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Deliverable abstract

The deliverable intends to present the status of best practices compilation and use at regional and international level. It also provides a sound strategy for how to overcome current bottlenecks. The document addresses the following topics:

- Who is currently working on the setup of best practices and how?
- What are the immediate problems in the setup of Best Practices (BPs)?
- What is the most effective way to produce a set of community approved dynamic MAS BPs?
- How can this become a permanent part of the GROOM RI structure?

Executive Summary

The use of Standardised Operational Procedures (SOPs) across a discipline or field improves efficiency, transparency, and reproducibility of scientific research, facilitates the transfer of knowledge, the expansion of scientific research, and the engagement of developing countries through lowering the entry barrier. In the use of marine autonomous systems (MAS) there are **several key points and processes that can be standardised** including interoperability of devices, sensors and data, operation of MAS in the sea and data management. Best Practices (BPs) are created through the **conversion of the methodologies used** by different labs and groups for each of these processes **into coherent documents**. These are then **reviewed** and **updated** by the relevant community thus evolving with the development of new technologies and better information almost in a real-time manner.

Creation, update, and dissemination of BPs require the **pooling of expertise** and the **coordination** of such expertise. European level Research infrastructures, such as the future GROOM RI, are built on exactly these attributes and consequently are the **competent body for managing the BP portfolio** of the groups that gather within.

This knowledge would then be passed on and **disseminated through** proper channels such as the **Ocean Best Practices System (OBPS) platform** and the EU-moderated **Ocean Observation Best Practices platform** that is currently underway. In addition, EC directives, recommendations and other certifying bodies will be able to use the GROOM RI endorsed BPs as the golden **standards for safe and efficient operation** integrating it within their processes.

In this task, we evaluated **the efforts in ocean research** that could lead to the establishment of BPs and the **roadmap towards a consensus** for MAS operation and data use in European waters which could be translated and used internationally. This endeavour is riddled with **bottlenecks and obstacles**, both **logistical** and **technical**. The GROOM II design study identified the **lack of convergence** as the first point of complication towards BPs. One of the main successes of this task was the **organisation of internal, European, and international meetings** and a **workshop dedicated to the operation of MAS and best practices**. These events attracted participants from an array of functions including engineers, technicians, MAS operating groups, other EU-funded initiatives (e.g., EuroSea, MINKE), data users and global ocean sciences organisations (GOOS), with the common effort towards harmonising methods/processes.

In conclusion, we suggest **setting up a GROOM RI Best Practices Working Group**. We recommend that this WG establishes a step-by-step process for the **convergence and endorsement of best practices**, within which established methodologies will be reviewed, endorsed and disseminated, while emerging technologies and methodologies will be tested and promoted. The WG will link all relevant stakeholders including experts, data users, policy makers and technology providers and. It will also coordinate efforts with EuroGOOS and other marine RIs (EMSO, EuroARGO, Eurofleets, Jerico). A central MAS BP working group could also help integrate best practices into EU legal documents, recommendations, and certifications, increase their acknowledgement, and integrate them into the science value chain.

Connected Deliverables

Deliverable 2.1 Access policy - the use of best practices will provide consistency to users accessing a distributed RI.

Deliverable 4.3 Contribution to statutory monitoring frameworks.

Deliverable D3.1 Governance and legal aspects.

Deliverable D2.2 Integration of the GROOM RI at European and Global level.

Deliverable D4.1 Report on plans for an EU contribution to OceanGliders, the GOOS/GCOS and EOOS, and data delivery on a sustained basis.

Deliverable D5.1 Glider services for public and private needs.

This task is also connected to other tasks that investigate GROOM RI contributions to statutory monitoring (T4.4), technology (T6.1), and other societal benefits (T5.1).

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List of Abbreviations

| | |
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| BPs | Best Practices |
| CINEA | European Climate, Infrastructure and Environment Executive Agency |
| DBCP | Data Buoy Cooperation Panel |
| DOI | Digital Object Identifier |
| EC | European Commission |
| FAIR | Findability, Accessibility, Interoperability, and Reusability |
| GOOS | Global Ocean Observing System |
| GTT | Glider Task Team |
| IOC | Intergovernmental Oceanographic Commission |
| IODE | International Oceanographic Data and Information Exchange |
| MAS | Marine Autonomous Systems |
| OBPS | Ocean Best Practices System |
| OCG | Observations Coordination Group |
| PI | Principal investigators |
| POGO | Partnership for Observation of the Global Ocean |
| SOP | Standard Operating Procedures |
| WP | Work Package |

DISCLAIMER

The contents of this publication are the sole responsibility of the GROOM II consortium and do not necessarily reflect the opinion of the European Union.

1. Background and context

Underwater and surface robots, in particular gliders, have become essential vehicles to carry scientific payloads for most environmental observations and activities supporting the blue economy from the surface down to 6000m. Their major advantages are being agile, 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 will require the compilation and recognition of community-approved standard operation procedures for the RI's proper functioning. Currently, various Standard Operation Procedures (SOPs) on gliders and other MAS are being developed worldwide. These are often dispersed across different forms of documents (technical documents, publications, internal operating procedure documents) and are not widely adopted. As a community, we aim to establish a set of agreed-upon Best Practices, enhancing collaboration, consensus, operational interoperability between groups and in the end increase the quality of data gathered from gliders and other MAS. While a methodology document is a static expression of a practice or process used by a laboratory or a group, a Best Practice is a dynamic, community-approved practice. Specifically, two conditions must be fulfilled for an operation to be considered as a Best Practice. (1) It has repeatedly produced superior results relative to other methodologies with the same objective; and (2) the method is adopted and employed by multiple organizations¹. A best practice should be aligned across several relevant actors at an organisation level ("convergence").

Over the past decade, numerous documents have been created to outline Best Practices in various initiatives such as FP7 JERICO, FP7 GROOM. Corresponding efforts in the USA² and Australia have led to multiple documents addressing Best Practices in the field.

At a higher level, groups and programs (e.g. POGO, GOOS) have shown their support and commitment to implementing a specific Best Practice through an endorsement process. The GOOS has already created an endorsement process which has confirmed the "Best Practice Status" for specific practices in the glider community³. These processes are to be shared and published on the Ocean Best Practices System (OBPS), an Intergovernmental Oceanographic Commission (IOC) project realised through the joint effort of the International Oceanographic Data and Information Exchange (IODE) and the GOOS.

Further to this, the European Climate, Infrastructure and Environment Executive Agency (CINEA) has recently launched an effort to compile information regarding Standards and Best Practices in Ocean Observation⁴. This has come as a response to a relevant public consultation concluded in 2021⁵. The consultation identified the need for an EU regulated BP repository that would link methodologies and

¹ Definition from the initial OBPS Workshop, Paris, December 2017

² NOS_Tech_report_139.pdf (noaa.gov)

³ GOOS Best Practice Endorsement Process. Version 1. (oceanbestpractices.org)

⁴ Standards and Best Practices in Ocean Observation (europa.eu)

⁵ Ocean observation – sharing responsibility (europa.eu)

inform policies. The envisioned task will include an overview of existing BP repositories and the agencies that have produced them, competent bodies that engage in the compilation of best practices and optimisation in the dissemination and use of endorsed BPs. Nevertheless, the process by which a methodology will be chosen, reviewed, and finally included in this EU-curated web platform is unclear. The present document offers recommendations on how the future GROOM RI can facilitate this process (see Section 4: GROOM RI endorsement of Best Practices as part of the European process).

The Glider European Research Infrastructure (GROOM RI) proposed by the GROOM II project could be the competent authority that will lead the effort for best practice convergence and implementation. This infrastructure will be a positive step to solve today's fragmented European landscape, aiding connections, and synergies among the different networks and projects operating gliders and other MAS. This document describes how GROOMII has recognised gaps in the GOOS BP endorsement process, and defines a roadmap to filling them, whilst offering a first step towards the establishment of BPs in Europe.

This deliverable outlines a pathway towards the harmonization of BPs for the operation of MAS. These BPs will include mission planning, glider preparation, sensor calibration, vehicle deployment and recovery including post-mission processing, fault reporting and sharing as well as data standardisation, management, and data usage. Through this deliverable, we explore the current landscape of BPs, provide a summary of the GOOS endorsement process, and propose a pathway to a GROOM RI tool that would propose and endorse community-approved best practices.

EUROPEAN EFFORTS TOWARDS BEST PRACTICES

European Union member states allocate over €1.5 billion to ocean observation by each year⁶. Nevertheless, many observations are excluded from analyses due to the unclear or non-standard methodology on how they have been collected or processed. This defies the European Commission's initiative to measure once and use data multiple times. Furthermore, different organisations involved in making observations may use different standards for the same process, and in the cases that standards do exist, users may be unaware of those standards. This hinders the integration of observations with other measurements by impeding the evaluation of their dependability.

EU funded projects have made significant strides towards BPs. Connections have been forged among EuroGOOS Glider Task Team (GTT), H2020 GROOM II, and H2020 EuroSea. This is not only due to their shared coordination, with EuroGOOS GTT co-chaired by Carlos Barrera, Pierre Testor, and Victor Turpin; H2020 GROOM II overseen by Laurent Mortier and Pierre Testor; and EuroSea WP3 T3.2 led by Pierre Testor, but also because their collaborative efforts have been reinforced through numerous video conferences and commonly attended workshops and efforts involving diverse stakeholders throughout the project's duration. The resources from GROOM II have been instrumental in advancing both European and international communities such as the GOOS OceanGliders, where Pierre Testor and GROOMII WP6 leader Alvaro Lorenzo Lopez among others in the GROOM II consortium are members. A document outlining these efforts and their results can be found in EuroSea D3.9: *EuroSea:*

⁶ Ocean observation – sharing responsibility (europa.eu)

*Improving and Integrating European Ocean Observing and Forecasting Systems for Sustainable use of the Oceans*⁷.

Certain EU legislations and Regulation (EU) No 1025/2012⁸ take into consideration some European or international standards. In addition, EU bodies such as the working groups for the Marine Strategy Framework Directive have established and documented best practices⁹. To improve effectiveness and efficiency, the EU has proposed the joint planning of observation activities and a framework for collaboration on a national and EU scale that will adhere to community-accepted standards and best practices¹⁰. These standards are not always easy to find or accessible. Recognising that several external sources of best practices already exist (e.g. HELCOM monitoring Guidelines¹¹, data management standards proposed by EU projects¹² or interest groups¹³) and that OBPS is largely unmoderated, the EU is currently exploring the setup of an IT platform that could direct users to community approved best practices.

Despite the clear mandate and multilateral efforts, there is no EU-competent body or procedure for suggesting, compiling, or agreeing on best practices. The advancements in terms of harmonization and collaboration and establishing a robust foundation for European and internationally applicable Best Practices are hindered by the lack of continuity, motivation and a mutually beneficial process for the establishment of BPs. These are pivotal aspects that a future GROOM RI, will address in terms of assimilating European glider and other MAS operations and data within the future European Ocean Observing System.

2. The GOOS Ocean Best Practices

At an international level, the Global Ocean Observing System (GOOS) has initiated efforts to identify and endorse standards and best practices. The GOOS is a global scale coordination activity posed to identify and help lead global partnerships to grow national ocean observing efforts towards interoperability and equity. This is achieved through integrated, responsive, and sustained observing systems. During the last international EGO meeting in 2019, spearheaded by GROOM II partners, it was agreed that the GOOS OceanGliders¹⁴ program required a robust framework for Best Practices to consolidate and synthesise the state-of-the-art glider Best Practices under the OceanGliders umbrella. The goal was to create a comprehensive document that not only highlights existing work but also identifies gaps and promotes the adoption of standardised glider observations globally. This initiative, supported by GROOM II under Task 6.5, seeks to unify the scattered knowledge and practices related to gliders. The 2021 workshop furthered these efforts, resulting in a common effort for the creation of an overview paper titled "*Towards OceanGliders Best Practices and Standards*," as well as SOPs¹⁴

⁷ EuroSea: Improving and Integrating European Ocean Observing and Forecasting Systems for Sustainable use of the Oceans

⁸ EUR-Lex - 32012R1025 - EN - EUR-Lex (europa.eu)

⁹ Marine Strategy Framework Directive - Competence Centre (europa.eu) and in particular MSFD Technical Group on Marine Litter (europa.eu)

¹⁰ Standards and Best Practices in Ocean Observation (europa.eu)

¹¹ Monitoring Guidelines – HELCOM

¹² SeadataNet Vocabularies

¹³ Darwin Core (tdwg.org)

¹⁴ Best Practices Task Team - Oceangliders

¹⁴ <https://github.com/OceanGlidersCommunity>

covering aspects of glider preparation/deployment/piloting, and data quality control/delivery, linked to the collection of oceanic variables. The overview paper targets principal investigators (PIs), while the SOPs cater to glider operators and users. GROOM II partners have significantly contributed to the draft of the overview paper and to the elaboration of 5 SOPs (Salinity, Oxygen, Currents, Nitrates, Chla) which are at various states of endorsement.

In line with this goal, the GOOS community has created a review process, the product of which will be a set of community-approved best practices. The review process aims to provide the basis for an open dialogue regarding established and evolving methodologies. This endorsement process took shape through GOOS working groups and was approved by the GOOS Steering Committee in October 2020¹⁵. Here we provide a short description of the GOOS endorsement process.

CONVERGENCE

The first step in the GOOS endorsement process is to bring together the stakeholders that plan, collect, use and analyse a specific ocean data set and the methodologies that each one uses. This set of information on different procedures is explored to assert whether they constitute a standard operating procedure. Furthermore, each process is broken down into its steps. If a step is identified as an integral part of the process, then it should be included in the BP. Other procedures or steps might be deemed as necessary in a case-by-case scenario, or to serve operations in specific regions (e.g. dealing with ice in polar regions).

The **best practice is created**, or identified, usually by an observing network. GOOS defines an observing network¹⁶ as a network whose mission is to address scientific questions relevant to national and regional science, policy and management needs, serving local and national needs whilst supporting globally relevant indicators through regular reporting. Networks would maintain long-term surveys using globally accepted standards and innovative technologies to produce information on trends over time and archive historical data which meet principles of findability, accessibility, interoperability, and reusability (FAIR). The network should also support development and technology transfer.

The **observing network reviews the best practice**, making sure it is fit for purpose and satisfies the OBPS definition for a best practice. During the community review process the document should be made available and publicly commented upon. Comments should then be adjudicated and actioned by the author. The best practice and complete metadata are then submitted to the relevant GOOS body.

The distillation of all the processes used by the stakeholders into a standard operating procedure that includes all necessary steps is called **convergence**.

ENDORSEMENT

The IOC Ocean Best Practices System (IOC-OBPS) project introduced the term “*Endorsed Best Practices*” to make aware of certain SOPs or even Best Practices that fulfil requirements defined by authorities. Given the global scope of the IOC-OBPS project, a first trial endorsement case was developed with the GOOS. The GOOS endorsement process targeted the observation coordination networks (e.g. OceanGliders, Argo, OceanSITES, DBCP, HF-Radar, GO-SHIP) assembled under the

¹⁵ Hermes, J. (ed.) (2020) GOOS Best Practices Endorsement Process. Version 1. Paris, France, Global Ocean Observing System, 7pp. DOI

¹⁶ GOOS Biological Observing Networks and 2030 strategic objectives (unfccc.int)

3. GROOM RI Best Practices

It is acknowledged by science communities that the usage and development of best practices is key to do better science, helping each other with techniques and processes. Nowadays almost any European project in the ocean domain tackles the issue of best practices, as we can see on different projects, such as Jerico, EuroSea, and Minke. The intrinsic problem to having a project-based approach is that once those projects finish, momentum and continuity gets lost, making it difficult to engage whole communities in the long term. It is true that with the rise of OBPS, the best practices developed by projects could get stored and be accessible to anyone but without OBPS moderation and the thrust provided by the projects there seems to be little room for the development and adherence to best practices at least at thematic level.

GROOM RI puts the best practices at the centre of the technical design. The figure 2 shows the envisioned GROOM RI technical framework¹⁸. The design is based on 4 pillars of activities around the planning and operation of MAS, programme management, data management, operations at base and operations at sea. For each one of those areas to work as a unified and cohesive infrastructure within the distributed GROOM RI, the RI Nodes will need to follow a set of common working practices and best practices that could be supported by the Central Hub, providing consistency.

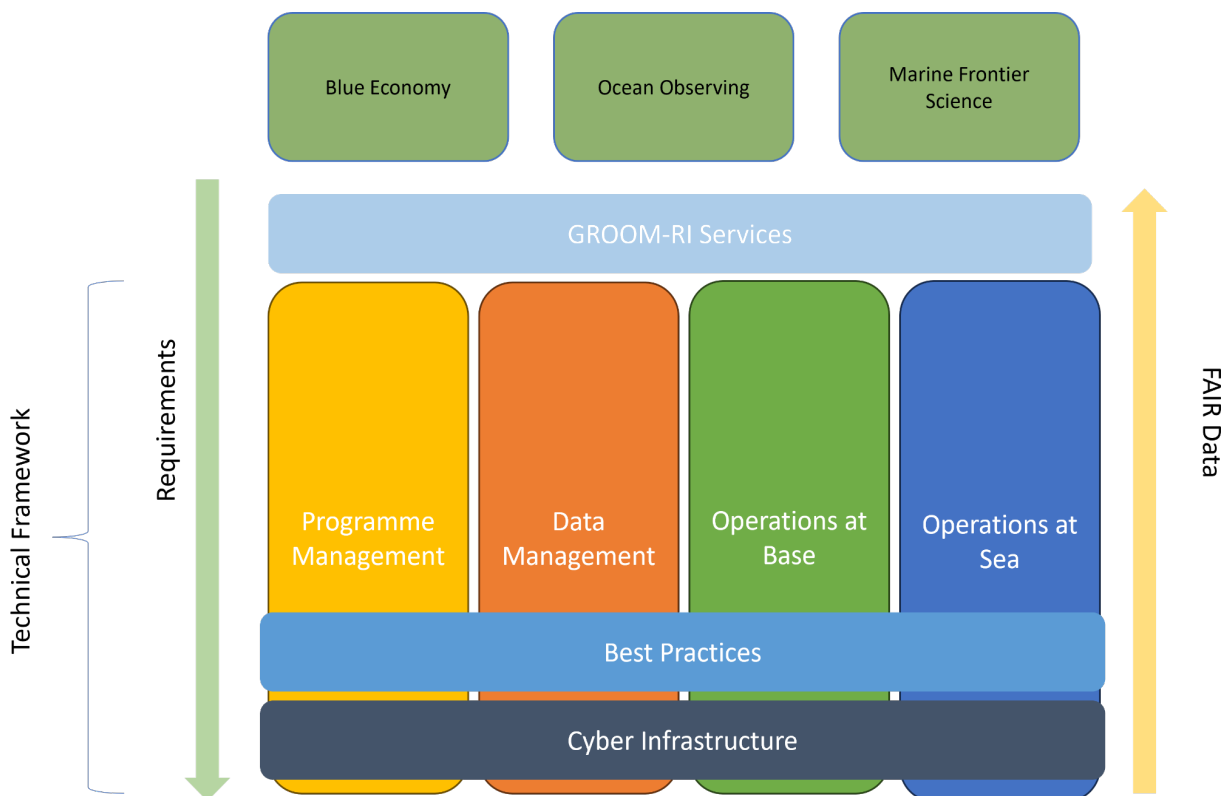


Figure 2 - Envisioned GROOM RI Technical Framework structure.

¹⁸ For more details, please see GROOM II Deliverable 6.1. Note that 6.1 was not finished by the time of submitting this deliverable, hence minor differences may appear.

GROOM-RI BEST PRACTICES PROCESS

The combined efforts and expertise gained through our participation in research projects (e.g. EuroSea and GROOM II), regional and international panels (e.g. GOOS and OceanGliders), along with the work that has been completed in the present task, has led to the assessment and the definition of the present gaps and bottlenecks. It has also allowed for the identification of the different levels of required actions. Here we present the envisioned process through which GROOM RI will generate and promote the use of Best Practices. The BP process, as all work we suggested through the deliverables, would require dedicated effort within GROOM RI.

GROOM RI BEST PRACTICES WORKING GROUP

As mentioned earlier, dedicated staff and appointed experts are the driver behind the identification of eligible methodologies, promoting an open dialogue between groups and writing-up of convergence documents and scientific papers, which then lead to BPs. The establishment of BP is actually driven by convergence, review and endorsement processes and cycles which can be technical, scientific, organisational, thematic, regional, slow/fast etc... depending on the topic of a BP. The need for EU-specific BPs for MAS (and support to establish those) becomes clear when talking about data management for instance, or when considering that there is a need for shorter cycles for convergence/review/endorsement than those set up at the international level or when such an international framework needs to be set up like for the developing ASV operations with a growing diversity of platforms.

A BP working group within GROOM RI, will be able to:

- **Identify known BPs:** The BP WG identifies the need for the endorsement of a method. Other GROOM RI WGs or external research groups could also suggest BPs. BP WG then appoints a group that will author or collect the necessary information regarding this BP.
- **Explore Emerging methodologies:** GROOM RI will encourage the use of innovative technologies and the conception of new methodologies for their use in MAS. When one such methodology is mature enough for beta-testing it will be promoted through the GROOM RI members and network. The GROOM RI will help such a methodology to be made public through OBPS, GitHub or other means, where its wider testing, review and improvement will be facilitated. The suitability of sensors/ electronic parts and other products for the operation of gliders/ MAS could also be included in this process. Once a methodology is mature enough it will be put forward to become a BP.
- **Link to GROOM RI expert network:** The authors of the BP share the results with the relative WG, which in turn distributes the results to relevant GROOM RI members who review and comment on the suggested BP. The document is then corrected as needed.

The final document would be submitted to the BP WG and then to the GROOM RI steering committee. Once the BP is approved for endorsement it will bear a relevant digital object identifier. The BP can be uploaded to GitHub, OBPS and other relevant databases. A common collaborative article can also be published. This would serve as an incentive to MAS operators for their engagement in the creation of the BP and to make the BP widely known to the research community.

GROOM RI ENDORSEMENT OF BEST PRACTICES AS PART OF THE EUROPEAN PROCESS

The endorsement of the BP by the RI will be made known to the European Commission with a recommendation to include the BP in the EU-moderated Ocean Observations BP platform. GROOM RI endorsement of a BP could help it to become part of directives (such as the Water Framework Directive and Marine Strategy Framework Directive) and EC recommendations for the collection of ocean data.

The community-approved, GROOM RI-endorsed standardised operations can also bear a certification that could be used for formal processes. This may include ISO certification processes, lab certifications and/or insurance coverage requirements.

For example, ISO has specific procedures for different types of certifications. These usually include providing information about processes, detailed record keeping, and in-person inspections.

EXAMPLES OF BEST PRACTICES

So far, each organisation and laboratory operating MAS has been creating its own unique set of standard methodologies based on the equipment they use, laboratory capabilities and engineering experience. This has created a diverse set of checklists uniquely answering the characteristics of each MAS laboratory. As such, the convergence of operational checklists could be the most crucial and challenging aspect of Best Practice conversions. Where region or application specific differences apply, these will be made clear through the BP documentation.

Best practices need to encompass at the minimum the following aspects:

1. Operation checklists: pre-launch, (pre) deployment, glider shipment, mission, recovery, piloting, site selection, quality assurance;
2. Equipment performance: Calibration of sensors, compasses etc, sensor sensitivity, power requirements, platform autonomy etc,;
3. Data standardisation, communication, and sharing, agile processing.

4. Conclusion

As of October 2023, the European Commission is investing in the setup of a platform that will serve as the source of information on European Ocean Observation Best Practices. The task will include the collection of historic data and sources of best practices as well as some recommendations regarding the structure and data that will be available on the platform. Although the consortium and its network are heavily invested in the set-up and use of BPs, it is not clear to the partners yet who will moderate the content of this platform, how BPs are to be chosen and whether there will be EU regulations that will promote the use of these BPs.

This task has identified that there are still several gaps in the agreement on and implementation of BPs. These can be summarised as such:

1. Lack of discoverability: Certain organisations or groups have internal documents and methods that have not yet been published or tested by other organisations.
2. Lack of convergence: Going from a pile of technical operation procedures to a coherent, inclusive but yet concise methodology document that is holistically accepted, is perhaps the most difficult bottleneck in this process.

3. Lack of continuity: The review and endorsement process might span over several years. Staff changes, the end of funded projects and other changes halt progress and impede the BP setup.
4. Lack of moderation/leadership: The fragmentation of efforts between short-term projects, different EU Directorates, and regional and international bodies decreases efficiency and results in duplication of effort and contradicting results.

Although several efforts are being made, the ephemeral nature of funded projects, the lack of communication among research groups and the lack of dedicated long-term solutions has created a minefield of multiple checklist methodologies and efforts to re-invent basic procedures. In this uncertain and difficult-to-navigate landscape, GROOM RI can provide a cohesive pathway towards community-approved and endorsed BPs, which will follow the recommendations of international intergovernmental organisations. To that end, this task has developed a set of concrete actionable recommendations that utilise the momentum gained at the international level through IOC-GOOS and the EU best practices mandate, through a GROOM RI motivated and moderated BP endorsement process.



Figure 3 - GROOM RI has the potential to be the main instrument for the proposal of community approved MAS best practices to the EC.

We recommend the set-up of a GROOM RI Best Practices Working Group that will facilitate and improve the convergence and endorsement of best practices helping to evolve the best practices landscape. GROOM RI will coordinate and support the promotion and creation of best practices with EuroGOOS and the marine RIs (EMSO, EuroARGO, Eurofleets, Jerico), improve the acknowledgement of best practices and increase their integration and formal recognition as a component of the science value chain. Finally, having a central MAS BP working group could help to integrate best practices into EU legal documents, recommendations and other types of certifications.

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-GROOM II Deliverable 6.1 *Technology roadmap of the GROOM RI*