A community-wide review of the Framework for Ocean Observing’s usefulness was launched in August 2017. Twenty-one extensive interviews have been conducted among representatives attending community Town Halls, and from federal agencies, research institutions, academia, and the private sector.

These discussions have focused on three broad categories: Technology and Implementation, Data and Analysis, and Management and Governance. This effort has resulted in several key findings that will guide the improved utility of FOO during the next decade.

This report features sections containing overarching, FOO aligned topics. Within each section discussion topics describe key findings each enumerated (in bold). They are explained in greater detail with additional supporting notes that follow.

- **Part 1:** List of-
  - Ocean Obs ’19 Activities or Outcomes
  - Decade of Ocean Science Activities
  - FOO Document Text Changes ................. 2-6
- **Part 2:** Technology and Implementation ........ 7-21
- **Part 3:** Data and Analysis ..................... 22-30
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*Please Note: The organization of this report is a reflection of comments that were made during the interviews and the responses that were given to the presented issue or topic. A more streamlined report will be presented at a later date.*

*(A list of interviewee titles and institutions is available.)*
PART 1. Notes Related to: Ocean Obs ’19 Outcomes, Decade of Ocean Science Activities, FOO Document Changes/Needs

Ocean Obs ’19 Outcomes:

Technology and Implementation: Today the process for becoming an official GOOS Pilot Project is far too ad hoc for there to be much concerted benefit from them. GOOS needs to champion cross-network and integrated pilots focused on EOVs across continents. Within the governance structure there exists a need for a process to get proposed ideas assessed, and then in a timely manner seek funding or secure the necessary resources.

➢ Would like to see this as an outcome of Obs ’19. This would include a better design and assessment of proposed pilots at the international level that results in obvious societal benefit. A good example or model is the path to maturity as seen as a result of GODAE and OceanView.

Data and Analysis: Embedding unique data solutions within specific technologies leads to a larger issue of data archeology that will persist into the future. Finding data is a problem, as often users really want to find level 2 or 3 data and start using it. Improved discovery and accessibility would be very useful, while some systems are not far from where they were 15 years ago, yet today there are also some groups with these practices already in place. Today, potentially with a greater understanding of architectural patterns and best practices, developing nations may be able to skip a layer of operational development and maintenance, and enjoy a step change in data accessibility (as many have cell networks). This is true as for the most part data managers no longer have to know and administer the underlying technology or infrastructure.

➢ The community may be well served by big data groups that are solving similar problems. The ocean community has been somewhat stalled by the GTS philosophy that the oceans needed its own system. By working within more open systems and technology solutions there could be a good deal of advancement. Hopefully, good guidance on this will be provided in related Ocean Obs ’19 CWPs.

Governance and Management: Need to better define role between GOOS and BluePlanet (among others). BluePlanet addressed the need to have a focus on the ocean within GEO, rather than as a consideration as part of other societal benefit areas. If GOOS continues to build its focus on the beginning elements of the value chain and providing products and services to internal users, BluePlanet can focus on building linkages to external users of data and providing input into the GOOS-led processes.

➢ BluePlanet determining what its role in Ocean Obs ’19 will be. The group will seek to make sure the outcomes reflect its goals. Once the CWPs are released they will seek to drive user needs forward and be a match-maker among needs and resources.

➢ BluePlanet creating a CWP on stakeholder engagement and how to communicate science by looking at the virtual network of users and how to facilitate their interactivity.
Governance and Management: There is a need for an observing system to be reviewed by engineering architects for overall system effectiveness. Such a review would distill what elements or practices can be replicated and which should be updated or eliminated. Similar reviews have been conducted at meteorological offices. There are some architects working within the system today; getting a concerted handle on this would be a good goal for the decade.
➢ Ocean Obs ’19 could launch an architectural review of effective interfaces and processes.

Decade of Ocean Science Activities:

Technology and Implementation: Today the process for becoming an official GOOS Pilot Project is far too ad hoc for there to be much concerted benefit from them. GOOS needs to champion cross-network and integrated pilots focused on EOVs across continents. Within the governance structure there exists a need for a process to get proposed ideas assessed, and then in a timely manner seek funding or secure the necessary resources.
➢ This process is of critical importance as there is an immediate need to develop ideas and get an “ask” in place in conjunction with Decade of Ocean Science goals.

Technology and Implementation: In further developing the FOO, it may be helpful to incorporate a consideration of different time scales when assessing the value of observations. This may drive a need for the creation of output driven and implementation efficiency score cards that provide feedback loops related to best practices for deployment and varying timeframes for assessment; from immediate or near real-time to more long-term monitoring evaluation.
➢ Improvement of observation infrastructure is one of 6 goals for the Decade of the Ocean. The observing community should now seek to identify transitional flagship technologies at varying levels of maturity that change the way the ocean is observed and use them as case studies on the complexity of the maturity lifecycle. Examples might include deep and/or bio Argo, SWOT for satellite ocean current observations, ecosystem genome sequencing or eDNA evolution.

Data and Analysis: It is critically important to have the ability to report on contributions. The idea of national commitment tracking is desirable and, in some instances, necessary for coordinating activities within nations. This type of activity facilitates more coordinated implementation and maintenance at the national level, helping to increase focus at regional/national/basin scales.
➢ IOC is the obvious way to do national commitment tracking and provide a link into Ocean Science Decade. All too often things get put in a spreadsheet but there is little-to-no follow-up.
  • An idea may be to have this be part of the large assembly, with groups saying what they plan to do – with sufficient follow-up so it is not meaningless.
  • Whatever the mechanism it needs to strike a balance of encouraging commitment and delivery yet not be perceived as too heavy-handed.
FOO Document Text Changes:

**Technology and Implementation:** There exists a need to recognize that the implementation of the entire observation lifecycle process takes a long time, and that it is often difficult to consistently engage the concerted expertise of science volunteers. Funders might benefit from a greater understanding of the end-to-end process. This would allow them to better appreciate the physiology or psychology of science – that observations don’t just magically provide data, rather there is an entire process leading up to results, and that this takes a good deal of concerted activity.

➢ It would be good to have in FOO the discussion of the voluntary nature of the lifecycle process and how to engage toward formalization of these practices.

**Technology and Implementation:** The FOO does not do a good job of reconciling local, regional, global needs. This becomes an issue especially as the communities that conduct implementation activities have varying levels of maturity and operate across various scales. Proposals articulated or plans often range from a laundry list of what is wanted, to well-established plans and processes for architecting system design, and outcomes.

➢ FOO has a difficulty in this instance because what is essential varies by area, yet is still considered part of the overall system design. This will require more flexibility in thinking about system outputs and products, which is a major issue for users. This is needed if the FOO is to be more helpful in taking processes and phenomenon observations from concept phase toward maturity.

➢ More needs to be articulated by the FOO with regard to effective end user engagement, regional user engagement, and how to manage platform and array trade-space/ space and capability trade-offs.

➢ Even with the most mature EOVs (e.g. SST) there is discrepancy when seeking an agreement on what is needed related to scale. In some instance it is not appropriate to resolve at smaller scales, yet in others it is vital. The FOO could assist in determining a set of processes or interfaces needed to determine what to resolve these types of issues.

**Technology and Implementation:** The FOO has been helpful as a process development tool but more detail is needed in order to be useful for implementation of an observing system. The goal would be to not give too much detail related to requirements setting for implementation, as then it may become an implementation best practices document or more of an FAQ than anything else. Rather, the aim would be to assess the process for articulation of EOVs and how that could translate into similar articulation of network or platform design and implementation and data integration solutions.

➢ The FOO may need to make a distinction between what processes are most helpful in defining what is needed to address as many aspects of science as possible and yet still contribute to specific research.
Data and Analysis: The global ocean observing system is under tremendous pressure to reconcile the requirements generated by the growing and inhomogeneous amount of data that are available from observing systems today and to provide consistency and interoperability. Improved coordination is needed such that all relevant information resources (data, metadata, services) appear to the user like a constellation of data and services (both satellite streams and those from small in situ efforts in remote regions). There are not enough data best practices in the data realm that can help facilitate the resolution of problems in front of the community today. In order to do this it may be best to look at the big solutions and users first, then determine what are the needs of the smaller entities/countries and make sure they have access to data rather than set up isolated observing systems that are too reliant on specialized/localized circumstances.

➢ Need to find a balance between sustainable development and tech transfer. GOOS can provide guidance here. While FOO can’t do too much here given its scope – but text can be added to acknowledge the need to mature the system overall.

Data and Analysis: An improved understanding of data management and implementation teams is needed; they seem to be more of an idea rather than organizations with long-term sustained funding and Terms of Reference. Even the teams that are well respected are often seen as projects, not ongoing groups with long-term Terms of Reference implementing well vetted data policies.

➢ FOO needs to raise the level of visibility and importance of data practitioners. A first step in maturing the conversation may be to bring together groups in Australia, Europe, and USA with groups in lesser-developed nations to agree on best practices.

Data and Analysis: In the data arena an issue exists that when projects are funded there is just enough funding to apply the data but little else to demonstrate ongoing progression of its use and resolution of known problem resolution. This creates a deficit as there is always something that is not solved, or over time a new problem presents itself that seems to defeat the progress made. There is a need to articulate the daisy-chain of events required to prevent or overcome this issue.

➢ FOO could do a better job of articulating the full suite of processes that lead to successful data outcomes; that this is highly iterative and continues beyond the project end – and encourages ongoing data uptake and use.

Data and Analysis: Certain data sets and streams should be allowed to mature prior to release in order to better assess and/or evolve their value to the system. Once the observational methodology is mature and determined to be of relevance to the global system, the data can be released and sustained as a baseline indicator of change.

➢ FOO (and related governance bodies) may need to acknowledge that in order to fully meet the needs for the preservation of long-term data it may be desirable to fully mature observations to ensure their accuracy prior to release of the data; allowing it to become a more stable baseline and thus better benefit science and society.
Governance and Management: Moving away from an EOV or science focus creates a need for a greater focus on standards and best-practices, such as case studies of successful results based on previous requests for funding. There is a fundamental need to make this change when selling the need for observations to senior officials. Shifting focus to standards and Best Practices allows for a demonstration of value-added products and, as possible, the articulation of a cost-benefit analysis. The importance of return on investment needs to be recognized as it is very powerful when justifying ongoing investment. This analysis, however, often lags behind the time of the greatest need for observations. To help bridge this gap it may now be beneficial to engage/enjoin social scientists into the ongoing needs analysis and selling process.

➢ FOO is not yet a tool for creating priorities, there is a need to get beyond the limitation of EOVs in prioritizing network design or the need to justify issues/science questions not EOVs. So FOO was helpful in defining what to measure but not how this is helpful in understanding the heat budget, carbon budget, or fresh water flux.

➢ Community needs to address that often what is required is the need to observe a combination of EOVs in order to address science or societal needs. EOVs are not the target of observations, rather it is a combination of them, FOO may need to articulate a process or set of interfaces required in order to roll this up.

Governance and Management: In general GOOS, and all of the community, could benefit from an enterprise approach, as this will facilitate the practice of attaching data from multiple sources to user solutions through improved interfaces among otherwise disjointed stakeholders and sponsor. There is a need for an overarching framework that brings the stakeholders across the entire community together to agree on a functional set of interfaces, or ways of working together. These strong partnerships or enterprise thinking keeps GOOS (BluePlanet and others) from stretching too far. The system will work best if each component focuses on its strengths and avoids duplication. This may also help GOOS focus support for users within the system; to those entities that are both providers and users, and that work with other groups to bolster the feedback loops into the system. Generally this speaks to a need to get providers and managers within in the system to both engage each other as well as external end users. This is a role that FOO 2.0 can facilitate however it goes beyond GOOS and encompasses all communities.

➢ FOO needs to articulate what a more mature observing system will deliver to science and society. The alignment with an overall architecture would be of benefit the community at large – as this is visible in some instance across the system (JCOMM, WMO/WIS) but not widely enough adopted across the community at large.
PART 2. Technology and Implementation (TI)

Since the adoption of the FOO by GOOs in 2012, and given the tremendous focused-work done on the ‘input’ or requirements setting elements of the observing system, it was no surprise that a good deal of effort for the next 5 – 10 years should seek to improve the downstream aspects of the system, as they relate to the system ‘processes’ or deployment and maintenance. Feedback on the effectiveness of using the FOO spoke to the difficulties related to implementation, especially when it came to activities associated with network design and prioritization.

<table>
<thead>
<tr>
<th>TI.1</th>
<th>Extending FOO Text Beyond Requirements (EOV) Setting</th>
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<tbody>
<tr>
<td>• <strong>Description:</strong> A redraft of the Implementation and Data sections of the Framework document is needed to reflect the same level of detail given to identifying measurement requirements (EOVs) in the initial document.</td>
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<tr>
<td>• <strong>Background:</strong> The Technology and Data Implementation Teams may benefit to the same degree of definition and emphasis that the Expert Teams received since their creation within GOOS during the past five years.</td>
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<tr>
<td>• <strong>Question:</strong> What type of detail would be of most benefit to the community?</td>
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Key Findings:

**TI.1.1:** There is a definite need to expand on the data and information components of the FOO. More language is needed in the document, such that more communities see themselves engaged in FOO processes, leading to greater engagement and thus participation. This also speaks to the need to meet the needs of data managers tasked with taking up and facilitating the integration of the data coming from observing assets, as well as internal members and intermediate users.

**TI.1.2:** The FOO has been helpful as a process development tool but more detail is needed in order to be useful for implementation of an observing system. The goal would be to not give too much detail related to requirements setting for implementation, as then it may become an implementation best practices document or more of an FAQ than anything else. Rather, the aim would be to assess the process for articulation of EOVs and how that could translate into similar articulation of network or platform design and implementation and data integration solutions.

**Supporting/Additional Comments:**

- It would be helpful to assess what was done to get to the GOOS EOVs. The community could benefit from a review process as there has been some difficulty when discussing EOVs. This is especially true when they are used in models to get to a product. As such there is a need to see how EOV data is used in models and thus how it was of assistance when designing the system.
The FOO may need to make a distinction between what processes are most helpful in defining what is needed to address as many aspects of science as possible and yet still contribute to specific research.

**TI.1.3:** It would be nice to see a critical assessment on how effective the FOO was in improving an observing system. Many found the document helpful but then difficult to implement. The idea of adopting or enforcing a certification process to assess technical or operational performance would prove next to impossible in a voluntary system, even though it may result in the overall evolution of the system (gaps become obvious and upselling is facilitated through the demonstration of leveraged funds). Shy of more detailed implementation guidelines a real benefit to system capability would come from an improved understanding of the funding cycles and needs of interagency and non-federal components and their priorities.

**Supporting/Additional Comments:**
- Need to find a balance between over prescription of implementation and reporting ‘rules’, and the best practices that aid the ability to readily identify weak spots or gaps in important aspects of technology implementation and data management.
- An important benefit to having well articulated implementation practices in place (or enforced) is it may result in better preparation for response to funding cycles from not only national sources but from private or non-government groups.
- There is a need for internal IOC engagement to discuss with senior managers the perceived value of GOOS. This may result in more focused prioritized activities related to the role of GOOS in improving the value chain.
- An assessment of how effective the FOO was in improving the observing system is important as it was generally found to be difficult to implement.

**TI.1.4:** The feedback loops need development or at least some measure of consideration, especially as to ‘the who’ of those most relevant here; ranging from national concerns to data integrators. The setting of priorities is difficult and will vary based on how to best take advantage of the work leading to the articulation and agreement on EOVs/requirements when designing or redesigning a network, or the system more generally. Some kind of process for reverse engineering the system is required that can trace or track the impact of an EOV measurement; this is neither simple nor obvious.
**TI.2 Platform Pro and Con Review and Assessment**

- **Description:** Various platforms hosting ocean-observing sensors have inherent strengths and weaknesses. Articulation of these can assist in tabulating trade-off assessments.
- **Background:** Articulating the effectiveness of measuring ocean variables from different platforms will assist in the evaluation of technology trade-off assessments needed to optimize observing networks.
- **Question:** If studies were to be conducted by expert teams, what platforms would be most in need of their review and assessment?

**Key Findings:**

**TI.2.1:** Given that EOVs did not drive the need for networks in place today there is a disconnect between the planning process and a path forward to improve upon the linkages among EOVs, the networks, and the nations which are building the networks. There needs to be a way to move from EOVs to networks as the FOO has not proven very effective in this practice. This is not necessarily only a scientific concern but also an engineering assessment of what is feasible; all of which must also be considered in the context of political (e.g. EEZ/national) concerns.

**Supporting/Additional Comments:**

- For some regional endeavors there is very little by way of *in situ* observations so there is a strong focus on remote capabilities. This dictates the needs for a rigorous assessment of what data is available remotely and fill the gaps with *in situ* capabilities.
- Often determining an appropriate network design and sampling strategy and then getting required resources allocated it is important to work in regional groups. To do this it becomes important to conduct cross-project technology capability assessments and document what is working and why, (e.g. SOOS).
- Target setting related to spatial and temporal needs is often constrained by budgets and research needs but should also be based on modeler requirements.
- In building strong justification for project or network design, user input is critical. However, much work needs to be done to gather user needs and collate them into requirements, as often their needs are difficult to understand and cultural differences are vast.
- Argo is an example of a successful project with a design based on a statistical analysis of what was needed in order to understand certain processes, in the future even more natural would be to look at phenomenon.
TI.2.2: In order to effectively create requirements of the system there is a need to look at incoming as well as outgoing needs of users as well as both internal and external users. Requirements range from EOVs to technology development and implementation to data. Within the FOO the use of the word “requirements” is okay, however, it should be clear that requirements are everywhere within the system and in order to get optimal solutions there must be an ongoing dialog or iterative process of requirement development throughout the system lifecycle planning and implementation.

Supporting/Additional Comments:
- Maturing requirements at all levels in order to build an optimal system is not necessarily just a scientific concern but is also an engineering and political concern related to what is possible and financially feasible. The FOO needs to provide guidance on how to best take all of these needs into consideration and explore both incoming and outgoing requirements.
- The satellite and in situ communities seem to have a disconnect with respect to accuracy – need to address how to assess this complexity in each of the EOVs (SST as an example).
- Not all of what is needed to measure are EOVs – FOO is useful for scenario setting and getting to global agreements but leaves gaps in some important areas. Governance bodies need to provide guidance as to which groups should be called upon to fill what gaps.
- Where in FOO is the reality check on ‘truth in advertising’? Agreement on best practices would uncover the where disconnects exist.
### TI.3 Documentation and Socialization of Best-Practices

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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Documentation of EOV measurement best-practices for operations and maintenance is needed, preferably similar to the guidance for EOVs in the original document.</td>
</tr>
<tr>
<td><strong>Background:</strong></td>
<td>To move beyond EOVs (system input) and mature all elements of an observing system, additional guidance is needed on best practices for implementation and maintenance. Streamlining implementation practices may reduce costs through adoption of standardized sensors and maintenance practices and data policies.</td>
</tr>
<tr>
<td><strong>Question:</strong></td>
<td>What level of granularity is needed for this guidance: Conceptual? Process? Step-by-step? What are suggestions for broadly informing the community?</td>
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</table>

**Key Findings:**

**TI.3.1:** The experience of agreeing to EOVs at all geographic scales has proven helpful, the outcomes did help with forward motion, however the process did not assist with implementation. Regionally important EOVs and associated indicators assist with getting better buy-in when demonstrating utility of a research program. Nonetheless in addition to EOVs, scientists require observation of indicators of change along with what is required to enable/implement research or a baseline understanding. This granularity is also needed when distinguishing between pilot and mature observations as regional self-assessment is a critical element in the path to demonstrating the utility of an observation globally.

**Supporting/Additional Comments:**

- FOO was a great way for building consensus on what to observe- EOVs need to lead to indicators of change (vs. something that enables research or understanding). Need to pin down phenomenon and demonstrate how they matter – (maturity confirmation).
- Examples of regionally important variable granularity is needed: as the distinguishing feature between pilot and maturity is self-assessment – which facilitates choices that can be made at all levels – the next step is to demonstrate observation utility.
- When assessing the theoretical value of observations versus what can be demonstrated it is often difficult to do even though the variable has been observed over a period of time. It would be helpful to better assess what are the steps to demonstrating observation utility for maturing some of these long-term observations.

**TI.3.2:** There is a need determine ways to more formally discuss how the Framework has had a positive impact on the most critical elements of an observing system. The work of the Best Practices Working Group (BPWG) is very useful, yet there is an important next step ensuring it continues in a useful way. The outcome must not be limited to a document repository but also include a way to determine fit-for-purpose best practices that can be used by the...
community. This will require some higher-level thinking, evaluation and uptake of successful enterprise patterns (this may or may not be an appropriate GOOS function).

**Supporting/Additional Comments:**
- Think about how the Obs ‘19 venue can help with assessing the adequacy of an EOV in selling up – many in the community could use guidance on how to best do this.
- With regard to addressing the FOO’s role in improving feedback loops and the need for improved clarity on monitoring objectives:
  - Integrated monitoring requires clear monitoring objectives with the lowest step on hierarchy being sampling coverage and data accessibility
  - Assessment of monitoring systems needs to reference those objectives
  - Provide the potential for assessing impact at many levels in a hierarchy, from measurement through reporting to uptake and impact.
  - May result in hierarchical monitoring system that allow for reporting progress reflecting different objectives.

**TI.3.3:** The Framework should highlight the where and why within the system architecture patterns exist and thus where the adoption of best-practices are most important and/or needed. The FOO needs a greater emphasis on integration beyond EOVs. This will include the development of where consideration of modeling needs are of the greatest importance, and how to integrate *in situ* networks and platforms with satellite data; creating not just satellite constellations but EOVs (or other phenomenon or indicators) focused constellations.

**Supporting/Additional Comments:**
- Need to create and socialize the how and the where documented best practices are vetted and archived.
- GOOS should consider and/or apply its SC oversight to community vetted best practices – not writing documents but reviewing and assessing their value.

**TI.3.4:** Identification of EOVs is important to research endeavors. However, research and science are not the same thing – science is more operational – so this recognition needs development across the system.

**Supporting/Additional Comments:**
- Observing community needs to articulate where research and development ends and sustained observing for global science begins - and how systems should be designed and developed accordingly (SST as an example).
- There is a concern that GOOS is trying to do too much or going too far downstream of the value chain – they play a vital role upstream for *in situ* observations with CEOS playing a similar role for satellites. There is a need for closer collaboration between GOOS and CEOS groups in order to exploit what can be learned from a more operational orientation. GOOS is well positioned to lead here.
TI.3.5: There exists a need to recognize that the implementation of the entire observation lifecycle process takes a long time, and that it is often difficult to consistently engage the concerted expertise of science volunteers. Funders might benefit from a greater understanding of the end-to-end process. This would allow them to better appreciate the physiology or psychology of science – that observations don’t just magically provide data, rather there is an entire process leading up to results, and that this takes a good deal of concerted activity.

**Supporting/Additional Comments:**
- It would be good to have in FOO the discussion of the voluntary nature of the lifecycle process and how to engage toward formalization of these practices.
- Need to spell out steps, and encourage adherence to ongoing client-service engagement. (Cost is often an impediment to this type of engagement, however without an ongoing mechanism many small contributions may be lost or under appreciated.)

TI.3.6: There could be real benefit to the development of courses that demonstrate concerted exposure to ideas and best practices rather than a formalized certification course. The BPWG work is important especially for giving some groups working internationally examples to look at and possibly strive toward. How to then best conduct the necessary technology transfer is a challenge.

**Supporting/Additional Comments:**
- More dedicated training may be something IODE or IOC takes up. A plan may be to support the Best Practices work and then build on that, (e.g. move from a BPWG to BP user group within IOC/IODE).
- Figure out how to get to a model for designing workshop or project output needs into a discussion that is agreed to by experts at the front end.
- As for the lessons learned from previous certification process: there are issues related to the relationship to specific best practices and how to make them part of an education or training program. It is probably more helpful to state that participants have been exposed to specific/highly practical content – not certified or exposed to a courses that offer a broad range of content.

TI.3.7: Generally, there needs to be a more formal way to identify major groups collecting ocean data, distributing it, processing it, and developing applications.

**Supporting/Additional Comments:**
- Conduct a pilot project (or projects) designed to assess and formalize a process that stimulates the technology transfer required to enable GRAs to conduct data analysis on a routine, sustained basis.
- Determine how to improve modeling and data assimilation maturation. Could start by looking at the application readiness levels of data then address gaps (e.g. NOAA’s Research Technology Acceleration Program – RTAP).
- Formalize a process of set of interfaces that facilitate engagement with internal
users of the observing system that are also providers of products and services. Evaluate what the observing community can do, what is being done, and prioritize gaps that lead to the next generation of data and data products.
## TI.4 The Path to Maturity

- **Definition:** Clarifying processes to assess the readiness of ocean observing technologies will help transition and mature technology into operational and sustained use.

- **Background:** Several GOOS processes test technologies for inclusion in global sustained observing efforts. The ability to declare new observing technologies “mature” or “fit-for-purpose” may assist funders and implementation teams in their efforts.

- **Question:** Would a GOOS certification process for observing technologies be useful? If yes: For scientists? For operational systems? For developing nations? For potential funders?

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### Key Findings:

**TI.4.1: Readiness Level assessment was a very positive outcome of adopting FOO processes; and has been one of the great benefits of using the FOO.** The assessment, however, can be improved upon by better definition of more Technology Readiness Levels (TRLs) such as those used by the space agencies.

#### Supporting/Additional Comments:
- Funders could use this type of an alignment with TRLs in the form of use cases with expected benefits explained. If funders can see the demonstrated value and benefits as vetted by the observing community it helps prioritize requests.

**TI.4.2: It may be helpful to apply ‘Science Readiness Levels’ to observations.** Determining whether or not the science community is ready to use the data, or importantly, do they know what data they need? If it is not known what data is needed or how to use it, the result may be a nice data set but not a resource useful for models or applications. The benefit may be lost because scientists aren’t ready to use the data or derive a product, this leads to an integration gap.

**TI.4.3: In further developing the FOO, it may be helpful to incorporate a consideration of different time scales when assessing the value of observations.** This may drive a need for the creation of output driven and implementation efficiency score cards that provide feedback loops related to best practices for deployment and varying timeframes for assessment; from immediate or near real-time to more long-term monitoring evaluation.

#### Supporting/Additional Comments:
- Improvement of observation infrastructure is one of 6 goals for the Decade of the Ocean. The observing community should now seek to identify transitional flagship technologies at varying levels of maturity that change the way the ocean is observed and use them as case studies on the complexity of the maturity lifecycle. Examples might include deep and/or bio Argo, SWOT for satellite ocean current observations, ecosystem genome sequencing or eDNA evolution.
• GOOS should explore how to acknowledge the role that small, localized projects that may never reach maturity play in the development of the observing system

TI.4.4: Need to develop cross-function interfaces designed to assess how well the system is responding to the needs of intermediate users. Given there is little institutional funding for these efforts and evaluation is difficult in a volunteer system it may be helpful to articulate the steps required to meet internal user needs (this can be more helpful than an attempt to enforce these steps and if helpful it could one day potentially be an audit function).

Supporting/Additional Comments:
• Evaluation in a volunteer system is difficult (this is very different when institutional funding is in place). However, if there is a clear articulation of core steps that lead to success along with encouragement of alignment, this is more helpful and reasonable than enforcing certain steps or creating certification requirements. (A self-imposed audit function may one day prove helpful.) A positive example is the value associated with OSSE’s design evaluations.
• There are lessons to be learned from a desire for certification and the relationship to best practices. Education and training might better serve the community by creating suites of ‘courses’ that expose implementation groups to well vetted best practices in a particular area of needed skill sets. This may be far more beneficial than strict certification.
• This type of feedback loop may require more resources than GOOS has, yet there is a need for some level of GOOS oversight possibly through an evolved version of the panels. This is an important internal process as most likely something that funders would not pay much attention to, other than to have an appreciation of the rigor associated with the evolution of the observing system.
• It may be helpful to also rethink the structure of workshops designed to help share best practices and progress. Rather than a transmit-and-receive format there is a need for a structure that encourages action-based or results-driven outcomes from the outset.

TI.4.5: A more robust user connection needs to be established with internal or ‘intermediate’ users. There needs to be recognition of internal users along with established forms of dialog and evaluation of system performance. As a community it is important to recognize that it is far too simple to say there is a need for better engagement with end users but this by itself does not necessarily help with the uptake of data and services or actual implementation of the network or system.
The Role of Pilot Projects

• **Description:** Pilot Projects can be a powerful tool in testing and assessing new technologies for ocean observing.
• **Background:** A better understanding of the various types and levels of pilots can help the community assess their role in establishing best-practices and maturing FOO processes and technologies
• **Question:** What Pilot Projects have been helpful, and why? What pilot projects would you like to see, and why?

**Key Findings:**

**TI.5.1:** If done properly a Pilot Project can be a mechanism to used to bring things into the mainstream so that all stakeholders seem smarter not appearing to know less. Pilots can be used to fulfill the important role of transition from prototype to local stakeholders and again to an operational system. As such it is important to set the operational goals from the beginning – even if a phase (or phases) of the project support research goals.
• There have been some good examples of pilot projects like Mbon and ATN as they have been instrumental in helping the community to determine how to answer complex questions. The challenge is how to then take results and integrate them into the mainstream in a manner that demonstrates that we know more now – not less. This is a particular challenge today in the biology realm.

**TI.5.2:** Today the process for becoming an official GOOS Pilot Project is far too ad hoc for there to be much concerted benefit from them. GOOS needs to champion cross-network and integrated pilots focused on EOVs across continents. Within the governance structure there exists a need for a process to get proposed ideas assessed, and then in a timely manner seek funding or secure the necessary resources.
**Supporting/Additional Comments:**

- This process is of critical importance as there is an immediate need to develop ideas and get an “ask” in place in conjunction with Decade of Ocean Science goals.
- There is a need for pilot projects focused in the data realm. While some exist they are generally funded at European or national level. Need to find a path by which these projects can next contribute to the needs assessment ranging from observation to data products. There is a need to organize at international level on how to do this.
- Would like to see this as an outcome of Obs ’19. This would include a better design and assessment of proposed pilots at the international level that results in obvious societal benefit. A good example or model is the path to maturity as seen as a result of GODAE and OceanView.
- Need a good description of what is meant by a pilot project. It would benefit the community to have an understanding of a pilot project’s value if there is agreement on what it is they are trying to accomplish. This may also result in a greater commitment of resources.
- Whether it is via FOO or not, there is a need to create a language that is used throughout the community that helps with pilot project buy-in and also helps demonstrations and show their worth. The role often played by OSSE’s is an example – they are of great benefit when going from concept to pilot – self-assessment/assessment is key to demonstrating their value.
- There is a lack of formality within GOOS and the GRAs on how to get projects approved endorsed as pilots. Currently there are 3 or 4 accepted via an informal process through the agreement of the SC – once this is given there is little support in assisting with funding or resource development; even so the affiliation with GOOS is of assistance within the project in securing resources. GOOS expertise could be well used to create a mechanism to put capabilities together in a coherent way and to even assist with securing resources. This should be work-shopped.
- As part of a more formalized pilot process or processes is there a way to create a formal mechanism to understand how to assess GRA technology transfer and capacity development needs in order to conduct sustained observing, data analysis, and reporting projects.
- It would be helpful to create a pilot between GOOS and BluePlanet under the UNDP umbrella. This will help resolve some issues related to a focus on EOVs and regional and national needs and resource allocation.
- There is a need for pilots – maybe sponsored by GOOS – that conduct the needed cross-network and data integration work focused on EOVs across continents. (A potential place to demonstrate this might be within the Tropical Atlantic project.)
TI.5.3: There exists a need for a good description of what is meant by a pilot project, this may be helpful toward understanding their value; to assess their contribution it is important to understand what it is they are trying to accomplish. Generally, today Pilots assist with helping the community determine how to answer questions, demonstrating how partnerships can work (e.g. the complementarity of BluePlanet, and the role that UNEP can play), helping with awareness building within the community but categorically not much more.

Supporting/Additional Comments:
- The FOO can help create this language for adoption throughout the community and help with buy-in and articulation of goals that demonstrates the worth of Pilot Projects to the community.

<POSSIBLE ADDITION: governance structure needs to id and socialize language of what pilots are and what they do – see breakdown in the TPOS 2020 First Report>
**TI.6** | **Design and Implementation of Best Practices**
---|---
- **Description:** Measurement of EOVs often requires a blend of technologies, so the determination of which sensors on which platforms can become quite complex.
- **Background:** The analysis and negotiations required to determine a cost effective, technologically feasible system often requires expertise from a broad spectrum of geographically distributed individuals and implementation groups.
- **Question:** What kind of resources could help you or your projects facilitate more effective/efficient assessment and determination of an optimal mix of technological solutions?

**Key Findings:**

**TI.6.1: The FOO does not do a good job of reconciling local, regional, global needs.** This becomes an issue especially as the communities that conduct implementation activities have varying levels of maturity and operate across various scales. Proposals articulated or plans often range from a laundry list of what is wanted, to well-established plans and processes for architecting system design, and outcomes.

**Supporting/Additional Comments:**
- An example is the tropical pacific observing system. While it is thought of globally or as a global system it has regional nuances that require consideration.
- FOO has a difficulty in this instance because what is essential varies by area, yet is still considered part of the overall system design. This will require more flexibility in thinking about system outputs and products, which is a major issue for users. This is needed if the FOO is to be more helpful in taking processes and phenomenon observations from concept phase toward maturity.
- More needs to be articulated by the FOO with regard to effective end user engagement, regional user engagement, and how to manage platform and array trade-space/space and capability trade-offs.
- Even with the most mature EOVs (e.g. SST) there is discrepancy when seeking an agreement on what is needed related to scale. In some instance it is not appropriate to resolve at smaller scales, yet in others it is vital. The FOO could assist in determining a set of processes or interfaces needed to determine a resolve these types of issues.

**TI.6.2: The global sustained observing system (facilitated by the FOO) needs to consider data needs as user driven.** While this is generally acknowledged, it is not categorically seen as part of the overall architecture and is therefore often unsuccessfully or inadequately implemented.

**Supporting/Additional Comments:**
- Conduct projects similar to Copernicus Marine – as a model it could be helpful in allowing users to get access to data while simultaneously teaching the data providers and managers on what is effective in encouraging data uptake.
- A well-defined architecture will benefit the observing system overall as often the provenance of data is buried in a service or a model – so when users unclear on
where their data comes from it is difficult to advocate for its continuance.
• Need to not only tag data, but to also trace its use, and further advocate strongly for data compliance with publication standards.

**TI.6.3:** Much planning, design, and implementation is still done in a compartmentalized way. There are Task Teams and Working Groups that may work thematically or are platform focused; however true integration thinking is often somewhat limited. There may exist a connection to global efforts that are focused on integration, but this tends to be more the exception than the rule. Concerted effort is often diverted from global thinking to addressing more local, coastal concerns, which are often viewed as too complex for integration. This is important as there is very little focus on taking advantage of what observing community is capable of accomplishing today and then use this understanding to improve integration; especially at the coastal level.

**Supporting/Additional Comments:**
• Determine how GOOS groups such as the GRAs and the OCG can do better by revising their silo-based manner of conducting business. Key to this is to demonstrate how platforms with open data assist with data take up.
• Articulate process by which known obstacles to progress can be resolved via special investigation and assessment. Examples today are how to persuade biologists to use data not taken from ships but to develop more of a reliance on autonomous platforms including satellites, (BGC being an upcoming example).
• Conduct cross-comparison studies of data and projects using similar technologies under different groups (GOOS, GEO, others) to determine if valuable expertise is being lost, and to determine ways to encourage the uptake of observing requirements.

**TI.6.4:** Once a project or program and its measurements mature it is beneficial to create theme driven Working Groups and depending on the scale, a coordinating Project Office. These thematic WGs (science, engineering, data management) can be organized to feed into Regional Working Groups (RWGs) that then become an effective way to keep the science moving forward through more efficient engagement. These smaller RWG are easier to manage and facilitate enhanced multi-disciplinary dialog. Funding bodies can also see more tangible benefits in supporting RWGs, as results are implemented locally or regionally. This funding structure encourages a strategy designed to solve problems regionally with an eye toward global reach as appropriate.

**Supporting/Additional Comments:**
• Need to help the GOOS SC become a body for providing advisory and strategic advice in its oversight role. This will help projects and program managers to better assess global observing capabilities and needs. In terms of implementation this will lead to a more robust technology conversation, which may ultimately speak to the need for technology and enterprise administrators not just science managers.
3. Data and Analysis

Much has changed in the data and analysis arena in the past decade. Open data policies, improved communications technology and methodologies, and the adoption of data management techniques that facilitate sharing and integration, now allow data managers and analysts to better serve their community with quality data, data products, and services. As the observing system becomes increasingly fit-for-purpose the data community is challenged to allow users to discover and use available data that addresses thematic, local, regional, and global concerns.

<table>
<thead>
<tr>
<th>DA.1</th>
<th>Improving Data Efforts (Legacy and New)</th>
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<tr>
<td>• <strong>Description:</strong> There are many legacy ocean data systems. The ultimate goal of each is to have all ocean observations quickly stored in standard formats, in rapidly accessible, user-friendly data stores.</td>
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<tr>
<td>• <strong>Background:</strong> There is a growing and urgent need to overcome the difficulties in data discovery, delivery, and stewardship to meet the needs of the entire ocean observing community.</td>
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<tr>
<td>• <strong>Question:</strong> What would you or your group most benefit from in terms of ocean data management or policies? Are you aware of exemplary efforts that you believe deserve to be highlighted?</td>
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</table>

**Key Findings:**

**DA.1.1:** The global ocean observing system is under tremendous pressure to reconcile the requirements generated by the growing and inhomogeneous amount of data that are available from observing systems today and to provide consistency and interoperability. Improved coordination is needed such that all relevant information resources (data, metadata, services) appear to the user like a constellation of data and services (both satellite streams and those from small *in situ* efforts in remote regions). There are not enough data best practices in the data realm that can help facilitate the resolution of problems in front of the community today. In order to do this it may be best to look at the big solutions and users first, then determine what are the needs of the smaller entities/countries and make sure they have access to data rather than set up isolated observing systems that are too reliant on specialized/localized circumstances.

**Supporting/Additional Comments:**

- Need to find a balance between sustainable development and tech transfer. GOOS can provide guidance here. While FOO can’t do too much here given its scope – but text can be added to acknowledge the need to mature the system overall.
- Need to evaluate and identify common tools that can be made available via the web (as web applications and service). This solves many issues as it allows for both the insertion of data and receipt of data (IMOS has done some of this).
• Some in the community need help in designing systems and sharing data. BPWG is good for some of this but now how to use the repository. There needs to be a path or expertise in helping others use the resource. For many this may go a long way toward facilitating the step change into a more modern environment.

**DA.1.2: Embedding unique data solutions within specific technologies leads to a larger issue of data archeology that will persist into the future.** Finding data is a problem, as often users really want to find level 2 or 3 data and start using it. Improved discovery and accessibility would be very useful, while some systems are not far from where they were 15 years ago, yet today there are also some groups with these practices already in place. Today, potentially with a greater understanding of architectural patterns and best practices, developing nations may be able to skip a layer of operational development and maintenance, and enjoy a step change in data accessibility (as many have cell networks). This is true as for the most part data managers no longer have to know and administer the underlying technology or infrastructure.

**Supporting/Additional Comments:**

- The community may be well served by big data groups that are solving similar problems. The ocean community has been somewhat stalled by the GTS philosophy that the oceans needed its own system. By working within more open systems and technology solutions there could be a good deal of advancement. Hopefully, good guidance on this will be provided in related Ocean Obs ‘19 CWPs.

- Need to explore cyberinfrastructures that are effective as there are lessons to be learned here. Need to understand how to make the shift from such a strong reliance on human in the loop to infrastructure that facilitates a user’s ability to access and use data sets? Generally the community is a long way off – but the trend is there and there are examples (Copernicus, EarthCube, low-orbit satellite constellations).

**DA.1.3: There is a need to build on the growing practice of sharing data by developing software data product management best-practices and maturing de facto standards.** Much can be learned from the big data and cloud computing arenas.

**DA.1.9: A structure should be created to support a federated data architecture.** An understanding of- and adherence to successful patterns (best-practices) is critical for adopting such an architecture.

**DA.1.4: A global data policy needs to find a sweet spot with not too much top down administration, but enough to allow for traction when adhered to, and results in funding or national support.** There is a need is to lean more heavily on what exists now that is working well and build this up rather than continue to develop (recreate) top down rules on how to manage and archive data. It may be that data management practices, rather than prescribing how data should be managed, should require a demonstration of an adherence to something
somewhat aspirational like the FAIR principles such that data can ultimately be discovered somewhere in a data portal.

**DA.1.5: Technology transfer and international science issues are deeply related to capacity building and data management.** The lack of real national data centers creates an endemic weakness for ocean science.

**DA.1.6: An improved understanding of data management and implementation teams is needed; they seem to be more of an idea rather than organizations with long-term sustained funding and Terms of Reference.** Even the teams that are well respected are often seen as projects, not ongoing groups with long-term Terms of Reference implementing well vetted data policies.

**Supporting/Additional Comments:**
- FOO needs to raise the level of visibility and importance of data practitioners. A first step in maturing the conversation may be to bring together groups in Australia, Europe, and USA with groups in lesser-developed nations to agree on best practices.
- The role that has been played by the IOC to date, while good, may be too aspirational as member states don’t tend to sign on despite the obvious need to move forward toward more open data sharing.
- There is also the issue of data that is available but cannot (for whatever reason) be accessed. As an example there has been some nice movement related to the GTS. However, in some important instances the met services charge for access to data – while this is not all bad as it does force a conversation of data needs – it is not the same a open ubiquitous access to the resources.
- IODE is a project that is taken seriously by all in the community yet could still use some support from GOOS to better brand and market their efforts and outcomes.

**DA.1.7: In the data arena an issue exists that when projects are funded there is just enough funding to apply the data but little else to demonstrate ongoing progression of its use and resolution of known problem resolution.** This creates a deficit as there is always something that is not solved, or over time a new problem presents itself that seems to defeat the progress made. There is a need to articulate the daisy-chain of events required to prevent or overcome this issue.

**Supporting/Additional Comments:**
- FOO could do a better job of articulating the full suite of processes that lead to successful data outcomes; that this is highly iterative and continues beyond the project end – and encourages ongoing data uptake and use.
- It may be worth exploring the genesis and activities of the WMO WIS2.0 as this effort is designed to explore and revise data products and product requirements along with optimal data discovery and access methods.
DA.1.8: To better meet user needs it may have been more helpful to have first looked at indicators rather than EOVs. Focusing on indicators facilitates data product development and ultimately data use. EOVs focus more on creating observing system requirements rather than a user requirement on data products.

DA.1.9: Certain data sets and streams should be allowed to mature prior to release in order to better assess and/or evolve their value to the system. Once the observational methodology is mature and determined to be of relevance to the global system, the data can be released and sustained as a baseline indicator of change.

Supporting/Additional Comments:
- FOO (and related governance bodies) may need to acknowledge that in order to fully meet the needs for the preservation of long-term data it may be desirable to fully mature observations to ensure their accuracy prior to release of the data; allowing it to become a more stable baseline and thus better benefit science and society.

DA.1.10: There now is a more developed or mature community working on hybrid, or coupled data assimilation models. It would be advantageous to get these groups to come together; though not sure what it looks like. There is the impression that atmospheric modelers are successful due to their access to so much satellite data. With such a small amount of in situ data available to the ocean modeling community, it is hard to generate the same level of interest in this data. Additionally, in situ data often are not used in modeling as they can shock the models. With regard to the data that is brought into models, it is not clear when/why it is used or rejected. The next generation of models and data tagging may be able to identify which in situ data are being used which may keep the model from being more helpful as a forecast tool; the coupled model community could do this.

DA.1.11: Data centers and data management need to develop as separate entities from the development of data products/models. These facilities and groups have very different concerns, and the skills required to manage and maintain them are also different. There are some good examples of this as it relates to data sharing going on in Europe. More said about this in the FOO could help inform the community and allow the data community to more fully benefit from the FOO.

Supporting/Additional Comments:
- Look to examples and lessons to be learned from cloud systems, big data, and research groups. The observing system needs to adapt and accommodate now open open data policies. There is a good deal of work to be done on understanding what data can be used, at what level, and for what purpose.
- Need to find better ways to get the ocean observing IT community working with scientists and managers. Across the community IT teams are doing great work, accomplishing interesting things by building tools for data use. However, there is a disconnect when it comes to discussing the utility of these advances with users.
The development of federated data systems and search tools has the potential to assist local and non-local users to access data. Once the data is in use, over time the community will come to an agreement as to what works best – it then becomes easier to immolate those practices. Once these de facto standards are common practice, progress can be made on seeking broader engagement, agreement on meta-data standards, development of common or more useful data sets, and ultimately access to web tool code for application extension. Getting visibility for these data practices is a huge first step and allows for broader discussion of its utility, and a more centralized set of priorities for getting observations funded.
DA.2 Supporting Various Data Levels

- **Description:** To encourage the publication and sharing of more ocean observing data, it may be desirable to define multiple levels of data standards. Data providers can then release data and products at these standardized levels without concern for the need to fully clean or refine their data.
- **Background:** Some data sources are reluctant to release their data because it is not of sufficient quality for use by other groups. A well-defined raw, unprocessed data level might encourage more sharing from such data sources.
- **Question:** Are there default data levels that could/should be approved for increased data-sharing within the GOOS community?

**Key Findings:**

**DA.2.1:** It is critical that all data generated from observations can be used, anything less is a waste of resources. Generally speaking this calls for a multi-pronged approach; first, all data is open, and second, all data is of sufficient quality and/or associated documentation is available to allow for its use.

**Supporting/Additional Comments:**

- A study of pilot projects being conducted by data centers around the world that are showing successful sharing and integration across data centers would be of great benefit. (The end result may even be a concerted investment dedicated to a specific data set or product.)
- Determine how to encourage open data policies for the community beyond the physics group. This could be most helpful as the BGC and Bio community are in the beginning stages.
- Conduct some training that is focused on working with different data levels with differing types of processing required. As often today it is not that the data is not useful, it is that training on how to analyze available data and build relationships with providers is required.
- Remain mindful that some of the issue is a data communications issue. Many practitioners are still using old technology that is expensive to maintain and has very limited bandwidth capacity. Now with less expensive platforms, sensor developers can use this more modern technology for improved data delivery – this will create a step-change in the data realm. More information about- and encouragement toward this change is needed.
- The FOO language could do a better job of promoting the benefits of improved data delivery and access that are possible today – and that they need to be explored at the time of investment in the observation. It should be encouraged that this type of methodology or standardization is an important foundation to moving forward, (e.g. EDMONET).
DA.2.2: Within governance there is little-to-no dialog between data providers and the rest of the observing system. Governance structure needs to have a better way to assess data stakeholders. It is not recognized that when the observing community speaks of users they are speaking of two different communities (internal and external users). Going forward, governance bodies need to routinely address both groups as they generally represent two uniquely focused activities.

DA.2.3: A well articulated suite of data levels and associated data quality definitions is a good thing with tags that data users use regularly would be of great benefit to the community overall. Caution against too many ideals associated with data levels and practices as this could lead to too much complexity and a “desert of data rather than parks.” Generally there is a need to train the community to pay attention to data tags – this could have a funding link in that in order to get funding data generators need to make traceable contributions to their national interest that can be demonstrated via use of their data.

Supporting/Additional Comments:
- Before a project has gone too far in planning and design stakeholders must be prepared to negotiate and articulate data products, and what their benefits will be. Need to develop a policy that supports user needs (funders, national groups, researchers) for data products and delivery (real time / delayed, etc.), and the associated infrastructure. This is very helpful in guiding and constraining the product development and delivery needs. This also helps with the management of data management resources throughout the lifecycle of the project.
- GOOS needs to decide how far into the data products realm they should engage. In addition they need to hook EOVs into national strategic efforts and goals for observations.
- Copernicus is a successful model of data and data product development and levels.

DA.2.4: Sometimes pushing data out openly is frowned upon because the benefit is not seen, as scientists need to more regularly cite the open data that they use – so community awareness is critical.
### DA.3 Building Data Analysis Capacity

- **Description:** There is a need for data analysis capacity development that includes data discovery/analysis, as well as technology training.
- **Background:** In many instances, 80% of data required by developing nations to address their scientific or societal needs already exists. Additional observational resources can be brought to address subsequently known gaps. Researchers trained in data analysis are needed, however, to make use of these resources.
- **Question:** Do you think assistance in finding and analyzing data may be of great benefit? How should we develop this type of program?

### Key Findings:

**DA.3.1:** A concerted training effort is needed to demonstrate the transformation from raw data to a data product as part of user capacity building.

**Supporting/Additional Comments:**

- There is a need to develop a repository of tools and capacity development material that is widely accessible and well supported.
- Training classes need to avoid being too disjointed. Often they are not building capacity but rather providing generalized exposure to a range of related (or not) topics. Courses should be designed to develop practitioner capability – possibly modeled after the outcomes from some of the more successful residential programs and groups.

**DA.3.2:** There may need to be fundamental changes in the IT infrastructure from the present Virtual Private Network (VPN) system to a cloud-based environment. This is already happening to a degree at WMO, but more is needed. The overriding issue is that it is impossible for the WMO to keep up relative to the strides made regarding the Internet; which is so much easier to maintain than the present VPN. It may be that the solution will look nothing like the current Global Telecommunication System (GTS). At a minimum the infrastructure needs to be less complicated, maintain a high-level of security, and an adherence to standards that are of a major concern to- and relied upon by users. These issues may prove a challenge when making a migration to- and creating a sustained environment on a cloud system.

**Supporting/Additional Comments:**

- WIGOS 2.0 has some legs at WMO given the history/legacy of this group. For WMO to go to an internet-based system accessible by everyone -not just met services- would change a great deal of things. It is worthwhile to find a mandate within the WMO given its critical role in providing data to developing countries. However, design and transition groups will need to remain mindful that there are issues of security as lives depend on weather and forecasting data, as well as some security issues related to where observations are taken.
DA.3.3: Often observing system funding involves planning for a common environment designed to facilitate the integration of data, yet lacks required national funding to develop applications or services to assist with the use of data. Developing this national orientation is important; some ocean data centers have done this, as has the satellite community. Lacking is the development of data applications and services as standard practice for sustained observing systems.

**Supporting/Additional Comments:**
- The in situ community may be well served by conducting some smaller, pilot activities on a specialized basis, with the goal of gaining a better understanding of how to more generally facilitate the progression from data to applications and services.
- In Europe some groups/pilots are trying to do some of the design output from scratch while at the same trying to ingest data that exists into more modern analysis systems.
- In some cases ocean-observing networks have national funding that supports common goals in the open ocean (Argo as an example). However, once efforts get closer to the coast unique national efforts become an issue – as many have their own needs and set of solutions. Often the result is that the data is slightly the same but does not lend itself to true integration – a better understanding on how to improve this would create a step-change in efficiencies. (AtlantOS did some of this with the US and Canada – more of this would have been of great benefit.)

DA.3.4: By refining observational data for use within models, we can use them as tools to both refine our models and gain a better understanding of where observations should be made.

**Supporting/Additional Comments:**
- This also helps to understand the backbone or baseline needs of an observing system. Once the core capabilities of the system are well understood and have been used with success by data integrators, modelers, and researchers, the system takes on added utility.
4. Governance and Management

When the FOO document was originally drafted it was unclear if an oversight group would adopt a system engineering approach as a working model. The FOO suggested that governance should include the ability to provide an interface to external groups and assist with the coordination of internal panels and teams with the end result of all feeling a part of the system or enterprise. Today there continues to be a need to better address the activities associated with the ‘feedback loops’ of science and societal need.

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<thead>
<tr>
<th>GM.1</th>
<th>Coordination of Global Programs</th>
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<tbody>
<tr>
<td>• <strong>Description:</strong> For large global networks and technology solutions, long-term and wide scale buy-in is needed to mature and sustain these observations. A review of each EOV, technologies required for observation, as well as desired data and information services will assist in an evaluation of coordination needs.</td>
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<tr>
<td>• <strong>Background:</strong> As some EOVs require the coordination of technology deployment and the integration of data, the level of buy-in among participants will vary. Therefore there is a need to assess the desired and/or potential need for coordination or collaboration based on the known levels of required ‘buy-in.’</td>
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<tr>
<td>• <strong>Question:</strong> Which EOVs, Networks, Technologies most need this assessment? Are there suggestions for a community review format?</td>
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**Key Findings:**

**GM.1.1:** In general GOOS, and all of the community, could benefit from an enterprise approach, as this will facilitate the practice of attaching data from multiple sources to user solutions through improved interfaces among otherwise disjointed stakeholders and sponsor. There is a need for an overarching framework that brings the stakeholders across the entire community together to agree on a functional set of interfaces, or ways of working together. These strong partnerships or enterprise thinking keeps GOOS (BluePlanet and others) from stretching too far. The system will work best if each component focuses on its strengths and avoids duplication. This may also help GOOS focus support for users within the system: to those entities that are both providers and users, and that work with other groups to bolster the feedback loops into the system. Generally this speaks to a need to get providers and managers within in the system to both engage each other as well as external end users. This is a role that FOO 2.0 can facilitate however it goes beyond GOOS and encompasses all communities.

**Supporting/Additional Comments:**

- Need to find a balance of scaling up projects and maintaining scientific integrity. As projects become more global they become more valuable regionally can create a tension between national funding goals and global concerns.
- FOO needs to articulate what a more mature observing system will deliver to science and society. The alignment with an overall architecture would be of
benefit the community at large – as this is visible in some instance across the system (JCOMM, WMO/WIS) but not widely enough adopted across the community at large.

- Would like to see GOOS, in coordination with other groups, build users into groups that share their uses of data allowing ocean observing practitioners to better meet their needs.

GM.1.2: Today many within the observing community are missing coordination and management at a national level. There is some international coordination, but it often lacks an associated national level contact point that has access to any form of a structure focused on coordination within the nation. Coordination at the national level is important if FOO is going to work well; as this is the only way to evaluate the benefit of FOO systematic processes, this is especially true with regard to the practical implementation of EOVs, networks, and data uptake. Put simply, coordination of management and a review process will be most helpful for evaluating fit-for-purpose observations, clarifying what is meant by experimental / sustained / operational.

Supporting/Additional Comments:
- Rethinking and looking for a balance between innovation and practicality – thus fit-for-purpose. Need to articulate what it is to be achieved as key to the question you are solving. Can you scale it down (benefit to users) / scale it up (role of GOOS).
- Clarification of what is meant by sustained versus experimental versus operational observations for research and/or science is needed especially in the context of standards use, what is needed for robustness, and data quality requirements. (NAS mid-2016 Report addresses this.)
- Also sustained versus experimental observations is an important consideration in need of clarification – this is a WMO concern – most of what we see is funded by research – so a balance is critical – this is hard for oceanography as an effective system will likely always require a heady bit of innovation – need to get to what can be sustained and make sure it is necessary.
- There is a need to identify key drivers that result in in decision-making. These require an ongoing evaluation and process for data analysis that lead to more dynamic environments and improvements.
- Use the Large Marine Ecosystem (LME) Approach as a method to avoid government entanglements. Maintain a focus on a balance of operational needs and impact. This could be accomplished via an Engagement Plan among peak governmental and intergovernmental groups, including NGOs, and industry. (Engage not only in shipping and fishing issues but look to corporate trainers as partners.)
- EOVs do need regular assessment. This is sometimes made clear during an initial attempt to socialize the GOOS EOVs, as there is push-back given the panels are such a small group and it is difficult to demonstrate they have
appropriate expertise. External alignment would be assisted if there is an external review cycle. (OCG may be able to advise on this.)

- So far FOO has not fully addressed the full ocean research requirements needs. There are requirements for mixing EOVs (getting to processes and phenomenon) and technology development. Beyond this there is a need for a transition path through research, as modelers will continue to need greater resolution and better measurements.
- GOOS and others need to identify and articulate win-win scenario for partnering with a stated emphasis on value brought and value given.
- GOOS is designed to serve the community by identifying observing needs in the context of science and scientific problems but also the end-user community in general. Beyond these national and international concerns there are the needs of the private sector which often are not open to disclosing what data they use and why. As well there is the difficulty in encouraging them to invest in observations that will be made publically available.

GM.1.3: GOOS processes, roles, and services need improved understanding as well as visibility to others in the coordination and management community. It is clear what the FOO has contributed toward the adoption of an architecture approach. With this focus on the entire enterprise of observing, there are examples of clear needs:

- Not clear what the GRAs do there is a feeling that the GRA are not evenly engaged into the GOOS processes. Would like to see exploitation of the huge opportunity for GRAs to play a valuable role to bringing observations to end-users,
- GOOS could benefit from improved ways to emphasize the research that it supports and the associated economic benefit of those observations,
- Need to identify a process that will ensure that researchers are a part of the operational system and/or otherwise taking advantage of it,
- Recognize that the physical EOVs are fleshed out, and find a way to help the community understand how GOOS will be focused on biology and biogeochemical EOVs and assist groups with their implementation,
- Partnering with others in the community such as POGO and its capacity building expertise,
- Work with groups like BluePlanet and GODAE OceanView to facilitate the building of networks of users (user groups) that have a strong relationships with GOOS stakeholders, and
- For GOOS, getting from observation to data (and all steps in between) has proven a challenge within an EOV parameter across in situ platforms. The issue is how to bring together data so users need help with merged products (GHRSST as an example). This is only the beginning, answering how to bring in situ and satellite (and modelers) together is now the holy-grail; need to achieve cross-parameter coordination and then finally to get to merged products.
Additional needs across the community include:

- Given its importance there is a need to create interfaces that address how to justify the expense of coordination. National coordination efforts have resulted in a recognition that there may be value in doing basin scale coordination.
- Models are coming far enough along that it is possible to see the benefit of having the observations in place to make them work better. This makes it easier to promote the use and development of new technologies as well.
- International projects, functioning as federated bodies, can help nations make commitments, as models can now allow them to see how their contribution is of benefit. The outputs can now show that observations are in the right place for the desired results.
- BluePlanet would like to work with GOOS and better understand how to make early part of value chain more transparent as this helps users.
- A FOO 2.0 could outline how to get coordination providers to talk to one another – and then to end-users. If this is the case 2.0 is beyond GOOS, it involves all of the communities. This will have the added benefit of keeping GOOS from stretching too far. The system overall will work better if each component focuses on its strengths and avoids duplication.
- There is a need to address pressing societal climate needs beyond prediction to mitigation - it is critical to understand what can we do, what can now be done, and to quickly move along to next generation.
- As a data provider the EOVs are important. Yet, there is a concern is that not all communities agree, so it can on occasion be difficult to get and maintain broad agreement on what to observe. It would be helpful to know how these EOVs relate to the broader enterprise.
- Generally the community needs to determine whether to invest based on a variable based approach or a mission-based approach. The one that is adopted will have a lot to do with how much data from others you use.
- GOOS needs better linkages to the satellite world as this community has a reputation of delivering data that is operations ready (fit-for-purpose, high quality, used for operational uses as well as research).
- Important to understand and track the use of the data as this allows for incremental change that may not be highly innovative but facilitates the maturation of applications and uses, products, and services.
- BluePlanet has been focused on getting data providers in better contact with data users. It would be good to see GOOS interact more with CEOS (GCMS) on an institutional level. This could change the management paradigm at a higher level.
- The FOO helps with maturity (especially in the non-physics space) as once you get to the higher (3+) technology readiness levels you are now going from a science to an engineering challenge, this helps with the prioritization of goals.
- There is a need to institutionally recognize that research and development and science endeavors are not necessarily the same thing. Science has more operational requirements.
- Need an overarching framework that brings the stakeholders together to agree on a functional set of interfaces or ways of working together. This may site the need for an
IFOO (Integrated FOO) designed to take an all-encompassing or enterprise view across the value chain.

- The community needs help architecting a holistic approach. Generally, folks know what needs to be done but, struggle with how to do it. Today the visions of various groups are coming into focus but now they need coordination and collaboration.

**GM.1.4: There is a need for an observing system to be reviewed by engineering architects for overall system effectiveness. Such a review would distill what elements or practices can be replicated and which should be updated or eliminated. Similar reviews have been conducted at meteorological offices.** There are some architects working within the system today; getting a concerted handle on this would be a good goal for the decade.

- Ocean Obs ‘19 could launch an architectural review of effective interfaces and processes.

**GM.1.5: Need to better define role between GOOS and BluePlanet (among others).**

BluePlanet addressed the need to have a focus on the ocean within GEO, rather than as a consideration as part of other societal benefit areas. If GOOS continues to build its focus on the beginning elements of the value chain and providing products and services to internal users, BluePlanet can focus on building linkages to external users of data and providing input into the GOOS-led processes.

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**Supporting/Additional Comments:**

- Today BluePlanet is not as focused as GOOS in being involved with the observing system, it seeks to be positioned to help identify gaps and provide that feedback to GOOS. Ideally this will assist GOOS in better supporting observing system internal practitioners and ‘intermediate’ data users or managers which in turn can better focus on data discovery and delivery.

- Generally, the community needs to explore how GOOS can compliment and work in concert with BluePlanet and GODAE OceanView as this needs exploration – especially in the context of the value chain.

- Generally observations reflect too much a collection of individuals not groups which are challenged now to get to a more coordinated approach.

- GEO has many complementary initiatives to GOOS there is one beginning in the Atlantic, is this an opportunity for collaboration/linkage?

- BluePlanet determining what its role in Ocean Obs ‘19 will be. The group will seek to make sure the outcomes reflect its goals. Once the CWPs are released they will seek to drive user needs forward and be a match-maker among needs and resources.

- BluePlanet creating a CWP on stakeholder engagement and how to communicate science by looking at the virtual network of users and how to facilitate their interactivity.

- It may helpful to start going to user meetings vs asking them to come to observation meetings, recognizing this may be difficult but a good investment.
GM.1.6: Conduct a series of activities that consider and explore a ‘cross-walk’ of items of mutual concern to both GOOS and BluePlanet. This can help build on the direction that GOOS is taking and assist with how improved engagement with partners can facilitate its transition related to FOO practices and processes. Need to consider a ‘cross-walk’ of items between GOOS and BluePlanet. GOOS has a strong desire to understand what the scientific community and other users care about. The transition to a focus on EOVs is certainly the right track. Would like to see greater engagement in more partnerships – as it is not clear how to initiate this with GOOS.

Supporting/Additional Comments:
- BluePlanet does not want to get heavily involved in the observing system but to identify gaps and feed that back into GOOS. This would allow GOOS to support the intermediate users (within the system/immediate interface) that then provide products downstream (which is the focus of BluePlanet). Success here would demonstrate the critical role of GOOS to help with data discovery.
- There is confusion as to what the scope of GOOS is. Does JCOMM have an interest in integrating satellite and modeling as part of the system? GOOS is talking more about engaging with users. Do they see observations as their target community or does this also include the data analysis.

GM.1.7: May want to consider a basin scale governance structure. The use of a limited governance structure more readily ensures that the activities within a basin-scale system are fit-for-purpose. With working groups focused regionally it is plausible to generate observing plans that are better equipped to evaluate at what level data integration is needed. This also helps to match up the type of data and products being generated with what is being observed and identify any gaps. Taken further this helps identify what international projects give to nations and how this results in impact driven contributions.

GM.1.8: The role of an EOV in driving network requirements needs to be addressed and a mechanism for this type of review defined. The FOO will only work if scientists and decision makers are convinced of an EOV’s value; a governance entity review can help provide this justification.

GM.1.9: Governance needs to better consider a vertical vs. horizontal structure or set of interfaces. These should be designed to drive requirements throughout the system from EOVs, to networks and technologies, to data management. It may be helpful in the near-term to structure international meetings similar to the way the large networks convene, or to examine successful integration activities similar to the OCG.

Supporting/Additional Comments:
- An example is how OCG brings networks together to interact on technologies, requirements, data concerns (examples are Argo, GO-SHIP). This role as an integrator is the greatest value of the OCG at its core.
- Once national observing efforts (such as IOOS and IMOS) have better
GM.1.10: A heightened focus (traceability) is needed on societal issues and the information services and products addressed via observation platforms and technologies. This focus will require an ongoing assessment of variables in need of being globally sustained, yet still require improved measurement; this will help address coastal versus open ocean issues.
### GM.2 Resource Commit and Review Process

- **Description:** There is a need to establish a method of tracking commitments made by nations and groups regarding their observing goals and plans.
- **Background:** The GOOS is a voluntary system of partners that agree to participate in the system given the benefit provided to all through coordination and cooperation. It is important to track these commitments as their success and failure will have impact across the system.
- **Question:** Do you have input on what this process may entail and how it may be effectively managed? Are there existing groups that you think it beneficial to engage?

### Key Findings:

**GM.2.1:** It is critically important to have the ability to report on contributions. The idea of national commitment tracking is desirable and, in some instances, necessary for coordinating activities within nations. This type of activity facilitates more coordinated implementation and maintenance at the national level, helping to increase focus at regional/national/basin scales.

### Supporting/Additional Comments:

- IOC is the obvious way to do national commitment tracking and provide a link into Ocean Science Decade. All too often things get put in a spreadsheet but there is little-to-no follow-up.
  - An idea may be to have this be part of the large assembly, with groups saying what they plan to do — with sufficient follow-up so it is not meaningless.
  - Whatever the mechanism it needs to strike a balance of encouraging commitment and delivery yet not be perceived as too heavy-handed.
- There is a real need to encourage commitment at the national level. This would not only result in greater national coordination, but would greatly help with coordination and implementation at the regional or basin scale levels.
- This would also help to better understand funding environment, which is highly needed. However, whatever is in place will need to distinguish between a promise and a commitment. Promises are often more aspirational whereas commitment will be used to leverage the delivery and implementation of resources.
- There is a need for a feedback loop in GOOS where nations say what their needs are, then scientists respond, and during a review process an assessment is also made as to whether needs were met. BGC does some of this on global acidification scale, but not on a national level. This provides input to decision makers on the value of obtaining information on what is required but also how to manage resources. This could define a role for
GOOS in informing decisions, (while the coastal areas are not as linked to GOOS) the conventions do create some of what is needed for this linkage at the GOOS level.

- Regional Working Groups in their planning evaluate needs based on coverage. This dialog can be ‘rolled-up’ to achieved national agreements.
Use of the FOO for Fundraising

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<tr>
<th>GM.3</th>
<th>Use of the FOO for Fundraising</th>
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<tr>
<td>• Description: The processes of the Framework can provide assurances to potential funders that resources requested will be well vetted among scientific experts, implementation teams, and users.</td>
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<tr>
<td>• Background: There is a need for guidance on how to build an effective business case to demonstrate return on investment from ocean observing.</td>
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<td>• Question: What is required in an updated Framework document to help effectively articulate to potential funders the societal need and justification for observations?</td>
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Key Findings:

GM.3.1: Today FOO is not a strong fund raising tool, but it could be if used to help facilitate the creation of a better business case for observations. The FOO can naturally be used to fund raise as a brand; similar to the way some Projects/Programs create a brand. Over time funding managers seek to use their operational resources to help projects; moving from a science to an infrastructure focus can be a way to get funding as a methodology or best-practice branding tool with a strong science underpinning. The reliance on FOO processes and practices may allow funders to better understand how their contributions are predictably used to fill operational gaps and sustain innovation.

Supporting/Additional Comments:
• In some instances use of the FOO brand is used to demonstrate community scientific buy-in and can used by managers as funders trust the project overall is progressing in a way that will fill their gaps.
• Adherence to the FOO under the GOOS umbrella can be used to demonstrate observation utility as there is recognition that there is some level of agreement and provides confidence in the path forward within the international community.

GM.3.2: Moving away from an EOV or science focus creates a need for a greater focus on standards and best-practices, such as case studies of successful results based on previous requests for funding. There is a fundamental need to make this change when selling the need for observations to senior officials. Shifting focus to standards and Best Practices allows for a demonstration of value-added products and, as possible, the articulation of a cost-benefit analysis. The importance of return on investment needs to be recognized as it is very powerful when justifying ongoing investment. This analysis, however, often lags behind the time of the greatest need for observations. To help bridge this gap it may now be beneficial to engage/enjoin social scientists into the ongoing needs analysis and selling process.

Supporting/Additional Comments:
• FOO is not yet a tool for creating priorities, there is a need to get beyond the limitation of EOVs in prioritizing network design or the need to justify issues/science questions not EOVs. So FOO was helpful in defining what to
measure but not how this is helpful in understanding the heat budget, carbon budget, or fresh water flux.

- Community needs to address that often what is required is the need to observe a combination of EOVs in order to address science or societal needs. EOVs are not the target of observations, rather it is a combination of them, FOO may need to articulate a process or set of interfaces required in order to roll this up.

**GM.3.3:** There is a need to find a governance structure that understands the importance of the role played by managers of observing networks. Within mature projects or programs the task is to rethink the emphasis on the face-forward science aspect of activities and reorganize them by putting the articulation of science needs at a working group level. Annual meetings now bring heads of WGs together to discuss how to manage the system (or network) and to better or fill gaps and prioritize system innovation.

**GM.3.4:** Governments need to recognize that successful observation projects require more than the volunteering of expert time alone; asset development, deployment and maintenance are equally critical. Expert time and contributions need to be recognized as core to the business of an observing project and thus requires a major investment. However, to take advantage of this investment over time, projects are challenged to improve the efficiency, not the expansion, of the science contribution. This is important as it naturally becomes difficult to keep scientists engaged, and there may become an increasing number of reasons to collect data that are not contributing to the original core science of the project.

**Supporting/Additional Comments:**
- As is may become difficult over time to keep scientists engaged, and given funding realities there may become an increasing number of reasons to collect data (beyond the original scientific focus), there may be a need to make scientific engagement more efficient rather than expand its role.
- Need to find a way to better recognize and take advantage of national contributions. This becomes obvious in the biology realm as ecosystem observation are not articulated as national concerns – requirements are dictated regionally or locally.
- Basin scale coordination may also have merit.

**GM.3.5:** Projects and program managers within the observing system need to better recognize the value-added of the groups that implement the observing system; presently too much emphasis, or recognition, is given to scientific endeavors. This creates a policy gap; when recognition leading to funding is given to publications, which are focused on scientific pursuit not sufficiently on technology implementation and operational successes. As a result, managers are constantly placed in a fund raising cycle. Interfaces and processes are needed to help prioritize what has been- and has yet, to be funded along with how it addresses societal and science needs.
### Supporting/Additional Comments:

- Changes in internal GOOS issue tracking and community engagement may help in assisting with the entire funding cycle:
  - There is a need to ‘follow the money’ mechanisms are needed to better track information on who is funding what and why. In addition governance bodies need to assist in the process of tying observations to sponsors’ missions. This will have the added benefit of understanding better where funding liabilities exist and to which communities.
  - GOOS SC communication and panel output need more emphasis on science to societal links (feedback loops). This issue stems from how the current academic or intellectual approach or development and promotion of specifications makes broader community engagement difficult.
  - Consider tracking issues and progress in a vertical fashion (issue or phenomenon driven). As in order to better serve the community there is a need to connect science to society. A timely example would be to place a focus on the problem of pollution and societies custodial duties associated with this issue and how science through observations can assist.