Good afternoon.

We are gathered this week at a critical juncture for our unique segment of the maritime industry. We face unprecedented challenges—a rapidly changing climate, a threatened blue economy, and a demand for actionable insights at a speed that traditional methods cannot match. These challenges are a strategic imperative, and they require a fundamental shift in how we conduct, and support, oceanographic research. The future of the research vessel is not an analog echo of the past, but a new, hyper-connected, and intelligent platform for the future. This transformation is being driven by three core technologies: artificial intelligence, machine learning, and advanced satellite communications. Our collective responsibility is to ensure that our fleets, and our funding models, remain capable and well-suited to address both the scientific and societal challenges that lie ahead.

For decades, our communities' operational model has been one of painstaking data collection followed by a slow, post-cruise analysis. We deploy a vessel, a team of scientists, and a suite of sensors. The vessel returns to port, often months later, and the backlog of data begins to mount, creating a significant bottleneck in the pipeline of scientific discovery. This approach is costly, time-intensive, and limits our ability to provide real-time, actionable intelligence. We must move beyond this model.

This is where the paradigm shift begins.

The first pillar is artificial intelligence and machine learning. As Eric Schmidt and his co-authors discuss in their book *Genesis*, AI compresses human timescales and enables us to make sense of a world of overwhelming complexity. They describe AI not merely as a tool, but as a "collaborator," a partner that can work alongside humans to achieve previously impossible tasks. AI is not about

replacing human ingenuity; it's about amplifying it. It can analyze the petabytes of data collected by modern sensors—from acoustic signals to visual imagery—in real-time, identifying patterns and anomalies that would take human researchers years to find. As the March 2025 issue of *Proceedings Magazine* notes, AI is already enabling oceanographers to analyze vast, complex datasets and make predictions with unprecedented accuracy, outperforming traditional ***weather*** models by a significant margin.

Consider the immense "analysis backlog" of underwater imagery. For every hour of deep-sea video collected, thousands of hours of human effort are needed to review and annotate it. This is a problem perfectly suited for machine learning. Tools like FathomNet are tackling this head-on. FathomNet is an open-source database of expertly labeled ocean imagery. It serves as the training ground for machine learning models that can automatically classify and identify marine life, debris, or geological features. It turns what was once a bottleneck into a streamlined, AI-assisted workflow, thereby increasing the return on investment for every cruise.

However, as we embrace these powerful collaborators, we must also heed one of the core warnings from *Genesis*: the challenge to human judgment. When machines can process more data and make a "correct" decision faster than a human, there is a temptation to cede our independent judgment. As vessel superintendents and technical managers, our entire profession is built on a foundation of experience, intuition, and critical decision-making in high-stakes environments. We must ensure that our fleets' AI systems are built as "human-in-the-loop" systems. These technologies must enhance, not usurp, the expertise of our crews. Our role is to maintain the "moral compass" of our operations, using AI as a cognitive force multiplier that allows us to focus on the most complex, strategic, and ethical

challenges, rather than on data processing. This ensures that our technological advantage is always guided by our professional values.

This isn't just about post-voyage analysis. The technology is being brought to the sea itself. Schmidt Ocean Institute, the US-based philanthropically funded nonprofit foundation that I joined 15 years ago, pioneered the use of high-performance computers onboard its first vessel *Falkor*, and now on *Falkor (too)*. In 2015 *Falkor* was the first research vessel with a true high performance supercomputing system at sea. This breakthrough allowed for complex modeling and data analysis to happen onboard, giving scientists the combined power and speed of dozens of high-end desktops. Today this capability enables real-time decision-making, allowing researchers to adapt their cruise based on the outputs of large-scale simulations, not just what they can observe. As *Workboat Magazine* highlighted in its May 2025 issue, this new generation of research vessels are embracing technologies that improve both scientific output and operational efficiency.

But the full power of onboard computers can only be unleashed with robust connectivity. This brings us to the second pillar: advanced satellite communications. Traditionally, data transfer from sea has been slow and costly. As recently noted in *The Maritime Executive*, the industry is on the cusp of a major shift to low-earth orbit (LEO) satellite constellations. These new networks are providing speeds of up to 200 Mbps per ship, turning a narrow data pipe into a superhighway. This enables the real-time, bidirectional transfer of massive datasets. As soon as a piece of data is collected, it can be instantly streamed to a supercomputing facility on land. This is the ultimate collaboration. The research vessel becomes a mobile data collection node, and the global scientific community becomes a real-time, analytical engine.

The synergy between these three elements—AI, ML, and satellite connectivity—is a true force multiplier. It is the difference between reading a historical account of a voyage and participating in the discovery as it unfolds. A powerful example is Schmidt Ocean Institute's ROV *SuBastian*. Through a platform called Divestream, the undersea world that is filmed by our remotely operated vehicle is broadcasted live in high-definition video, now possible from nearly anywhere on the planet. Last month a Schmidt Ocean Institute cruise with research vessel *Falkor (too)* to the Mar del Plata Canyon off the coast of Argentina captured the attention of literally millions of viewers from Argentina and around the globe, demonstrating the value of this approach far beyond the scientific community.

This application is truly transformational in three ways. First, for scientific research: it enables a distributed team of experts on land to participate in the dive. A marine biologist in one country, a geologist in another, and a chemist in a third can all provide real-time guidance to the ROV pilots, ensuring no discovery is missed. This model maximizes the intellectual return on our operational investment. Second, for educational outreach: it makes the wonders of the deep sea accessible to everyone, inspiring a new generation of scientists and ocean stewards. This is a critical component of our institutional mission and a direct response to the need for a larger workforce. Third, for community engagement: the live chat and social media interaction during these dives create a shared experience, building a new, engaged community around ocean science.

This new paradigm is not only accelerating discovery; it is also fundamentally changing the societal role of the research vessel. Oceanographic research is no longer just an academic endeavor; it is a critical component of our response to global challenges. In the March issue of *Proceedings Magazine* notes, AI and machine learning are being used for predictive maintenance on vessels and to

improve sonar detection, helping us navigate and secure our seas more effectively. And a recent report from the World Resources Institute highlights, this year is critical for the Ocean, with a major focus on illegal fishing, plastic pollution, and the impacts of climate change. Embracing AI and advanced connectivity will give our research, enforcement and monitoring platforms the tools to address these issues directly. We can use AI-driven analysis of satellite imagery to detect illicit activities, use real-time data to track the spread of pollutants, and provide the foundational knowledge needed to inform international agreements on ocean health.

But with this new power comes a profound institutional challenge that we, as leaders, must address head-on. As Eric Schmidt argues, AI will redefine how we live and work, raising the critical question of how we co-evolve with this technology without losing our essential human capabilities. For our industry, this means considering the skills of our crew. While AI automates routine tasks, from engine monitoring to data logging, we must be proactive in ensuring we are not allowing critical human skills to atrophy. Our investment in technology must be matched by an equal investment in our people, training them to become "hybrid mariners" who understand not just how to operate a ship, but how to manage, interpret, and leverage these new intelligent systems. The future workforce will be empowered by AI, not replaced by it, and our institutions must lead the way in this evolution.

Earlier this year the *Marine Technology Society Journal* demonstrated that the scientific community is already focused on harnessing AI for seabed mapping and leveraging improved remote sensing for discovery. The research vessel's mission is no longer about simply collecting data; it's about providing actionable, real-time insights that can protect marine ecosystems, safeguard coastal economies, and inform global policy.

This vision requires us to rethink the very design of our research vessels. The ship of the future will not be defined solely by its engines or its size, but by its data infrastructure. It will be equipped with edge computing capabilities to run AI models onboard and be a constant, living node in a global network of scientific discovery. The many members of our crews will be a new kind of mariner—a hybrid of seasoned sailor and data scientist, empowered by technology to make smarter, faster decisions.

This is not a distant fantasy. The pieces of this future are already being built. The transition is underway.

So, where do we go from here? The next chapter of ocean exploration is not simply about more ships; it's about smarter ships. It’s about leveraging the incredible power of AI, the data-driven insights of machine learning, and the boundless reach of advanced satellite communications to secure our institutions' leadership, optimize our investments, and finally, truly, understand our home planet.