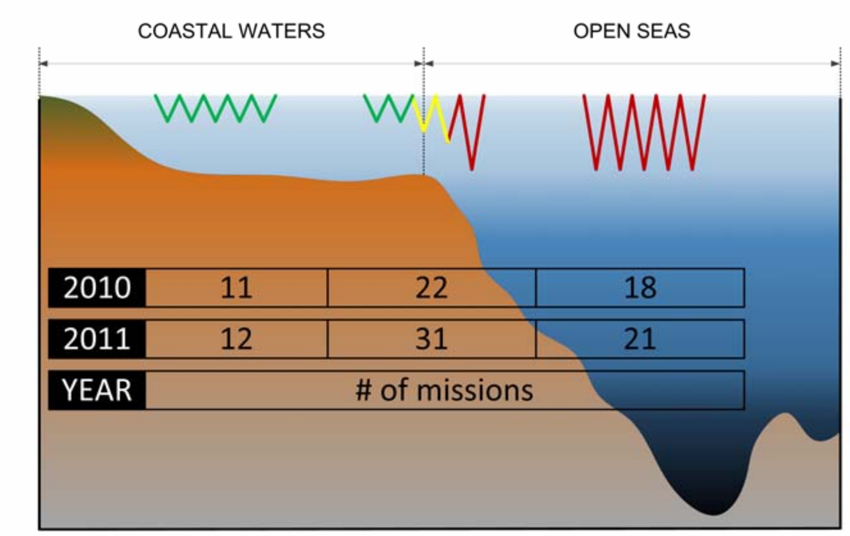


Figure 4.29 *- All-group mission productivity by category of navigated water. That is to say (a) coastal waters [0-200m], (b) open ocean [>200m] and (c) both if the glider surveyed, within the same deployment, the previous types*

The number of missions performed in coastal waters, open seas or in mixed waters shown in Figure 4.29 reveals that there are no high inter-annual changes in the environment. The most significant variation is found in mixed water (coastal and open seas) missions, rising a 40% between 2010 and 2011. Particular records indicate that this increase is related to missions performed by two observatories, performing five more mixed missions in 2011 each of them.

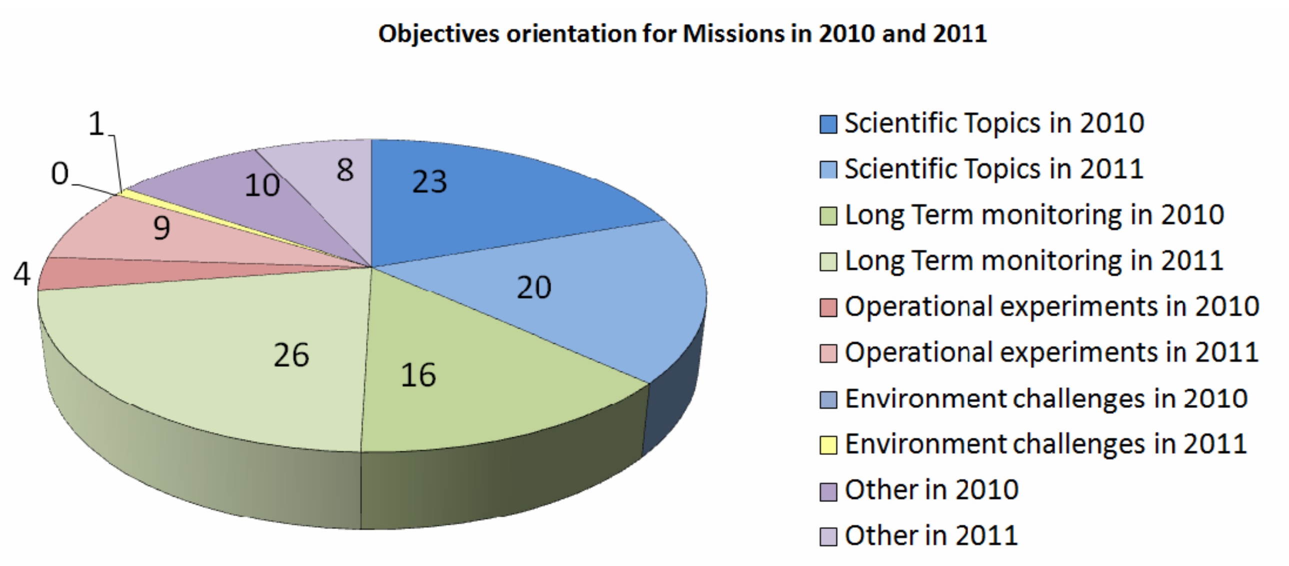


Figure 4.30 *- Missions characterization by the orientation of the sought main objectives –*

Missions carried out in 2010 and 2011 were predominantly oriented to fulfil scientific and operational objectives. That tendency could be a consequence of the nature of the surveyed institutions, which are mainly scientific research groups and marine observatories. However, three centres did perform test and training for engineering/development purposes, focusing their interest in the development of the glider platform (their activity is represented by purple colour in Figure 4.30). There might have been a misunderstanding on “environment challenge” and the conclusion is, either groups tend to avoid areas that are environmental challenges, because of the risks, or that most of the scientific groups are still focused on hydrographic and biogeochemical data, and do not use their gliders for “environmental” studies, or a mix of both.

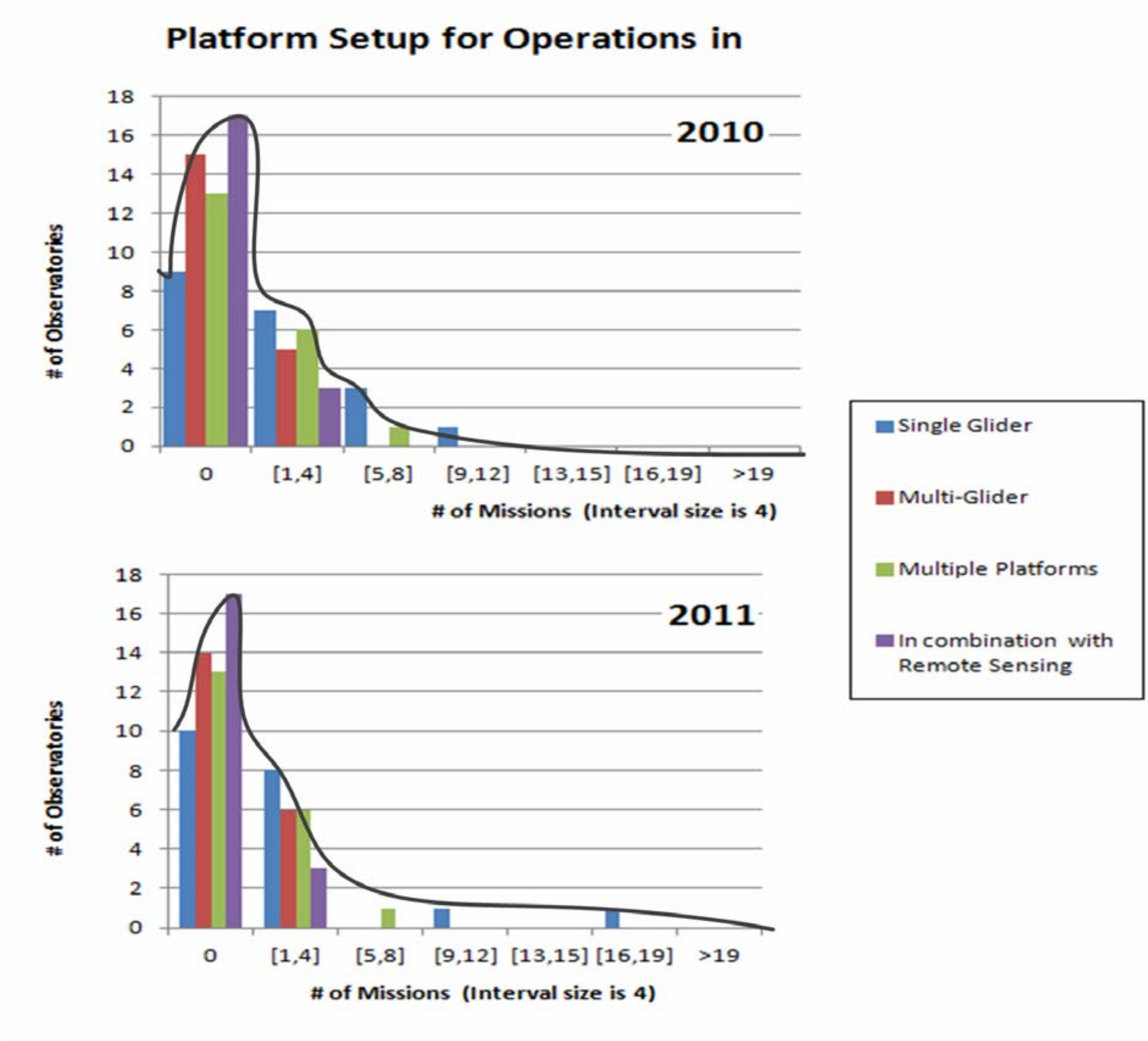


Figure 4.31 *- Histograms of years 2010 (up) and 2011 (down) plotting the number of observatories which are included in each number of missions interval (size of 4). A different colour has been used to discriminate between different platform setups and a contour black line to allow tendency comparison -*

It is relevant to note that very few groups had the interest and/or capability of doing glider missions in cooperation with other platforms (of their same kind and/or another such as CTD rosettes) as shown in Figure 4.31. From the data obtained it can be seen that, first, the majority of the groups surveyed didn't deploy gliders and, of those who did, only a few carried out more than four missions per year (Interval-0 with the highest density). It is remarkable that this tendency didn't change from 2010 to 2011. That could be due to many factors such as, for instance, those who undertake missions that can run through months.

Second, activities in combination with remote sensing are the least frequent, and those involving multiple platforms and more than one glider are distributed very similarly. Additionally, particular results indicate that the groups with the highest numbers of single glider missions correspond to those more focused in monitoring activities.

When analysing this information it is important to note that (1) multi-platform deployments are possible only on-board relatively big R/V; also that (2) running costs and robustness associated to gliders do not help with multi-glider experiments and, finally, that (3) limited resources force groups to go either for a few complex deployments (multi-platform / multi-glider) or for a major number of well established and repeated long term missions for which the use is typically of a single glider.

4.2.2. Logistics involved in European glider operations

The present subsection intends to provide the reader with a general idea of the processes and tasks needed to operate a glider fleet. The capabilities are obviously highly influenced by the background of the team members, the resources available as well as the strategic plan of each institution.

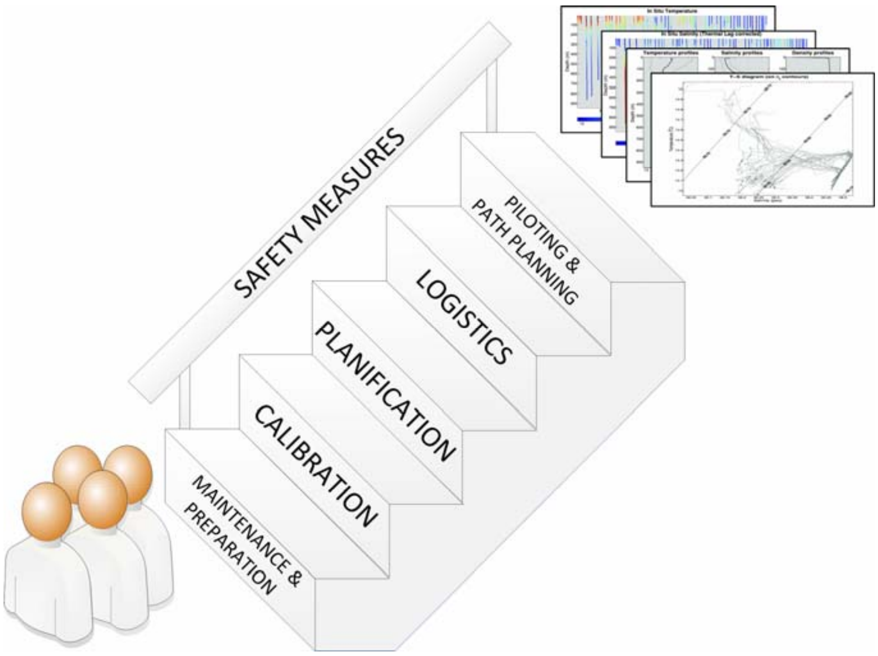
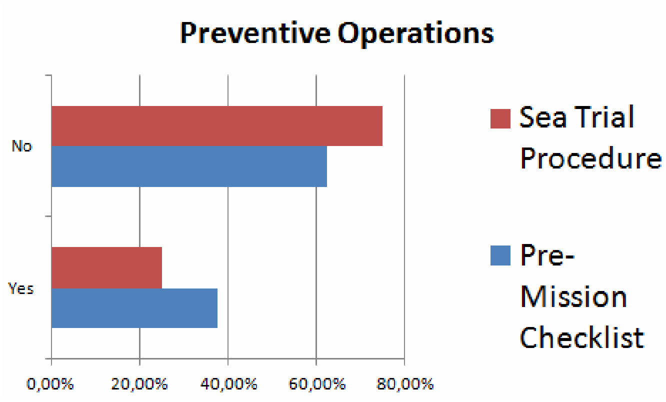


Figure 4.32 *- The productivity of a glider fleet is determined by many processes ranging from the hardware maintenance at workshops to the decision making at the coordination spots -*

Following the classification of operations shown in Figure 4.32, the first step to ensure success in the glider fleet operation is to perform a correct maintenance of the glider units (mechanically and logically). As any remotely operated tool, the best is to perform at the lab as much as possible tests and verifications to minimize the probability of suffering on-field problems. To accomplish that there are different approaches that can be implemented: (1) outsourcing the refurbishment of the vehicles completely and (2) setting up a glider laboratory to perform different levels of hardware and software maintenance. The implications of both options are out of the scope of this document (see subsection 4.1.3 for information about the European glider infrastructure).

Careful work needs to be done in the lab but also at the moment of the deployment and performing short testing missions. However, there are groups who either do not have enough resources or do not consider these tasks necessary (Figure 4.33). Additionally, these groups may be following instructions from the manufacturers promoting a non-intrusive user profile. Note: Observatory #3, that accumulated more than 200 days of sea trials, evenly distributed between the different glider models it manages, dedicated to the familiarization with new units and upgrades of operative gliders.



	Days in Lab	Days at Sea	People in Lab	People at Sea
Mean	7	18	3	4
Max	25	**210**	6	9
Min	1	1	1	1
STD	6,73	**57,6**	2,01	2,31

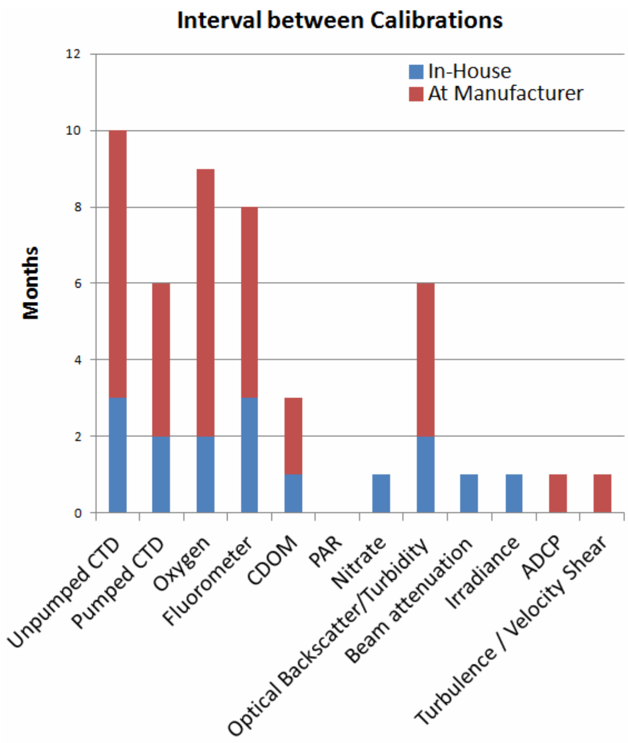
Figure 4.33 *- (left) Percentage of groups who have answered if they implement some kind of preparation protocol by following a preparatory checklist (blue) and perform sea trials to test their platforms on the field (red). (right) Quantification of Time and HHRR resources invested in the pre-mission preparation stage -*

As it occurs with any production system, a glider fleet requires a preparation period the duration of which will in time depend on multiple bottlenecks and constraints in the work flow. Understanding these choke points, and being able to reduce their effects, can be crucial, for instance, in multi-platform missions based on R/V or gliders being shipped to begin a mission in a remote deployment location. Table 4.9 resumes the bottlenecks identified by the surveyed glider groups. We have found that sending the gliders for refurbishment to the manufacturer's facilities (USA) and properly adapting the vehicle's density to the waters to be navigated (process known as *Ballasting*) are relevant bottlenecks.

SeaGlider	***Slocum Coastal***	***Slocum Deep***	***Spray***
Poor communications during testing.	**Ballasting**	**Ballasting**	**Ballasting**
Sending them back to US (**Refurbishment**)	Opening and closing too often	Opening and closing too often	
Not enough experience with the platform	**Ballasting** after battery exchange	**Ballasting** fitting new payloads	
Lack of direct communication with Seaglider in the field (like Freewave)	**Ballasting**, repairs, simulating missions	Pressure testing and checklist verification	
Optimal flight parameters	**Ballasting** after battery change from alkaline to lithium	**Ballasting**	
Staff availability and **Refurbishment** time	**Ballasting** and checklist verification	**Ballasting** & Shipping	
Sensor calibration, **Refurbishment**	**Ballasting**		
Obtaining funding			

Table 4.9 *- Most recursive answers to the question of which are the biggest bottlenecks when preparing gliders for a mission (considering the best sellers) -*

Additionally to what concerns the preparation of a glider, the calibration of the scientific sensors on-board stands for a crucial step. There is no chance to achieve good quality datasets, which is the ultimate goal of all glider groups, if the sensors are not properly maintained. Figure 4.34 reveals the majority of the groups rely on the manufacturers to calibrate their sensors. This is because the high setup and running costs of professional calibration facilities. Data from the table of Figure 4.34 show that most of the sensors are calibrated every 12 months. However, this number can rise to 2 years and also can be inferior to 3 months in one particular case in which the sensors are calibrated prior to every cruise (done by those who own in-House calibration facilities). In conclusion, sensor calibration is a significant preparation step that will be difficult to reduce in time. At least until new technological advances produce low drifting sensors or calibration laboratories become affordable. (Note: The two observatories from UK that own the two only PAR -*Photosynthetically Active Radiation*- sensors in the European glider fleet have not provided time interval for these units and there is not enough information to extract further conclusions. Additionally, there are not Radiance sensors in the fleet as shown in Figure 4.11)



	Mean	Max	Min	STD
Unpumped CTD	12,00	24	2,4	7,04
Pumped CTD	12,00	24	2,4	9,40
Oxygen	12,00	24	2,4	6,20
Fluorometer	12,00	24	2,4	6,20
CDOM	12,00	18	2,4	6,45
PAR	N/A	N/A	N/A	N/A
Nitrate	N/A	N/A	N/A	N/A
Optical Backscatter/Turbidity	9,00	18	2,4	6,12
Beam attenuation	2,40	2,4	2,4	0,00
Irradiance	2,40	2,4	2,4	0,00
ADCP	12,00	12	12	0,00
Turbulence / Velocity Shear	3,00	3	3	0,00

Figure 4.34 *- (Left) Location (Blue for In-House and Red for At-Manufacturer) of calibration facilities for the different sensors used by the European groups and (right) statistical figures regarding time gaps between recalibrations –*

The major requirements to plan a mission are: (1) defining the route to be followed, (2) configuring the navigation parameters, (3) organizing logistics (deployment, recovery, etc.), (4) structuring the sampling strategy for the sensors and (5) scheduling the communications between the glider and the laboratory; amongst others depending on the particularities of each group and mission.

Figure 4.35 shows that the definition of the mission relies on the decision of the Principal Investigator's (PI) (within all survey groups but one), while Glider Team members (operators, pilots, and technicians) take the decision on the operations. There are 4 groups in which PI's are in charge of all mission aspects and, on the contrary, only 1 group with no PI involvement (which could be the case in which gliders are offered to external PI's). The PI is generally solicited in the definition and planning while the glider team is more concerned by the definition and the operations.

The aspects listed in Figure 4.35 must be considered and we need to assign them different levels of priority and/or importance. The resulting classification is leaded by concerns which are vital to a glider missions as listed at the beginning of the present paragraph (Scientific objectives, Vessel availability, Currents, Launching Point...).

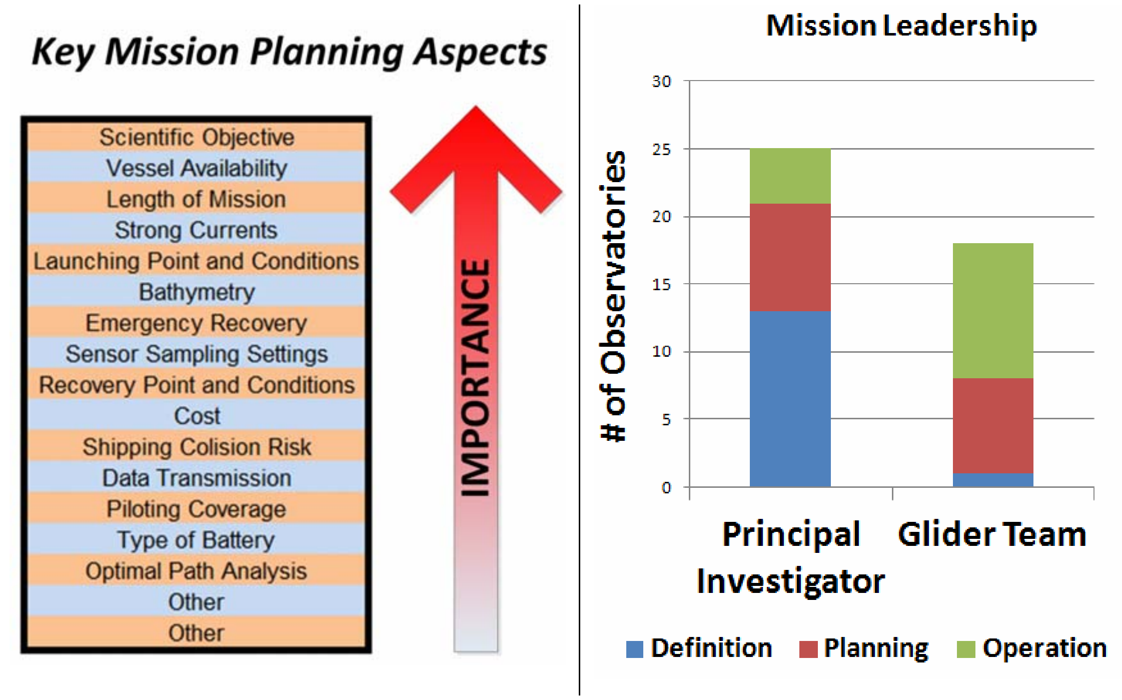


Figure 4.35 *- (Left) List of the key mission planning aspect sorted (top to bottom) by degree of importance for surveyed groups and (Right) the repartition of leadership between investigator staff and members of the glider team -*

It is important to take into consideration the following aspects in the logistics and planning of a glider mission:

- Type of vessel to be used in deployment and recovery operations
- Level of expertise and training of the field teams (especially when gliders are deployed/recovered by partner organizations)
- Distance between the deployment point, and/or surveyed area, and a local support base (if any)
- Risks for humans and gliders (in case an emergency recovery is required)
- Sea and meteorological conditions

It is important to note that the changes in sea and weather conditions and the possible glider failures introduce a considerable amount of uncertainty that prevents an accurate planning. Figure 4.36 shows the European glider groups opinion about the different Safety Aspects, by level of dangerousness. This figure reveals that the Deployment and Recovery are the most worrying operations. Additionally, the possibility of suffering a leak which shortcuts the lithium pack installed on-board also stands as one of the primary concerns. No cases of deflagration by shortcut lithium batteries have been made public to the European glider community, but this danger must be considered when operating lithium-powered gliders. Finally, the weight of the units (50-60 kgs. approx.) has also to be considered when lifting the gliders by personnel. Some allusions to the interference with other sea activities (such as fisheries) and the performance of emergency recoveries have been also received, amongst others.

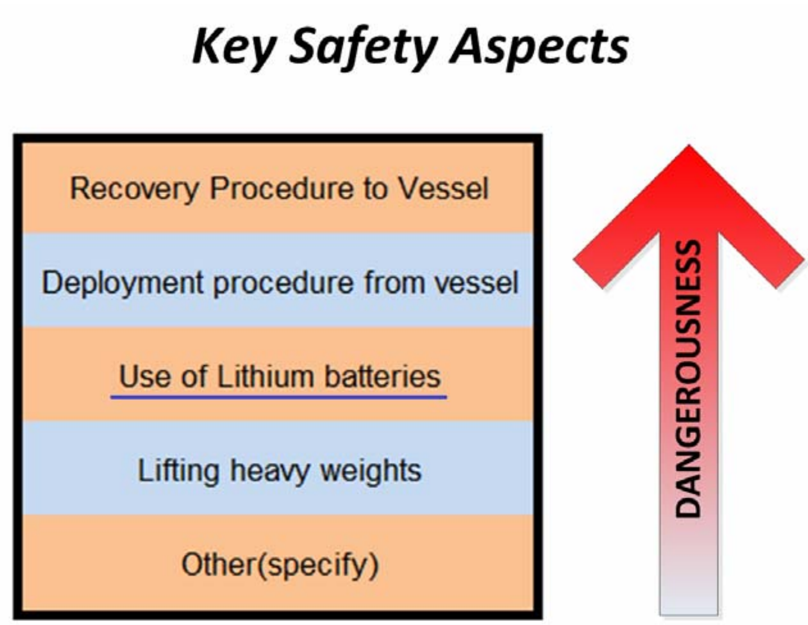


Figure 4.36 *- List of the key safety aspects sorted (top to bottom) by degree of dangerousness to humans and gliders -*

Once the gliders have been deployed and the mission initiated, the next steps that need to be considered for safe and optimal navigation are (1) the general status of the different mechanisms which conform the glider platform, (2) the sample logging and usage of scientific sensors, (3) the geospatial information such as the followed track, the current location and the next target waypoint and, finally, (4) the environmental conditions. Figure 4.37 shows how piloting tasks rely onto the Glider Operators and Scientific staff. There are groups in which the investigator unifies all the roles and/or the figure of the glider operator doesn't exist as such and its duties are assigned to members with a scientific background and also with a technical proficiency. Postdocs and PhD Candidates seem to be the least active in terms of piloting. Some answers included under the 'Other(s)' category make reference to Automated scripts (running on glider control computers - for the Slocum model -), Scientific staff under contract and Trained contractors. (Note: there is a remarkable French initiative to provide an online control site, available to the Global glider community. It intends to provide an integral management of glider fleets covering aspects related to Maintenance, Automatic Piloting -with alarms-, Data Processing -of Real-Time data, and Deployment Logistics - shifts, logbook...-)

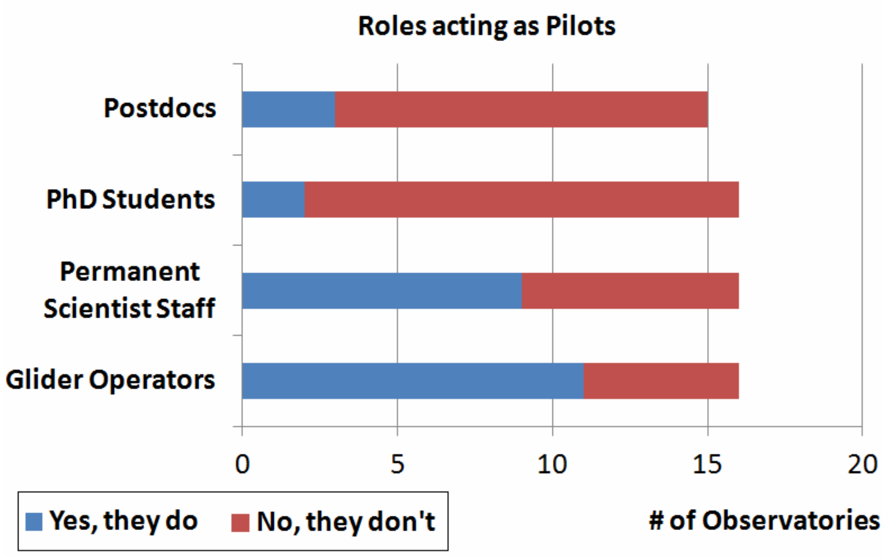


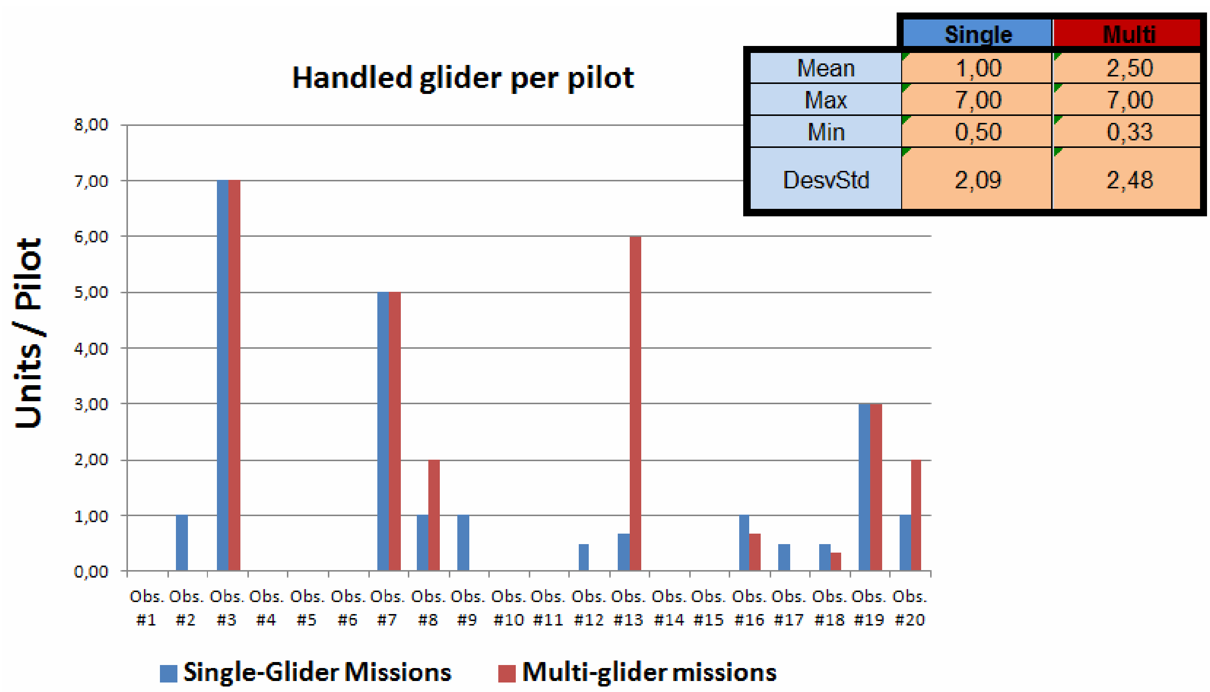
Figure 4.37 *- Relation of the different roles, within the surveyed groups, with the piloting task -*

Pilots are controlling a number of gliders that is dependent on the different European observatories (Figure 4.38); precisely, on their operating environments (shallow or deep water in particular makes a significant difference) . Although the mean value indicates there is one pilot for each vehicle (single glider operations), the plot shows how some groups carry concurrent single mission that can elevate that ratio up to 1 pilot per 7 gliders. These groups are certainly the ones having Glider Operators as pilots (see Figure 4.37). On the other hand, groups with scientific staff and PhD students piloting their gliders do not appear to exhibit such number of gliders per pilot because they do not have piloting amongst their principal duties. At the same time, when considering multi-glider deployments, it can be seen how some groups increment the number of pilots, maintaining the same Units/Pilot ratio as single glider operations. Nevertheless, there are several groups that do not increment the number of pilots, increasing the ratio more than double.

The watch of the gliders is one of the major constraints. One of the most important principles in the glider operation is that vehicles cannot be unattended, which is not really a synonym of autonomous work. On the other hand gliders need to be checked only once in a while. The key point here is determining the duration of the interval between piloting interventions. This has implications in terms of risks and scientific data acquisition and may vary from one situation to another. For instance, a failure close to the coast could result in the glider to be crashed on the shore, if no human intervention. If this might not be relevant in terms of risks when having enough funding (or insurance) to replace a glider if lost, the scientific data acquisition would always suffer from that. Consequently, everything should be done to respond relatively fast to failures. Obviously, most of the groups consider one must be available to react upon any situation in which the glider requests interaction (due to a failure or mission change). Figures 4.39 (and 4.40 in case of multi-glider missions) show the majority of the groups have set up 24 hour glider and week-end shifts.

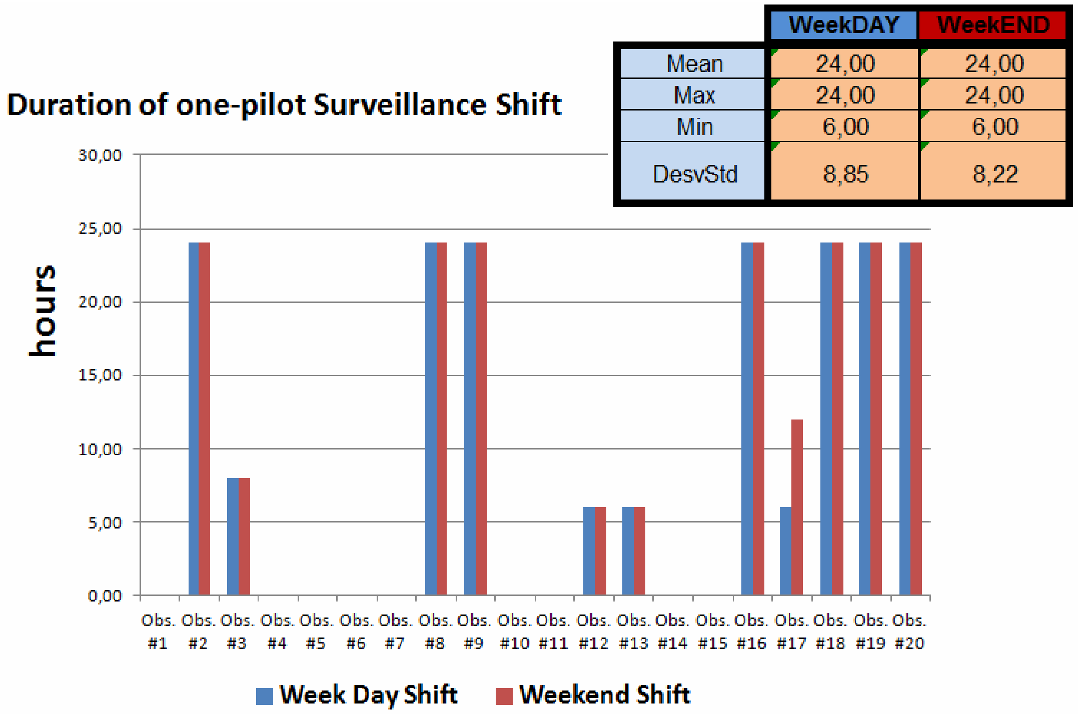
On the other hand, the need of relying on a pilot during the whole mission period can be a stress generator because that can seriously condition the professional-private conciliation if a pilot has to support very long shifts like that. There are several possible improvements to help reducing the effects of long shift piloting while keeping the same glider activity at sea:

- Maximizing the quality of the preparation steps described in this section in order to suffer less incidents while the glider is deployed. This includes maintenance, IT and Comms supervision and route planning (to avoid on-field dangers)
- Hiring more part-time pilots to spread the load among a lot of people.
- Increasing the ratios expressed in Figure 4.38 (or reducing the number of pilots for the watch of the gliders). Setting up a transnational and virtual Call Centre composed of trained pilots assigned by various European partners. The load of surveillance on a glider could be then shared amongst these members and the owning group. Including partners from other Time Zones could help to reduce, and even, avoid overnight shift. However, there would be a agreement to be found between the groups (in terms of responsibilities in particular) before such a system could work fine.



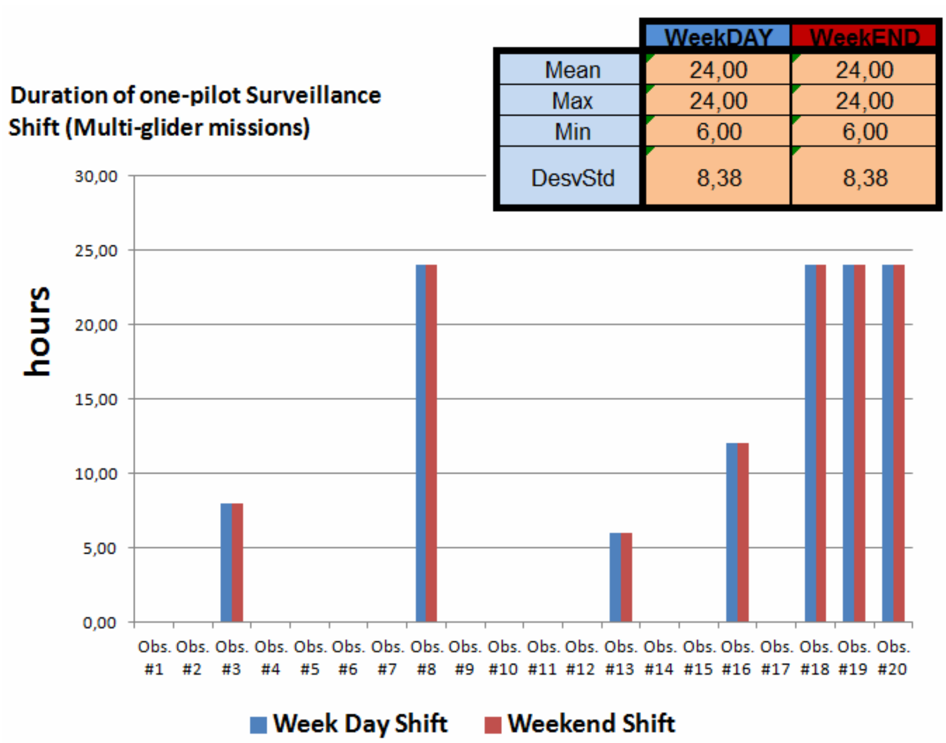
	Single	Multi
Mean	1,00	2,50
Max	7,00	7,00
Min	0,50	0,33
DesvStd	2,09	2,48

Figure 4.38 *- (Plot) Ratio of gliders to be handled per available pilot, for each surveyed group and (Table) some statistical figures for both (Blue) single gliders deployments and (Red) multiple glider deployments-*



	WeekDAY	WeekEND
Mean	24,00	24,00
Max	24,00	24,00
Min	6,00	6,00
DesvStd	8,85	8,22

Figure 4.39 *- (Plot) Duration of the shifts covered by the glider pilots, for each surveyed group and (Table) some statistical figures during both (Blue) weekdays and (Red) weekends while performing single glider missions -*



	WeekDAY	WeekEND
Mean	24,00	24,00
Max	24,00	24,00
Min	6,00	6,00
DesvStd	8,38	8,38

Figure 4.40 *- (Plot) Duration of the shifts covered by the glider pilots, for each surveyed group and (Table) some statistical figures during both (Blue) weekdays and (Red) weekends while performing multiple glider missions -*

4.3. Review of the European glider data management strategy

4.3.1. Evaluation on the current situation

Gliders gather enormous amounts of data while deployed at sea. Engineering, scientific and navigation data are collected approximately once every two seconds. This leads to a high quantity of data that, from a very general point of view, needs to be extracted from the glider, converted to standard formats, verified, and exported to allow its public access. To perform all these processes a glider Data Management process is needed by all European groups.

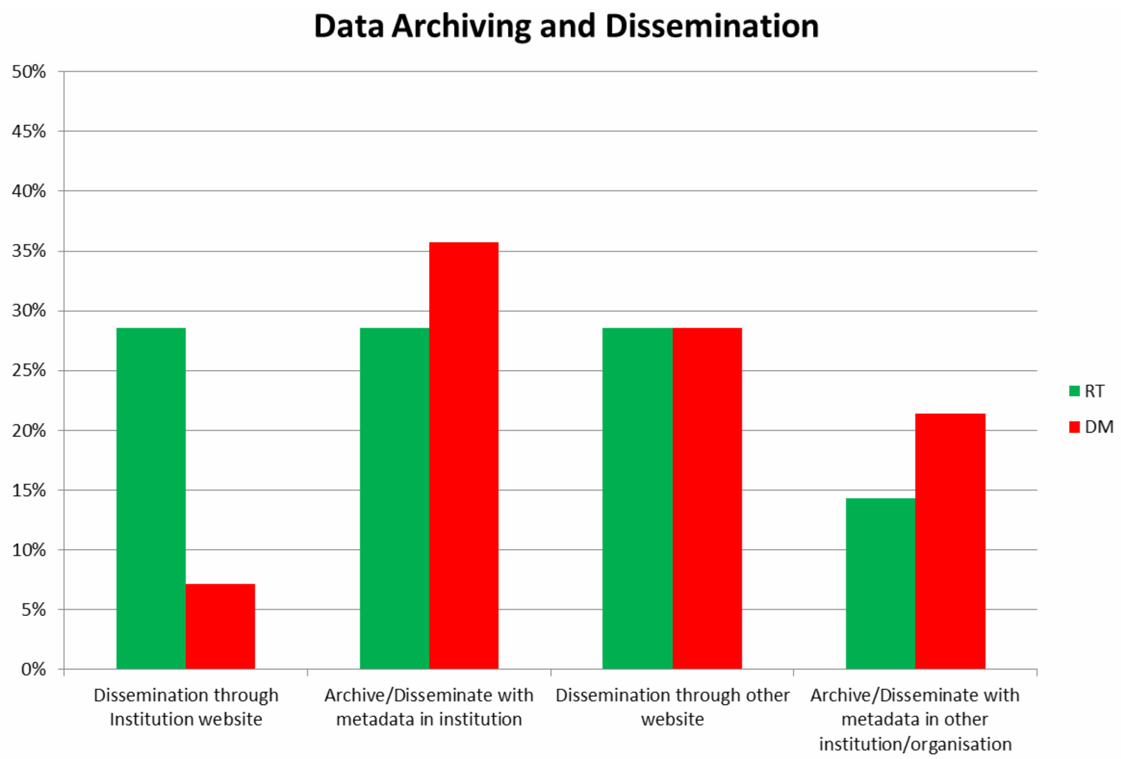


***Figure 4.41** – Glider data archive and dissemination in near Real Time (RT) and Delayed Mode (DM).*

All the institutions using gliders in Europe transfer part or all the data in near Real Time (RT) through the Iridium satellite communication system. However, as shown in Figure 4.41, just a 58% of them then disseminate this data in RT through a webpage or a data portal. Half of the institutions that disseminate glider data, use their own website; the other half, use an external organization's platform (i.e. Coriolis or OceanSITES). It is also important to note that only a 25% of the data disseminated in RT are first disseminated in a NetCDF format, the de-facto standard for scientific data sharing.

The glider data not transferred in Real Time using the satellite connection are downloaded from the glider once it has been recovered, so-called Delayed Mode (DM) data. Just 29% of the groups make this complete dataset available to the public (half in NetCDF format) and all of these make the data available through an external organisations' portal (the already mentioned platforms plus BODC). Only one group is actually using its own website and an external website to broadcast the DM data. Groups sending DM data to European archive projects represent 43% of the total (33% in NetCDF format and 67% with metadata).

Data acquisition technology and sensors are still evolving and as a result, significant work on data processing procedures is needed. In this respect, general Quality Control (QC) and Validation procedures need to be established, and this is one of the objectives of the EU FP7 GROOM project. Figure 4.42 shows that few European groups have QC procedures in Real-Time and just over half correct data in Delay Mode, although few adhere to internationally established guidelines. It should be noted that this is in part because these international standards are in the process of being established (see EU FP7 GROOM project). Figure 4.43 shows some of the QC procedures actually implemented by European glider groups.

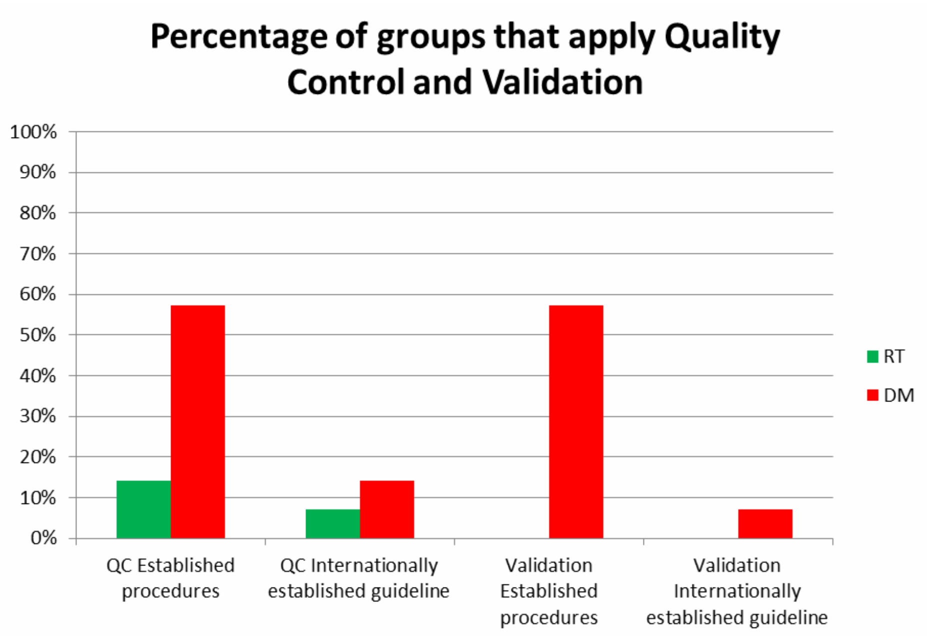


***Figure 4.42** – Glider data Quality Control (QC) and Validation in near Real Time (RT) and Delayed Mode (DM)*

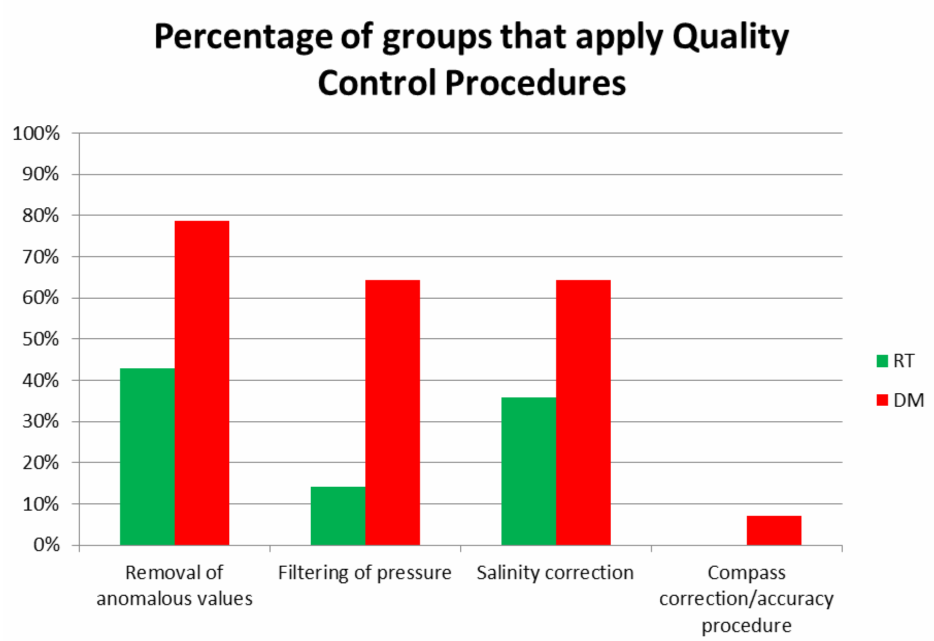


***Figure 4.43** –Quality Control procedures in near Real Time (RT) and in Delayed Mode (DM)*

Calibration of data is done by comparing glider sensor data against that of a more precise and recently calibrated instrument. Over three-quarters of the groups, 77%, verify data from the hydrographical sensors, less, 46%, verify data from biogeochemical sensors and only 31% perform some sort of check of the navigation sensors data that provide the depth-averaged current variable.

Only 29% of the groups perform outreach and communication of glider activities through a web application or tool.

As seen in Figure 4.44, half of the European institutions routinely use glider data to characterize the ocean state and its variability. Many have also used glider data for assimilation into models for forecasting, however to date, glider data is seldom used to create products for marine users.

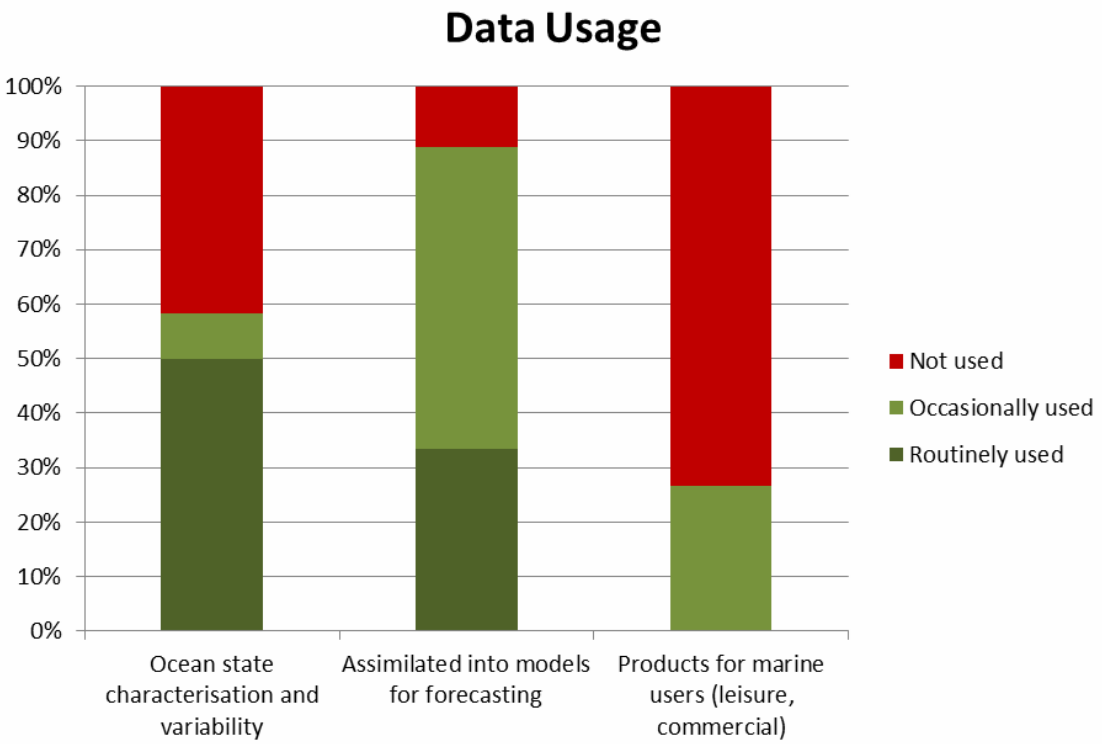


Figure 4.44 *– Questionnaire responses regarding glider data usage*

In summary, many groups have established QC and Verification procedures for DM data, however a significant percentage do not perform QC and verification, and a general strategy or standard is still lacking, which is the aim of recent EU funded initiatives. Few groups have established QC procedures for RT data.

4.3.2. Details of data management from 3 good examples

Detailed data flow schemes of three institutions from three different countries and different fleet sizes are shown in order to present specific examples of on-going procedures:

DT INSU (Obs. #3) is one of the groups with more experience in Europe regarding Slocum glider operation. The high number of days in water induced the development of an Agent, installed in both the Dockserver (server that controls the Slocum gliders) and the Basestation (Server that controls the Sea Gliders), that manages different processes automatically (all in RT), freeing humans from routine tasks (see figure 4.45). These processes are data backups, execution of automatic piloting instructions and transferring the data to the Data Processing unit. This unit is in charge of transforming the raw binary files from Slocum gliders to ascii files and sending it to the Coriolis Data Centre where users will find glider data among many other platforms'. It is also in charge of displaying plots of the technical/scientific data it receives in RT through the EGO Network portal. This unit is also used by some other European groups and is, by now, the only European initiative to unify glider data display. The GFCP (Glider Fleet Control Panel) allows for mission tracking and configuration by using a visual intuitive web-based tool. Some other European groups have already used it and commissioned their gliders in it.

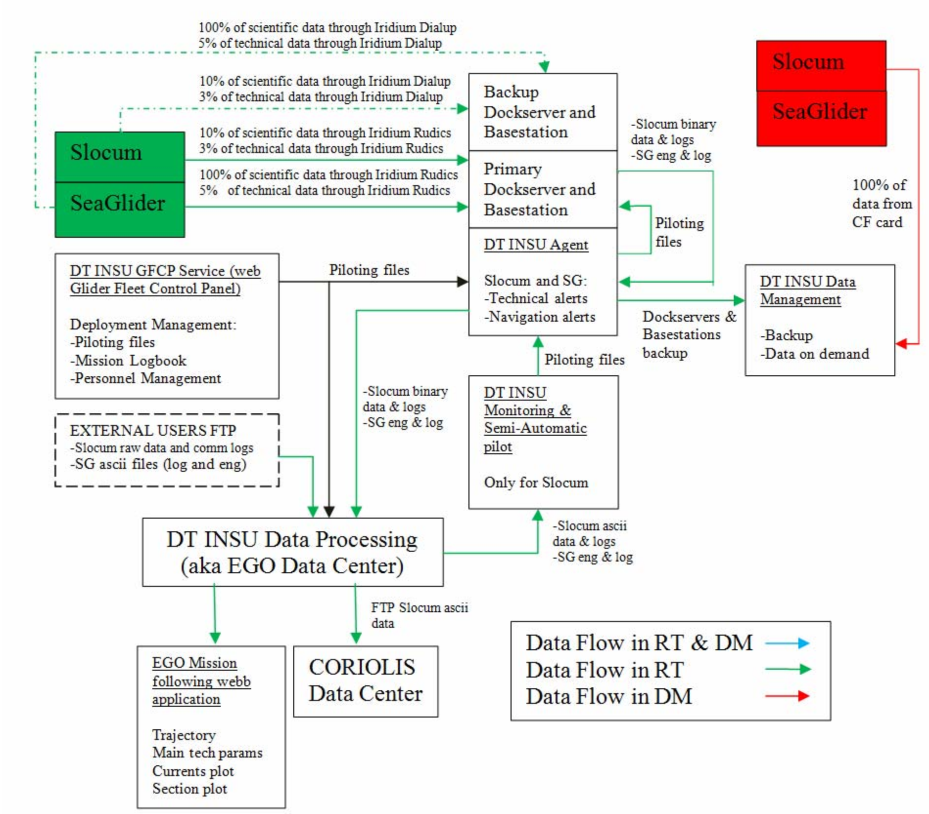


***Figure 4.45** – DT INSU (Obs. #3) Glider Data Flow –*

DT INSU's Slocum gliders (12 units) transfer about 15% of the collected data in RT (and about 30% of the scientific data) in order to save air time and keep the time at surface short. These data are displayed on the EGO Network portal and are also sent to the Coriolis Data Centre. The remaining of the data is downloaded from the glider, once it has been recovered. It is stored and made available upon request.

Seagliders (2 units) are relatively new and are progressively being integrated to have the same data processing features Slocum gliders have. They transfer 100% of scientific data in RT but it is not forwarded to Coriolis since it is not ready to assimilate its format yet.

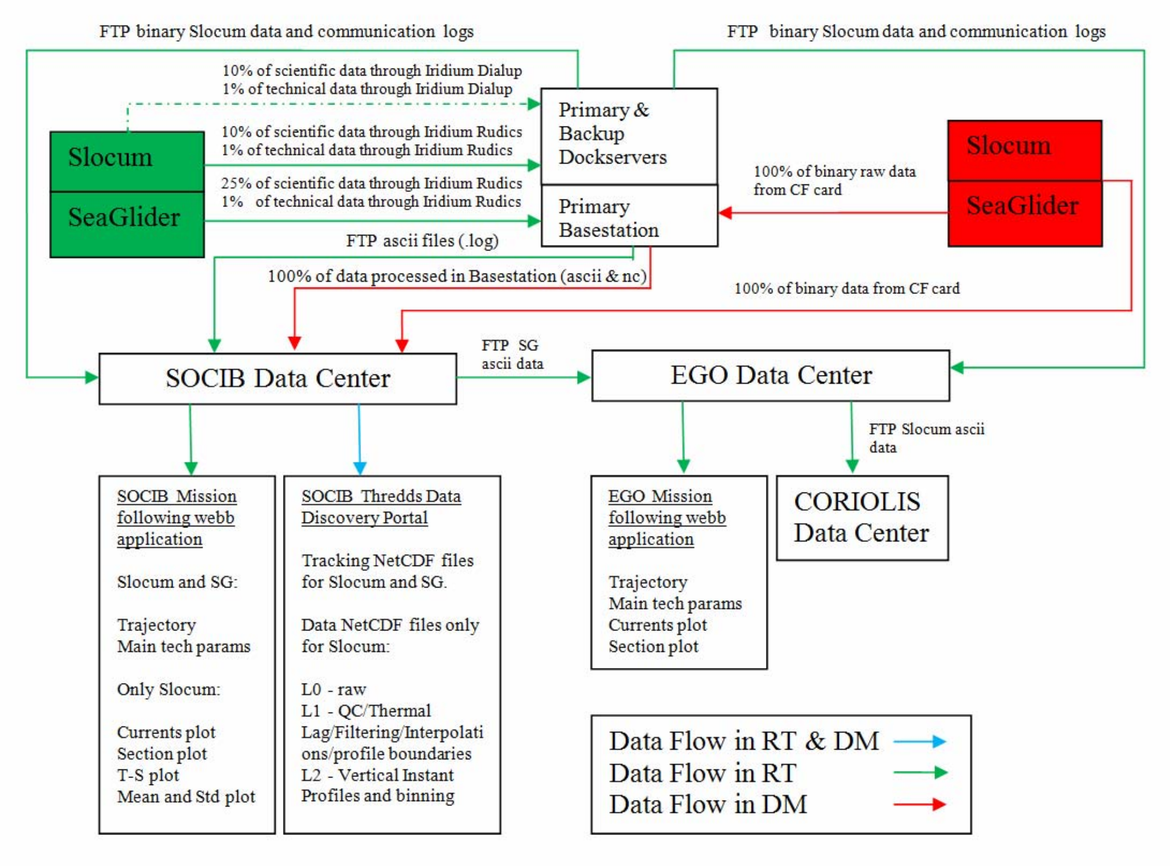


***Figure 4.46** - SOCIB/IMEDEA (Obs. #16) Glider Data Flow -*

Figure 4.46 shows SOCIB/IMEDEA's (Obs. #16) data flow scheme. This institution tries to minimize satellite communications costs (Iridium) by sending just 10-25% of the data collected in RT; the remaining is downloaded from the gliders directly and treated as DM data.

For Slocum gliders (5 units), 10% of the data is treated in RT by both SOCIB's Data Center and EGO Data Center. The first has its RT tracking application showing where the glider is and also displaying plots for technical and scientific data. These data are processed in RT and three levels of NetCDFs files are available on the portal. The second retrieves the raw binary data directly from the Dockserver (where data from Slocum gliders are transferred through Iridium), transforms it into ascii files and forwards it to the Coriolis Data Center. It also shows technical and scientific data plots through the EGO Network portal. In DM, only SOCIB Data Center receives the data.

Sea Gliders (2 units) were introduced later in SOCIB/IMEDEA and therefore the data flow is still adapting to the observatory's structure. In RT, they transmit data from approximately one out of four profiles. Technical data/plots and glider trajectory appear in the same web application as Slocum gliders but neither scientific data plots nor NetCDF file generation are implemented in RT/DM. However, RT data is made available to the EGO Data Center who plots the scientific data and glider trajectory.

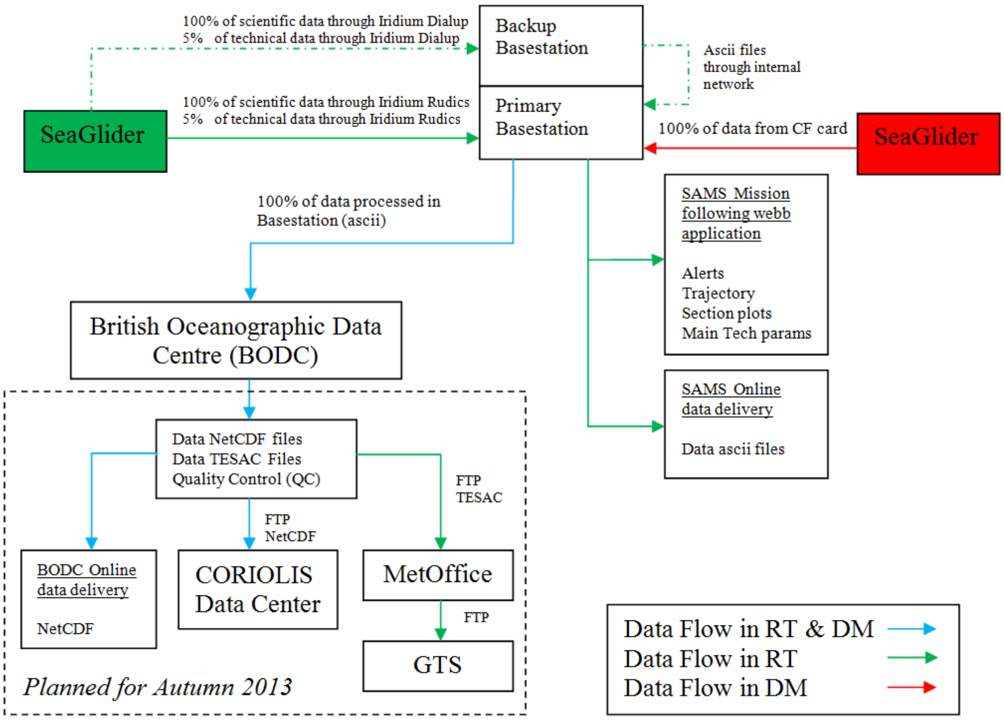


Figure 4.47 *– SAMS (Obs. #18) Glider Data Flow –*

SAMS (Obs. #18), figure 4.47, will rely mostly on the British Oceanographic Data Centre (BODC) to broadcast and QC the data its Seagliders (2 units) gather in the sea. In-house, it has a Mission following website where plots of scientific data and glider trajectory are displayed in RT and from which one can download the data in ascii format (its gliders transfer 100% of scientific data in RT). Its gliders can be found on the EGO Network portal even though their link goes to the SAMS mission following web application. It also has developed an alerts system to ease glider piloting.

Its plan for autumn 2013 is to send all files in RT/DM to the BODC who will apply a Quality Control and will transform it to other formats such as NetCDF (for Coriolis) and TESAC (for MetOffice). It will also deliver the data through its own portal.

The featured examples show how differently the observatories tackle the data management issue. Each one of the remaining observatories would show a different data flow scheme and action plan. Some observatories focus more on automating processes and piloting while others may be more focused on data dissemination and QC procedures. Some transfer all data in RT or a part of it depending on the glider model and a majority of them have their own website to follow the mission and check the main glider technical parameters. Some groups have more sophisticated Data Centers that can deliver files in standard formats and others just offer the files in ascii format.

Despite the differences, some common aspects can be found: the use of the EGO Network portal to display glider activity and, specially, the effort the groups do to have their gliders' data on the Coriolis Data Center.

4.3.3. Proposed coordinated strategy for glider data management

The use of European gliders as a coordinated observing network is critical to boost gliders' contribution to the characterisation of the state of our seas and oceans. Programs such as Argo, with more than 3000 floats drifting worldwide, are an important reference for coordinated deployment and data management strategy. Synergies with such established, but also under development, observing systems are also essential to demonstrate glider data complement other observations.

The different glider observatories need to collaborate to obtain more glider data profiles together than they would obtain operating gliders by themselves, to get better performance out of their respective fleets and build new tools and products. Efforts to maintain endurance lines need to be shared by different groups who are geographically close and missions oriented to scientific topics that may require a large number of gliders should be tackled with a multiple observatory approach.

To support this, different Data Centres (DACs) should be well coordinated and have established common procedures for glider data processing. A centralized Global Data Centre (GDAC) that pulls data from the different DAC servers is required to monitor the global activity of the network and to serve as a reference portal for European glider data and activity. A Glider Data Management team should coordinate the different DACs during missions, with the Mission Coordinator, and govern the GDAC, which will be responsible for the establishment of new procedures and standards in all DACs.

Data formats need to be standardized, as well as quality control, and all steps performed during the data processing need to be clearly defined and documented. If necessary, the glider operations, glider preparation in the lab, and other procedures should adapt to respond to the requirements of the GDAC and DACs. The whole glider network infrastructure must turn around providing high quality data at predictable time steps. A percentage of the acquired scientific data should be transmitted in near Real Time (RT), within less than 24 hours of its acquisition, so that monitoring and forecasting users can benefit from it. This percentage will be defined prior to the mission according to the variability encountered in the studied area and other factors. Real Time Quality Controls need to be compulsory for the core measured parameters (T, S, currents, Chl and 02). Data provided in Delay Mode (DM, after glider recovery) will be validated and calibration corrections will be applied.

Every step in data management needs to take into account what other leading regional institutions, such as IMOS (Australia) or IOOS (USA), have done or are about to do, with JCOMM as the international reference point.

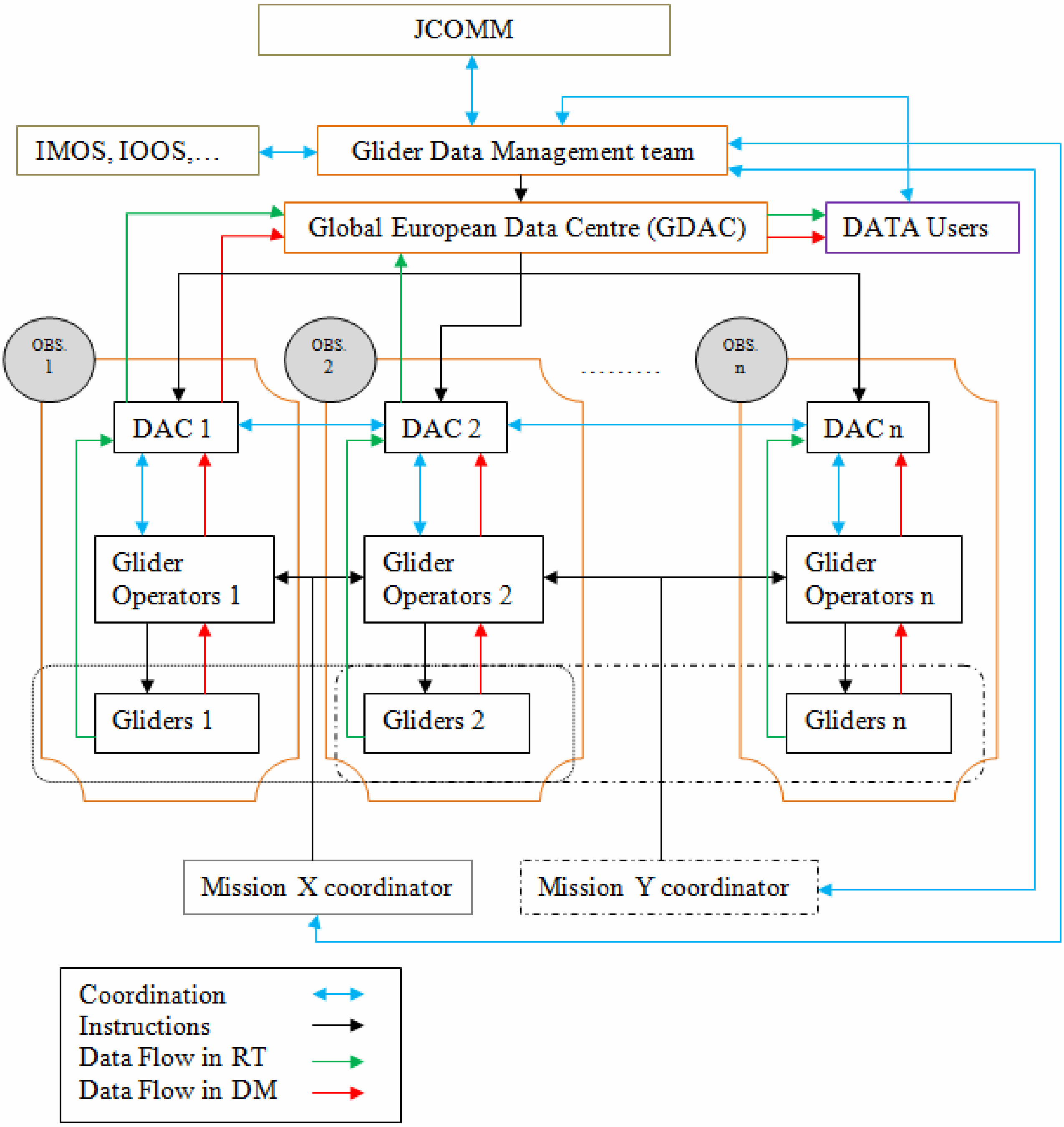


Figure 4.48 *- Proposed structure for glider data management and glider data flow for the European Glider Observing Network*

4.4. Costs analysis of European glider observatories and fleets

This section is based on the response to the JERICO Glider Questionnaire from 11[1] of the 12 active glider laboratories in Europe. The questionnaire asked about the investment, operational and personnel costs associated with running the glider facilities in 2011, to provide an overview of the costs of running the glider observatories. However it should be recognized that depending on the funding available investment in gliders and glider operations will vary from year to year. In addition, the cost of operations can vary depending on the type of mission, for example for coastal vs. open ocean, multi glider vs. single glider, monitoring vs. specific experiment and Mediterranean vs. Arctic operations. The costs outlined below however may provide some initial insight into the order of magnitude of costs associated with running a glider facility across Europe.

4.4.1. Summary of costs related to Investments

The questionnaire asked about the investment in gliders and glider related equipment and infrastructure during 2011. Below is a table of the mean investment across the 11 active glider laboratories.

The mean investment in gliders is approximately equivalent to 1.5 gliders per glider lab, most of the investment was in the purchase of gliders (93%), with 7% in sensors and 4% in infrastructure. Seven of the 12 labs invested in gliders and 6 in sensors during 2011. Two labs made large investments in gliders, accounting for 58% of the total investment (2,317,994€) across the 11 glider labs.

Investment	Mean €
Purchase of gliders	195,091
Purchase of sensors	13,817
Glider infrastructure (e.g. pressure chamber)	8,591
Glider equipment (e.g. tools, R&D, launch)	4,641
Safety equipment	405
Total	222,545

***Table 4.10** - Mean investments (€) in 2011 (approx.), excluding VAT (€) -*

4.4.2. Summary of costs related to Operations

The operational costs associated with running a glider lab were divided into fixed and variable costs, and 10 of the 12 active glider labs responded to this section of the survey[2]. Below is a summary table of the total and mean operational costs across the glider labs. The fixed costs rent, waste disposal, data centre, and insurance were not accounted for by most of the glider labs (with 1, 1, 3 and 1 answers respectively).

[1] UoC, DT-INSU, GEOMAR, HZG, AWI, IMEDEA/SOCIB, PLOCAN, NOCS, SAMS, UEA, and CMRE

[2] UoC, DT-INSU, GEOMAR, HZG, AWI, IMEDEA/SOCIB, PLOCAN, NOCS, SAMS and UEA

OPERATIONS	Total Europe	Mean	As % of mean costs
Variable Operations			
batteries	234,788	23,479	41%
consumables other (e.g. cables)	11,336	1,134	2%
iridium	121,457	12,146	21%
communications other (Argos, mobile)	4,960	496	1%
spare parts for repair or upgrade etc.	56,303	5,630	10%
calibration (outsourced)	31,380	3,138	6%
vessel costs (e.g. hire, fuel)	27,632	2,763	5%
transportation of equipment	79,773	7,977	14%
Subtotal	567,629	56,763	100%
Fixed Operations			
rent buildings	5,600	560	13%
waste disposal/service from institute	500	50	0%
data centre costs	27,210	2,721	63%
insurance (gliders)	10,000	1,000	23%
Subtotal	43,310	4,331	100%
Total Variable and Fixed Operations	610,939	61,094	

Table 4.11 *- Operational costs 2011 (approx), excluding VAT (€)*

For the variable costs, batteries and iridium account for approximately 60% of the mean costs, 41% and 21% respectively, transportation of equipment accounts for 14%. The mean annual cost operations was approximately 61,000€, however and the variable costs accounted for 93% of the total operational costs.

4.4.3. Summary of costs related to Personnel and Depreciation

The mean cost of personnel in 2011 was approximately 80,000€, with approximately 40% on permanent personnel, travel accounted for 8% of the spend and training 2%.

PERSONNEL	Total Europe	Mean	As % of mean costs
personnel permanent	304,647	30,465	37%
personnel contracted	208,489	20,849	26%
personnel indirect (estimate)	216,731	21,673	27%
travel personnel	66,932	6,693	8%
training personnel	17,500	1,750	2%
Total Personnel	814,299	81,430	100%

Table 4.12 *- Personnel costs 201 (approx.), excluding VAT (€) -*

Two of the 10 respondents accounted for depreciation of the gliders and equipment, with a mean depreciation cost of approximately 41,000€.

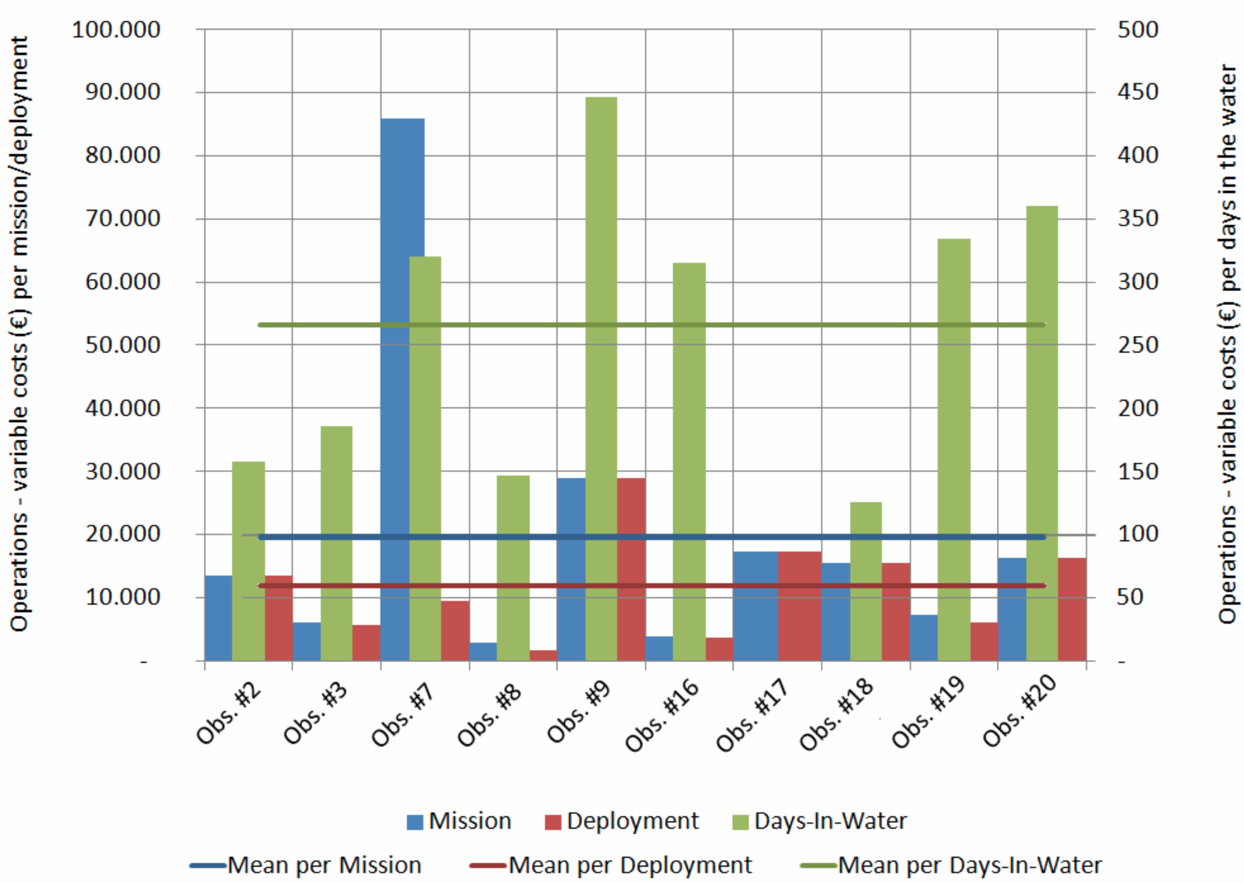


Figure 4.49 - Variable costs for each respondent and mean values (as a function of missions, deployments and Days-in-Water) –

4.4.4. General Summary

As glider laboratories vary in number of personnel, gliders and mission, for example smaller labs have 2 gliders and the largest 14 gliders, the personnel and variable costs are divided by mission, deployment and number of days in the water to provide a view of the costs as viewed per glider operation across the various glider labs and mean values. There is a large range in the variable costs per mission, deployment and days in the water, as noted in the introduction this can be due to many factors associated with the type or style of glider operations. These numbers are represented in Figure 4.49 (Variable costs) and Figure 4.50 (Personnel costs). Table 4.13 quantifies the means represented in these figures whereas Table 4.14 summarizes table of total costs for glider operations across Europe in 2011.

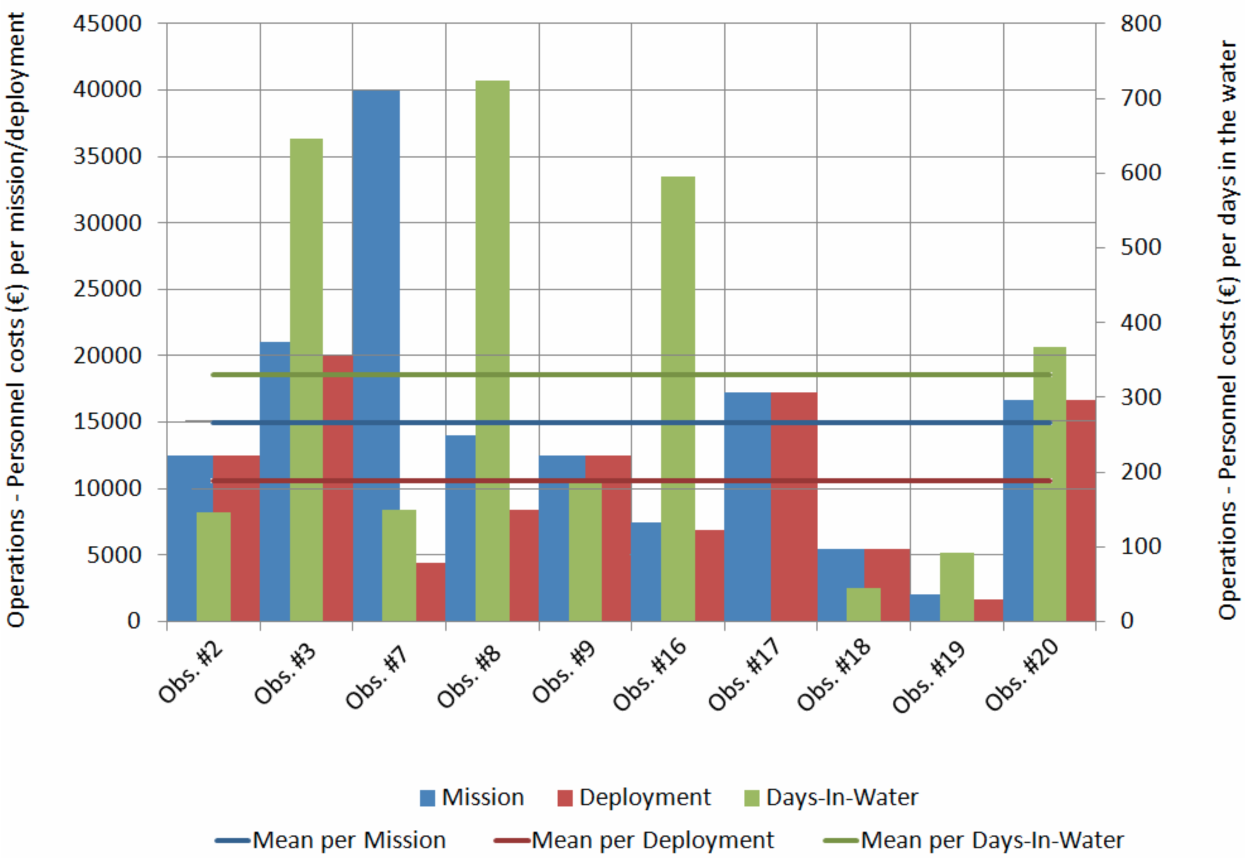


Figure 4.50 *- Personnel costs for each respondent and mean values (as a function of missions, deployments and Days-in-Water) –*

Variable costs by:	Mean
Mission	19,752
Deployment	11,824
Days in the water	266
Personnel costs by:	
Mission	14,880
Deployment	10,573
Days in the water	329

Table 4.13 *- Mean variable costs and personnel costs as a function of missions, deployments and days in the water for 2011 (€) -*

TOTALS	Total Europe	Mean	As % of mean costs
Total Investment	2,317,994	222,545	54%
Total Variable and Fixed Operations	610,939	61,094	35%
Total Personnel	814,299	81,430	20%
Depreciation (gliders, sensors, equipment)	414,896	41,490	10%
TOTAL Annual (investment, operations, personnel and depreciation)	4,158,128	415,813	100%

***Table 4.14** - Summary table of total costs for glider operations across Europe in 2011 (€) -*

Across Europe, three countries, France, Spain and the UK, made similar and higher levels of investment/spending in gliders and glider operations (see Table 4.15). Germany invested approximately 50% less and Cyprus 90% less, the figures for Italian investment/spending are unknown. Norway is now developing their glider observatory and Poland and Greece both have interest and/or intend to commence operations.

Summary of spending per country	Investment	Operations (variable and fixed costs)	Personnel	Total (inc. depreciation)
FRANCE	230,494	138,019	537,968	1,092,858
GERMANY	274,000	152,400	107,000	533,400
SPAIN	601,500	933,000	183,100	1,333,000
UK	852,500	110,540	65,450	1,078,990
CYPRUS	28,000	26,880	25,000	119,880
ITALY	130,000	no data	no data	no data
NORWAY	no data	no data	no data	no data
POLAND	no gliders	no gliders	no gliders	no gliders
GREECE	no gliders	no gliders	no gliders	no gliders

***Table 4.15** - Summary of the total spending per country, in glider investment, operations and personnel for 2011 (€)*

5. Summary

This report is based on work carried out in the frame of JERICO project and includes (1) an exhaustive questionnaire completed by all European groups working with gliders (or that will work with them in a near future), (2) the discussions that took place in the glider meeting in Mallorca in May 2012 and (3) the discussions and iterations that continued after the meeting and during 2013.

5.1. Main conclusions

This report reflects the present status of glider operation in Europe and is mostly centered on infrastructures, operations, data management and costs. Besides different origins and drivers in the different teams, there are evidences of an evolution towards similar approaches to common infrastructure and operation procedures. With respect to infrastructures, human resources seem to be limited when compared with the size of the fleets to be managed. Considering that the intentions of fleet growth are close to 25%, fully dedicated personnel will be needed to sustain the number of missions planned in forthcoming years. Additionally, there is a good pool of hydrographic and biological sensors, although higher variety could be interesting to increase the potential of a near future European glider fleet.

In terms of operations, there is already a varied catalogue of missions in terms of their nature, execution, objectives and geographical location. Undoubtedly, this vast know-how will enforce the idea of a versatile European glider network. Considering the majority of the operations are undertaken locally, although some groups carry out operations outside European waters, there are some gaps in the glider action coverage (i.e. South Mediterranean and Golf of Biscay). Also noticeable is the interest to increase the number of glider missions to be carried out in collaboration with traditional methods/platforms.

In terms of Data Management it evident that further efforts are needed to disseminate the data both in Real Time and Delayed Mode, although it is important to say that RT glider data are now available in the frame of JERICO, an important contribution to operational oceanography. Quality Control and Validation of these data is a key component to foster gliders as central players in the national and European ocean observing infrastructures. Good news is that there are already European scale initiatives to gather all data and glider activity for public distribution (Coriolis and EGO Network). A centralized Global Data Centre (GDAC) that pulls data from the different DAC servers is required to monitor the global activity of the network and to serve as a reference portal for European glider data and activity. Good advances along this line have been established in the frame of JERICO in good coordination with GROOM.

Regarding the associated costs, the wide range of variable and personnel costs observed through the observatories evidences the benefits of a future common funding strategy that would take into consideration the particularities involved in gathering glider data in different locations and scenarios. As mentioned above, there is a moderate expense in personnel in comparison to investments and variable costs. At the end, the total figure representing the annual monetary investment at a European level in 2011 supports the idea of a sustainable and cost-efficient European coastal glider observing infrastructure.

In conclusion, the level of maturity and experience of the different European glider observatories offer a valuable asset for establishing a European multidisciplinary multi-platform ocean observing network to provide coastal data inputs for operational ocean observing and forecasting, and also to answer some of the needs of the environmental research and societal communities.

5.2. Key topics for further discussion

In this section we present, in line with the questionnaire results, the major elements raised for discussion and, within those, the priorities and levels of importance that were given by the glider observatories with respect to relevant aspects.

5.2.1. *Desired improvements in gliders as oceanographic instruments*

IMPROVEMENT PRIORITY

SEAGLIDER	SLOCUM	SPRAY
Reduction in cost of batteries	Reliability of performance-mechanical	Reduction in costs other
Ease of maintenance / repair	Ease of maintenance / repair	Reduction in cost of batteries
Increase mission length capability	Reduction in cost of mission communications	Reduction in cost of mission communications
Reliability of performance-mechanical	Increase mission length capability	Increase depth capability
Increase depth capability	Reduction in cost of batteries	Increase mission length capability
Reduction in costs other	Reduce time taken in pre-mission preparation	Ease of maintenance / repair
Realiability of performance-communications	Realiability of performance-communications	Provide AIS or other anti-collision capability
Reduction in cost of mission communications	Provide AIS or other anti-collision capability	Increase ease of launchrecovery procedure
Increase in sensor accuracy	Increase in sensor accuracy	Reliability of performance-mechanical
Increase ease of launchrecovery procedure	Reduction in costs other	Increase in sensor accuracy
Provide AIS or other anti-collision capability	Increase ease of launchrecovery procedure	Realiability of performance-communications
Reduce time taken in pre-mission preparation	Increase depth capability	Reduce time taken in pre-mission preparation

Figure 5.1 *- Ranking of most liked (on Top) improvements in gliders as oceanographic instruments -*

5.2.2. *Top contributions from glider manufacturers*

CONTRIBUTION IMPORTANCY

SEAGLIDER	SLOCUM	SPRAY
Certification/training for battery change	Provide advanced technical training	Provide advanced technical training
European support centre	European support centre	Host technical discussion forums
Provide advanced technical training	Host technical discussion forums	European support centre
Host technical discussion forums	Faster resolution of issues	Faster resolution of issues
Faster resolution of issues		

Figure 5.2 *- Ranking of the most important (on Top) contributions that glider manufacturers could make to support European best practices in glider operations -*

5.2.3. Top services glider research infrastructures could provide to support national/European glider operations

National Infrastructure	European Infrastructure
A maintenance facility or glider pool	Scientific/technological forum
Data management	Data management
Technical services, such as calibration	Training/support for glider operators
Training/support for glider operators	Technical services, such as calibration
Outreach/dissemination activities on glider topics	Outreach/dissemination activities on glider topics
Links with other glider teams, i.e. USA, Australia, Canada	Links with other glider teams, i.e. USA, Australia, Canada
Portal for access to gliders for the wider scientific community	Portal for access to gliders for the wider scientific community
Scientific/technological forum	A multi-platform interface for piloting
Advise on safety issues	A maintenance facility or glider pool
A multi-platform interface for piloting	Links with the manufacturers
Links with the manufacturers	Advise on safety issues

***Figure 5.3** - Ranking of the most important (on Top) services that a national/European glider research infrastructure could provide to support national/European glider operations -*

5.2.4. Best ways of reducing costs of glider operations

"Reduced need for shipping gliders around the world for batteries, calibration, and maintenance (local/regional facilities should be created for this purpose). Even for experiments, it would save a lot of money to use a local glider rather than ship your own to an experimental site. In general, this shared infrastructure concept would extend to pilots/engineers as well, again local/regional teams rather than building your own."
"deploy more"
"Fewer failures of systems"
"Centralise battery supply"
"For Seaglider - the European service center for refurbishment and calibration Generally - increasing the glider endurance to achieve longer missions"
"Improving reliability of gliders and making maintenance and ballasting easier would significantly decrease the costs for personnel and handling/logistics at sea."
"reduce the cost of the battery and of the transmissions"
"- Communications usage tailored to operation - Reduce piloting costs via support tools and improved autonomy - Shared facilities"
"Reduce the number of failures of platforms (increase in robustness).And reduce the costs of batteries and communications."
"- To reduce COMMS and batteries costs. .- Enlarge glider fleet in operation. .- International and changeable operational glider fleet under a common workframe of procedures, terms and conditions. .- Reduce risk of failure."

"Pooling of people (pilots) and equipment"
"1. Introduction of rechargeable batteries. 2. Improved buoyancy pumps so shallow and deep water operations can be spanned. 3. Reduction in Iridium costs 4. Reduce power consumption."
"Doing our own refurbishments (already doing this since we are trained by iRobot) and reducing the cost of batteries."

Table 5.1 - *Opinions of some European glider observatories with respect to best ways of reducing costs of glider operations -*

5.2.5. Key technological advances for gliders

"Increased payload and interoperability for a wide variety of sensors and applications."
"rechargeable batteries"
"Propellers for Slocum gliders as a glider-AUV mixture. Better modularity of sensors."
*" simplification of ballasting/larger range of buoyancy change * rechargeable lithium batteries * software side: easier piloting/automated piloting"*
"Hybrid gliders Acoustically navigated gliders Gliders as data messengers for other platforms (acoustic data transfer) New, more energy efficient sensors"
"Larger pump volumes will hopefully allow for higher speeds, the capability to go against stronger currents, and to operate in regions with higher density variations."
"integration of new sensors energy consumption reduction"
"Add intelligence on board to improve autonomy - Improve sensors technology"
"Increase the mission durability. And increase the number of sensors attached."
"1.- Reduce/Improve COMMS and battery costs. 2.- Enlarge endurance. 3.- New payload configurations. 4.- Reduce dimensions and weight in some glider applications. 5.- Improve deloyment and recovery procedures."
"Longer endurance, deeper, improved velocity measurements"
"1. Improvements in battery technology. 2. Improved anti fouling as deployment length increases. 3. Acoustic sensors 4. Improved navigation 5. Generally available under-ice capability"
"Full depth gliders, with carbon cycle sensors, and longer missions of about a year, plus under ice acoustic navigation for gliders"

Table 5.2 - *Opinions of some European glider observatories with respect to potential key technological advances for gliders as a platform -*

5.2.6. Key topics that gliders will help address in the European Seas

Coastal Water	Open Ocean	Both
"pollution monitoring, ecosystem health status"	*"improved ocean forecasting (physical and biogeochemical) because of increased use of glider data for assimilation"*	*"near-real-time flow and hydrographic conditions to validate other observations and models"*
"long term monitoring"	*"ocean models, mitigate emergency/risk situation"*	*"both"*
"yes"	*"seasonal variability"*	*"meso-scale processes, long-term monitoring"*
"pollution, small scale models"	*"long term monitoring, shelf processes, biological processes"*	*"x"*
"shelf / ocean exchanges"	*"air-sea interaction"*	*"understand the interaction between open and coastal waters"*
"biological monitoring, pollution monitoring"		*"submesoscale dynamics"*
		"Shelf/open ocean interactions, transports and ecosystem response"

***Table 5.3** - Opinions of some European glider observatories with respect to key topics that gliders will help address in the European Seas in the next 5 years -*

5.2.7. Key contributions to European Coastal Observatories

"Much more detailed and complete observational data sets can be collected at previously undersampled time scales and spatial resolutions. This would provide a more solid foundation for models, environmental response preparedness, and for decision-makers in a number of areas."
"long temporal series of data multiparameters data"
"Simplify real-time 24/7 monitoring."
"building an extensive database"
"Gliders used operationally for long-term monitoring 'Event-triggered' high resolution surveys by gliders' fleets"
"Study of processes in specific regions such as eddy dynamics or mass formation"
"understand the sub-mesoscale structures that contribute to the exchanges/interactions between the open and coastal waters knowledge of the water column in the areas of deep water formation"
"Endurance lines."
"Monitoring key transects, mesoscale and sub-mesoscale variability, and eddy-mean flow interactions"
"Increase the quality and quatity of oceanograhic data needed for improving models and tools related to weather forecast and climate trends, in a cost-effective way reducing operation cost."
"Improve description of spatial variability"

"Sustained monitoring. 4-d process measurement"
"Monitoring all year round including rough weather"

Table 5.4 *- Opinions of some European glider observatories with respect to key contributions gliders can make to the European Coastal Observatories over the next 5 years -*

5.2.8. Best applications of eventual European funding

"The initiation of 3 regional centers for maintenance, calibration, backup-piloting. Support for regular endurance lines in key areas."
"common piloting tool"
"A dedicated not-for-profit calibration center for all glider types would be helpful. Maybe even for other instruments too."
"Alternative ways of powering (fuel cells)"
"Developing a low-cost, hybrid European glider. Building European infrastructure for maintenance and testing of different gliders (internationally available)."
"Developing best practices for glider data processing, data validation, QC and data formats. "
"create an european infrastructure for the refurbishment, change of batteries and sensor calibration, ballasting in order to reduce the costs at the minimum. "
"EU should maybe fund gliders operations (glider costs amortization and operational costs) to facilitate data sharing between different organizations."
"Invest funds for a better coordination of national gliderports (exchanges of technicians, engineers, exchanges of protocols, software applications, coordinated missions,...). Creating an European glider facility, including new sensor development and training. "
"1.- To support a sustainable large glider fleet under a common opertation protocols framework. 2.- To develop European glider technology. "
"Collaborative esearch projects Collaborative technical experiments Glider pool "
"Purchase a glider fleet for rent or loan to smaller institutes and users. Fund strategically placed coastal institutes to offer gliderport facilities."
"Funds to develop and test new sensors for gliders, e.g. pCO2, pH"

Table 5.5 *- Opinions of some European glider observatories with respect to best applications in which eventual funding, at a European level, could be invested -*

6. Annexes and References

6.1. Annex I: Directory of European Glider Observatories

BELGIUM

VITO	
Formal Name	*VITO - Flemish Institute for Technological Research NV*
Summary	*As independent and customer-oriented research organisation, VITO provides innovative technological solutions as well as scientifically based advice and support in order to stimulate sustainable development and reinforce the economic and social fabric of Flanders*
Address	*Boeretang 200;BE-2400 MOL;Belgium*
Contact	*Wesley Boenne [Researcher]* — *Email: wesley.boenne@vito.be* *Tel.: +32 14 33 55 11* — *Fax: +32 14 33 55 99*
Web Site	*Corporative: http://www.vito.be* *Glider Specific: N/A*
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Postdoc (1)	50	X			Technician (1)	50		X	

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

CYPRUS

CYCOFOS	
Formal Name	*Cyprus Coastal Ocean Forecasting and Observing System*
Summary	*The Oceanography Centre (University of Cyprus) developed and operates the operational CYCOFOS, which constitutes one of the ocean forecasting and observing system of relevant European and Mediterranean operational oceanographic forecasting and observing networks*
Address	*P.O. Box 20537; 1678, Nicosia; Cyprus*
Contact	*Dan Hayes [Researcher]* — *Email: dhayes@ucy.ac.cy* *Tel.: +22893987* — *Fax: N/A*
Web Site	*Corporative: http://www.oceanography.ucy.ac.cy* *Glider Specific: www.oceanography.ucy.ac.cy/cycofos/glider.html*
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	75			X	Glider Operator (1)	25			X
					Technician (1)	25			X

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

FRANCE

DT-INSU

Formal Name	*Division Technique de l'Institut National des Sciences de l'Univers*
Summary	*Since September 2008, this division centralizes the management of the gliders owned by various french institutions to overcome the technical challenges presented by these underwater instruments. Those challenges are widely shared by all glider users and are related to the vehicle preparation, maintenance and mission execution, amongst others*
Address	*INSU / Division Technique; Zone portuaire de Brégaillon; BP330; 83507; La Seyne cedex; France*
Contact	*Laurent Beguery [Head Engineer]* — *Email: laurent.beguery@dt.insu.cnrs.fr* *Tel.: 33 (0) 494304980* — *Fax: 33 (0) 494301672*
Web Site	*Corporative:* http://www.dt.insu.cnrs.fr *Glider Specific:* http://gfcp.ego-network.org
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	40		X		Glider Operator (2)	100		X	
Glider Operator (1)	50		X		Technician (1)	100			X
Technician (1)	70		X						

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

ENSTA

Formal Name	École Nationale Supérieure de Techniques Avancées Bretagne
Summary	*ENSTA Bretagne is a French national graduate engineering institute which offers three year engineering programmes to both civilian and military students. Its glider group is involved in the design, construction, sensor integration and hydrodynamics study of their own glider Sterne*
Address	*2 rue François Verny; 29806 Brest; France*
Contact	*Irvin Probst [Engineer]* — *Email: N/A* *Tel.: N/A* — *Fax: N/A*
Web Site	*Corporative:* http://www.ensta-bretagne.fr *Glider Specific:* N/A
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(2)	100		X		Glider Operator (1)	100		X	
Postdoc (1)	100			X					

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

IFREMER	
Formal Name	Institut français de recherche pour l'exploitation de la mer
Summary	*Ifremer is a public institute of an industrial and commercial nature which undertakes research missions, offers expert advice and acts as a funding agency. It is supervised jointly by two French ministries. Ifremer is one of these groups which cedes its own glider fleet to DT-INSU, centralizing organism which is hosted at Ifremer's Mediterranean centre in La Seyne-su-Mer (Toulon)*
Address	*Ifremer; BP70; 29280 Plouzane; France*
Contact	*Patrick Farcy [JERICO Project Coordinator]* *Email: patrick.farcy@ifremer.fr* *Tel.: +33 298224408* *Fax: N/A*
Web Site	*Corporative:* *http://www.ifremer.fr* *Glider Specific:* *N/A*

IRD	
Formal Name	Institut de recherche pour le développement
Summary	*The IRD is a French research organisation that, together with its southern partners, addresses international development issues To improve sanitary conditions, understanding the evolution of society and preserving the environment and resources are the pillars of its work. Similarly to Ifremer, IRD relies on the DT-INSU to manage and operate their gliders although, in that case, IRD is also an active glider group which is operating in French Caledonia*
Address	*N/A*
Contact	*Jean Luc Fuda [IRD Glider Responsible]* *Email: jean-luc.fuda@ird.fr* *Tel.: N/A* *Fax: N/A*
Web Site	*Corporative:* *http://www.ird.fr* *Glider Specific:* *N/A*

GERMANY

GEOMAR

Formal Name	*Helmholtz Centre for Ocean Research Kiel*
Summary	*GEOMAR is an institute in the field of marine sciences. It investigates the chemical, physical, biological and geological processes of the seafloor, oceans and ocean margins and their interactions with the atmosphere. It is dependent on federal and state ministries*
Address	*Düesternbrooker Weg 20; 24015 Kiel; Germany*
Contact	*Gerd Karhmann [Senior Scientist]* — *Email: gkrahmann@geomar.de* *Tel.: +49 431 600 0* — *Fax: +49 431 600 2805*
Web Site	*Corporative:* http://www.geomar.de *Glider Specific:* http://gliderweb.geomar.de
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	75		X		Glider Operator (1)	25		X	
PhD Student	25	X			Technician (1)	75		X	

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

HZG

Formal Name	*Helmholtz-Zentrum Geesthacht*
Summary	*The spectrum of activities at the Helmholtz-Zentrum Geesthacht has moved to accommodate the shifting focus of social, scientific and economic inquiry in order to arrive at the centre's present profile. Work in the field of coastal research is devoted to the growing and complex problems facing coastal regions worldwide*
Address	*Max Plancks str 1; D-21502 Geesthacht; Germany*
Contact	*Lucas Merckelbach [Scientist]* — *Email: lucas.merckelbach@hzg.de* *Tel.: +49 0 4152 87 1541* — *Fax: +49 0 4152 87 1525*
Web Site	*Corporative:* http://www.hzg.de *Glider Specific:* http://www.hzg.de/institute/coastal_research/cosyna/011570/index_0011570.html
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	100			X	Glider Operator (1)	100		X	
					Technician (2)	100		X	

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

AWI

Formal Name	*Alfred Wegener Institute for Polar and Marine Research*
Summary	*Centre for polar and marine research to contribute to Earth system and climate research in polar regions and coastal waters, aiming the identification of past and future changes in the global environment from a marine and polar perspective. It also pursues long-term research goals of the federal government.*
Address	*Bussestrasse 24; D-27567 Bremerhaven; Germany*
Contact	*Agnieszka Beszczynska-Möller (Scientist)* — *Email: agnieszka.beszczynska-moeller@awi.de* *Tel.: +49(471)4831-1807* — *Fax: +49(471)4831-1797*
Web Site	*Corporative:* *http://www.awi.de* *Glider Specific:* *N/A*
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Postdoc(1)	50	X			Glider Operators(4)	100			X
Technician(1)	20	X							

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

BWB

Formal Name	Bundesamt für Wehrtechnik und Beschaffung
Summary	The BWB and its agencies represent the armament sector below the Federal Ministry of Defense. As part of the armament sector, the BWB and its subordinate agencies have the task to ensure that the Bundeswehr demand is met by suppying state-of-the-art technology and modern equipment at economic conditions
Address	Berliner Str. 115; 24340 Eckernförde; Germany
Contact	Andreas Funk (Scientist) — Email: *adreas2funk@ bundeswehr.org* Tel.: +49 431 607 4148 — Fax: +49 261 400 5290
Web Site	Corporative: http://www.bwb.org/wtd71 *Glider Specific:* *N/A*
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	10	X			Scientific Staff(2)	20		X	
Glider Operators(1)	10		X		Technician(1)	10		X	

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

GREECE

HCMR

Formal Name	Hellenic Centre for Marine Research
Summary	The HCMR aims to carry out scientific and technological research, and experimental development, dissemination and implementation of produced results, especially in the fields of study and protection of the hydrosphere, its organisms, the coast and the sea bottom amongst others
Address	46,7 Km Athens-Sounion Road; 19013 Anavyssos; Greece
Contact	Leonidas Perivoliotis [Head of Operational Team] Email: *lperiv@hcmr.gr* Tel.: +302291076400 Fax: +302291076323
Web Site	Corporative: *http://www.poseidon.hcmr.gr* Glider Specific: N/A
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Postdoc (1)	25			X	Technician(1)	25			X
PhD Student(1)	25			X					

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

ITALY

OGS

Formal Name	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale
Summary	It promotes and implements on a national and international scale with similar partners scientific and technological research with the adi of global oceanographic research vessels as well as strategic and excellence infrastructures according to the field of competence
Address	Borgo Grotta Gigante 42/c; 34010 Sgonico (Trieste); Italy
Contact	Riccardo Gerin [Researcher] Email: *rgerin@inogs.it* Tel.: +39 040 2140314 Fax: +39 040 327307
Web Site	Corporative: *http://www.ogs.trieste.it* Glider Specific: N/A
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	100		X		Scientific Staff(1)	100			X
Technician(1)	100			X					

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

NATO STO-CMRE	
Formal Name	NATO's Science & Technology Organization Centre for Maritime Research & Experimentation (formerly known as NURC)
Summary	The Centre for Maritime Research and Experimentation (CMRE)is an established, world-class scientific research and experimentation facility that organizes and conducts scientific research and technology development, centered on the maritime domain, delivering innovative and field tested Science & Technology (S&T) solutions to address defense and security needs of the Alliance.It is an executive body of NATO's Science and Technology Organization (STO)
Address	Viale San Bartolomeo 400, 19126 La Spezia, Italy
Contact	Daniele Cecchi [Glider Pilot & Data Processing] Email: *cecchi@cmre.nato.int* Tel.: N/A Fax: N/A
Web Site	Corporative: *http://www.cmre.nato.int* Glider Specific: N/A
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Glider Operators (1)	100		X		Glider Operators (1)	30		X	
Glider Operators (1)	35			X	Technicians (1)	70	X		
Technicians (1)	95		X		Technicians (1)	20			X
Scientific Staff (2)	100			X	Scientific Staff (1)	25			X
PhD Students (1)	15			X					

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

NORWAY

University of Bergen	
Formal Name	University of Bergen
Summary	University of Bergen sponsors the Bjerknes Centre for Climate Research, which is the largest climate research centre in the Nordic countries. Its main expertise resides in climate understanding, climate modeling and scenarios for future climate changes and quantification of climate changes
Address	Allégaten 55; NO 5007; Bergen; Norway
Contact	Svein østerhus [Senior Scientist] Email: *svein.osterhus@uni.on* Tel.: +47 555582607 Fax: +47 55589883
Web Site	Corporative: *http://www.folk.uib.no/ngfso* Glider Specific: N/A
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff (1)	100		X		Glider Operators (3)	100		X	
Technician (1)	100		X						

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

POLAND

IOPAS	
Formal Name	Institute of Oceanology, Polish Academy of Sciences
Summary	It was founded as the successor to the Marine Station of the Academy with the mission to generate knowlegde required to support the understanding, the sustainable use and protection of the marine environments
Address	Powstancow Warszawy 55; 81-712 Sopot; Poland
Contact	Waldemar Walczowski [Researcher] Email: *walczows@iopan.gda.pl* Tel.: +48 587311904 Fax: +48 585512130
Web Site	Corporative: *http://www.iopan.gda.pl* Glider Specific: N/A
Glider Team	(see table below)

Position (#)	(%)	I	P	C	Position	(%)	I	P	C

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

SPAIN

IMEDEA-SOCIB	
Formal Name	Sistema d'Observació i Predicció Costaner de les Illes Balears/Institut Mediterràni d'Estudis Avançats
Summary	SOCIB is a multi-platform distributed and integrated system that provides streams of oceanographic data and modeling services to support operational oceanography in a European and international framework. IMEDEA is an institute which develops scientific and technical interdisciplinary research in the area of Natural resources. Both organisms cooperate by providing personnel and vehicles to a common glider action
Address	C/Miquel Marqués, 21; 07190 Esporles; Illes Balears, Spain (photo N/A)
Contact	Miguel Martinez [Glider Coordinator] Email: *miguel.martinez@uib.es* Tel.: +34971611838 Fax: +34971611761
Web Site	Corporative: *http://www.imedea.uib-csic.es* , *http://www.socib.es* Glider Specific: *apps.socib.es/gapp* , *apps.socib.es/dapp* , *http://imedea.uib-csic.es/tmoos/gliders/*
Glider Team	(see table below)

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	15		X		Postdoc (1)	50	X		
Glider Operator (1)	100		X		Glider Operator (2)	100			X
Technician (1)	100			X	PhD Student (1)	75			X

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

PLOCAN	
Formal Name	Plataforma Oceánica de Canarias
Summary	PLOCAN is a general marine science and technology mobilization initiative that seeks to obtain the international socioeconomic business competitiveness derived from access to the oceanic space. The plan is to construct and operate an oceanic platform to install a group of experimentation facilities and laboratories located on the border of the continental platform
Address	Taliarte Road s/n; 35200, Telde; Las Palmas, Spain
Contact	Carlos Barrera [Head Underwater Vehicles] Email: *carlos.barrera@plocan.eu* Tel.: +34928134414 Fax: +34928133032
Web Site	Corporative: http://www.plocan.eu Glider Specific: N/A
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(2)	100		X		Postdoc (1)	100			X
Glider Operator (1)	100			X	Technician(2)	100			X
PhD Student (3)	100			X					

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

UK

SAMS	
Formal Name	Scottish Association for Marine Science
Summary	SAMS, through its department of Physics, Sea Ice and Technology, aims to make ocean observations more representative by moving away from ship-based measurements towards smart autonomous platforms focusing on flows over topography and the stirring and mixing that results, oceanic exchanges with/between the Atlantic and the Arctic and the mechanisms by which sea ice can modify the ocean-atmosphere interactions, amongst others
Address	Scottish Marine Institute, Oban; Argyll PA37 1QA; UK
Contact	Estelle Dumon [UUV Technician] Email: *estelle.dumont@sams.ac.uk* Tel.: +44 01631559 433 Fax: +44 01631559 001
Web Site	Corporative: http://www.sams.ac.uk Glider Specific: https://velocity.sams.ac.uk/gliders/
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	50		X		Glider Operator (1)	50		X	
Technician (1)	5		X						

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

NOCS	
Formal Name	National Oceanography Centre, Southampton
Summary	The MARS (Marine Autonomous and Robotic Systems) facility of NOCS delivers National Capability in Autonomous Vehicles in an impartial and transparent manner to the UK's marine science community, incorporating operations, research and development and to provide a focal point and champion for this community, raising its profile and impact with key stakeholders, research funding bodies and the public
Address	European Way Southampton; SO14 3ZH; UK
Contact	D. White [Glider Manager] Email: *dwh@noc.ac.uk* Tel.: +44 02380596154 Fax: N/A
Web Site	Corporative: *http://www.noc.ac.uk* Glider Specific: *http://www.noc.soton.ac.uk/omf/projects/glider/data.php* , *http://cobs.pol.ac.uk/cobs/gliders/*
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	30	X			Glider Operator (3)	100		X	
Technician (1)	5		X						

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

UEA	
Formal Name	University of East Anglia
Summary	The Metereology, Oceanography and Climate Dynamics group in the School of Environmental Sciences at UEA focuses its research in Physical Oceanography. Ocean circulation, its role in climate, and the interactions between atmosphere, ocean, cryosphere and biosphere. Stable isotope oceanography, particularly interaction with sea ice and glacial ice; ocean mixing; forcing and dynamics of fronts and circulation; satellite altimetry, particularly of eddies
Address	University of East Anglia, Norwich NR4 7TJ, UK
Contact	Bastien Queste [Postgraduate Researcher] Email: *b.queste@uea.ac.uk* Tel.: N/A Fax: N/A
Web Site	Corporative: *http://www.uea.ac.uk* Glider Specific: *ueaglider.uea.ac.uk*
Glider Team	see table below

Position (#)	(%)	I	P	C	Position	(%)	I	P	C
Scientific Staff(1)	30	X			Glider Operator (3)	100		X	
Technician (1)	5		X						

(%): Percentage of dedication to glider tasks; Type: (I) Indirect, (P) Permanent, (C) Contract

6.2. Annex II: Questionnaire to JERICO partners regarding glider observatories

In this section we present the questionnaire prepared during the initial phase of the JERICO project. The large spreadsheet generated has not been annexed to this document but is available upon request to the JERICO Coordinator.

Respondent

1 Please indicate your details:

- Organisation: ____
- Completed by: ____
- Email: ____
- Role: ____
- Address: ____
- Website: ____
- Glider specific website (if available): ____

PART 1: Review of existing glider operations

2 How many missions and/or deployments did you undertake in 2010 / 2011?

	2010	2011
Missions		
Deployments		

Missions signify an experiment and can be single glider or multi-glider missions, deployments are the number of gliders deployed in the year, i.e. the total number of gliders deployed across all missions

3 How many days total (in the water) did you achieve during these missions in 2010 / 2011? For multi-glider missions the days total are the total number of days (in the water) across all gliders deployed, sum of all 'glider' days for the mission

	2010	2011
Please indicate a number		

4 What were the location of these missions in 2010?
(e.g. Gulf of Lions, Sargasso Sea, South of Cypress)

Answer

5 What were the location of these missions in 2011?
(e.g. Gulf of Lions, Sargasso Sea, South of Cypress)

Answer

6 Please indicate the number of these missions that were focused on

	2010	2011
coastal waters		
open seas		
both		

7 Please indicate the number of these missions that were

	2010	2011
single glider operations		
multi-glider operations		
in combination with other in situ platforms		
in combination with remote sensing		

8 Please indicate the number of missions with the following objectives
note: missions may have more than one objective, please indicate primary

	2010	**2011**
Specific process orientated / scientific topics		
Long term monitoring		
Operational experiments		
Environmental challenges – MSFD/GES/emergency response		
Other (specify)		
Other (specify)		
Other (specify)		

9 Please rank from 1 to 3, with 1 being the highest, the areas to which gliders have contributed to most and area to which you believe gliders will contribute the most in the next 5 years?

	have contributed	**will contribute**
Specific process orientated / scientific topics		
Long term monitoring		
Environmental challenges (MSFD/GES/emergency response)		
Other (specify)		

PART 2: Review of glider facilities and technology

10 How many gliders do you currently have / plan to purchase (2012-2013)?
note: indicate number per type

	currently have	plan to purchase
Seaglider		
Slocum Coastal G1		
Slocum Coastal G2		
Slocum Deep G1		
Slocum Deep G2		
Spray		
ACSA		
Other (specify)		

11 How many gliders with extended battery capability do you currently have / plan to purchase (2012-2013)?

	currently have	plan to purchase
Please indicate a number		

12 How many of these gliders are currently operational or operationally ready?
note: i.e. not in repair

- Other (specify)
- Seagliders
- Slocum Coastal
- Slocum Deep
- Spray
- ACSA

13 How many people are there in your glider team, by role and type?
note: If a person is not full time indicate the average % of a working year that they spend working with the glider team, e.g. 25% = 0.25 persons

	indirect	**permanent**	**contract**
Postdocs			
Glider operators (glider trained technicians)			
Technicians (general support for gliders)			
Permanent scientist staff			
PhD students			

14 What workshop facilities do you have / plan to have, and are these facilities available for outside use. Please indicate the size (m^3) and if appropriate the type of facility.

	have (yes/no)	**plan to have (yes/no)**	**available to outside use (yes/no)**	**size / type**
Ballasting facilities				
Repair / preparation labs				
Pressure testing				
Calibration facilities				
Other				

15 What sensors do you have / plan to purchase (2012-2013) and what is the sensor model?
Please indicate the number and separate with a comma if more than one model, e.g. Wet Labs FLNTU (x3)

	have (sensor model/s)	**plan to purchase (sensor model/s)**
Un-pumped CTD		
Pumped CTD		
Oxygen sensor		
Fluorometer		
Optical backscatter / Turbidity		
CDOM		
PAR		
Nitrate		
Beam attenuation meter		
Radiance		
Irradiance		
ADCP		
Turbulence / velocity shear		
Other (please specify)		
Other (please specify)		

16 What vessels and/or launch methods do you have / plan to have / use regularly for the launch and recovery of gliders?
For those vessels available, please indicate if the vessels are controlled by the glider group.

	plan to have	under group control	have available	use regularly
Large RIB (5 – 9 m)	☐	☐	☐	☐
Small vessel (< 12 m)	☐	☐	☐	☐
Medium vessel (< 25 m)	☐	☐	☐	☐
Large vessel/survey ship	☐	☐	☐	☐
Beach launch	☐	☐	☐	☐
Other	☐	☐	☐	☐

PART 3: Review of best practices for a fleet of gliders

17 Do you have a standard pre-mission preparation checklist?

- ☐ Yes *(Incluir hoja de checklist)*
- ☐ No

19 Have you developed a standard procedure for sea trials that is undertaken before scientific missions?

- ☐ Yes
- ☐ No

Tests of gliders include status.mi, overtime, ovrdepth, w50, and v100 missions to ensure correct flight and pressure testing. The gliders that have suffered a mechanical change or have been received from factory must be tested in a 1 or 2 weeks technical mission to ensure proper working and behaviour. The pressures of the glider in those technical mission increase every 200m. Also they perform a 12h mission during night at the maximum depth reached during day. Those consecutives increases of depth minimize the posibility of damages and glider loss.

21 How long (approx. number of days) does your pre-mission preparation take in the lab / at sea and on average how many people are involved?
note: number of people at sea excludes boat crew

	days in lab	days at sea	number of people in lab	number of people at sea
Seagliders				
Slocum Coastal				
Slocum Deep				
Spray				
ACSA				
Other				

22 What (if any) are the biggest bottlenecks in preparing gliders for missions, by platform?

- Seagliders
- Slocum Coastal
- Slocum Deep
- Spray
- ACSA
- Other

23 Do you have a standard calibration procedure (in-house or by manufacturer) for the glider sensors? What is the usual time interval between calibrations (in months)?

	standard procedure (none / in-house / manufacturer)	time interval (in months)
Unpumped CTD		
Pumped CTD		
Oxygen sensor		
Fluorometer		
CDOM		
PAR		
Nitrate		
Optical backscatter / Turbidity		
Beam attenuation meter		
Radiance		
Irradiance		
ADCP		
Turbulence / velocity shear		

25 Who leads your mission definition, planning and operation?

	definition	planning	operation
PI	☐	☐	☐
Glider team leader	☐	☐	☐
Other	☐	☐	☐

26 Although glider mission planning is complex (e.g. sampling strategy vs. battery life), please indicate the key mission planning aspects generally considered for your glider missions.
Please rank from 1 to 15, with 1 being the highest and list any not mentioned

	Rank
scientific objective	
length of mission	
cost	
strong currents	
bathymetry	
risk of collision with shipping	
optimal path analysis	
type of battery	
sensor sampling settings	
data transmission	
availability of piloting coverage	
launch location and conditions	
recovery location and conditions	
vessel availability	
emergency recovery in case of failure	
other (specify)	
other (specify)	
other (specify)	

27 What are the key safety aspects considered when working with gliders?
Please rank rank all that apply from 1 to 4, with 1 being the highest and list any not mentioned

	Rank
Recovery procedure to vessel	
Deployment procedure from vessel	
Use of lithium batteries	
Lifting heavy weights	
Other (specify)	

28 Do you have tools for path-planning analysis that consider environmental conditions? How frequently are they used?

	no	every mission	some missions	occasionally
pre-mission path planning tools	☐	☐	☐	☐
in-mission path planning tools	☐	☐	☐	☐
in-mission adaptive sampling tools	☐	☐	☐	☐

29 Who pilots your gliders during the mission?

- ☐ Glider operators (glider trained technicians)
- ☐ Permanent scientist staff
- ☐ PhD students
- ☐ Postdocs
- ☐ Other:

30 How many pilots to gliders do you have for single and/or multi-glider operations?
If you have a standard system of watches please indicate the number of pilots and the number of hours each pilot is on watch during the week/weekend, e.g. 2 / 12 hrs.
If you use an automated piloting system as support please indicate what system used.

	pilots/gliders *(e.g. 1/3)*	**weekdays (pilots/hours per watch)**	**weekends (pilots/hours per watch)**	**automated pilot system (what system)**
single glider missions				
multi-glider missions				

31 In 2010 how many gliders failed whilst deployed on mission, or were lost?
note: please indicate by platform

	failed during deployment	lost
Seagliders		
Slocum Coastal		
Slocum Deep		
Spray		
ACSA		
Other		

32 In 2011 how many gliders failed whilst deployed on mission, or were lost?
note: please indicate by platform

	failed during deployment	lost
Seagliders		
Slocum Coastal		
Slocum Deep		
Spray		
ACSA		
Other		

33 In the last year what have been the causes of mission failure, if any, by platform?
e.g. leak, early battery failure

- Seagliders
- Slocum Coastal
- Slocum Deep
- Spray
- ACSA
- Other

34 What communications systems do you use, as primary and secondary?

	Primary	Secondary
RUDICS	☐	☐
Dial-up	☐	☐

35 Have you experienced problems with biofouling?

- ☐ Yes
- ☐ No

PART 4: Review of best practices for a glider fleet

37 Do you have established data management procedures for the following? And if so do they follow internationally established guidelines?

	established procedures (yes/no)	internationally established guideline (please specify)
Real Time QC		
Real Time Validation		
Delayed Mode QC		
Delayed Mode Validation		

38 Are you routinely performing in situ quality control / verification procedures on the following types of data? Please note the in-situ quality control / verification procedures routinely performed.
e.g. CTD cast from deployment vessel, in-situ mooring CTD

	quality control / verification (none / what procedure)
Hydrographic data	
Biogeochemical data	
Navigation data	
Acoustic data	
Other (please specify)	

39 Which of the following data processing procedures do you ordinary use for real-time / delayed mode data?
Please tick all that apply

	realtime	delayed mode
Removal of anomalous values	☐	☐
Filtering of pressure	☐	☐
Salinity correction	☐	☐
Compass correction/accuracy procedure	☐	☐

40 In what format / formats do you archive and/or disseminate your glider data (please name format), and is this with metadata?

	Archive (format)	Disseminate (format)	With metadata (yes/no)
Real-time data made publically available through institution web site			
Real-time data made publically available through other web site			
Delayed mode data archived and made publically available through institution web site			
Delayed mode data archived and made publically available through other web site			
Data sent to European/other data management and archive projects			

41 Is your glider data used for any of the following?

	Not used	Ocassionally used	Routinely
Ocean state characterisation and variability	☐	☐	☐
Assimilated into models for forecasting	☐	☐	☐
Products for marine users (leisure, commercial)	☐	☐	☐

42 Do you have or use any specific glider web application or tool for public outreach and communication of glider activities?

- ☐ Yes
- ☐ No

44 What was the total annual operating budget of your glider facility in 2010 / 2011 in €?

- 2010
- 2011

45 What was spent (approx.) in the following areas in 2011, in € (excluding VAT)?

- purchase of gliders
- purchase of sensors
- glider infrastructure (e.g. pressure chamber)
- glider equipment (e.g. tools, R&D, launch)
- safety equipment
- batteries
- consumables other (e.g. cables)
- iridium
- communications other (Argos, mobile)
- spare parts for repair or upgrade etc.
- calibration (outsourced)
- vessel costs (e.g. hire, fuel)
- transportation of equipment
- personnel permanent
- personnel contracted
- personnel indirect (estimate)
- travel personnel
- training personnel
- data centre costs
- insurance (gliders)
- rent buildings
- waste disposal/service from institute
- depreciation total (gliders, sensors, equipment) 0

PART 5: Review of future glider operations and technology

46 What features would you most like improved in gliders as an oceanographic instrument, by platform?
Please rank from 1 to 13 where 1 is the highest

	Seaglider	Slocum	Spray
Ease of maintenance / repair	☐	☐	☐
Reliability of performance - mechanical	☐	☐	☐
Reliability of performance - communications	☐	☐	☐
Reduce time taken in pre-mission preparation	☐	☐	☐
Increase in sensor accuracy	☐	☐	☐
Increase ease of launch/recovery procedures	☐	☐	☐
Increase mission length capability	☐	☐	☐
Increase depth capability	☐	☐	☐
Reduction in cost of mission communications	☐	☐	☐
Reduction in cost of batteries	☐	☐	☐
Reduction in costs other	☐	☐	☐
Provide AIS or other anti-collision capability	☐	☐	☐

47 What do you consider the most important contribution that glider manufacturers could make to support European best practice in glider operations, by platform?
Please rank from 1 to 5 where 1 is the highest

	Seaglider	Slocum	Spray
Certification/training for battery change (seaglider only)			
European support centre			
Faster resolution of issues			
Host technical discussion forums			
Provide advanced technical training			

48 What do you consider the most important services that a national/European glider research infrastructure could provide to support national/European glider operations?
Please rank from 1 to 11 where 1 is the highest

	National infrastructure	European infrastructure
scientific/technological forum		
training/support for glider operators		
data management		
a multi-platform interface for piloting		
portal for access to gliders for the wider scientific community		
links with the manufacturers		
links with other glider teams, for example USA, Australia, Canada		
outreach/dissemination activities on glider topics		
advise on safety issues		
technical services, such as calibration		
a maintenance facility or glider pool		

47 What do you consider the most important contribution that glider manufacturers could make to support European best practice in glider operations, by platform?

Please rank from 1 to 5 where 1 is the highest

	Seaglider	Slocum	Spray
Certification/training for battery change (seaglider only)			
European support centre			
Faster resolution of issues			
Host technical discussion forums			
Provide advanced technical training			

48 What do you consider the most important services that a national/European glider research infrastructure could provide to support national/European glider operations?

Please rank from 1 to 11 where 1 is the highest

	National infrastructure	European infrastructure
scientific/technological forum		
training/support for glider operators		
data management		
a multi-platform interface for piloting		
portal for access to gliders for the wider scientific community		
links with the manufacturers		
links with other glider teams, for example USA, Australia, Canada		
outreach/dissemination activities on glider topics		
advise on safety issues		
technical services, such as calibration		
a maintenance facility or glider pool		

49 What do you think will be best way of reducing the cost of glider operations in the next 5 years?

Answer

50 What do you think will be the key technological advances for gliders as a platform in the next 5 years?

Answer

51 What do you think will be the key topics that gliders will help address in the European Seas in the next 5 years?

- coastal waters
- open ocean
- or both

52 What do you think will be the key contribution that gliders can make to the European Coastal Observatories over the next 5 years?

Answer

53 If funds were available at a European level for investment in gliders, what in your opinion would be the best application for this funding?

Answer

6.3. Annex III: Report after JERICO/GROOM – EGO Glider Workshop (22nd-23rd May 2012, Mallorca)

[Note: The inclusion of Annex III has been discarded in order to avoid this D#3.2 report to grow excessively in number of pages. Therefore, as stated in the Document Description of the present report, Deliverable 3.2 should be accompanied by a PDF version of the JERICO/GROOM – EGO Glider Workshop report at whichever resource, physically and/or electronically, the first may be available]

6.4. Annex IV: Presentations exposed during the JERICO/GROOM – EGO Glider Workshop (22nd-23rd May 2012, Mallorca)

[Note: Notes in Annex III apply to the PDF collection of slides presented during the Workshop]

6.5. References

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