DIALOGUES WITH INDUSTRY

Report out from Dialogue 1

Instrument Provision: Supply and Development of Sensors and Platforms

October 6, 2022

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Dialogue 1 Description

The first Dialogue brought together twenty-one participants representing key stakeholders from industry, government, and academia (see list of the participants in Appendix 1) to discuss opportunities and barriers to collaboration for instrument provision, covering the supply and development of sensors and platforms. In preparation, the participants were provided the Industry Dialogue Background Paper and the Use Case paper (Appendix 2).

The session was moderated by Chris Ostrander, Executive Director Marine Technology Society (MTS). The Use Case was divided into three sections: (1) Understanding, predicting and communicating the market needs; (2) Facilitating acquisition opportunities; and (3) Innovation investments and structures in place to meet the challenges of ocean services and climate change. Each section included a set of questions to help participants to prepare for the dialogue and which acted as a base for the discussions. The participants provided feedback from an operational, technical or policy perspective. The event was held on a non-attribution basis and this synthesis document is delivered correspondingly.

In addition, there were approximately seventy observers. Both participants and observers were able to engage in the dialogue. The first two hours were a facilitated discussion among participants with the observers providing input through the Q&A that were brought into discussion by the facilitator. The last thirty minutes were an open question and answer session among participants and observers.

This is the first of four dialogues. The key takeaways and potential paths forward provide a foundation for subsequent dialogues.

Key Takeaways from the Dialogue

- Governments and intergovernmental organizations (e.g., Global Ocean Observing System (GOOS)) have a key role in developing frameworks and setting standards

The lack of standards in both hardware and data protocols is a significant barrier to the growth of the ocean observing market. Intergovernmental programs such as GOOS could lead this discussion and work with member governments and industry to establish standards/best practices and/or request them within tenders. Frameworks such as Essential Ocean Variables (EOV) are important.

- Governments and intergovernmental organizations (e.g., GOOS) have a key role in providing collective information about requirements

Clearly defining observing needs (science, applications, decision tools) is a technology enabler. However, there needs to be early, on-going, and consistent communication between industry and the public and academic sectors to ensure a shared understanding of the requirements. Industry needs to have confidence in the scale of opportunity to justify investments in a particular technology path.

- Understanding and articulating the market size drives investment.

Start-ups articulated that market reports e.g., National Oceanic and Atmospheric Administration (NOAA) Ocean Observing Enterprise, are vital to convincing investors that the startup is addressing a real need/marketplace. There is a need for independent and credible market evaluations that address both the international scale of the ocean observing enterprise as well as the niche and smaller scale markets (i.e., uncrewed systems market). The ocean observing market is often framed in the context/in support of other market sectors (i.e., Blue Economy). The participants also brought up the question as to whether the ocean observing market can be a standalone market sector. Further a case should be made for restructuring funding for sustained observations; funding should be from a perspective of infrastructure, rather than being funded as a positive side effect of short-term research projects. There is a need to identify and discuss ‘market failure’ gaps in technology – what is the market just not prepared to engage in or failing to understand how to engage in and how can the public (government) sector engage.

- Early engagement with commercial partners is critical for transitioning innovation from the public and academic sectors.

Transitioning technology from a public or academic institution or start-up is complex and involves intellectual property protection, manufacturing considerations and sensor integration challenges. Early engagement is critical for creating shared expectations rather than waiting to engage once the technology reaches higher Technology Readiness Levels (TRL) and some market relevant decisions have already been taken that can limit or slow product development.

- Private companies have to make trade-offs between easy to use, affordable and high quality/precision in product development.

Product development will involve compromise along the common axes of easy to use, affordable and high precision on sensors and platforms, it is generally not possible to have all three.

- Easy to use instruments cost more to develop

Easy to use and affordable is often conflated with low development costs when industry experience shows the reverse is true. Easy to use technology requires longer development times and significant effort to build-in the operational intelligence required so that it is easy to use. This means higher cost to develop and higher risk. If the ocean observing community is interested in easy-to-use instrumentation, then industry will need some guarantee of market size or other methods to reduce investment risk.

- High potential for efficiency and cost savings in instrument and platform acquisition.

Procurements of ocean instrumentation are often single, short-term and piecemeal across many projects and programs even within a single institution. Greater harmonization at the institutional, national and intergovernmental level can increase the efficiency of procurement and create less administrative burden on industry and institutions. Industry would be able to pass this increased efficiency along in reduced costs, and would enable industry to better plan and provide lower costs, improved service, and greater investment commitment to the ocean observing market.

- Building and retaining the workforce is a major challenge.

The ocean observing enterprise is competing with other sectors that are likely to pay more, especially for software engineers and programmers, however there is interest and other rewards for working in this sector. There s a need to articulate that (1) successful oceanographic-based careers are within reach; (2) this career path is challenging and has real impact on humanity; and (3) is global. The workforce opportunities in the ocean observing enterprise are interdisciplinary and are needed along the spectrum of education levels. Need to expand outreach to non-coastal regions, as engineering disciplines employed in ocean sciences seldom are used just in ocean sciences (e.g., mechanical engineering, software engineering, etc.)

- Opportunity for a new paradigm of data as a service and missions as a service.

This concept, while new to the in-situ ocean observing community, has been adopted in the space (remote sensing) sector. While licensing and data validation/quality assurance are issues that need to be resolved, this business model can alleviate some acquisition, operation and maintenance costs. There is more discussion needed about how the ocean observing enterprise can apply the lessons learned from the space sector to speed up this paradigm shift.

- Appetite for sustained engagement.

There was support to further examine how to improve, increase, and sustain discussions among stakeholders in the ocean observing enterprise, especially among funders and industry, on product development, market opportunities, and standards etc. Many players have been in the market for decades and have a strong commitment to investing time towards improving the market conditions. Considering potential opportunities for doing large-scale international projects to spur innovation was an additional approach discussed. Evaluate "piggy back testing," by looking for opportunities to test new sensors on a not to interfere basis to existing observing platforms (ships/gliders/moorings etc.) missions.

Dialogue Purpose

MTS, GOOS, NOAA, and industry partners have identified a significant need to improve and expand communication if we are to collectively face the demand for a resilient, and responsive global ocean observing, forecasting and information delivery system.

To date, the ocean observing enterprise has been a largely research focused effort driven by government investments, which has created a highly fragmented value chain. Increasing societal demands for ocean data for climate adaptation and mitigation, to sustainably manage ocean resources, and improve the forecast of extreme events to reduce loss of life and property, requires a more rapid expansion of the ocean observing enterprise. However, the immaturity of the market significantly inhibits the speed and efficiency of system development.

New commercial ocean observing services are finding opportunities to exploit, yet it remains unclear as to how these will interact with the established global and national observing operations, as coordinated under the GOOS. The observing system will continue to need new technology, but there remains no established way to fast track promising technology candidates into existing systems.

GOOS, MTS, NOAA, together with industry have co-designed these fora for compact and meaningful dialogues with new and established companies, academia, and government to dismantle barriers and highlight opportunities towards achieving a mature and vibrant Ocean Observing Enterprise, through a successful and thriving mix of the public and private technologies and players. Working together will solve problems... faster.

Discussion Synthesis

Section 1: Understanding, Predicting and Communicating the Market Needs

The first session of the exercise focused on understanding, predicting and communicating sensor and instrument market needs. GOOS has grown rapidly and stands to continue exponential growth for years to come. A deeper connection is needed between the public and private sectors to support further maturation of both observing systems and the sensor and instrument market that supports them.

Market Drivers

The increase in public awareness of the importance of the ocean and the seriousness of climate disruption are the highest-level drivers of market growth. The need for sustainable economic growth was also indicated as a significant market driver, especially in the Blue Economy, and finally new technology was also indicated as a driver of the growth on the ocean observing market.

While industry is seeing an increased investment from the private sector in ocean instrumentation, public sector funding still represents a significant portion of investment and there are large contrasts in spending increases in the public sector. For example, the Chinese government is investing heavily in ocean observing instrumentation, but the United States government agency budgets are remaining level at best. Further, it was noted that funding at levels necessary to observe the EOVs at the required spatial or temporal scales does not exist. In addition, it was noted that while funding for capital expenditures is more readily available, that longer term operational funding is not, and that this impacts how industry is able to interact and support the public sector.

The panelists asked, under the New Blue Economy, where the currency is the ocean information, if there was a stand-alone market for an ocean observing sector? As long as sensors/instruments/platforms etc. are built to serve several Blue Economy markets (and not just ocean observing market), it's difficult to optimize them for the ocean observing needs. Several companies stated that they have to identify additional fields of applications beyond ocean observing to develop instruments and run a viable business, and that this is one of the major impacts on the caliber of the instruments for the purpose of ocean observing. Hence it would be a great exercise to identify how large the ocean observing market could become and how this relates to the other markets the manufacturers serve in parallel (e.g. waste water, inland water, fishery, etc.). This topic was not discussed fully in the first dialogue, but is an interesting topic to investigate in subsequent dialogues.

An additional market driver raised by observers is the push for net zero targets. There is increasing demand for and investment in carbon dioxide removal research, but there is a gap in available funding for measuring, reporting and verification (MRV) instruments. The participants would like further dialogue on developing models to further MRV funding.

Market Identification and Impacts

On the demand side, the ocean observing market comprises many niche markets that make it difficult for industry to determine where the potential is for growth and scaling. There is also a lack of credible information about the overall international ocean observing market The majority of information is in reports quantifying subsets of the market, such as surface vehicles, gliders, floats. For start-up companies seeking outside investors, there is a need for authoritative market reports, and these companies look to governments, intergovernmental programs and other international entities to provide those reports. It would be useful if the government and industry sectors agreed on what type of information should be analyzed, to what granularity, and for what time frames. The information could be collected and reported in a way that is helpful to companies and their business activity planning.

For small companies, the participants suggested there could be benefits to establishing consolidated locations to discover opportunities to work with GOOS. Smaller companies have much more difficulty identifying what are ocean observing opportunities, vs. one off projects. There is a need to strengthen the management of market opportunities information and bring more structure to procurement.

On the supply side, there is a strong push for low cost, high quality and easy to use sensors. While there are market opportunities to provide cheaper modular technologies that can be bought, deployed and used by more people (i.e., move away from highly customized, highly specific equipment), this should not be conflated with low development costs. Developing easy to use instruments requires longer development cycles and more complexity in the design process, it is a bigger risk development. For industry to develop easy to use technology at reasonable cost, there needs to be an assurance of high volume, to reduce the risk. It is very difficult to take the leap of faith to invest in long and complex development cycles without some level of surety of the market. It was acknowledged that there will still be a need for highly customized and specific instruments will continue for certain applications. There needs to be an investment in flexible, modular technology in order to meet these needs, as well as be able to quickly utilize new technology such as new sensors, or sampling algorithms. Developing modular systems also requires up-front investments. For industry to make these investments, we need to see a commitment for future purchases. There is a need to move towards a longer horizon, away from “one-of” projects.

From the governmental perspective, it is hard to understand the pace of technology development and it is a challenge to take advantage of the new technologies when they are also seeking funding to field systems on a sustained basis. This points to the need for multiple funding streams that can support both innovative and sustained observations. This point is discussed further below in Section 2.

Requirements and Standards

Industry is looking to the intergovernmental programs to set standards, define requirements and increase/facilitate communication between researchers and industry. This can increase confidence that the product developed will be readily usable/accepted, and that there are opportunities then to exceed these thresholds. Shifting the ocean observing enterprise from niche to norm will require a shift in focus to instruments that are interoperable and standardized like other easy to operate, plug and play systems.

It is critical that standards are global and consensus within each of the observing networks about the accuracy and stability requirements, and the parameters of their missions would be helpful. The current lack of standards leads to higher cost sensors because the companies cannot realize economies of scale. The more consistency and the more coordination within the scientific community on what the need is, the better the private sector can deliver at a lower cost. Industry can develop and incorporate technologies faster by reducing the number of variables. In order to realize these global standards more discussion is needed about (1) who is the authority for the standards (consider the Intergovernmental Oceanographic Commission (IOC) UNESCO Oceans Best Practices System), (2) how is the community motivated or incentivized to incorporate these standards, and (3) specifically, what standards are needed? The Biogeochemical (BGC) Argo program was noted as a good example for how global standards supported product development.

Industry representatives indicated that the needs of emerging science provide great opportunity for innovation and they want to hear from the national agencies and intergovernmental programs early and often on these emerging needs - together with aspired unit numbers and time horizons for the related products. Industry commented that they have enquiries for many great technology projects, but understanding which ones will have the customers/stakeholders to support a future for the technology is critical to know before they can comfortably invest. Additionally, industry also needs insight on what are the differentiators that would drive purchasing decisions? Is it the time it takes to fulfill new development? Cost? Staff expertise? Or having a reliable, customized/optimized observing platform for deploying the technology? For example: Autonomous Underwater Vehicles (AUV) optimized for sampling Arctic/sub ice regions vs. deep sea canyons, capable of long missions, etc. My company focuses on animal-borne sensors, which requires customized platforms for suitable species. Having sensor and data interoperability standards lets our engineering team focus on our differentiator- platform type.

Section 2: Facilitating Acquisition Opportunities

The second session focused on facilitating acquisition opportunities and understanding the challenges presented by the fractured landscape of buyers and public sector purchasing constraints at all points in the value chain.

Economies of Scale

Several factors were discussed with respect to achieving economies of scale. The first one being volume. Volume thresholds that are high enough to benefit suppliers reduce the costs of development. Another important area is the number of customers you are working with. Currently multiple small purchases are a factor in higher costs. Organizations can see efficiencies if they consolidate their procurement, so industry has fewer transactions, tech support needs, and shipment locations. Additionally, there is a need for consistent and standard terms for things like warranty or ongoing support and service agreements. Negotiating each of these multiple times has a cost, which is reflected in the price of instruments and services. For ocean observing, the sensor manufacturer is not always the same as the platform developer/vendor, so organizations/programs can see additional potential efficiencies for governments in purchasing or setting a single agreed-upon sensor package to offer to the platform manufacturer for standardized and commercial integration.

There is a clear opportunity for government programs to see efficiencies when they holistically view procurement and data collection for platforms that provide services with multiple sensors. At a practical level, in the un-crewed market, mission duration is a factor. In general, longer missions are more cost effective than shorter missions.

For smaller companies, the type of contract can also be important, for the same overall price a longer guaranteed revenue stream can be more important, than a single large purchase; the investment justification can be more strongly made if there are ongoing purchases.

Further, there must be recognition that in some areas of the observing the industry is different when compared to consumer-based products. The volume thresholds are different between companies. It was stated that seldom have the companies attained economies of scale due to lower component costs because the volume is just not that high. As a result, there are challenges procuring components because the volume is so low. Similarly, the low volumes are a barrier to higher levels of automation.

The participants suggested citizen engagement as a driver for low cost, smaller scale systems and vice versa. The example of low-cost weather stations was used: low-cost weather stations carved out a large market for private weather stations and the accompanying data sharing platforms. Demand for small scale, lower priced ocean observing instruments could likewise increase citizen science engagement in ocean observing programs and enable more data access for blue economy companies.

The participants, while appreciating that acquisition processes must conform to agency/institutions, they are difficult to navigate and would like to see procurement strategies aligned with the suppliers. While the participants did not think that larger multi-agency procurement was possible at this time, examples already exist within the space (remote sensing) market where this has been a success. In addition, the G7 has taken up the topic of sustained ocean observing and under the Future of the Seas and Oceans Initiative and there is an effort for the G7 governments to work together to strengthen and sustain observing systems. To date, there is agreement that Biogeochemical Argo is a priority for coordinated investment.

Funding

Purchasing patterns generally reflect funding patterns, however there has not been much discussion about what this means in terms of supply costs and lost opportunity. Purchasing across the ocean observing enterprise remains fractured, and a conversation about the implications of this must continue, and focus on how we sustain observing systems as an infrastructure. The level of sustainability of observing infrastructure varies around the world, however in Australia (Integrate Marine Observing System (IMOS)) and the United States, (Integrated Ocean Observing System (IOOS) and NOAA's Global Ocean Monitoring and Observing Program) are examples where longer term and relatively stable budgets exist, although not at the level or through structures to enable the required partnerships, data delivery to users, etc. There are some examples of programs who have developed leveraged funding models. For example, IMOS operates under some co-invest models that result in around a doubling of total national investment, but this is not a universal practice. Argo was identified as an international funding model and BGC Argo was endorsed by the G7. This endorsement enabled some countries, e.g., United States, Australia and France to provide sustained funding. However, this also is not universal as other countries, e.g., United Kingdom, are only able to participate ad hoc and on a project -to-project basis.

There remains a tension around funding for new technology innovation and investment in mature technologies. While there are small efforts to invest in innovation in some of the national observing systems, they should be coordinated at the national or intergovernmental levels and focused towards areas of high need for sustained observing. There was some discussion about where innovation funding does and could come from. In some countries it is primarily from national agencies and while in other countries taxes on other sectors and on industry are invested in science and technology, one clear example is Brazil that has a small portion of the tax on the oil and gas industry that is earmarked for ocean science and technology, this has supported a number of start-ups. There is also growing investment by the philanthropic community in ocean observing technology. Identification of markets and needs is important to drive philanthropic investment, assurance that, “this is a technology that's needed,” it is a powerful statement to take to their boards.

Data/Missions as a Service

Increasingly companies are offering data and or missions as services. This represents a new way of doing business. Company-owned, company-operated mission partnerships with customers, where the platform, sensors, data and the mission are treated as a commodity, has the potential to avoid acquisition, operation and maintenance costs. Further there are potential human resource savings; instead of agencies using personnel to deploy and maintain equipment they can focus on translating the data into applications and decision support tools.

There are however trade-offs to consider when shifting to the commercial sector as the primary provider of data, mission, and technology solutions, such as when an agency or intergovernmental program has a number of requirements that cannot be met in total by commercially available provision or that are not cost effective. Having requirements more clearly defined by both the government and industry could help to minimize the tradeoffs.

There was also discussion about the quality, verification, right to use, and longevity of the data. Questions were raised about 1) how the government sector ensures the data is of sufficient quality (if missing raw and metadata), and 2) how industry proves that they are meeting the required quality (if provided by a single source)? This could require field validation against standards, which currently don't exist for all sensors. In the area of sufficient quality, IMOS, for example, requires operators to provide documentation on all protocols used in the collection of observations and data. All operations must be conducted using nationally standardized protocols that are recognized as international best practice and are registered with the Oceans Best Practices System. Other concerns include the likelihood of interrupted observations from the commercial sector, and limited data access for publishing especially relevant for international observing networks. Collectively, the government and industry should define standards, including "test data sets" and the test specifications that industry must follow.

Section 3: Innovation Investments and Structures to Meet the Challenges of Market Growth

Several observing projects involve collaborative efforts between government, academia and industry for the purposes of the development of technologies, the demonstration of concepts, and the execution of pilot projects. The landscape varies with which sectors are responsible for funding research and development, training next generation workers, and developing the next generation of commercial technologies. Understanding the present-day constraints on these types of collaborations can help us to unlock any best practice for future modes of operation across all of our sectors

Trusted Partnering

The ocean observing companies are here for the long-term and working closely with the procuring partners allows for more stability. But there needs to be open and trusted communications to avoid issues such as over-design, which can render a product too expensive for the need. Similarly, for transitioning new technology, there was a clear consensus that early partnering and collaboration was critical to developing fit for purpose new technology. The transition of technologies from research institutions, innovators to companies is difficult. Transition is costly and complex on many levels, including the protection of intellectual property, the understanding of commercial viability, and the ability to scale up manufacturing.

If an entity spends years developing a technology and then seeks to commercialize it, it might be too late, and they may find out that they had unrealistic expectations of their returns. Early communication is critical for a company to develop realistic expectations, reasonable plans for commercialization, and secure budgets.

Risk

Risk is a large cost driver. For example, if an agency expected a warranty that an ocean observing platform (i.e., uncrewed vehicle) will never be involved in a collision with a vessel, that will be costly. In several cases the platform builder is not the sensor builder. If an agency expects the platform holder to warranty a sensor produced by another vendor, this also increases the cost. In many instances the sensors are more costly than the platform as the platform vendor does not receive a discounted price for the sensor. If the government can procure or negotiate a bulk purchase of those sensors this could drive down costs. Alternatively, the governments /intergovernmental programs could consider universal insurance funds to reduce the risk and costs.

Risk can be somewhat mitigated by risk-sharing. This can be done by establishing formalized, longer-term relationships and coming to agreement on where the risks sit and where the parties can provide support to reduce risk for everyone. Government and industry should share not only by financial means and agreements, but also with their commitment to adapt the new technologies in order to ensure the long-term success of the products.

Work Force

This community needs a diverse pool of talent that can translate their skills to produce instruments and platforms that can operate in the harsh ocean environment. This community is competing for talent and has the additional constraint that salaries are not at the level of other sectors. Further we need a workforce that spans skill levels from technician to PhD scientists. As the Blue Economy develops, there is an opportunity to build a more diverse workforce. The challenge is working together to communicate and generate excitement about having an ocean-based career regardless of your discipline, e.g., engineering, software programming or robotics. There are potentially appealing aspects about the social impacts of an ocean-based career and the opportunity to work on complex issues and travel. For example, IMOS can assist to communicate these stories. IMOS routinely tracks and reports on the impact and societal benefit that comes from their observations with metrics developed through their impact database.

Outreach programs need to broaden and include partnerships with community colleges, the development of feeder programs, and outreach to create awareness. The focus needs to be on all aspects of ocean observing operations, including, field work, program management, policy management, data and information services, and of course engineering and the higher education arena.

This needs to be a partnership between industry and academia where careers in industry are viewed on par with careers in research. Many of the dialogue participants encouraged the development of a “passion” for ocean observing and career paths in today’s younger generation and early career professionals. Some suggestions are to offer guest lecturers and to open more avenues for internships as well as considering topics such as entrepreneurship as courses within science studies. Also, while there is opportunity to move up the ladder at the mid-career level, there are challenges in moving to or from oceanography and technology careers.

The first hurdle is that ocean observing jobs are often the best jobs you’ve never heard of. There is more discussion needed on how the market can support and advocate for the addition of ocean observing degree concentrations and certifications/credentialing at all levels of technical, college and university studies.

To promote awareness and to help develop these kinds of programs and syllabi at all education levels, academia first needs to know what ocean observing end users need. The participants would like to see governments encourage and support more academia-industry joint projects. Projects like these will provide a direct link from industry not only to academic programs, but to ocean observations research and development.

Advertising was also identified as a challenge. It should be noted that while companies are finding it difficult to recruit and retain a strong workforce, it was also suggested that ocean observing job seekers are also finding it difficult to locate jobs. Why are they missing each other? Standard search terms for recruitment sites would help to capture ocean observing jobs in a user’s search results. There is a need to explore better ways to advertise and search for open positions. This includes reaching out to non-coastal regions.

Potential Pathways Forward

While the next three Dialogues with Industry will refine and develop the issues and ideas across the value chain from ocean observation to service delivery, this will be synthesized through a final summary paper for the series, with a concise set of practical and implementable recommendations. Below is an initial take on the key issues and potential pathways forward drawn from the first exercise.

- Continue to enhance and publicize Market Reports

GOOS could undertake the development of a repository of the existing Ocean Observing Enterprise/market reports to make these existing documents accessible. Additional market reports could be encouraged, through sharing methodology. This would also enable an ongoing and increasingly sophisticated assessment of the existing landscape to understand where there are gaps and how to more effectively communicate market opportunities.

- Conduct a Market Needs Assessment

Conducting and analysis and/or having a facilitated conversation about what specific market information would be most useful to the commercial sector is a potential first step towards providing more market foresight. One method could be to develop a small set of market studies, coordinated by GOOS, working with other organizations such as Organization for Economic Co-operation and Development (OECD) and the Group on Earth Observations (GEO)-Value community activity. However, a clear understanding of what market information would be a minimum to support investment is the prerequisite. Ultimately, a global market (potential) assessment broken down by EOV and deployment mode/platform would allow for private sector focus and investment, also helping with the identification of which sensor/instrument/platform will create a market. This however would require a systemic change towards ocean observing integration, tradeoffs, and sustained funding models. It could require a shift in thinking of observations for scientific purpose to identifying ocean observing as critical infrastructure. Seeking a model for this work from other sectors should be undertaken and the model/s assessed for fit.

- Determine a way forward for developing global standards/best practices

GOOS and/or individual observing networks could develop a decision framework for establishing global standards. There are current efforts underway such as the World Meteorological Organization (WMO) Global Basic Observing Network that could help to inform this process and avoiding duplication of efforts is important. Here, using models from other sectors could be useful, in setting up an efficient, practical, inclusive and sustainable mechanism. Identifying a small number of standards that would significantly advance the community, as a starting point would be useful. Working with appropriate bodies such as MTS, IEEE/Oceanic Engineering Society (OES), GOOS, Open Geospatial Consortium (OGC), etc. on pilots could develop these standards. Would the IOC UNESCO Oceans Best Practices System be where these standards could be managed and maintained? Standards require stronger governance and transparency which might also require a framework of market regulators.

- Communicate on the impact of unstained funding on the cost of ocean observing

Create a discussion piece on the potential cost to society of continual short-term thinking about key social infrastructure.

- Identify and implement a technology innovation project(s)

Identify and sponsor a pilot project that would highlight solving new technologies that represent a multi-sectoral (i.e., public, private, academic) ocean observing architecture ('packaging of solutions') to solve a problem/ocean observing system gap. Definition of such a project could be on done in consultation with the Ocean Decade's approved projects (e.g., Marine Life 2030) and industry. The project could be focused on future markets and provide a blueprint for achieving a multi-sectoral observing architecture, through collaborative assessment and mixed public and commercial sector investment, development, and testing.

- Create an Industry Technology Forum

Emulate WMO's industry technology forum under the IOC/GOOS and other relevant organizations such as MTS. This forum could focus on developing a market place and advance the community. To be successful with this will require industry engagement as well as a further advanced international ocean observing community alignment.

- Develop a needs assessment and communications plan for expanding the talent pool for ocean observing workforce

Work with existing ocean literacy efforts to highlight the specifics of our needs, can existing work be expanded to develop this, such as IOC Ocean literacy, which has an education focus. Conduct an evaluation of current internship, fellowship, post-doc programs and technical programs/certification to determine if there are opportunities for having ocean observing specific foci. Consider developing industry-university partnerships to create opportunities for students to create majors and step into careers in the ocean observing enterprise. Identify opportunities for increasing the communication of job opportunities and/or for raising awareness of the career potential. Work with MTS, GOOS, Partnership for the Observation of the Global Ocean (POGO) members and national agencies to advocate for ocean careers.

Appendix 1: Participants

Sector	Affiliation	Name
Public/Australia	Integrated Marine Ocean Observing System (IMOS)	Paul Van Ruth
Public/Germany	GEOMAR Helmholtz Centre for Ocean Research Kiel (GEOMAR)	Toste Tanhua
Public/UK	Natural Environment Research Council	Leigh Storey
Public/UK	UK G7 Marine Science Coordinator	Katy Hill
Public/USA	National Oceanic and Atmospheric Administration (NOAA); US Integrated Ocean Observing System	Carl Gouldman
Intergovernmental	National Oceanic and Atmospheric Administration (NOAA), representing Global Ocean Observing System (GOOS)- Observation Coordination Group	David Legler
Intergovernmental Academia	Argo/Scripps Institute of Oceanography	Nathalie Zilberman
Industry	Blue Robotics	Rusty Jehangir
Industry	Kongsberg Maritime	Peer Fietzek
Industry	MRV Systems	Beth Curry
Industry	Nortek	David Velasco
Industry	Ocean Aero, Inc	Andrew Ziegwied
Industry	RDSEA International	Rick Cole
Industry	Saildrone	Matt Womble
Industry	Sea-Bird Scientific	Rob Ellison
Industry	Seatrec	Yi Chao
Industry	Sofar Ocean Technologies	Duncan Mactavish
Industry	Sonardyne International	Graham Brown
Industry	Teledyne Technologies	Clara Hulburt
Industry	Wildlife Computers	Melinda Holland
NGO	Schmidt Ocean Institute	Mark Schrope

Appendix 2: Use Case

Dialogue 1 | Instrument Provision: Supply and Development of Sensors and Platforms

Background and scope

Increasing societal demands to solve our planet's greatest challenges, such as climate change, means that the need for ocean data has never been greater and we propose that these needs can be met by a rapid expansion of the ocean observing platforms and sensors. Ocean observing is still based on carbon- and cost-intensive methods e.g., manual sampling, while key variables to monitor ocean heath and biodiversity remain critically under-sampled.

Currently, the immaturity of ocean observing as a market significantly inhibits, among others, system development and efficiency, market growth, new technologies' speed to market, economies of scale, and cost and range of service delivery. Working with the private sector, GOOS and MTS would like to co-develop practical steps to greater market maturity, which will benefit companies, governments and ultimately society.

Section I – Understanding, Predicting and Communicating the Market Needs

The global ocean observing system has grown rapidly and stands to continue exponential growth for years to come. A deeper connection is needed between the public and private sectors to support further maturation of both the observing systems and the sensor and instrument market that supports them. The private sector needs to understand what the government and academic funders of observing systems want and will purchase in order to meet stakeholder needs for data and information. The public sector needs to better understand how industry determines future technology development and service requirements, what investments industry is prepared to make to grow the marketplace, and how best to inform the development of new technologies. Both sectors stand to benefit from an understanding of roles and where the line between public and private responsibility sits.

DIALOGUES WITH INDUSTRY

The GOOS system consists of national and regional networks that are largely funded by national agencies and largely have been developed through research partnerships and operated by national/government entities. A number of these large-scale observing networks began as research infrastructures but are also being used in daily decision making. The landscape is changing in the following ways: (1) funding by governments for sustained ocean observing is level in many areas and not keeping up with the demand, (2) there is a growing commercial sector that is providing ocean instrumentation, (3) there is a growing philanthropic and private sector community applying funding in the Blue Economy, and (4) there is a greater mandate by shareholders that companies incorporate environmental sustainability goals. The established government and research-based ocean observing programs could view the commercial sector as competitors. Further integrating commercial technology should be iterative and a journey rather than a transactional effort. Understanding how the private sector is determining its requirements and the connection to the communication of these requirements by national agencies is a key component of maturing the market. The corollary is that the private sector also needs to understand what the observing systems want and/or will employ in order to be able to deliver highly suitable solutions. There is also discussion regarding clearer roles and responsibilities between the public and private sector and an opportunity to have a conversation about where the line between public and private sits.

Discussion Topics

- Generally speaking, what economic forces do you see that are growing the sensor and platform markets?

- For our industry partners, what shortcomings do you see (if any) in the marine sensor and platform market? Are there any issues related to market size (i.e., how many gliders will a nation or observing system realistically buy?) Is the potential end-user market for some highly specialized sensors and platforms too narrow to generate the revenue needed to enter?

- What market opportunities do you see that are provided by developing cheaper modular technologies that can be bought, deployed, and used by more people, by a broader swath of the public to capture information, as opposed to maybe more highly customized, highly specified equipment that has a narrow market use?

- There are several programs, projects, networks that are generating requirements for new sensors and instruments - how could they be better captured from a global perspective/how could this information be made more easily available to industry?
    a. Should there be an international effort that captures these forward-looking requirements in a way that can be translated to public and private production? How could this be achieved?
    b. How can the ocean observing requirements information (e.g., observation/variable needs, accuracy, data standards and formats, geographic gaps etc.) be articulated to give greater clarity to the market for innovation?
    c. How do other sectors do this? Is there a good example from the meteorological community, hydrological community, other communities outside of environmental communities?

- What are the barriers that national (government) agencies have in communicating requirements for sensors and instruments? How can these barriers be overcome?

- Where does the balance lie between the private and public sectors in driving the market requirements? Which functions are "inherently governmental" and which should be left to the private sector?
    a. What fora are appropriate for establishing and discussing guard rails on roles and responsibilities?

- How do we better understand the new downstream services that will be driving sensor innovation – horizon scanning for new technology needs?
    a. How does this connect to the industry and public sector?
    b. How do other sectors do this, is there a good example, e.g., meteorological community?

- Capturing and communicating requirements is one aspect of industry assessment of the marketplace. Once an asset has entered the market, customer feedback on performance, reliability, and accuracy are essential to manage the product lifecycle. For our industry participants, do existing forums and feedback mechanisms ensure useful feedback is received from implementers? For our non-industry participants, is providing regular feedback to vendors part of your standard of operations?

- Are there any issues related to market size? For example, how many gliders will a nation or a GOOS Regional Alliance (GRA) buy? Is the potential end-user market too limited (i.e. not enough profit) to fully drive some of the outcomes we are seeking? The more specialized the platform, the narrower the potential market.

- Are there technical issues that are preventing commercial scalability e.g., standardized connections, cables etc. If so, what, where, and how do we evolve global standards?

- How does the private sector determine marketing strategies/requirements for commercial customers? Is this different from determining market strategies/requirements for the public sector?

Section II - Facilitating Acquisition Opportunities

Varying forms of regulations apply to public and private sector purchasing around the world. Intellectual Property and copyright laws, a fractured landscape of buyers, and public sector purchasing constraints affect the sale and use of products and services at all points of the value chain. Are there ways in which collectively the community can work together to streamline and revolutionize the acquisition of marine technologies?

Discussion Topics

- Observing system procurement is largely national or regional in scope, providing a complicated and inefficient landscape for vendors to navigate. What international coordination is needed to establish economies of scale?

- As the community contemplates growth in observing system infrastructure, how do we balance the reality that technologies can be procured both from a commercial vendor, built/developed by a national lab or academic research facility, or ownership can be bypassed using a mission/data as a service procurement?
    a. How do we delineate these boundaries and lay out guiding principles of engagement?

- How do supply chain vulnerabilities (particularly wrt limited flexibility and suppliers) and requirements for system resilience affect the adoption of new technology, and the recapitalization of existing assets?

- How can industry and government/public partnerships grow the market together – e.g. lower cost technology can open markets, make new observations viable?
    a. Are there examples from other sectors that we can identify to understand what made them successful and how the marine sector can employ these mechanisms?

- How does supply chain vulnerabilities (limited flexibility and suppliers) and system resilience affect the purchase of technology?

Section III - Innovation Investments and Structures to Meet the Challenges of Market Growth

Several observing projects include collaboration between government, academic, and industry for the development of technology, demonstration of concepts, and execution of pilot projects. The landscape is varied, however, on which sectors are responsible for funding R&D, training the next generation of technical workers, and developing the next generation of technologies that will be commercialized. Understanding present-day constraints can help to unlock future modes of operating across the industry, government, and academic sectors. Understanding the present-day constraints in this space can help us to unlock future modes of operating across all of our sectors. So exponential growth in observing system assets is going to require a corresponding growth in the human capital that's required to create, to operate and to maintain the technologies we need in the future.

Discussion Topics

- For a company, choosing to pursue internal technology development versus in-licensing known assets from another venture in part, comes down to an assessment of risk tolerance that a technology will be both functional and, from a patent standpoint, protectable. Is there opportunity for partnership between government, research organizations, and industry that evenly distributes risk and reward in the development of new technologies? Are there exemplar models that work from other sectors?

- Exponential growth in observing system assets will require a corresponding growth in human capital to create, operate, and maintain the technology that will be needed in the future. How do we hire and train the necessary talent we need to enable the technology to operate (and survive) in the ocean? How do we compete against established industry players in other sectors, particularly for software, mechanical, and electrical engineers, that also need this type of talent.

- R&D investment is essential to mature the technological landscape in which we operate. For our sensor and instrument company partners on the call today, you can invest in R&D directly (either inside the company or under contract to an academic institution) and you can look to the academic sector, under funding from a government source, to develop technologies you can then in-license. Can you speak to why your company has taken one of those approaches, or a different one to generate new technologies?

- Is there potential for industry to be embedded with government agencies/observing programs or academic research institutes (or vice versa) to help facilitate and accelerate the development, testing, and adoption of new technologies?

- How can we identify opportunities to fast-track promising technology in an efficient and standardized way - interface between the innovation and mature market?

Q&A Session

- How do we tackle the issues raised today that limit innovation and at-scale adoption of new technologies (e.g., connectors, requirements, well-defined EOVs, global standards, etc.)? Appetite for global ocean observing technology forum to collectively address these issues?

Appendix 3: Planning Team

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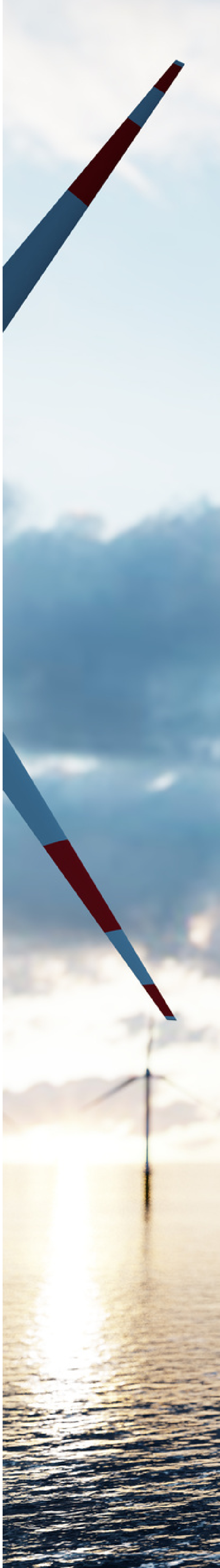
Intergovernmental	GOOS	Laura Stukonyte
Industry	Kongsberg Maritime	Peer Fietzek
Industry/NGO	L3 Harris/MTS	Donna Kocak
NGO	IMOS	Michael Heupel
NGO	MTS – India	R. Venkatasen
NGO	MTS	Chris Ostrander
NGO	MTS	Monica Ostrander
NGO	MTS	Zdenka Willis
NGO	Society for Underwater Technology (SUT)	Ralph Rayner

The Global Ocean Observing System

marine technology SOCIETY

2021 2030 United Nations Decade of Ocean Science for Sustainable Development



DIALOGUES WITH INDUSTRY

Report out from Dialogue 1

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