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Deliverable abstract

GROOM II is a H2020 European project whose objective is to design the future European research infrastructure harnessing advantages of Marine Autonomous Systems (MAS). MAS open new possibilities to observe the Marine world, providing long term observation from the surface down to thousands of metres with a very small energy consumption and for a limited cost. With the development of new miniaturised sensors, MAS now can measure parameters for ocean physics, chemistry and biology, which makes them useful in many sectors, from research, sustained observation including for meteorology, to industrial applications with fisheries and energy.

This deliverable documents how the objective of developing and upgrading synergies and co-operation with other research Infrastructures through the GROOM II design study project will deliver a seamless integration of the proposed GROOM RI into the European Marine RI landscape towards a multi-platform, multi-parameter and multi-scale observing capacity and system for Europe.

The deliverable includes two **Policy brief documents**:

- The Role of Marine Autonomous Systems in the European Marine Research Infrastructure Landscape and completion of the European Ocean Observation System;
- The Role of GROOM RI in advancing Marine Autonomous Systems in International Ocean Observations.

The policy briefs consider the broad application areas of MAS in frontier science, ocean observation and the blue economy.

A **Fact Sheet** which highlights areas where GROOM RI can contribute to capacity building and innovation in Ocean Observation to support frontier science and the implementation of the EOOS/GOOS is also presented.

Deliverable executive summary

The future GROOM Research Infrastructure (GROOM RI) that is being designed during GROOM II can serve a key role in providing a trusted link between national glider observation efforts and European and international observing coordination efforts. The objective of this deliverable is to document how progress toward actual synergies with other related Research Infrastructures (RIs) including ESFRI landmarks as well as other RIs (Eurofleets, JERICO) have been developed and upgraded as part of GROOM II. This progress is a significant step towards the GROOM RI integration within the European marine RI landscape towards a multi-platform, multi-parameter and multi-scale observing system. The deliverable describes the development of plans to coherently integrate a distributed GROOM RI with a legal entity into the European landscape of Marine Research Infrastructures and related facilities or frameworks; In particular, integration into EOOS - European Ocean Observing System (EOOS) - the infrastructures, platforms, sensors and people that gather this essential data and information about Europe's ocean, seas and coastal waters.

2 Policy briefs and a fact sheet are presented which include analysis and recommendations on how the GROOM RI completes the European Marine Research Infrastructure (MRI) landscape in supporting frontier science as well as the full implementation of the EOOS/Global Ocean Observing System (GOOS), capacity-building and innovation.

Policy Brief 1 addresses the **role of GROOM RI in the European Marine Research Infrastructure Landscape** with the following conclusions and recommendations: GROOM RI advocates for the sustainability of National MAS related systems or MAS infrastructures at European and global levels to establish a lasting Research Infrastructure for Marine Autonomous Systems (MAS). Proposing a central hub with distributed nodes, GROOM RI aims for efficiency, economies of scale, cost savings, and higher service standards for MAS operators, including MAS operators from ESFRI landmarks. Key performance indicators are developed for assessment. Coordination of MAS actions centralises efforts, providing a technical framework for cohesive integration, generating added value and cost savings. GROOM RI bridges the gap between open and coastal oceans, offering operational advantages and cost-effectiveness.

GROOM II's efforts include collaboration roadmaps with MRIs, resulting in MoUs or MoCs (Memorandum of Understanding/Collaboration) with key initiatives. Policy recommendations emphasise that policy maker support for a sustainable GROOM RI is essential. GROOM RI facilitates increased, cost-effective ocean observations, aligning with the EU Integrated Maritime Policy for smart, sustainable, and inclusive growth. The fragmented Ocean Observation landscape without a Marine Autonomous System research infrastructure risks Europe lagging in observational capacity, hindering scientific discoveries

and international collaboration. Continued support for established structures ensures collaboration, addressing common topics and completing the EOOS.

Policy Brief 2 considers **GROOM RIs Contribution at the Global level** and concludes that the strategic design of the GROOM RI ensures seamless integration into the Global and European Ocean Observing Systems. Leveraging national research infrastructures and global coordination, GROOM RI establishes organisational and legal foundations with a sustainable business model. As a formal entity, it will enhance cooperation, coordination, and integration to provide world-class glider services, connecting scientists, industry, and oceanographic platform operators.

Central to GROOM II's vision is the strategic utilisation of shared components from GOOS programs, exemplifying the value of co-developing GROOM RI components. The key imperative lies in consistent support from policymakers at both National and European levels, ensuring GROOM RI's evolution into a world-class, sustainable infrastructure. Emphasising the centralisation of MAS efforts in Europe through GROOM RI, the recommendations stress ongoing collaboration with OceanGliders, the glider associated program of the GOOS. These policy suggestions underscore GROOM RI's pivotal role in addressing the challenges of International Ocean Observations over the forthcoming decades.

The Fact Sheet entitled "*How does the GROOM RI contribute to an Integrated European Ocean Observing System and an Improved global Infrastructure for Marine Autonomous Systems*" summarises details relevant to the promotion of GROOM RI to stakeholders and contains essential information about GROOM RI and summarises progress during GROOM II to provide information to GROOM RI stakeholders in concise, simple language.

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List of Abbreviations

ARGO	Scientific international programme for ocean observation using a fleet of robots
ASV	Autonomous Surface Vehicle
AUV	Autonomous Underwater Vehicle
CMEMS	Copernicus Marine Environment Monitoring Service
ECV	GCOS Essential Climate Variables
EGO	Everyone's Glider Observatories
EMBRC	European Marine Biological Resource Centre
EMODnet	European Marine Observation and Data Network
EMSO	European Multidisciplinary Seafloor and water column Observatory
ENVRI	ENVRI is a community of environmental Research infrastructures working together to observe the Earth as one system.
EOOS	European Ocean Observing System
EOV	Essential Ocean Variables
EUROARGO	European contribution to the ARGO programme
EUROGOOS	European component of the Global Ocean Observing System of the Intergovernmental Oceanographic Commission of UNESCO (IOC GOOS)
EUROFLEETS	Alliance of European marine research infrastructure to meet the evolving needs of the research and industrial communities
EUROSEA	Improving and integrating the European Ocean Observing and Forecasting System
FAIR	Findable-Accessible-Interoperable-Reusable
GOOS	Global Ocean Observing System
GCOS	Global Climate Observing System
GROOM RI	GROOM Research Infrastructure
JERICO	Joint European Research Infrastructure of Coastal Observatories: Science, Service, Sustainability
MAS	Marine Autonomous Systems
MRI	Marine Research Infrastructure
MTS	Marine Technology Society
OGST	OceanGliders Science/Steering Team
R&D	Research & Development
WP	Work Package

1. Background to this Deliverable

History of the European Glider Community Development

Autonomous Underwater Gliding Vehicles (AUGVs), also known as gliders, are the most mature MAS and their increasing use and adoption by oceanographers triggered a community effort to exploit this complex technology. Recognizing the historical background and the collaborative efforts made over the years is important to understand the current status and future directions. The idea for a glider community emerged in October 2005 at the first "EGO" (Everyone's Gliding Observatories[1]) Workshop and Glider School. Since 2006 the glider activity in Europe, and later at global level, has been facilitated by EGO, and the coordination of glider activities in Europe rose in 2010 with the COST Action ES0904 "European Gliding Observatories Network" (EGO) to map the scientific, technological and logistical opportunities related to this technology in Europe but also considering global activities. A major spin-off from the COST Action ES0904 was the FP7 Design Study for a European Research Infrastructure (RI) "Gliders for Research Ocean Observation and Management" (GROOM, hereafter GROOM-FP7).

GROOM-FP7 evaluated scientific opportunities and technical requirements to define how a European glider infrastructure, then called GERI and from now on called GROOM RI, could operate this technology to create a continuum of observations from coastal seas to open ocean and addressing multiple stakeholder needs. GROOM-FP7 also initiated a dialogue with EuroGOOS.

The GROOM-FP7 project concluded that:

1. A "Glider European Research Infrastructure" (GROOM RI) is needed to ensure world-class ocean observational services to the research and environment monitoring communities;

2. The GROOM RI is based on a distributed architecture of nodes around the European seas and overseas, working in close coordination to address the required and cost-effective way to operate fleets of gliders in combination with other observing platforms and for the benefit of observing systems.

3. The GROOM RI is the suitable entity to deploy, maintain and operate individual as well as fleets of gliders continuously for operational monitoring and research.

GROOM-FP7 addressed the full scientific and technical functional design of the proposed infrastructure, including the complex issue related to the non-existence of a legal status of glider regarding the Law of the Seas and maritime regulations. However, it did **not** address its full legal organisational design as upheavals undergoing in the evolution of Marine RIs (MRIs) organisation at the European Level during the last decade made such a design premature. The GROOM II project is addressing the design issue and the positioning of the GROOM RI in the MRI Landscape is a key issue in this process.

[1] EGO glider website (ego-network.org)

Parallel to that, a **EuroGOOS Glider Task Team** was set up in 2015, representing the European voice of the glider community and to contribute to the GOOS and the EOOS framework. It works to support the coordination of the European glider activities, assist the standardisation of glider operations, data and applications, ensure data availability for the Copernicus Marine Environment Monitoring Service (CMEMS), generate and promote best practices in applications, technologies, data management, and scientific development.

The GROOM RI is currently being designed by the GROOM II H2020 project (groom-ri.eu) running from October 2020 - March 2024 under the the INFRADEV-01-2019-2020 “Design Studies” topic, building on the work performed during GROOM-FP7, adopting a more holistic and mature approach and expanding from underwater gliders to MAS, following the emergence of Autonomous Surface Vehicles (ASVs) and their similarities with AUVs.

GROOM II strongly relates to the ESFRI “Strategy Report on Research Infrastructures Roadmap 2021”, the aim of GROOM II being to provide design study, business case, politic and financial support obtained, common access policy, top-level breakdown or costs, governance and HR policy, which will lead to preparation, implementation and finally operation.

A core objective of GROOM II is the full detailed design of the GROOM RI for a possible integration into the ESFRI roadmap after 2024 and implementation. Governance and funding schemes will be formally designed. The integration of the GROOM RI in the landscape of European MRIs and its interaction with similar systems servicing the GOOS (USA, Australia, Asia) will be formally established. The number of countries in Europe supporting this infrastructure is a key metric assessing the success of GROOM II in that respect. How GROOM RI continues to ensure global leadership by supporting the global integration of existing (USA, Australia) and new facilities in non-European countries will be another metric.

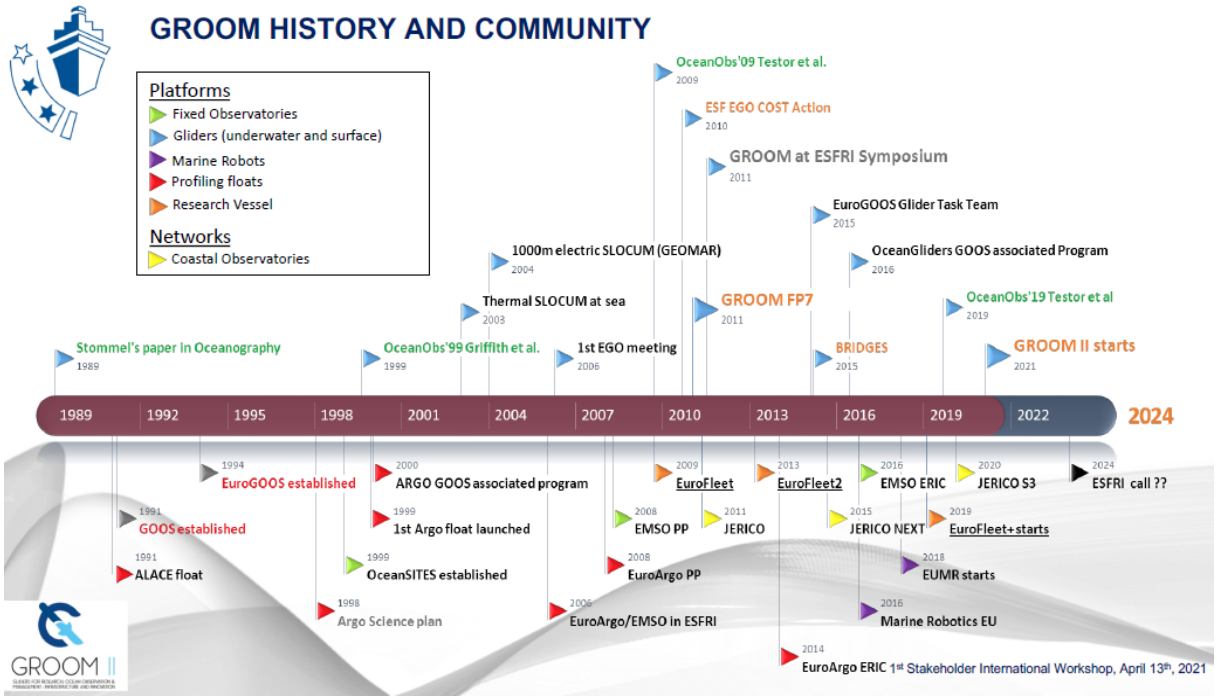


Figure 1 - Key Milestones in the evolution of GROOM RI and the Glider community since 1989

GLOBAL BACKGROUND

European coordination efforts have led to the creation in 2016 of the OceanGliders GOOS associated program, which is now supported by a technical coordinator at OceanOPS, formerly JCOMM-OPS, the Joint Technical Commission for Oceanography and Marine Meteorology - Operation Support. In September 2016, the OceanGliders program started, being established in recognition of the maturity of the glider systems and their potential role in **GOOS** and **GCOS** via JCOMM. OceanGliders was approved by the Joint WMO-IOC JCOMM at their 5th Intergovernmental Session in October 2017 as an associated program. The OceanGliders Steering Team reports to its Observation Coordination Group (OCG) (like Argo, OceanSITES, DBCP, etc.). The OceanGliders program was presented to the community during the OceanObs'19 conference [7], having prospects for the next decade of moving from the present ~20 up to ~100 gliders collecting data at any time in a global and sustained observing framework.

Since the launch of the OceanGliders program in 2017, the number of yearly glider deployments has nearly doubled. This great improvement goes along with an increasing number of countries involved in the program and harmonisation of the data exchange format that strongly contributes to achieving the FAIR (findability, accessibility, interoperability, and reusability) data principles promoted by the GOOS.

GROOM RI is developing strong links and synergies with other Marine Research Infrastructures both in Europe and at global level. The ambition of GROOM II lies in the fact that the GROOM RI will really bring the missing piece to the existing and future (e.g. EOOS) ocean observing systems, by providing the capability to extensively observe the ocean from surface to 1000m and soon 6000m or the bottom,

at all relevant spatial/temporal scales, and for most of the Essential Ocean Variables (EOV) that are essential for science, observation, monitoring and market activities.

DELIVERABLE OBJECTIVES

The main objective of this deliverable is to document how synergies with other related RIs, including ESFRI landmarks as well as other RIs (Eurofleets, JERICO etc.), have been developed and upgraded as part of GROOM II. This progress is a significant step towards the GROOM RI integration within the European Marine RI (MRI) landscape towards a multi-platform, multi-parameter and multi-scale observing system capacity. The deliverable describes the development of plans to coherently integrate a distributed GROOM RI with a legal entity into the European landscape of Marine Research Infrastructures and related facilities; In particular, integration into the EOOS which encompasses the infrastructures, platforms, sensors and people that gather this essential data and information about Europe's ocean, seas and coastal waters.

Having achieved efficient pan-European networking, harmonisation and cooperation procedures across the European glider community via the GROOM-FP7 project, GROOM II aims to continue this progression and establish links as well as integrating on-going efforts with other marine observatory programs and RIs.

This deliverable describes how GROOM II is collaborating with relevant ESFRI landmarks (EMSO and Euro-Argo) and RI projects such as JERICO-S3 and JERICO-DS, Eurofleets+ and other projects such as EuroSea. How GROOM II links with related European Research Infrastructure Consortia (ERIC's) including EMSO, ICOS, Euro-Argo, LifeWatch, EMBRC and EPOS building synergies with the ENVRI cluster and the related projects such as ENVRI-FAIR is also highlighted.

The development of Formal agreements/Memorandums of Understandings (MoU's) and Memorandums of Collaboration (MoCs) with an emphasis on infrastructural synergies and data sharing is a key strategy of this deliverable and is also described in detail.

This deliverable comprises 2 **Policy briefs and a fact sheet** which include recommendations on how the GROOM RI completes the European MRI landscape in supporting frontier science, the full implementation of the EOOS/GOOS, capacity-building and innovation. **Policy Brief 1** addresses the role of GROOM RI in the European Marine Research Infrastructure Landscape while **Policy Brief 2** will consider GROOM RIs Contribution at the International level.

2. Background and context for the European Marine Research Infrastructure Landscape and the GROOM RI

Underwater and surface Marine Autonomous Systems (MAS) - especially gliders, have become essential vehicles to carry scientific payloads for most environmental observations from the surface down to 6000 m and for activities supporting the blue economy. Their major advantages are being mobile, steerable, persistent and usable in large numbers and at relatively low costs. However, the distributed infrastructure required to exploit these assets must be able to meet different demands from research and monitoring of the marine environment to public service missions and industry needs, requiring customised payloads and operations. The rapid evolution of such technologies (robotics, artificial intelligence, sensors, big data) requires that the R&D resources offered by this distributed infrastructure continuously adapt to users' demands.

The complex hardware and information technology characteristics of such a distributed European infrastructure, optimising access to resources and R&D for gliders, were analysed during the GROOM-FP7 design study from the perspective of research and the Global and (future) European Ocean Observing System (GOOS & EOOS) needs. Since then, several "Gliderports" (called nodes in GROOM II) have developed which have fostered a corresponding European industrial innovative sector in the field of Marine Autonomous Systems.

GROOM II, building on its predecessor, is a design study project that will deliver the decision basis for an advanced Marine Research Infrastructure (MRI) that promotes scientific excellence, fosters innovation, supports the blue economy, builds industrial and public partnerships, and works towards helping achieve the common research and innovation mission for future Europe. The project will define the overall organisation of an infrastructure dedicated to ocean research and innovation, and maritime services supporting Blue Growth: GROOM RI. This proposed infrastructure will be a positive step against today's fragmented European landscape, aiding connections and synergies for the completion of the GOOS and EOOS.

The GROOM RI vision and mission statements have been crafted to reflect the ambition and drive of the GROOM II consortium to design and build a fully integrated, fit for purpose, service-oriented research infrastructure.

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.	
This European Research Infrastructure integrates national infrastructures for Marine Autonomous Systems (MAS) to provide access to platforms and services to the broadest range of scientific and industrial users, as well as other ocean observing RIs. It maintains a unique centralised provision of cyber-infrastructure, data and knowledge for the optimised use of MAS to study climate and marine environments, and to support operational services and the blue economy.	

3. Policy Brief 1: Role of Marine Autonomous Systems in the European Marine Research Infrastructure Landscape and completion of the European Ocean Observation System

THE POLICY CONTEXT

A meeting on developing a cooperation framework between marine research infrastructures was held at the EuroGOOS conference in May 2021 [8]. During this several policy challenges and issues were identified. These included:

- The current ocean observing system landscape is very complex and there are several established RIs and ERICs focusing on various aspects of ocean observations
- There is a need for collaboration among RIs and ERICs and to highlight what can be achieved through this collaboration.
- There is currently fragmentation in the various elements of the ocean observing system and there is a need for better coordination [1].

The aim of this Policy Brief is to raise awareness of the issue of the positioning of a proposed Marine Research Infrastructure based on Marine Autonomous Systems, GROOM RI, in the increasingly complex European Marine Research Infrastructure landscape. This positioning is a key consideration of the GROOM II design study project.

GROOM RI role is being clearly defined through the **development of synergies and designing of mutual support and interactions with other related Research Infrastructures (RIs) including ESFRI recognised RIs as well as other RIs. This represents a significant step towards the GROOM RI integration within the European marine RI landscape towards a multi-platform, multi-parameter and multi-scale observing system for the benefit of EOOS**

KNOWLEDGE LANDSCAPE

Having achieved efficient pan-European networking, harmonisation and cooperation procedures across the European glider community via the GROOM-FP7 project, GROOM II is continuing this progression and integrating on-going efforts with other marine observatory programs and RIs.

GROOM II is collaborating with relevant RI projects such as JERICO-S3 and JERICO-DS, EuroSea, Eurofleets+, and the more recently started MINKE and EuroGO-SHIP, across a range of areas of mutual interest. GROOM II has established links with related European Research Infrastructure Consortia (ERIC's) including EMSO, ICOS, Euro-Argo, LifeWatch, EMBRC and EPOS, building synergies with the ENVRI community and the related projects such as ENVRI-FAIR. Formal agreements/Memorandums of Understandings (MoUs) and Memorandums of Collaboration (MoCs) have been signed (Eurofleets+) and will be signed (JERICO-S3) with an emphasis on infrastructural synergies and data sharing while regular meetings (at common events where possible) for participation in the project specific events will be pursued.

This policy brief lays out clear evidence of the solutions that the European glider community can bring to the problem of gaps in measurement capability across the existing marine research infrastructure landscape in Europe.

This policy brief along with the accompanying fact sheet will act as a 'business card' in presenting important developments in the GROOM RI design study helping to establish a credible reputation with policy actors and stakeholders. It is also an important way to bring GROOM RI development and progress to the attention of policy actors, by presenting these research findings into knowledge, recommendations and targeted information.

METHODOLOGY / APPROACHES

Initiatives are well underway within the European glider networks to converge in methodologies and best practices. GROOM II project Design study is focusing on a multi-faceted approach to address the role of GROOM RI in the European Marine Research Infrastructure landscape. The various methodologies and approaches taken across the GROOM II project in achieving this integration are described below. Each methodology has been underpinned and supported by the hosting of various Workshops/Webinars and the development of White papers to define strategic direction across the different areas. The Communications and Dissemination work carried out under GROOM II has also been beneficial in highlighting the objectives of the GROOM RI in a consistent targeted way.

Interactions with established glider groups in the scope of EOOS

The EuroGOOS and EOOS perspective on glider contributions to European ocean observing were outlined by EuroGOOS General Secretary Inga Lips at a workshop organised as part of the GROOM II General Assembly meeting on 17th February 2022. The diagram below is adapted from this workshop and outlines the GROOM RI collaborations in relation to European and broader international glider activity.

Figure 2 - GROOM RI interactions with glider groups both at a European and international level. The respective roles of the entities and the formalisation of their relationship will be the subject of a dedicated workshop at the next International Underwater Glider Conference in June 2024 in Goteborg.

This diagram provides an overview of how GROOM RI interacts with the various glider groups both at a European and international level. This includes the EuroGOOS Glider Task Team which is the operational part of the European glider community. Continued interaction is recommended between GROOM RI and the EuroGOOS Glider Task Team to ensure the objectives of both groups align and that operational cooperation is achieved. A fully functioning GROOM RI would be the glider component of the evolving EOOS which would provide European integration of ocean observing networks and sustainability. The EuroSea project aims to improve the European ocean observing and forecasting system, with the glider network key to achieving this through the development of standard operating procedures and data management. OceanGliders is the international organisation for the glider community and is a key partner for GROOM RI.

According to the EuroGOOS and EOOS perspective on glider contributions to European ocean observing, the next steps for the glider community in Europe are summarised in the table 1 below.

Table 1 - Description of the next steps for the glider community in Europe

I. Data Management	II. Sustain the existing and develop new observatories	III. Towards a Glider Research Infrastructure in Europe
A European Gliders Workshop organised by EuroGOOS, GROOM II	•Strengthen long-term perspective and planning of glider areas and lines and	•Leverage capabilities of the European glider community to make

and EuroSea took place in June 2022 to: •Improve the management of real time glider data and metadata in Europe •Identify bottlenecks and obstacles faced by data providers and operators to standardise the glider data flow •Discuss delayed mode glider data management objectives, approach and funding •Propose a roadmap for glider data management in Europe and contribute to the global system	promote sustainability of operations •Promote new observatories in the European glider array, serving the EOOS framework and supporting relevant European directives and policies (e.g. MSFD, MSP, CFP) •Extend the observing capacity with new piloting capabilities and sensors, serving excellence in marine science and operational monitoring of European seas	observations on more variables and in more regions and sustainably deliver FAIR data •Engage with other autonomous vehicles (wave gliders, sail drones) •Contribute to the EOOS strategy and implementation plan 2023-2027

It is recognised that a supporting RI with a strong operational component is required to follow these steps effectively. The GROOM II design study focuses on how GROOM RI will operate as this operational component.

A **Whitepaper D4.2 [2]** on how GROOM RI can contribute to the development of the EOOS is being prepared in WP4 of GROOM II. The whitepaper presents the detailed factual evidence of the benefits GROOM RI can offer EOOS. This involves identifying requirements for GROOM RI and defining expectations to ensure its seamless integration into EOOS. It will do this by developing exchange mechanisms among the glider community, identifying the added value of GROOM RI, developing an organisational structure for GROOM RI, ensuring FAIRness of data and facilitating capacity development and glider training. A definition of what is the added-value of a distributed GROOM RI for the current development of the future EOOS (WP4) in line with the global strategies (e.g. GOOS, G7 initiative, 2030 sustainable development goals, UN decade of ocean science) is included in the Whitepaper.

Formal Agreements and Membership of Infrastructure Networks

In order to determine the role of GROOM RI, fostering MAS activities, in the completion of the EOOS and interaction with other RI's, a number of initiatives including Formal Agreements and Memberships of Networks are being implemented to strengthen collaboration, reduce duplication and eliminate gaps in the MRI landscape.

Formal Agreements

A number of MoUs (Memorandum of Understandings) and MoCs (Memorandum of Collaboration) are in the process of being signed with related marine environmental research infrastructures and ERICs,

initiated within GROOM II. An MoU is a document signed by representing entities that describes the general principles of an agreement between parties but does not amount to a substantive contract. A MoC is similar to a MoU but signed by scientific coordinators of the projects and RIs as representing the community. Existing MoU's between ERICs and various research performing organisations were reviewed for this task. Below is a table showing the organisations that GROOM II are in the process of signing a MoU/MoC with. The MoUs or MoCs in progress with JERICO-RI, EuroFleets-RI and EuroArgo ERIC provide a basis for the development of further MoUs with the other related RIs and ERICs identified.

Table 2 - Organisations in the process of signing formal agreements with GROOM II.

Name of RI/organisation	Description of role (domain, type of infrastructure, etc)	Relation to GROOM RI/Common interests	Level of engagement (eg MoU signed, draft MoU under discussion)
JERICO-RI	JERICO-RI is an integrated pan-European multidisciplinary and multi-platform research infrastructure dedicated to a holistic appraisal of coastal marine system changes.	Gliders are also a component of the JERICO RI	Signature of a Memorandum of Collaboration (MoC) in progress due for completion - early 2024
EuroFleets-RI	An alliance of European marine research vessels to meet the evolving needs of the research and industrial communities.	Research Vessels can be used for the deployment/recovery of gliders and ASVs	Signature of Memorandum of Understanding (MoU) completed July 12th 2023.
EuroArgo ERIC	Co-ordinates the European contribution to the global Argo programme	Common sensors and data flows. Sharing of the Coriolis European GDAC facility	MoU with EuroArgo remains under discussion. Collaboration between GROOM RI and EURO Argo will continue under the Advance Marine

			Research Infrastructures Together AMRIT Project - HORIZON-INFRA-2023-DEV-01-04.

In addition to the MoU activity outlined above, a workshop on engagement with other ERICs and RIs was organised. The workshop was held as a hybrid event as part of the GROOM II General Assembly in Paris on February 17th, 2022.

In preparation for the workshop, key questions on the potential interaction with a GROOM RI were sent to the coordinators of ICOS ERIC, EuroFleets-RI, EMSO ERIC and JERICO-RI. These questions related to three topics related to Research Infrastructures: Governance, operations and synergies/risks. The questions and outputs from the workshop are provided in Annex B and are summarised below.

Table 3 - Summary of outputs from the workshop on GROOM II engagement with other ERICs and RIs.

RI Topic	ICOS European Research Infrastructure Consortium	Eurofleets+	emso ERIC	JERICO-R Science · Services · Sustainability
Governance	ICOS ERIC platforms are used as test facilities for new technologies. ICOS ERIC supports collaboration to increase availability of good and usable data. While there are no formal agreements in place with other RIs, ICOS has synergies with EMSO ERIC, EuroArgo and JERICO-RI.	EuroFleets RI are developing policies and plans to better serve and co-operate with RIs such as GROOM, EuroArgo, EMSO ERIC, etc. While there is no formal process of cooperation between EuroFleets and other RIs, there are many networking and ad-hoc arrangements for the launch and recovery of autonomous infrastructures.	The barriers identified for countries to join or interact with a future GROOM RI include the need for additional financial resources to support this.	Countries providing long term funding for RIs will assess several mechanisms for coordinating activities – such as through a loose network maintained by project funding, a separate legal entity (ERIC, AISBL, etc) and/or ongoing engagement. The barriers identified include the complexity of the ocean observation system.
Operations	GROOM and glider/ASV operations could contribute to ICOS by filling gaps in the data using in particular surface autonomous vehicles, validating stations and adding spatial and	New research vessels are being designed to address the deployment and recovery challenges of gliders/ASVs and other autonomous underwater vehicles. Innovations have	Glider operations and data will contribute mostly for scientific purposes but also to support functional and technical specifications of new equipment-autonomous platforms.	JERICO RI are working with several RIs and ERICs at an operational level (i.e EMSO ERIC, AQUACOSM, EPOS ERIC, EuroArgo ERIC, DANUBIUS and others (with a number of MoUs in place). As

	temporal data for specific stations.	been developed to better meet the needs of new and emerging technologies and will allow for better integration on-board research vessels.		JERICO-RI is a multiplatform RI, glider data is needed for the delivery of JERICO-RI products and services.
Synergies/Risks	ICOS would support a GROOM RI and the data it could provide on the marine carbon system. It was noted that GROOM RI could contribute to EOOS by working towards the development of a common data platform with other RIs.	A coordinated approach to the long term planning of operations at sea across RIs to avoid duplication of efforts and to deliver maximum impact. GROOM RI could contribute to EOOS by sharing best practices with other RIs, promoting a fit for purpose multi-platform approach.	In order for GROOM to contribute to a EOOS, a stronger alliance among the glider community should be fostered, as is happening through the GROOM II project.	The synergies between GROOM and JERICO must be well defined, otherwise there is a risk that both RIs would not progress to the next stage of development in the ESFRI process.

Armines as project Coordinator along with other partners in GROOM II have been instrumental in a new proposal called AMRIT - Advance Marine Research Infrastructures Together, also coordinated by Armines. The proposal was submitted in March 2023 to TOPIC ID: HORIZON-INFRA-2023-DEV-01-04. The application was approved for funding in July 2023 with the project due to start in March 2024.

By setting up the **EOOS Technical Support Centre** that will maintain an information system, the goal of AMRIT is to build and establish the appropriate synergistic mechanisms which will allow European MRIs to:

1. better support research with an improved flux of ocean data;

2. function as truly integrated components of EOOS and, ultimately, GOOS;

3. better support the Copernicus Marine Service by providing detailed metadata information throughout the data value chain.

As requested in the HORIZON-INFRA call, the ambition of AMRIT is to meet this challenge with the overall objective of developing maximum synergies between three marine ERICs (EMSO ERIC, EURO-ARGO ERIC, and ICOS ERIC), whilst involving the set of pan-European MRIs, Eurofleets+, EuroGO-SHIP, **GROOM RI**, JERICO RI, and MINKE, to prepare for the generalisation of the established synergies for all components of EOOS resulting in shared services between these MRIs.

The **AMRIT EOOS Technical Support Center** is already recognized as the cornerstone to establish and maintain EOOS, upon which European ocean observing can be strengthened in the coming decades. AMRIT will provide a catalyst for the development and consolidation of all MRIs throughout Europe. Despite the absence of a dedicated MAS RI for the time being, the important role of gliders in the EOOS Technical Support Center is clearly acknowledged in the AMRIT proposal and MASs form a key element in a number of work packages.

It must be noted however that **AMRIT is not a replacement** or an alternative for GROOM RI which remains essential to drive the advancement of Marine Autonomous systems in Europe, but rather AMRIT will ensure that a **future GROOM RI will integrate seamlessly into the Operational Monitoring Dashboards, Common Data standards, Tools, Services and Unified Governance that are the Key exploitable results of AMRIT.** As with other platform-oriented (Euro-Argo, EMSO, EuroFleets and EuroGO-SHIP) or thematic (JERICO-RI and ICOS) infrastructures, the lack of systematic sharing of information through common metadata maintained by a permanent centre largely undermines the effectiveness of operations at sea. AMRIT's objective is to remedy this situation.

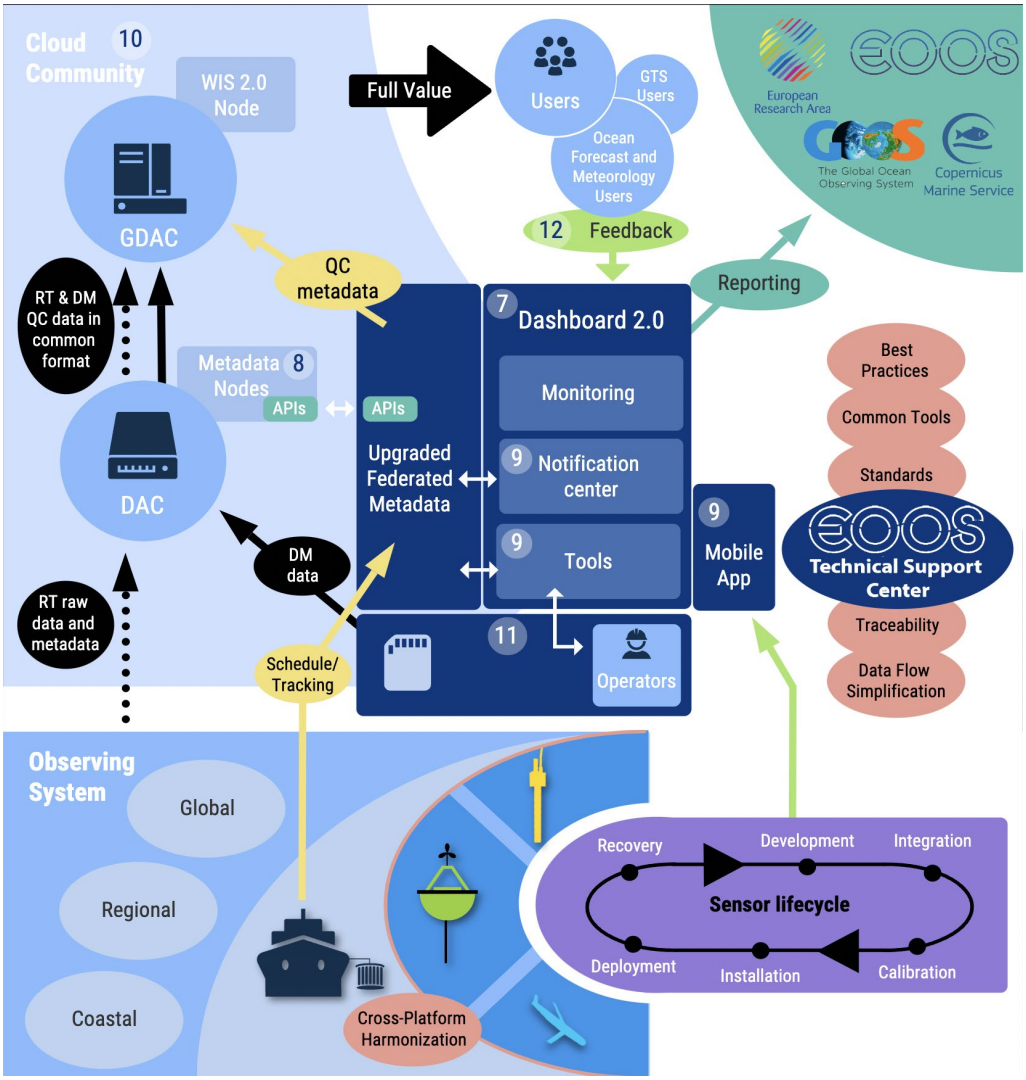


Figure 3 - Schema of the proposed EOOS TSC featuring Marine Autonomous systems as a key component.

Memberships

GROOM RI became a member of the **ENVRI community** in **June 2021** (as it was already the case for GROOM-FP7), when it was accepted again as a member of the BEERi (Board of European Environmental Research Infrastructures). BEERi works on common strategies, positions, policies and participations, and consists of RI directors or coordinators from the environmental domain research infrastructures in Europe. BEERi meets regularly and works on common messages towards the European Commission and ESFRI on behalf of the cluster of environmental Research Infrastructures.

GROOM RI Links to Industry, Innovation and the Blue Economy at a European level

Through GROOM II an Industry Advisory Group for Marine Autonomous Systems (IAG-MAS) has been set up to develop systematic and sustained interactions between the glider science community and the ocean industry. The ocean industry has clearly understood the advantages of MASs for their activities and there are now many areas of the Blue Economy where MASs are being used for e.g. “reference state” and impact studies and environmental monitoring.

IAG-MAS identifies and advances industry/science priorities for innovation in developing new glider products and applications. This innovation will lead to new knowledge, technologies and services that can be transferred to the market, typically via SMEs, in order to advance safe, responsible, and effective commercial operations, benefiting the Blue Economy.

IAG-MAS brings together leaders from over 20 organisations that specialise in manufacturing marine autonomous platforms and marine sensors as well as maritime service providers. The group unites professionals with considerable technical, commercial, and manufacturing expertise in the marine autonomous system space – from AUV fleet operators to marine surveyors to environmental monitoring data scientists and maritime security executives.

This advisory group have organised a series of online workshops during the project duration to:

- build collaboration and trust between industrial and national/EU scientific and technical stakeholders
- identify and advance priorities for innovation in developing new MAS products and applications
- share ideas about a cooperative framework between GROOM RI providers and users

The IAG-MAS workshops will produce a set of inter-related outcomes for the emerging research infrastructure:

- to identify emerging applications relevant to MAS that need large scale coordination to be properly addressed
- to identify and design a framework of cooperation between the private sector and the marine research infrastructures with a focus on MAS. This can be done in collaboration with other RIs such as JERICO-RI, EMSO ERIC, EuroFleets-RI, etc by using their international links through existing channels such as those established in the ENRIITC project[2]. This is expanded on in the following paragraph.
- feedback (on the designed framework) from the IAG-MAS/GROOM consortium will be communicated to the European Commission and national stakeholders in marine observation.

In addition to the IAG-MAS activity, the ENRIITC project provides another mechanism for industry collaboration. The project aims to establish a pan European network of Industry Liaison and Industry Contact Officers (ILOs/ICOs) to improve RI industry cooperation and boost the innovation ecosystem in Europe. The project provides valuable advice on how to interact with industry and organises brokerage events to help establish relationships between the sectors. The ENRIITC network provides an opportunity for GROOM RI to access industry using contact points established in other RIs.

[2] European Network of Research Infrastructures and Industry for Collaboration, https://enriitc.eu/

The IAG-MAS and the ENRIITC provide mechanisms for collaboration between GROOM RI and other RIs in relation to industry interaction. GROOM RI could use these platforms to work with other RIs to jointly engage with common industry stakeholders, both as users and suppliers.

GROOM RI Services

The GROOM RI Access model described in deliverable 2.1 - Access Policy and Rules, has outlined a framework on how to access GROOM RI facilities. D2.1 determined that providing a single consistent access system for all Glider Facilities is not possible, hence two different access models will be supported by the GROOM RI:

- The first, market driven access model, acknowledges the diversity of the GROOM RI partners and the different access constraints associated with each. In this approach, similar to the EMBRC system, the GROOM RI would act as a facilitator between the potential user and the individual glider facilities. The final contractual relationship would be between the user, including from the private sector, and the individual glider facility.
- The second, excellence driven access model, would be used for situations where the GROOM RI is able to fund (e.g. through European projects) to provide free or subsidised access to the facilities. In this model the GROOM RI would sub-contract the individual glider facilities using pre-arrange agreements between the RI and the individual glider facilities. This second access model GROOM RI would significantly simplify the collaboration between the different research projects, and other European RIs.

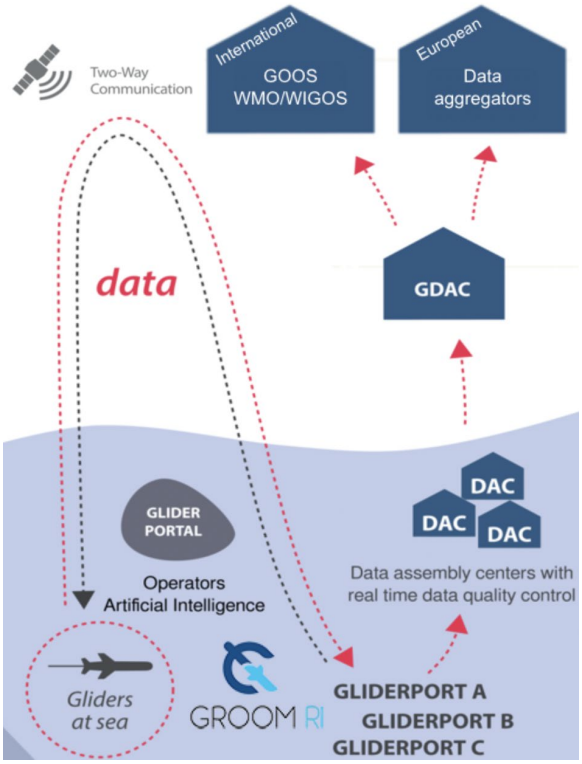


Figure 4 - Artistic view of the workflow of planned GROOM RI Service provision model with Glider ports (nodes) at the interface of Glider data collection.

As real-time data delivery is a vital issue for the operation of gliders, GROOM RI is already developing towards an 'RI service' stage for this real time service, which will build on existing infrastructures at the National Levels where glider facilities can act as a Data Assembly Center DAC.

The complete design of the Data management service is described in GROOM II D6.2 - Data management road map, with the objective of ensuring harmonisation of real-time and delayed mode data and interoperability. This involves working together to build a federated data platform for glider ocean observations (mentioned at the IAG meeting that there are currently different types of data in different repositories and a long term database for data from different platforms should be developed as ongoing activity. OceanGliders are doing this at an international level). To pave the way and engage users, EGO and GROOM RI partners are thus already providing data 'proto' services for glider deployment registrations and real-time data management (https://www.ego-network.org/dokuwiki/doku.php?id=private:add_an_ego_glider) that rely on vocabularies maintained by OceanGliders based on the NOC vocabulary server (NVS) format highlighting benefits of the cooperation and coordination. This 'proto' service of the future GROOM RI consists of online tools to efficiently push data in real time to DACs and GDACs, like Coriolis, which ensure quality control and delivery of the data to the data aggregators, improving FAIRness of the data. Training for this service is also provided.

It is worth noting here GROOM RI interacts with EMODMET, Copernicus, Seadatanet (European Data Aggregators) by adding the needed services to allow better and easier delivery of data to these platforms.

Similarly, it is envisaged that the MAS planning and operation service provided by GROOM RI would be more consistent if offered jointly for the other platforms. The Marine Facilities Platform (MFP, https://www.marinefacilitiesplanning.com/) established as a service by NERC, NIOZ for Research Vessel operations planning already offers a relevant example. The AMRIT project plans to define the interfaces with the MFP so that it can be used widely, including for MAS operations planning, as is already the case by the NOC for its MAS operations.

CONCLUSIONS

- GROOM RI recognises that the National systems' sustainability at European and global levels is essential to underpin a sustainable Research Infrastructure for Marine Autonomous Systems. Coordinating the MAS actions in Europe will help centralise the efforts already put in place. GROOM RI is proposing a Central Hub with distributed Nodes of technical organisation to deliver efficiency and economy of scales resulting in cost savings and benefits to MAS operators across Europe combined with higher standards in service delivery to stakeholders. A series of Key Performance Indicators is being developed to assess the efficiency and benefits of a GROOM RI versus an ad-hoc network of regional/national glider facilities.

- Coordinating the MAS actions in Europe will centralise efforts to provide a full technical framework for the cohesive integration of existing national infrastructures into the GROOM RI and the generation of added value and cost saving, which facilitates access to the GROOM RI facilities, their vehicles and services across Europe and beyond.

- A GROOM RI where MAS are operated will make the multiplatform approach paradigm fully operational in European Ocean Observation effort. It will bridge the gap between the open ocean and the climate-oriented Argo program and the coastal ocean where most of the economic activities take place, which includes the shelf break. The fact that gliders are steered and can be deployed by numbers in coordinated and "automated" fleets at relatively low costs, provide them with an outstanding interest in the present and future Marine Research Infrastructure landscape in Europe. As the MAS platforms mature, it is clear that gliders could enhance and even partly replace at a very competitive cost other platforms currently in use by maritime industries that try to acquire the relevant information and above all could offer new possibilities.

- GROOM II has investigated possibilities and challenges for European countries to connect with a future GROOM RI through a series of consultations, workshops and surveys, this has resulted in a roadmap for collaborations between a future GROOM RI and selected existing emerging initiatives and Marine RIs. This interaction is being strengthened through a series of Memorandum of Understanding (MOU) agreements between GROOM II and key MRI's including Jerico-RI, Eurofleets and Euro Argo ERIC. A strong collaboration has also progressed in parallel with EuroGOOS and the EuroGOOS Glider Task team to explore and define the means via services and deliverables, the ways the future GROOM RI will contribute to a European Ocean Observing System addressing key stakeholders requirements.

Table 4 - Summary Matrix of GROOM II methodologies being applied to deliver GROOM RI objectives in completing the European MRI landscape and the development of EOOS.

	Research Methodology Used to achieve Objectives			
GROOM RI Objectives	EUROGOOS Task Team Collaboration	Agreements with Research Infrastructures & RI Networks	Industry Advisory Group	GROOM RI Services Development
Facilitate and harmonise access to MAS services.	**X**	**X**	**X**	**X**
Acting as a common voice in connection with global efforts (GOOS, EOOS, ENVRI community)	**X**	**X**		**X**
Co-designing a common strategy, setting priorities	**X**	**X**	**X**	**X**
Mapping user requirements, creating external partnerships, and strengthening cooperation.	**X**	**X**	**X**	**X**

POLICY RECOMMENDATIONS

Support from Policy makers for the Implementation of a sustainable fit for purpose, service-oriented GROOM RI will facilitate the delivery of increased Ocean Observations at lower cost, high frequency and resolution with a lower ecological impact in terms of carbon footprint. The infrastructure will be installed and operated through multinational cooperation and support, providing consistent in situ data from the seas and oceans in support of the EU Integrated Maritime Policy and as a driver for smart, sustainable and inclusive growth. The development of GROOM RI will help to address important gaps in the European MRI landscape.

The existing fragmented Ocean Observation infrastructural landscape without the inclusion of a MAS research infrastructure risks Europe falling behind other regions in terms of observational capacity with negative impacts, resulting in limited ocean observations, reduced scientific discoveries, missed operational and environmental benefits, limited technological advancements, and reduced international collaboration. Establishing such an infrastructure is crucial for advancing our understanding of the oceans, addressing societal challenges, and promoting sustainable ocean management.

In addition, greater support and funding for established structures (such as the BEERI, ERIC Forum, ENRIITC project) will help to ensure continued interaction between GROOM RI and other RIs to further strengthen collaboration. This will help to enable collaboration on a number of common topics that were identified using the various methodologies outlined in this policy brief on the role of MAS in the European Marine Research Infrastructure Landscape and completion of the European Ocean Observation System.

4. Policy Brief 2: The Role of GROOM RI in advancing Marine Autonomous Systems in International Ocean Observations

POLICY CONTEXT

GOOS coordinates sustained ocean observing activities in order to support the delivery of harmonised data that is fit for use by those who need this information, for example for climate policy, hazard warnings and weather prediction, management of marine resources, marine and coastal operational decisions. GOOS has three key delivery areas: climate, weather and ocean prediction, and ocean health.

GOOS comprises of 13 in situ operational networks, the Glider network being *OceanGliders*[3]. Internationally, the OceanGliders program helps the glider community focus on GOOS requirements and contributes to all GOOS key delivery areas.

GOOS, however, is facing a number of challenges in ocean observations. Launched in 2019, the Global Ocean Observing System 2030 Strategy calls for a **step change** in the level and effectiveness of partnerships to deliver 'a truly integrated ocean observing system that provides the essential information needed for our sustainable development, safety, wellbeing and prosperity'. For a truly global and integrated system, more States need to be involved in the observing system and all regions of the oceans need to be adequately sampled, including waters under the jurisdiction of coastal States. This will be vital to meeting the challenge of the UN Decade of Ocean Science for Sustainable Development (launched in 2020), since observations are one of the foundational components underpinning sound ocean policy, management, and prediction.

The maturity of MAS operations, the wide range of MAS applications that map onto growing GOOS regional needs, and the maturity of glider data flow all justified the formal implementation of gliders into the GOOS. Challenges remain however including: (1) the execution of coordinated multinational missions in a sustained mode as well as capacity-building aspects in (2) glider operations and (3) glider data use. Providing solutions for these 3 areas specifically for (underwater) gliders, GROOM RI can provide the platform and capability to address these challenges through its services and capabilities.

A new network dealing with observations at the ocean-atmosphere interface is currently emerging in the GOOS. Among other observation platforms, this network will use ASVs, and as with the gliders, GROOM RI will be able to support them, guaranteeing synergies between this new network and the other GOOS networks, and especially OceanGliders.

KNOWLEDGE LANDSCAPE

By 2030, GOOS's vision is to have a global ocean observing system truly responsive to the needs of end-users, able to mitigate mounting pressures on the ocean and enable resilient and sustainable blue economies.

[3] https://www.oceangliders.org/about-us/

The glider component of the integrated GOOS *OceanGliders* was started in 2016. OceanGliders is organised in Task Teams (TTs), chaired by recognized specialists in their domains and fully open to engage broader communities. Six TTs are currently identified, namely: **Boundary currents, Storms, Water transformation, Ocean health and ecosystems, Best practices, and Data management** - https://www.oceangliders.org/taskteams/. As new issues are being raised and scientific areas related to gliders are expanding, new TTs are emerging. Through a call for proposals of new TTs in 2023, 3 new TTs with international applicability and relevant to societal applications have started on 1) glider data assimilation, 2) polar operations and 3) passive acoustic measurements. It is piloted by the OceanGliders Science/Steering Team (OGST) providing scientific leadership to promote ocean sub-surface gliders as a tool for sustained ocean observations globally, responding to integrated requirements of the GOOS (also incorporating GCOS requirements), and reporting to the WMO/IOC Observations Coordination Group (OCG). The OGST oversees the development and implementation of a global-scale glider array for observing key regions of the ocean on the long term, based on national and regional glider projects.

METHODOLOGIES TO DEVELOP THE ROLE OF GROOM RI IN INTERNATIONAL OCEAN OBSERVATIONS

GROOM II project stakeholders are applying a range of methodologies and approaches in determining the GROOM contribution to International Ocean Observation initiatives. These are described in detail below:

Strengthening GOOS/GCOS/Ocean Decade Interactions with GROOM RI

The key contribution of GROOM RI to the GOOS is to fill the gaps left by other *in situ* platforms. There is a lack of data in the present GOOS observations in the transition regions between the open ocean and shelf seas that gliders can address. Also, as gliders can remain in the sea for a long time, move over large distances and be sent to specific regions of interest they add valuable control and spatial coverage to the GOOS network.

GOOS has launched Ocean Decade Programmes

- Ocean Observing Co-Design;
- Coast Predict;
- Observing Together.

Increasing cooperation between observers, modellers and communities, involving the civil society in ocean observing, as well as bridging the gap between technology innovation and user capacity are some of the focuses of multiple new actions under these GOOS Ocean Decade Programmes.

GROOM RI as a functional European Research Infrastructure has the capacity to contribute to the MAS component within these 3 programmes. The key advantages of Marine Autonomous Systems in terms of **broad coverage, relatively low cost and low carbon impacts** will be important in contributing to the goals of these programmes over the next decade and beyond.

GROOM RI is structurally aligned with OceanGliders and will follow and contribute to the global efforts in the GOOS to align the 13 GOOS programs, avoiding adding extra layers and adding efficiency to the overall system. To this end, GROOM II is developing a set of Use Cases to better understand how to link the services, the strengths of a distributed RI and the capacities of different nodes and partners. The Use Case is a way to develop a concrete, coherent and shared understanding of what GROOM RI will offer, how it will do it, and for who. It corresponds to the external services and role that GROOM RI will provide in the international landscape.

Table 5 - Example

Use case Title: The European MAS contribution to the GOOS, GCOS, other international initiative (UN Decade).	
Potential users: IPCC, G7 priorities, UN Decade of the Ocean actions, World Ocean Database (National GOOS initiatives, EU GOOS contributors)	
The GROOM Offering:	**GROOM will help to design and implement a fit for purpose system to provide sustainable net zero MAS observations to the GOOS**.
The system will complement the ARGO and OceanSites arrays, filling the gaps in coverage and capability. This will contribute to the uptake of MAS operations during the decade of the Ocean. GROOM will monitor and collaborate with initiatives like the UN sustainable development goal 14, CoastPredict, OceanPredict and Observing Together, the need of high quality, targeted observations will be required. GROOM RI will develop the system to provide observations coming from MAS, and an interoperable framework to integrate current and emerging MAS platforms on a close feedback loop to be utilised by those UN activities.	

There is a global Argo programme and a EuroArgo ERIC at the European level, there is a global OceanSites programme and an EMSO ERIC at the European level, there is a global OceanGliders programme but no European equivalent. A dedicated Research Infrastructure for Marine Autonomous Systems offered by GROOM is the ideal operational component to support the OceanGliders programme of the GOOS at a European level.

With regard to the place that the use of ASVs will take in a possible new GOOS programme, GROOM RI will also be able to take on this role. This point has been addressed as part of the H2020 EuroSea project, and obvious potential synergies have been identified. For example, they would make it possible to approach data management in this new network using the existing methods and resources in OceanGliders, which are themselves fully consistent with those of Euro-ARGO and ARGO.

International Agreements Memberships

Building on the MOU's and Memberships with Research Infrastructures and Networks instigated at the European level, GROOM RI is working towards membership of the FIERI, the *Forum for the International cooperation among Environmental Research Infrastructure*s - an open platform for improving global, co-ordinated and long-term cooperation between RIs and Networks in the environmental domain. GROOM II proposes to link with the FIERI and to further develop long-term collaboration between RI's on a global basis.

The option of directly representing GROOM RI within the OGST should also be examined. This would support the European teams already present in the OGST coordination efforts and connect OGST with a wider European community. Few teams in Europe actually have the resources to really engage in the OGST.

GROOM RI Links to Industry and Innovation at an international level

GOOS has a long history of dialogue with industry through various organisations such as the Marine Technology Society (MTS). These dialogues concern in particular the possibilities of creating a mature and dynamic ocean observation company, including the industrial sector, which in turn benefits from this for its many maritime activities, for example of course transport. To enable MASs to be included more effectively in these dialogues, GROOM II has set up an Industrial Advisory Group for Autonomous Marine Systems (IAG-MAS) to develop systematic and sustainable interactions between the glider science community and ocean industry. IAG-MAS identifies and advances industry/science priorities for innovation in developing new glider products and applications. This innovation will lead to new knowledge, technologies and services that can be transferred to the market, typically via SMEs, in order to advance safe, responsible, and effective commercial operations.

IAG-MAS brings together leaders from over 20 European and international organisations that specialise in manufacturing marine autonomous platforms and marine sensors as well as maritime service providers, including for ocean observing. The group unites professionals with considerable technical, commercial, and manufacturing expertise in the marine autonomous system space – from AUV fleet operators to marine surveyors to environmental monitoring data scientists and maritime security executives.

This advisory group have organised a series of online workshops during the project duration to:

- build collaboration and trust between industrial and national/EU scientific and technical stakeholders;
- identify and advance priorities for innovation in developing new MAS products and applications;
- share ideas about a cooperative framework between GROOM RI providers and users.

The IAG-MAS workshops has produced a set of inter-related outcomes for the emerging research infrastructure that permits:

- to identify emerging applications relevant to MAS that need large scale coordination to be properly addressed;

- to identify and design a framework of cooperation between the private sector and the marine research infrastructures with a focus on MAS. This can be done in collaboration with other RIs such as JERICO-RI, EMSO ERIC, EuroFleets-RI, etc. by using their international links through existing channels such as those established in the ENRIITC project;
- To give feedback from the IAG-MAS/GROOM consortium to the European Commission and national stakeholders in marine observation.

GROOM RI data services development

Through the services designed in GROOM II, some of which are already operating as 'proto' services of the future GROOM RI, GROOM RI will ensure that MAS operators in Europe provide a sustainable MAS data flow for GOOS. The GROOM RI will help the operators, as shown in fig. 5, by supporting them to provide standardized raw data and metadata to be ingested by the DACs. The concept is as follows: at national level, MAS infrastructure operators supply data to their national oceanographic data centres, which in turn feed the GDAC, currently Coriolis maintained by Ifremer. The GDAC in turn feeds European data aggregators/consumers, such as SeadataNet/EMODNET/CMEMS, guaranteeing controlled and consistent data quality. This takes place within the framework of the European marine infrastructures coordinated by EuroGOOS. GROOM RI will also develop a data portal where all the data with controlled quality and following a defined data flow chain will be accessible.

At international level, OceanOPS acts as a global focal point to support the implementation of MAS and the distribution of their data in coherence with other platforms/data sources. In particular, OceanOPS collects and distributes information on the status of the observing system from MAS (and other platforms) at global level. This greatly facilitates the planning, implementation and evolution of MAS observation. The data management of the gliders has been developed from the outset in total coherence with that of the ARGO programme, and at a global level with a single data standard.

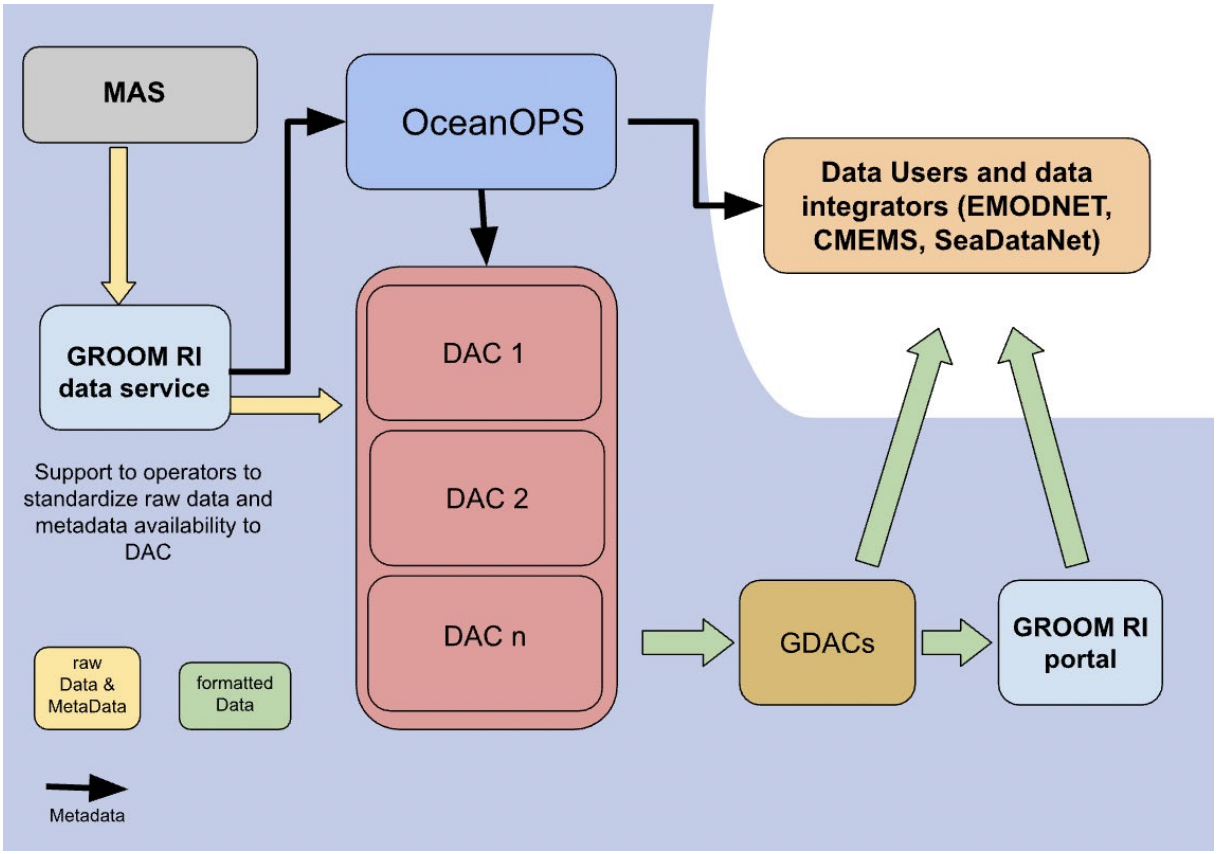


Figure 5- Diagram on how GROOM RI proto-services could interact with GOOS and GCOS.

The coordination between the European level guaranteed by GROOM RI and the global level with the different stakeholders makes it also possible to meet emerging requirements in terms of services needed for MAS operations.

- MAS data management will need to encompass developments within the MAS networks, the GOOS and outside of the oceanographic domain in order to anticipate future changes in global data management. For example, the implementation of Findable-Accessible-Interoperable-Reusable (FAIR) data principles is now a common theme in environmental data management and is placing demands for development on the services of the GROOM RI data infrastructure;
- The integration of data from different networks within GOOS as part of the Essential Ocean Variables (EOV) framework is continually placing new demands on data management, especially as new variables are defined to address the major challenges linked in particular to the preservation of marine biodiversity;
- In addition, other MAS operations requirements are emerging, such as automated piloting and automated technologies for monitoring or reconfiguring operational MAS networks, for example. These needs have already been analysed in depth in the GROOM II project.

CONCLUSIONS

- The strategic design for the GROOM RI shall ensure through the outcomes of the research methodologies described, a seamless integration into the Global and future European Ocean Observing Systems (GOOS and EOOS).

- GROOM RI leverages from the national RIs that have developed in Europe over the past decade, and from the long-lasting coordination initiated in Europe and globally. GROOM RI is establishing the organisational and legal bases for the RI with an adequate business model, able to offer services to users from the academic world, governmental and non-governmental entities, and private companies.
- As a formal entity, the GROOM RI will ensure cooperation, coordination, integration, and simplification to provide world-class glider services. This new glider infrastructure will connect scientists and industry with other oceanographic platform operators and marine system integrators to capture high value ocean data for society.

Table 6 - Summary Matrix of GROOM II research methodologies applied to deliver GROOM RI objectives at the international level.

GROOM RI Objectives	Research Methodology Used			
	GOOS/Ocean Decade Interactions & Use cases	Agreements/ Memberships	Industry Links	GROOM RI Services
Facilitate and harmonise access to MAS services,	X	X	X	X
Acting as a common voice in connection with global efforts (e.g. GOOS, EOOS, ENVRI community),	X	X	X	X
Co-designing a common strategy, setting priorities,	X	X	X	X

Mapping user requirements, creating external partnerships, and strengthening cooperation.	X	X	X	X

POLICY RECOMMENDATIONS

The research findings to date from the 4 methodologies applied in the GROOM II project are clear in terms of how they relate to the need for a sustainable fit for purpose Research infrastructure for Marine Autonomous systems to address the concrete realities and challenges of International Ocean Observations over the coming decades:

- Based on the existing National components and on the outstanding potential of Marine Autonomous systems when organised within a distributed RI, GROOM II has the ambition to capitalise on shared components of GOOS associated programs (Argo/EuroArgo, OceanSITES/EMSO, etc.), and to demonstrate the added-value of sharing and co-developing the diverse components of the GROOM RI that would meet the requirements of marine research, ocean sustained observation and environmental issues.
- The key recommendation is that continuing support from Policy makers at the National and European level is continued to ensure the completion of the GROOM RI so it becomes a world-class sustainable infrastructure to better service research, ocean observation, and to favour innovation for new technologies, services and products for the maritime sectors, the Blue Economy and for the society in general.
- Coordinating the MAS actions in Europe via a GROOM RI will centralise the efforts already put in place. Collaboration with OceanGliders to share best practices, requirements, and scientific knowledge needed for glider operations, data collection and analysis is a logical extension as most of the OceanGliders participants are part of GROOM II project.

6. GROOM II Factsheet

Factsheet definition

A factsheet, is a single page document containing essential information about a product, substance, service or other topic. Factsheets are frequently used to provide information to an end user, consumer or member of the public in concise, simple language.

GROOM Fact Sheet Title: *- GROOM RI contributes to an Integrated European Ocean Observing System and improves the global Infrastructure for Marine Autonomous Systems*

GROOM RI Nodes

- 24 Nodes with a defined unified data management scheme
- 1 GDAC at Coriolis-Ifremer
- Related Marine RIs Identified

9 identified Marine RIs: JERICO-RI, Eurofleets-RI, EuroArgo ERIC, EMSO ERIC, ICOS ERIC, eLTER, EMBRC ERIC, LifeWatch ERIC, DANUBIUS-RI

Related European RIs Engaged: 5 (JERICO-RI, Eurofleets-RI, EuroArgo ERIC, EMSO ERIC, ICOS ERIC)

Number of MoUs/MoCs in progress: 3 (JERICO-RI, Eurofleets-RI, EuroArgo ERIC)

GROOM II Workshops on Integration: 1

Industry Links (Industry Advisory Group –Marine Autonomous Systems): 1

Number of members of the IAG-MAS: 22

Number of industry sectors represented/served: 2 (Marine manufacturing, construction and engineering - sensor manufacturers; maritime service providers, maritime commerce)

Number of IAG-MAS workshops: 3

Workshop Topics: Parameters measured, Directives served (MSFD), Link to EuroGoos Glider Task Team

GOOS Delivery Areas Addressed by GROOM RI

- Ocean health
- Climate
- Operational oceanography services

GROOM RI Services - See deliverable 2.1

- Services for GOOS
- Services for EOOS
- Services for MSFD
- Services for Industrial Sector
- Links with other RIs
- International links
- Maximising Glider Deployments in Europe

Scientific Axes for Glider Deployment

- Boundary currents
- Storms, hurricanes, typhoons
- Water transformation
- Polar regions
- Ocean Health & Ecosystems

GOOS Phenomena Addressed by Marine Autonomous Systems

- Circulation fronts and eddies
- Air-sea fluxes
- Freshwater cycle
- Heat storage
- Mixed layer / stratification
- Watermass upwelling
- Primary production
- Ocean acidification

GOOS Applications Addressed by Marine Autonomous Systems

- Climate forecasting and projections
- Climate analysis and assessment
- Climate cycles
- Weather forecasting
- Ocean forecasting
- Ecosystem assessment
- Sustainable management
- Pollution assessment
- Marine hazard response
- Assessing human impact on the ocean
- MAS Platform Characteristics

GROOM RI Readiness Levels: - GROOM RI MAS Sensor Characteristics have a Readiness level of Mature Level 7 , “Fitness for purpose” - See http://www.goosocean.org/improvingreadiness**.**

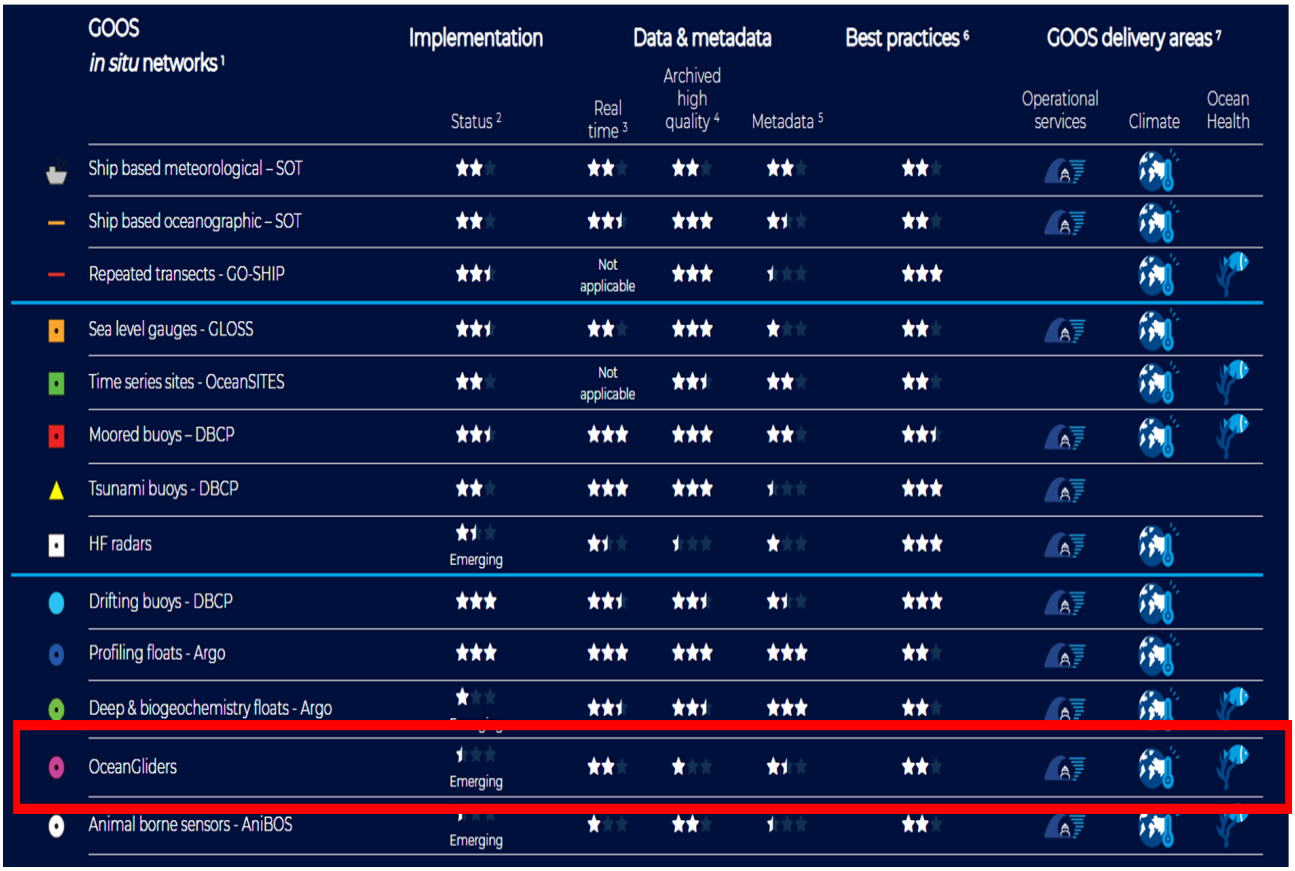
Essential Climate Variables (ECVs) that can be measured by GROOM RI gliders:

- Sea Surface Temperature
- Sea Water Temperature
- Sea Surface Salinity
- Sea Water Salinity
- Dissolved Oxygen
- Chlorophyll-a Concentration
- pH
- Carbon Dioxide (CO2)
- Ocean Currents

Essential Ocean Variables (EOVs) that can be measured by GROOM RI gliders:

- Sea Surface Temperature
- Sea Water Temperature
- Sea Surface Salinity
- Sea Water Salinity
- Dissolved Oxygen
- Chlorophyll-a Concentration
- Turbidity
- pH
- Carbon Dioxide (CO2)
- Ocean Currents
- Nutrients (Nitrates, Phosphates, Silicates)
- Primary Production
- Ocean Acidification Parameters
- Light Attenuation
- Particulate Matter

How GROOM_RI will contribute to improving European contribution to OceanGliders as an enhanced GOOS in situ network:



GOOS *in situ* networks[1]	Implementation	Data & metadata			Best practices[6]	GOOS delivery areas[7]		
	Status[2]	Real time[3]	Archived high quality[4]	Metadata[5]		Operational services	Climate	Ocean Health
Ship based meteorological – SOT	★★☆	★★☆	★★☆	★★☆	★★☆	✓	✓	
Ship based oceanographic – SOT	★★☆	★★½	★★★	★½☆	★★☆	✓	✓	
Repeated transects - GO-SHIP	★★½	Not applicable	★★★	½☆☆	★★★		✓	✓
Sea level gauges - GLOSS	★★½	★★☆	★★★	★☆☆	★★☆	✓	✓	
Time series sites - OceanSITES	★★☆	Not applicable	★★½	★★☆	★★☆		✓	✓
Moored buoys – DBCP	★★½	★★★	★★★	★★☆	★★½	✓	✓	✓
Tsunami buoys - DBCP	★★☆	★★★	★★★	½☆☆	★★★	✓		
HF radars	★½☆ Emerging	★½☆	½☆☆	★☆☆	★★★	✓	✓	
Drifting buoys - DBCP	★★★	★★½	★★½	★½☆	★★★	✓	✓	
Profiling floats - Argo	★★★	★★★	★★★	★★★	★★☆	✓	✓	
Deep & biogeochemistry floats - Argo	★☆☆	★★½	★★½	★★★	★★☆	✓	✓	✓
OceanGliders	½☆☆ Emerging	★★☆	★☆☆	★½☆	★★☆	✓	✓	✓
Animal borne sensors - AniBOS	½☆☆ Emerging	★☆☆	★★☆	½☆☆	★★☆	✓	✓	✓

Of the 13 types of GOOS in situ Networks, **Gliders are 1 of the 5 who contribute to all 3 of the GOOS Delivery Areas** (Operational Services/Climate/Ocean Health). Gliders have advantages over the other in situ Networks.

OceanGliders: Status for Gliders is currently rated as Emerging (low) level – An operational GROOM RI can improve this grading.

Real time data is made available on GTS medium

Archived high quality data (Low): GROOM RI will improve data management

Metadata (medium) – Information required by Ocean Ops

Best Practices level (Low) - GROOM RI will improve best practices level

Gliders helping in 3 GOOS delivery areas: – Operational Services/Climate/Ocean Health

7. Appendix A: Summary of Responses by RI representatives to GROOM RI questions at Workshop 17/2/2022

Summary of Workshop 3 at GROOM II General Assembly February 17th 2022

Discussions Questions were asked under the following headings:

- **Governance**
- **Operations**
- **Synergies/Risks**

	ICOS	**Eurofleets**	**EMSO (Portugal)**	**JERICO**
Governance				
What are the **opportunities & barriers for countries to join or interact** with a future Glider European Research Infrastructure?	ICOS platforms are used as test facilities for new technology. ICOS supports collaboration to increase availability of good and usable data.	Eurofleets-RI is working towards developing policies and plans to better serve and cooperate with RI's such as GROOM, EuroARGO, EMSO ERIC etc.	Opportunities - The need and the will for Portugal to expand its ocean monitoring network. Barriers - The need for additional resources.	Countries are going to long term fund RIs that need to be at an international scale in order to allow "improvement" and "efficiency." The Countries will evaluate the pro & cons between a (loose) networks (existing thru projects funding) and a legal entity (ERIC, AISBL, etc.) existing thru an engagement. Barriers: complexity of the Observation system Landscape => doesn't help !

Does your RI **co-operate** at an operational level with other Marine RI's - please describe	Overlaps with JERICO, EMSO and EU-Argo - synergies detected and informal collaborations. ICOS is well connected to similar global initiatives (SOCONET, SOCAT,…)	Transition to RI's in parallel, opportunity to share progress, experience and best practice.	Collaboration at an operational level: EMSO-PT is based on a research consortium joining 15 Portuguese supported in a legal agreement.	EMSO: Technological cooperation, EGIM -> cEGIM (Coastal Environmental Generic Instrument Module) => LoS/Informal. Operational cooperation => Coastal Bottom observatories are part of EMSO and JERICO-RI ACQUACOSM: Joint Transationational Access EPOS: Technological cooperation for the JERICO-CORE => MoU BlueCloud: Integration of JERICO-CORE in BlueCloud VRE => MoU EMBRC: Ecotaxa service (VRE) => LoS/Informal EuroArgo: Operational cooperation: Coastal float are part of EuroArgo and JERICO DANUBIUS, and others: Ongoing collaboration.
How this **cooperation** is structured - MOU/Legal Agreement/Contract agreements/Informal	No formal agreements with other RI's	Currently, there is no formal process of cooperation between Eurofleets and other RI's but there are many networking and adhoc arrangements for the launch and recovery of autonomous infrastructures.		

Operations				
How do you see glider **operations & data from Gliders contributing** to your RI - now and in future?	Gap filling, Station validation, Adding information for specific stations (spatial and temporal).	New vessels are being designed to address the deployment and recovery challenges of marine equipment such as AUV's and Gliders. Innovations have been developed as a direct response to better meet the needs of new and emerging technologies and will allow for better integration on-board RV's.	Glider operations & data will contribute mostly for scientific purposes but also to support functional and technical specifications of new equipment-autonomous platforms	JERICO-RI is a multiplatforms and integrated observation research infrastructure. => the main objective of JERICO-RI is to develop for its users some products, services and easy access dedicated to coastal science and the land sea continuum. => So glider data are NEEDED for JERICO-RI.
Are your operations focused on data collection for scientific purposes of use/design of data services for scientific analysis/thematic by your RI User Community?	The stations are operated by scientists with their own research agenda. ICOS helps to make the core measurement of C parameters better and more reliable. Each station is normally science driven.	Eurofleets+ Data Management Policy for funded cruises is subject to the FAIR data Principles. Data collected through Eurofleets Automatic Reporting System (EARS)deployed for each cruise. RVs collect both underway data and data related specifically to each cruise.		

Synergies/Risks				
Are there areas of **potential overlap/duplication** between your RI and a future GROOM RI and how could synergies be developed?	ICOS is carbon centric and unfortunately we are still not in the position to tell if our observational network is good enough - more data are welcome. A future GROOM RI would be very welcome from ICOS perspective and both RI's will benefit from a close collaboration for data around the marine C system.	Better coordination of the long term planning of at sea operations is necessary to maintain a multiplatform ocean observing network. Need for coordinated approach across RI's to avoid duplication of efforts and to build a communal response to deliver maximum impact.	There areas of potential overlap/duplication between EMSO-PT and a future GROOM RI. If these areas of overlap are acknowledged and planned it can be helpful in, e.g., data validations and sensor calibration. If not, they may represent a risk in terms of management of resources	Gliders Transnational Access (see slide about it), Best practices, Harmonisation, Products and services (VRE)
How could **GROOM RI contribute to a European Ocean Observing System** in a positive way without adding to the complexity of the landscape?	Work with other RI's towards a common data platform.	Streamlining: Sharing of best practices through strong cooperation with other RI's promoting a Fit for purpose multi-platform approach and align with other programmes.	For GROOM RI to be positive contribution to a European Ocean Observing System an alliance among the glider community should be fostered (e.g. EUROFLEETS+). Convergence versus fragmentation	That's the question ! Synergies between GROOM RI and JERICO must be very well defined. In case it is not, both ESFRI applications could fail.

8. Appendix B: GROOM RI and EuroFleets - Memorandum of Understanding Press release

Link: https://www.GROOM RI.eu/mou_groom_ef/

Press release Text issued July 12th 2023: **Eurofleets+,** a leading consortium of research vessels facilitating marine science and research, and **GROOM II**, an innovative research infrastructure for marine autonomous systems, are pleased to announce a ground-breaking Memorandum of Understanding (MoU) to foster collaborative efforts in advancing the field of marine science. This strategic partnership will focus on sharing experiences, optimising operations, and developing joint training activities to benefit members and users of both initiatives. **The aim of this joint initiative is to leverage the strengths of both initiatives to promote the sharing of expertise, optimise operations, and drive innovation in the realm of marine science.**

The **Eurofleets+ Project** is renowned for its commitment to facilitating multidisciplinary marine research by **providing access to state-of-the-art research vessels and cutting-edge marine equipment**. With a strong emphasis on fostering collaboration among European research communities, Eurofleets+ has been instrumental in promoting knowledge sharing and scientific advancements in the field.

GROOM II has established itself as a key player in the field of ocean observation by **developing data interoperability, metadata standardisation, and operational services for Marine Autonomous Systems (MAS)**. Thanks to its innovative approaches to data integration and federation, GROOM II has paved the way for enhanced data sharing and sustainable research practices.

By joining forces, Eurofleets+ and GROOM II aim to leverage their respective expertise and resources to drive advancements in several key areas:

- **Sharing experiences and best practices on data interoperability and metadata standardisation:** The collaboration will facilitate the exchange of knowledge and insights, allowing both parties to streamline data management processes and enhance data compatibility across diverse research domains.
- **Sharing experiences and skills in integrating data through a federated sustainable approach**: By pooling their expertise, Eurofleets+ and GROOM II will explore innovative methods of integrating data from various sources, ensuring seamless access to comprehensive datasets and enabling comprehensive analysis.
- **Sharing relevant information and available materials for the implementation and operation of core services to users**: This collaboration will enable the efficient exchange of information and resources, fostering the development and implementation of essential services to support the scientific community and stakeholders.
- **Discussing innovation in e-science and IT systems development for hosting and operating core services:** Eurofleets+ and GROOM II will engage in discussions and collaborative efforts to identify and implement innovative solutions in e-science and IT systems. This will ensure the efficient hosting and operation of core services, ultimately benefiting researchers and users.
- **Optimising planning and operations of marine autonomous systems (MAS) and research vessels:** By sharing expertise and best practices, both initiatives will work towards improving the planning and operations of MAS and research vessels. This will result in more efficient and effective research expeditions, maximising the scientific output.
- **Developing calibration and other operational services for members and users:** Eurofleets+ and GROOM II will collaborate on the development of calibration services and operational tools, enhancing the capabilities and reliability of scientific instruments and services offered to their members and users.
- **Developing joint training activities based on common requirements:** Recognizing the value of shared knowledge and skills, Eurofleets+ and GROOM II will develop joint training activities tailored to the common needs of their members and users. These activities will empower researchers and stakeholders with the necessary expertise to drive scientific advancements.

This MoU represents an exciting milestone in the field of marine science and research, marking the beginning of a collaborative journey that will unlock new opportunities for innovation, knowledge sharing, and enhanced operational practices. Eurofleets+ and GROOM II are committed to working closely together, leveraging their collective strengths to overcome challenges and shape the future of marine science.

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