



SHAPING A
SAFER, CLEANER
FUTURE **TOGETHER**

ANNUAL REVIEW

2021

ABS MISSION

The mission of ABS is to serve the public interest as well as the needs of our members and clients by promoting the security of life and property and preserving the natural environment.



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SHAPING A SAFER, CLEANER FUTURE TOGETHER

Between the powerful forces of global decarbonization and the COVID-19 pandemic, the events of 2021 underlined how it is only by working together that we can solve the biggest challenges that face both our industry and our world.

We saw the fourth industrial revolution take shape, and understood how it will be faster, infinitely more complex and expensive than anything that has gone before. The biggest challenge we all face in terms of realizing ambitious net zero commitments is the sheer gradient of the curve ahead of us.



The maritime industry has a very long history of resourcefulness and innovation in the face of great challenge, and 2021 saw the industry begin to work together to take the first steps on the road to carbon neutral operations.

ABS teamed up with some of the marine and offshore industries' leading players to launch joint development projects (JDPs), vital building blocks that will ultimately deliver sustainable operations at sea. As the decarbonization agenda cuts across the industry's value chain, these efforts sought to safely and sustainably advance everything from vessel design to alternative fuel adoption, carbon capture, green hydrogen production, and fuel cells to autonomous operations and remote-control operations, just to highlight a few.

Teamwork was again key to supporting the industry to adapt and thrive in the new pandemic paradigm. ABS worked with owners and shipyards to develop new approaches to design and operations, pioneering infection mitigation strategies and developing a wide range of remote services.

This is a great example of how, amidst a dynamic environment, ABS remained focused on safety. Similarly, as the industry pushes forward with the decarbonization agenda, ABS is guarding against the unintended safety consequences that will inevitably be born out of the rush for lower carbon operations.

We have witnessed the industry move decisively toward end-to-end digital transformation. ABS has been working to support and facilitate this potentially daunting process with practical and smart ways to develop tangible results from data analysis. Together, we have been able to apply ABS' advanced analytics and digital technologies to clients' fleets to reduce fuel consumption, lower carbon emissions, navigate routes safely, predict equipment health and take decisions proactively.

It is striking, looking back at a genuinely remarkable year, how the common thread in our outstanding performance has been a willingness to collaborate to deliver results and, indeed, a recognition that it is only together we can deliver a sustainable industry for the next generation.

CHAIRMAN'S MESSAGE

Our world is changing and will continue to change. We are in the early innings of a decade of change marked by the clean energy transition, digitalization, post-COVID build back and of course, geopolitics – all driven by a new family of global shipping shapers addressing a new language of shipping – CO₂ emissions per ton mile or net zero by 2050, and requiring that we deal with a new set of safety boundary conditions, technology readiness timelines and commercial relationships.

Against this backdrop of change and uncertainty, ABS continues to follow its mission and safety-centric strategy, which has served us well over the last 10 years, as we leverage our domain expertise to create new growth opportunities and value for our clients.

Our steadfast focus on exceptional and timely product development, strong client and industry relationships, highly efficient services, and effective talent development and learning capabilities has guided our decision-making and investments. As a result, we continue to grow and to perform at world class levels as the safety conscience of the industry.

Through 2021, our focus on industry fundamentals allowed us to grow our classed fleet to 279 million gross tons (m gt); secure the number one position in orderbook share; maintain our industry leadership across the entire global offshore market; and continue to guide the industry in safety and retain our position as the top performing Recognized Organization (RO) since 2017 in the three most active port State regions, with a record zero port State detentions in 2021 – a truly exceptional performance.

Our ongoing dedication to being recognized as the marine, offshore and energy industry technology authority saw us partner with leading industry players in groundbreaking international joint development projects (JDPs), positioning ABS as a leader in the future of classification and the recognized technology leader in our increasingly digitized and data-driven world. We demonstrated this leadership in many ways, such as through a landmark 3D modeling collaboration resulting in the first commercial vessel in U.S. history to be produced and ultimately constructed using only 3D models in design and construction.

Other industry technological milestones were passed when we shared our additive manufacturing (AM) expertise in a JDP that successfully fabricated, tested and installed functional AM-created parts on board an oil tanker at sea, and when we supported development of the world's first fully remotely controlled commercial tugboat.





Our commitment to lead the industry and support our clients with advanced analytics and intelligence to facilitate decision-making was underlined when we launched the ABS Global Simulation Center in Singapore and applied our advanced multi-physics modeling and simulation expertise to introduce a pioneering new SIM-based Energy Efficiency Evaluation (EEE) Service to support shipowners with evaluating their vessel decarbonization options and assessing new concepts in design, engineering and operations.

We are well positioned and continue to make the right investments in our people, our systems and technologies to drive and shape the future of class. We continue to make significant investments in digital technologies to advance the cause of safety and operational excellence in tandem with the industry's decarbonization and sustainability ambitions while moving us toward a more condition-based approach to class.

A key element of this was developing the industry's most comprehensive suite of remote surveys, which saw nearly 150 percent year-on-year growth. We successfully piloted 360-degree cameras on board that provided visuals back to our team in the ABS Decision Support Center (DSC) to make class decisions in real time, and we completed an important systems integration allowing any computerized maintenance management system (CMMS) to now link directly to the ABS MyFreedom™ Client Portal for survey, compliance and maintenance reporting, which offers clients a path to receive class credit for executing approved planned and condition-based activities.

Rich new functionality and enhanced capabilities ensured ABS My Digital Fleet™ was further established as the industry's only risk management platform that seamlessly integrates data to provide real-time insights for driving sustainable operations and reducing operational risks. Through the ABS My Digital Fleet Alliance program, we collaborated with some of the world's leading digital developers to give our clients access to trusted intelligence and technology providers with integrated insights on one unified platform.

Recognizing early on that the clean energy transition requires teamwork, cooperation and sharing of expertise, ABS built on our position as a founding member of the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping by joining leading flag States and classification societies to launch the Maritime Technologies Forum (MTF) in 2021 to facilitate the safe testing and adoption of new technologies and help shape global regulation. We also supported formation of the Blue Sky Maritime Coalition dedicated to achieving a commercially viable net-zero emissions waterborne logistics sector for North America.

In 2021, we expanded our global sustainability client support by opening the ABS Shanghai Sustainability Center, adding to our existing network of centers in Houston, Copenhagen, Athens, Singapore and London, and we launched our third Sustainability Outlook, offering a global view of the value chain and the innovative carbon-reduction practices in play today.

At the same time, we continued developing new tools and strategies to help shipowners decarbonize their fleets, such as offering our SUSTAIN-1 notation attesting to a vessel's alignment with key elements of the ESG requirements outlined in the United Nations' (U.N.) Sustainable Development Goals (SDGs). We also launched new sustainability reporting and assurance services to help service providers demonstrate to clients their commitment and progress toward sustainable operations.

In the offshore sector, ABS led the formation of a working group comprised of leading companies and regulatory authorities to focus on developing best practices to address the safety challenges of the aging global floating production, storage and offloading (FPSO) fleet, and we expanded our safety-focused guidance to support operators looking to extend the operational life of floating production installations.

Our expertise with floating offshore energy platforms has informed our work with floating offshore wind installations, and, in 2021, we helped the growing sector make inroads into this key clean energy source around the world. ABS accepted Portugal's Windfloat wind farm into class – a world first and another industry milestone. We went on to class the world's largest floating offshore wind farm off the coast of Scotland and provided verification services related to the first U.S. project offshore Rhode Island.

We also reinforced our longstanding technical support of governments around the world, including working closely with the U.S. Navy on development of ship acquisition programs for autonomous operations and for a wide range of auxiliary ships and support vessels. We continued our pioneering work with the U.S. Military Sealift Command (MSC) to implement the ABS condition-based program and cybersecurity notations for the MSC fleet and utilized our modeling and simulation expertise for a U.S. Department of Energy (DOE) program for evolving the design and use of advanced nuclear reactors.

In Singapore, the Maritime and Port Authority again renewed its research, development and innovation partnerships with ABS, continuing a wide-ranging relationship that covers such diverse areas as decarbonization, artificial intelligence, predictive maintenance, cybersecurity and additive manufacturing. ABS also introduced a pioneering digitalization learning program in a collaborative effort with SGUnited, a Singapore government organization dedicated to skills building and education of the country's youth, where ABS is providing hands-on training in the modeling and simulation of systems.

These diverse and exciting achievements demonstrate the strength, capability and vision that have long been the hallmark of ABS and continue to define us today.



In 2021, our subsidiary, the ABS Group of Companies, Inc. (ABS Group), continued to deliver the kind of industry-leading performance and solutions that have built a reputation for excellence – surpassing six years without a lost-time incident in 2021, and winning recognition from Forbes and Statista as one of America's Best Management Consulting Firms.

ABS Group supported clients around the world with cybersecurity services from its centralized Industrial Security Operations Center. Continuing its long relationship with the U.S. government, ABS Group also aided the Department of Defense (DOD) and Department of Homeland Security (DHS) in their initiatives for enhanced digital safety and sustainability.

At the same time, ABS Nautical Systems® (NS) continued its global leadership in digital transformation assistance by adding 460 vessels to its client list in 2021, bringing the total vessel user count to over 4,000, while continuing to enhance the features of NS eLogs™, the first electronic logbook solution on the market offering the complete suite of The International Convention for the Prevention of Pollution from Ships (MARPOL) books that seamlessly integrate with NS Enterprise.

None of this would have been possible without the skill and spirit of our people, who are also affected by this time of change. We understand how digitalization and decarbonization have introduced a requirement for hybrid skillsets, thinking and mindsets. Historically, talent has been defined as the sum of age, experience, skills and training. However, today's redefined talent equation couples technology and people with continuous learning models to develop leaders who have systems and design thinking skills as well as a convergent mindset and greater strategic perspective centered around technical feasibility, economic viability and social sustainability.

That's why, throughout 2021, we continued our investments in people – delivering more than 90,000 hours of new or enhanced training for our employees, transforming our continuous learning program for surveyors, auditors and engineers and building our talent pipeline through our Aspire rotational program for newly hired graduates.

Across ABS and ABS Group, in all that we do, we remain focused on our cornerstone values of safety and integrity, serving our members and clients with the professionalism and commitment they expect and deserve.

An organization is only as great as its people, and I applaud our incredible dedicated employees who live and work in the SPIRIT of ABS every day – committed to Safety, People, Integrity, Reliability, Innovation, Teamwork and Quality. I also want to thank our loyal clients for putting their trust in ABS, recognizing that we trade on integrity every day.

Success is a team sport. All that we accomplished – we did together.

2021 represents a significant chapter of our developing story, and we are looking forward to sharing it with you.



Christopher J. Wiernicki
Chairman, President and CEO, ABS
Chairman, ABS Group of Companies, Inc.

“We are well positioned and continue to make the right investments in our people, our systems and technologies to drive and shape the future of class.”

CHRISTOPHER J. WIERNICKI
CHAIRMAN, PRESIDENT AND CEO

INDUSTRY LEADING SAFETY AND QUALITY

SAFETY LEADERSHIP

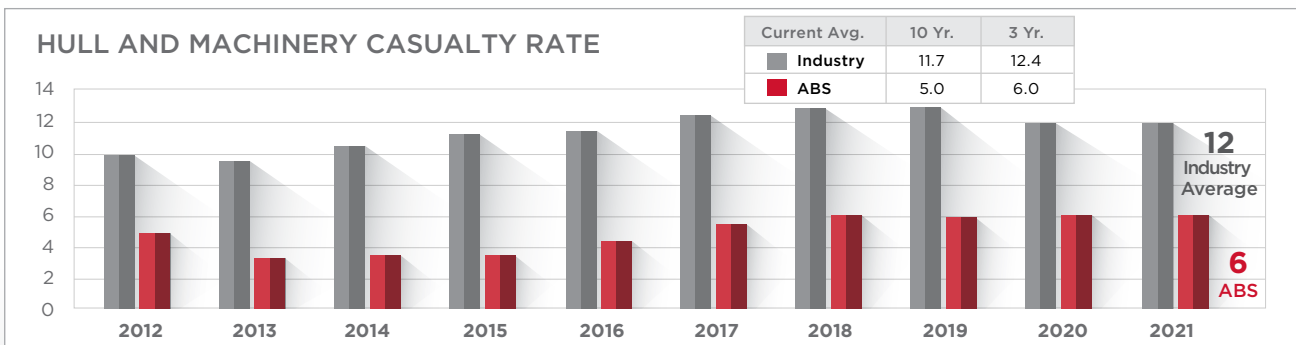
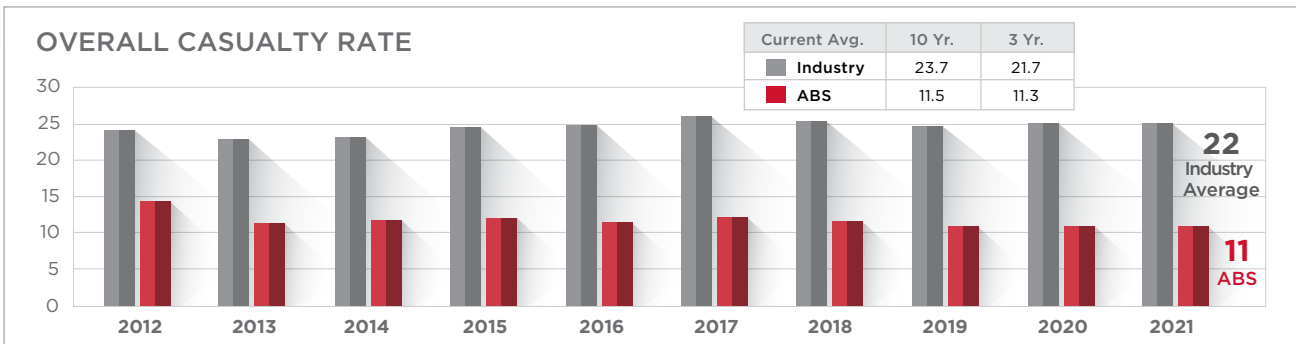
Safety is the foundation of everything we do at ABS and an endless pursuit. For ABS, safety is a core value. We have built our reputation as an industry leader in maritime safety underpinned by a commitment to continual improvement and developing a strong safety culture for our workforce. What we do matters to the lives of people and the quality of the environment. ABS empowers employees with the knowledge, tools and authority to maintain safety at work and in everyday life. Our safety record has been compiled on countless ships, offshore facilities, shipyards, industrial sites and corporate offices globally. We are vigilant in our goals to improve safety practices and dedicated to making our workplace a safe environment.

“Safety is the ultimate boundary condition. Everyone at ABS is laser focused on ensuring that this does not get overlooked in the rush for low carbon operations or the digitalization of our industry.”

CHRISTOPHER J. WIERNICKI
CHAIRMAN, PRESIDENT AND CEO

ABS SAFETY PERFORMANCE

In our long safety tradition, each year's successes form the foundation of next year's achievements, fueling the voyage that has made ABS a global Health, Safety, Quality and Environmental (HSQE) leader. Our field staff continue to have weekly safety meetings, and office staff meet monthly to discuss specific safety issues locally or cover elements of our safety theme that we develop each year. In 2021, our safety theme was “Working from home through COVID-19.” In 2022, our safety theme is “SafetyPresent,” a program dedicated to mental focus and monitoring changes in behaviors and in the immediate environment.



Source: ABS, Informa (LMIU) Database, December 2021

In 2021, we issued 12 Golden Eagle Health and Safety awards to individual employees worldwide dedicated to a proactive health and safety program, while our Chairman's Safety award was issued to all field staff. This further demonstrates that we are a safety-driven organization and is a testament to the safety awareness of our staff, their commitment to safe practices and procedures and the success of our overall safety methodology.

OCCUPATIONAL HEALTH AND SAFETY PERFORMANCE

The ABS ongoing safety excellence initiative incorporates strong occupational health and safety processes and policies, including a Stop Work Obligation rule authorizing all employees to intervene if safety is in question in any aspect of their work. ABS continues to increase engagement in leading safety behaviors, including timely reporting of potential incidents or hazards and documenting near misses. Health and Safety campaigns and robust incident reporting campaigns were used to reinforce reporting non-loss incidents.

- ABS' three-year averages of key safety measurements continue to be among the best in our industry:
 - Lost-time incident rate (LTIR) of 0.25
 - Total recordable injury rate (TRIR) of 0.36
- ABS employees continue to make good use of our global reporting system to capture unsafe conditions, unsafe behaviors, near misses, and work-related injuries or illnesses.
- ABS maintained our ISO 45001 certification in 2021, with external audits performed by the British Standards Institute (BSI).

QUALITY PERFORMANCE

In 2021, ABS continued high-quality service delivery to our global client base. ABS maintained its leading position on overall Port State Control (PSC) performance, being the top performing Recognized Organization (RO) in the three most active PSC regions of the world from 2017 to 2021. In 2021, ABS had zero RO-related detentions in the three most active PSC regions, establishing an all-time record – a major achievement and testament to ABS' quality performance.

- U.S. Coast Guard (USCG) – ABS maintained zero RO-related detentions for the last 13 years
- Paris MoU – ABS had one or fewer RO-related detentions each year over the last eight years
- Tokyo MoU – ABS averaged one RO-related detention per year over the last six years

ABS GROUP OF COMPANIES, INC. SAFETY PERFORMANCE

Building on the parent organization's ongoing commitment to its safety mission, ABS Group of Companies, Inc. (ABS Group) surpassed six years without an LTI in 2021.

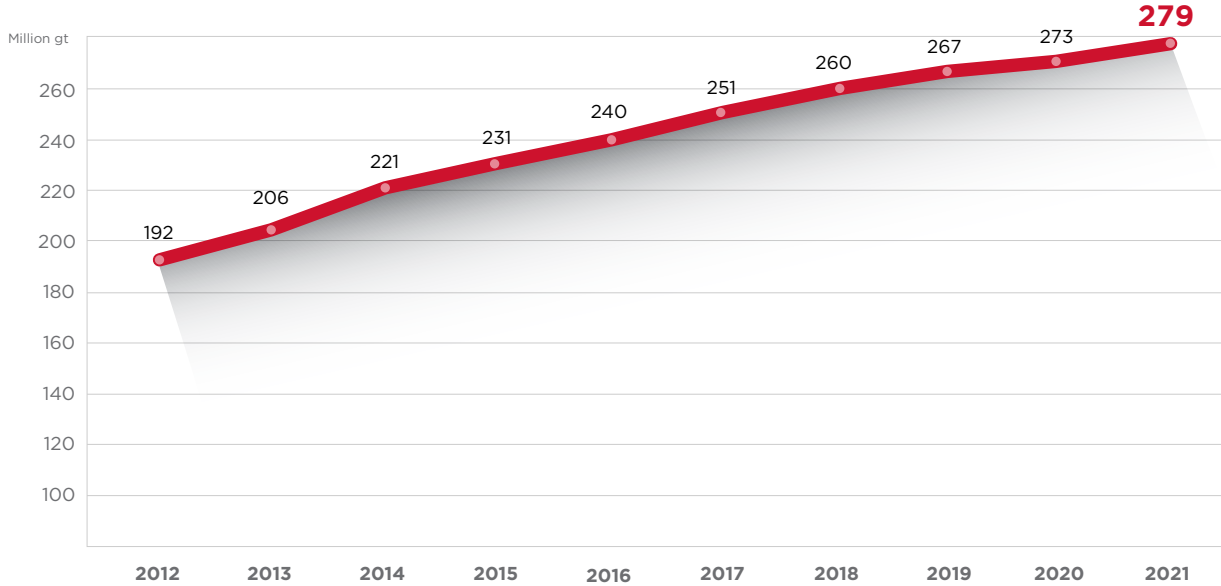
In 2021, we issued four Golden Eagle Health and Safety awards to individual employees worldwide, while our Chairman's Safety award was issued to all field staff.

- ABS Group's three-year average of key safety measurements continue to be among the best in our industry:
 - Lost-time incident rate (LTIR) of 0.00
 - Total recordable injury rate (TRIR) of 0.00
- ABS Group employees continued to make good use of its global reporting system to capture unsafe conditions, unsafe behaviors, near misses, and work-related injuries or illnesses.
- ABS Group achieved recertification to ISO 45001 in 2021, with external audits performed by the British Standards Institute (BSI).

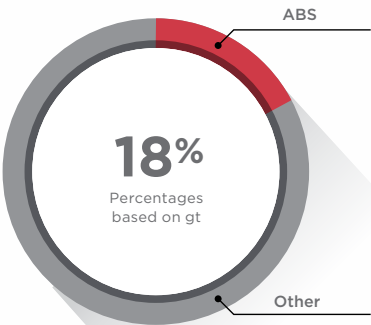
This achievement demonstrates ABS Group's focus on continually improving the effectiveness of its health, safety, quality and environmental culture, performance and management system.

INDUSTRY LEADING PERFORMANCE

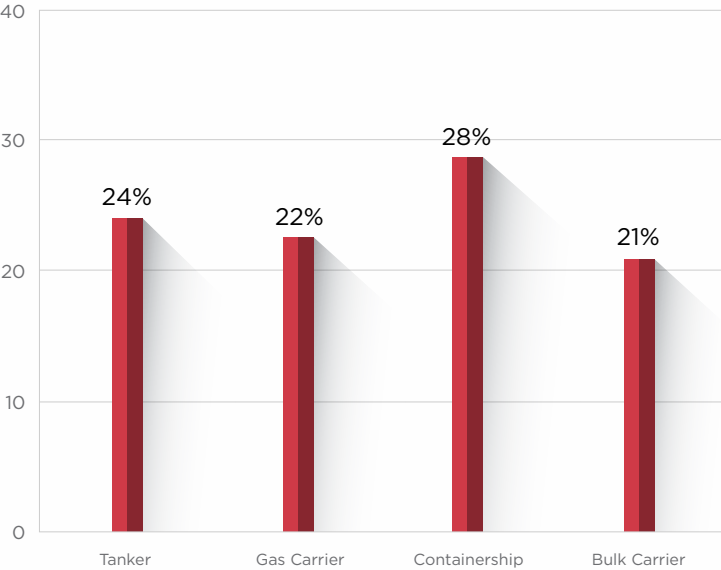
EXISTING FLEET 2021



EXISTING FLEET 2021



MARINE ORDERBOOK SHARE 2021



LEADING ORDERBOOK FOR SHIPBUILDERS

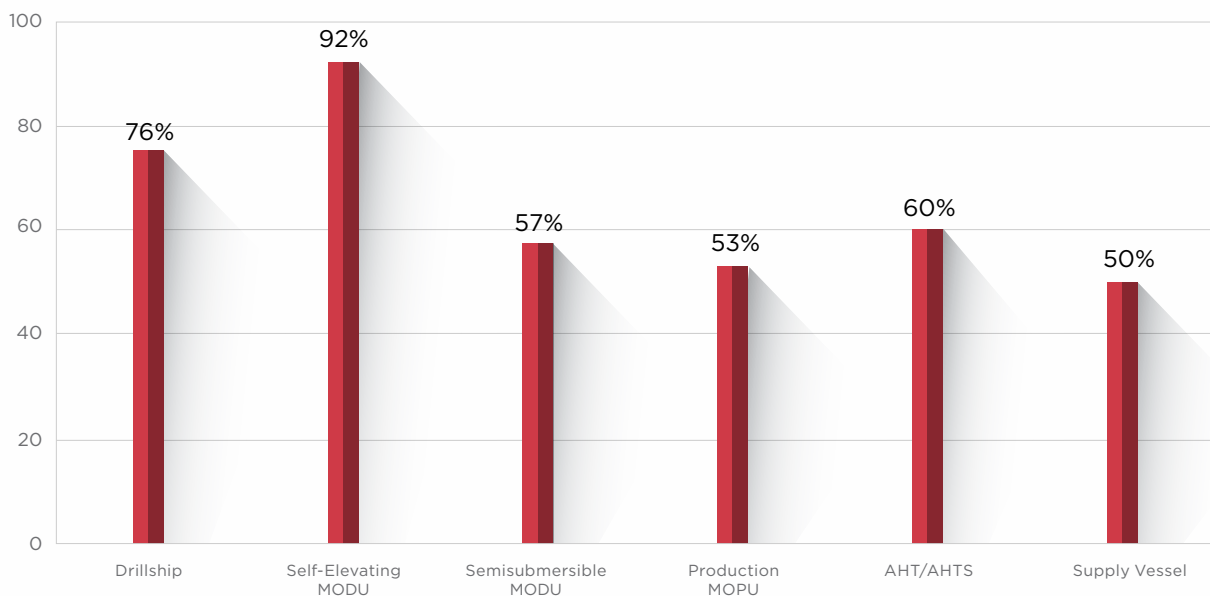
- BRAZIL
- CHINA
- JAPAN
- SINGAPORE
- S KOREA
- TAIWAN
- USA

LEADING EXISTING FLEET FOR OWNERS

- BRAZIL
- DENMARK
- GREECE
- HONG KONG
- JAPAN
- SINGAPORE
- S KOREA
- TAIWAN
- USA



OFFSHORE ORDERBOOK SHARE 2021



SHAPING A
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DIGITAL SOLUTIONS AND **INNOVATION**



DIGITAL SOLUTIONS AND INNOVATION

ABS MY DIGITAL FLEET™ DELIVERS UNMATCHED DIGITAL SUSTAINABILITY LEADERSHIP

Recognizing that connectivity and data-informed decision-making is a critical enabler in maritime digitalization, ABS My Digital Fleet™ created an Alliance Program to elevate product intelligence and high-quality data for its users and ABS clients. Today, the Alliance Program facilitates secure connectivity between both maritime and technology companies, then combines these data streams through the ABS My Digital Fleet platform. It is a growing ecosystem of industry players who share a common goal of developing tools and products to provide integrated insights for clients on one unified platform to support the maritime industry in operating more sustainably and efficiently.

By adding rich functionality and new capabilities to support operational, environmental, structural and machinery asset health and performance, the 2021 product enhancements to ABS My Digital Fleet placed intense focus on the maritime industry's dual challenge of maintaining business competitiveness while adjusting operations for achieving environmental compliance.

“ABS My Digital Fleet is bringing voyage insights that enable the flexibility to optimize for what is most important for each voyage, delivering the optimal route that supports charterers and ship managers in their daily operational decision-making towards meeting decarbonization goals.”

PAUL SELLS

CHIEF EXECUTIVE OFFICER
DIGITAL SOLUTIONS

- In August, ABS launched enterprise-grade artificial intelligence (AI)-powered chatbots and voicebots on ABS My Digital Fleet. It was an important industry first, because no such digital solution had previously been deployed to provide shipping companies with useful information and support in a conversational manner on a global scale.

Yellow.ai's technology, the world's leading conversational AI platform, is capable of conversing in 100+ languages. This service gives users data-driven insights from the ocean of information streaming off the world's vessels and is geared toward helping users increase efficiency in managing operational risk.

ABS AND KONGSBERG DIGITAL JOIN FORCES TO POWER MARITIME DIGITALIZATION AND DECARBONIZATION

In October, two of the maritime industry's most advanced digital service providers joined forces to deliver a sophisticated analytics service that simplifies access, both at sea and shoreside, to AI-powered insights that support voyage optimization through reduced fuel consumption, lower bunker cost, lower carbon intensity and improved charterparty compliance. A product integration of Kongsberg Digital's Vessel Insight program and the ABS My Digital Fleet™ platform, the AI-driven service merges data acquisition capabilities from Kongsberg Digital and ABS' business intelligence capabilities to offer shipowners, ship managers and charterers seamless access to the industry's most powerful analytics.

Vessel Insight performs vessel-to-cloud data infrastructure captures, then aggregates and contextualizes the data and transfers it for storage in the cloud through Kongsberg's proprietary "Kognifai Cloud" network. This data is then accessible for analytics on the ABS My Digital Fleet platform. As part of the ABS My Digital Fleet Alliance Program, Kongsberg Digital's Kognifai open digital marketplace offers ABS My Digital Fleet as an integrated service, and ABS offers Kongsberg Digital's Vessel Insight as an integrated service within ABS My Digital Fleet.

SEAMLESS CONNECTIVITY

KONGSBERG

ABS

VESSEL INSIGHT
The gateway to next generation shipping

ABS MY DIGITAL FLEET™
Connect Your Data.
Reduce Your Risks.
Drive Sustainable Results.

POWERFUL INSIGHTS

The AI chatbot acts as a virtual fleet manager to assist users with critical fleet tracking information, including weather, equipment and fuel monitoring, Carbon Intensity Indicator (CII) monitoring, route optimization, generating easy-to-view dynamic charts on demand and more through the ABS platform.

- For decades, industry has sought to improve weather forecasting and, through better understanding of weather patterns and prediction capabilities, improve such important aspects of the transport chain as voyage routing. In August, ABS added on-demand, high-resolution historical and forecast weather data service to its ABS My Digital Fleet risk management platform.

Meteomatics, one of the world's leading weather service providers, joined the Alliance Program, providing weather data that enables actionable insights for users to help them delineate and lower a vessel's fuel consumption, improving its bunker costs and carbon intensity levels. It also exposes the potential structural impacts from weather exposure during a ship's voyage, helping operators better understand and reduce risk.

By overlaying the most up-to-date weather data on the voyage map, the system delivers on-demand forecasts while a vessel is underway, which lets operators react by, for example, adjusting timetables and routes. The resulting efficiencies in fuel consumption and optimized voyage speeds increase reliability in arrival times and improve navigational safety. Coupled with the machine-learning capabilities of the ABS My Digital Fleet platform, the service is a significant step for the maritime industry in its journey towards digitalization and decarbonization.

ABS AND SOFAR OCEAN DRIVE DECARBONIZATION THROUGH VOYAGE OPTIMIZATION

The maritime industry has a long history of pursuing route optimization with the goal of combining efficiency and safety. In November, Sofar Ocean joined the ABS My Digital Fleet™ Alliance Program to help the industry move toward the day when truly optimized voyage routing will be part of everyday operations.

Sofar Ocean operates an “ocean intelligence platform” informed by a large network of coastal and open ocean drifting sensors, known as spotter buoys, covering all five of the world's oceans. The resulting data enables Sofar to provide dynamic route guidance, evaluating over 100 million routing options daily based on the latest weather forecast data, charter party requirements and decarbonization goals. The Sofar Ocean platform integrates with ABS My Digital Fleet to deliver voyage-planning insights tailored for each vessel and journey, supporting shipmasters and fleet operations staff to act when needed to support desired outcomes.

Actionable insights available from this system include optimization of sea route, speed and heading, and arrival time, with calculations based on such considerations as weather, vessel performance and bunkers.



- In the sustainability journey there are many moving targets, meaning knowledge security is a delicate thing; one can never have too much input because there is always a higher level of informed decision-making to attain. For this reason, ABS and AVEVA, a global leader in industrial software, joined forces in October to deliver real-time digitalization and decarbonization insights for the maritime community.

ABS My Digital Fleet works with AVEVA's PI System™ operational data management platform to absorb and normalize large quantities of fleet sensor data. This operational data is then analyzed by ABS' machine learning models, which provide insightful solutions to help strengthen smart ship operations and enable users to derive powerful live insights into voyage performance, through which they can reduce fuel costs and meet decarbonization goals.

The capability to store and blend real-time data streams with ABS' advanced analytics capabilities contextualizes and visualizes operational data, which grants users an unprecedented degree of visibility into their fuel consumption trends and carbon footprints.

- The ever-changing ocean of international environmental regulations can be challenging to navigate. To help clients address this issue, ABS welcomed into the ABS My Digital Fleet Alliance Program EMH Systems, which operates a comprehensive global database of the most up-to-date regional and international environmental regulations.

The combination of the ABS My Digital Fleet platform with EMH Systems' advanced database and management capabilities delivers visibility into waste stream restrictions and allowances and detailed insights into all applicable regional and international regulations throughout a voyage. This enables vessels to manage operational risks through such actions as advanced route-planning and active monitoring of discharges based on geolocation, which help minimize penalties and improve efficiency among even experienced crews.

- A key part of the ABS My Digital Fleet risk management platform, Environmental Monitor is a cloud-based application performing vessel waste stream and emissions data analysis to help vessels, fleets and companies meet their decarbonization, digitalization and wider sustainability ambitions. Through advanced data analysis, this digital solution provides deep insight into environmental performance, through such actions as monitoring and tracking overall fleet or vessel-specific environmental categories such as emissions, garbage, waste and consumables data.



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JOINT DEVELOPMENT **PROJECTS**



JOINT DEVELOPMENT PROJECTS

OPENING A NEW ERA OF COLLABORATION

We call the journeys of decarbonization and sustainability “team sports” for a very good reason: no individual company or single organization has sufficient resources to meet this challenge alone. It is a multilayer, multipart challenge extending over time and reaching across all levels of virtually every industry on the planet, and the maritime sector is the glue that will hold together all its value chains. This means we in the maritime and offshore industries need to work together on an unprecedented scale, pooling resources, experience and knowledge, to achieve not only our sustainability ambitions, but also those of the entire world.

Indeed, the maritime and offshore energy sectors can make a significant impact on the global sustainability journey. For, although they have comparatively little impact to offer in terms of pure carbon reduction – according to many estimates the maritime industry produces about three percent of world carbon emissions and the entire oil and gas industry contributes about six percent, as compared with heavy industry at about 40 percent – they can add significantly to the global carbon value chain in both transportation and sequestration capacities.

That is why in 2021, ABS initiated a record number of joint development projects (JDPs) and collaborative industry efforts geared towards various aspects of the decarbonization challenge.

FOUNDING MEMBERSHIPS IN GROUNDBREAKING COLLABORATIVE EFFORTS

Recognizing that shipping faces increasing technology challenges that can only be resolved through deep collaboration and pooling of resources, experience and knowledge, ABS became a founding member of two new groups that will be key to the future of the industry’s decarbonization and sustainability efforts. This is a logical and necessary follow-up to our work as a founding member of the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping in 2020.

- In April, ABS joined leading flag States and classification societies to launch the Maritime Technologies Forum (MTF), a group whose goal is to provide technical and regulatory research, consultation and leadership to help the shipping sector, the International Maritime Organization (IMO) and other regulators to address technical and regulatory challenges related to decarbonization and sustainability. MTF members collaborate on research and draw on their collective regulatory expertise to offer unbiased advice to the shipping sector, sharing insights and guidance with the marine industry for the purpose of facilitating the safe testing and adoption of new technologies, while also helping shape global regulation.



HARBOR TUG DEVELOPED BY KEPPEL O&M THE FIRST TO RECEIVE ABS REMOTE-CONTROL NAVIGATION NOTATION



ABS leadership in autonomous and remote control vessel technologies was underscored by another project in which a remotely operated harbor tug, developed by Keppel Offshore & Marine (O&M), became the first in the world to receive the ABS Remote Control Navigation Notation. The vessel received the REMOTE-CON notation after passing sea trials under remote control from Singapore's Maritime Innovation Lab in April.

The need for a group with such a focus is more evident now than ever before, as we are entering an era where regulations and standards need to move at the same pace as technological breakthroughs, within a responsive and evolving global regulatory framework that will be used for the adoption of the technologies that will support the new value chains that we must create.

- In June, to support development of new North American maritime value chains, ABS helped establish the Blue Sky Maritime Coalition, an organization whose goal is to develop and take action on projects designed to achieve a commercially viable net-zero-emissions waterborne logistics sector.

LEADERSHIP IN ALTERNATIVE FUELS RESEARCH

- In January, ABS collaborated with Nanyang Technological University (NTU) Singapore, the Ammonia Safety and Training Institute, and a group of leading industry organizations to study the supply, bunkering, and safety challenges of ammonia as a marine fuel. The joint study *Ammonia as a Marine Fuel in Singapore – Supply Chain, Bunker Safety, and Potential Issues*, covers sustainable technologies, safety protocols and possible gaps related to establishing an ammonia supply chain.

- In April, ABS brought its experience with solid oxide fuel cells (SOFCs) to a JDP funded by a grant from the Danish government, the goal of which is to accelerate development of high-efficiency SOFC technologies with the scalability to support marine industry decarbonization. SOFCs electrochemically convert fuel into electricity, and therefore have the potential to produce power with higher efficiency than internal combustion engines running on the same fuel, but without producing particulates and other emissions pollution. The JDP SOFC4Marine targets the use of SOFCs and green fuels for reducing the carbon footprint of future vessel designs. The program builds on the work of previous JDPs between ABS and Daewoo Shipbuilding & Marine Engineering Co., Ltd. (DSME), which developed SOFC technology to replace diesel generators aboard a very large crude carrier (VLCC) and makes use of the *ABS Guide for Fuel Cell Power Systems for Marine and Offshore Applications*.
- In June, a group of 23 industry leaders invited ABS into a joint study program to examine issues surrounding the use of ammonia (NH₃) as a marine fuel and the development of a global ammonia supply chain. Hailing from such diverse industrial sectors as energy, mining, power generation, chemical production, terminals, shipping, shipbuilding, manufacturing and bunkering, the partners are sharing their knowledge and expertise to resolve questions and concerns in areas including the safety assessment of NH₃-fueled vessels, the safety assessment of NH₃ bunkering, general NH₃ fuel specifications and net CO₂ emissions of NH₃ production.
- In November, ABS entered into two JDPs that have the potential for revolutionary results in the areas of green hydrogen fuel production and carbon capture, utilization and storage (CCUS) technologies for maritime decarbonization and global sustainability efforts. Partnering with Hyundai Heavy Industries (HHI) and Korea Shipbuilding and Offshore Engineering (KSOE), ABS will help develop technology and guidance for green hydrogen production from offshore platforms, which will be a key first step to the design and construction of a facility by 2025. Later stages potentially include obtaining ABS approval in principle (AIP) and generic design approval to support project engineering and construction. Most notably, the project is focusing on the electrolysis of seawater as the means of generating green hydrogen, which will be extremely important for the long-term sustainability of global freshwater reserves. The second JDP between these partners is focusing on securing an AIP for HHI's and KSOE's design for an offshore platform containing specialized CO₂ injection equipment for offshore sequestration.
- Another fruitful JDP between ABS and HHI concluded in September with production of an enhanced liquefied natural gas carrier (LNGC) design that featured an optimized hull form and advanced machinery, electrical and piping arrangements. The project also furthered development of new Rule requirements, introduced a simplified approval process and addressed growing industry demand for crew accommodation and workspace designs to mitigate the spread of infectious diseases.



GROUNDBREAKING JDPS IN LOW-CARBON VESSEL DESIGN

- In February, ABS entered a long-term JDP with global towage operator Svitzer and Kongsberg Maritime to produce the world's first fully remotely controlled commercial tugboat. The JDP RECOTUG™, aims to develop a vessel capable of full towage services while controlled solely from a remote operations center. The goal is to achieve a safety level for the technology that will lead to class and flag approval, ultimately permitting Svitzer to conduct commercial remote tug operations in the Port of Copenhagen.
- Two other advances in remote monitoring and autonomous operation of tugboats occurred in the Port of Singapore in 2021. In one, ABS awarded AIP to the technology employed in an autonomous tug that passed sea trials in the Port of Singapore. Under the Smart Maritime Autonomous Vessel (SMAV) project, a harbor tug was retrofitted with autonomous navigation, collision detection and collision avoidance technology,

ABS, HUDONG-ZHONGHUA SHIPBUILDING AND WÄRTSILÄ LAUNCH JOINT DEVELOPMENT PROJECT FOR IMO 2050 CII-READY LNG CARRIER

To help shipowners face the daunting challenges and uncertainties stemming from IMO's Carbon Intensity Indicator (CII) and its 70 percent carbon reduction target for 2050, ABS engaged in a JDP with Hudong-Zhonghua Shipbuilding and Wärtsilä to develop a flexible, modular concept for a multi-fuel electric liquefied natural gas carrier (LNGC). Using advanced multi-physics modeling and simulation, specialists from the ABS Global Simulation Center and Global Sustainability Centers in Singapore, Houston and Athens began working with partner research and development (R&D) teams to test various decarbonization technologies and solutions for this novel design and to assess its performance against IMO's CII requirements.



which were remotely monitored from a shoreside control center in the Maritime and Port Authority of Singapore's Maritime Innovation Lab. The SMAV project was one of several initiatives that informed development of the *ABS Guide for Autonomous and Remote-Control Functions*, which introduced the AUTONOMOUS notation and set a goal-based framework for implementation of such technologies on vessels and offshore units.

- March saw ABS and Aries Marine complete a JDP that piloted the use of 3D models to streamline the plan review process for classification of piping systems. The program included using 3D computer aided design (CAD) models and 3D laser scans to represent a retrofit design. In confirming that the 3D process works for piping system design, the project represented a significant step forward in shaping the digital future of classification.

ABS APPROVES 3D PRINTED SPARE PARTS AFTER SUCCESSFUL TESTING ON AN OIL TANKER



© Polar Tankers

In February 2021, ABS shared its additive manufacturing (AM) expertise in a JDP with Sembcorp Marine, 3D Metalforge and ConocoPhillips' Polar Tankers that successfully fabricated, tested and installed functional AM-created parts on board the oil tanker *Endeavor*. The parts passed rigorous approval, reliability and safety tests. The three parts are: a gear set and gear shaft for a boiler fuel supply pump; a flexible coupling that connects a driver and shaft for power transmission to a marine sanitation devices pump; and an ejector nozzle for a freshwater generator that increases the fluid velocity to transform high static pressure into velocity pressure.

In November, the parts were validated to be in good working condition. This small but important success brought the industry a significant step closer to the day when ships will no longer be stranded because of mechanical issues because with the right training and use of technology, they will be able to make repairs at sea using new parts fabricated on board.

- May saw the end of one landmark JDP and the beginning of another. First, ABS joined with the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping in a JDP aimed at addressing looming technical issues for today's newbuildings, whose operating lives will take them through a period of constantly evolving regulatory demands and expectations. The JDP's remit includes assessing the technical, environmental and financial challenges confronting the owners of existing vessels who may wish to switch from fossil fuels to zero-carbon technologies at some future time. Informed by the *ABS Guide for Gas and Other Low-Flashpoint Fuel Ready Vessels*, which introduced an *Alternative Fuel Ready* program for the marine industry, the JDP will focus on the needs of such vessel types as containerships, tankers and bulk carriers.
- Also in May, ABS announced completion of a JDP with HHI and Hyundai Global Service (HGS) that explored decarbonization and digitalization in the marine and offshore industries. The project covered simulation and modeling of the carbon footprint of a vessel incorporating energy efficiency technologies, LNG bunkering analysis and smart systems. ABS also issued approval in principle (AIP) to the Hyundai Intelligent Smart Solution Service System, which uses artificial intelligence (AI) to assist fleet monitoring and performance analysis.
- CCUS technology is key to a low-carbon future, but its full potential cannot be realized without a solid shipping solution to transport captured carbon. Understanding this, ABS engaged with DSME to jointly develop designs for a 70,000 cubic meters (m³) liquefied CO₂ (LCO₂) carrier. The project is historically necessary because existing LCO₂ technologies are geared towards the comparatively small existing carriers used by the food industry, and the future carbon value chain will need much larger LCO₂ tank sizes. In order to develop larger containment tanks, the JDP is focused on studying the application of various steel materials, both new formulations and existing low-temperature steels.

Around the time that project began, ABS marked another advance in LCO₂ technology when it granted AIP to a new vessel design resulting from a six-month JDP between ABS, Hyundai Mipo Dockyard, KSOE and the Republic of the Marshall Islands Maritime Administration.

- Going forward, decarbonization and emissions reduction goals will demand increasingly complex ship systems and vessel designs, which in turn gives an ever-increasing importance to digital simulations in the early stages of the design spiral.

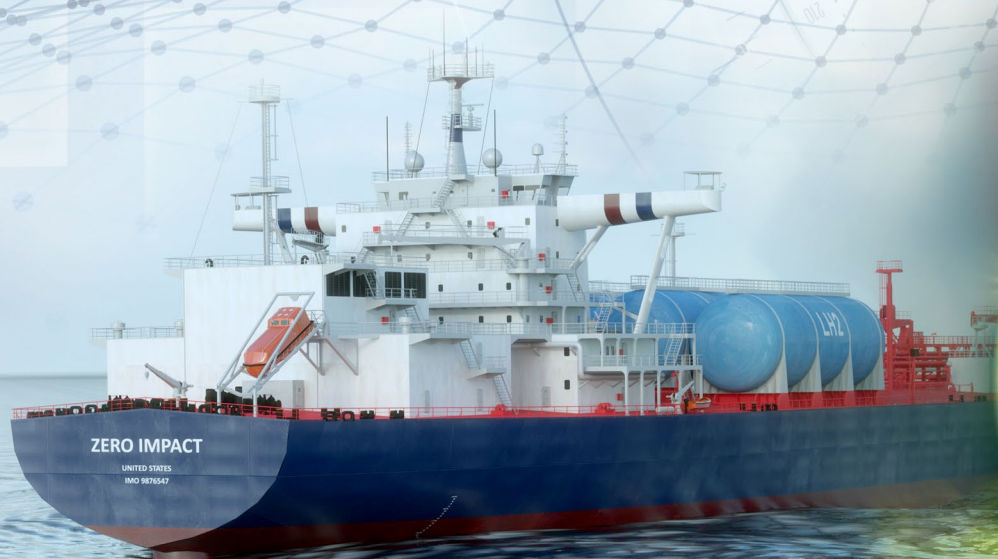
Recognizing that the faster path to achieving the necessary level of simulation accuracy requires a pooling of diverse expertise and operational experience, in December ABS joined forces with the NYK Line to assist the Monohakobi Technology Institute and Winterthur Gas & Diesel to develop modeling and simulation methods for evaluating the impact of new technologies on pure car and truck carrier (PCTC) designs. The goal of this important JDP is to build a richly detailed digital model that will allow high-fidelity simulation of the greenhouse gas (GHG) reduction potential of hybrid propulsion and electric power generation and distribution systems. The model will incorporate a deep understanding of real-world PCTC seakeeping performance, derived from simulations that use meteorological data to recreate a range of conditions experienced at sea.

This effort goes hand-in-hand with an earlier service development from ABS, an industry first named the ABS Simulation-based Energy Efficiency Evaluation Service. Launched in September, the service uses sophisticated modeling and simulation techniques to assess the impact of decarbonization technologies at the design stage and simplify Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) compliance.

LEADING THE WAY IN ADDITIVE MANUFACTURING

ABS first published an advisory on applications of additive manufacturing (AM), also known as 3D printing, in the maritime industry in 2017. Continuing that valuable line of assistance, in 2021, ABS published its *Guide for Additive Manufacturing*. Focusing on two main categories of metal AM processes, Powder Bed Fusion and Directed Energy Deposition, the Guide defines ABS approval and certification processes for AM facilities and AM parts by providing standards for design, feedstock material, pre-build, build and post-build processes, inspection and testing.

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SUSTAINABILITY



SUSTAINABILITY

LEADERSHIP IN THE SUSTAINABILITY JOURNEY

The uniquely broad and deep global effort demanded by global sustainability ambitions requires not only new technology, new science, new infrastructure and new approaches to commerce, but also new ways of thinking about how to accomplish these goals. For this reason, ABS embarked on a program of sharing a cutting-edge series of insightful publications and guidance documents for the industry related directly to navigating the challenges of decarbonization and sustainability.

During 2021, ABS launched a series of publications relating to application of new marine fuels, introduced new services and guidance documents related to sustainability and decarbonization, and engaged in joint development projects (JDPs) dedicated to helping industry accumulate the insight needed to succeed in this historic feat.

AUTHORITATIVE GUIDANCE FOR THE SUSTAINABILITY JOURNEY

- Although its uptake and application as a marine fuel is only beginning, methanol's potential to reduce the CO₂ footprint of marine operations is drawing increasing interest from owners of oceangoing vessels, short-sea shippers, ferries, cruises and inland waterway vessels. In February 2021, ABS published new guidance, *Methanol as Marine Fuel*, evaluating the challenges in design and operation of methanol-fueled vessels. It is the latest in ABS' ongoing series of sustainability-focused whitepapers examining various fuel options for the marine industry.
- Biofuels have been identified as highly promising, low-carbon fuels that can enter the global market relatively quickly and help shipping approach International Maritime Organization's (IMO) greenhouse gas (GHG) reduction targets. Produced from biomass, biofuels have the potential to offset a vessel's carbon emissions through CO₂ absorption of the feedstock, which can help counterbalance combustion emissions. However, the total carbon reduction potential of different biofuels clearly depends on a range of factors related to their value chains.

“Sustainable business practices are quickly becoming a key component of success for businesses globally. No longer are these practices considered optional, but instead necessary to remain competitive in today's market. ABS is marrying its industry-leading marine and offshore experience with world-class sustainability expertise to provide a unique new service to the industry.”

GEORGIOS PLEVRAKIS

ABS VICE PRESIDENT
GLOBAL SUSTAINABILITY



Recognizing this, ABS developed a new document providing guidance on biofuels in shipping. Published in May, the *Sustainability Whitepaper: Biofuels as Marine Fuel* gives an overview of the various types of marine liquid biofuels that are “drop-in” fuel options for replacing conventional fuels in both the near and long term and their potential to contribute to industry decarbonization goals. Other aspects considered include safety, vessel design implications and regulatory challenges.

- Hydrogen is another promising future fuel that appears ideal for power generation on land and at sea, but it carries several daunting challenges to overcome, including a need for special containment materials and a particular risk regarding fire hazard mitigation. If it is to become a competitive alternative marine fuel, hydrogen may also face challenges in availability and cost to scale production and transportation infrastructure. Hydrogen is considered to have a very low tank-to-wake emissions impact, but to assess its overall GHG emissions the life cycle of hydrogen production must, again, be considered.

In June, ABS produced a long-awaited guidance document on the potential of hydrogen in maritime applications. The *Sustainability Whitepaper: Hydrogen as Marine Fuel* explores hydrogen's potential to reduce emissions from shipping and evaluates its safety, regulatory and design implications. The report also details industry projects utilizing hydrogen and ABS' support for its development.

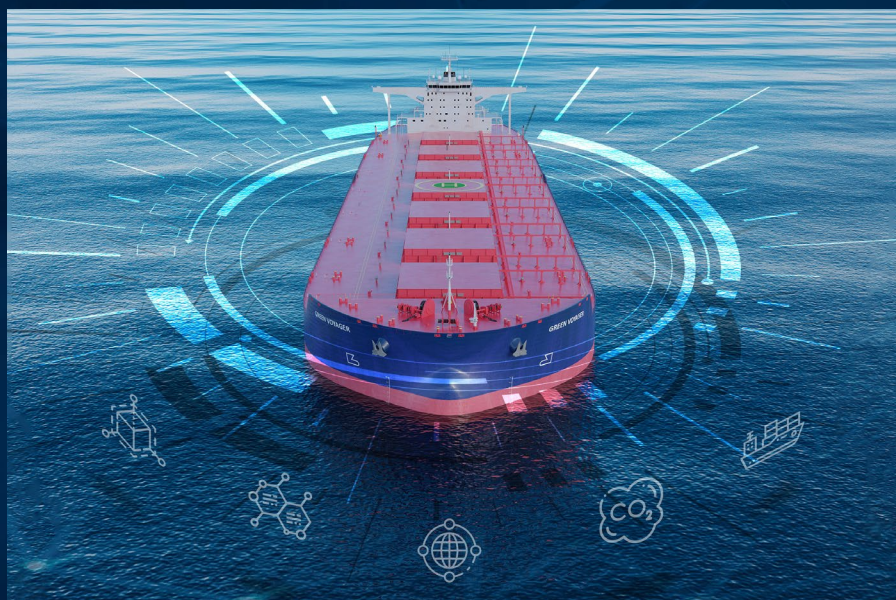
TAKING A LIFE-CYCLE APPROACH TO ALTERNATIVE FUELS

It is widely known that a key element of the sustainability journey is the tracking of greenhouse gas (GHG) emissions, but it is less well-recognized that even green technologies and “net-zero” solutions usually have a GHG footprint hidden somewhere along the value chain.

That's why ABS released a report in April offering insight into the GHG footprint of shipping's value chains. *Setting the Course to Low Carbon Shipping – View of the Value Chain* is the third in a series of outlook documents published by ABS to showcase the latest decarbonization research and thinking.

The report is the result of a pioneering piece of research conducted by ABS and Herbert Engineering to explore the feasibility of transitioning from three conventional vessel designs to low-carbon variants. The research identified differing levels of difficulty, depending on a range of factors including maturity of technology and degree of investment. The report examines potential technical requirements and operational trade-offs that may be necessary in future versions or conversions to low-carbon operations of three existing ship types: a chinamax bulk carrier, an aframax tanker and a feeder containership. The report also explores the present carbon-reduction practices in ports and other shoreside value chain elements. It is a landmark document because it provides some essential thinking relative to continuous process improvement under the umbrella of decarbonization.

The report includes detailed life-cycle, or value-chain, analysis of the GHG footprint of the leading alternative marine fuels. This first-of-its-kind analysis is the heart of the third edition of the *ABS Low Carbon Shipping Outlook* series, which includes an update on the marine sector's progress in reducing emissions and a review of potential future vessel designs.



- With the variety of emerging alternative fuels, it is becoming increasingly clear that the fuel transition is not a search for a one-size-fits-all kind of solution, but for tailored solutions specific to vessel type and service. Each vessel type has its own needs and challenges. For example, attempting to transition a tanker fleet to low- and no-carbon fuels is an incredibly complex process that requires managing compliance against a range of regulations, new technologies, design options and evolving markets. This demands complex decisions and options that were not available even a decade ago. As the leading class for tankers, ABS possesses the necessary blend of corporate knowledge, experience and expertise to help the shipping community navigate this dynamic environment.

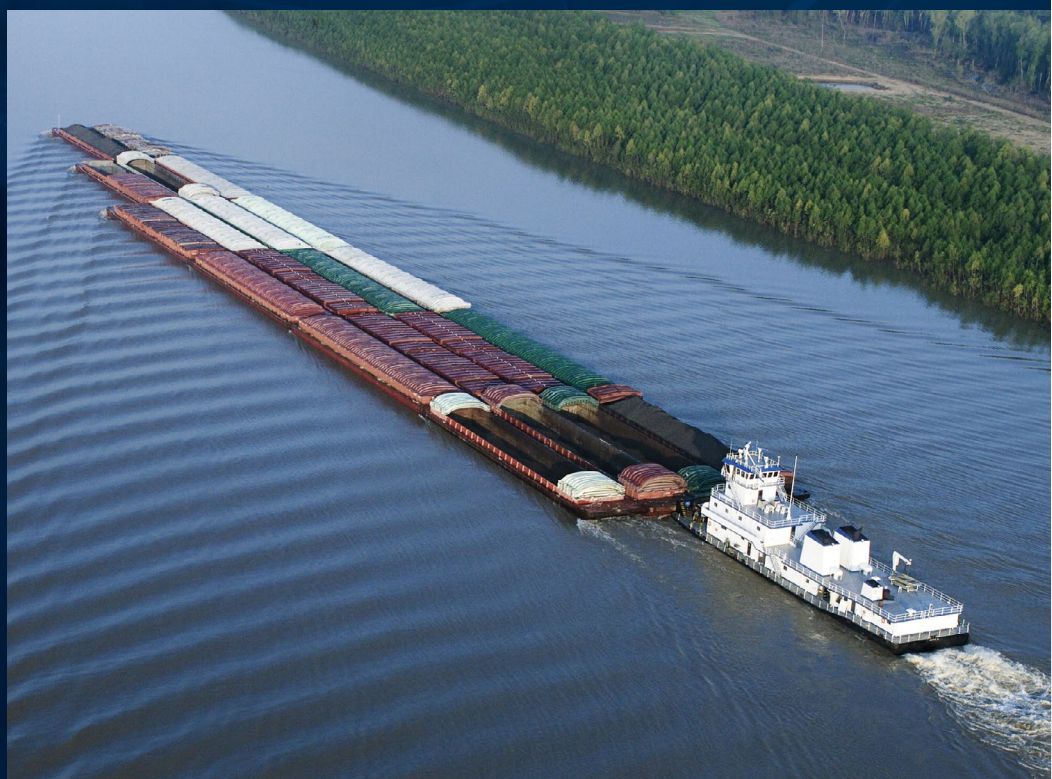
In July, ABS released *Sustainability Trends: Tankers*, the first in a series of publications from ABS evaluating the effects of environmental regulations on different sectors of global shipping. This useful report reviews such regulatory topics as Energy Efficiency Design Index (EEDI), Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII), analyzes the current tanker market, and examines the evolution of vessel design and the latest technological solutions for enhanced efficiency.

ABS AND VANDERBILT UNIVERSITY DELIVER LANDMARK U.S. WATERWAYS DECARBONIZATION REPORT

Much of the shipping industry's decarbonization discussions to date have concerned ocean shipping, but the world's inland waterway systems also have their own sustainability challenge. That's why ABS released a report in September analyzing decarbonization strategies specific to U.S. inland waterways. *Decarbonization of the Inland Waterway Sector in the United States*, was developed in collaboration with Vanderbilt University – specifically, the Vanderbilt Center for Transportation and Operational Resiliency and the Vanderbilt Climate Change Initiative.

The report provides landmark guidance on the potential of possible future propulsion technologies and alternative fuels to reduce carbon emissions. The report also demonstrates the feasibility of near-term electrification of smaller vessels operating on the inland river system with a case study and renderings of a weighted and balanced boat retrofitted with electrical propulsion.

This collaborative study with a leading university evaluates technology options and approaches to help drive decarbonization of the U.S. inland waterways and support a safer, more sustainable fleet. While the emissions profile of the inland waterways is low compared to other shipping sectors, the need to decarbonize is equally imperative. The report also explores the wider decarbonization landscape that will need to be navigated to put this sector on a sustainable footing.



- Carbon capture, utilization and storage (CCUS) is another decarbonization technology being evaluated by ABS as part of its sustainability guidance for industry. Released in August, the ABS whitepaper: *Carbon Capture, Utilization and Storage* gives an overview of the current state of CCUS technologies, assesses opportunities for utilization and storage, and reviews the requirements of vessels that will carry the liquefied product.
- Decarbonization pathways can be highly complex and challenging to evaluate, which complicates the decision-making process for determining an asset's lifetime GHG-reduction strategy. In this difficult decision pathway, every insight helps, which is why ABS undertook a pioneering study to compare the relative lifetime carbon footprints of newbuilds and conversions.

The study, released in September, suggests that dual-fuel newbuilds could have a decarbonization advantage over conversions, providing a CO₂ reduction of approximately one-third. A newbuild, dual-fuel gas carrier vessel generates lower CO₂ emissions over the course of its operational life than an existing gas carrier converted to dual-fuel operations. ABS compared potential GHG emissions between a newbuild, dual-fuel very large gas carrier (VLGC) and the conversion of two VLGCs over 20- and 25-year life cycles. The findings suggest conversion increases emission intensity by between 13.7 and 32.6 percent over new construction.

- Ammonia has begun attracting increasing attention as a potential future marine fuel, and with that interest has come a serious need for guidance in its storage, bunkering, handling and usage. Recognizing the need to minimize ammonia-related risk to vessels, crews and the environment, ABS gathered its knowledge and insight on the subject and published industry-leading guidance for the design and construction of ammonia-fueled vessels.

The *ABS Guide for Ammonia-Fueled Vessels* sets out classification design criteria for the arrangements, construction, installation and survey of machinery, equipment and systems for vessels operating with ammonia as fuel. The Guide is supported by notations recognizing a vessel as arranged to burn ammonia for propulsion or auxiliary purposes, and as being designed, constructed and tested in accordance with the requirements of the Guide. The class notation LFFS will be issued in tandem with suffixes denoting dual-fuel propulsion (DFD) or reliquefaction systems (RELIQ) and with remote monitoring notations (ACC, ACCU or ABCU) reflecting elements of individual vessel arrangements.

ABS LAUNCHES SUSTAINABILITY REPORTING AND ASSURANCE SERVICES

ABS launched new sustainability reporting and assurance services in November to help clients demonstrate their commitment and progress towards sustainable operations. These services involve a straightforward, three-step process that simplifies sustainability reporting and produces a detailed, authoritative and easily understood sustainability report.



- In April, ABS also published guidance on a range of alternative propulsion and power generation technologies that have the potential to reduce maritime GHG emissions. The *ABS Advisory on Decarbonization Applications for Power Generation and Propulsion Systems* focuses on the tank-to-wake impact of a variety of power generation and propulsion technologies, addressing the technological complexity, fuel options, current regulatory requirements and safety concerns of such systems as steam turbines, gas turbines, fuel cells, wind power, solar cells, nuclear power and batteries as well as more conventional internal combustion engines.
- Combustible fuels are clearly elements of the industry's future, but battery systems may have a role to play by providing power storage in all-electric vessels or in hybrid systems that, for example, store for later use the excess power produced by a ship's main engines. To support the growing interest in this decarbonization strategy, ABS published a new report exploring the decarbonization potential of several emerging battery technologies.

Published in November, *Emerging Battery Technologies in the Maritime Industry* covers a variety of promising battery technologies relevant to maritime applications, giving pros and cons for each and analyzing their maturity compared to today's lithium-ion batteries. These technologies include Metal-Air, Redox Flow, Ammonia and Solid-State batteries.

ABS AWARDS WORLD'S FIRST SUSTAIN NOTATION TO SBM OFFSHORE'S LIZA UNITY FPSO

In September, the ABS-classed *Liza Unity* became the world's first floating production, storage and offloading (FPSO) to receive the SUSTAIN-1 notation from ABS, and in December, ABS awarded the notation to the *Harvey Blue-Sea* and *Harvey Sub-Sea*, a pair of multi-purpose supply vessels (MPSVs) owned by Harvey Gulf International Marine.



INDUSTRY-LEADING PRODUCTS AND SERVICES

The increasing number of companies requiring a sustainability commitment from the vendors in their supply and distribution chains has significantly raised the importance of sustainability monitoring and reporting. Things are now at the point where sustainable business practices, and the tracking thereof, are no longer optional activities for polishing one's reputation, but necessary components for maintaining market competitiveness. As a result, businesses now need credible sustainability data that is supported by independent verification.

INDUSTRY LEADERS ANSWER KEY DECARBONIZATION QUESTIONS AT 2021 ABS SUSTAINABILITY SUMMIT

In October, ABS convened its second annual ABS Sustainability Summit, an industry event in which leading voices from shipping, finance, academia and industry discussed key questions regarding maritime sustainability and decarbonization. Key questions tackled by the summit included: How a decarbonized economy will reshape the maritime industry; how consumer demand is influencing sustainability decisions; and how having a complete value chain view might impact future fuel choices.

SUSTAINABILITY SUMMIT

YOUR QUESTIONS ANSWERED



Another emerging reality of the sustainability journey is that shipping must embrace new ways of visualizing things in order to bring forward innovation for greener vessels. At ABS, we can now use advanced simulation (SIM) and modeling to help owners make more informed decisions regarding new concepts in design, engineering and operations while a vessel is still in its design stages. In an industry first, ABS launched an advanced service using sophisticated modeling and simulation technologies to evaluate the operational impact of a wide range of vessel decarbonization technologies at the start of the design spiral, which also help simplify EEXI and CII compliance.

SHIPPING IS THE ENABLER IN GLOBAL TRANSITION, ABS CHAIRMAN, PRESIDENT AND CEO TELLS COP26

At the *UN Framework Convention on Climate Change (COP26)* in November, ABS Chairman, President and CEO, Christopher J. Wiernicki discussed how shipping is the critical enabler in the world's transition to low-carbon operations and needs government support to ensure its adoption of next-generation fuels.

Speaking during the International Chamber of Shipping's (ICS') *Shaping the Future of Shipping* at COP26 in Glasgow, he stressed that shipping needs support because it will be the means by which future fuels are distributed throughout the world. At the World Climate Summit event panel entitled *Accelerating the Green Transition and Technologies through Partnerships - Best Practices from the Shipping Sector*, he also noted that the "fuel of the future" will not be a product, per se, but a mixture of leadership and cooperation, because the sustainability challenge is too great for any single organization to tackle alone and will only be conquered through collaboration and a global pooling of resources, experience and knowledge.



Introduced in September, ABS' SIM-based Energy Efficiency Evaluation (EEE) Service supports propulsion system design optimization, providing system level assessment of the fuel consumption of a vessel, supporting life-cycle cost analysis as well as detailed design comparison and equipment parameter optimization. For existing vessels, the service assists with evaluating the retrofit options and operational changes to reduce fuel consumption and maintain compliance with regulations.

CLASS NOTATIONS TO SUPPORT DECARBONIZATION INVESTMENT

Decarbonization and sustainability are noble goals but are also expensive endeavors to undertake. Respecting the risks and expenses that owners undertake to do the right thing, ABS has developed class notations that distinguish and recognize the vessels and owners that have taken the bold step of early adoption of decarbonization technologies.

- In 2021, ABS developed special notations to distinguish the extra investment that vessel owners will be making to help usher in the future of shipping. The HVSC-Ready notation will be granted to vessels equipped for High Voltage Shore Connection systems that will be installed in the future, and the Wind-Assist Ready notation to vessels designed to have wind-assist equipment installed on board.
- The HVSC-Ready notation was introduced with the update to the *ABS Guide for High Voltage Shore Connection*, published in July, while the Wind-Assist Ready notation was introduced with the update to the *ABS Guide for Wind Assisted Propulsion System Installation*, published in August.
- ABS worked with Capital Ship Management to develop these notations as the company began an extensive new construction program, and in October announced that Capital would be the world's first shipowner to secure them for a series of newbuild medium-range (MR) tankers.
- ABS also developed another new notation, SUSTAIN-1, which attests to a vessel's alignment with key elements of the Environmental, Social and Governance (ESG) requirements outlined in the United Nations' (U.N.) Sustainable Development Goals (SDGs), and attests that its design and construction have been assessed against and adhere to the requirements of the *ABS Guide for Sustainability Notations*. The Guide focuses on sustainability aspects of asset design and covers pollution and waste, coastal and marine ecosystems, energy efficiency and performance monitoring, low-carbon fuels, human-centered design and asset recycling.

INTERNATIONAL COLLABORATION TO ADVANCE SUSTAINABLE SHIPPING

ABS understands that no one company has the resources to develop a solution to shipping's decarbonization challenge, and it is only through working together that industry can find its path forward to sustainability. For that reason, ABS has engaged in projects all over the world with leading industry players to develop practical solutions and support their safe adoption by the industry.

- In July, a consortium led by ABS, CE Delft and Arcsilea was commissioned to perform six studies on alternative fuels and decarbonization technologies for the European Maritime Safety Agency (EMSA). This is a four-year project to study key aspects of the decarbonization of shipping, including biofuels, ammonia, hydrogen, wind-assisted propulsion, air lubrication and other promising technologies. The initiative is part of EMSA's mission to provide technical assistance to the European Union (EU) Commission and member states in the promotion of sustainable shipping and support the shift to low- and zero-carbon operations.

The studies will analyze the industry's use of each fuel or power technology, examining its availability, life-cycle emission characteristics and economic aspects. Project partners will also review the current regulatory framework, identify any gaps and include safety assessments for the application of each fuel and power source to cargo as well as passenger vessels.

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GLOBAL **MARINE**



GLOBAL MARINE

ABS has supported the introduction of new maritime technologies throughout its 160-year history, helping advanced designs, materials and equipment safely enter service. Continuing this tradition in 2021, ABS participated in some notable industry firsts and groundbreaking achievements by leading maritime companies.

LEADERSHIP IN LOW-CARBON FUELS

The transition to alternative fuels is a cornerstone of the maritime industry's journey towards net-zero emissions, and it seems increasingly clear that the voyage to 2050 will be powered by a basket of fuels including oil, liquefied natural gas (LNG), methanol, ethanol, fuel cells, hydrogen and ammonia. For the fuel transition to succeed, industry stakeholders must work together in establishing the safety and efficiency of new fuels and propulsion technologies as they develop the building blocks of the hydrogen and carbon value chains upon which the future global low-carbon economy will depend.

In service of this goal, ABS developed a suite of industry-leading guidance for navigating the benefits and drawbacks of various alternative fuels. In addition, ABS has introduced an "Alternative Fuel Ready" approach to help shipowners prepare their fleets for the introduction of alternative fuels. Introduced through the *ABS Guide for Gas and Other Low-Flashpoint Fuel Ready Vessels*, it is designed to support shipowners looking to build a new vessel or convert an existing one to use LNG, methanol, ethane, liquefied petroleum gas (LPG), hydrogen, ammonia and other gases or low-flashpoint fuels.

- Ammonia, for example, is gaining increasing recognition as a potential future global fuel, but is not without certain challenges, including greater prescriptive requirements for containment tanks and handling equipment than most other alternative fuels. Recognizing ammonia's potential within shipping's decarbonization objectives, ABS moved to assist those pursuing its early adoption with the publication of insightful guidance including its *Sustainability Whitepaper: Ammonia as Marine Fuel and the ABS Guide for Ammonia-Fueled Vessels*.
- Methanol, too, is a fuel with significant potential to help the maritime industry meet its decarbonization objectives, and ABS has engaged in a number of joint development project (JDPs) to help turn its promise into reality.

"ABS advanced technology at sea in so many ways in 2021, using innovation and knowhow to solve the challenges our clients and members face, always with a laser focus on safety."

VASSILIOS KROUSTALLIS
ABS SENIOR VICE PRESIDENT
GLOBAL BUSINESS DEVELOPMENT



In December, at the culmination of a five-month collaboration, ABS granted approval in principle (AIP) to the design of a methanol-ready, medium-range (MR) tanker developed by K Shipbuilding. The JDP evaluated a range of aspects including storage, bunkering and issues caused by methanol's corrosive properties. The basic design was reviewed in accordance with the principles of the *ABS Guide for Gas and Other Low-Flashpoint Fuel Ready Vessels*. When built, the vessel will be able to claim the ABS Methanol Fuel Ready notation.



- Meanwhile, LNG remains the most mature of the alternative fuels and the fastest growing in global application throughout the power generation, maritime and offshore industries. ABS has more than 70 years' experience helping industry develop technology relating to LNG transport and floating production and storage. This expertise was underscored during the summer, when an ABS-classed floating storage and regasification unit (FSRU) was delivered to Turkey's state-owned BOTAŞ Petroleum Pipeline Corporation. Built by Hyundai Heavy Industries (HHI) under the *ABS Guide for Building and Classing LNG Regasification Vessels*, the 295-meter-long vessel can hold 170,000 cubic meters (m³) of LNG and has a gasification capability of 28 million m³ (990 million standard cubic feet) per day, one of the world's highest send-out capacities.

In November, Saudi Arabian shipowner Bahri took delivery of the ABS-classed *Rayah*, its first gas-ready, dual-fuel very large crude carrier (VLCC). The 319,000 deadweight (dwt) double-hull oil carrier was built at HHI in compliance with the ABS SUSTAIN-1 and LNG Ready notations, which recognize its sustainable design and capability for future retrofit to LNG fuel operation. The ABS SUSTAIN notation demonstrates adherence to United Nations' (U.N.) Sustainable Development Goals (SDGs) for vessel design, outfitting and layout and grant marine assets a pathway for sustainability certification and reporting.

ABS-CLASSED SUEZMAX IS WORLD'S FIRST AMMONIA READY VESSEL

In 2021, the world's first ammonia-ready vessel began construction to ABS Class at New Times Shipbuilding for Avin International. The pioneering vessel, a suezmax tanker, will use conventional fuels at the start of its life, but is being built in compliance with the ABS Ammonia Ready Level 1 requirements, indicating it can be converted to use ammonia as fuel in the future. The Ammonia Fuel Ready Level 1 notation indicates compliance with the requirements outlined in the *ABS Guide for Gas and Other Low-Flashpoint Fuel Ready Vessels*.

Another step forward in the advance of ammonia as a fuel occurred in December, when ABS granted approval in principle (AIP) to an innovative ammonia-fueled, newcastlemax bulk carrier designed by Anglo-Eastern Shipping. The dual-fuel vessel design sacrifices no cargo space because it uses deck-mounted IMO Type C tanks mounted under the accommodation block, a system that can be retrofitted to existing vessels.

PIONEERING 3D TECHNOLOGIES, DIGITAL TRANSFORMATION AND THE EVOLUTION OF DIGITAL CLASS

3D design and modeling have been with the maritime industry for decades, but only now is an integrated chain of concept development, design, plan approval, engineering, procurement and construction driven seamlessly by 3D technologies becoming a reality.

ABS was the first class society to bring 3D models into plan review, then the first to accept 3D models for class surveys. This latest success is an important milestone on the road to when the industry has the infrastructure to handle 3D models in shipyards and a pure 3D process becomes the default approach to design and construction.

- In July, we saw yet another advance in the application of 3D modeling technologies, when a barge modification by Stillwater Marine Services was delivered using the ABS 3D model-based class process. The modification, made to the bulwark on its aft deck section, was submitted to ABS in 3D model format. The model was created through laser scanning, from which accurate files were created for fabrication and a 3D model developed that represented the true, current state of the vessel and the planned work. Approval was swift and the completed work successfully passed survey.
- In November, ABS announced another safety-oriented digital acceleration of the process through which vessel class is maintained. Now, any computerized maintenance management system (CMMS) can be directly linked to the ABS MyFreedom™ Client Portal, through a true single interface for survey, compliance and maintenance reporting that is fully integrated with ABS Nautical Systems® (NS) software and available to any CMMS provider. Yet another building block of maritime's digitally-connected future, this open and secure platform offers seamless melding of safety and compliance with everyday operations through streamlined data flow. An enhancement to the ever-evolving ABS MyFreedom service of total fleet oversight, it allows digital survey crediting and provides a more condition-based approach that helps optimize operations, transactions and the management of maintenance priorities, which in turn improves condition monitoring and increases asset availability.

“ABS, Hyundai Heavy Industries and Hyundai Global Service are together shaping the future of the marine and offshore industries with a series of trailblazing projects that will deliver practical benefits for operators and advance the sustainability of shipping. To achieve the IMO's ambitious sustainability goals, a broad focus across decarbonization and digitalization is required. These projects combine these essential elements.”

PATRICK RYAN

ABS SENIOR VICE PRESIDENT
GLOBAL ENGINEERING
AND TECHNOLOGY

GROUNDBREAKING MÆRSK METHANOL VESSELS TO BE BUILT TO ABS CLASS

In September, ABS was awarded classification of a four-plus-four series of dual-fuel containerhips capable of running on low-sulfur fuel oil or methanol. Building for Mærsk at Hyundai Heavy Industries (HHI), the class award for these groundbreaking 16,000 TEU vessels follows an earlier ABS Class award from Mærsk for methanol dual-fuel container feeder vessels. Together these orders underscore industry recognition of ABS' leadership in the development of low-carbon marine fuels in general and methanol in particular, expertise that was demonstrated with the release of the *ABS Sustainability Whitepaper: Methanol as Marine Fuel*. These methanol-fueled vessels will contribute significantly both to the shipowner's emissions reduction goals and to establishing important industry experience in the safe bunkering and operation of carbon-neutral vessels.

LAUNCH OF ABS-CLASSED JIANGNAN BLUEBONNET VLEC

Ethane is another key ingredient in the development of the world's new low-carbon value chains, both as an industrial feedstock and a fuel. ABS' long-recognized expertise with technologies related to this useful gas was underscored in September, when it classed the world's first very large ethane carrier (VLEC) to use IMO Type B containment tanks. The vessel, *Pacific Ineos Belstaff*, was launched at Jiangnan Shipyard as the lead in a four-ship series of the largest VLECs ever commissioned. The 99,000 cubic meters (m³), dual-fuel vessel is designed for long-haul ethane transportation and can also handle other liquefied gas cargoes such as liquefied petroleum gas (LPG) and ethylene.



Technological advancements routinely generate fresh challenges. Increased adoption of digitally enabled systems introduces cybersecurity risks into vessel operation, business transactions, the maritime supply chain and, ultimately, safety at sea. That is why ABS has a special branch of activity dedicated to maritime cybersecurity.

- In October, ABS awarded its CyberSafety® Product Design Assessment (PDA) to the DS4 Smart Platform developed by Daewoo Shipbuilding & Marine Engineering (DSME). The DS4 Smart Platform collects data from equipment and systems on board a vessel and assimilates it to provide enhanced operational information to the ship operator. The platform supports device connectivity, data storage as well as data processing and visualization. The PDA process includes ABS review of known system vulnerabilities, which are listed in the vendor report, and verification of all mitigation measures that were made during type testing. It is part of our ongoing effort to impart confidence that digital integration is completed with as much safety and security as possible given the current state of technical knowledge.

Finally, it must be stressed that, although the digital transformation of our industry is rapidly accelerating, it is not yet realized and will only ultimately be achieved by the next generation of maritime professionals.

- In 2021, ABS introduced a pioneering digitalization learning program in a collaborative effort with SGUnited, a Singapore government organization dedicated to skills building and education of the country's youth. Working with SGUnited's Pathways Program for Company Training (SGUP-CT), ABS is providing educational services in computer-based modeling and simulation, an essential component of digital transformation for the maritime, aerospace, electronics, transportation and energy industries. The ABS Digitalization Learning Program in Modeling and Simulation of Systems is designed to teach and empower participants to deploy modeling and simulation strategies and techniques by developing valuable skill sets through hands-on training. The program is designed to impart knowledge and techniques for building models of typical maritime systems using leading commercial software and systems, which will be applied for such purposes as concept selection, design optimization, carbon footprint evaluation, reliability and interoperability evaluation and process optimization.

LEADING THE SAFE INTRODUCTION OF NEW TECHNOLOGIES AT SEA

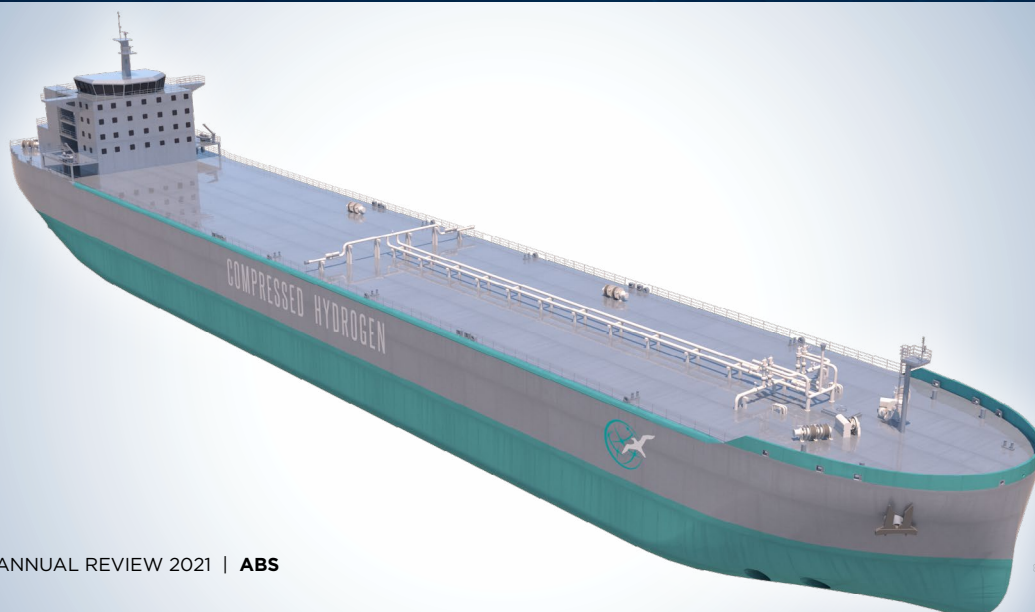
ABS has always worked to marry the excitement of progress with awareness of potential unintended safety consequences. We are proud to note that, during 2021, we helped pioneer the safe application of a number of new technologies at sea, including additive manufacturing (AM), smart technologies, autonomous systems, composite materials and fuel cells. At the same time, we helped early adopters demonstrate the ease with which accommodations designs can incorporate new knowledge concerning the spread of infectious diseases.

- Through a partnership with Keppel Offshore & Marine (O&M), ABS continued to demonstrate its leadership in the advancement of digital technologies for the maritime industry by supporting development of the world's first LNG bunkering vessel to incorporate smart technologies. This leadership was recognized in January, when FueLNG, a joint venture between Keppel O&M and Shell Eastern Petroleum, selected ABS to class the 7,500 m³ *FueLNG Bellina*, which will be Singapore's first LNG bunkering vessel. The groundbreaking vessel will receive class notations for Smart Infrastructure (Smart INF) and Crew Assistance and Augmentation (Smart CAA), relating to technologies that support remote monitoring, predictive maintenance and real-time support of vessel operations.

ABS AIP FOR GEV'S HANDYMAX HYDROGEN CARRIER DESIGN

Hydrogen is another gas widely recognized as having the potential to play a significant role in global decarbonization initiatives, both within the shipping sector and the wider world economy. Safe and efficient transport of hydrogen at sea will be critical to the development of the infrastructure required for its wider adoption. In November, ABS granted approval in principle (AIP) to the design of a 430-tonne cargo capacity, handymax-size, compressed hydrogen carrier from Global Energy Ventures (GEV). The innovative vessel, which GEV intends to be the first commercial-scale vessel available for the marine transport of hydrogen, is equipped with a dual-fuel engine powering generators that can be coupled to two electric-drive fixed pitch propellers or a dynamic positioning system.

The AIP was granted following a review of GEV's design in accordance with the ABS *Guidance Notes on Review and Approval of Novel Concepts* incorporating relevant principles from the ABS *Guide for Vessels Intended to Carry Compressed Natural Gases in Bulk* and the *IMO IGF Code*. It follows another ABS AIP granted to GEV in July for a compressed hydrogen vessel having a 2,000-tonne capacity.



- Recognizing that fuel cells will have an important place in the future of maritime propulsion, ABS has focused on supporting the development of commercial maritime fuel cell technology in partnership with industry leaders around the world.

Another important step in fuel cell evolution was taken when, following a JDP between ABS and DSME, ABS granted AIP to solid oxide fuel cell (SOFC) technology developed by DSME. The award follows two earlier JDPs between ABS and DSME, the latest of which developed SOFC technology to replace at least one of the three diesel generators typically on board a VLCC. Previously, the JDP partners demonstrated the high efficiency of an SOFC/gas turbine hybrid system that re-used hot exhaust gas. ABS is now working with DSME on future research and development areas to be carried out during detailed design and testing of the SOFC technology.

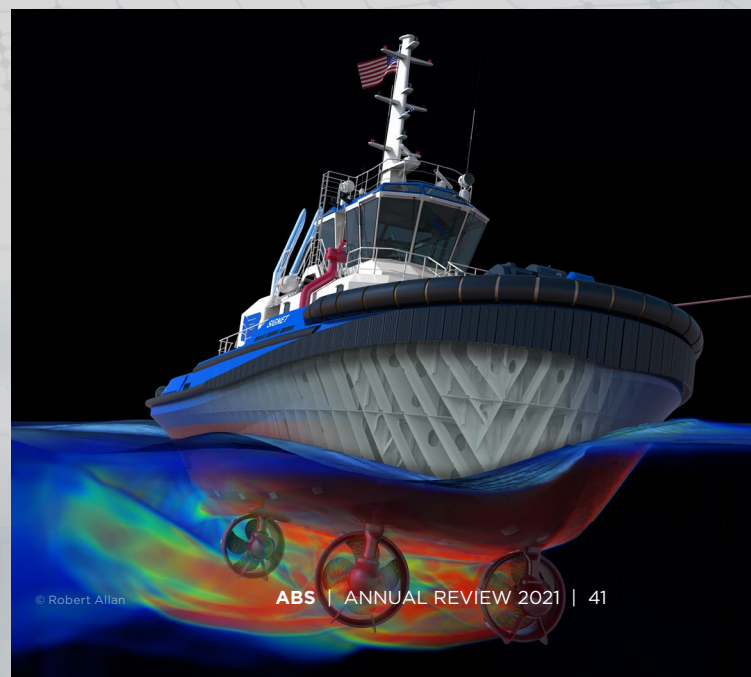
The first commercial use of a fuel cell came during the Gemini Program in the early years of the U.S. Space Program and was followed by a sophisticated fuel cell that was employed in powering the Lunar Landing Module that put the first men on the moon. As fuel cell technology makes a promising migration into home, automobile and maritime power applications, another space technology also has the potential to impact the shipping sector.

In June, ABS granted design approval to developments from the SpaceTech4Sea project, a JDP between ABS, OceanFinance and Cimarron Composites that seeks to develop shipping applications – notably ultra-lightweight fuel tanks – from composite materials originally created for use in space. The basis for this work is that certain new rocket propulsion concepts rely on liquid methane as a fuel, and the composite materials used in their fuel tanks have the potential for use in liquid hydrogen transport as well. One significant promise of these advanced composite materials is that they are unaffected by corrosion, which is extremely important for some of the more aggressive alternative fuels, and that they offer a weight savings of up to 80 percent over conventional tanks of equivalent capacity.

The project, supported by funding from the European Union (EU), explores whether these advanced composite technologies can be developed into a competitive alternative to traditional marine LNG fuel tanks. Initially, the focus of the development effort is small, short-sea shipping applications where component weight is a critical issue. Having ABS design approval opens the technology to the vital next step of installation and at-sea testing aboard a commercial vessel.

HISTORIC U.S. FIRST AS ABS, ROBERT ALLAN, SIGNET AND USCG USE PURELY 3D PROCESS TO DELIVER COMMERCIAL VESSEL

Advances in 3D design and modeling were demonstrated by a collaborative effort that concluded last year in a true industry first: a totally paperless 3D process that delivered a commercial vessel designed and built in the U.S. Working with Robert Allan Ltd. (RAL), Signet Maritime and the U.S. Coast Guard (USCG), ABS developed a paperless methodology that safely accelerates the plan review process. Designed by RAL, the Advanced Rotor Tug® will escort vessels and offshore assets in the Port of Corpus Christi, Texas. It will receive its Certificate of Inspection from the USCG and will be built and operated by Signet to ABS Class, making it the first commercial vessel in U.S. history to be produced using only 3D models in design and construction for all structures.



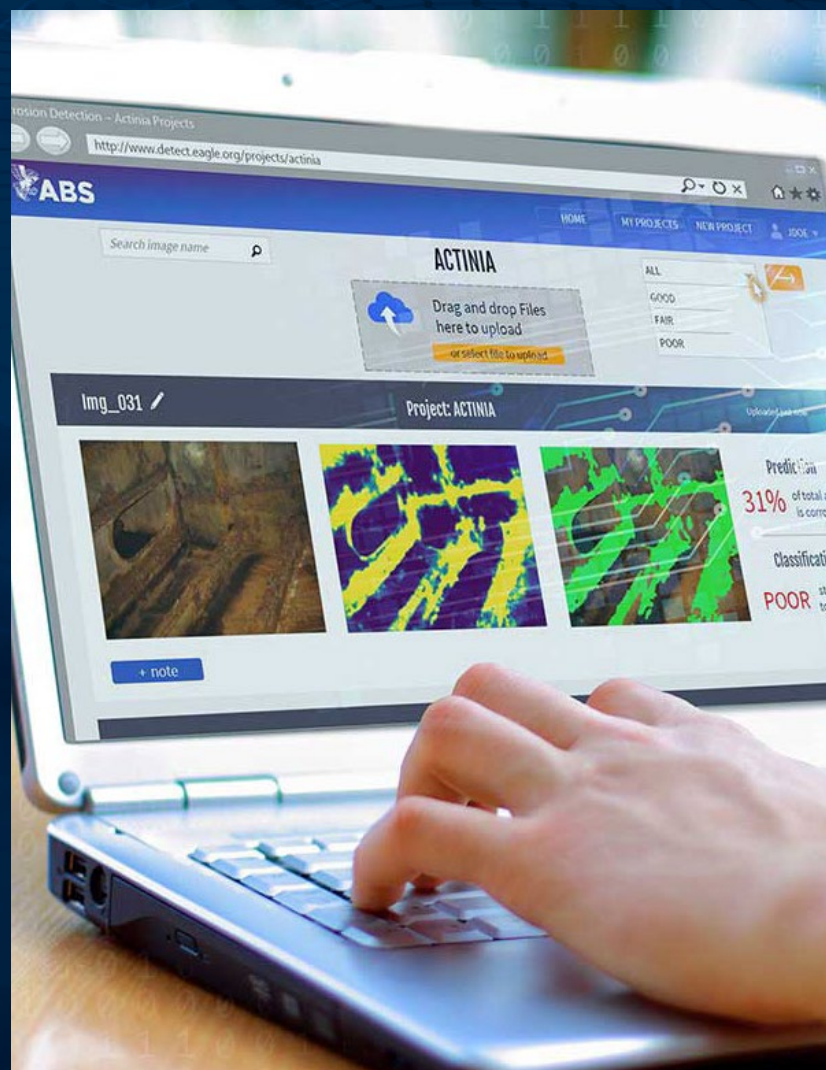
- Another foreshadowing of our industry's not-too-distant future is the increasing presence of artificial intelligence (AI) in the workplace. With its constant evolution and seemingly limitless promise to revolutionize many aspects of the maritime and offshore industries, AI is already being used to enhance management, operations and decision-making. Now a unique, innovative AI tool from ABS has been proven effective for identifying corrosion with an accuracy of 98.9 percent.
- Additive manufacturing (AM), also called 3D printing, holds great promise to revolutionize the capability of vessels to perform repairs at sea, increasing both their operational efficiency and their sustainability. ABS has followed closely the evolution of AM technology for the past five years and provided industry-leading guidance every step of the way to support its safe, efficient and sustainable adoption by the maritime sector.

The latest phase of this work was the publication in April of the *ABS Guide for Additive Manufacturing*, a comprehensive document covering AM applications in the marine and offshore industries. The Guide focuses on two main categories of metal AM, Powder Bed Fusion and Directed Energy Deposition, defining the ABS approval and certification processes with standards for AM design, feedstock material, building processes, inspection and testing.

PIONEERING ABS AI CORROSION DETECTION™ SOLUTION HIGHLY EFFECTIVE IN REAL WORLD APPLICATION

Corrosion is one of the biggest maintenance expenses in the maritime world, costing the industry an estimated \$50 billion to \$80 billion annually. In an effort to help reduce this burden, ABS developed its proprietary AI Corrosion Detection™ tool, which learns to recognize corrosion damage by analyzing still images and videos. In March, the ABS AI Corrosion Detection Tool was used to assess the coating condition in the water ballast tanks of two vessels for the presence of corrosion.

Using an AI algorithm that analyzes images and video files to generate prediction scores and percentages for tank coating breakdown and corrosion, the tool allows users to benchmark and monitor coating breakdown and corrosion growth over time, generating alerts for such structural defects as coating failures, fractures and deformations. In this real-life test, the AI algorithm learned to recognize corrosion by analyzing more than 600 tank images and videos provided by the client. The strength of AI and machine learning will enable the tool to continuously improve its performance over time as more images are uploaded and evaluated.



- For many years, ABS has been in the vanguard developing autonomous and remote-control technologies for maritime applications. In July, ABS released a new *ABS Guide for Autonomous and Remote-Control Functions*, which sets out a risk-based approach within a goal-based framework for implementation of these technologies on vessels and offshore units. The new Guide also introduced two new notations attesting that its requirements have been satisfied. Development of the guidance was informed by experiences on remote-control and autonomous operations tug projects in Europe, Asia and the Americas.
- One of the less obvious aspects of the sustainability journey is the necessary technical evolution of vessel design with respect to medical health preparedness. Following the COVID-19 pandemic, the maritime industry acquired a heightened awareness of the need for vessel accommodation designs geared towards mitigating the spread of infectious diseases. ABS led the way in this evolution with its publication in late 2020 of the *ABS Guide for Mitigation of Infectious Disease Transmission On Board Marine and Offshore Assets*, which was developed from a range of independent governmental and commercial guidance, including the United States Centers for Disease Control and Prevention. Subsequently, ABS awarded AIP for infectious disease mitigation to the design of crew accommodation and ventilation systems for a crude oil tanker, a containership and an LNG carrier.

ABS AWARDS WORLD'S FIRST NOTATION RECOGNIZING INFECTIOUS DISEASE MITIGATION TO TASIK SUBSEA'S SOUTHERN STAR

In February 2021, a diving support vessel designed for Tasik Subsea became the industry's first to be awarded the ABS Infectious Disease Mitigation-Arrangements (IDM-A) notation, which attests that a vessel meets the requirements outlined in the Guide for configuration of spaces that can be used for isolation and segregation of crew, passengers and onshore visitors in the event of a disease outbreak, as well as for the required ventilation systems and interior surfaces of certain accommodation or working spaces.



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GLOBAL LEADERSHIP IN SERVING THE OFFSHORE ENERGY SECTOR

ABS was the offshore energy sector's first classification society chosen to provide classification services and technical assistance when the first platform was installed out of sight of land 75 years ago. We are proud to have had a part in shaping that sector's history, helping usher in nearly every significant development the offshore sector has produced, advancing shoulder-to-shoulder with its brave innovators into ever-greater depths, ever-harsher environments, and ever-more-challenging extraction, production, storage and offloading scenarios.

We continued this tradition in 2021, providing leadership in floating production, storage and offloading (FPSO) classification, in the safe life extension of the aging global FPSO fleet, in guidance on how to safely reduce manning on offshore facilities, and in guidance and services that help clients safely reactivate, modernize and improve offshore fleet performance.

CONTINUED LEADERSHIP IN VESSELS FOR FLOATING PRODUCTION, STORAGE AND OFFLOADING

- Floating rigs were invented and first deployed under ABS guidance over 60 years ago, and 2021 saw this long history continue with delivery of the world's first 100,000 ton deepwater semisubmersible production and storage platform.

Built to ABS Class for the China National Offshore Oil Corporation (CNOOC), the platform has a maximum oil storage capacity of nearly 20,000 cubic meters (m³) of condensate for ship-to-ship offloading and is a key component of the Lingshui 17-2 gas field development project.

"The offshore industry is faced with an evolving risk profile, with opportunities to enhance protocols and systems to address these risks. With almost 60 percent of the global operating fleet of FPSOs classed by ABS, we are committed to addressing these issues and ensuring the ABS-classed fleet remains the safest and best performing fleet in the world."

PETER FITZPATRICK
ABS SENIOR VICE PRESIDENT
GLOBAL OFFSHORE



ABS is also the certifying agency for the Lu Feng 12-3 oilfield development, and in August was awarded classification of a 100,000 deadweight (dwt) FPSO for the project ordered by the CNOOC Energy and Technology Services Company (Cenertech). The FPSO is the centerpiece of the field's development plan, which also includes an ABS-certified wellhead platform that will be the second largest ever installed in Asia. Asia's largest wellhead platform, the Lu Feng 15-1, is also certified by ABS.

- ABS has been involved with FPSOs since the earliest days of this important offshore technology, and classes the majority of these vessels around the world. In 2021, we continued to lead the sector in both new construction advances and critical approaches to dealing with the existing, aging FPSO fleet.
- Today, the offshore industry finds itself in a uniquely challenging position: it must not only look forward into the most advanced technologies for future projects but must also look backwards into aging assets and figure out how to keep them safely in service and in compliance with modern regulations.
- Looking beyond FPSOs, ABS expanded its *Guide for Life Extension of Floating Production Installations* with guidance to support operators looking to extend the operational life of floating production installations. Critical issues addressed include pre-life extension data collection, hull corrosion rate, mooring fatigue assessment, rapid corrosion areas, wire rope, tendon and composite repairs. The Guide is applicable to all hull forms, including ship-type, column stabilized and tension leg platforms (TLPs).

A LEAD PLACE IN THE VANGUARD OF SUBSEA MINING

For over a decade, ABS has been helping subsea mining technology make the long trek from concept to reality with a laser focus on safety. Following years of technical cooperation, joint development projects (JDPs), guidance documents and, ultimately, the ABS *Guide for Subsea Mining*, in 2021, ABS recorded a number of significant milestones and industry firsts in supporting the safe evolution of the technology.

- In January, ABS awarded approval in principle (AIP) to China Merchants Industry (CMI) for the design of a deep-sea mining system that focuses on retrieving cobalt-rich ferromanganese crust deposits attached to seamounts, which will be accomplished through use of subsea mining machines, high-concentration and large-particle slurry lifting systems and offshore mining support vessels. A prototype deep-sea mining vehicle was successfully tested on the seabed 1,300 meters below the South China Sea and completed the first joint operation test with a manned submersible. ABS also granted CMI an AIP for design of a deep-sea mining riser and lift system, which is a key part of its deep-sea mineral extraction system, handling ore-seawater slurry and transporting it to the surface vessel.
- October saw the start of a conversion project that will turn a drillship into the first ABS-classed subsea mining vessel. Operated by Allseas, the vessel, *Hidden Gem*, is to be equipped with a proprietary deep-sea mineral collection system for recovering polymetallic nodules from the ocean floor and transferring them to the surface for transport to shore. Such nodules contain high grades of nickel, manganese, copper and cobalt, which are key metals required for building electric vehicle batteries and renewable energy equipment. The project includes a subsea vertical transport system, a subsea collection vehicle and a surface nodule handling and storage system.

ABS GRANTS AIP FOR HHI'S FLOATING STORAGE AND OFFLOADING DESIGN

In February, ABS awarded an AIP to Hyundai Heavy Industries (HHI) for a new design of a two million barrel (bbbl) FPSO intended for operations in Mexican waters, and in August won classification of a pair of new FPSOs for Brazilian owner-operator Petrobras. Both vessels will operate in Brazil's pre-salt Buzios field in the Santos Basin. Due to enter service in 2025, they have an installed capacity to pump 180,000 barrels of oil per day (BOPD) and process 7.2 million cubic meters (m³) of gas per day. ABS also developed detailed practical guidance to help offshore operators through Brazil's unique regulatory environment. The document, *Practical Considerations for Regulatory Compliance in Brazil*, guides compliance with local content rules and other requirements that are specific and set forth by multiple local agencies.

LEADING INDUSTRY WITH ADVANCED TECHNOLOGY AND SAFETY SERVICES

- Being an early adopter of new technology can be advantageous but is not without challenges, not least of which is the risk of unintended safety consequences. To aid the safe adoption of new technologies, ABS developed its New Technology Qualification (NTQ) service, which last year was applied to several groundbreaking advances.

In July, ABS issued an NTQ to SBM Offshore's artificial intelligence (AI)-powered Intelligent Agent Mooring Line Integrity Tool, allowing the technology to be integrated into offshore systems for the first time. Powered by AI, this novel tool collects such data as wind speed, vessel heading and GPS information to provide continuous feedback on system integrity and can detect potential mooring line failure and location without using a traditional tension monitoring system. The tool was evaluated using the framework outlined in the *ABS Guidance Notes on Qualifying New Technologies* and *ABS Guide for Smart Functions for Marine Vessels and Offshore Units*.

One aspect of the introduction of AI-driven technologies and smart systems on board is the potential they afford for reduced manning. While reduced manning offers opportunities to lower capital and operating expenses, it must be done carefully to avoid any unwanted safety consequences to personnel and the asset itself. That's why ABS published its whitepaper *Reduced Manning on Offshore Facilities*. This important document examines some of the considerations essential to reducing manning or even remotely operating floating facilities.

ABS BRINGS TOGETHER LEADING INDUSTRY PLAYERS TO TACKLE SAFETY CHALLENGE OF AGING FPSO FLEET

One example of the offshore industry's evolving risk profile is the situation of its aging floating production, storage and offloading (FPSO) fleet. The challenges surrounding maintenance and structural fitness of aging FPSOs require the involvement and cooperation of all stakeholders.

That's why ABS brought together leading companies in the FPSO sector to address the safety challenges of the global FPSO fleet, nearly three-quarters of which is over 30 years old. The working group consists of operators Chevron, Shell, Petrobras, MODEC and SBM, and regulatory authorities including

The Bahamas Maritime Authority, the Republic of the Marshall Islands Registry and the U.S Coast Guard (USCG). The group has already created five joint industry projects (JIPs) aimed at using technology to tackle a range of FPSO safety issues. These include composite materials repairs for offshore structures, life extension of wire ropes, gauging management software, applications of photogrammetry and 3D Lidar Laser Scanning and the role of artificial intelligence (AI) in corrosion analysis.



- Evaluating and mitigating risk is an area in which ABS has developed a true industry-leading expertise. In April, our Integrated Software Quality Management (ISQM) service, which is unmatched in its risk-based approach to establishing the safety of critical software control systems, helped a client restore systems integrity aboard one of the world's largest semisubmersible, heavy-lift crane platforms.

The vessel underwent failure modes and effects analysis (FMEA) and criticality analyses, plus thorough functional testing, to ensure that its power management, dynamic positioning, ballast and bilge and loading computer systems all meet critical risk safety parameters.

In this case, the client experienced software failure, which was linked to poor commissioning and FMEA that caused a vessel to suddenly lose control. Good crew training and preparedness saved the day but highlighted the value of the ISQM notation. As a result, the client ordered the ISQM notation for all critical onboard systems.

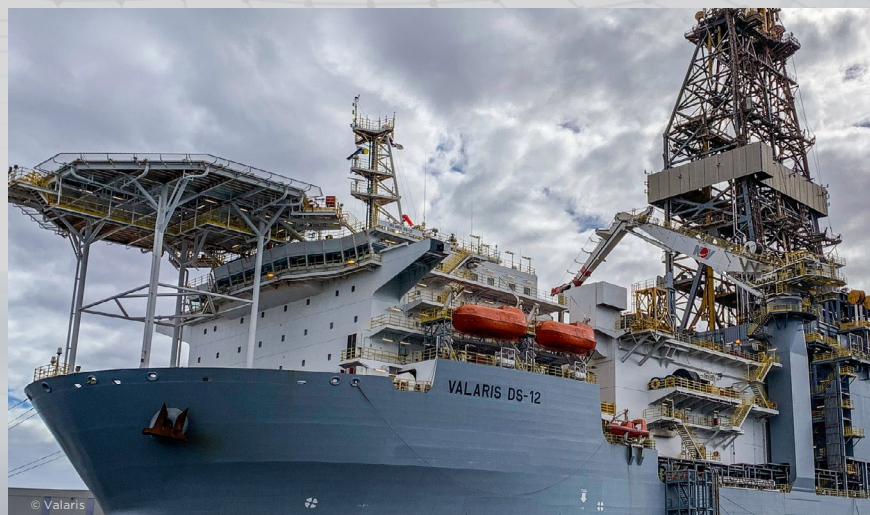
Developed in response to industry needs, the ABS ISQM process and notation provides a framework to coordinate and control the way software development, integration and maintenance are managed throughout the life of the equipment.

INDUSTRY FIRST AS OSI'S DEEP SEA MINERAL RISER DESIGN REVIEWED BY ABS

In July, ABS granted design approval to a pioneering deep-sea mineral riser system capable of reaching more than 6,000 meters beneath the waves. Developed by Oil States Industries (OSI), the Merlin™ Deepsea Riser System is the world's first deep-sea mineral riser to undergo design review by a classification organization. ABS is supporting OSI on the next phase of the project, which is the construction and certification of the riser. The Merlin Riser, which won an Offshore Technology Conference Spotlight on New Technology® Award earlier this year and is now under construction, has been contracted for operations in the remote Pacific Ocean Clarion Clipperton Zone.

VALARIS DRILLSHIP ACHIEVES ABS ENHANCED ELECTRICAL SYSTEM NOTATION IN WORLD FIRST

October saw another industry first, when ABS granted its Enhanced Electrical System notation EHS-E to the ultra-deepwater drillship *VALARIS DS-12* for an upgraded electrical system that was specifically designed to allow the drillship to optimize power plant performance, enabling the vessel to operate on fewer generators than previously and, consequently, with reduced emissions. The notation, introduced in the *ABS Guide for Dynamic Positioning Systems*, asserts that ABS surveyed the upgraded system and tested it to ensure it can operate safely on reduced generator power.



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GLOBAL **OFFSHORE WIND**



GLOBAL OFFSHORE WIND

MAINTAINING LEADERSHIP IN THE FLOATING OFFSHORE WIND MARKET

As near-shore areas become crowded with fixed wind power installations, countries around the world have begun turning their attention to the installation of wind turbines in deeper waters and further offshore. For countries like Scotland, South Korea, Australia and New Zealand, their near term offshore renewable resource will be with floating turbines at scale.

Floating wind turbines present an alternative to fixed installations because they are not restricted by water depth and can therefore provide access to countries that have this challenge. ABS recognized this in the early days of the renewable energy movement and became involved with floating wind turbine technology when it first appeared in concept form over a decade ago. Today, ABS is a world leader in classification and certification services for floating offshore wind installations and their support vessels and has become a key player in the developing U.S. offshore wind market.

In 2021, we classed the world's largest floating offshore wind farm, accepted the first offshore wind farm into class and secured classification status for a succession

“To achieve the scale of the U.S. offshore wind market by 2030, the industry will be reliant on the delivery of the variety of vessels that will be needed to install and maintain the turbines, while navigating various port constraints. ABS has been at the forefront of supporting this process, facilitating a succession of vessel developments that will prove critical to the future of this industry.”

GREG LENNON

ABS VICE PRESIDENT
GLOBAL OFFSHORE WIND



of new Jones Act-compliant offshore wind service vessels for the U.S. market, where our deep knowledge of regulation and excellent working relationship with the United States Coast Guard (USCG) contributed to local content requirements and the smooth progression of concepts from design into construction for some of the vessels.

BRINGING OFFSHORE WIND TECHNOLOGY TO U.S. WATERS

- In January, ABS was awarded classification of the first wind farm service operations vessel (SOV) to be designed and built in the United States. Engineered, constructed and to be operated by Edison Chouest Offshore, the Jones Act-compliant SOV will serve under a long-term charter in the planned *Revolution Wind*, *South Fork Wind* and *Sunrise Wind* offshore wind farms in the northeast United States. At 80 meters in length, the vessel will be capable of housing 70 people, will operate on diesel-electric power (therefore meeting EPA Tier 4 emission standards) and will employ a proprietary Variable Frequency Drive technology to reduce fuel consumption and greenhouse gas (GHG) emissions.
- In addition, ABS is classing four advanced Jones Act-compliant crew transfer vessels being built by Blount Boats for American Offshore Services. The 30 m vessels, ready for installation of future hybrid propulsion technology, will be delivered during 2023 and 2024, and upon delivery will begin working in wind farms on the U.S. East Coast.

WORLD FIRST AS WINDFLOAT ATLANTIC WINDFARM IS CLASSED BY ABS

In July, *WindFloat Atlantic* became the world's first classed offshore wind farm, after its three 8.4 megawatts (MW) floating turbines were accepted by the ABS Class Committee. The three semisubmersible units, which have a combined power rating of 25 MW, are installed 20 kilometers (km) off the coast of Viana do Castelo, Portugal. It is a landmark step, proving the reliability of a technology that has been evolving steadily since 2012, when ABS supported development of the 2MW *WindFloat* prototype.



GROUNDBREAKING FLOATING WIND FARMS IN ABS CLASS

In August, ABS classed the world's largest floating offshore wind farm, *Kincardine*, a 50 megawatt (MW) project off the southeast coast of Scotland. Installed in water depths of 60 meters (m) to 80 m, the farm is expected to generate up to 218 gigawatt hours (GWh) of electric power per year. Class services to the facility include verifying compliance with the *ABS Guide for Building and Classing Floating Offshore Wind Turbines*, and covers all phases of the project including design, fabrication, transport and service inspections.

APPROVALS IN PRINCIPLE FOR ADVANCED WIND TECHNOLOGIES

In September, ABS awarded AIP to Ned Project Inc. for the design of a novel wind turbine installation vessel. Its innovative approach is to load monopiles vertically on an 8,000 m² deck, eliminating the need to rotate the monopiles to the vertical position at sea, which enhances both the efficiency and safety of the operation. The design includes a leg-encircling heavy cargo crane with a working load of 3,500 metric tons (tonne) capable of handling turbines with a rotor diameter of 240 m and a tower height of 150 m.

December saw two AIPs awarded for innovative designs for floating wind turbine foundations. In one, an AIP was granted to Bassoe Technology for its T-Floater foundation, designed to carry a 10 MW turbine in the harsh conditions of the North Sea. It features a tow-out draft of only eight meters with turbine installed, which gives flexibility in selection of the assembly port. In the other, ABS awarded Wison Offshore & Marine an AIP for its w.semi platform foundation. The novel concept behind the w.semi is a modular design that will allow final assembly on-site near the installation site. The AIP verifies that these designs are feasible for their intended applications and, in principle, comply with the requirements of the *ABS Guide for Building and Classing Floating Offshore Wind Turbine Installations*.

ABS TO CLASS FIRST EVER JONES ACT WIND TURBINE INSTALLATION VESSEL

In February 2021, ABS was awarded classification of the first-ever Jones Act-compliant offshore wind turbine installation vessel. Currently, under construction at Keppel AmFELS for Dominion Energy, the 472 foot vessel is an important piece of the developing U.S. offshore wind industry. *Charybdis*, is designed to handle turbine sizes of 12 megawatts (MW) and larger and will also be able to install wind turbine foundations and perform other heavy lifts.

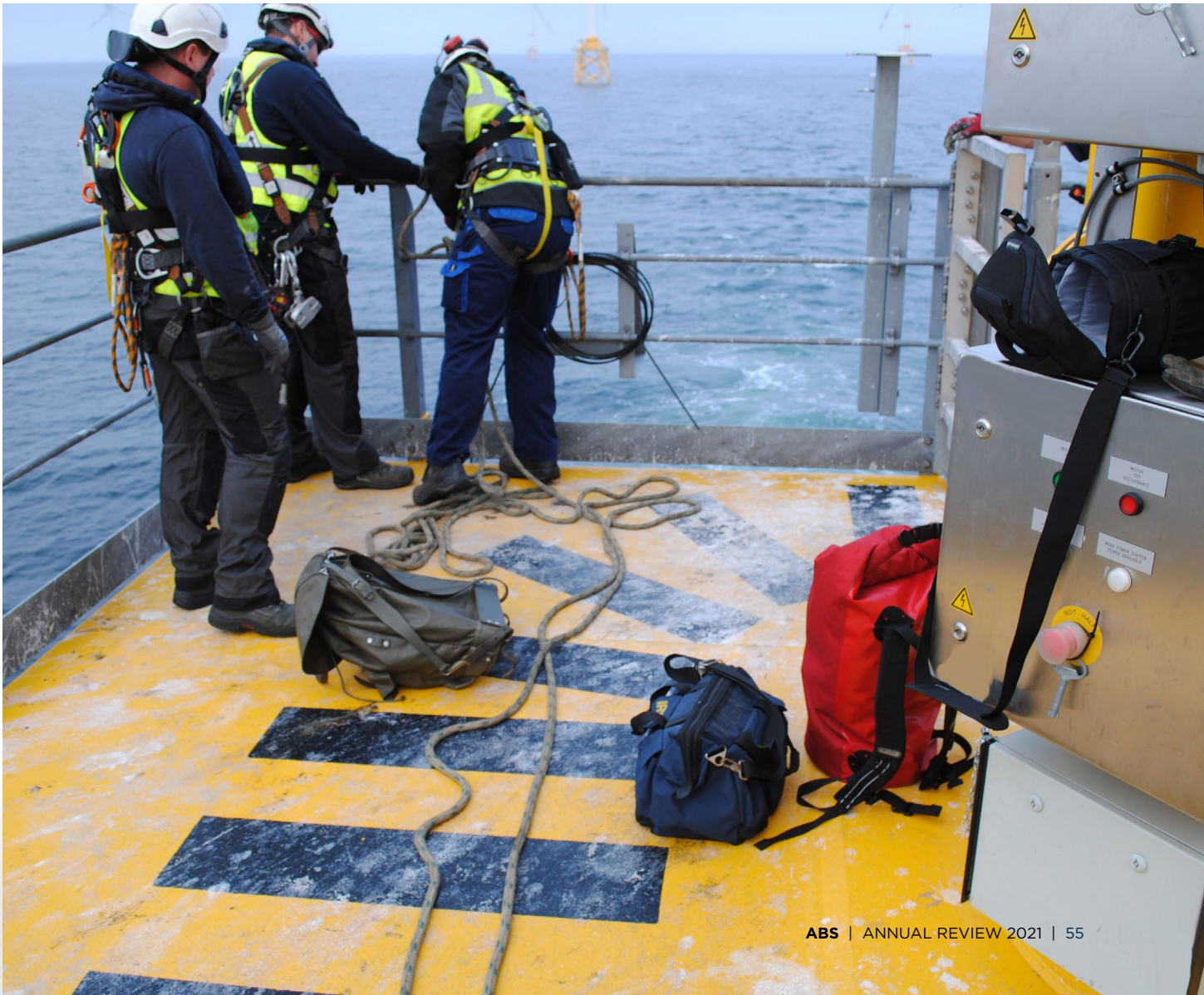


VALUABLE GUIDANCE FOR DEVELOPMENT OF OFFSHORE WIND FARMS IN THE U.S.

In 2021, ABS published two important reports to support the evolution of the offshore wind power sector in the United States. The first, issued in March, evaluates the U.S. offshore wind industry's readiness to deliver the support to the path to 30 GWs by 2030. *Offshore Wind Report, Positioning for U.S. Expansion: U.S. Ports and Vessels Innovation*, assesses U.S. port infrastructure and the availability of proper support tonnage, and looks at emerging industry trends and challenges for the growing U.S. offshore wind market.

Then in June, responding to industry demand for insight into specific operational requirements for the U.S. offshore wind market, ABS published *Safety and Compliance Insights: Understanding U.S. Regulations for Offshore Wind Vessels*. This report details Jones Act implications for offshore wind support vessels, service operation vessels and crew transfer vessels. It includes USCG and federal regulations for vessel design, construction and operation and addresses the most frequently asked questions on safety and compliance by ABS specialists.

ABS ended the year by convening the ABS Offshore Wind Forum, in which a group of industry leaders discussed various aspects of the challenge in accelerating the evolution of the U.S. offshore wind market and developing the innovative vessels needed to do the job. Under the theme *Accelerating the U.S. Market with Vessel Innovation*, discussions touched on the potential for creating a carbon-neutral offshore wind supply chain, developing sustainable offshore wind vessel designs and cultivating the necessary U.S. regulations for wind vessels.



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GLOBAL **GOVERNMENT**



GLOBAL GOVERNMENT

INDUSTRY-LEADING MARITIME EXPERTISE HELPS GOVERNMENTS AROUND THE WORLD

Our uncompromising dedication to safety enabled by robust digital technologies energizes every area of our activities, especially our work with global governments.

SUPPORTING THE U.S. GOVERNMENT

The relationship between ABS and the U.S. government dates to World War I, when the government sought assistance from ABS in creating a larger and up-to-date merchant marine to support the war effort. Over the century since, ABS has rendered invaluable assistance to numerous U.S. government organizations, helping realize important advances in engineering, technology and construction.

“2021 saw the ABS Government Team deliver new levels of support to the public maritime sector. We are well positioned to adapt to the dynamic worldwide maritime environment, bringing the latest commercial innovation and technology to our government clients.”

BRUCE BAFFER
ABS VICE PRESIDENT
GLOBAL GOVERNMENT

ABS AIP FOR VARD'S NEXT GENERATION OFFSHORE PATROL VESSEL

In September, ABS granted approval in principle (AIP) to VARD Marine for its 115 meter (m) next generation offshore patrol vessel design. The new design, unveiled at the Defense and Security Equipment International Show in London, serves a range of mission requirements including air, surface, and sub-surface surveillance and engagement. Its arrangement features a multi-mission bay and a set-down area for containerized mission payloads, with a configuration that can be tailored to meet a variety of mission objectives. The design was evaluated in accordance with the *ABS Rules for Building and Classing Light Warships, Patrol and High-Speed Naval Vessels* and carries ABS notations: ✕A1, DV NAVAL CRAFT, Ⓢ, ✕AMS, ✕ ABCU, NIBS, R2.



For more than 100 years, ABS has been the official classification organization of the United States, and under U.S. law, the only classification organization permitted to class U.S. government vessels. There are over 200 government-related ABS-classed vessels in the U.S. alone – a vast fleet that benefits from our committed support and dedication to advancing technology in the service of safety. Today, ABS continues to provide steadfast support for the U.S. government and its required safety regimes, through classification, maritime advisory and new technology development services that help the U.S. Coast Guard (USCG), U.S. Navy and other government shipowners maintain uninterrupted naval, law enforcement, research, survey and logistic operations.

Our long and fruitful relationship with the U.S. government continued in 2021, as we participated in and led a number of ongoing technical, educational and research and development projects, including efforts to develop new technologies for civilian as well as military applications. Some highlights of these activities include:

- We made significant progress working with the U.S. Military Sealift Command (MSC) on implementation of the ABS condition-based program and cybersecurity notations for the MSC fleet. In addition, we initiated a National Shipbuilding Research Program (NSRP) to support MSC with adoption of additive manufacturing for production of critical and obsolete parts.
- ABS worked closely with the U.S. Navy on development of naval ship acquisition programs for autonomous operations and a wide range of auxiliary ships and support vessels. We have worked to incorporate cost-saving ABS' technical and other commercial standards into the U.S. Navy's new ship specifications, and we continue to support the U.S. Navy with condition-based analytics supporting ship sustainment programs. ABS also provided design review and surveyor attendance supporting on-time and on-budget delivery of the USCG's new cutters into ABS Class.





- In October, the U.S. National Institute of Standards and Technology (NIST) awarded a grant to the Webb Institute to develop a 10-hour course on maritime industry standards in collaboration with ABS and the USCG Academy. It is one of five NIST awards granted to support standards education in undergraduate- and graduate-level curricula.

The NIST Standards Services Curricula Development Cooperative Agreement Program and its awardees are dedicated to building a modern workforce that recognizes standards as the bridge linking innovation, manufacturing and the global marketplace. Projects awarded under this program support development of curricula that integrate content on documentary standards and standardization processes into courses, modules, seminars and learning resources at U.S. colleges and universities. The 10-hour course will cover multiple topics related to marine industry standards, including: standards for the design, construction and operation of commercial and military marine vehicles; why and how maritime standards are developed; national and international maritime regulations; and standards for emerging technologies.

- ABS is also leading a U.S. government-backed project dedicated to developing tools and technologies that can accelerate approval processes for new metal-based additive manufacturing (AM) applications. AM is a fast-moving technology that has immense potential to revolutionize supply chain and maintenance procedures in many industries.

Funded by a grant of almost \$1 million from the NIST, ABS will work to develop standards and guidance for the rapid qualification of metal-based AM, collaborating in the effort with the I-DREAM4D National Consortium, an educational and research group that includes the University of Texas campuses of Rio Grande Valley and Austin, the Virginia Polytechnic Institute and the Applied Research Laboratory at Pennsylvania State University. The overall goal of this joint project is to ensure that qualification processes can keep pace with the growing use of AM across many industries and not become a roadblock to the technology's adoption.

SUPPORTING INTERNATIONAL GOVERNMENTS

Likewise, our work with international governments continued, as we supported class and class-related services including technology development and educational programs. A few highlights include:

- In Canada, ABS continued to support the Canadian Navy and Canadian Coast Guard with digital analytics for structural and machinery health monitoring. We also leveraged the ABS Newfoundland-based Harsh Environment Technology Center in partnership with Memorial University to study and develop polar ice technologies.
- In Singapore, the Maritime and Port Authority again renewed its research, development and innovation partnerships with ABS, continuing a wide-ranging relationship that covers such diverse areas as decarbonization, artificial intelligence, predictive maintenance, cybersecurity and additive manufacturing. Additionally, ABS collaborated with SGUnited, a Singapore government organization to implement a digitalization learning program with hands-on training through the ABS Digitalization Learning Program in Modeling and Simulation of Systems.

EXPLORING THE POTENTIAL OF NUCLEAR TECHNOLOGY

Advanced nuclear technology is a promising component of the decarbonization journey. For that reason, in November, the U.S. Department of Energy (DOE) awarded a total of \$8.5 million in five grants directed toward helping commercialize promising advanced nuclear technologies. The funding supports industry-led projects across the country that will incorporate the latest modeling and simulation technologies, siting analysis techniques and other research tools to inform the future deployment of advanced reactors for various uses including maritime applications.

The overall goal of the effort is to reimagine the way nuclear reactors are engineered, built and operated. ABS will focus on addressing hurdles in the maritime domain so that new reactor technology can be deployed for commercial applications, with the aim of accelerating the development of commercial maritime demonstration projects.



TALENT DEVELOPMENT AND CORPORATE CITIZENSHIP

DEVELOPING OUR TALENT PIPELINE

As the global maritime industry continues to transform with increasing digitization, automation, machine learning and big data analytics, digital technologies will be a key enabler in our quest to build a cleaner, better, safer and more sustainable future.

In this rapid evolution of technology, ABS is well-positioned as a technical and safety leader. The core engineering and technology competence of our people and the wealth of experience they bring to problem solving is a key differentiator for us. That's why ABS is focused on continuing to develop our employee base to be best in class through continuous learning, training and preparation to support our commitment to set standards of excellence as a leader in maritime safety – now and in the future.

The path forward for ABS is clear based on three defining goals – safety, service and solutions. We have been able to achieve those goals through the innovative thinking, enthusiasm and professionalism of our highly experienced staff. Years of experience, training and continued education have made us confident in our actions and secure in our decisions.

As an organization committed to investing in and cultivating a sustainable, diverse, multi-skilled talent pipeline across a broad range of disciplines – traditional marine and offshore architecture, engineering studies, data analytics and cybersecurity – ABS is well-prepared and ready to meet the challenges of an evolving industry.

Our robust internal career development efforts at ABS are designed to provide a balance of development activities for employees, using a combination of job experience, mentoring, coaching and formal training.

TRAINING

ABS continued to expand and elevate its training and development programs, even though the pandemic restricted in-person training programs. Almost 270 hours of course development provided new or enhanced online or virtual training for ABS surveyors, auditors and engineers, contributing to the more than 90,000 total hours of training completed by ABS employees.

In 2021, a long-standing rotational technical training program was transformed into a blended continuous learning program. ABS surveyors, auditors and engineers now attend interactive quarterly virtual workshops to reinforce fundamental knowledge, learn new skills and embrace for emerging technologies.

Robust online and virtual client training activities continued throughout 2021 with the most popular programs continuing to be our Incident Investigation and Root Cause Analysis Implementation, ISM Code: Internal Auditor, and Effective SMS Implementation: DPA Requirement programs.

CAREER DEVELOPMENT

ABS places great emphasis on career growth and development at all levels and across all areas of our organization. In 2021, ABS continued these efforts through two key development programs:

- The *Beacon Career Development Program* offers a wide variety of professional and career development tools, resources, trainings and opportunities for all staff members. In 2021, ABS employees completed over 11,300 hours of micro-learning trainings for professional and career development available within the Beacon program, and more than 70 ABS managers attended the instructor-led training, "Leader as Coach," totaling over 560 hours of training.

- The *Propel Accelerated Leadership Development Program* offers tailored development opportunities for identified high potential staff. In 2021, over 140 high potential employees from around the world expanded their careers and capabilities through targeted assignments, projects and trainings delivered as part of the Propel program.

ASPIRE PROGRAM

Another way ABS cultivates the talents of our people is through the Aspire program. In this program, newly hired graduates are given the opportunity to work alongside professionals in the Engineering, Survey, Technology, Business Development and Digital Solutions groups through a series of developmental rotations. The Aspire program fosters broad-based knowledge development by exposing participants to the diversity of career paths across ABS, such as data analytics, naval architecture, ocean engineering and mechanical engineering. Since Aspire's founding, 96 early career professionals have completed the program, gaining a strong foundational knowledge of the mission of ABS and the role we play in supporting the marine and offshore industries.

UNIVERSITY RELATIONS

In 2021, ABS provided scholarship commitments to 353 scholars at colleges and universities in the Americas, Europe, Middle East, Africa, China and Pacific regions.

Additionally, ABS supported endowed academic chairs at seven campuses:

- ABS Chair of Naval Architecture and Marine Engineering and ABS Chair of Marine Transportation at the State University of New York (SUNY) Maritime College
- ABS Chair of Engineering at the California State University Maritime Academy (formerly known as the California Maritime Academy)
- ABS Chair of Metallurgical and Materials Engineering at the Colorado School of Mines
- ABS Chair of Ocean Engineering at the University of California Berkeley (UC Berkeley)
- ABS Chair of Marine and Offshore Design Performance at the University of Michigan
- ABS Career Development Chair at the Massachusetts Institute of Technology (MIT)
- ABS Chair of Naval Architecture and Marine Engineering at the Webb Institute



ABS ESG

ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG) EXCELLENCE

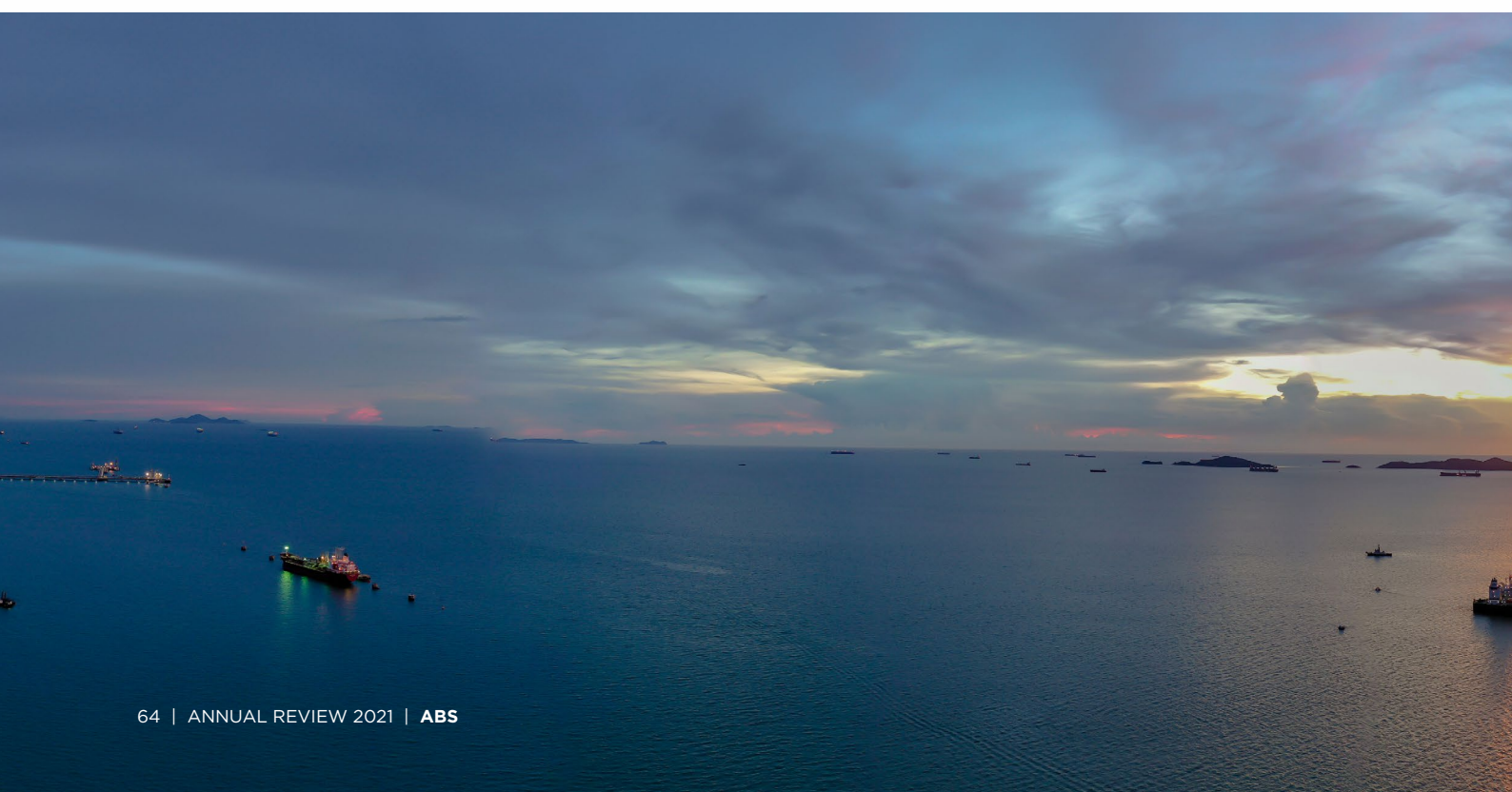
In 2021, we saw how the powerful combination of International Maritime Organization (IMO) requirements, United Nations' (U.N.) Sustainable Development Goals (SDGs) and increasing stakeholder pressure leveraged through ESG reporting, began spurring the marine and offshore industries to both evaluate and begin to address the carbon impact of their operations and supply chains. Against this backdrop, ABS continued to support our clients in creating sustainable business outcomes by helping them take an intentional, balanced approach to the ESG elements, reflected in an ESG framework and reporting.

We expanded our global sustainability support network, with the opening of the Shanghai Sustainability Center, adding to the existing network in Houston, Copenhagen, Athens, Singapore and London. Each of the six centers has specific functions and employs specialists in a range of sustainability disciplines to support our clients with some key focus areas including:

- Studying the viability of alternative fuels and new energy sources.
- Analyzing decarbonization pathways and the impact of seaborne trade growth and IMO targets.
- Pioneering new technologies and techniques in data, digital, classification and sustainability services to support decarbonization at sea.
- Using digital technology to simplify transactions and increase operational efficiencies.
- Assisting companies in their journey to ESG excellence.
- Launching new sustainability reporting and assurance services to help service providers demonstrate to clients their commitment and progress toward sustainable operations.

To further advance maritime decarbonization, ABS published an industry-leading series of outlooks and guidance documents throughout 2021 to assist the industry in navigating the uncharted waters of the 2030/2050 emissions challenge.

We also looked inward to assess how we can continue to progress our own ESG journey. It is the mission of ABS to serve the public interest as well as the needs of our members and clients by promoting the



security of life and property and preserving the natural environment. A sustainable future is an integral part of our mission, and we are committed to promoting sustainability in all our operations and in the way we work at ABS.

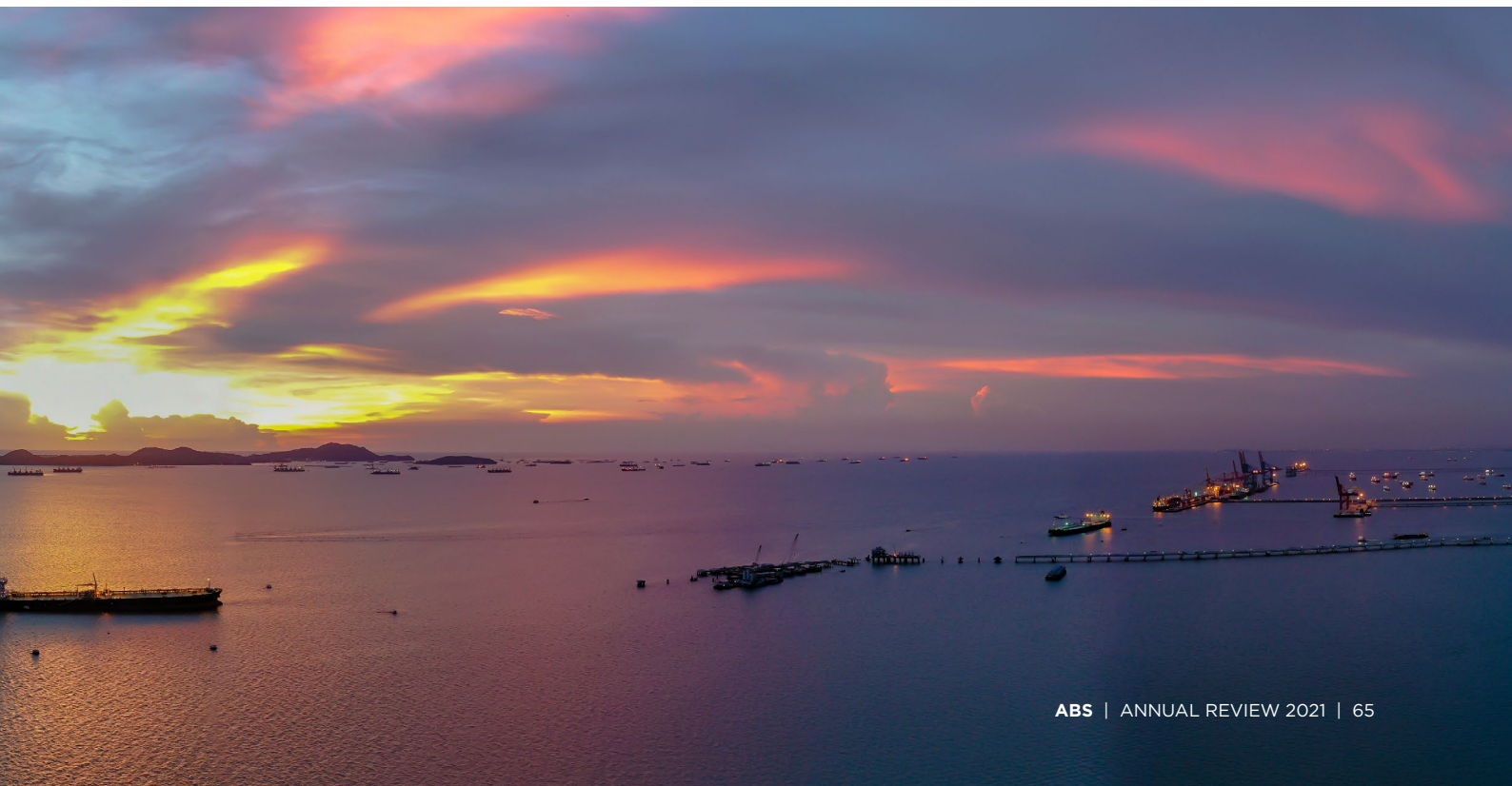
Recognizing the importance of the diversity of our workforce, we strengthened our SPIRIT of ABS values description as it relates to people, where the “P” for people now directly speaks to our global workforce: “We have a globally diverse and engaged workforce that is trained to the highest level. The various skills, perspectives and experiences of the ABS employees is what makes them our best asset.”

Furthermore, we created and approved a Diversity, Equity and Inclusion Statement, expanded our Human Rights Statement and modified our supplier contract language to reflect these values.

At ABS, our reputation for ethical and reliable service is one of our most important assets. Our Code of Ethics sets forth the standards and practices that form the foundation for our conduct and governance. Our strong commitment to ethics and integrity is not just good for business – it is part of the fabric of who we are as an organization and as individuals. Our clients trust us to be their partner, and we trust one another to operate according to the highest standards of conduct. Our commitment to ethics and integrity benefits both ABS and our clients.



MÆRSK MC-KINNEY MØLLER CENTER FOR
ZERO CARBON SHIPPING





SHAPING A
SAFER, CLEANER
FUTURE **TOGETHER**

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*Emeritus Member

SHAPING A
SAFER, CLEANER
FUTURE **TOGETHER**



ABS GROUP OF **COMPANIES, INC.**



ABS Group of Companies, Inc. (ABS Group), through its operating companies, provides risk-based engineering, safety, performance and certification solutions to support operational excellence in the industrial and government sectors. The organization's technical advisory services deliver value to global markets including the aerospace, automotive, critical infrastructure, manufacturing, marine, oil and gas, petrochemical, pharmaceutical and process industries.

ABS GROUP OF COMPANIES, INC.

SHAPING A SAFER, CLEANER FUTURE TOGETHER: LEADING THE INDUSTRY WITH RELIABLE, DATA-DRIVEN AND ENVIRONMENTALLY COMPLIANT SOLUTIONS

ABS Group of Companies, Inc. (ABS Group), which encompasses safety and risk consulting operations across the Americas, Europe, Middle East and Asia Pacific regions, marked half a century of industry leadership in 2021 when Forbes and Statista named it one of America's Best Management Consulting Firms.

ABS Group continued to adapt to a remote environment in 2021 while delivering new and improved solutions to support the global push for more reliable, data-driven and environmentally compliant operations. We invested in capabilities and services to meet growing demand related to the ever-changing landscape of safety and security risks. Throughout 2021, ABS Group expanded services across its portfolio, most noticeably in cybersecurity, with a new Managed Security Service for Industrial Cybersecurity, services to support the Department of Defense (DOD) Cyber Maturity Model Certification (CMMC), and expanded cybersecurity supply chain work with the Department of Homeland Security (DHS), aligning with our commercial and government clients' drive for more digitally enabled safe and sustainable operations.

ENHANCING CYBER RESILIENCE INDUSTRY-WIDE

In 2021, ABS Group continued to expand its cybersecurity capabilities and offerings, supporting the escalating safety risks related to the convergence of information technology (IT) and operational technology (OT), with a focus on protecting critical infrastructure.





PROTECTING CRITICAL INFRASTRUCTURE: NETWORK MONITORING AND MANAGED SERVICES

Launched in 2021, ABS Group's Industrial Cybersecurity Managed Services are uniquely focused on OT cybersecurity, positioning the organization as a leading industrial Managed Security Service Provider (MSSP). We provided clients vigilant protection through network monitoring and alerts, asset discovery and management, vulnerability management, configuration monitoring and management, policy management, and analytics and reporting – capabilities that seamlessly create a detailed picture to help clients deter, prevent, detect and respond to cyber attacks.

Additionally, ABS Group delivered new capabilities offering 24/7/365 monitoring of OT networks from a centralized Industrial Security Operations Center (ISOC). Installing passive monitoring technology for operational networks can help reduce disruptions to operations. The service delivers company-wide coverage for IT, OT, industrial control system (ICS) networks and devices. This gave ABS Group cybersecurity experts access to raw system data to analyze with a variety of cyber intelligence sources for active monitoring and actionable guidance.

ABS Group's portfolio now includes deep domain OT knowledge and expertise for critical infrastructure operations with services to prioritize health, safety, environmental and operational risks over IT-related information and data risks. Our remote and onsite OT cybersecurity services are available for the marine and offshore, oil, gas and chemical, industrial manufacturing and power and energy markets.

SECURING OPERATIONAL TECHNOLOGY FOR MARINE AND OFFSHORE

The marine and offshore industries continue to embrace the rising tide of advanced technology and digital solutions. Driven to meet or exceed decarbonization targets, this push has accelerated digital transformation, exposing the need for cybersecurity tailored to OT environments. The next chapter of growth demands innovative solutions and data-driven change that can adapt to the challenges today's technology present.

ABS Group worked across the marine and offshore value chain to help clients reduce their operational cyber risk, improve safety and remain competitive. Key industrial cybersecurity offerings include cyber risk management for International Maritime Organization (IMO) compliance, as well as consulting training services for global ports and terminals and Maritime Transportation Security Act (MTSA) regulated facilities.

In 2021, ABS Group was selected to perform a vulnerability and risk assessment for MTSA-regulated facilities in one of the major U.S. maritime ports – a critical project as the U.S. Coast Guard (USCG) in its Navigation and Vessel Inspection Circular (NVIC) 01-20 has called for increased cybersecurity and cyber risk management controls across maritime facilities regulated under 33 CFR 105 and 106. ABS Group evaluated the client's cybersecurity posture and identified cybersecurity risks that could cause financial impacts, operational disruptions or physical consequences resulting in a Transportation Security Incident (TSI) in ports or waterways.

CYBER CERTIFICATION SERVICES

ABS Quality Evaluations, Inc. (ABS QE), the management systems certification subsidiary of ABS Group, achieved CMMC applicant (C3PAO) and Licensed Training Provider status (LTP) by the DOD to conduct CMMC audits to the defense industrial base. ABS QE remains a world-leading certification body, providing accredited management system certification audits, supply chain assessments, training and assurance services in over 40 countries.

ABS QE strengthened its position and commitment to certify and guide organizations in critical areas such as data security, quality, health and safety, environmental, corporate social responsibility, risk and asset management. ABS QE's cyber certification product portfolio helped clients build trust while enhancing enterprise value through the management of cyber risks. Key markets focusing on cyber certification include financial institutions, software as a service (SaaS) service providers, oil, gas and chemicals and marine, with one of the largest global banks choosing ABS QE as their cybersecurity service.

ACCELERATING THE PATH TO SUSTAINABLE SHIPPING WITH DATA-APPLICATION TOOLS

ABS Nautical Systems® (NS) partnered with Siemens Energy Marine, a global provider of energy technology, to automate data capture and enhance compliance, including decarbonization targets, for shipowners and operators. Launched in 2020, NS' powerful digital solution NS eLogs™, integrated with Siemens' data application, SISHIP EcoMAIN, to automatically capture, consolidate, manage and visualize essential emissions data. By integrating these data-application tools, clients have a more comprehensive and automated way to monitor and manage highly regulated sustainability goals. NS has continuously improved as a leading environmental compliance solution for the maritime industry with hundreds of enhancements made every year to the NS Enterprise Suite.



SUPPORTING GOVERNMENT INITIATIVES: CYBERSECURITY

A new contract with the Cybersecurity Division in the Department of Homeland Security (DHS) will enable better information sharing and analysis across the federal government. ABS Group also expanded its cyber support to the National Risk Management Center and continued to support ABS with cyber assessments of Military Sealift Command (MSC) and United States Maritime Administration (MARAD) vessels.

ADDRESSING CHALLENGES OF THE MODERN WORLD: ENVIRONMENTAL AND SOCIAL RESPONSIBILITY

ENHANCING OPERATIONAL RESILIENCE AGAINST THE EFFECTS OF CLIMATE CHANGE

Europe remains a leader in the concept of carbon capture, utilization and storage (CCUS) and hydrogen fuel for the transport sector, both industrial and domestic. In 2021, ABS Group applied its vast risk management experience in the oil, gas and chemical sectors to ensure that safety was at the forefront of U.K. operations, including Process Safety Management (PSM) considerations. 2021 saw flooding become the most frequent natural hazard in the U.K., with the risk continuing to rise due to climate change. ABS Group assisted facility operators, including Control of Major Accident Hazards (COMAH), with flood management, including assessment, mitigation and emergency response.

The focus on solar energy also increased in 2021 as well as the correlating demand for research and development related to solar technology and new facilities. In addition, there was an increase in the interest in probable maximum loss (PML) evaluations for solar power stations and onshore wind farms, driven in large part by federal guidelines and infrastructure grants. ABS Group's Extreme Loads and Structural Risk (ELSR) division uses state-of-the-art catastrophe modeling platforms to develop results rapidly for clients while maintaining quality analysis through the support of internal databases on hazard, construction, and vulnerability within the models.

Additional prominent offerings included facility siting, computational fluid dynamics (CFD) modeling, and building design, with key clients including Marathon Petroleum, PPG, Westlake Chemical, and Honeywell. ABS Group's relationships with AECOM, Jacobs, and AIP Risk have cemented its position within the market, setting up continued success in 2022.

EXTENDING OFFSHORE ASSET LIFE CYCLE WITH ULTRASONIC NON-DESTRUCTIVE TESTING

ABS Group signed an exclusive global licensing agreement to offer an innovative ultrasonic non-destructive testing (NDT) solution that supports the expanded use of composite materials on offshore assets to extend service life. The advanced technology, developed by The Aerospace Corporation (Aerospace) for National Aeronautics and Space Administration (NASA), will assist the offshore industry with corrosion repair and enhance mitigation strategies to support the structural integrity of new and aging assets. ABS Group worked with global leaders in composite repair and offshore clients to further develop the technology for new and expanded applications in the offshore industry. Energy industries were also involved in this advancement with plausible applications towards renewable energy assets in the future.



SUPPORTING GOVERNMENT INITIATIVES: DOT AND FEMA

In 2021, new priorities emerged from the U.S. Federal government that aligned with ABS Group's core capabilities to address challenges in transportation, climate resilience, and cyber. ABS Group won a new contract with the Department of Transportation (DOT) to support Congressional mandates and strategic engineering initiatives. Under this contract, ABS Group led the way in helping the DOT determine the resources needed to establish an LNG research hub, developed research and development (R&D) strategies to support their safety mission and identified best practices to reduce methane gas emissions.

ABS Group also won a new five-year contract to continue support to the Federal Emergency Management Agency (FEMA), aiding the government's climate resilience initiatives by evaluating natural hazards risk and providing post-disaster loss analyses. ABS Group helped FEMA develop and release the National Risk Index (NRI), which is used by the public to make risk-informed decisions across 18 national hazards.

POWER AND ENERGY: MOVING TOWARDS A GREENER FUTURE

In today's evolving, highly competitive energy market, asset owners and investors are seeking new ways to produce resources, implement capital projects and make acquisitions that maximize return on investment. In addition, there are increasing demands for safer, more reliable and environmentally compliant assets and operations. With the call for renewable energy across the global footprint and legislative changes setting clear deadlines, the power sector is moving in the same direction as alternative fuels in the battle to address climate change.

In 2021, ABS Group re-launched its services in the power and energy markets, utilizing decades of experience and deep expertise in the onshore and offshore energy industries to address new and emerging risks. This included integrated service offerings across the asset life cycle for wind, nuclear, and solar power, with solutions ranging from initial concept and development to acquisition support, engineering, construction, operations, and maintenance, through to end-of-life decommissioning or asset reuse.

SNOW EAGLE GROUP: JOINT VENTURE SUPPORTING SBA MENTOR-PROTÉGÉ PROGRAM

To aid the federal government in expanding its base of qualified small businesses in 2021, S&K Mission Support (SKMS) and ABS Group entered the U.S. Small Business Administration's (SBA) Mentor-Protégé program. The SBA program is designed to enhance the capability of small business participants to successfully compete for federal government contracts. The partnership was enhanced by the establishment of a joint venture named Snow Eagle Group. SKMS, the program protégé, is an SBA Section 8(a) tribally-owned small business providing services for the federal government and private sector in the aerospace and energy industries. It supports critical programs for agencies within the Department of Defense (DOD), Department of Energy (DOE) and Department of Transportation (DOT), offering business oversight, as well as technical, administrative, information technology (IT) and engineering services.





INVESTING IN KEY PARTNERSHIPS AND GROUNDBREAKING TECHNOLOGY

New technologies give rise to cutting-edge business models and products that not only simplify market challenges, but also provide competitive differentiation. In 2021, ABS Group invested in game-changing tools and software to unlock innovation and build trust with clients as they embarked on their digital journeys.

TECHNOLOGICAL INNOVATIONS: ULTRASONIC NON-DESTRUCTIVE EVALUATION

Game-changing composite analysis tools for marine and offshore life extension were brought to the market in 2021 with an exclusive global licensing agreement offering an innovative non-destructive testing (NDT) solution. The advanced technology, originally developed for NASA, will assist the offshore industry with corrosion repair and enhance mitigation strategies to support the structural integrity of new and aging assets. This breakthrough technology provided our clients with a unique and cost-effective approach to the challenge of servicing assets beyond their original design life.

ABS NAUTICAL SYSTEMS®: ACCELERATING THE PATH TO SUSTAINABLE SHIPPING

ABS Group's proprietary fleet management solutions continue to support the digital journey through compliance management, environmental reporting and mobile applications that deliver insights in real-time. In 2021, the ABS Nautical Systems® (NS) platform shifted focus to provide clients with more efficient ways to capture and manage emissions data to meet and exceed decarbonization targets.

NS continued to enhance the features of NS eLogs™, the first electronic logbook solution on the market offering the complete suite of International Convention for the Prevention of Pollution from Ships (MARPOL) books that seamlessly integrate with NS Enterprise to resolve recordkeeping challenges for marine customers. Integration with third-party data applications, such as Siemens Energy Marine's SISHIP EcoMAIN Suite, allowed clients to automatically capture, consolidate, manage and visualize essential emissions data, unlocking the competitive need to meet today's compliance challenges with ease.

NS continues to drive growth as a digital transformation tool, adding 460 vessels in 2021, the largest expansion to date, taking the total vessel count to over 4,000.

GOVERNMENT OUTREACH

The ABS Group Government team has worked with agencies and government clients for over 20 years, providing holistic solutions and applying risk-informed strategies. With risk management at the core, ABS Group delivers comprehensive solutions to both civilian and military agencies. Our support to the federal government improves the risk posture of the government and advances the resilience of the private sector, which the government regulates and communicates with on critical national initiatives.

In 2021, ABS Group demonstrated its commitment to small businesses by creating a joint venture with The Confederated Salish and Kootenai Tribes (S&K Mission Support) called “Snow Eagle Group” as part of a mentor/pro-tégé business relationship. With this joint venture, ABS Group will be better positioned to foster improved business practices with S&K and enhance its ability to serve federal clients through streamlined procurement options.

MANAGING SAFETY AND RISK: REMAINING A TRUSTED PARTNER FOR OPERATIONAL EXCELLENCE

In 2021, ABS Group responded to industry-wide demand for more reliable, data-driven and environmentally compliant solutions. Investments in cybersecurity for operational technology, environmental, and social responsibility service offerings and trailblazing technologies continued to help our clients mitigate uncertainty and achieve operational excellence. Over the decades, ABS Group’s range of services and solutions have expanded and adapted to support the ever-changing risk landscape that its clients must address to properly power, fuel and regulate the world. As new risks emerge, ABS Group will continue to add value to its clients in the marine, offshore, oil, gas, chemical, government, power, energy and industrial sectors.

STRENGTHENING INDUSTRIAL CYBERSECURITY IN THE POWER AND ENERGY SECTOR

ABS Group partnered with NAES Corporation, the energy industry’s largest independent provider of Offshore and Marine (O&M) services, to provide industrial cybersecurity services for critical infrastructure in the power and energy sector. Through this collaboration, NAES will have enhanced access to the services, technology, and expertise to meet the North American Electric Reliability Corporation Critical Infrastructure Protection (NERC CIP) requirements. With access to ABS Group’s cybersecurity managed services, NAES and its clients gained access to a broad range of risk-based solutions on every stage of their cyber defense, converging operational technology (OT) and industrial control systems (ICS), and leveraging specific domain expertise in the power and energy sector.



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ANNUAL REVIEW

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