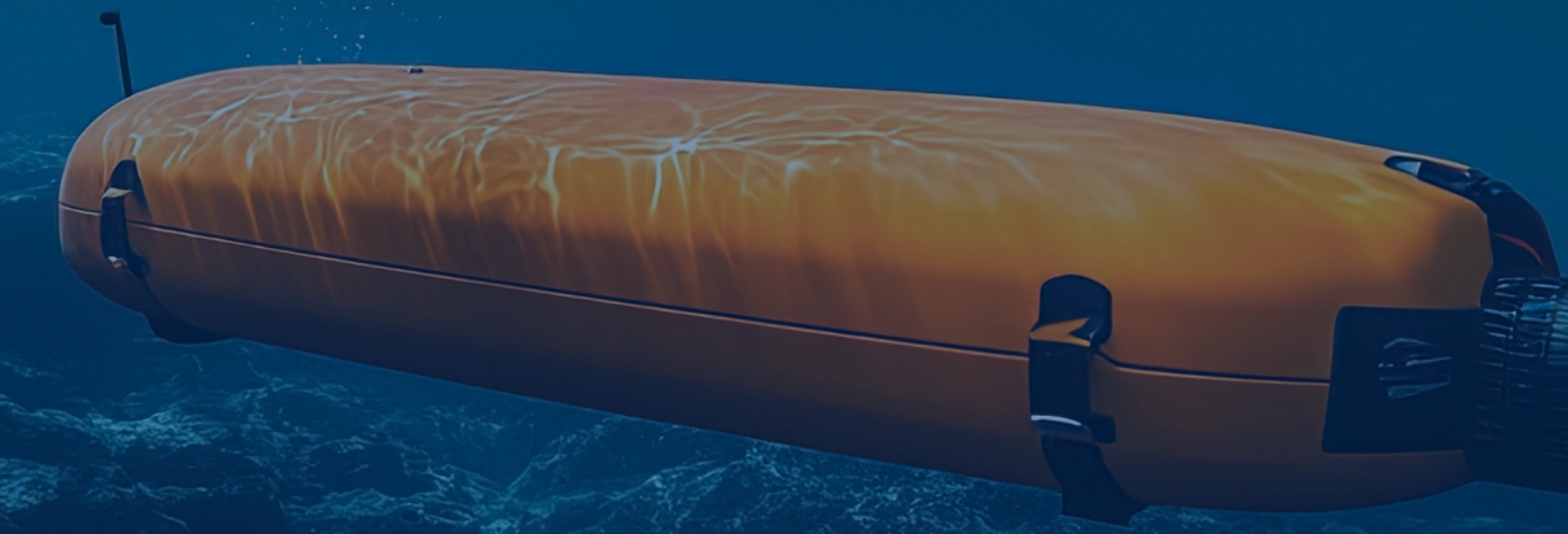
OCEAN ENTERPRISE INITIATIVE

Dialogues with Industry

Ocean Observing of the Future:
Summary Report



MTS marine technology society
Opportunity runs deep™

Global Ocean Observing System

NOAA

IOOS Integrated Ocean Observing System

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Executive Summary

The Marine Technology Society (MTS), Global Ocean Observing System (GOOS), National Oceanic and Atmospheric Administration (NOAA), United States Integrated Ocean Observing System (IOOS), and Industry (Kongsberg Discovery and L3Harris), lead the Ocean Enterprise Initiative, which focuses on understanding how to mature the Ocean Enterprise.

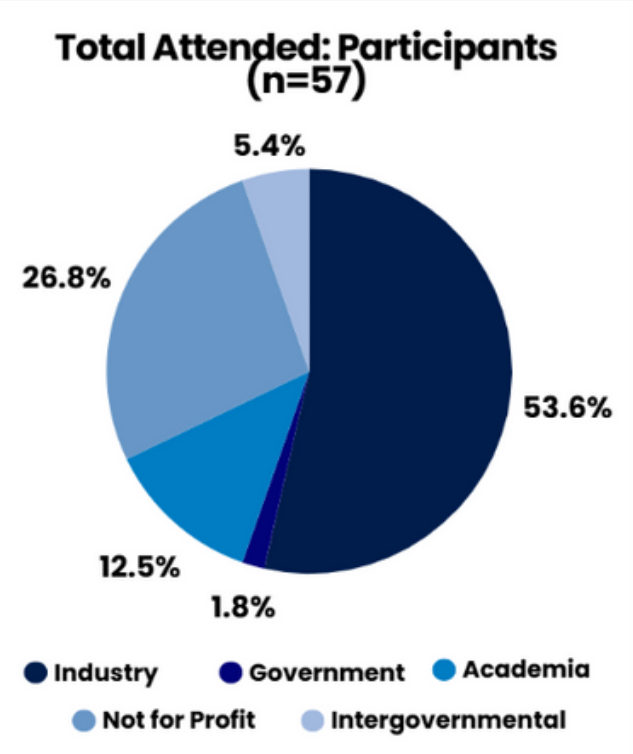
The third *Dialogues with Industry* (hereafter, *Dialogues*) on Ocean Observing of the Future, with a focus on related issues of technology advancement, accessibility, and cost, consisted of three curated dialogues held in October and November 2025. Invited Participants contributed to a moderated discussion, followed by Observers who could comment on the dialogue and contribute questions and comments (see Figure 1). The Ocean Observing of the Future *Dialogues* concluded that incremental advancements are not enough; instead, a transformative approach is necessary to align technology, market forces, and community needs.

Overall findings include:

- Shift the focus from purchasing cost to Total Cost of Ownership, as ongoing operational costs like maintenance and logistics often surpass initial sensor expenses.
- The Ocean Enterprise has a limited presence among private investors. Few venture capital firms specialize in ocean technology, and traditional VC models are often mismatched to the sector's longer timelines and focus on impact. Philanthropy and government funding are important in supporting early-stage development and mitigating risk.
- Developing manufacturing and decentralized maintenance in the Global South requires a better understanding of intellectual property regulations, market incentives, legal frameworks, and skills capacity, all of which currently restrict innovation and investment.
- Achieving success requires balancing affordability and technical skill-building, focusing less on hardware supply and more on seamless data access, and encouraging collaboration among scientists, private companies, startups, and established businesses to address both societal and market demands.

This report supports strategic implementation through collaboration across the Ocean Enterprise. It outlines key points and recommends connecting action pathways to existing initiatives, unifying efforts rather than starting new projects unless necessary. The full reports from the dialogues can be found here: Report 1, Report 2, Report 3.

The *Dialogues* seek a global audience across the Ocean Enterprise sector. There were 57 participants and 365 observers. Figure 1 depicts the sectoral and geographical distribution.



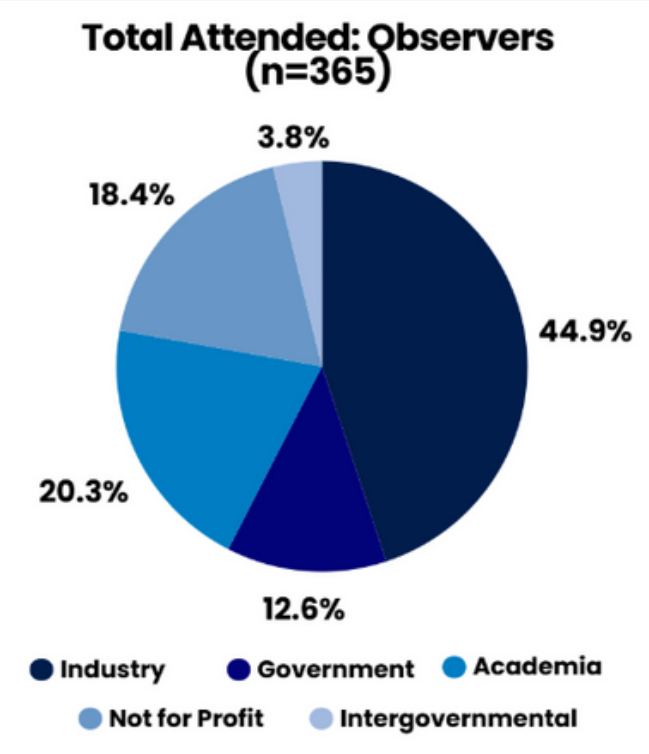


Figure 1: *The pie charts visualize the sectors represented by the participants and observers. The map displays the geographic reach of the dialogues by highlighting the countries of all participants and observers with pins.*

The action pathways of this third *Dialogues* have been mapped to the priority areas defined in the *Dialogues with Industry* Roadmap (hereafter Roadmap):

- Improving the Marketplace
- Collaboration to Grow and Impact Change
- Shaping the Future

Twenty-one (21) action pathways were identified during the third *Dialogues*, which connect to eight of the ten original challenges defined in the Roadmap, as shown in Figure 2 below.

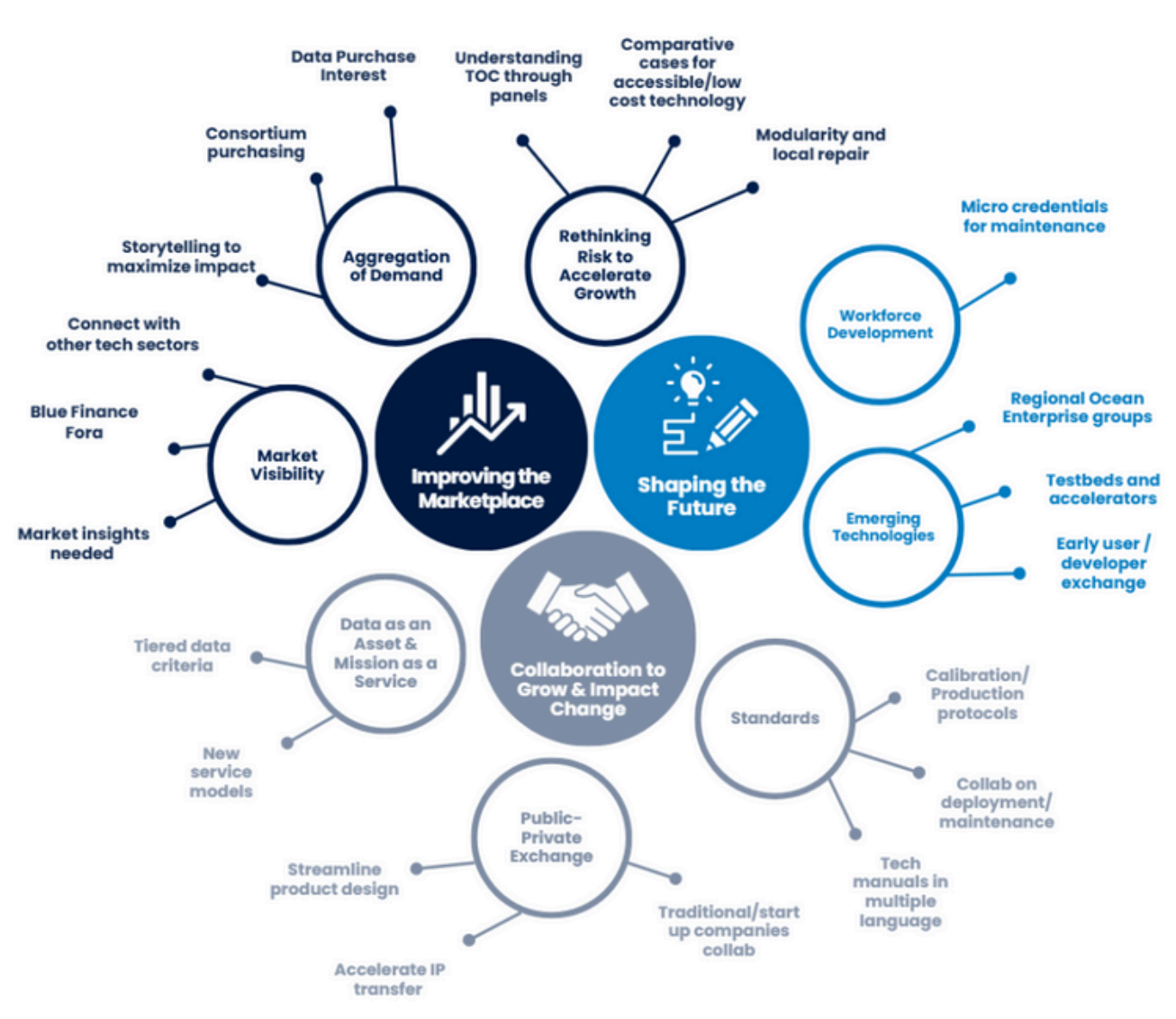


Figure 2: *This graphic connects the key outcomes of the Ocean Observing of the Future Dialogues with the Roadmap structure. The action pathways (outermost boundaries) are identified with the challenges (encircled elements) they are addressing and associated with the three priority areas in the center.*

About the *Dialogues with Industry*

The Ocean Enterprise constitutes an integral segment of the ocean economy dedicated to maritime monitoring activities, with an emphasis on ocean observation, forecasting, and associated services. The *Dialogues* are a key product of the Ocean Enterprise Initiative. The Ocean Enterprise Initiative and the *Dialogues* are distinct in their value; they focus on the global perspective of all three Ocean Enterprise components– public, private, and academia - and on actions across the Ocean Information Value Chain, Figure 3, where these components interact. The third *Dialogues* focused on the following areas: (1) Emerging Technologies, Enablers, and Infrastructure, (2) Reducing Costs and Increasing Utility, and (3) Business Case and Market Maturity.

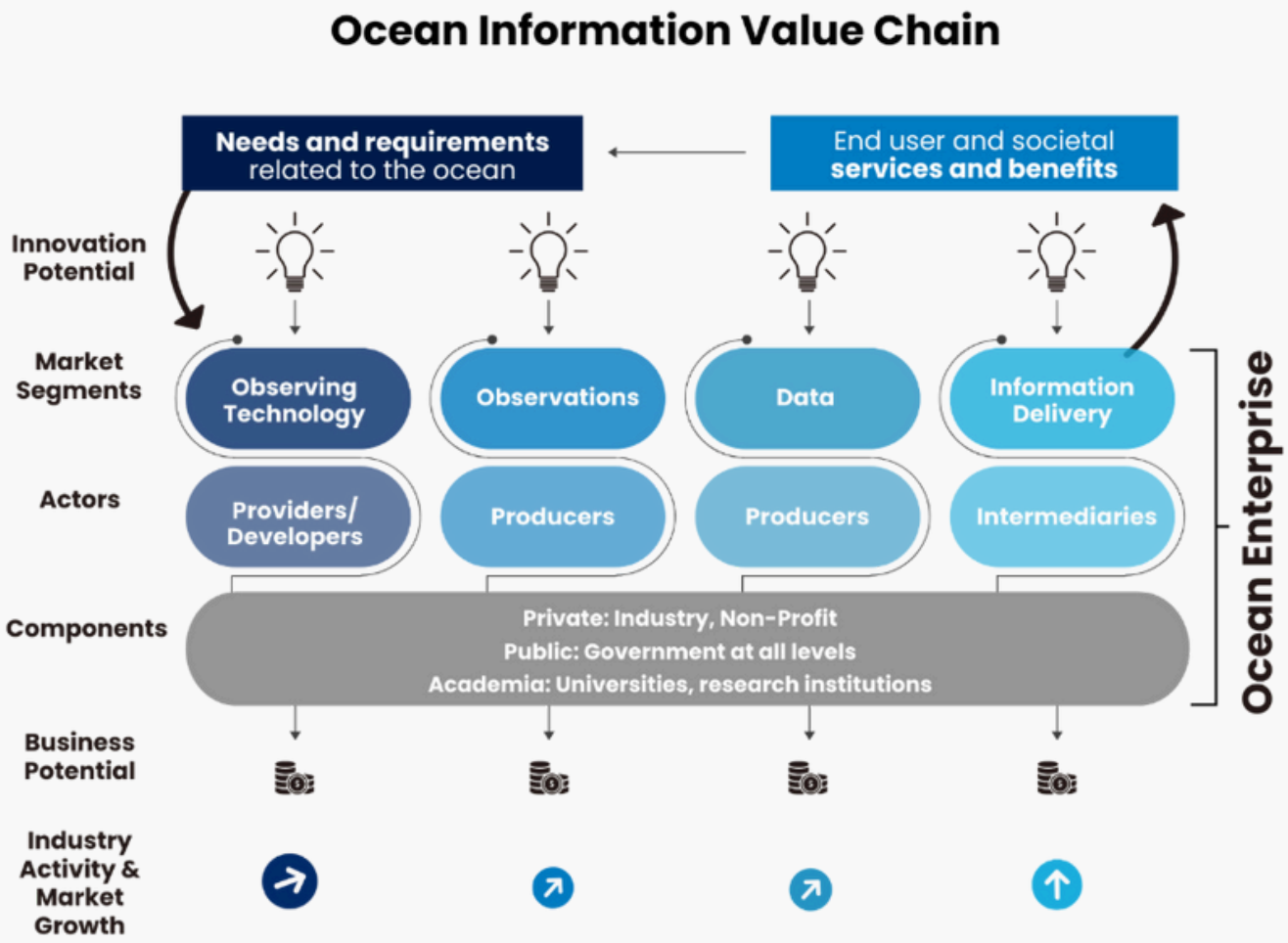


Figure 3: *The Ocean Enterprise and its interconnected components and activities across the Ocean Information Value Chain. The blue discs visualize the current level of private industry involvement in the segment, i.e., they offer an estimate of the current relative market size. The arrows indicate our estimate of private industry growth potential in each area (vertical is high). All market segments have the potential for innovation and commercial exploitation. This graphic is based on the value chain depicted in the Dialogues with Industry, Background Paper, September 2022, and was first published in this form in Roadmap.*

As the planning team for the third Dialogues convened, it was noted that definitions for "accessible" and "low-cost sensors/technologies" were not available. The Ocean Observing of the Future Background paper presents several “working” definitions for contextual reference. Although these definitions have not yet received endorsement from the observing community, ongoing discussion aims to lead to consensus and formal adoption of these terms.

Working Definition ‘Accessible Ocean Technologies’: A combination of sensor, instrument, and platform affordability in terms of cost, operations, and maintenance. An accessible sensor meets the same quality standards as the current technology for a given parameter but achieves a one order of magnitude cost differential compared to the status quo.

Working Definition ‘Low-Cost Ocean Technologies’: A combination of sensor, instrument, and platform affordability in terms of cost, deployment, operations, and maintenance. Low-cost sensors are defined as costing less than $1,000 USD and can be deployed in sufficient quantities to monitor rapidly changing areas where early warning is necessary. We note that when starting at a specific price, differences arise in the observed parameters, while in general, there seems to be a perceived threshold linked to the desired wide applicability. Additionally, it may be defined by its cost-effectiveness, i.e., a sensor that achieves a two-magnitude reduction in cost compared to currently deployed sensors for a given parameter.

The planning team also introduced an additional diagram to supplement the Ocean Information Value Chain. Figure 4 was designed to illustrate the innovative environment of ocean technologies, which served as the context for this dialogue series. Using the radar chart, we mapped key technological trends by readiness, time-to-market impact, and potential impact on the Ocean Enterprise. Trends closer to the diagram center have lower technology readiness levels (TRL) and longer times to impact; those farther out are more mature with quicker effects. Point size indicates the projected impact, and some trends span multiple market segments.

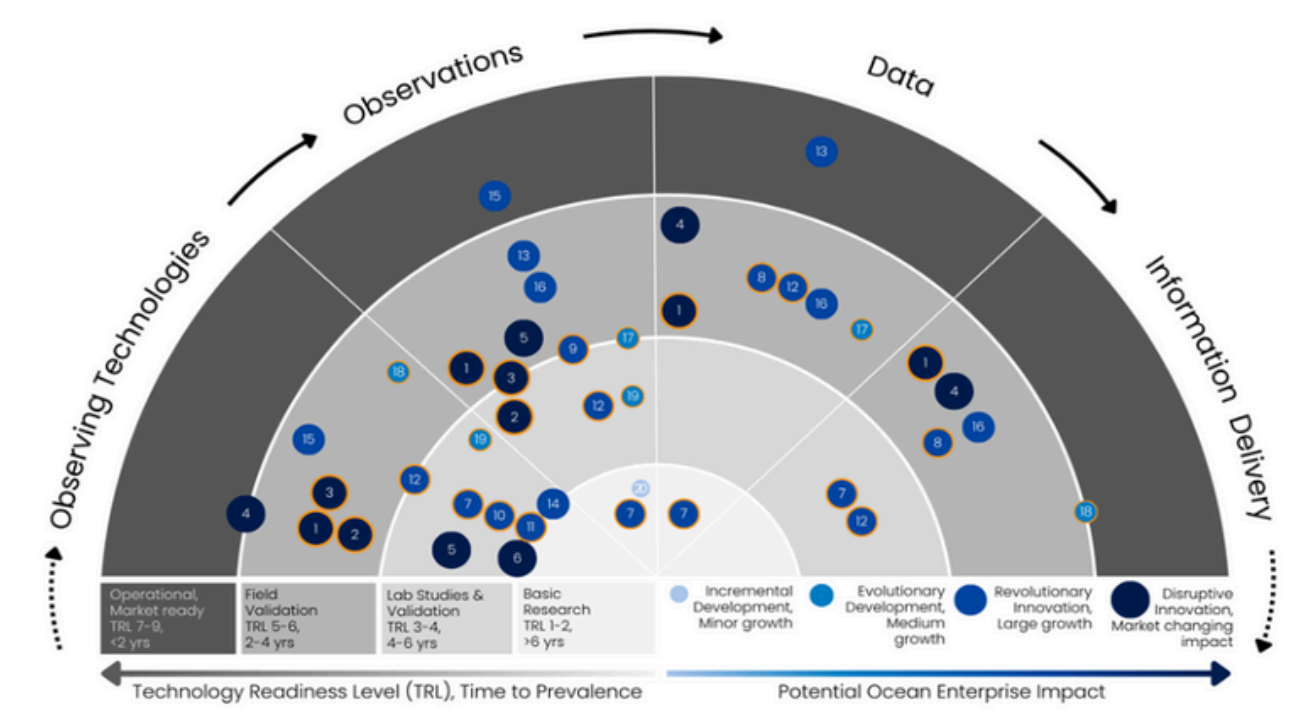


Figure 4: *Radar chart showing the readiness levels and time to prevalence as well as potential impacts on the global Ocean Enterprise of trends, enablers, infrastructure, and emerging technologies of the Ocean Information Value Chain. Those outlined in orange specifically enable accessible ocean observing technologies.*

The highest concentration of trends appears in the initial market segment, "Observing Technologies," with fewer trends observed as the value chain advances towards information delivery. This could be due to the planning team's focus on observing technologies, or it may genuinely reflect where innovation is currently taking place. Thus, perhaps signaling that more innovation is currently occurring upstream (observing), as proposed, rather than downstream (delivery). This trend might suggest that the next wave of change involves advances in data availability, e.g. from more places and at lower cost. This offers a noteworthy comparison to the Ocean Information Value Chain formulated at the outset of this initiative in 2022, which posits that the principal market opportunities lie downstream from the observing technologies.

Sixty percent of the identified trends facilitate and influence accessible ocean observing technology by supporting distributed, lower-cost, and scalable deployments. About half of the trends are considered revolutionary innovations that could drive growth, while 30% hold the promises of disruptive innovation capable of shifting markets. Additionally, shifts in societal attitudes and increased appreciation for ocean-related information, especially when linked to political action, could either accelerate or delay the timelines for the coming six years.

In summary, the radar chart highlights where innovation is clustering, how soon it is likely to matter at scale, and which developments may materially alter – not merely improve – the Ocean Enterprise. The key implication is that the sector is approaching a transition from limited, high-cost, campaign-based observing toward persistent, accessible, and distributed observing infrastructure. If coupled with sustained public priorities and political momentum, these shifts could drive substantial growth and meaningful restructuring across the ocean information economy.

Structure of the Document

This document links the action pathways identified from the third Dialogues to the priority areas and a subset of the challenges identified within the Roadmap.

- **Improving the Marketplace** focuses on improving the market visibility, aggregation of demand, and rethinking risks to accelerate growth.
- **Collaboration to Grow and Impact Change** focuses on data as an asset and missions as a service, private-public exchange, and standards.
- **Shaping the Future** focuses on workforce development and emerging technologies.

Each section begins with a summary of the discussion as it relates to the established priorities. Subsequently, there is one box per challenge that provides content on three topics:

- **Challenge:** Elaborates on the challenge in focus in that box.
- **Success Indicators:** Defines key indicators to evaluate success.
- **Action Pathways:** Suggested actions to move ahead.

The full list of key takeaways arrayed under the challenge areas is included in Appendix 1.

Improving the Marketplace

Despite a growing trend in investment, customer reluctance to pay, and government-focused funding models limit market growth. Developing countries, especially in Africa, are adopting low-cost, accessible ocean technology solutions rapidly, often leapfrogging traditional infrastructure, which fosters broader participation and data collection. Demonstrating demand—either societal or industrial—is critical for attracting investors, but bureaucratic and market risks continue to hinder progress. Governments play an essential role by reducing risks, providing subsidies, and setting standards, which can stimulate market growth and encourage broader entrepreneurial engagement. Overall, the sector requires stronger market pull, innovative funding mechanisms, and continued government support to realize its potential.

Developing countries, in particular, present opportunities for low-cost/accessible sensors, as other, more traditional data-generating methods are prohibitively expensive and thus discourage investment in data that could yield important and beneficial results. Thus, low-cost data generation can create markets that would not otherwise exist in many parts of the world, given the high cost of these investments. This also means that, regardless of ocean observing data needs, many places around the world are essentially barred from accessing data through traditional ocean observing methods – this creates both economic and ethical challenges, as some ocean data becomes increasingly relevant due to anticipated changes in ocean environments.

Challenge: Market Visibility

The Ocean Enterprise faces unique investment challenges, as traditional venture capital often does not align with their longer development cycles and specialized needs. The discussion addressed the potential for unicorn-level success within ocean technologies; however, additional dialogue is required before definitive conclusions can be reached. Few venture capital firms specialize in the Ocean Enterprise, limiting early-stage funding to those with domain expertise or to later-stage companies. Alternative investment strategies and sources may be needed that support smaller, impact-driven firms that prioritize societal value over rapid growth. In addition, effective market shaping strategies could involve demand-pooling organizations to attract investors once market viability is established.

The Ocean Enterprise lacks accurate, forward-looking market data, which hinders startup attraction, industrial growth, and investor engagement. Existing reports mainly project historical trends and miss new opportunities, highlighting the need for more precise segmentation and realistic sizing, especially for smaller markets worth tens to hundreds of millions of dollars. It was noted that venture capital may not always be the ideal fit for the Ocean Enterprise, as its expectations may not align with the specific needs of the ocean sensing sector. Building a strong Ocean Enterprise and demonstrating clear demand can help attract investors, but what type of investors are most suitable is not clear.

It was noted that private capital won't enter the sector without proactive steps by governments. In the short term, governments can shape markets and facilitate discussions. Without government support, private investment and innovation will lag. The lack of public backing hinders private firms from scaling and improving data quality for future needs.

Building a strong global Ocean Enterprise, like defense, could attract more investment. For developers, considering ocean technologies developed for and applied to dual use could accelerate innovation, reduce costs, and expand the market. Dual use in this context refers to innovations that serve both civilian, scientific, and commercial purposes as well as defense or security applications. The adoption of such technologies is seen as a key driver of future growth and collaboration in the sector, supporting both scientific research and industry needs. Related to dual use is teaming up with other sectors to grow and build additional momentum, for example, with the wastewater market, and looking to other sectors, such as agriculture, to adapt accessible/low-cost sensors for ocean use.

The ocean technology market also faces two significant structural challenges: long delays between customer engagement and contract finalization hinder rapid adoption and discourage investment; meanwhile, short-term R&D funding cycles do not support, or even allow new technologies to test and mature.

Further, it is important for the government sector to view ocean observing and data generation as critical infrastructure and to identify the changes needed to ensure this. Governments should agree on the need for a global basic observing network, understand that they cannot deliver this on their own, and that private industry can be a key contributor, partner, and ally.

Success Indicators

- Successful launch of BlueConneX and tracking of increased marketing reports. BlueConnex is a trusted AI powered platform designed specifically for the ocean enterprise sector and is an Ocean Enterprise Initiative effort being launched in 2025.
- An educational package for venture capital and other investors is created and published on **oceanenterprise.com**, introducing the Ocean Observing sector and the Blue Tech market opportunity.
- Track of Blue capital sources and trends.
- Ocean Technologies is a recognized Tech sector.

Action Pathways

- Identify and summarize existing market reports and actively seek funding for additional marketing reports. The Ocean Enterprise Initiative's BlueConneX can be a tool to identify existing market reports. Examples include BlueInvest Report
- Create a standard educational package to introduce investors from the financial and philanthropic sectors to the Ocean Enterprise, define the Blue Tech market (drawing on Defense Tech market framing as a model), and organize/convene a Blue Finance tech event to connect stakeholders.
- Identify other markets and organizations that represent their interests, which could be suitable for a closer connection with the Ocean Enterprise, and investigate options for collaboration, e.g., wastewater, defense, and agriculture.

Challenge: Aggregation of Demand

Market growth constraints for ocean technologies primarily stem from demand-side issues rather than technology development or production capacity. There is a disconnect between supply and demand, leaving many engineering solutions that may not address actual demand-side needs. Thus, one question of particular interest is how to align demand-side needs with supply-side technologies. This will be a critical component for the emergence of mass markets. Low-cost, accessible sensors offer opportunities to generate new demand in emerging markets that are not easily accessible by traditional technology, but they also have the potential to attract new consumers into more mature markets. For example, early adopters of accessible/low-cost technologies can garner interest in emerging markets and established firms. The demand for accessible/low-cost technologies will vary by geographic location; developing countries may be of particular interest to low-cost data generation, given budgetary constraints. Importantly, to gain additional momentum on the demand side, accessible/low-cost ocean observing must also address constraints related to education, such as data literacy, as well as product repair and maintenance costs associated with accessible/low-cost sensors and platforms.

Demand risk, as much as technological risk, determines market growth; for example, developing a platform for shrimp farming required clear evidence of market demand to secure funding. Sensor developers often lack a full understanding of oceanographic requirements, underscoring the need for better communication between them and scientists who are typically separate from private-sector players. Bridging this gap and aligning technologies with actual user needs are necessary to reach and expand mass markets.

Forming coalitions and consortia can boost order quantities, lower member prices, and strengthen negotiation power. Building stronger ties between science and industry can also maximize quantity benefits. Their primary goal is to pool resources and expertise to facilitate the acquisition and deployment of advanced ocean observing technologies. By working together, these coalitions can reduce individual costs, negotiate better pricing with manufacturers, and ensure broader access to cutting-edge sensors and platforms. Additionally, coalitions often foster knowledge sharing and joint problem-solving, helping members overcome barriers related to technology integration, data management, and operational logistics.

Industry advancement relies on partners willing to invest in innovation and address real needs through scalable solutions. Coastal regions, with their concentrated demand, offer significant market potential, especially for accessible/low-cost ocean technologies in developing countries. Creating a global report on trends and types of organizations and clients that have expressed requirements for ocean technologies and ocean data would be valuable.

Success Indicators

- Quantified impact of Ocean Observing Networks.
- Document case studies and procedures where consortium purchases were successful.
- Within BlueConneX or another identified source annually produce global client trends report.

Action Pathways

- Identify and link programs like SCOOP, BlueConneX, the US IOOS BOOC, AOC storytelling, and others to maximize their collective impact. Drive support by including these on the Ocean Enterprise website www.oceanenterprise.com.
- Provide examples where strategies such as bulk purchasing through consortiums have been successful.
- Developing a comprehensive report that identifies organizations worldwide and the types of clients interested in purchasing observational data.

Challenge: Rethinking Risk to Accelerate Growth

Risk, discussed during the dialogues, encompassed financial, operational, supply chain, and credibility. The companies participating in the *Dialogues* reported that investors are hesitant to fund ventures in this sector due to concerns about low profit margins and uncertain market growth, a perception that should be explored and understood.

An important factor that was addressed multiple times across the dialogues was that ocean technology costs are only a small part of the overall total cost of ownership (TOC), and that the TOC should be the main consideration for dialogues between suppliers and purchasers. While companies in the sector have cut costs by improving infrastructure versatility and sensor capacity, these other factors also matter. The focus should shift from capital expenditure (CAPEX) to operational expenditure (OPEX). CAPEX is influenced by competition and purchase volume, while OPEX can be lowered by designing better operations and data flows. Often program funding overlooks TOC resulting in inefficiencies and unused equipment.

The participants discussed supply chain risks associated with their dependency on a single supplier. Geopolitical pressures push for in-country purchasing, which can both limit access to global suppliers and increase the threat of market concentration, where a single domestic provider dominates. Such concentration introduces operational risks for the buyer, including the potential discontinuation of critical parts, which can jeopardize long-term projects.

Trust and reliability are critical factors when considering accessible/low-cost ocean technologies. While affordability and ease of deployment have greatly expanded data collection opportunities, stakeholders often express concerns about compromising data quality and sensor durability. Building trust in accessible/low-cost technologies depends on transparent validation processes, standardized calibration protocols, and robust data quality assurance measures. Industry participants emphasized the importance of rigorous validation, consistent performance, and transparent reporting to build confidence in these tools. As emerging technologies continue to drive down costs, ongoing collaboration between industry, researchers, and end users is essential to ensure that these sensors are fit for purpose and meet the rigorous demands of scientific and operational applications. Ultimately, building trust in accessible/low-cost ocean technologies will require a combination of technical innovation, open communication, and adherence to and setting up open quality standards.

Finally, the expertise of users deploying these technologies introduces another layer of risk for both companies and their customers. Data gathered by trained scientists is typically trusted more than that collected by citizen scientists or non-experts, raising valid questions about data credibility from untrained sources. Addressing this risk requires both improved training and the development of user-friendly, robust technologies that can deliver reliable results regardless of the operator's background.

Success Indicators

- Ocean observing technologies are framed in terms of Total Cost of Ownership.
- Comparability studies are conducted and methods for those studies are documented and published in an appropriate location, e.g. Ocean Best Practices.
- White paper assessing feasibility of modularity and local repair in a region of the world, e.g. Africa.

Action Pathways

- Organize specialized panels during ocean-focused conferences and create informative resources that shift attention to the TOC for these technologies. Encourage dialogue and inspire comprehensive analyses of ocean technology ownership costs, extending beyond mere technical comparisons.
- Evaluate as a first step the accuracy and stability of accessible/low-cost sensors as compared to traditional technologies to overcome the primary trust barrier.
- Discuss strategies for employing modularity for local repair with industry and government.

Collaboration to Grow and Impact Change

The Ocean Enterprise is a comparatively small industry relative to sectors such as semiconductor manufacturing, making it essential to adopt open, standardized protocols rather than develop specialized hardware or software. Recent discussions highlight the shift toward treating ocean data as a strategic asset, prioritizing scalable access to high-quality, actionable data over merely reducing sensor costs. This approach emphasizes the adoption of plug-and-play technologies, standardized metadata, and user-friendly data platforms, while balancing data quality with affordability through tiered standards and diverse acquisition models such as purchase, rental, or leasing. Key challenges include ensuring open data access, securing funding, and leveraging AI and licensing agreements to enhance innovation and operational efficiency. Additionally, there is a strong call for better communication and collaboration among user communities, technology providers, industry, and scientists. This collaboration should be supported by testbeds, accelerator programs, and dedicated funding to facilitate testing, evaluation, and effective matchmaking between technology developers and end-users.

Challenge: Data as an Asset and Mission as a Service

The discussion shifted to treating ocean data as a strategic asset and promoting "mission as a service" models for ocean observing. Rather than focusing solely on the upfront cost of sensors, the emphasis was placed on scalable access to high-value, actionable data that supports operational, scientific, commercial, and societal goals. The value of an ocean observing system is therefore determined less by the cost of the instrument itself and more by the quality, usability, and fitness-for-purpose of the data it produces. Investments – whether in traditional platforms or emerging technologies – do not deliver impact if the resulting data are inaccessible, poorly documented, or not usable for the intended application.

The central topic of discussion focused on whether affordable sensors can deliver sufficient data quality. Some applications require high-precision data and traceable calibration, while others accept lower accuracy if data are timely, spatially dense, or frequent. Establishing open, practical standards for applications can help match sensor capability to mission performance thresholds. A belief that accessible/low-cost sensors inherently produce low-quality data was challenged; advances in software, edge processing, and integration with commonly available devices (including smartphones) may improve performance, quality, and make accurate measurements achievable at lower cost than in the past. Participants suggested a tiered approach to data standards, like those used in the Weather Enterprise, could satisfy different market requirements while enabling and supporting innovation and scaling adoption.

Democratization of data and stronger "data intelligence" were also identified as vital for accessible/low-cost observing technologies to have a transformative impact. Achieving FAIR (Findable, Accessible, Interoperable, Reusable) data status remains central to expanding accessibility and increasing the number and types of users. User-facing tools like community dashboards and automated analytics can help make raw measurements clear and actionable for non-expert audiences.

As the pool of private sector providers of ocean data grows, there is a recognized data dichotomy. The long-held principles for free and open-access data, which underpin science and international policy, must be maintained to advance science and protect life and property. There is also a nascent market for the commercialization of ocean data for uses beyond science and safety. While data accessibility is crucial, participants acknowledged that the expectation of free and open-source data can create financial and intellectual property challenges for private-sector providers. This can be compounded through the adoption of new technologies and/or data models by the user community, putting additional strain on industry as industry investments must be made upfront without guaranteed returns. These constraints must be acknowledged in recommendations to ensure that public benefit objectives remain compatible with sustainable private-sector participation. Here, license agreements could improve profitability on the private side and reduce redundancy on the public side; e.g., governments could ensure that a certain number of key variables remain publicly available, while other data could be made available for pay, thereby ensuring the continuation of private investments in technological advancements. There are examples within the remote sensing sector and the Weather Enterprise. It should be noted that data sharing models vary by company; for example, some focus on promoting their mission rather than the data itself. Therefore, collaboration across the Ocean Enterprise is necessary to develop a comprehensive solution.

Improving data visibility and usability were highlighted as priorities. Too often, existing datasets are unknown or underutilized, leading to redundant and costly data collection. AI-enabled tools may reduce data processing costs and expand access in infrastructure-limited regions, although automation could reduce human labor demand over time.

Finally, "mission as a service" models – such as leasing, renting, and service contracts – were viewed as promising mechanisms to increase access to advanced sensing capabilities while reducing procurement, storage, maintenance, and lifecycle burden for users. However, adoption depends on funding structures and constraints, particularly on the differing flexibility of CAPEX versus OPEX across research, government, and commercial organizations. Aligning contracting mechanisms with these realities will be important to enable scalable service-based delivery.

Success Indicators

- Development and adoption of a tiered data standards structure linked to application requirements (e.g., precision, uncertainty reporting, latency, spatial/temporal resolution, calibration traceability).
- A white paper is published assessing existing and potential rental/subscription business models for sensors and platforms.

Action Pathways

- Collaborate with GOOS and WMO to adapt weather-enterprise tiered data standards structure for ocean observing, aligned to application-driven performance needs and operational use cases.
- Evaluate the feasibility of rental, lease or subscription models for sensors and platforms to expand utilization, reduce upfront costs, and improve scalability of observing networks independent of certain applications and in certain regions.

Challenge: Public/Private Exchange

Accessible/low-cost ocean technologies can foster collaboration between public and private sectors, empowering local communities to actively participate in data collection and decision-making. When coastal stakeholders are equipped with practical tools and clear guidance, participation transitions to active contributors within systems supported by both public investment and private-sector innovation. This collaborative approach helps minimize data fragmentation, strengthens decision-making, and supports robust policies that can attract further investment and foster cost savings through improved forecasts and planning. Regional technology development and local ownership can also reduce traditional reliance on international scientific support, reducing costs and environmental impacts associated with travel and data analysis abroad while strengthening decision-making frameworks.

Public-private collaboration is critical throughout the technology readiness pathway, from research and development to product qualification. Co-designed projects facilitate the transfer of knowledge and appropriate sharing of intellectual property (IP) between universities, manufacturers, and end users, ensuring that technologies meet both academic and industry needs. These collaborations help define infrastructure requirements, identify new markets, and clarify effective approaches for technology transfer as the Ocean Enterprise matures.

The discussions on the relationship between traditional companies and start-ups highlighted the complementary role each plays in advancing ocean observing technologies. Established companies can bring established experience, resources, and robust manufacturing capabilities, while start-ups can contribute innovative ideas and the ability to rapidly prototype new solutions. The relationship between the two is characterized by both collaboration and competition, with larger companies sometimes partnering with or acquiring start-ups to accelerate innovation, and start-ups benefiting from the mentorship and networks of their more established counterparts. Both groups recognized the value of collaboration, with traditional companies acknowledging that partnerships with start-ups could accelerate the adoption of new solutions and expand market reach, while start-ups saw opportunities to leverage established networks and expertise to validate and improve their offerings.

Governments play a central role in enabling public-private exchange by incentivizing or regulating access to ocean data and by recognizing ocean observing infrastructure as an essential service. Panelists suggested that mixed public-private models—such as long-term partnerships, contracts, or service agreements —can provide sustainable revenue for private providers while enduring the availability of critical data for public needs. Coordinated collaboration is therefore required to deliver reliable, scalable data services that benefit both society and commercial markets.

Successful expansion of participatory science and citizen engagement depends on coordinated public and private support, including funding, organizational capacity, and sustained coordination. By broadening the concept of citizen science to include communities involved in daily ocean activities, such as sailors, fishers, port operators, and aquaculture producers, data acquisition and relevance can both be enhanced. In addition, value-added services and platforms that return useful insights to participants encourage sustained involvement and can yield new business opportunities, as demonstrated by real-time data-sharing practices already present in some marine communities.

Success Indicators

- Co-developed production designs for accessible ocean technology are finalized and published (as appropriate for IP and licensing constraints).
- Guidance and curriculum materials are developed and published on IP transfer mechanisms and best practices for public–private collaboration.
- A documented case study is published demonstrating collaboration between an established company and a start-up to develop an accessible ocean technology solution.

Action Pathways

- Streamline product design around specific deployment needs, investing in co-development and leveraging public-private partnerships to share technical risks and lifecycle costs.
- Identify and address current barriers related to restrictive intellectual property (IP) policies by raising awareness through appropriate industry and policy fora and promoting practical approaches to technology transfer.
- Explore company mentorship programs between established business and start-up to promote collaboration, reduce barriers to entry, and accelerate commercialization pathways.

Challenge: Standards

Standards have emerged as a recurring issue across all *Dialogues* to date. In addition to reflecting on the need for data standards, this *Dialogues* emphasized that broader standards are also needed for sensor production, maintenance, calibration, and mission operations. Inconsistent calibration practices and measurement methodologies limit data reliability, reduce comparability across organizations, and erode trust. Similarly, the absence of standardizing mission-planning tools increases operational complexity and cost, particularly as sensing networks scale.

The transition to more sustainable, durable, and field-ready sensors and platforms is closely tied to the development and adoption of robust industry standards. By defining clear benchmarks for sensor longevity, performance, calibration traceability, and maintenance requirements, standards can drive investments in technologies that reduce lifecycle cost while improving the reliability and comparability of results across organizations. Calibration and measurement quality are central to effective data standards. The challenge lies in balancing affordability with the need for rigorous, standardized methods to ensure reliability and enable meaningful uncertainty quantification. Trust in ocean data – especially for decision-makers and non-expert users – depends on consistent calibration standards and transparent reporting of measurement uncertainty.

Standardized, user-friendly technologies facilitate efficient maintenance, calibration, and redeployment, reducing both operational complexity and the overall cost of ownership. By embedding standards into the design and deployment of equipment, organizations better manage CAPEX and OPEX and support the long-term viability of ocean technology investments.

Government leadership plays a key role in establishing baseline standards through procurement requirements, regulatory guidance, and reference frameworks for both public and private-sector entities. Consistent standards improve accountability and interoperability, help level the playing field for technology providers, and ensure that instrumentation and resulting data products are fit-for-purpose across a broad set of missions.

Success Indicators

- Production manuals follow a standardized template and include required technical content (e.g., calibration procedures, tolerances, maintenance intervals, and troubleshooting guidance).
- Production manuals and technical instructions are translated into multiple languages appropriate for deployment regions.
- Sensors are delivered with documented calibration traceability and uncertainty reporting.
- Maintenance procedures and inspection intervals are defined and consistently applied across deployments.
- Mission-planning and data-handling tools support interoperability through common formats, metadata, and quality-control practices.

Action Pathways

- Publish clear calibration standards and reference protocols, including uncertainty reporting expectations, and provide training to support local maintenance and sustainment.
- Develop and distribute standardized technical documentation packages in multiple languages, aligned to regional deployment needs.
- Encourage collaboration among government, industry, and partners to design systems that are easier to deploy, maintain, and service in the field, reducing operational barriers to adoption.

Shaping the Future

Advancements in ocean technology, including affordable sensors, AI-driven automation, and locally adapted solutions, are making data collection more accessible, especially for developing countries. Africa is leading by prioritizing practical, innovative approaches over copying Western models. Despite these gains, parts of the Ocean Enterprise remain cautious, hindered by operational traditions, cultural attitudes, and complex system updates required by new technologies. Establishing a regional ocean industrial base will require strategic investment, demand, and careful attention to legal, market, and policy frameworks. Low-cost tools such as small buoys and specialized software empower local and remote communities to monitor their environments, emphasizing the importance of local manufacturing and knowledge sharing. Ultimately, the growth of the Ocean Enterprise depends on a skilled, diverse workforce and the ability to harness new technologies to maximize the impact of ocean data and innovation.

Photo Source: Southby, J. (2024). These are students on a research vessel. MTS Summer Workshop, Rutgers University, New Brunswick, NJ.

Challenge: Workforce Development

The integration and maintenance of advanced technologies present significant technical challenges, particularly regarding calibration and ongoing upkeep. Addressing these issues is essential not only for expanding market reach but also for ensuring cost-effective ownership and long-term sustainability.

Mitigating technical challenges in maintenance and calibration requires the development of standardized training programs and instructional resources. Implementing robust in-house training that adheres to industry standards empowers organizations to handle calibrations independently, thereby expanding the user base and reducing costs. This approach to capacity building is fundamental for the widespread adoption and sustainable implementation of new technologies.

Micro-credentials and short-term specialized courses are poised to play a vital role in facilitating the exchange of expertise across different sectors and skill levels. These educational opportunities help bridge knowledge gaps and support the dissemination of specialized skills necessary for technology maintenance and calibration.

Success Indicators

- Develop micro credentials for maintenance and calibration to be deployed globally.

Action Pathways

- Build local expertise and capacity to address cost factors such as repair and maintenance should receive more attention to increase access to ocean data globally.

Challenge: Emerging Technologies

Emerging technologies such as artificial intelligence (AI), edge computing, and quantum sensors for navigation present significant opportunities for the Ocean Enterprise. These advancements can reduce operational costs and enhance both data processing and sensor performance. For instance, edge processing and AI applications enable sensors to make real-time, local decisions, which also decreases the need for extensive data transmission.

Quantum navigation and sensor systems offer greater precision and resilience but remain costlier than older technologies. Military research may speed up development and lead to future civilian use. Networks of affordable sensors can produce detailed magnetic maps, aiding navigation where GPS fails. Plug-and-play compatibility increases accessibility, and better communication between developers and users helps match needs with solutions.

Several practical innovations have been emphasized. For instance, ultrasonic radar water level sensors are now supplementing pricier stations, and new anti-biofouling technologies help sensors last longer. AI-powered automation reduces human involvement, which in turn reduces operational expenses. Improved satellite communications enable faster, more cost-effective data transmission.

Adapting technologies from other fields, like agricultural sensors and container tracking modules and utilizing existing resources such as fishing vessels for deploying sensors present even more affordable options for gathering data.

Africa is turning to affordable ocean technologies as traditional equipment proves too expensive, with workshops at major conferences boosting early adoption. Low-cost sensors are especially valuable for developing nations, making data collection more accessible and opening new markets. Instead of replicating Europe and the U.S., African countries increasingly use cost-effective, locally tailored tools, sometimes outpacing wealthier regions in innovation, as seen with mobile banking. The aim is to build practical observation networks using current resources rather than simply imitating foreign advancements.

Philanthropic organizations are increasingly investing in the development of ocean technologies to advance their missions. Their financial resources enable them to provide these technologies at reduced costs. By subsidizing specific applications and sensor expenses, philanthropic organizations lower prices to improve access to essential data for individuals and communities, thereby decoupling price from accessibility.

Success Indicators

- Through the Ocean Enterprise Initiative advisory team establish criteria for a regional group to advocate the concepts of the Ocean Enterprise.
- Through BlueConneX document testbeds and accelerators and provide links between commercial customers and developers.
- Establish a forum for discussion between users and developers and conduct such forums at meetings such as Oceanology International, AGU sciences meeting, Ocean Business. Identify 2 conferences annually in related sectors to conduct similar forums.

Action Pathways

- Establish regional groups that represent the Ocean Enterprise and apply the concepts of the Ocean Enterprise to a regional issue.
- Identify and encourage test deployment opportunities with high quality reference methodologies in place that also try to act as direct links with commercial customers going forward.
- Foster early and low-barrier "users meet developers" exchange at conferences.

Going Forward

The *Dialogues with Industry* – Ocean Observing of the Future has been instrumental in defining and refining a set of clear priority actions across the ocean information value chain to lower barriers and increase opportunities for public-private partnerships. Overall, the third Dialogues was a success, with over 400 attendees. This highlights that broader topics concerning the Ocean Enterprise are attracting attention and encouraging more involvement and identification. One important aspect of these initiatives is to promote a broader understanding of the Ocean Enterprise concept within the ocean observing community. Our Dialogues have begun to generate increased support for this idea. Several ideas on how to strengthen this effort included:

- Establishing regional subsidiaries or local constellations to address context-specific challenges and opportunities.
- Focusing on concrete regional problems (e.g., blue carbon, fisheries, ocean health) to demonstrate impact and community benefits.
- Enhancing public-private partnerships to secure long-term contracts and scale ocean observing infrastructure.
- Engaging stakeholders across science, industry, government, and indigenous communities to co-design observing systems aligned with user needs.
- Promoting regulatory frameworks that mandate data sharing and coordinate efforts to avoid duplication.
- Leveraging philanthropic and government support to catalyze innovation and market development.

Moving forward we will build on and further improve the Dialogues. The next Dialogues is planned for Spring of 2026 will focus on Future Markets. As well the Ocean Enterprise Initiative will launch BlueConneX in March of 2026, a vibrant, trusted AI powered platform designed specifically for the Ocean Enterprise. Unlike other platforms with a narrow focus, BlueConneX will provide a dynamic and interactive environment, where one can explore, connect, and grow alongside passionate peers. With its ability to synthesize content and offer customizable views, BlueConneX will enable deep engagement to gain meaningful insights into the growing Ocean Observing market sector.

Appendix 1: Key Takeaways

Priority Area: Improving the Marketplace

Market Visibility

- Forward Looking marketing data and patient investment is needed to overcome investment challenges.
- Lack of willingness to pay for ocean observing products and declining government support are obstacles exacerbating private financing.
- Ocean technologies must respond to data-driven environmental and market challenges and, even more, address the underlying evolving societal needs that are independent from technological advances.
- Accessible/low-cost ocean technologies are primed to fill gaps in areas with price-sensitive deployment schemes.
- Ocean Observing networks should be designated as national critical infrastructure.

Aggregation of Demand

- Coalition building for procurement enhances negotiation power.
- Accessible/low-cost sensors provide access but can also grow the existing market.
- Government has a role in demand stimulation.
- Coastal areas have a role in developing mass markets.
- Constraints to growth lie primarily on the demand side.

Rethinking Risk to Growth

- Total Cost of Ownership (TCO) shifts the emphasis to cost per profile collected
- Distrust in accessible/low-cost sensors could be mitigated; how well requires further examination, especially keeping related cost in mind to still meet the requirement of low overall cost.
- Leaping to new, affordable technologies could enable developing countries to quickly set up observing networks.
- Global standardization and widely available components reduce the risk of single sources and uncertainty of longevity of start-ups.
- Enhancing local capacity could support affordable, accessible ocean observing , especially in under-observed regions.

Priority Area: Collaboration to Grow and Impact Change

Data as an Asset and Mission as a Service

- A shift is needed from sensor/platform accessibility to data accessibility.
- Democratizing data and data intelligence turns complex data sets into actionable information for all.
- Service-Based Delivery Models should be explored.

Public Private Exchange

- Need for collaboration between startups and established companies.
- Communication and connection across the Ocean Enterprise lower barriers and map market activities.
- Public-Private Scaling requires streamlined IP transfer approaches.

Standards

- Maintenance Best Practices are needed to sustain regional ocean technologies.
- Affordability is important but not the only criterion for enhancing accessibility.

Priority Area: Shaping the Future

Workforce Development

- Regionally maintained equipment needs a skilled workforce.

Emerging Technology

- Philanthropic and non-profit organizations' financial flexibility enables the development and offering ocean technologies at lower costs and supports addressing early-stage risks and quality control initiatives.
- Recognizing key trends affecting the Ocean Enterprise, beyond accessibility labels, can unify the sector and address societal needs.
- Addressing misalignments between developers and end-users can result in cost savings.

Appendix 2: Planning Team

Sector	Affiliation	Name
Academia	Stanford University	Collin John-Erik Closek
Intergovernmental	GOOS	Patrick Gorringe
Intergovernmental	GOOS	Emma Heslop
Private/For Profit	Kongsberg Discovery	Peer Fietzek
Private/For Profit/Not for Profit	L3Harris/MTS	Donna Kocak
Public	NOAA/GOMO/UCAR	Ann-Christine Zinkann
Public	NOAA/IOOS	Zach Baize
Public	South African Environmental Observation Network (SAEON)	Juliet Hermes
Private/Not for Profit	Euro-Mediterranean Center on Climate Change (CMCC) Foundation	Viviana Piermattei
Private/Not for Profit	MTS	Hans VanSumeren
Private/Not for Profit	MTS	Caisey Myers
Private/Not for Profit	MTS	Zdenka Willis
Private/Not for Profit	MTS	Maik Kecinski

OCEAN ENTERPRISE INITIATIVE

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