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Deliverable abstract & Executive summary
Marine Autonomous Systems (MAS) are key systems for the present and future of the Global Ocean Observing System (GOOS) and Ocean Observing in general. Maintaining and developing the MAS observation capacity in Europe requires long-term sustainability in terms of finances, human resources, and operations, which is lacking today and that GROOM RI intends to provide in the future. This document presents the financial aspects of a MAS Research Infrastructure, looking at the investment and running costs of MAS operations (specifically gliders), analysing in which aspects and to what extent a GROOM RI would benefit the RI partners from a financial perspective. The first part of this document explores the costs associated with MAS operation. In the case that the main expenses are related to investments and product purchase (of the platform and sensors), the MAS operations are then mainly limited by the human resources, preventing more deployments and leaving unused platforms on the shelves. Having that in mind, GROOM RI's objective is to: maximise the impact of the investments from the partners, and support operators, engineers and scientists to increase efficiency and simplify the whole data value chain, from purchase of the platform to the data delivery. At first glance, although adding the RI layer on top of institutes and countries capacity might be considered as adding costs and complexity. In reality, by harmonising, optimising and coordinating everyone's action through its services, GROOM RI will increase cost-efficiency, improve data and operation quality and provide a structured method for the overall MAS operations in Europe. This document highlights that while having an intrinsic functioning cost, the added value of the RI will overcompensate the added cost of the RI, while also improving capacity and quality of the operations and data. Assessing the performance, and the results delivered by the RI, is central to validate its operation and determine pathways to improvement. For that, various and more general KPIs are proposed and presented in this document with more specific ones, at the future stages of GROOM RI. Monitoring the activity through these KPIs ensures the RI sustainability, providing quantitative and qualitative measures of the work provided by GROOM RI. Finally, this deliverable acknowledges the need for sustained funding to answer the Grand Challenges that we are facing. As of today, funding is sparse and fluctuates from one year to another. By establishing a recognized and endorsed RI, GROOM will push MAS agenda in the countries and develop institutions' long term commitment, overcoming these issues. This document examines the different financial funding options that are offered to GROOM RI, depending on its legal status, and how it would benefit the MAS community for long term sustained operations.

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List of Abbreviations

CII	Core Impact Indicators
ASV	Autonomous Surface Vehicle
CNRS	Centre National de Recherche Scientifique (France)
EOOS	European Ocean Observing System
FMI	Finnish Meteorological Institute (Finland)
GEOMAR	GEOMAR Helmholtz Centre for Ocean Research Kiel (Germany)
GOOS	Global Ocean Observing System
HCMR	Hellenic Centre for Marine Research (Greece)
KPI	Key Performance Indicators
MAS	Marine Autonomous Systems
MI	Marine Institute (Ireland)
NOC	National Oceanography Center (United Kingdom)
PLOCAN	Plataforma Oceánica de Canarias (Spain)
UCY	University of Cyprus (Cyprus)
UG	Göteborgs universitet (Sweden)
UB	Universitetet i Bergen (Norway)
UP	Universidade do Porto (Portugal)
CMRE	Centre for Maritime Research and Experimentation
(M)RI	(Marine) Research Infrastructure
GOOS	Global Ocean Observing
GTT	Glider Task Team
ESFRI WG	European Strategy Forum on Research Infrastructures Working Group
KII	Key Impact Indicators
IGN	Irish Glider Network (IGN
PNG	Parc National Glider” PNG
NACO	Norwegian Atlantic Current Observatory

1. Background and context

Underwater and surface drones, labelled as Marine Autonomous Systems (MAS), particularly gliders, have become ubiquitous vehicles for transporting scientific payloads in various environmental locations, providing high quality observations, ranging from surface levels to depths of 1000 metres and even deeper for some of them. They play a crucial role for frontier marine research, ocean observing and in activities supporting the blue economy.

The complex physical and digital technology features of a distributed European infrastructure (composed of a central hub and nodes) required to optimise the use of Marine Autonomous Systems (MAS) were examined during the GROOM-FP7 design study. This analysis considered the perspectives of research and the needs of the Global and (future) European Ocean Observing System (GOOS & EOOS). Building on its predecessor, GROOM II aims to lay the groundwork for an advanced Marine Research Infrastructure (MRI), namely GROOM RI.

The viability of an MRI hinges on its ability to operate effectively and efficiently over an extended period of time, with a significant spatial imprint. For it to be considered viable, sustainability in terms of funding and operation is crucial. Key factors contributing to viability include sustained funding from reliable sources, operational efficiency through effective management, alignment with research priorities and technological advancements, support to high-impact research projects, and accessibility for researchers and scientists.

Consequently, this document aims to demonstrate how a GROOM RI can be cost-effective through reduced duplication, increased efficiency, shared principles and economy of scale. A first assumption is that the future GROOM RI will not have any equipment initially, and that the nodes will continue to operate MAS. GROOM RI will build on these capacities and provide tools and principles to foster collaboration and develop MAS operations to answer the European needs and build theEOOS and contribute effectively to the GOOS.

This deliverable, titled "*Financial Sustainability at Regional, National, and EU Levels*", results from work conducted in T3.2: *Financial Sustainability at National Level* and T3.3: *Financial Sustainability at Regional and EU Level*. The document's first part delves into the analysis of financial sustainability at the national level by assessing the cost of MAS operations and identifying levers of cost effectiveness improvement. The second part explores how the services provided by the GROOM RI will impact the financial aspects and increase the sustainability of MAS operations in Europe, while the third part determines a list of Key Performance Indicators (KPI) that will verify and acknowledge the added value of a GROOM RI. Finally, different paths for funding to set up the RI, as well as to maintain it, are explored in the fourth section.

2. Analysis of costs for a GROOM RI

This section will start the analysis by presenting the survey that was carried out to update the evaluation of MAS operations in terms of costs, followed by a focus on the European landscape, demonstrating it is a growing sector, which shows strong interannual and facility variability, and ending with overall cost estimates for MAS operations.

2.1. A SURVEY TO EVALUATE THE CURRENT LANDSCAPE

This part of the deliverable is based on the response to the GROOM questionnaire (see Appendix) from the partners operating gliders. This questionnaire has been first elaborated for 2011 for JERICO project, then improved for GROOM FP7 for 2011 to 2013, and then sent again during GROOM II H2020. The questionnaire asked about the investment, operational and personnel costs associated with running glider facilities and funding sources from 2015 to 2022. It was sent to all partners and spread through the EuroGOOS channel. The questionnaire was opened from January to April 2022 and reopened from June to September 2022 with some minor improvements. A total of 10 institutes answered this questionnaire.

- In order to increase the repeatability of the questionnaire and facilitate the analysis, the choice was made from the beginning to focus only on underwater vehicles, gliders, and not take into account the surface and other autonomous vessels which represent a smaller but developing amount of activity in Europe. This is relevant as the glider activity is more mature in most GROOM II partners and Ocean Sciences in general, hence giving more robust numbers.

- The results from this survey have to be analysed carefully, as some partners did not answer all questions for privacy reasons or simply because financial implications of glider activity are not separate from the global activity, thus making it impossible to give specific numbers. Keeping in mind that institutions from different countries have different financial models that can influence the results of the survey, clarifications were asked when necessary and good care has been taken in order to avoid misinterpreting missing or incomplete datasets.

- In a second run of the questionnaire, number of days at sea per year were asked, to compare financial efforts and results in terms of deployments.

In 2020, which is the last year considered in the questionnaire, there were an estimated 140 gliders in Europe (an investment of about 21 M€). In this survey, the respondents detail the costs of operating 84 gliders and all the main public operators have answered this questionnaire. One main caveat of this questionnaire is that, for privacy reasons (as they have commercial activity), NOC did not provide financial numbers, and just information on the workforce and the activity in itself. Hence, out of the 84 gliders owned by institutes who answered the questionnaire, only 50 relate to funding.

Some information from other institutes with glider activity or potential interest in the technology was recovered through the EuroGOOS GTT channel or through T2.4: Engagement of other countries/stakeholders, but no institution out of the project provided financial numbers. Getting these numbers requires a heavy process, to assess which numbers are public, which are not, what is directly related to gliders, what is more general, etc…, and only funded partners of the project would make this effort. GROOM II is only a design study and such study should be made more thoroughly to get more consistent figures in the next phases, but still provides a methodology and shows interesting patterns and ways to improve cost efficiency.

Respondent	Number of gliders owned in 2020
NOC - National Oceanography Center (UK)	34
UB - University of Bergen (NO)	14
GEOMAR (DE)	10
CNRS - National Scientific Research Center (FR)	8
PLOCAN (ES)	5
UG - University of Gothenburg (SE)	4
HCMR (GR)	3
MI	3
UP	1
OCY	1
FMI	1

2.2. A MATURE AND STRUCTURED EUROPEAN LANDSCAPE

As mentioned earlier, an extensive mapping of MAS capacity in Europe was performed in 2023, showing that the European MAS landscape consists of roughly 200 autonomous platforms (181 gliders and 20 ASVs) located in 58 facilities in 22 countries. This information is displayed on the GROOM-II website (https://www.groom-ri.eu/groom-ri-and-the-mas-european-landscape/).

Figure 1 - Map of the institute with MAS activity in Europe

The 11 institutes who answered the questionnaire represent around 35 FTE dedicated to glider operations. According to the questionnaire, the 35 FTE comprise 18 FTE for operators and technicians and 15 FTE for scientists and PHD/Post-Doc. This number is an order of magnitude as some data was missing and personnel time dedication specific to gliders can vary and is difficult to track, especially in the case of scientist and time accounted to producing science using glider data. Also, most operators are only partly dedicated to MAS and the repartition of their work is difficult to quantify. Relating this number to the 84 platforms owned by the respondents, this gives a ratio of around 2 to 3 gliders per FTE on average.

The glider community is large and well-structured by the EuroGOOS Glider Task Team (European level) and Oceangliders (representing the GOOS at global level), and the EGO network (all people with a glider related activity. More than 400 persons registered to the EGO network, which is primarily European but has a global footprint. The EuroGOOS GTT, on its side, comprises 45 members (https://eurogoos.eu/gliders-task-team/), which provides good representativity of the community. However, participation to EuroGOOS has a cost, which explains why not all institutions with glider activity participate to the EuroGOOS GTT

The surface vehicle community, although very close to the glider one, is less mature, as the technology is more recent, but is being structured right now. Work initiated in WP3 of H2020 Eurosea and continued within GROOM II gathered USV (Uncrewed Surface Vehicles) users together, mapping capacities and requirements of this emerging community. This process is also pursued within the OASIS project (https://airseaobs.org/) that is partly led by UG who is part of GROOM II consortium.

2.3. A GROWING SECTOR

2.3.1. Future science requirements

The oceans are a significant source of protein, economy and culture for billions of people around the world. Marine waters contain some of the most biologically diverse ecosystems on the planet, and a healthy ocean is essential for our survival and wellbeing. Human activities that affect ocean health are growing rapidly in variety, intensity, and impact. There is increasing development pressure in coastal waters for aquaculture, tourism and renewable energy, and there are both on-going and new stressors and threats to all parts of the ocean from land-based pollution, overfishing, other forms of extraction, and climate change. Existing management systems are insufficient to address the increasing impacts and to balance multiple planning objectives across sectors. New management approaches are essential for ensuring that coastal communities and the world's ocean nations will continue to reap long-term benefits that healthy oceans can provide.

90% of global warming happens in the ocean. Climate change already affects our ocean, and to ensure Good Environmental Status of the ocean, policies and directives have described the growing data and observation needs. These have been summed up in T5.1 - *Key societal benefits of a sustained glider infrastructure*, and D4.3 *"GROOM RI contribution to statutory monitoring frameworks"* which highlight the rising need for monitoring of the ocean and the role that MAS will have to meet these challenges.

The need for oceanographic data is growing, and MAS have become valuable tools in oceanography and marine science due to their ability to collect data over extended periods with high spatial resolution, minimal human intervention, and relatively low operational costs compared to traditional research vessels. They are a pillar for the future of Ocean Observing, and capacity is increasing in Europe and at global scale.

2.3.2. Towards sustained zero-carbon Ocean Observing

Decarbonation of the Ocean Observing System is key to maintaining sustained oceanographic capacity. MAS provide low carbon observations and as such, reduce the carbon footprint of the data. Decarbonation is one aim of the GROOM RI, as written in its vision statement : "*Be the European Research Infrastructure harnessing the advantages of Marine Autonomous Systems (MAS) to provide high-quality ocean observation data and services for the benefit of society, enabling scientific excellence* ***and moving towards net-zero activities***."

In its net-zero Oceanographic capability project, NOC sought to identify options for developing a world-class oceanographic capability with a reduced carbon footprint by presenting a range of options for transitioning to low or zero carbon capabilities. It is stated that MAS will play a central role in the future Marine Research Infrastructure, complementing ship and other platforms capacities.

To face the increasing demand for oceanographic data, all the while reducing its carbon footprint, autonomy, through floats, moorings and more importantly MAS are central. In OceanObs'09 whitepaper : Gliders as a Component of Future Observing Systems, it was estimated that, at global level, 300 endurance lines would be required and OceanObs19' whitepaper : OceanGliders: A Component of the Integrated GOOS, and in 2019, the objective was set to have 100 gliders at sea at any time during the following decade, which at European level means that the present activity should be multiplied by 3.

2.3.3. Technological developments

Technical development and improved capacities of the platforms make them suitable for a wider range of activities, targeting new fields of research, like carbon exchanges and Biological measurements. D5.2 - *Ensuring continued evolution with industry* provides an extensive view of the different sectors in which MAS can be used, showing great potential for the future. Markets for MAS platforms have been listed in D5.2, namely:

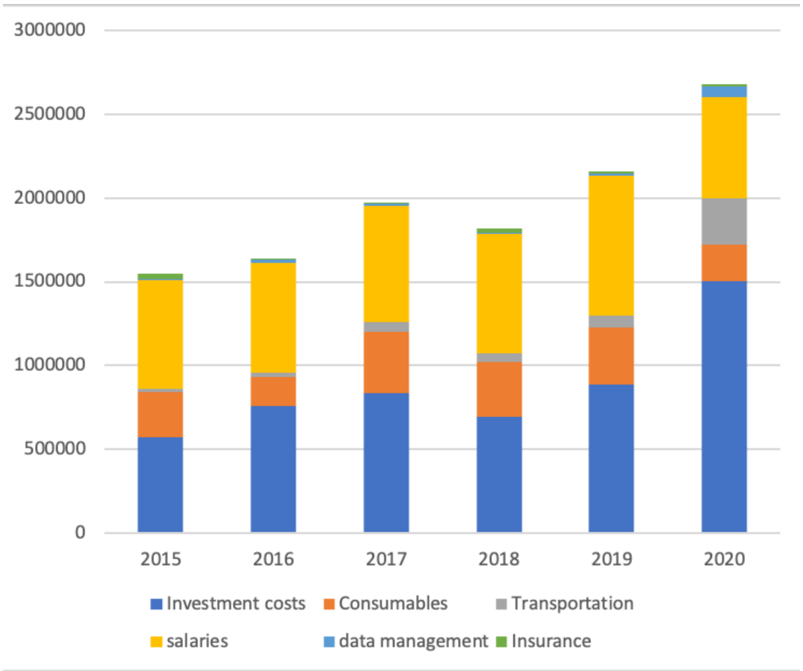
- Deep Sea Observation and potential exploitation
- European Marine directives
- Defence and maritime surveillance
- MRE: Offshore wind, Wave and tidal energy

Finally, the task *2.4 : Engagement of other countries/stakeholders*, by contacting every institute owning and using MAS, showed a growing interest in the MAS activities, and a general uptake of the technology by Institutions.

2.3.4. MAS growth in Europe

Due to all the above mentioned factors, MAS usage has been expanding since the first glider deployment in Europe by GEOMAR in 2004. Most institutions already using MAS are acquiring new platforms, developing new capacities and expanding their operations, and new institutions are starting to use MAS. These platforms have a key role in the future Ocean Observing capacity and are being uptaken by the oceanographic community.

One way to represent this growth is to look at the evolution of the expenses from the respondents of the financial questionnaire during the 2015-2020 period.



Overall expenditures for the MAS operations from the aggregated answers of the questionnaire, from 2015 to 2020.

In 2020, there were 2,77 M€ expenditures for 50 gliders, which, scaled up to the 181 gliders in Europe, can lead to a global budget of around 10 M€

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2.4. WITH STRONG HETEROGENEITY AND INTERANNUAL VARIABILITY

The community has expanded coordinated by the loose steering of EGO and EuroGOOS GTT, and has yielded to a heterogeneous landscape, with various fleet sizes, experiences and funding capacities. Every facility has a different size, expertise and maturity, and the scope of the glider activities greatly vary, from simple lab activity to more structured facilities. If at European level, the investment shows a rather steady increase, this is not the case any more when looking at each partner separately. Cost greatly varies from one institute to another and also from year to year. The global repartition of costs every year among the respondents is shown in the following graph.

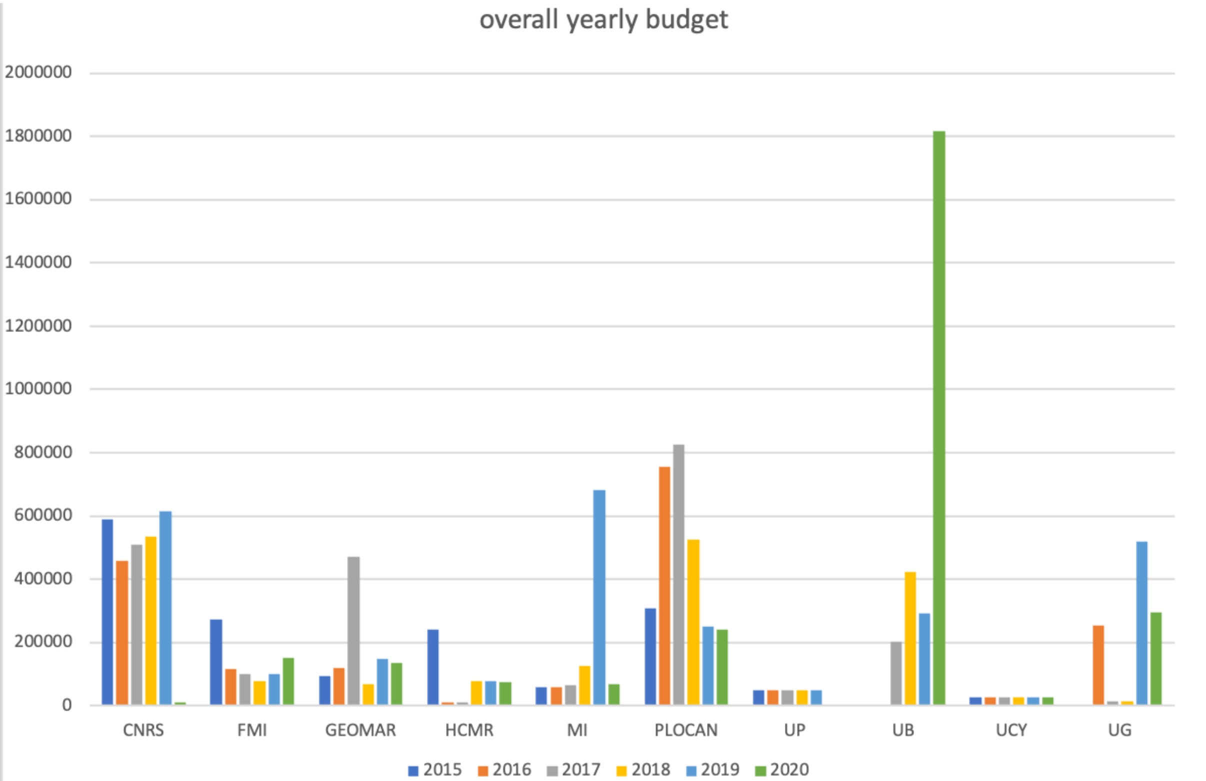


Figure 2 - Overall budget by year and by institute, according to the survey

Within institutions, budgets can strongly differ from one year to another, mostly impacted by the purchase of the platforms themselves. For a small entity with few platforms, investing in a new MAS is not done every year and represents a strong portion of the budget assigned to MAS operations. This complexifies the trend analysis for each partner, but regrouping at European level soothes out this variability, hence providing a more accurate picture of the European capacity and associated costs. By structuring the MAS activities at European level and requiring long term commitment of the nodes, GROOM RI will help sustain each nodes' budgets and involvement.

While some pioneering institutions started glider activity in 2004 (GEOMAR, CNRS/LOCEAN), other institutions only recently set up their facility. This difference in maturity impacts the investments, which are higher for starting facilities, as will be described in the section *Costs repartition for each partner*.

Setting up a robust activity requires expertise and knowledge, and while the investments for newly arriving institutions will remain, as platforms will be owned and purchased by the institutions, GROOM RI, by coordinating the nodes and sharing capacities, will help these newly arriving institutions to set up their MAS operations, integrate them in the Ocean Observing landscape, and optimise the activities of more mature facilities. This will save time and personnel costs, and the option to rely on other nodes' services will also limit the investments. For instance, glider ballasting, sensor calibration, or data management do not have to be necessarily done in-house and can be externalised to expert nodes.

2.5. Overall costs for MAS operations

In the questionnaire, the different sources of costs have been asked and have then, for the analysis, been regrouped in different categories described in the following table, following the categorisation done in GROOM FP7.

Table 1 - Categorisation of the different costs induced by MAS operations

Category	Cost source		
Investment	Purchase of gliders	Purchase of sensors	Glider infrastructure equipment (e.g. pressure chamber, ballast tank, etc):
	Glider equipment (e.g tools, R&D,....):	Glider safety equipment	Building rent/construction:
Consumables	Batteries	Iridium	Argos
	Other communication & consumables	Spare parts/repairs	Calibration
Transportation & vessel hire	Vessel hire	Transportation of equipment	
Salary	Permanent people	Contracted people	People travel
	People piloting	Outsourced piloting	People training
Data management	Delayed mode data management cost	Other costs related to data management	
Insurance	Shipping insurance	Glider loss insurance	
Indirect cost	Indirect cost / overhead (estimate)	Other	

Total operation costs can be quantified in 3 different ways. This categorisation was used in GROOM FP7 and is used again here.

- The marginal cost represents the extra cost induced by adding one glider at sea for a mission. It includes the costs directly related to the glider at sea: batteries, iridium, and first level maintenance of gliders. (consumables, transportation and vessel hire, and insurance).
- The intermediate costs include marginal costs, salaries, data management and overhead.
- Consolidated costs include all the functioning costs including depreciation to give the most complete acknowledgment of what the facilities pays.

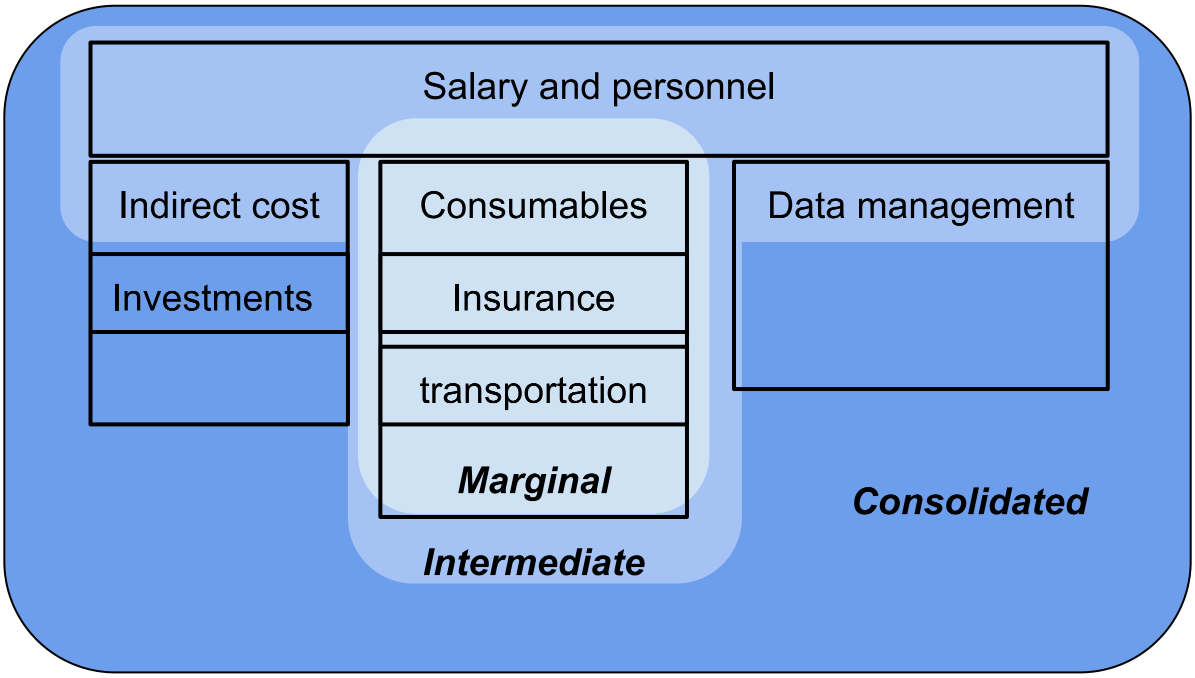


Figure 3 - Quantification of the costs

2.5.2. Costs repartition for each partner

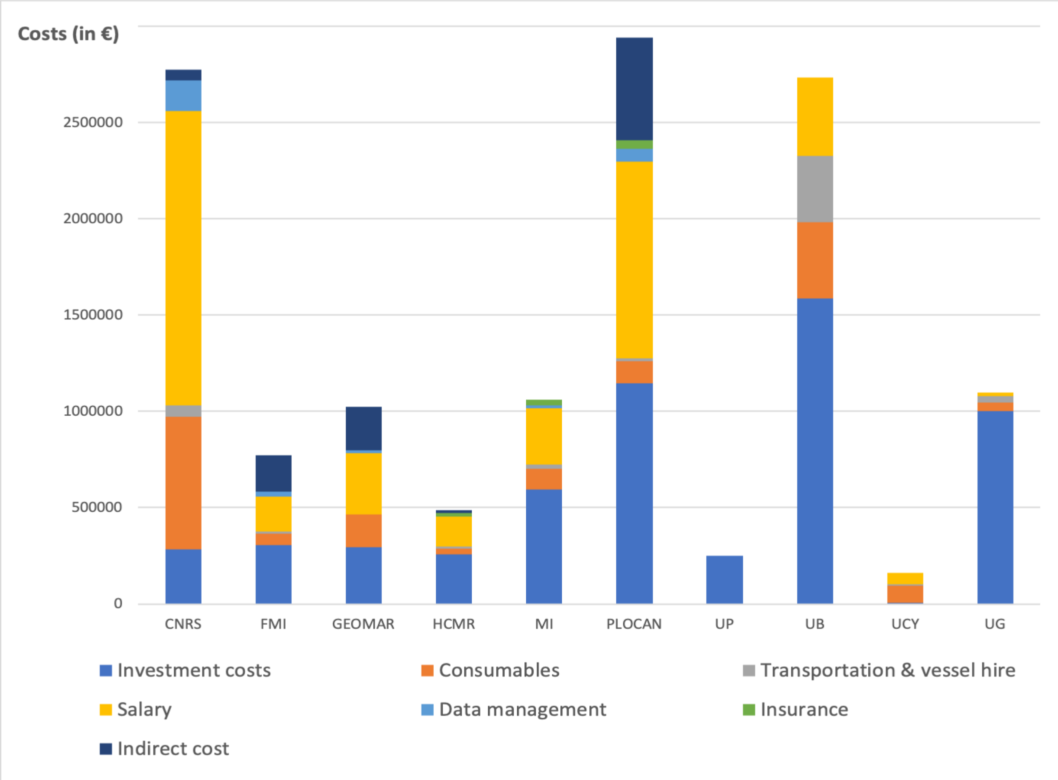


Figure 4 - Repartition of costs in each institution by category for the whole 2015-2020 period

Table 2 - Repartition of costs (in %) by category

In %	CNRS	FMI	GEOMAR	HCMR	MI	PLOCAN	UP	UB	UCY	UG	TOTAL
Investment costs	10	40	29	52	56	39	100	58	4	91	41
Consumables	25	8	17	7	10	4	0 - N/A	15	54	4	13
Transportation & vessel hire	2	1	0	2	2	1	0 - N/A	13	4	3	4
Salary	55	24	31	32	28	35	0 - N/A	15	37	2	31
Data management	6	3	1	0	1	2	0 - N/A	0	0	0	2
Insurance	0	0	0	4	3	2	0 - N/A	0	0	0	1
Indirect cost	2	24	22	3	0	18	0 - N/A	0	0	0	8

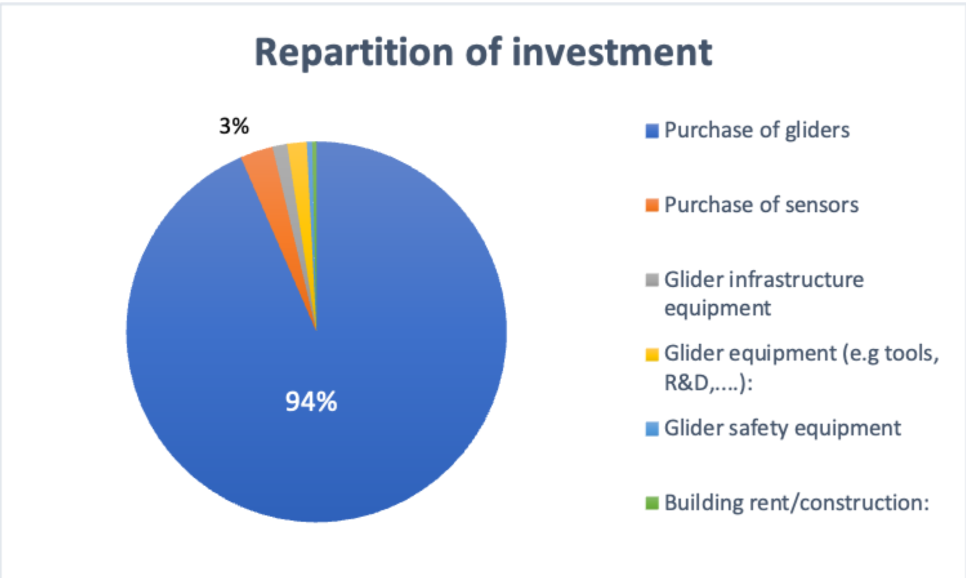
Investments and salaries are the biggest expenses. This ratio depends on the maturity level of the facility. For example, comparing CNRS, which had an established facility set up in 2009, and UB, which started an ambitious facility during the years of the questionnaire, show that difference.
Setting up a facility or expanding requires strong investments, which are 58% of the total expenses of UB (only 10 % for CNRS). Running a facility already equipped requires trained and proficient personnel, which represent 55% of CNRS budget (15% for UB). One way to take this into account is to account for depreciation of the investments.
Another note is that salaries depend on the country, by up to a factor 3, while other expenses like glider purchase are mostly equivalent across Europe.
Insurance costs represent negligible costs, with multiple entities not having one specifically dedicated to gliders and that are embedded in the global insurance of the institute. GROOM RI could implement best practices and rules on that matter, providing more security and more reliability to the operations at sea.

2.5.3. Limits of the analysis

The above first description of the results from the questionnaire make visible the limits and the lack of data from the survey:

- At a general level :
  - Personnel is often not only recruited to work on MAS and thus salary is spread within different activities, and specified as a portion of FTE. But in reality, the repartition of work is difficult to assess and might not be reflected by the portion of FTE displayed.
  - Data Management is also difficult to quantify as, in small organisations, the PI is in charge with no special dedicated time, even though this aspect is crucial as data is the end product of the operations.
- UP : the numbers given only refer to the purchase of one glider
- NOC : for privacy reasons according to their commercial activity, did not disclose any costs.
- UG : only travels as a mean of 3000 euros/year is displayed (hence the limited 2% salary cost) and lack of information from salaries.

2.5.4. Investments



Investments are highly dominated by platform purchase. Sensor purchase represents only 3 % of the investments, but it should be noted that standard sensors are frequently part of the glider purchase and not accounted for here. So the investment in sensors here relates to sensor replacement and backup or new sensors purchase.

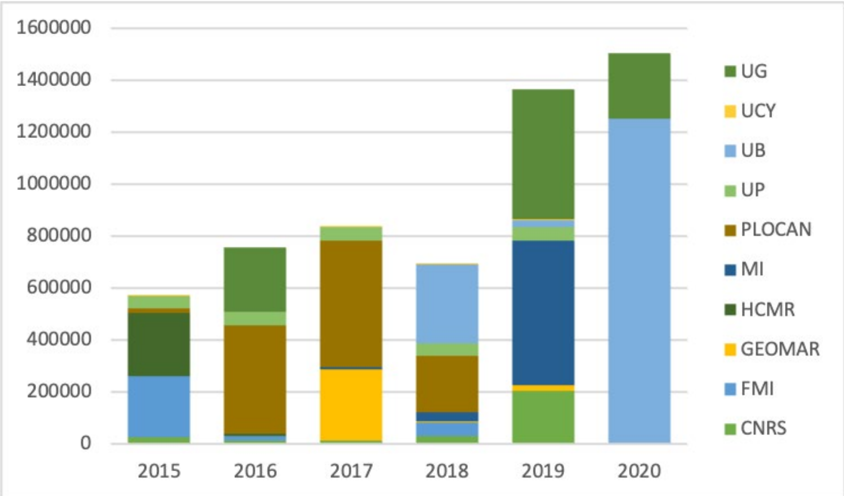


Figure 5 - Repartition of the investments for each partner by year

Investments remain very variable from one year to another, when funding is given to purchase platforms. In total, during our period of survey, 23 gliders were bought by the respondents. As the fleet is expanding, investments represent an important part of the expenses. With the massive uptake of autonomous platforms for ocean observing & monitoring, this trend will continue and investment will remain high.

Having secured funding and larger activity will help smooth out these investments and make them more repeatable from one year to another. NOC, who owns 34 gliders, buys one every year to renew the fleet.

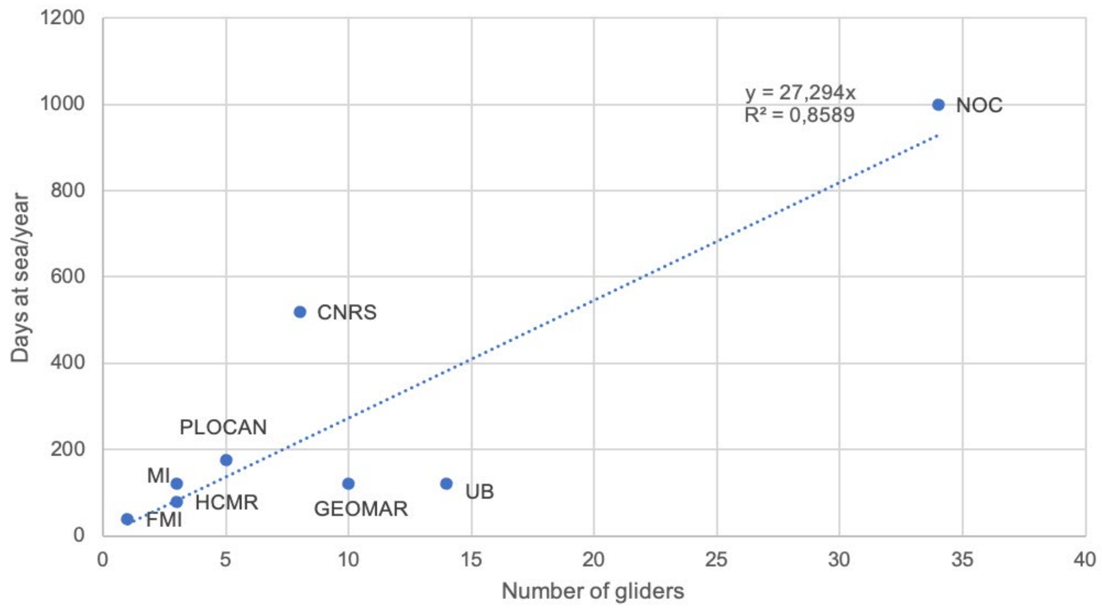


Figure 6 - number of days at sea per year by gliders

This is data from 2020 extracted from the questionnaire. Now, NOC displays their stats online (https://mars.noc.ac.uk/stats). In the past 24 months, NOC has reached 23 527 hours at sea, so around 1000 days, and have put 16 gliders at sea as part of their fleet of around 30 gliders, which shows steady numbers between 2020 and 2024. Activity is partially monitored and these numbers should be easily accessible through a portal, which is not the case yet. GROOM RI, in conjunction with other relevant networks described above (and OceanOps) will help have more consistent numbers and help monitor this interesting KPI of time at sea/glider/year.

It was imagined that an endurance line could run all year long with 3 rotating gliders, which would mean 120 days/sea per glider and per year. The previous figure shows that these numbers in Europe are not reached (at least in 2020), with only 30 days/sea/year/glider.

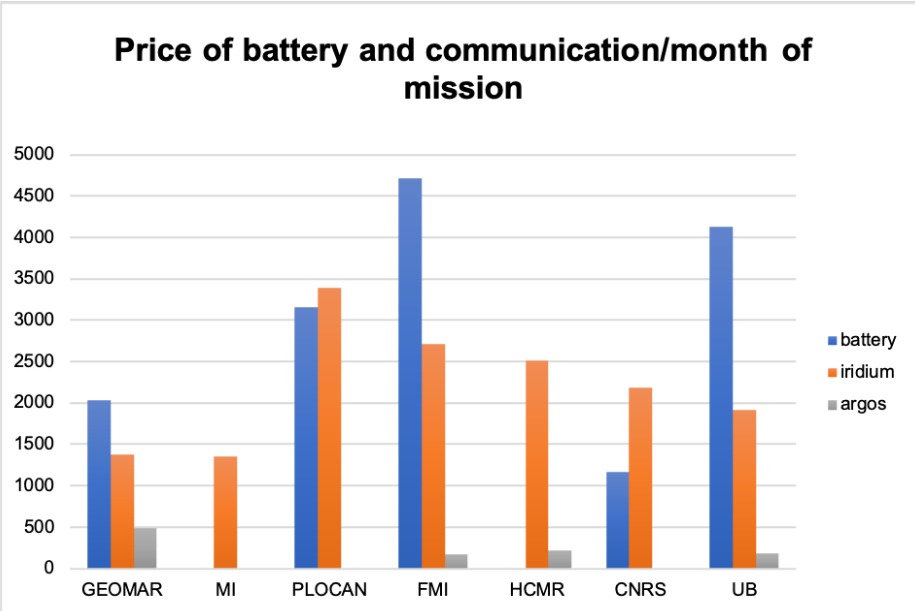
In 2024, VOTO has been running 4 endurance lines for the past 3 years with 16 gliders, with on average 3.4 gliders at sea at the same time, which gives 80 days/sea/year/glider (https://observations.voiceoftheocean.org/stats). VOTO is dedicated to these endurance lines that are near their facility. Having a clear mission and easy access allow for efficient operation and this statistic can be seen as an objective in the future.

The relative scattering along the regression (R^2=85%) shows that gliders are not used with the same efficiency in every institution. For example, CNRS reached 60 days/gliders/year and this number could be used as a good example of what an institute should be capable of. Hence, there are possibilities to improve the efficiency of MAS use, and that the number of gliders is not the main limiting factor for more observing time, and as such, better access to MAS from other institutes could allow usage of unused MAS platforms.

Gliders and sensors have a lifetime of roughly 15 years, so a 7%/year depreciation will be accounted for in further analyses. Taking as an estimate 200 000 €, amortised cost is 200 000 *7%=14 000 €. In order to adequate this value to the time at sea, one possibility is to look at the total amount of time that a glider spends at sea per year. On average, one glider spends around one month at sea per year. Hence, amortised cost per year = amortised cost per month at sea = 14 000 €.

2.5.5. Consumables

Consumables during a mission represent 3 types: the batteries, the iridium communication and the Argos.



First, we can see great disparity in batteries costs/month at sea, which is not surprising. Consumption depends on the type of mission: what sensors are used, the sampling rate and depth. For example, FMI uses its glider mostly on coastal and short missions, where battery consumption is high, due to the number of patterns and coastal missions tend to require higher sampling rates.

On average, the batteries cost 2700 €/month/glider (excluding MI and HCMR), which is lower than the results obtained during GROOM FP7: 140€/day/glider = 4200€/month/glider. On the one hand, technology has evolved in recent years, with sensors and gliders requiring less energy to function, but on the other hand, more capable sensors have also been integrated.

This calculation is not perfect, as the battery costs represents the batteries purchased and not the cost of the used ones. For example, if an institute has bought numerous batteries to increase the stock and that most has not been used, then we would see high costs for a few missions, which would increase the price. On the contrary, if batteries were already purchased before and have been used during the time of the questionnaire, the result will be lower battery price. This could explain the low cost for CNRS, of 1160 €/month/glider.

MI and HCMR have a cost of 0 because they use rechargeable batteries. Also, rechargeable batteries are now available, and are used by HCMR and MI. Even if the purchase cost is higher (around 40 000 euros), the battery does not need replacement after. This technology is still young and it is hard to assess the viability in the long term, but if we estimate a 15 year lifespan like above, depreciation would be of 2600 euros/year, which is the cost for around one month of glider/year with a standard battery. With this technology maturing, the price should get lower. Also, the carbon footprint should be taken into account, favouring rechargeable batteries. Hence, both solutions (one-time or rechargeable batteries) are, at the time present, similar in terms of costs with different advantages: rechargeable for lower footprint, with less servicing (no need to open the glider each time), but providing less energy and limiting the length of the mission.

GROOM RI, by promoting and developing best practices, will help optimise the battery consumption.

Iridium costs in the mean 80€/day/glider = 2400€/month/glider, which is stable from GROOM FP7 study, where the cost average was around 75€/day = 2250€/month/glider. With new applications for near real time glider data like meteorology and new sensors with heavy data, iridium communication requires a bit more data transfer. Iridium costs greatly depend on the institutions (a ratio of 2 can be seen), that could be explained by the amount of data transferred (how deprecated is the real time data sent from the glider to shore), and also by the contract in place, that depends on the size of the fleet and other components not evaluated here. GROOM RI, as a coordinator of the nodes, could centralise all the communication costs, and leverage the prices, by negotiating with the contractor and avoiding duplication in setting up the transmission using only one dock for all gliders.

Finally, Argos costs are mostly negligible.

- *Spare parts*

Spare parts are difficult to quantify, as they can be bought as prevision and be kept in case of a problem, hence be used later than they are paid for; they also are very dependent on the damage that a glider can undergo during its mission; they depend on the business plan of the institution (if it is better to repair or to buy new). In any case, this can be added to the investment costs, and be taken into account as glider purchase.

- *Calibration*

Calibration is an essential part of the preparation of the glider before launching it at sea. It takes into account the calibration of the sensor, of the compass & navigation station, and the ballasting (which might not be relevant for a surface vehicle).

Calibration facilities are expensive to set up. From the previous study during GROOM FP7, a calibration facility for CTD and optical sensors costs around 150 k€ (HZG) and 170k€, 50 k€ for CTD and 120 k€ for optical sensors (CMRE).

More devices are required for other sensors, which ends up being very costly. HCMR had invested more than 250k€ and OGS more than 500 k€. During GROOM FP7, OGS explained that it cost 450 euros for a standard CTD calibration.

The sensor calibration landscape is already developed in Europe, coordinated by MINKE (https://minke.eu/), and is not limited to gliders (and MAS in general). Most partners are already equipped with calibration and ballasting facilities that might not be used to their full capacity. More synergies, especially for very specific and targeted sensors, that are costly and difficult to calibrate, could be very useful.

Using other partners' facilities for calibration and preparation requires transporting of the platforms, which leads to extra time, extra risks and extra cost, but we believe that avoiding duplication and using already existing facilities, capacities and expertise will be profitable to the European MAS capacity, both in terms of costs and quality, relying on most experts' facilities in this domain.

2.5.6. Transportation

Transportation takes into account multiple costs: shipping the platforms for refurbishment or for sensor integration, and all the costs to bring the platform to its deployment area, and back to the lab.

For the first part and refurbishment, GROOM RI would help centralising and sharing all the necessary capacities in Europe, and in the case of the Slocum glider for example (manufactured and repaired by Teledyne Webb Research in the United States), this would limit the need to send the glider overseas and limit the transport costs.

For the access at sea for the deployments, the situation depends heavily on the type of deployment and the organisation within each country, as well as agreements with oceanic fleets. Multiple possibilities may include:

- Deployment from a research vessel, or an opportunity ship. This requires access to shipping time, and is mostly used when gliders and surface vehicles are used for specific missions combining multiple observation platforms (ship measurements, moorings, etc…)
- Rental or ownership of a small boat for coastal deployment. This is used mostly for coastal missions and testing, and also to run endurance lines. Renting or owning a boat are two options that depend on the investment capacity and the potential usage rate of such a boat. In 2014 during the GROOM FP7 study, only PLOCAN, that has a strong technological driver and hence as a lot of testing to perform, owned a rubber boat.

GROOM RI, by developing partnerships with other MRIs (as with the MoU signed with Eurofleets+) and providing a better planning management, will help access vessels of opportunity and research vessels and thus diminish costs and simplify the deployment logistics.

2.5.7. Human resources

Salaries represent 20 to 50 % of the running costs of a facility. Levels of salaries are very variable depending on the country (ratio of 2) and on the professional category, and part of the salaries that institutes pay directly in relation to glider operation is often not clear. However, human resources are critical and a limiting factor to maximise the fleets' capacities.

The following graph shows the correlation between the number of days at sea /year (vertical) and the FTE (horizontal).

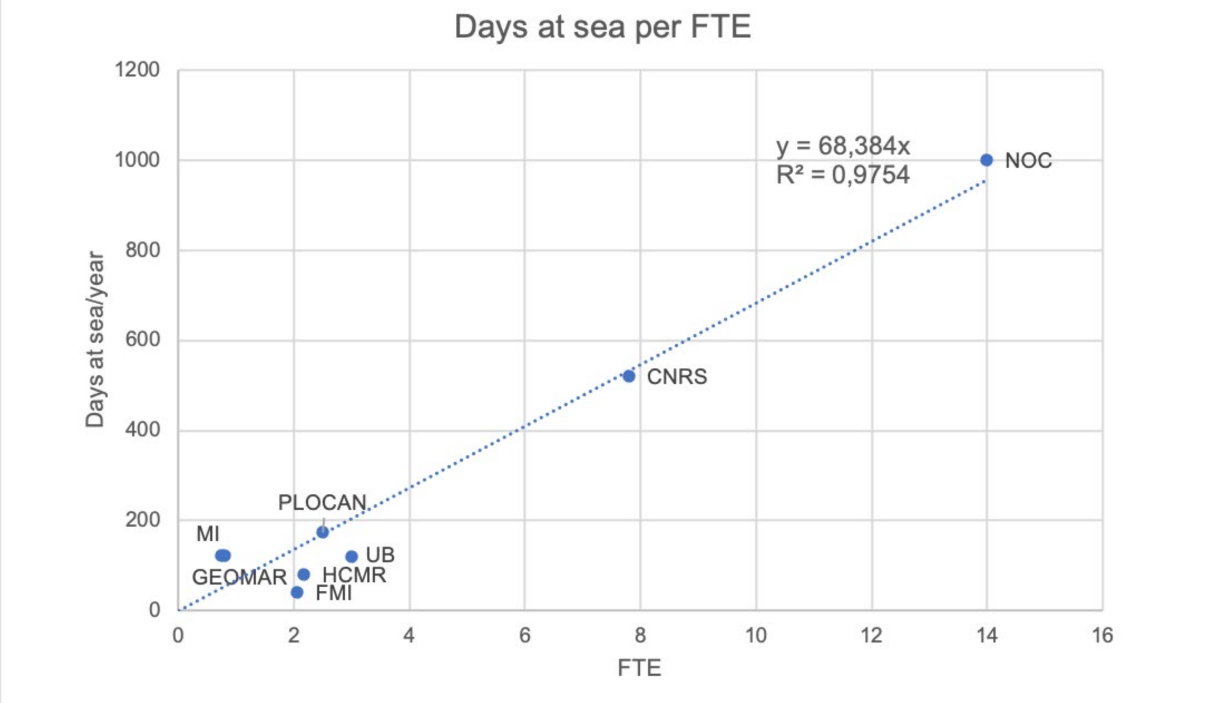


Figure 7 - Number of days at sea per year compared to the FTE in each facility

1 FTE=70 days at sea.

The linear regression explains has a r-squared of 97%. The 3 partners, CNRS, PLOCAN and NOC, have sustained operations for multiple years and fall right in the line. We could expect bigger institutions to be more efficient (economy of scale), which is not the case according to this data. 2 explanations have been discussed:

- Some work can not just be added and at some point, things become more complex (need for coordination when multiple gliders are at sea at some point). That is a critical reason to build a dedicated digital infrastructure that is in line with the growing physical capacity. This was detailed in WP6
- Bigger institutions have a much wider field of activity, and control more of the whole chain, from refurbishment to operation at sea to data management and software and technical developments, hence not providing more time at sea directly.

FMI, HCMR and UB have less days at sea compared to their personnel. This can be explained by 2 factors : these facilities have been set up more recently, and their missions are more coastal, which requires more piloting and shorter missions, hence more effort. UB was starting a period of growth and had just acquired multiple gliders in 2020, and the facility was being set up. Having more recent data would certainly show much improved results from them.

In the graph, one FTE amounts to 70 days/sea. In VOTO, around 10-15 persons were involved in the glider operations, which leads to **80-120** days/year/FTE that can be assessed as an objective at European level.

2.5.8. Data management

Over the 5 year span of the survey, the aggregated numbers shown in the following table show great disparity. Data management has been a topic well discussed at European level, relying on DACs and GDACs, namely Coriolis.

Data management costs correspond to salaries or hardware investments. However, rarely are data management work accounted for in salaries, where the DM is done by the PI 'on the side' as its main job, hence the 0 for HCMR, UB, UG. CNRS hired an engineer on data management from 2015 to 2018, which stimulated the community at European level.

Table 3 - Data Management aggregated expenses 2015-2020

Entity	Data Management aggregated expenses 2015-2020
CNRS	159000
FMI	25150
GEOMAR	15000
HCMR	0
MI	12000
PLOCAN	63368,1
UP	0
UB	0
UCY	0
UG	0
TOTAL	274518,1

To quantify data management costs other than direct related salaries and purchases, some entities declared an annual fee between 2000 €(MI) and 10000€ (PLOCAN). This part of the work is really embedded in the European landscape and various European calls have allowed to harmonise procedure and formats, hence limiting the requirements at institution level. It can be expected that within GROOM RI, this EU support will be sustained and developed, limiting the resources required by each partner.

2.5.9. Total mission cost

The total operating costs is difficult to assess with a lot of different aspects hard to quantify, and multiple aspects are highly dependent on the country, and the mission type. Having a precise costing is nearly an impossible task, and depends on each institute. This is shown by the diversity of answers that were received to this question, whose results are displayed in the table below:

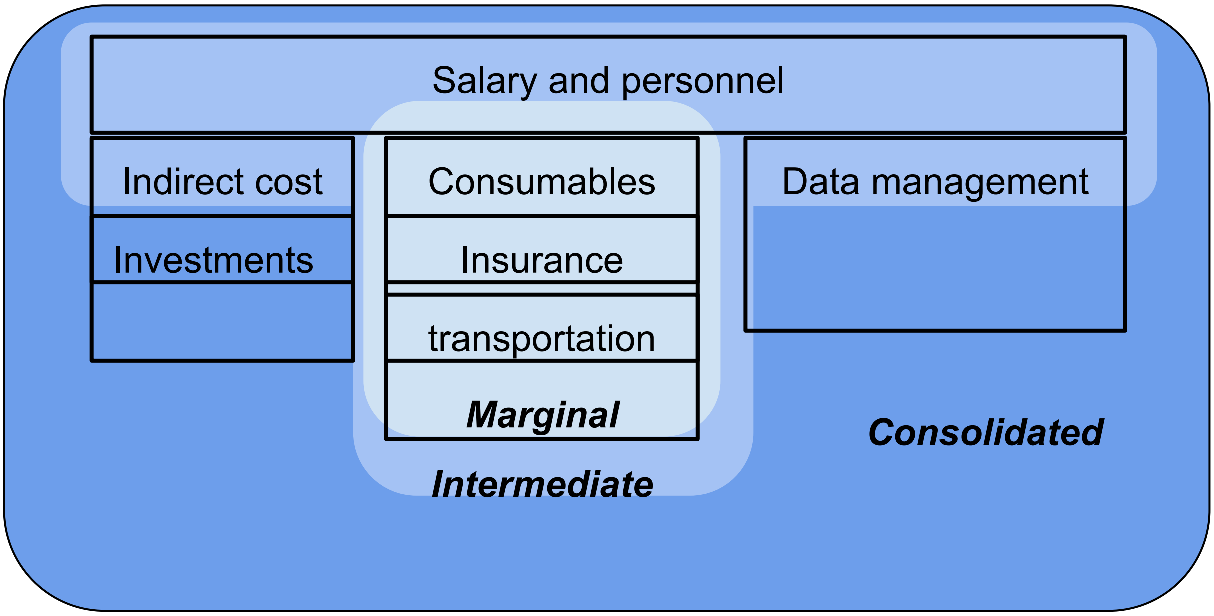
Organization	Average cost of a mission (in Euros)
GEOMAR	20K /month
MI	900/day (27 K/month)
PLOCAN	15K /m
FMI	15K/m
HCMR	8625
CNRS	30K/month
UP	_
UB	12K
UCY	10K (for a 4 month mission)
UG	2200 - 3800

The cost of a mission can vary a lot, depending on:

- The calculation (marginal, intermediate, or consolidated) used, which depends on the target of the mission (if it is performed for a scientist from the institute, a TNA, or else)
- The type of mission. The longer at sea, the less costly per day, as the preparation, refurbishment only happen once prior to the launch. Also, coastal vs offshore requires different level of piloting, hence different pressure on the HR
- The area of the mission. Transport and launch costs vary greatly between a deployment from a small boat in front of the institute, and a deployment in Antarctica for example.
- The more mature the institute, the more investments are already made in the facility, the more can be made in-house, saving time and money.

Hence, a month of glider at sea roughly costs between 3000 € (minimum marginal cost) to 30 000 € (maximum consolidated costs). In order to better determine these costs, and taking into account the study performed above, the following section aims at determining a costing model for glider operations.

2.5.10. *Costing Model*



Based on this cost repartition, a model can be developed using data obtained from the questionnaire. Investments will be amortised with an estimated lifespan of 15 years, and consumables will be separated into 2 categories: what is costing once a mission (spare and calibration), every day at sea (batteries, iridium, argos…)

Hence, a typical one-month mission will cost:

	per mission	per month at sea
Batteries	2700 €	
Iridium	2400 €	
Calibration	500 €	
Insurance	Neglected	
Transport	very dependent on the type and location of mission (mean = 1000)	
Salary		0,4 FTE (very dependant but mean = 2500 €)
Data management	Neglected	
Indirect costs	It varies around 20% of the overall costs	
Glider depreciation		14 000 €

Therefore:

Costing type	Value	Total mean estimation
Marginal cost	iridium + batteries + transport+ calibration	6 700 €
Intermediate cost	(Marginal cost + Salary) * indirect costs	11 000 €
Consolidated costs	Intermediate cost+ Glider depreciation	25 000 €

As GROOM RI will not own gliders and have a centralised facility, how can GROOM RI decrease the overall operation costs and improve its operation capacities, leveraging the different capacities at EU level and supporting the institutions and staff to improve efficiency?

This question will be answered looking, in the next section, at the services that will be provided by the GROOM RI.

3. GROOM RI Services

The GROOM RI will provide services to its users, whether internal (to the partners) or external (to various stakeholders outside the GROOM RI partnership), in order to accommodate and foster scientific and technological research and innovation. According to "D5.1 Glider Services for Public and Private Needs", internal services are identified as Core Services namely the tasks and activities that GROOM RI partners perform for each other within the organisation, while these Core Services are necessary for GROOM RI to enable the various External Services and Products that are meant for government agencies, research institutes, Science, and Industry. The completion of various combinations of Core Services result in products that GROOM RI partners provide to third parties. Some of these end-products may include datasets, live-stream data, environmental monitoring, and reports.

As it is explicitly described in D2.1 'GROOM RI Access Policy and Rules' the GROOM RI will act as a catalyst in order to identify and optimise the use of MAS resources. This model of managing services will allow the evolution and development of the services provided by the research infrastructure from its first steps to a more mature RI, taking advantage of the GROOM RI nodes' capacities.

3.1. Description of the services

Five key sectors were identified to focus MAS External Services over a time span from present day to 5 to 10 years into the future, as described in detail in D5.1:

- Fishery Management and Scientific Support
- Marine Renewable Energies
- Climate Observations

- Statutory Ecosystem Monitoring/Assessment Ecosystem Stressors
- Operational Monitoring for Good Environmental Status (GES) and Emergencies in the Ocean

All the above services and products that the GROOM RI will provide to the external users will be the compound of several core services/processes that have already been listed as follows:

- **Software repositories:** GROOM RI will provide open-source repositories with software control tools that meet best practices.
- **Best Practices:** GROOM RI will facilitate and take part in the establishment and evolution of best practices on the operations of MAS to incorporate them into the Ocean Best Practices System (OBPS).
- **Hardware (spec. sensors) Calibration & Integration**: GROOM RI will develop and offer standardised protocols for instrument testing, inter-comparison, integration of new instruments into MAS and sensor calibration, as well as facilitating access to partners facilities through market-driven simple contractual access.
- **Training**: GROOM RI will provide endorsed training, linked to the best practices, facilitating, coordinating or organising training activities and workshops concerning the RI partners as well as external users.
- **Networking & Capacity Building**: GROOM RI will facilitate and foster collaborations to develop and advance new technologies in operations and applications in science.
- **Data Management, Sharing, & Harmonization**: GROOM RI will coordinate and support the efforts on data management and harmonisation, developing associations with the NODS, DACs and data aggregators in the framework of the GOOS, EOOS and ENVRI communities' standards.
- **Piloting e-Infrastructure**: GROOM RI will provide a catalogue of e-Infrastructures including electronic services, networks, archives, databases, and databanks. The RI will facilitate joint collaborations and access to unique capabilities to support operations and advance software development to meet the heightened needs of the partners.
- **Procurement:** GROOM RI will coordinate purchases on behalf of the partners to get more competitive offers from marine system hardware manufacturers and distributors and services (e.g., Iridium, Argos, AIS, etc…).
- **Operations & Maintenance**: GROOM RI will support pre to post deployment operations of MAS following the implementation of protocols and best practices to ensure the optimal operation of the systems.
- **Pan European Coordination**: GROOM RI will be a key actor to ensure that European leadership strengthens and consolidates the global OceanGliders coordination activity with direct links to the GOOS and GCOS via the Observation Coordination Group (OCG). The RI will assist partners coordinate within other frameworks (e.g. EuroGOOS GTT) and connect with other European stakeholders as well as global RIs fostering and facilitating collaborations among GROOM RI partners and external institutions to identify gaps and develop new operating technologies and legal frameworks.
- **Legal Frameworks**: GROOM RI will support and facilitate diplomatic clearances and other legal matters (e.g. shipment regulations) around Marine Autonomous Systems operations targeting to make the whole administrative process of deploying gliders and other MAS in water

frictionless and efficient, thus providing expert services and connect with the best practices developed by the RI.

- **Outreach**: GROOM RI will coordinate a joint approach to disseminating the work done by the RI and its partners, helping the partners to better communicate with the public while saving resources by taking a common approach.
- **Environmental Monitoring**: GROOM RI will facilitate the coordination and implementation of baseline environmental surveys on water properties, operational met-ocean studies, monitoring services for national governments, having the capacity to estimate the environmental conditions of direct influence on coastal or offshore engineering projects and select appropriate solutions to facilitate goal achievement (e.g. implementation of marine infrastructures, sustainability of marine protected area, etc.).
- **Support to Innovation**: GROOM RI will foster cooperation with Industry by providing data, dedicated services, and experimental facilities to the private sector, developing and testing new components, instruments and capabilities, while also organizing training opportunities for industry stakeholders.

The GROOM RI will provide access to its services through three distinguished models given the diversity between the European nodes regarding national funds, policies and procedures. Depending on the service, these models can be used to provide services to internal and external users, providing financial and qualitative benefits to MAS facilities members of the GROOM RI all over Europe, while also invigorating the RI's sustainability by providing services to the externals: First, the broker access model in which the GROOM RI will act as a broker/facilitator providing online search tools to the users and the glider nodes/service providers. The contractual relationship would be between the user and the individual glider facility. Second, the excellence-driven access model where the GROOM RI will be directly contracted and funded to provide services, in which falls TNAs for example. Finally, the wide access where GROOM RI provides open resources to the whole community (e.g. Best Practices work).

3.2. Added value of the RI

The partners will contribute to the GROOM RI services while in addition have access to products, facilities and knowledge provided within the framework of the infrastructure. Benefits and advantages due to the existence of the GROOM RI for the MAS community users are listed below:

- Access to knowledge and expertise through the Best Practices products and Software Repositories available within the GROOM RI as well as the Capacity Building and Training services. Collaborations will be fostered among the partners targeting identified gaps and strengthening the MRI landscape. This will strongly support operators that are now the limiting point for MAS operation. While these activities are already in place, they have been provided by motivated members and without financial support, which limits both the extent of the work done and the coordination between the different initiatives. Hosting them in a structured infrastructure ensures sustainability, thus leading to assured results.
- Data quality and quantity improvement and at the same time effort reduction (and costs) through Data management, sharing and harmonisation.

- Scientific excellence attained through Environmental Monitoring and Support to Innovation services, while in addition facilitating collaborations with Pan European Coordination.
- Advance efficiency of scientific operations in terms of Legal Frameworks involving the operations of MAS.
- Costs reduction:
    - Use of Piloting and e-Infrastructure will provide electronic services, networks, databases, at partners' level as well as piloting e-infrastructure that will facilitate joint collaborations and access to unique capabilities for operations' support, having remarkable mitigation of costs in case of individual initiative/efforts.
    - Operations and maintenance services will offer a full range of tasks from the preparation and maintenance of MAS instruments to the deployment and recovery of MAS, the users can make use of and reduce the costs of individual efforts. Furthermore, typical examples comprise access to the glider facilities, vehicles, sensors, pilots, access to geographically dispersed facilities for launch & recovery, technology and engineering services.
    - Hardware Calibration and Integration services can reduce costs of platforms and sensors calibration, integration and testing traditionally performed by manufacturers.
    - Procurement service use will coordinate purchases on behalf of the partners to get more competitive offers from marine system hardware manufacturers and distributors.

The added value, in terms of cost efficiency, quality and quantity of operations, is summarised in the table below.

Objective	Costs	Data	Situation	Action/services
Limit costs : **Limit nodes investments** by Sharing MAS & infrastructure	-	=	Vehicles are not used at full potential (in 2020 =30 days/year)	• Procurement (buy cheaper) • Collaboration and shared services (buy less)
Improve efficiency in the nodes	=	+	FTE are critical and are limiting MAS operations	• Support to operators : Best practices & training & CB • Clear Data Flow and Tools (repositories, e-piloting, DM support)
Improve (data) **quality** (FAIRness)	=	+	Community work on data management but no direct funding to support/steer it.	• Best practices endorsed by GROOM RI • OG1.0 format

At this stage, it is possible to assess the impact of the services (and thus of GROOM RI) on the operations of the partners of the RI and the wider MAS community, but it is still too early to provide numbers and cost estimations of the impact. This will be developed in the future stages of the setting up of the RI, provided that there will be: a more complete assessment of the costs (with more data available through better monitoring of the activity performed), and a better vision of the services provided, and how developed they will be.

This added value, in order to be properly assessed, will rely on well-defined KPIs (Key Performance Indicators) and KIIs (Key Impact Indicators) that will be described in the next section.

4. Key Performance and Impact Indicators (Scientific Impact, Access, Training and Education Impact, Economic Impact, Social and societal Impact)

Carrying out Research and Innovation activities requires significant financial resources to be invested in order to produce desirable impacts. Key Performance Indicators (KPIs) are project management tools used to monitor the performance of an RI, vis-à-vis its objectives and the efficient use of resources.

GROOM RI will develop a set of indicators to assess its impact and thus its long-term sustainability. These indicators will be based on work done by the Organisation for Economic Cooperation and Development (OECD, 2019) to develop a framework to assess the socio-economic impact of research infrastructures.

OECD framework aims to provide funders, decision-makers, and RI managers with a generic and versatile tool, based on current community practices, to evaluate the achievement of scientific and socio-economic objectives in a realistic way. The ultimate goal of this tool is to facilitate the communication and reporting between different RI stakeholders.

As underlined in the OECD policy paper (March, 2019), a single framework cannot cover all types of impacts and include every existing indicator. Each RI has its own objectives and performs specific activities. Their impact cannot always be assessed solely in traditional ways – with an exclusive focus on scientific activities or financial return on investment.

The proposed OECD framework includes a list of Core Impact Indicators (25 CIIs), which can be used for most RIs whatever their type, and can provide a general picture of the socio-economic impact of an RI at a given time. CIIs can be considered as KPIs. They may include a diversity of indicators including many that are not directly linked to impact (for example on how the budget is respected, etc.). The CIIs are complemented by a more detailed list of standard indicators (58 in total, 25 CIIs, and 33 additional indicators) which can supplement these CIIs as needed. The indicators chosen will be linked to the strategic objectives of GROOM RI and will be used to assess its performance in achieving these objectives. As detailed in the report, although there are a number of representative indicators commonly used by RIs, none of these are mandatory. Each indicator will be carefully selected and adapted, as necessary, to the GROOM RI objectives and context, and the framework itself will be adapted and expanded as required. Furthermore, impacts often result from cumulative effects over time. Because indicators usually only provide snapshot information at a given time, a more precise impact assessment can be generated by pooling data series consequently consistent indicators over time are needed.

It must be underlined that performance evaluation and impact assessment are not identical: Performance relates to the efficient use of resources. Impact relates to the transformative effect of an RI. The OECD Reference Framework prioritises impact assessment even though performance and impact can be linked and some of the impact indicators can be used by RI management to evaluate their RI's performance.

Since one of GROOM RI's possibility is to enter the ESFRI roadmap, the Report of the ESFRI Working Group (WG) on Monitoring of Research Infrastructures performance (2019) will also be taken into consideration in the final selection and adoption of KPIs. For this, the following key recommendations of the ESFRI WG, as presented in the report will be taken into account:

- All KPIs should be aligned with the objectives of the RIs and fulfil RACER criteria: Relevant, Accepted, Credible, Easy to monitor, and Robust. A reference sheet should accompany each KPI,
- Adaptation may be needed for a specific KPI to be applicable to a RI,
- KPIs to be used will be determined in a dialogue between the RI and ESFRI involving other relevant parties e.g ministries or funders of the RI.

The final set of quantitative KPIs proposed by the ESFRI WG are presented in Table 4.

Table 4 - Quantitative KPIs per objective proposed by the ESFRI WG

Objective	KPIs
Enabling scientific excellence	1. Number of user requests for access 2. Number of users served 3. Number of publications 4. Percentage of top (10%) cited publications
Delivery of education and training	5. Number of master and PhD students using the RI 6. Training of people who are not RI staff
Enhancing collaboration in Europe	7. Number of members of the RI from ESFRI countries 8. Share of users and publications per ESFRI member country
Facilitating economic activities	9. Share of users associated with industry and publications with industry 10. Income from commercial activities and the number of entities paying for service
Outreach to the public	11. Engagement achieved by direct contact 12. Outreach through media 13. Outreach via the RI's own web and social media
Optimising data use	14. Number of publicly available data sets used externally
Provision of scientific advice	15. Participation by RIs in policy related activities 16. Citations in policy related publications
Facilitating international cooperation	17. Share of users and publications per non-ESFRI member country 18. International trainees 19. Number of members of the RI from non-ESFRI countries
Optimising management	20. Revenues 21. Extent of resources made available

In this category, for example, two KPIs developed in the first part of the document will be monitored: days at sea/glider/year, which is now around 30 and could go up to 80, and days at sea/FTE/year, which is now around 70 and could go up to 100.

Since quantitative indicators can only provide a partial view of impact, they should be complemented whenever possible with more qualitative indicators and narratives which can help illustrate the diversity of impacts generated by the RI. Considering this, quantitative and qualitative KPIs will be adopted during the implementation period of the GROOM RI as it might not yet be able to gather the data needed to track all KPIs and specific tools may need to be developed for this purpose.

Table 5 - Qualitative KPIs per objective proposed by the ESFRI WG

Objective	Rational	Proposed Indicators	Type
Enabling scientific excellence	Attractiveness of RI	5-year trend in number of proposals/ user requests/ registered users	Narrative
	Added value to science	Impact studies	Narrative
Enhancing collaboration in Europe (Sub-objective) Integration of distributed facilities	Policies related to integration of distributed RIs	A single access point to RI's data, services and/or facilities, as a prevailing more of access	Y/N
	Policies related to integration of distributed RIs	A single access point to resources of multiple partners of a distributed RI by industry	Y/N
	Policies related to integration of distributed RIs	Centralised evaluation and selection, based on excellence	Y/N
	Policies related to integration of distributed RIs	A common strategy and policy for intellectual property and know-how protection and exploitation adopted	Y/N
	Policies related to integration of distributed RIs	A central communication strategy adopted by the GA A joint research infrastructure roadmap	Y/N
	Policies related to integration of distributed RIs	A research infrastructure roadmap of the RI	Y/N
Facilitating economic activities	Partnerships with industry	Existence of an Industry Engagement Plan and Dedicated Resources	Y/N Narrative
	Technology transfer	Existence of a TT-Office and dedicated resources to support its activities	Y/N Narrative
Outreach to the public	Extent of outreach and engagement achieved by direct contact (events, visitors, guided tours	Events organised satisfaction - % satisfaction rates of attendees	Narrative
		Visitor satisfaction – average % satisfaction rates of visitors	Narrative
Optimising data use	Check of the adherence to open data guidelines	Compliance to FAIR: Measure of interoperability, by number of cross-collaborations between communities or projects, benefiting of the RI data uses	Y/N Narrative

	Check whether the data warehouses are in-house or on external clouds Decision includes guarantee for sustainability	Maintenance and sustainability of data: public or commercial storage vs in-house storage *to be related possible to EOSC connectivity and usage	Narrative
	Adhesion to EOSC project (and overall EU strategy for scientific data). Involvement in EOSC development	EOSC connectivity (in place or planned). Participation (Y/N) to one of the EOSC integrating projects	Y/N Narrative
	Check of the entry point to the data	Centralised entry gateway to RI data	Y/N
	Qualify the way data can be accessed and made or considered as interoperable. Potential relationship with the RDA	Existence of on-line metadata description and indexing of data	Y/N
	Potential limit to export and sharing Do the RI have an ethical chart or policy in place for its data	Ethical measures (Y/N)	Y/N
Provision of scientific advice	Standardisation / regulatory impact	Impact cases illustrating contribution of RI to standardisation or regulatory development	Narrative
Facilitating international co-operation	Internationalisation strategy	Y/ N Narrative	Y/N Narrative
Optimising management	High standard of 'social responsibility'	Corporate Social Responsibility system, Diversity policy; gender balance, corporate ethics charter	Narrative
		Compliance with EU charter of access	Y/N
	Effective safety and risk management	Risk management plan and procedures adopted and updated periodically	Y/N Narrative
		Environmental management system adopted (e.g. ISO14001, EMAS)	Y/N Narrative
	Sound financial management and accountability	Budget and milestones in plan/deviations	Y/N Narrative

KPIs for the strategic scientific objectives could be the number of publications, the number of GROOM RI - related articles, the number of citations, the number of services provided, the number of patents co-developed with the industry, etc. The number of publications generated by the GROOM RI data and services will be considered when selecting KPIs. KPIs for the technical efficiency of the RI could be the number of applications to the online portal for access to the e-infrastructures and the number of cruise programs for launch and recovery support. For collaboration and cooperation enhancement both on the European and international level, the number of projects with which GROOM RI collaborates may as well define the RI's performance. The number of students using the GROOM RI and the training of people who are not GROOM RI staff can be selected as KPIs for the Education and training category. Finally, the outreach through media and the outreach via the GROOM RI web and social media activities could also be considered in the selection of the KPI list.

Some initial work to develop indicators that can also be used to monitor and measure the communication and dissemination performance of the GROOM RI has been done within the GROOM II project (Deliverable 1.4). These KPIs are listed in Table 6.

Table 6 - Indicative performance indicators for communication and outreach of the GROOM RI

Indicators	Type
Website	Quantitative
Analysis of the website impact (n° of visits)	Quantitative
Evidence of debates and discussions in the social media	Qualitative
Number of followers in the social media	Quantitative
Number of articles in the press (online/ paper)	Quantitative
Number of people asking for feedback or more information	Quantitative
Presentations in conference	Quantitative
E-newsletter	Quantitative
Posters/ Flyers/ Roll-up	Quantitative
Participation in dedicated workshops, trade shows, congresses	Quantitative

For each KPI, GROOM RI will develop a fact sheet that will provide information on the definition, rationale, detailed methodology for the KPI calculation, unit of measure, and frequency of measurement. The development of these indicators will enable the GROOM RI to estimate its up-to-date socio-economic impact and assess future performance as the development of the RI progresses.

5. Funding Schemes

Sustained financing for European research infrastructures refers to the long-term financial support and resources allocated to research infrastructure projects in Europe. Research infrastructures encompass a wide range of facilities, resources, and services that support scientific research and innovation. To ensure that these research infrastructures continue to operate effectively and support the scientific community, sustained financing is necessary. This funding can come from various sources, including:

European Union Programs: The European Union, through initiatives like Horizon 2020 and its successor Horizon Europe, provides funding for research infrastructures. These programs allocate funds to maintain and upgrade existing research infrastructures and establish new ones.

National Governments: Many European countries provide ongoing financial support for research infrastructures. National funding agencies and ministries of science often allocate budgets for this purpose.

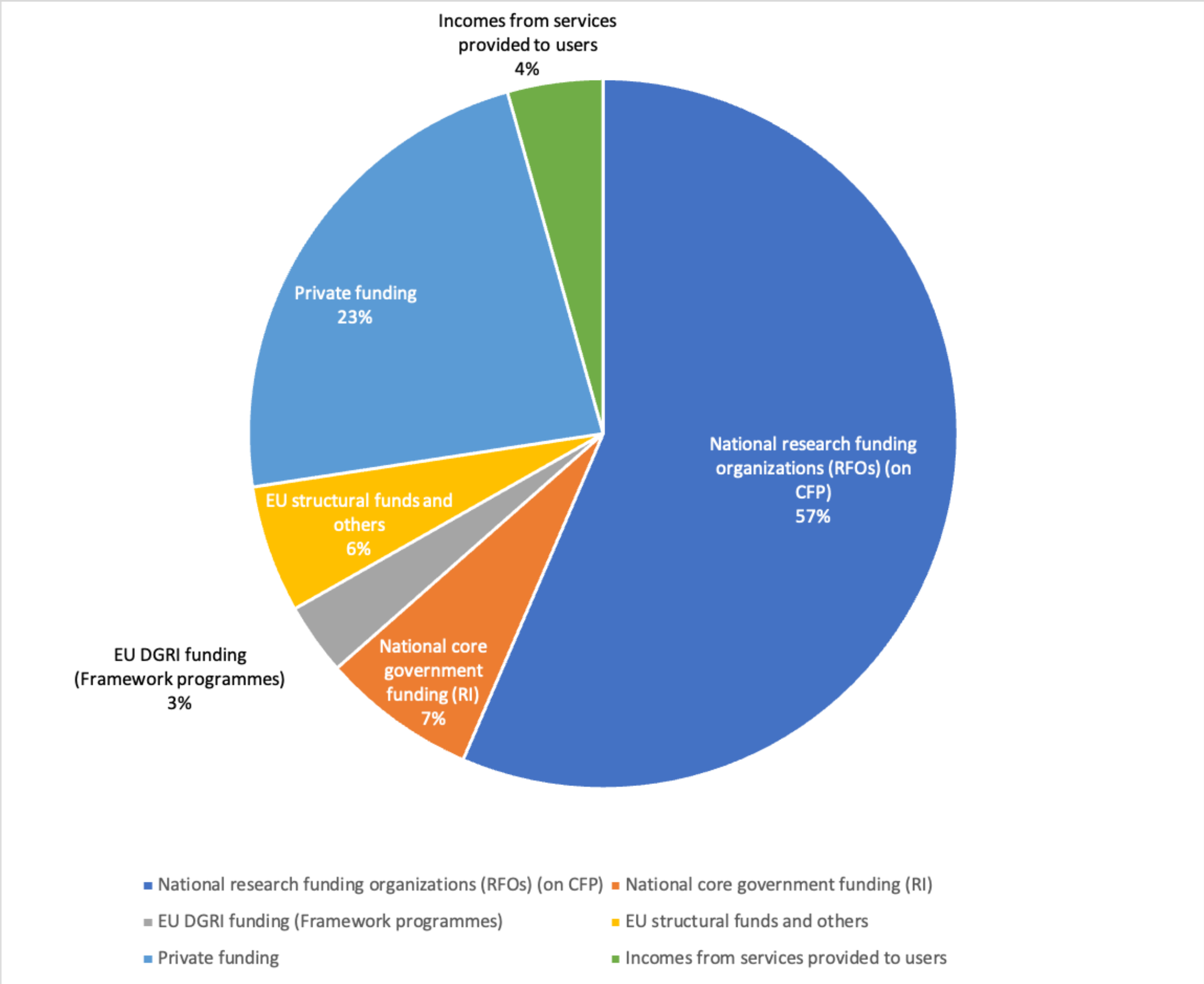
Public-Private Partnerships: Collaboration between public and private entities can also contribute to sustained financing. In some cases, private companies invest in research infrastructure projects for mutual benefit.

User Fees: Some research infrastructures charge fees for their services, and these fees can help sustain their operations.

International Collaboration: Collaborative projects among multiple countries can secure financing from various sources, making it easier to ensure the sustainability of research infrastructures. Endowments and Foundations: Some research infrastructures benefit from the support of foundations or endowments established to promote scientific research.

The goal of sustained financing is to ensure the long-term viability of these research infrastructures, as they play a critical role in advancing scientific knowledge and innovation. This funding helps maintain, upgrade, and expand the capabilities of these facilities, ensuring that they continue to serve the scientific community effectively.

The repartition of funding, from the results to the financial questionnaire, is as follows:



The biggest part of the funding comes from the national research funding organisations, while private funding (philanthropy) are the investments made for VOTO and represent a strong part of the global funding. It has to be noted that some information is lacking, with no numbers received from PLOCAN and NOC, incomplete information from FMI, GEOMAR, UP and UCY. Still, the landscape is representative, with mainly national funding which complicates decision-making at European level.

5.1. National RI funding

During the GROOM II General Assembly held in Paris, a workshop was conducted defined as "Towards an organisational model of the future infrastructure to maximise the national benefits" where all partners presented their country's model and state in terms of sustainability and funding at the national level. The main objectives were to map the different national/European decisional levels, starting from the GROOM II partners level, presenting the National case and showing the current and future organisational structure of each country.

Description of the national cases shows that while in most countries gliders and other MAS are a significant part of the observing infrastructure and the national coordination is considered a target – few countries have a national framework.

The mapping of each national case in regards to national/European decisional level, and participation to MRIs and projects, was made in *D4.2 'Whitepaper on the GROOM position in the European Marine Landscape with emphasis in EOOS'.* As mentioned earlier, the objective of GROOM RI is to provide a sustainable frame for the RI partners to maintain long-term observing programs and have established MAS operations that last in the long run. Thus, the following sections describe each institute's contribution to sustained observing, as well as the current funding and costs as described by each GROOM RI partner is presented as follows.

5.1.1. Finland

Gliders and sensor purchases in Finland have been done partly with FINMARI funding. Furthermore, FIRI, the Finish Research infrastructures committee, who was granted at the end of 2020 according to the national roadmap, monitors and develops Finnish national and international research infrastructure activity & funding, while it supports 29 research infrastructures in Finland.

FMI in Finland owns three Slocum gliders, while performing yearly deployments in the Bothnian Bay. TalTech in Estonia has participated in large scale experiments supported by VOTO to map broad scale circulation in the Eastern Gotland Basin. German partners have worked extensively in the Gotland Basin as well.

In the following diagrams (Fig. 8), it can be seen the kind of funding that supported the FMI glider facility and activities through the years 2015 to 2020 (1 to 6 respectively), coming from national funds in total.

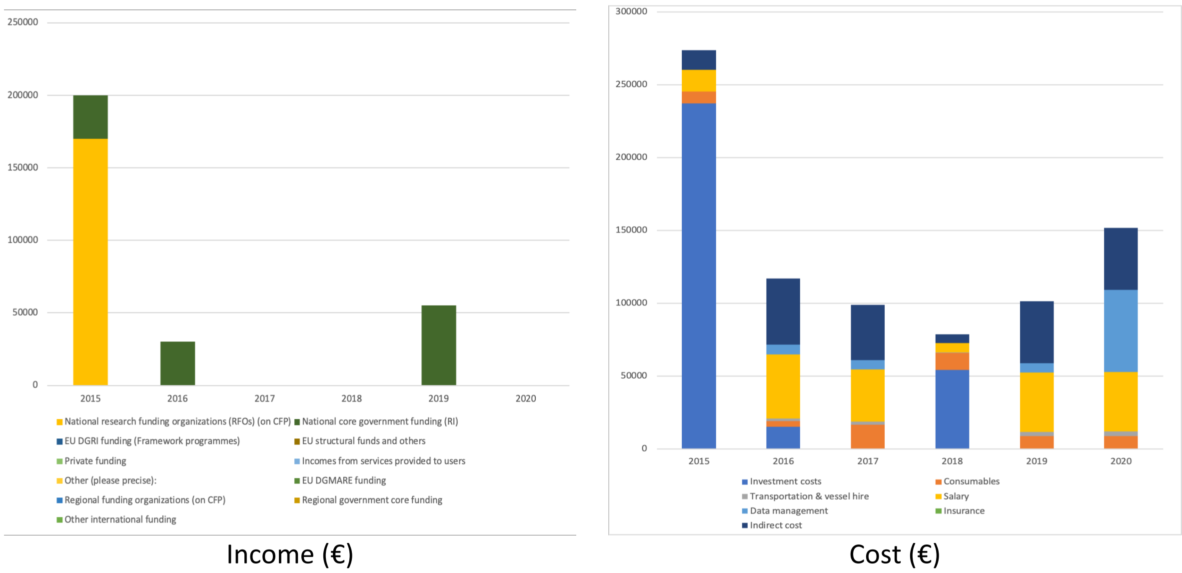


Figure 8 - FMI glider facility and activities funding through the years 2015 to 2020

5.1.2. Sweden

VOTO owns and operates 15 gliders and 4 sailbuoys. One aspect of this is their establishment of Ocean Observatories around the Baltic Sea, at known sites of water mass exchange. These observatories are targeted to be continuously occupied by at least one glider and since March 2021 there has been one glider in the water at least 98% of the time (87% occupancy on the western side of Sweden, 93% in the Baltic Proper).

Funding of glider work is either through research projects (H2020, KAW-F, VR, Formas, ONRG), or via VOTO for Baltic relevant work. This includes both long-term observatories (currently 4, soon 5 sites), collaborations with other Baltic partners (Estonia+Finland) and individual research projects. In the following diagram (Fig. 9), it can be seen the kind of funding that supported the UG glider facility and activities through the years 2015 to 2020, coming from private funds mostly.

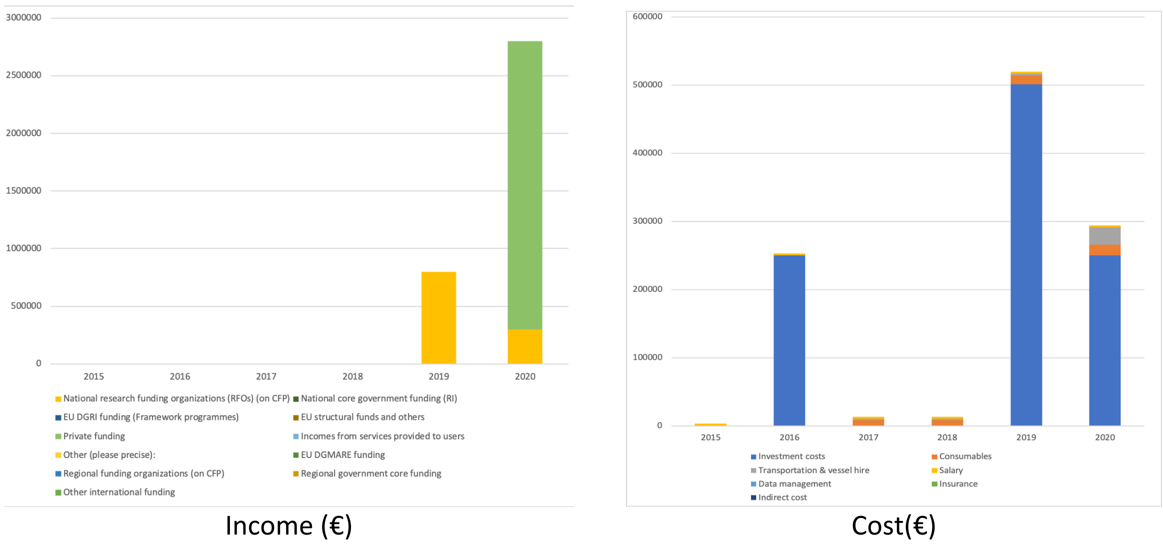


Figure 9 - UG glider facility and activities funding through the years 2015 to 2020

5.1.3. Spain

PLOCAN has a fleet of MAS as well as facilities to prepare, transfer, deploy, recover the MAS and conduct missions, while joining R&D projects with private and public entities as well as prototype testing. It supports activities into specific programs and initiatives and conducts the Glider School for training. PLOCAN joins R&D projects with private and public entities and supports activities into specific programs and initiatives, conducts every year the Glider School as well as prototype testing. All these activities and partnerships offer additional funds to the core funding from the national and regional framework.

Access to data and the physical infrastructure is not centralised, all infrastructures have their own procedure. PLOCAN & SOCIB provide competitive open-access (has to deliver free open access to users at least up to 20% of the use time) and as a service, while ULPGC have available a service of rental through its website. SOCIB gliders are accessible through JERICO TNA, while PLOCAN and SOCIB manage their own open data portals through THREDDS and standard formats feeding data infrastructures, while PLOCAN also serves their data through GDAC/Coriolis.

PLOCAN & SOCIB are Singular Scientific and Technical Infrastructures which are co-funded by national and regional government, 50% each, meaning the Spanish Ministry of Science and Innovation (PLOCAN & SOCIB), and the Government of the Canary Islands (PLOCAN) and the Government of the Balearic Islands, respectively (SOCIB), while the University of Las Palmas de Gran Canaria / SITMA has different ways of funding itself.

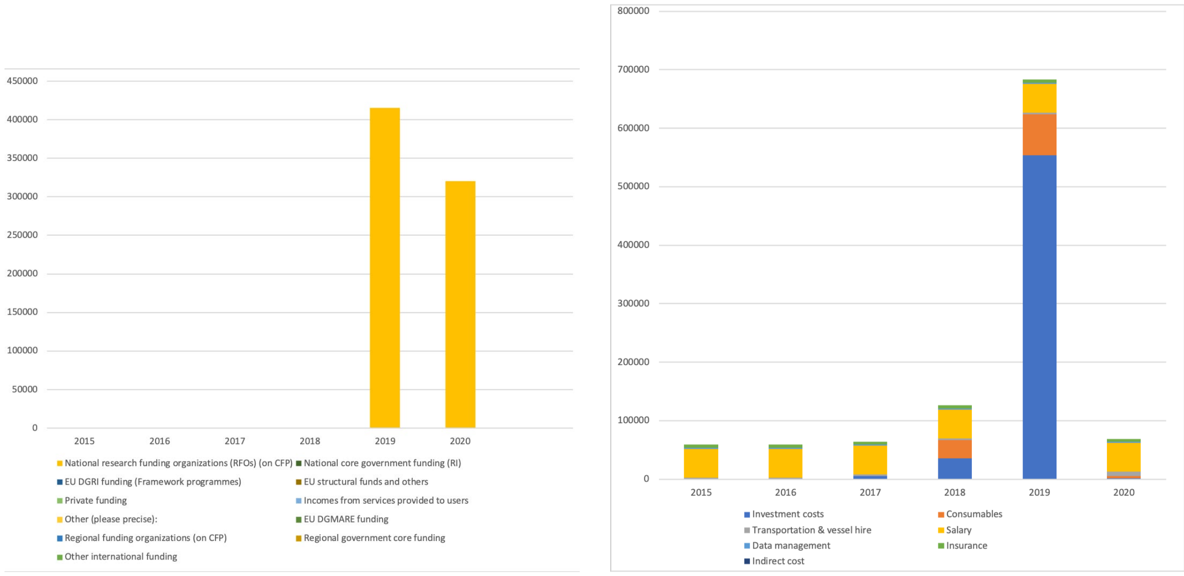
PLOCAN has not provided any numbers.

5.1.4. Ireland

The Irish Glider Network (IGN) currently consists of a fleet of 3 operational Slocum S3 Gliders offering cost-effective autonomous and adaptive observations of physical and biogeochemical ocean parameters.

Gliders are available to the user community for oceanographic surveys and can be operated from the RV Tom Crean, RV Celtic Explorer and RV Celtic Voyager, they may also be operated from other appropriate vessels, subject to approval. Gliders available to Researchers/Scientists/Industry on per day access charges rate, depending on whether the internal marine institute staff or external users, academic or industrial. IGN – may require access to 3rd party gliders when the existing fleet is busy.

In the following diagram (Fig. 10), it can be seen the kind of funding that supported MI's glider facility and activities through the years 2015 to 2020, coming from national research funding organisations.



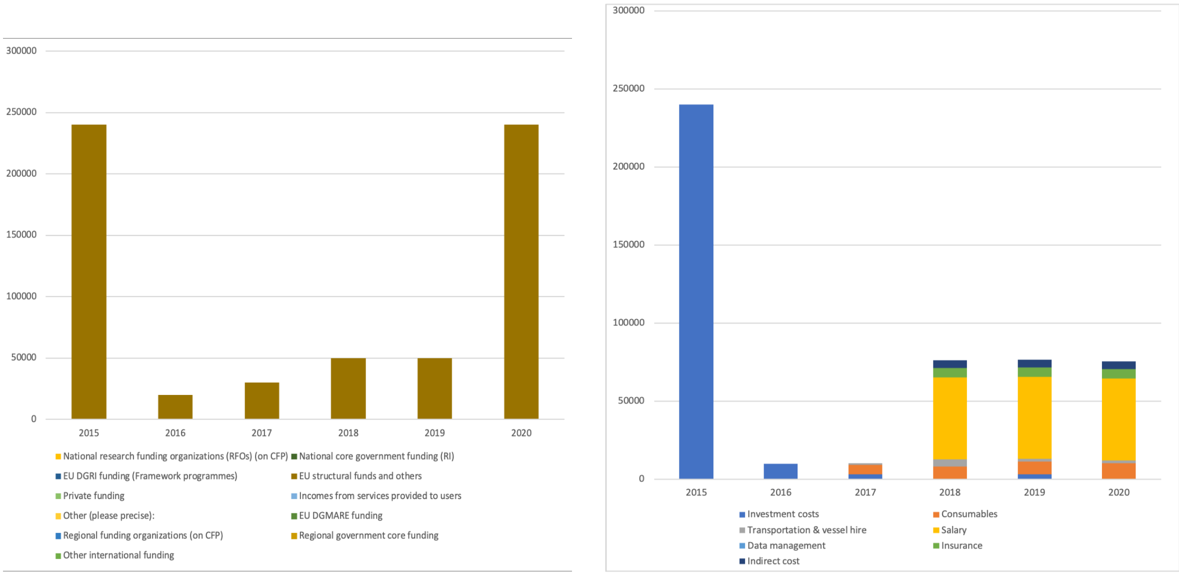
Income (€) Cost (€)

Figure 10 - MI glider facility and activities funding through the years 2015 to 2020

5.1.5. Greece

Glider activity in Greece started in 2017 with the integration of two SeaExplorer gliders in the observing network of the Poseidon System, HCMR, while in 2021 a third glider was added in the fleet. Recently, two more institutes in Greece have implemented gliders in their research, LPCO (Laboratory of Physical and Chemical Oceanography) Aegean University and Remote Sensing Laboratory, NTUA (National Technical University of Athens).

In the following diagram (Fig. 10), it can be seen the kind of funding that supported HCMR's glider facility and activities through the years 2015 to 2020, coming from structural funds exclusively.



Income (€) Cost (€)

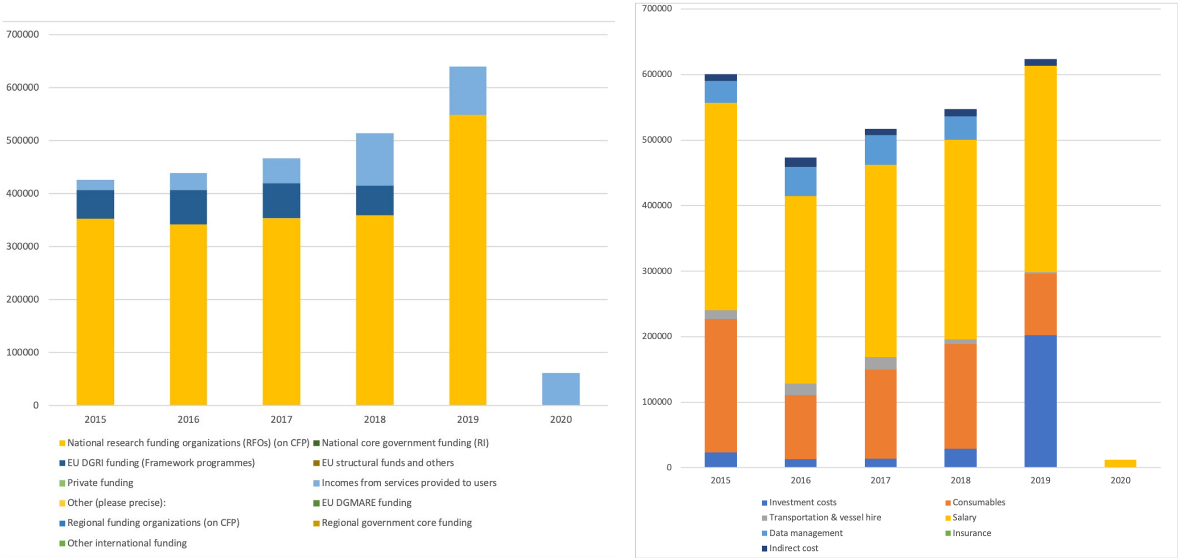
Figure 11 - HCMR glider facility and activities funding through the years 2015 to 2020

5.1.6. France

In 2016 ILICO National RI was created, dedicated to coastal observations and included all coastal networks. ILICO contributed significantly to the secure funding and sustainability of the endurance lines operated in the framework of a long-term ocean observatory in the northwestern Mediterranean Sea (Mediterranean Ocean Observing System for the Environment, MOOSE[1]). In 2020 the Data Terra National RI was also created (ODATIS being the ocean part) providing also potential staff resources for delayed mode.

The kind of funding that supported PNG activities through the years 2015 to 2020 can be seen in the following diagram (Fig. 12).

[1] http://www.moose-network.fr



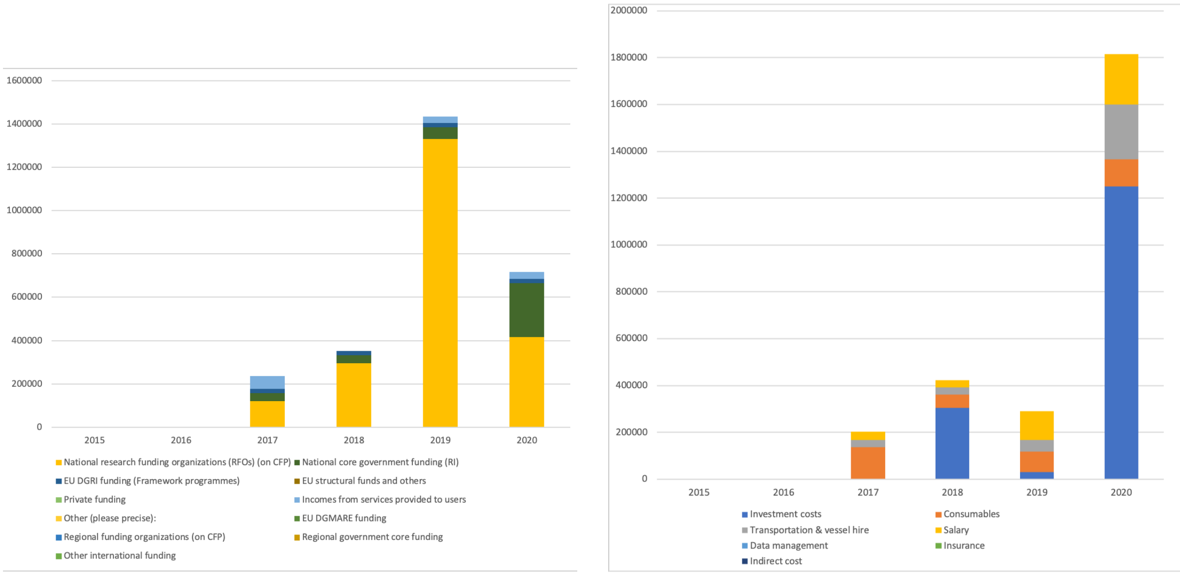
Income (€) Cost (€)

Figure 12 - PNG activities' funding through the years 2015 to 2020

- *Norway*

In addition to short-term infrastructure funding for establishment, funding is also obtained by rental to own research projects and external projects/institutions.

NorGliders has established a national team of pilots and a web portal for gliders. The RI is considered nationally as the expert and go-to in national glider operations, however each institute develops its own capability – there is no clear national RI. Presently, a dialogue with IMR (Institute of Marine Research) has started to formalise a joint RI. MRI operates research vessels and conducts standard hydrographic sections, where glider RI can be integrated but there is no operational funding to support long term funding at the moment. The kind of funding that supported NorGliders activities through the years 2015 to 2020 can be seen in the following diagram (Fig. 13).

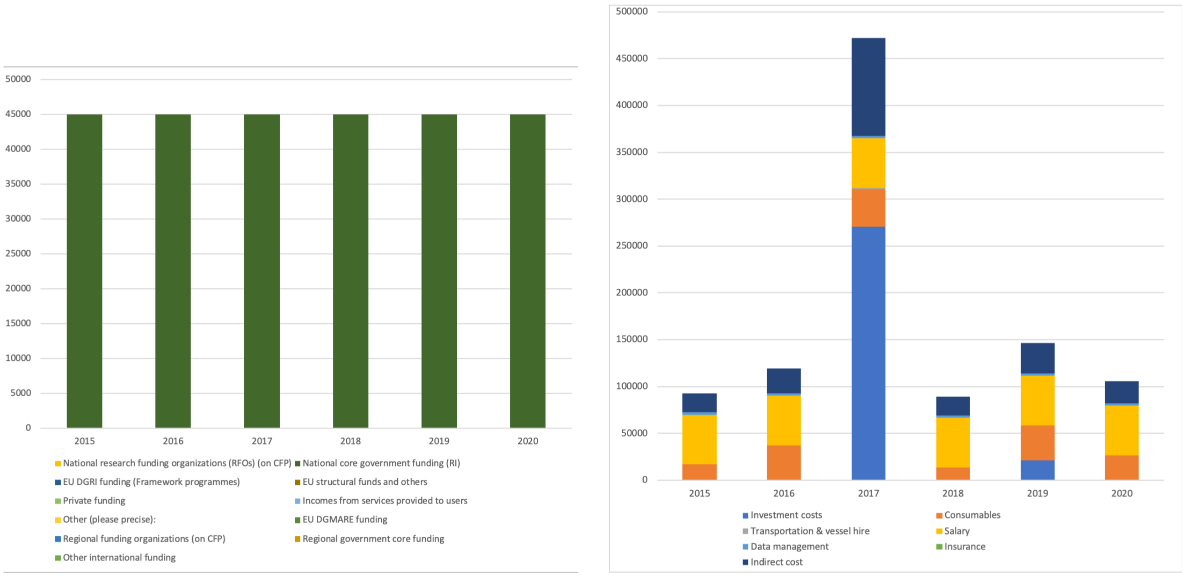


Income (€) Cost (€)

Figure 13 - NorGliders activities funding through the years 2015 to 2020

5.1.7. Germany

The kind of funding that supported GEOMAR 's glider activities through the years 2015 to 2020 can be seen in the following diagram (Fig. g).



Income (€) Cost (€)

Figure 14 - GEOMAR glider activities' funding through the years 2015 to 2020

5.1.8. UK

NOC owns 35 gliders and surface vehicles, and has extensive research operations, running as well the Ellet line. Unfortunately, NOC did not provide any financial data when asked, due to privacy reasons to not conflict with their commercial operations.

5.2. EU and Regional funding

5.2.1. *EU projects*

- *Horizon Europe*

Horizon Europe is the Research and Innovation funding programme with a budget of EUR 95.5 billion for the period from 2021-2027. This includes EUR 5.4 billion from the Next Generation EU instrument, particularly to support the green and digital recovery from the COVID crisis. The budget is divided amongst four pillars and 15 components to create a programme that will support all the areas of research and innovation: excellent science, global challenges and industrial competitiveness, innovative Europe and widening participation and strengthening the European Research Area.

Horizon Europe is the EU's key funding programme for research and innovation that facilitates collaboration and strengthens the impact of research in developing, supporting and implementing EU policies. It tackles global challenges, climate change, while helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. Legal entities from the EU and associated countries can participate in the programme. Horizon Europe offers support for innovations with potential breakthrough and disruptive nature with scale-up potential that may be too risky for private investors. This is 70% of the budget earmarked for SMEs, while the new approach to partnerships underpins objective-driven and more ambitious partnerships with industry in support of EU policy objectives. Furthermore, Horizon Europe is one of the main tools to implement Europe's strategy for international cooperation: the global approach to research and innovation. The programme is open to researchers and innovators from around the globe who are encouraged to team up with EU partners in preparing proposals. It also includes targeted actions with key partners from non-EU countries, including the development of the Africa initiative that will draw on topics across the clusters of pillar II of Horizon Europe.

Horizon Europe is structured across three pillars with Research Infrastructures being part of the first one, that of Excellent Science together with the European Research Council (ERC). The ERC's mission is to encourage the highest quality research in Europe through competitive funding and to support investigator-driven frontier research across all fields, based on scientific excellence. Pillar 2 of Horizon Europe on Global challenges and European Industrial Competitiveness is also very relevant for the GROOM community considering the various Clusters and in particular those of Climate, Energy and Mobility, Digital Industry and Space and Food, Bioeconomy, Natural Resources, Agriculture and Environment.

- *Mission*

One of the novelties of the Horizon Europe programme are the missions, namely sets of measures to achieve bold, inspirational and measurable goals within a set timeframe. EU Missions are a new way to bring concrete solutions to some of our greatest challenges. They have ambitious goals and will deliver concrete results by 2030. Each mission will operate as a portfolio of actions – such as research projects, policy measures or even legislative initiatives - to achieve a measurable goal that could not be achieved through individual actions. One of the five (5) EU missions is "Restore our Ocean and Waters by 2030".

With a 2030 target, the EU Mission "Restore our Ocean and Waters" aims to protect and restore the health of our ocean and waters through research and innovation, citizen engagement and blue investments. The Mission's new approach will address the ocean and waters as one and play a key role in achieving climate neutrality and restoring nature. Cross-cutting enabling actions will support this objective, in particular broad public mobilisation and engagement and a digital ocean and water knowledge system, known as Digital Twin Ocean. The Mission supports regional engagement and cooperation through area-based “lighthouses” in major sea/river basins: Atlantic-Arctic, Mediterranean Sea, Baltic-North Sea, and Danube-Black Sea. Mission lighthouses are sites to pilot, demonstrate, develop and deploy the Mission activities across EU seas and river basins. New funding opportunities opened to contribute to the Mission implementation with the adoption of the new horizon programme on 6 December 2022.

- *MSFD*

The EU Marine Strategy Framework Directive (MSFD) was put in place to protect the marine ecosystem and biodiversity upon which our health and marine-related economic and social activities depend. To help EU countries achieve a good environmental status (GES), the directive sets out 11 illustrative qualitative descriptors. The joint communication on international ocean governance proposes concrete measures at international level, for example to address environmental, fisheries and climate issues. Research efforts are needed to better define the descriptors to achieve GES. Under the Oceans of Tomorrow initiative under the Seventh Framework Programme (FP7), the Commission explicitly published calls to support the implementation of the MSFD. In the 2012 call for proposals (10 projects were selected for an EU contribution of almost €44 million), the focus was on research gaps in the definition and monitoring of the GES of EU waters to be achieved by 2020.

Nations in Europe implement and support MSFD through the European Structural and Investment Funds – ESIF [2021-2027] and the Cohesion Policy which targets all EU regions and cities in order to support job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life. In order to reach these goals and address the diverse development needs in all EU regions, € 392 billion – almost a third of the total EU budget has been set aside for Cohesion Policy for 2021-2027. Cohesion Policy is delivered through specific funds:

- The European Regional Development Fund (ERDF), to invest in the social and economic development of all EU regions and cities.
- The Cohesion Fund (CF), to invest in environment and transport in the less prosperous EU countries.
- The European Social Fund Plus (ESF+), to support jobs and create a fair and socially inclusive society in EU countries.
- The Just Transition Fund (JTF) to support the regions most affected by the transition towards climate neutrality.

In particular, DIRECTORATE-GENERAL | ENVIRONMENT (DG/ENV) is the Commission department which is responsible for EU policy on the environment. It proposes and implements policies that ensure a high level of environmental protection and preserve the quality of life of EU citizens. MSFD can also be funded through HORIZON projects (e.g. policy-oriented PERSEUS and DOORS projects).

- *WFD*

Since 2000, the Water Framework Directive (WFD 2000/60/EC) has been the main law for water protection in Europe. The purpose of the Directive was to establish a framework for the protection of European waters in order for Member States to reach “good status” objectives for all ground and surface waters (rivers, lakes, transitional waters, and coastal waters) throughout the EU. Good status means both good chemical and good ecological status. Funding for the implementation of the WFD is supported at both National and European level. At National level, Member States ensure the establishment of funding programmes for the monitoring of water status. At European level, WFD implementation activities can be co-financed by the OECD and the European Commission's Directorate-General for Environment (DG ENV) programmes, to assist regional or (sub)regional cooperation among Member States.

- *MSP*

Since 2016, the European Maritime spatial planning (MSP) Platform, financed by the European Maritime and Fisheries Fund, provides administrative and technical support to EU countries in implementing the MSP legislation. MSP is the tool to manage the use of the seas and oceans coherently and to ensure that human activities take place in an efficient, safe and sustainable way. EU-funded MSP cross-border projects and conferences facilitate cooperation between EU countries in managing maritime space and support the implementation of the MSP legislation. The EU cooperates with the Intergovernmental Oceanographic Commission of UNESCO to accelerate MSP processes worldwide through the MSPGlobal project. New international guidelines on transboundary MSP are currently developed. EU funding also supports regional MSP projects in the West Mediterranean and in the South-East Pacific.

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- *EMFF*

The European Maritime and Fisheries Funds (EMFF) is the principal financial tool supporting the EU common fisheries policy (CFP), and improving quality of life along European coasts. EMFF calls for proposals serve to implement the EMFF annual work programmes. The overall budget for the period 2014-2020 was €6 400 million, 11% of which was managed by the European Commission to support EU-wide objectives in maritime and coastal affairs, and 89% was managed by the Member States by means of operational programmes. The overall budget of the European Maritime Fisheries and Aquaculture Fund (EMFAF) for the period 2021- 2027 will be more than 6 000 million. The European Climate, Infrastructure and Environment Executive Agency (CINEA) is the successor organisation of the Innovation and Networks Executive Agency (INEA). Officially established on 15 February 2021, it started its activities on 1 April 2021 in order to implement parts of certain EU programmes. CINEA is supporting the EU Green Deal and a sustainable blue economy with targeted actions in the field of the Union's Maritime Policy, the Common Fisheries Policy and the EU international ocean governance agenda.

5.2.2. Regional funds ie. ERDF[2]

The European Regional Development Fund (ERDF) aims to strengthen economic, social and territorial cohesion in the European Union by correcting imbalances between its regions. The ERDF finances programmes in shared responsibility between the European Commission and national and regional authorities in Member States. The Member States' administrations choose which projects to finance

[2] https://ec.europa.eu/regional_policy/funding/erdf_en

and take responsibility for day-to-day management. Organisations that can benefit from regional funding include public bodies, some private sector organisations (especially small businesses), universities, associations, NGOs and voluntary organisations. Foreign firms with a base in the region covered by the relevant operational programme can also apply, provided they meet European public procurement rules.

An example of ERDF funding is Interreg Europe 2021-2027 Programme structured around one single cross-cutting priority meaning that beneficiaries can potentially cooperate on any topics of shared relevance in line with their regional needs, as long as this falls within the scope of cohesion policy. The programme finances two types of action: a) Interregional cooperation projects: 4-year partnerships from different countries in Europe work together to exchange their experience on a particular regional development issue; and b) Policy Learning Platform: a space for continuous learning where any policy relevant organisation dealing with regional development policies in Europe can find solutions and request expert support to improve the way it delivers its public intervention. The direct beneficiaries of the programme are organisations across all the regions of the EU, plus Norway and Switzerland, who are involved in designing and delivering regional development policies.

5.2.3. In-kind and Monetary Contribution

GROOM RI's objective is to be operating at both making and implementing policy level, as well as at the service provision level, and is pondering entering into the ESFRI Roadmap. In-kind and monetary contributions will depend on the governance structure and the legal form GROOM RI will adopt., which will take into account both the needs of the community and the requirement for a functional and long-term sustainable governance model. Although eight legal forms are already in use by different forms of European Research Infrastructures and e-infrastructures, for GROOM RI objectives, maturity, and nature, three remain as the main options: an international organisation, an entity under national legislation (AISBL), or an entity under the European legislation (ERIC).

International organisations are composed of at least three member states, having activities in several states, and whose members are held together by a formal agreement. International organisations may also include other entities, such as other international organisations, firms, and nongovernmental organisations. Although it is a stable legal basis independent of member countries, with privileges, immunities, and with economic advantages, the establishment process is often long lasting and legal documentation such as by-laws are required.

The European Research Consortium (ERIC) is a specific legal entity for non- economic purposes recognized in all EU countries. Members from non- European countries can also join the consortium. Although its establishment process is faster than international organisations, several by-laws are also required, in addition to the founding documents. The ERIC regulation has been extensively tested since 2009.

The Association internationale sans but lucrative (AISBL) is a legal entity under the national legislation of Belgium. It's a well-known, proven and flexible legal structure with a quick and simple establishment process and allows for membership from private and public entities. Membership is at institutional level and members can either be people or legal entities. In contrast to ERIC for which location of the statutory seat can be in any Member State or Associated State that is a member, the AISBL statutory seat must be in Belgium.

The funding scheme for In-kind and monetary contributions to the GROOM RI differs according to the type of legal entity chosen. We must underline that currently, the most common legal status among RIs within the ESFRI 2021 Roadmap in the Environment thematic domain is the European Research Infrastructure Consortium with 6 out of 8 being ERICs, 1 an AISBL, and 1 a Scientific Association. The latest (EISCAT_3D) is a single-sited international Research Infrastructure that conducts research on the lower, middle, and upper atmosphere and ionosphere using the incoherent scatter radar technique that has very little in common with the GROOM RI nature and objectives. Taking into consideration the legacy of other European Research Infrastructures (e.g. EMSO, JERICO) and projects (e.g EuroFleetsPlus), before applying and entering the ESFRI Roadmap, in this analysis we focus only on the ERIC and the AISBL legal status and we conduct a comparison with the loose Network option. The results of this comparison are summarised in Table XX.

In-kind contributions (IKC) are non-cash contributions in the form of (durable and non-durable) goods, work, services, and use of distributed resources that typically support non-profit organisations. They refer to non-exchange transactions: an entity either receives value from another entity without directly giving approximately equal value in exchange or gives value to another entity without receiving approximately equal value in exchange. Membership Fee means a non-redeemable fee that a member must pay to the RI as a condition of admission to or retention of membership in the RI that is not member capital or a fee for goods, services, or facilities.

- *ERIC*

ERICs are positioned as non-profit organisations set up by the European Commission (EC). It has legal personality and full legal capacity recognised in all Member States. The ERIC Regulation allows contributions to the ERICs by the Member to be in cash and in-kind. In order to accomplish their mission, apart from governmental grants and European Commission's funding, their sources of revenues can come from membership fees and in-kind contributions provided by Member States or donors.

All participating countries/members are required to contribute to the central coordination costs, composed of a basic membership fee and an additional amount, calculated according to the GDP of each country. In addition, each country covers the cost of fieldwork and national coordination. The amount of the membership will be defined in the statute of the GROOM when becoming an ERIC.

An explicit reference to the in-kind contributions can be found in the ERIC Practical guidelines. Commenting art.14 of the ERIC Regulation, the Directorate-General for Research stated that the Statutes might provide for contributions to be made in cash or in kind. In this document it is stated that the statutes should also lay down the procedure for the Assembly of members to decide on in-kind contributions and to include them in the ERIC budget. The ERIC statute should also define the procedure for assessing the value of in-kind contributions.

In the ERIC Practical Guidelines, another important reference to the IKC is linked to the liability of the Consortium, extending the limited financial liability of the members for the debts of the ERIC to the in-kind contributions which are paid, provided or promised in a legally binding way. Art.14.

In ERICs, for distributed Research Infrastructures like GROOM RI, IKC refers to an expense sustained directly by the National Nodes to the benefit of the ERIC in order to facilitate the achievement of its objectives; without any transfer of ownership.

- *AISBL*

The financial means available to the GROOM RI as an AISBL organization will come from:

- membership fees from active members and associate members;
- fundings from public and private institutions;
- payments receivable for general services and the sale of publications;
- donations and legacies; and
- any other financial or in-kind contributions from active members or associate members.

Compared to an ERIC, monetary and in-kind contribution from the members is usually lower, but, on the other hand, an AISBL can have more members as both private and public entities can participate.

- *Collaboration Networks*

As an alternative to the above legal structures, GROOM partners may decide to set up a collaboration network which will provide a general framework for networking. Again there are several options here which range from a very loose structure without legal bindings and financial commitments, to a more structured system that operates under agreed Terms of References (ToRs). One example of an operational network is EuroGOOS, which through its Task Teams (TTs) offers a collaboration framework to platform specific operators (in this case the Glider Task Team).EuroGOOS Task Teams are operational networks of observing platforms, promoting synergy and technological collaboration among European ocean observing infrastructures. Task Team members exchange open-source tools, collaborate in areas of common interest, and jointly make European data available to the EuroGOOS ROOS regional data portals, which in turn are feeding data to pan-European portals, e.g. EMODnet and Copernicus Marine Environment Monitoring Service, CMEMS. Each TT operates under agreed ToRs and there are no legal bindings among the members. Anyone can join the network and can profit from the network's support. Since there is no direct funding from EuroGOOS to the TTs, all contributions are in-kind by the members. However, funding opportunities may arise through participation in research projects. EuroGOOS is a focal point for European operational oceanography since 1994, and one of its key objectives is to integrate European operational oceanography into the global context. The partners of the GROOM RI by participating in EuroGOOS can profit from the 44 members pool of the network which increases to more than 100 institutes if we consider the members of EuroGOOS ROOSs namely MONGOOS, IBIROOS, NOOS, BOOS, and Arctic ROOS. Moreover, they profit from the different networks with which EuroGOOS interacts. EuroGOOS Gliders Task Team was established in 2015 to sustain and support the European part of the global glider community, while several among the present partners of the GROOM consortium are already members of this team: FMI (Finland), CNRS (France), HCMR (Greece), MI (Ireland), UB (Norway), UPORTO (Portugal), University of Gothenburg (Sweden), NOC, BODC (United Kingdom).

The results of the analysis conducted are summarised in Table 7.

Table 7 - Pros and cons of an ERIC, an AISBL and Loose Networks (qualitative approach: + = minor, ++= moderate and +++=major)

		ERIC	AISBL	Network
Participation	Who	Nations	Anyone	Anyone
	Popularity	+	++	+++
Sustainability	Commitment	Long-Term	Member Fees	Free
	Funding	+++	++	+
	Project participation	+++	+++	-
	Visibility	+++	+++	+++
Cooperation	Establishing/Sharing of BP	+++	+++	+++
	Data mgt	+++	++	++
	Common Deployments	+++	+	-
	Links with other RIs	+++	++	+
Coordination	System Design	+++	++	+
	Contribution to global	+++	++	++
Integration	Mission planning	+++	++	+
	Service Provision	+++	+	+

5.2.4. Private sources

The work done for the D3.3, the results of the questionnaire sent to companies and the three seminars of the IAG MAS demonstrated clearly that there is an appetite for industrials to join the project. The European companies interested in GROOM belong to the worldwide leaders of marine autonomous vehicles and instrumentation, and could be highly qualified suppliers of the RI. They could be partners in the integration of engineering services and development of hardware equipment not limited to MAS and their maintenance.

But to become a funder the private companies need to have a legal status in the RI, allowing them to invest and expect a return on investment.

We can distinguish two types of private sources:

- One coming from industrial companies cooperating or working directly in the RI
- The other one coming from private or public invest companies.

Financing by industrial companies

Regarding the markets targeted by the future GROOM RI, the positioning on Ocean observation is totally shared with industry, next to traditional markets such as defence and marine surveillance, or emerging markets such as renewable energy and deep minerals resources which are very important for them. These markets are supported by innovative technologies where they are very skilled and which are at the heart of the future RI: advanced automatic navigation and planification of mission using AI, passive and active real time acoustic sensors and monitoring, data acquisition and treatment.

For these reasons Industrial companies could be favourable to invest in the RI. We can identify four ways of financing the RI:

- through paying an annual fee to access the works or be part of the RI.
- Be involved directly in the RI with in-kind work force.
- Paying the RI for services it will be able to deliver to the companies interested in. The price will depend on the type of services: dissemination of results, promotion of products, sea operations, R&D contracts.
- Work with the RI in European or national R&D projects granted by EU and national countries.

The level of the industrial contribution will depend on the number of major companies and SME who will confirm their interest to be part of the RI, but regarding the results of IAG MAS and industrial questionnaire (cf D3.3) we can be optimistic.

Financing by invest companies

To encourage the involvement of industrials in GROOM RI, especially on the development of innovative projects inside the RI, a partnership with BlueInvest would become extremely helpful. They are interested in and could bring investment readiness support to SMEs and maybe facilitate the creation of links between the RI and **private investors**.

BlueInvest is a platform and accelerator to foster innovation and investment in sustainable technologies for the blue economy. It supports growth, economic development, and investment readiness of SMEs in the Blue Economy. It is enabled by the European Maritime and Fisheries Fund.

After a first successful phase (200 SMEs that have received investment readiness support; more than €100 million public EU funds allocated that will enable private actors to invest up €300 million), the European Commission announced its continuation until 2026.

The EIF BlueInvest Fund in its pilot version will be replaced by the InvestEU Fund, which aims to mobilise more than €372 billions of public and private investment through an EU budget guarantee of €26.2 billion that backs the investment of implementing partners such as the European Investment Bank (EIB) Group and other financial institutions.

This platform is an opportunity for SMEs who have an interest in Groom RI to:

- Be part of a community fostering networking (Euroquity) between potential partners and investors and facilitating access to exclusive information on markets and upcoming business opportunities.
- Benefit from the Investment Readiness Assistance programme targeted to high potential start-ups and SMEs with innovative and sustainable products and solutions for the Blue Economy. The selected beneficiaries will receive feedback on their investment readiness level, benefit from coaching services (one-to-one coaching sessions over 3 months) and participate in exclusive-to-exclusive networking and B2B matchmaking sessions. A new initiative, the Tailored Fundraising Assistance will be added to the existing services. It will provide advisory services to secure private equity and venture capital finance by investors and investment-readiness experts.
- Be part of the BlueInvest Project Pipeline gathering relevant projects and companies in the Blue Economy that are either receiving assistance from BlueInvest or identified as having high potential to develop innovative technologies. It is a great opportunity for SMEs to display themselves to investors. ·
- Benefit from BlueInvest Grants (EMFF - European Maritime and Fisheries Fund): Blue Window Call for proposals are published regularly to help advance market-readiness of new products, services, or processes in the Blue Economy.
- Benefit from BlueInvest Fund (European Investment Fund), structured as an EFSI (European Fund for Strategic Investment) Equity Product to provide finance to funds that are targeting the blue economy.

Pôle Mer Méditerranée for the D3.3 has made a presentation of the GROOM II project and potential benefits BlueInvest could have by collaborating with the future RI. A few examples of mutual interests were suggested:

- Visibility for BlueInvest opportunities and for GROOM RI services.
- Projects supported through GROOM RI can have an interest in Blue Invest;
- Projects supported through BlueInvest mechanisms can have an interest in GROOM RI.

Now, there is a new regulation on ocean observation that is leading to higher interest from investors on ocean observation technologies and is leading to market movement as well. According to BlueInvest representatives, it would be interesting for GROOM II to present the project and future RI to the Blue Invest community and more specifically highlight what are the technological developments on ocean observation and new markets identified by the RI. Increasing the knowledge of potential investors about ocean observation is crucial.

6. Conclusion

Autonomy is ubiquitous in the present and future of Ocean Observing, providing high quality decarbonised data for a fraction of the price of ships. However, MAS are complex systems that require multiple steps to provide efficient use. Thus, the full operation chain, from acquiring the platforms and the sensors, to the calibration, the operation at base and at sea, the recovery of the platforms and the data and the refurbishment, cannot be controlled as a whole by most institutions, and in most cases today it is not done in the most efficient way (qualitative and quantitatively). The survey allowed us to develop a methodology to assess the cost associated with all these steps, and estimate an average operating cost that is around 6700 € (marginal) to 25 000 € (consolidated) for one month at sea. This analysis helped determine the main levers that limit MAS operation. While currently the available platforms are numerous and could be used more (they are used 30 days/year on average), human resources are clearly the limiting factor that GROOM RI can play a significant supporting role.

Through its services, GROOM RI will help reduce costs by sharing and diminishing purchase costs, increase operation quantity and quality levels by supporting operators with Best Practices, training and developing digital infrastructure for the pilots, etc. Although it is impossible at this stage to provide direct numbers of the added value, it is certain that they will surpass the added cost induced by the functioning of the RI (financing of the central hub).

If the added value is at this stage difficult to quantify monitoring, it is critical to sustain the future RI, providing proof of the value that it brings to the partners. For that, in line with the ESFRI recommendation, an appropriate set of KPIs and KIIs will be set up, covering both quantitative and qualitative aspects. This will also be a way to have a clearer vision of MAS activities in Europe at large.

As expected the added value of structuring the existing assets comes with an added cost to set up and maintain the RI, and thus, multiple funding schemes, based on those already in place in the member states, are investigated. The required funding will depend on the legal status and on the governance adopted in the future for GROOM RI. While ERIC is the most sustainable RI form, other possibilities like AISBL are available and easier to establish. A loose network structure, as it has been done for the last 15 years, is another option, but comes with a severe loss in terms of sustainability and capability of the infrastructure.

GROOM and the MAS community are at a crossroads and MAS operator's efforts towards a structured European facility are reaching a limit. Hence establishing a structured GROOM Ri with sustained funding to follow the uptake and development of MAS in a cost-efficient and high-quality way is crucial. This document demonstrates that coordination and centralisation at European level will be beneficial both for MAS operators and the society, contributing with answers to the grand challenges ahead of us that cannot be addressed by individual institutions.

7. References

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ESFRI Working Group Report on Monitoring of Research Infrastructures Performance, December 2019. https://www.esfri.eu/sites/default/files/ESFRI_WG_Monitoring_Report.pdf

8. Annex - Questionnaire GROOM II

GROOM II Task 3.2 Survey on financial sustainability at national level

Thank you for participating in the survey. All of your answers are private and confidential. Please note that all questions marked by an * require an answer.

The Task 3.2 "Financial sustainability at national level" addresses the possible funding strategies that would support the implementation and long term sustainability of the GERI component at the national level, whether it is already considered a national RI, or included in the national RI roadmap, or neither of the two. **These strategies must rely on an accurate estimation of the costs and present funding of each node of the infrastructure.** In this questionnaire, we are asking about:

- cost estimation of the amount that has to be engaged for the design, preparation, construction or set up, operation, maintenance, and upgrade of your glider facility;
- current status of your facility;
- incomes and funding of your facility.

This financial analysis of glider facilities should enable better informed decisions about their sustainability and will allow GROOM II to make a creative proposal for the design of a sustained GERI. Each partner representing a Member State is supposed to contribute to the assessment of the cost of the glider facilities in its country and to the mapping of the national funding potential. **As a first stage, each partner will provide the costs/funding estimation of their own facility.**

Two approaches are proposed in the questionnaire for the costs/funding estimation:

- one based on an annual basis on the 2015-2020 period. This is what was done during the GROOM FP7 on the 2012-2014 period and overall robust statistics could be built with this approach.
- a gross estimation of the running costs that a facility could have estimated by any mean.

Please fill in this questionnaire by providing as much information as you can. We provide several tips to facilitate understanding of the questions. We are aware that we are asking for many details - take your time to provide as much information as possible. Don't hesitate to fill this questionnaire with the help of an administrative person within your organisation or any other relevant person. If you meet any problem, have additional questions or you need any assistance, a Q&A section is available on the wiki or feel free to contact us to obtain more explanations (see contact details below). Your effort should be considered as the best possible investment in the future of GERI and the global quality of the final deliverable depends on the quality of your answers.

In the first step we suggest your familiarise yourself with the question - with the link of the survey we also distribute a pdf and an excel version of this survey, which you can use to prepare your answers before using the online survey for the final version. In a second step, when your answers would be in a final version, please fill in the online survey. This link provides an explanation on how you can pause the survey and how your browser saves the results until you continue in a later stage.

A "Questions and Answers" section is available here.

We will be grateful for filling the online version of this survey by 31 January 2022.

Thank you in advance for your answers and feedback.

If you have any questions related to the content of this survey, please contact Kamil Szafranski (kamil.szafranski@ensta-paris.fr), Evi Bourma (evibourma@hcmr.gr) and groom@hcmr.gr. If you have any questions related to the survey software, please contact Charlotte Lucas (charlotte.lucas@ecorys.com).

Please take note of the following definitions used:

Facility	Any kind of organization operating "long endurance marine robots" and/or managing their data which is delivering observational services to users: • Research users • Users from Ocean Observing System and other monitoring systems • Industrial users • Other users The facilities considered in the project could be the nodes of the future distributed GERI.
Service	The service to users starts with the very first interest of a user for using such marine robot, and goes up to the delivery of quality checked data with all required information to exploit these data. It includes every thing needed for the performance of the field work and data management. It excludes a scientific

analysis unless this has been agreed upon in a separate agreement.
This definition of a 'service' seems quite obvious for our current research uses and practices, but the essence of an European Research Infrastructure is to offer a service to its users. We will certainly have to elaborate about these definitions during the project.

*** 1. Privacy information and authorization section:**
a. Personal data will only used in this study to trace back respondents for validating en follow-up if necessary
b. Survey data will only be publicized on a aggregated level

○ I accept ○ I do not accept

Please indicate your details below.

TIP: Don't hesitate to fill this questionnaire with the help of an administrative person within your organization or any other relevant person.

2. Organization

3. Department

4. Completed by

5. E-mail

6. Role (scientist, admin, ...)

7. Address

8. Website

9. Glider specific website (if available):

COSTS

Cost estimation of the amount that has to be engaged for the design, preparation, construction or set up, operation, maintenance, and upgrade of your glider facility (data analysis excluded). An analysis of the running costs of glider facilities would enable better informed decisions about their sustainability.

10. Gliders in your facility:

How many gliders do you currently have in your facility?

How many gliders do you operate in your facility?

Have you experienced any glider losses (2015-2020)? If YES, how many?

Do you plan to buy or lease a glider ? Yes/No

If yes, how many gliders do you currently plan to purchase (2021- 2025)?

If yes, how many gliders do you currently plan to lease (2021- 2025)?

11. How many people (full time equivalents) are there in your glider team ?

TIP: Consider here all man power which contribute to the provision of the service, whether it include an explicit cost (the facility have to pay for it) or not. The assessment of the PMs and their cost may strongly depend from a facility to an other, so provide the information in such a way we could assess the overall cost of PM of the GERI.

Glider operators

Technicians

Permanent scientific staff

Postdocs (providing service to the infrastructure)

Students (providing service to the infrastructure)

Others (please precise)

12. What vessels and/or launch methods do you have/plan to have/ use regularly for the launch and recovery of gliders?

13. Average cost of a mission taking into account the number and duration of the missions within one year (preparation, vessel costs, transportation, deployment, recovery, communications, piloting, emergency recovery, etc): [EUR/month]

It will be very usefull if you can provide this information, whatever is the method used to compute it. It could be as well what the facility is presently charging to the user for one month of service. If a different unit is used (e.g. EUR/day) please precise.

14. What were the average annual operating costs of your glider facility over the past 6 years (2015- 2020) in €?

TIP: for the three cost categories in *italic*, consider here the internal cost of your facility related to data

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management. Is should be small if the facility is not a DAC, higher if it is a DAC, and probably even higher for a GDAC or similar structures. Answers can be merged.

	2015	2016	2017	2018	2019	2020	If this information is not available year by year, please provide the average per year for 2015-2020 period	N/A
Purchase of gliders								
Purchase of sensors								
Glider infrastructure equipment (e.g. pressure chamber, ballast tank, etc):								
Glider equipment (e.g tools, R&D,....):								
Glider safety equipment								
Batteries								
Iridium								
Argos								
Other consumables								
Other communication								
Spare parts/repairs								
Calibration								
Vessel hire								
Transportation of equipment								
Permanent people								
Contracted people								
People travel								
People training								
People piloting								
Outsourced piloting								
Real-time data management cost								
Delayed mode data management cost								
Other costs related to data management								
Shipping insurance								
Glider loss insurance								

Liability insurance								
Other insurance								
Other								
Indirect cost / overhead (estimate)								
Building rent/construction:								

15. What do you think will be the best way of reducing the costs of glider operations in your facility within the next 5 years ?

16. What do you think will be the best way of reducing the costs of glider operations by integration with other similar facilities within the next 5 years ? (indicate cost categories from the matrix above)

17. Do you have in place agreements with other national and international entities to assist with launch and recovery of gliders on an opportunistic basis? If YES, please provide more details.

STATUS

Qualitative assessment of the positioning of your facility and similar ones in your country/region. Task 2.4 is in charge of engaging the facilities which are not represented in the project.

18. Do you know other organizations in your country that have glider facilities? (* Details will be asked about these organisations at the end of this survey)
If YES please provide the number of organisations:

TIP:
The EuroGOOS Glider Task Team have done this survey in May 2021 where you may have contributed. Please do a check considering that GROOM II footprint is larger than the one considered by the GTT. You can find the list of facilities here.

Governmental agencies	
Private industry	
Educational/ Research Institutions	
Other	

* **19. How are glider facilities considered in your country? Please select:**

○ National RI ○ Included in the national RI roadmap
○ Neither of the two

20. If you selected the "national RI", please list other organizations in your country that have glider facilities NOT included in the national RI

* **21. What are the funding mechanisms for glider facilities in your country? Select all that apply:**

- ☐ National research funding organizations (RFOs) (on CFP)
- ☐ National core government funding (RI)
- ☐ Regional funding organizations (on CFP)
- ☐ Regional government core funding
- ☐ EU DGRI funding (Framework programmes)
- ☐ EU DGMARE funding
- ☐ EU structural funds and others
- ☐ Other international funding
- ☐ Private funding
- ☐ Incomes from services provided to users
- ☐ Other (please precise):
- ☐ None of the above

22. If you selected more than one, do you know who funds the largest part of glider facilities? Please rank (there will be a follow up question on the next page).

1 2 3 4 5 6 7 8 9 10 11 National research funding organizations (RFOs) (on CFP)

1 2 3 4 5 6 7 8 9 10 11 National core government funding (RI)

1 2 3 4 5 6 7 8 9 10 11 Regional funding organizations (on CFP)

1 2 3 4 5 6 7 8 9 10 11 Regional government core funding

1 2 3 4 5 6 7 8 9 10 11 EU DGRI funding (Framework programmes)

1 2 3 4 5 6 7 8 9 10 11 EU DGMARE funding

1 2 3 4 5 6 7 8 9 10 11 EU structural funds and others

1 2 3 4 5 6 7 8 9 10 11 Other international funding

1 2 3 4 5 6 7 8 9 10 11 Private funding

Incomes from services provided to users

1 2 3 4 5 6 7 8 9 10 11

1 2 3 4 5 6 7 8 9 10 11

Other (please precise):

23. Are there any interactions with other infrastructures/facilities including existing ERICs?

TIP: Your facility may be part of an existing European RI (ERICs such as EMSO), or is participating to a project for an RI or a network of RIs (e.g. Eurofleet, EUMR, ...). Give any useful information here

*** 24. Are there mechanisms to access long-term (6-10 years) funding for glider facilities in your country?**

- No
- Yes, namely

*** 25. If funding for glider observatories is from core government funding, is this through how many ministry(-ies)?**

- Yes, 1 - 2
- Yes, 3 - 4
- Yes, >4
- No core government funding

*** 26. Is your facility a legal entity? Has your glider facility its own/separate accounting?**

- Yes
- No

INCOMES AND FUNDING

Quantitative assessment of the business plan of your facility. This include everything which will allow GROOM II to make a creative proposal for the design of a sustained GERI.

27. Who is funding your glider facilities? Please provide the amounts in each year.

	2015	2016	2017	2018	2019	2020	If this information is not available year by year, please provide the average per year for 2015-2020 period	N/A
National research funding organizations (RFOs) (on CFP)								
National core government funding (RI)								
Regional funding organizations (on CFP)								
Regional government core funding								
EU DGRI funding (Framework programmes)								
EU DGMARE funding								
EU structural funds and others								
Other international funding								
Private funding								
Incomes from services provided to users								
Other (please precise):								

28. Incomes from services provided to users

	2015	2016	2017	2018	2019	2020	If this information is not available year by year, please provide the average per year for 2015-2020 period	N/A
Research								
Ocean observations (monitoring,...)								
Training								
Industry/Innovation								
Other (please precise):								

*** 29. As a glider operator organisation, do you make your facility/vehicles available to external users? If YES how? (direct selling, maintenance contract, renting vs leasing, other)**

NO   Yes, by ...

SUGGESTIONS

30. Please provide other glider facilities in your country and elsewhere to be further asked with this questionnaire (* if not already listed in EuroGOOS questionnaire)

TIP: List of existing facilities already mapped by GTT survey can be found here

	1	2	3
Organization:			
Contact person:			
Email:			
Role:			
Address:			
Website:			
Glider specific website (if available):			

Your responses have been registered!