



ANNUAL REVIEW

2017

LIVING OUR MISSION

LEADING THE FUTURE



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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LIVING OUR MISSION

LEADING THE FUTURE

As companies evolve, tradition and innovation are often seen as opposing forces. Pushing outward, innovation seeks to spur change. Looking inward, tradition seeks to achieve durability and strength through constancy.

Although opposites, the two philosophies go hand-in-hand to build a relevant, thriving organization. Alone, neither is sufficient to drive long-term prosperity in a changing world. Together, they become the foundation of the future combining vitality and stability. The challenge facing our industry today is embracing both tradition and innovation, leveraging the best in each to drive continuous self-improvement and sustainable growth, especially as we enter the Digital Age.

For ABS, safety is both the core of our tradition and the driver of our innovation – not only the safety of life and property at sea, but also the safety of people who work in shipyards and aboard marine and offshore assets around the world. Metrics quantify certain aspects of that tradition, such as ABS ending 2017 with no

work-related lost-time incidents and a hull and machinery casualty rate far below the industry average. But no numerical measure can express how deeply safety permeates every aspect of our work. It was our mission when ABS was founded in 1862, and remains our guiding light today and tomorrow. All the innovations and advances we have introduced over the years, whether in industry technology or client service, were made with safety foremost in mind.

Now, as we continue our digital journey, this combination of tradition and innovation is leading us to develop new ways of using data and digital technologies in the service of safety. These advances give our surveys greater focus, make them less intrusive, and improve workplace safety for our surveyors. They enable us to add value through new data-driven advisory services that help our clients improve the safety and reliability of their assets and operations. In some ways they bring transformational change, but even when they break with past practice they reinforce our core tradition. Throughout our history that is how we have always led the future – by living our mission.



CHAIRMAN'S MESSAGE

Continued market pressures and widespread change dominated 2017 with fluctuations in global economics, industry fundamentals, technology advancements, and regulatory expectations. While the only constant seemed to be change, ABS continued its commitment to safety, reliability, and efficiency – achieving industry leading safety metrics, including a ZERO work-related lost-time incident rate for the full year. ABS is truly living our mission and leading the future on multiple fronts.

The global economy improved and oil prices stabilized; however, these changes became evident only in the last half of the year. As a result, the marine and offshore industries remained focused on improving efficiency and reducing operating expenditures. ABS weathered this environment with incredible strength and resilience, growing our classed fleet and maintaining the highest orderbook share in the tanker and offshore segments. ABS made significant investments in future technologies, and did so with a keen eye focused on improving the safety and performance of marine and offshore assets, and the people that power them.

ABS launched its strategic ABS FutureClass™ plan in 2017 to further solidify its leading position across the marine and offshore industries. Accelerating its digital evolution, ABS charted its journey towards the future as a data-driven, innovation-inspired, agile technology company dedicated to sustaining and strengthening its leadership role.

The organization remained steadily balanced and keenly focused on its safety mission while strengthening its core competencies of Survey and Engineering through enhanced training and development opportunities. These

fundamental efforts were reinforced through investments in designing and deploying state-of-the-art systems and technology capabilities as well as continued financial support and academic partnerships to develop the next generation of industry leaders.

LIVING OUR MISSION

Nothing embodies living our mission more than our exemplary safety performance. With no work-related lost-time incidents during the year, ABS had a total recordable injury rate of 0.28 for the year. This is a truly remarkable health and safety success milestone and testament to the fact that ABS treats every day as Safety Day. Our employees' conscientious safety focus permeates throughout the organization and nothing is more important than everyone returning home safely at the end of each day.

In a time when the industry was flat or saw declining numbers, the ABS-classed fleet grew to 251 million gross tons (gt), and 22 percent of all new orders were contracted to ABS class. ABS remained the preferred class for tankers and firmly held its place at the top of class organizations for the offshore energy sector, as it has for 70 years. More than 90 percent of jackups, 86 percent of all drillships, and roughly half of the remaining markets in the offshore sector are ABS class. Also, in testimony to the exemplary quality ABS inspires in its clients, the machinery casualty rates and serious casualty rates of ABS-classed vessels remained at less than half of industry averages.

ABS continues in top positions with shipowners in Brazil, Denmark, Germany, Greece, Italy, Japan, Singapore and the United States.

Further, ABS stays in top positions with shipbuilders in Brazil, China, Japan, Singapore, South Korea and the United States.

From a digital perspective, the Internet of Things, big data analytics and cloud computing figured large in many of the year's notable achievements, including ABS leadership in the industry's transformation.

One concrete example of this transformation is found in our new state-of-the-art global headquarters building in Houston. It will be home to our digital laboratory – a technology acceleration center where new product development opportunities offered by the Digital Age will be put into practice. In everyday terms, our digital lab will provide an entrepreneurial, collaborative environment populated by cross-functional teams that join forces with clients, industry and academia to significantly shorten the traditional development track for new ideas. Typical development timelines can consume months and even years of effort, but, through our digital lab, working prototypes known as minimally viable products can be produced and tested in a matter of weeks.

Eager to embark on their own data-driven futures, many global companies sought assistance from ABS during 2017 in pursuing this dawning digital destiny. With these partners, we engaged in groundbreaking projects in diverse areas including remote control of vessels, structural condition prediction and precision planning of maintenance and survey operations.



The limitless ocean of data live-streamed from vessels today is already sufficient to render them 'functionally transparent', visible to a once-unimaginable depth of technical clarity. The digital capabilities to accomplish that are not yet fully developed, but they are coming and ABS is charting the course. This will truly be 'disruptive technology', because its effects will reverberate, not only through the industry, but also through the working lives of its marine assets. Every aspect from management to maintenance, repair and survey will be informed, improved and inspired by the insights of digital transformation.

These transformations – and more – are embodied in the ABS FutureClass plan. Through FutureClass, ABS is transforming and modernizing its Class-centric strategy to deliver its services more efficiently in the new world of fast-paced change and digital and data-driven technology.

Our digital journey is a key part of our FutureClass plan and continues program developments already underway. Key foundational building blocks, such as the ABS Freedom™ survey workflow system and our industry-leading ABS CyberSafety® program, have built a solid foundation from which we are continuing to develop game-changing products and services. Through FutureClass, ABS is transforming the traditional survey process.

The digitally-informed survey of the future will involve a new kind of teamwork. Remote data scientists will be part of local survey teams, developing risk-based vessel advisories and digital models for surveyors. Further, there will be a new era of collaboration on safety between Class; and the industry. Clients are sharing an unprecedented amount of operational and maintenance data, making digital models possible. Class, having a truly comprehensive view of vessel risks, will then be able to help operators make better-informed decisions about their assets through an independent lens. Ultimately, the world fleet will be in better physical condition and operate at better efficiency overall.

ABS GROUP OF COMPANIES, INC

A subsidiary of ABS, ABS Group and its affiliated companies delivered strong operational and financial results in a difficult year. As one of the leading risk management organizations globally, ABS Group delivers world-class, independent technical advisory and certification solutions across industrial sectors.

ABS Group works closely with national oil companies, global governments and pharmaceutical companies, among other industries. Helping industrial clients around the world improve their operational risk profile and extend asset life, ABS Group leveraged its unrivaled technical expertise in 2017 to:

- Certify management systems for aviation, space and defense companies.
- Train, mentor and monitor 1,000 personnel in process safety improvement at an international oil refinery.
- Verify and certify the first operational wind farm in the United States.
- Assist the U.S. Federal Emergency Management Agency with post-disaster recovery efforts following three of the most devastating storms in the nation's history.

These accomplishments demonstrate the diversity ABS Group brings to ABS through its industrial advisory focus. ABS Group is well-positioned to lead the future of safety and risk management globally.

LEADING THE FUTURE

Building from our extensive technical leadership foundation, ABS is leading the future of Class by delivering precisely what the industry needs today while simultaneously preparing for what will inevitably be needed tomorrow to improve safety and performance. Through this journey, I acknowledge our loyal clients for their continued trust, our talented employees for their unwavering commitment to our mission and values, and our accomplished governing Board of Directors who provide solid and steady leadership.



“Where technology enables, people achieve. In the future, as always, it is the dedicated people of ABS who take firm hold of the latest technologies and bring them to bear in the spirit of our mission and in the service of safety.”

CHRISTOPHER J. WIERNICKI
CHAIRMAN, PRESIDENT AND CEO
ABS

Amid the excitement of navigating continuous change, it is important to remember that data and digital technologies, for all they can accomplish, are but tools. Technology will advance and enhance the surveyor's job, but will never replace the surveyor's judgment. While technology drives the digital revolution, only people can turn its promise and potential into reality. How well we as an industry manage the human factor as we absorb today's disruptive changes will define a large part of our legacy to the future. ABS will persevere

and succeed through our strategic FutureClass plan, because we are solidly grounded in executing all our work with the highest degree of integrity, recognizing fully that people are the common denominator in our industry's digital transformation.

Where technology enables, people achieve. In the future, as always, it is the dedicated people of ABS who take firm hold of the latest technologies and bring them to bear in the spirit of our mission and in the service of safety. I am continually humbled by our employees' passion as trusted technical advisors and recognized leaders who deliver exceptional technology solutions and services – for the industry and our clients – all in support of our mission.

Each and every day, we live our mission and lead the future of Class.

Chris

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

INDUSTRY LEADING SAFETY AND QUALITY

For ABS, safety excellence is both an annual goal and an endless pursuit. In our long safety tradition, each year's successes form the foundation of the next year's achievements, fueling the voyage of continuous self-improvement that has made ABS a global Health, Safety, Quality and Environmental (HSQE) leader. ABS maintained this leadership through 2017, recording zero work-related lost-time incidents (LTIs) and a corresponding lost-time incident rate (LTIR) of 0.00 – a combination that represents a significant milestone in the organization's continuing journey of safety excellence.

OCCUPATIONAL HEALTH AND SAFETY PERFORMANCE

The ABS ongoing safety excellence program incorporates strong occupational health and safety processes and policies, including its 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.

- ABS LTIR of 0.00 can rightly be called a spectacular achievement.
- ABS total recordable injury rate (TRIR) of 0.28 remained very low year-on-year.
- ABS employees continued to make good use of the global reporting system to capture unsafe conditions, unsafe behaviors, near misses, and work-related injuries or illnesses.
- ABS maintained its Occupational Health and Safety Assessment Series (OHSAS) 18001 certificate with external audits performed by the British Standards Institute (BSI).

“A world-class safety culture requires care, attention and consistent actions to drive safety excellence, positive behavior and beneficial change. I am proud to see these values passionately put into practice each day by our employees worldwide.”

CHRISTOPHER J. WIERNICKI
CHAIRMAN, PRESIDENT AND CEO
ABS

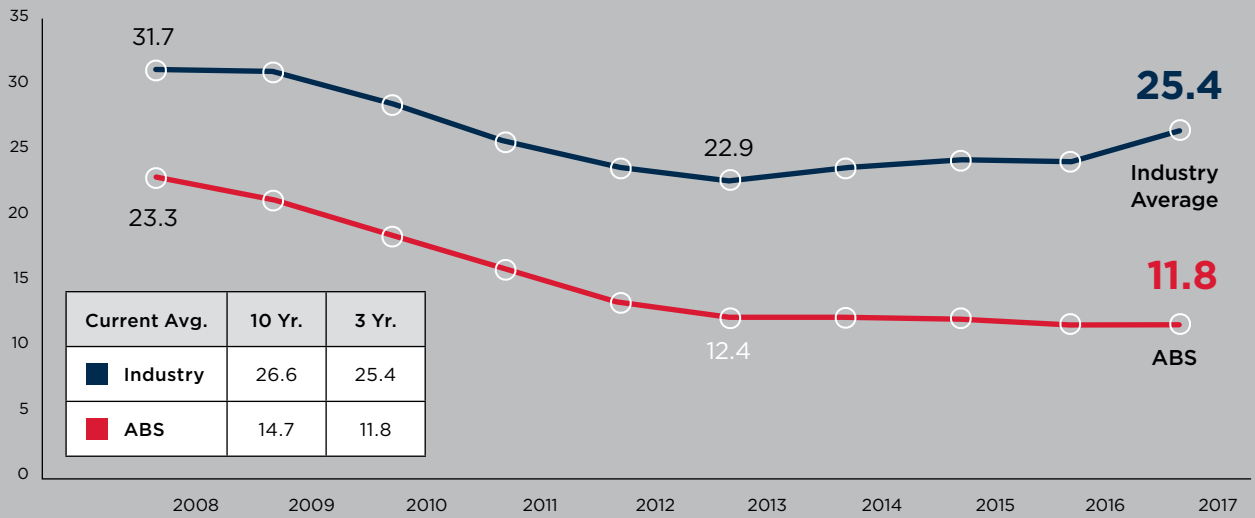
QUALITY PERFORMANCE

In 2017, ABS continued high-quality service delivery to our global client base.

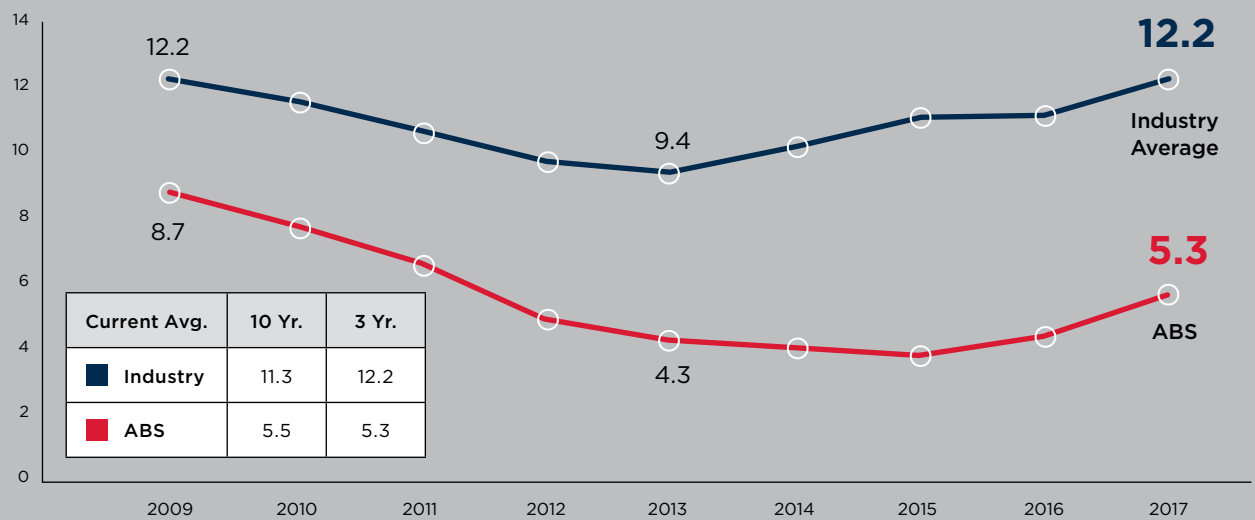
ABS maintained its leading position on overall Port State Control (PSC) performance. Notably in 2017, the Tokyo Memorandum of Understanding (MOU) recorded no deficiencies for which ABS was found responsible – a first since Tokyo MOU began assessing responsibility to Recognized Organizations (RO) in 2003.



OVERALL SERIOUS CASUALTY RATE

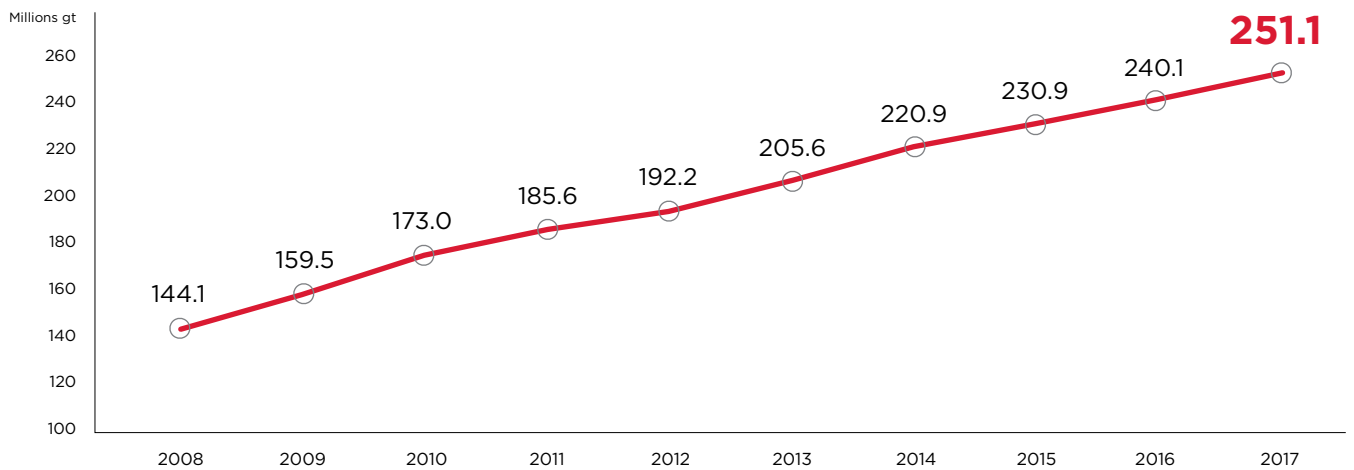


HULL MACHINERY SERIOUS CASUALTY RATE

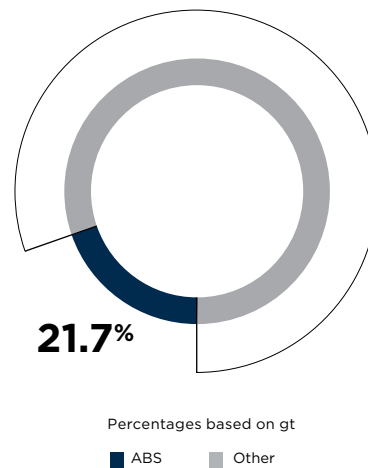
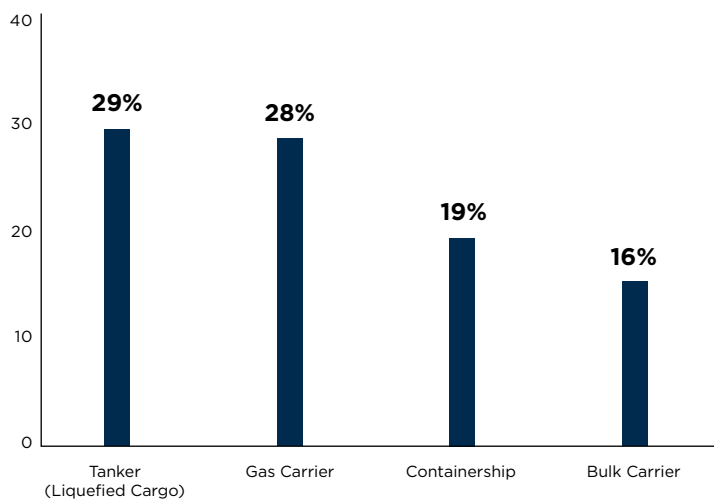


INDUSTRY LEADING PERFORMANCE

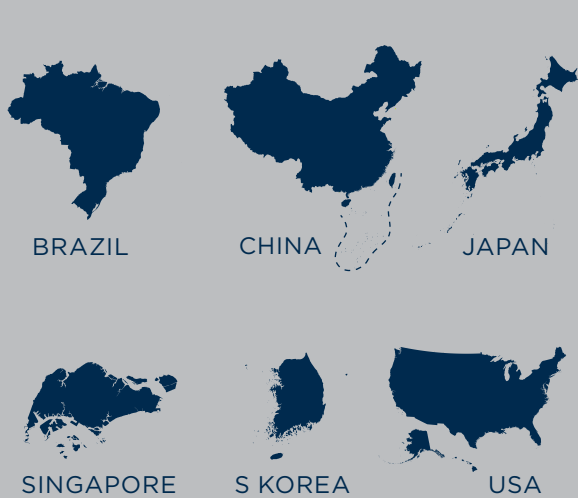
EXISTING FLEET 2017



MARINE ORDERBOOK SHARE 2017



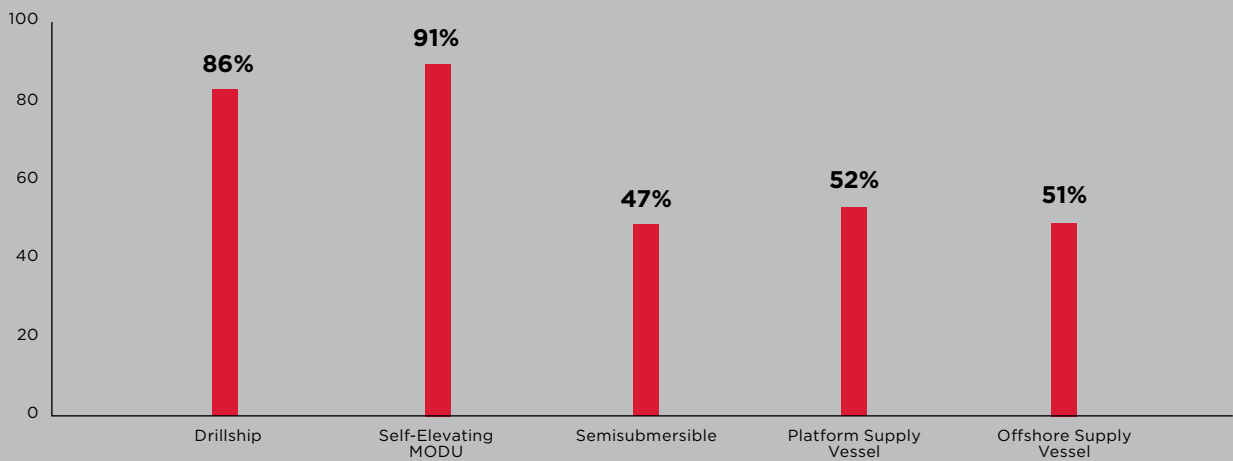
LEADING ORDERBOOK FOR SHIPBUILDERS



LEADING ORDERBOOK FOR OWNERS



OFFSHORE ORDERBOOK SHARE 2017



GLOBAL CORPORATE CITIZENSHIP AND SUSTAINABILITY

DEVELOPING OUR TALENT PIPELINE

Digital Age tools are expanding both the scope of our knowledge and our ability to act on it. As the maritime sector evolves towards a future in which data and digital technologies are regularly leveraged to enhance productivity, efficiency and optimization, success will increasingly require a multi-skilled workforce with a cross-functional team mindset and the broad vision to meet new and challenging objectives – technical viability and economic feasibility – simultaneously. This rapid evolution in technology and capability is exerting new demands on the various services supporting the highly educated, diverse workforce that has for years made ABS a technical and safety leader of the industries it serves.

Looking forward, ABS remains committed to building a sustainable pipeline of up-and-coming professionals in a broad range of disciplines – traditional marine and offshore architecture and engineering studies and, just as importantly, data analytics and cybersecurity – through planned philanthropic giving to academic institutions around the world as well as robust internal talent development programs.

In 2017, ABS designed and deployed a global shaft alignment training series to address evolving industry challenges related to current shaft designs. Combining blended, simulation-based and classroom-based training methods, ABS introduced continuous learning programs during the year, including drilling fluid and well control circulation systems, high voltage safety awareness and welding management. These programs were implemented



worldwide adding to an already robust online and instructor-led technical curriculum, which supports today's pressing industry issues.

ABS maintains a three-year recertification requirement for all survey and engineering personnel. During 2017, ABS fundamentally upgraded and instituted improved training modules across its certification programs, which ensure excellent technical proficiency of survey and engineering personnel. Averaging more than 80 hours of training and development per technical employee, ABS personnel are well prepared and ready for evolving industry challenges.



During the year, ABS worked with the United States Coast Guard (USCG) Academy to develop an industry-leading curriculum for a degree program in cybersecurity. ABS also provided scholarship commitments to 330 scholars at colleges and universities in the Americas, China, Europe and Pacific regions.

Additionally, ABS funded eight endowed academic chairs:

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

ASPIRE PROGRAM

ABS is as committed to encouraging the personal development of its employees as it is to supporting students at educational institutions around the world. One in-house effort to cultivate the talents of its employees is the Aspire program. Through Aspire, newly hired graduates take an active role on the ABS team, working alongside professionals from more than 60 countries to develop broad-based knowledge of the maritime and offshore industries through rotations in the Engineering, Survey, and Technology departments. Upon program completion, graduates are placed throughout the organization to support ongoing projects. In 2017, 14 recent graduates were in various stages of the ABS Aspire program. Aspire participants bring diverse backgrounds and skill sets to ABS, including data analytics, naval architecture, ocean engineering and mechanical engineering to support the marine and offshore industries and the future of ABS.



LIVING OUR MISSION | LEADING THE FUTURE

LEADING DIGITAL

A DIGITAL ORGANIZATION

As the Digital Age unfolds, the marine and offshore markets are experiencing transformational challenges from rapidly developing technologies, a changing market landscape, and increasing societal expectations regarding safety and the environment. ABS is meeting these profound challenges through digital innovation, focusing on digital developments and opportunities in every aspect of its activities.

Strengthening its digital leadership, ABS established a Chief Digital Officer position that will guide company growth as it evolves in the data- and digital-driven marketplace. The ABS global digital team is setting the pace in digital innovation, building digital solutions – a data platform, data analytics, data-centric inspection technologies, mobile technologies, and cybersecurity programs and services – which will transform marine and offshore





inspection processes. When fully realized, the digital transformation of survey will benefit clients with more effective decision-making – ultimately helping increase asset uptime and reliability while reducing maintenance and operational costs. This also improves the surveyor's work experience by streamlining communications and increasing vessel condition foreknowledge.

KEY MILESTONES

Several activities in our digital journey were realized in 2017, including industry-leading work with shipowners, regulators, equipment manufacturers, governments, academia and others on topics such as wearable technology, drones and unmanned systems, data strategy validation, condition-based health monitoring, structural digital twin development and predictive analytics.

- Across the United States, ABS equipped survey teams with wearable inspection technologies including two-way visualization and communications glasses. The feasibility study validated improved survey efficiency, safety and quality to streamline information capture, data sharing and advisory communications.
- ABS worked with the University of Michigan, Vanderbilt University and Stevens Institute of Technology to validate its data strategy, which is designed to improve the Class process related to inspection technologies, digital models and data analytics.
- When the International Association of Classification Societies (IACS) established a Cyber Panel in 2015 under the leadership of Christopher J. Wiernicki, IACS Chairman 2015-16, ABS was identified as the recognized leader to chair this important working team and continued this leadership in 2017.

- ABS joined the Unmanned Cargo Ship Development Alliance located in China to work across the industry with other class organizations, shipyards, equipment manufacturers and designers to advance autonomous shipping. The alliance will develop a design integrating features of independent decision-making, autonomous navigation, environmental perception and remote control.
- ABS updated its *Guidance Notes on Using Unmanned Aerial Vehicles (UAVs)* for drone technology service provider selection helping owners evaluate task suitability, quantify data quality and integrity, and account for human factors considerations.
- In an end-to-end cloud-based solution, the ABS Data Lab was designed in 2017 to incorporate, process and visualize data from batch uploads as well as live streams. This Machine Learning model provided groundbreaking insight to predict fuel consumption, and created visualizations for data quality assessments.
- ABS developed a unified data model, which imports data from multiple computer-aided design (CAD) platforms, improving input consistency throughout design phases and reducing duplication of modeling efforts in engineering work.



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- ABS published an Advisory detailing metal Additive Manufacturing technologies (e.g, 3D printing), its technical challenges and tradeoffs, and changes to the design process to aid vendors and owners.
- Supporting the success of its industry-leading ABS C-LASH™ container lashing software program, ABS introduced the S-LASH dynamic link library for software developers to embed an improved run-time C-LASH program with results that replicate lashing rods, twist-lock gaps, container racking deflections and container stack displacements.
- Through an improved ABS Rules Manager app, clients have full access to more than 100 ABS Rules and Guides, and additional enhancements will provide full access to all ABS Rules, Guides, Guidance Notes and select IMO publications during 2018.
- As the organization continued its digital journey, ABS formally implemented its FutureClass plan during 2017.

ABS FUTURECLASS

The Digital Age is introducing new technologies, new ideas and new ways of doing business around the world. As the maritime and offshore sectors absorb these new influences, Class is changing, evolving alongside the industries it serves, and ABS is at the forefront of driving that change.

As industry navigates this latest evolution, ABS remains keenly focused on leveraging data analytics and digital technologies to help our clients achieve stronger performance and operational efficiencies – while also living our safety mission. This combination of tradition and innovation compels us to develop new ways of using data and digital technologies in the service of safety.

The ABS FutureClass program expands our ability to fulfill the ABS Mission, providing new tools that inform classification services and enable us to work collaboratively with our clients to align asset maintenance practices with class requirements. The heart of this capability

expansion is technology – remote data collection devices, drones and crawlers; wearables; advanced sensors; and satellite connectivity – which has reached a stage of readiness and maturity allowing us to connect with our clients and share information to provide data-driven services.

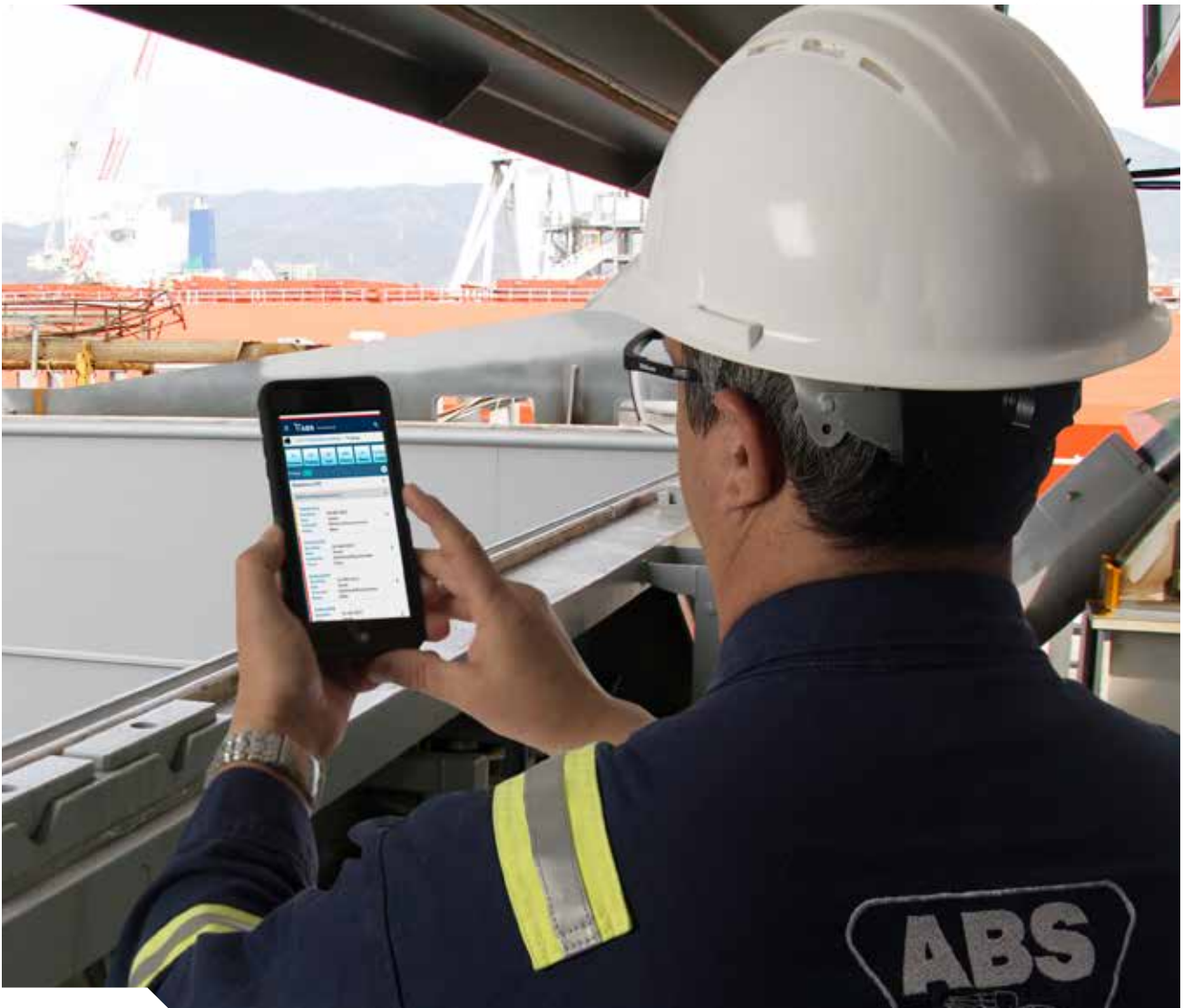
Data management and analytics help verify that the right information is provided to the right people at the right time, enabling more informed, data-driven decisions. This underpins our vision of a condition-based class model that enables us to tailor services based on diagnostics of a particular asset.

These advances will continue to give our surveys greater focus, make them less intrusive, and improve workplace safety while adding value for our clients through new data-driven advisory services that will help improve the safety and reliability of assets and operations.

ABS FREEDOM

In 2017, ABS continued to build on its vision for the future of Class with significant developments in the ABS Freedom survey workflow system, which is a key part of the ABS FutureClass digital platform. The platform brings together





a range of systems into one powerful solution, dramatically improving access to data for surveyors and customers alike. Its improved visualization and streamlined workflow also reduces the reporting time for surveyors. The digital platform, which will ultimately offer ABS surveyors access to a virtual vessel model, is already bearing fruit, with testing in progress on several of the first applications.

Taking another step forward in digital transformation, ABS also delivered a new data access platform with the launch of the Mobile Survey Manager App, which offers up-to-date vessel data via a smartphone or tablet.

ABS closed the year with a significant advance in the evolution of electronic certificates. In November, the organization introduced Certificate Automation, which uses software to deliver significantly enhanced services to customers. Certificate Automation greatly speeds up certificate delivery, improves accuracy and ensures that users have on-demand access to all needed documentation. This service paves the way for electronic certificates (e-Certificates) – always available, tamper-proof, legally verifiable, digital equivalents of traditional ABS paper certificates. E-Certificates are available to customers in early 2018.

ABS CYBERSAFETY

ABS has raised itself into the vanguard of cybersecurity development for the maritime industry, to protect data and digital integrity for itself and its customers. Among its latest advances is the ABS CyberSafety program.

The ABS CyberSafety program equips ship and asset owners, vendors, and managers with the industry's first risk-based management tool for mitigating risks connected to cybersecurity, automated systems safety, data integrity, and software verification. With this program, ABS compiled an industry standard with actionable tasks to improve cyber intelligence and security implementation. A suite of tiered services and optional notations support a risk-based approach to tackling some of today's most pressing cyber concerns.

“The focus on cyber safety is increasing, and that is changing the expectations industry has for classification services. ABS is ahead of the curve in tackling this fast-moving challenge, creating actionable guidance and helping clients protect themselves against cyber threats.”

CHRISTOPHER J. WIERNICKI
CHAIRMAN, PRESIDENT AND CEO
ABS



Because cybersecurity is a wide-ranging, cross-platform issue, ABS brings together information technology (IT) and operational technologies (OT) in a unique approach that moves clients from a traditional set of basic procedures covering corporate organization and governance to a digitally informed, detailed capability and task-assessment cycle. This approach enables ABS to understand assets, gaps and vulnerabilities, develop a risk profile, and execute a project plan with asset owners.

The ABS CyberSafety team of experts brought its deep experience with information and operational technologies – encompassing cybersecurity, software integrity and software testing – to aid numerous clients in their cybersecurity maturation efforts.

KEY MILESTONES

- ABS issued its first notation (CS1) under the *ABS Guide for Cybersecurity Implementation for the Marine and Offshore Industries - ABS CyberSafety® Volume 2*. ABS worked closely with the client to increase protection for its industrial control systems from a cybersecurity-related incident or failure of its offshore assets.
- Launching a two-year agreement with the USCG Academy, ABS helped develop curriculum for a degree program in cybersecurity, assembling industry lessons learned along with regulatory requirements.
- In collaboration with Stevens Institute of Technology Maritime Security Center, a Department of Homeland Security Science and Technology Directorate Center of Excellence, ABS developed a practical cyber-risk model allowing clients to make measurable improvements in vessel cybersecurity.
- ABS developed a CyberSafety Builder Specification with two shipyards so builders and owners can collaborate on new construction vessels to prepare cybersecurity programs prior to delivery, emphasizing the lifecycle readiness requirements for ship crew needs in working with networked systems.
- ABS issued its first Integrated Software Quality Management (ISQM) Product Design Assessment (PDA) Certificate in the Asia Pacific region for Industrial Control Systems software. Singapore-based Excel Marco, a premier solutions provider for process automation and safety systems for the marine and offshore industries, also adopted the ABS CyberSafety Software Provider Conformity Program (SPCP). The SPCP assesses 81 requirements and best practices to improve delivered software quality and integrity. The ISQM PDA certificate demonstrates software integrity, which helps avoid unplanned downtime due to software and system issues.
- The ABS CyberSafety program continued educational awareness through a series of high-level seminars across Asia, Europe, and North America to deliver critical safety guidance for existing and new clients.



NAUTICAL SYSTEMS FLEET MANAGEMENT SOFTWARE

In 2017, the marine and offshore regulatory environments continued to evolve and challenge businesses with complex, demanding, and sometimes fragmented requirements. In response, ABS Nautical Systems (NS) delivered industry-leading compliance solutions to help customers meet those challenges and minimize impact on day-to-day operations. These solutions included a number of new software systems designed to simplify compliance and manage performance.

- NS Workboat™ is a mobile application designed to streamline onboard tasks related to Subchapter M compliance. The app is purpose-designed to minimize disruption of day-to-day operations for the workboat sector.

The software is delivered on a tablet pre-configured to an operator's selected Subchapter M compliance option. For companies selecting the USCG inspection option, required documents demonstrating compliance are also included. Designed to facilitate "walk around" tasks with

"By introducing ABS NS5 to our fleet and key modules within our operating system, we envision the delivery of this advanced technology to our OSV fleet to ensure success for our clients and our internal stakeholders. This comprehensive solution allows the company to grow by leaps and bounds, yet ensures standardization in our processes for efficient and effective mobilization of our resources."

OSSAMA Z. AL-MUHTASEB
DEPUTY GENERAL MANAGER
RAWABI-VALLIANZ OFFSHORE SERVICES





an easy-to-use interface, the mobile app makes managing critical Subchapter M compliance requirements nearly effortless. No onboard software is needed, and very little training is required. NS Workboat also integrates maintenance and compliance data across a fleet for greater visibility and access to data to support day-to-day operations.

- NS Voyage Manager, a cloud-based compliance software solution, captures and manages data and simplifies compliance with environmental regulations, including European Union Monitoring, Reporting and Verification (EU MRV) and the International Maritime Organization's Data Collection System (IMO DCS) mandates for CO₂ emissions. Reducing the administrative burden on crews, NS Voyage Manager also automates compliance reporting, integrating data collected for noon reports and from the optional NS AutoLogger, and automatically transmits verified data.

The application is fast and easy to deploy, so clients always have the latest version to aid compliance with new regulations.

- NS AutoLogger, a secure, marine-grade database solution, captures data directly from sensors and ship systems and improves the accuracy of logged data to meet additional regulations – for example, the IMO DCS requirement. Data captured for compliance

“We are rolling out the ABS Workboat app to our towing fleet and our other inspected vessels. Bringing our HSQE and Maintenance programs together under one easy-to-use software program will provide our crews a way to ensure ship and shore have access to useful tools and data.”

STEVE ISAACS

PORT ENGINEER

BERING MARINE CORP/ALASKA MARINE LINES

reporting can be expanded to support other operational activities, including performance management.

- NS Insight, a business intelligence (BI) module that unlocks the power of data, turns operational data into management information through data visualization and analytics. Introduced as part of the new and improved NS HSQE Manager, NS Insight delivers key performance indicators (KPIs), supports quarterly management reporting, and enables trending and root cause analysis.



LIVING OUR MISSION | LEADING THE FUTURE

LEADING CLASS IN GLOBAL MARINE



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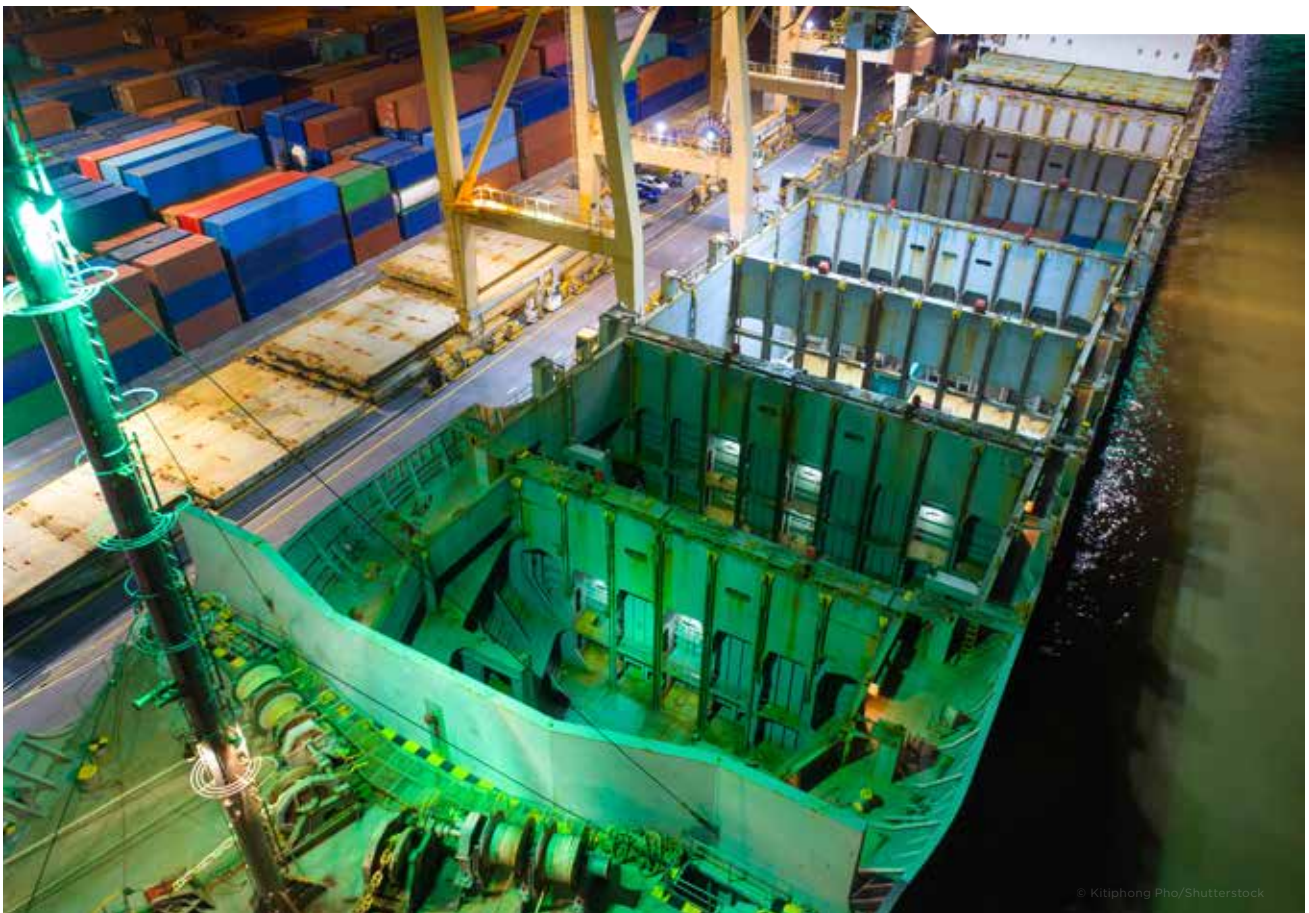
GLOBAL MARINE

Innovation often springs from the seed of challenge. So it was during 2017, in a challenging shipping market with increased regulatory complexity, that the marine industry began seizing new opportunities to achieve innovative milestones. ABS was a prominent voice in this changing landscape and, through its industry-leading guidance and deep technical insight, helped drive many projects from concept to reality, contributing to major landmark achievements.

Faced with a mountain of regulatory requirements, clients turned to ABS for its experience and trusted advice. With an eye to the

future and a firm grasp on the challenges at hand, ABS introduced new tools and services focused on improving operational efficiency, streamlining environmental compliance, and delivering solutions that matter most to its clients and the industry.

Technology continued to change at record pace during 2017, elevating the marine industry's digital transformation and bringing insights into new ways of operating. ABS was at the forefront of this change, building the industry's digital foundation and leading innovative projects that are guiding industry into the future.





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MARINE SECTOR LEADERSHIP

CONTAINERSHIPS

After a prolonged downturn, the containership market began to show signs of improvement in 2017. While existing fleets continued to focus on improving operational efficiency and safety performance, new ship orders emphasized environmental compliance, alternative fuels, and smart technology.

Of the 20,000 plus twenty-foot equivalent unit (TEU) containerships delivered in 2017, two-thirds were classed by ABS.

- The Orient Overseas Container Line (OOCL) received delivery of five ABS-classed 21,413 TEU containerships in 2017, with the last one in the series in early 2018. These ultra large container vessels (ULCV) represent the world's largest containerships by carrying capacity.
- ABS introduced its Fire-fighting On-deck Container - Restricted (FOC-R) notation, which expanded application of the ABS *Guide for Fire-Fighting Systems for On-Deck Cargo Areas of Container Carriers* to existing vessels, improving standards for onboard firefighting capabilities.
- ABS released its groundbreaking *Guide for Certification of Container Securing Systems* along with an associated software tool, ABS C-LASH, to support owners and operators in designing and developing smarter lashing systems that reduce risk and increase efficiency and safety.

BULK CARRIERS

The dry bulk markets began to show signs of recovery at the end of 2017, setting a cautiously optimistic future outlook. Improvement in the global economy was largely responsible for the increased demand for bulk transport.

- Recovery in the dry bulk market was evidenced by the uptick in new orders toward the end of 2017. ABS was awarded class on a large share of the new orders, including very large ore carriers (VLOCs), newcastlemax, capesize, and kamsarmax bulk carriers.
- ABS introduced a new service and analysis tool to allow atypical cargoes on bulk carriers. This new capability helps improve efficiency, enabling faster decision-making regarding the safety of nontraditional loads. Using the ABS loading analysis software supports timely and accurate decisions impacting the achievable safety for steel coil loads not included in the loading manual.

LIVING OUR MISSION

LEADING THE FUTURE

ABS ESTABLISHES GLOBAL SHIP SYSTEMS CENTER

ABS unveiled its Global Ship Systems Center in Athens, Greece, a cutting-edge facility bringing together industry-recognized technical leaders to support clients and other industry stakeholders, throughout the entire life cycle of their assets.

Through a systems-based approach, the Global Ship Systems Center team addresses the increasing complexity of mechanical and cyber-enabled systems on board vessels. As these systems are increasingly interconnected and optimized, an improved approach to address design and construction is required.

The team collaborates with clients on innovative projects ranging from applications of advanced analysis on design, construction, and operations to techno-economic evaluations of regulatory compliance options. Aligning with local and world-leading universities and research centers, the ABS Global Ship Systems Center provides a premier research and development capability to help address today's industry issues while determining tomorrow's solutions.



© TE SubCom

FIRST POLAR CODE OPERATIONAL ASSESSMENT IN NORTH AMERICA

ABS facilitated a Polar Code Operational Assessment, a milestone in the implementation of the IMO Polar Code. The assessment, which identifies operational risks and limitations, was performed with Tyco Electronics Subsea Communications (TE SubCom), a TE Connectivity Ltd. company and industry pioneer in undersea communications technology, on its cable-laying vessel, *Responder*.

To obtain a Polar Ship Certification (PSC), vessels undergo an assessment that defines the intended operational profile and identifies relevant hazards. Understanding these variables helps owners and operators select the most appropriate risk control measures for PSC compliance. In assessing TE SubCom's *Responder*, ABS carried out extensive analyses of air temperature and sea ice data for the intended operational area, establishing a foundation for the assessment that led to a more thorough understanding of the associated operational risks.



TANKERS

New tanker orders rebounded in 2017, but stagnant day rates coupled with the continued oversupply of vessels remained a key challenge for owners and operators. ABS remained the preferred class organization for tanker owners and led the market in new class orders.

- New orders were predominantly for very large crude carriers (VLCC), suezmax, and aframax tankers.
- ABS was awarded class for two new liquefied natural gas (LNG)-fueled, 113K-dwt aframax tankers which are currently under construction at Samsung Heavy Industries (SHI) in Korea for AET Inc. Ltd.
- Trafigura, the world's largest independent commodity trading house, chose ABS to class 32 tankers, representing the large majority of its new fleet under construction.

GLOBAL GAS SOLUTIONS

Gas continued to play an important role in the global shipping industry, both as a cargo and as a fuel. ABS remained a class leader for LNG carriers and maintained the largest global orderbook for the classification of LNG-fueled vessels. Throughout the year, ABS played a key role in a number of industry milestones and major initiatives.

- ABS was awarded class on a number of significant LNG-fueled projects for a variety of ship types, including tankers, containerships, and car carriers.
- The ABS-classed *Harvest*, an articulated tug barge purpose-built to transport liquefied anhydrous ammonia and the first built in the United States since 1982, was delivered by U.S. shipbuilder Vigor.
- ABS was awarded a class contract for an LNG bunkering barge, under construction at VT Halter Marine, which will expand the LNG supply chain in North America.
- To further support the industry in the development of floating storage and regasification units (FSRUs), ABS released its *Guide for Building and Classing LNG Regasification Vessels*.



LIVING OUR MISSION

LEADING THE FUTURE

ABS REVEALS KEY INSIGHTS INTO BALLAST WATER MANAGEMENT SYSTEMS

ABS published a report providing insights into industry's progress on ballast water management (BWM) systems. Based on input provided by vessel owners and operators with BWM systems on board, the report covers a range of topics, including installation, commissioning, and operations of BWM systems.

To form an accurate picture of the current progress with BWM compliance, owners and operators with installed BWM systems were surveyed and invited to participate in the workshop. Survey results from approximately 30 owners and operators were aggregated to help identify trends and understand common practices while maintaining anonymity.

In analyzing the responses, ABS learned that only 57 percent of the systems installed on the vessels were being operated. The remaining systems were either deemed "inoperable" or considered "problematic."



© GasLog

JOINT STUDY WITH GASLOG ADVANCES NEW METHOD TO PREDICT LNG BOIL-OFF RATE

ABS and GasLog LNG Services Ltd. (GasLog) completed a joint development project demonstrating a new approach to evaluating LNG boil-off rate (BOR).

LNG is a cryogenic liquid, transported in insulated tanks at temperatures approaching -260° F (-162 °C). As its surface temperature rises during transport, due to heat migration through the insulation and agitation (sloshing), the LNG "boils off" — begins reverting to gaseous form. Some LNG carriers consume their boil-off gas as fuel, while others reliquefy and return it to the tank. Either way, accurate assessment of LNG BOR is critical to the design of cargo tanks and boil-off gas processing systems.

ABS supported this collaborative project by developing a robust computational fluid dynamics (CFD) analysis procedure to model the physics of heat transfer, boiling, phase change, and vapor flow, and by running extensive simulations on a representative LNG carrier and taking actual BOR measurements to demonstrate the accuracy of the analytical results.

Thanks to this innovative, expanded application of CFD analysis to simulate the BOR in LNG cargo tanks, owners are now able to better predict boil-off and account for it in future designs and operation of LNG carriers.



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MARINE REGULATORY LANDSCAPE

A number of regional and international regulations were amended or adopted in 2017, and some came into effect, adding to the already-complex regulatory environment. To support the industry in navigating this landscape, ABS developed new guidance and compliance solutions.

- New deadlines for owners to comply with the IMO BWM requirements were established during MEPC 71. Through its BWM Technology Evaluation service, ABS continued to help owners by providing a like-for-like comparison of systems to support smarter decisions on matching available technology to a specific vessel's profile.
- Compliance with the U.S. Ballast Water Regulations presented additional challenges to the industry. Applying its comprehensive understanding of the requirements, ABS enabled owners and operators to find compliance options.
- Ahead of the IMO 2020 Global Sulfur Cap, ABS updated its Scrubber Advisory to offer comprehensive guidance on the latest available exhaust gas abatement technologies.
- With the looming IMO 2020 Global Sulfur Cap, ABS saw increased interest from owners and operators seeking options for an effective fuel strategy that balances operational and regulatory requirements. ABS participated in joint industry projects (JIPs) and carried out techno-economic assessments to evaluate best compliance options based on a vessel's operational profile and assumptions on the fuel price differentials.
- As an invited industry advisor to the European Commission, ABS participated in the stakeholders meetings held by the European Sustainable Shipping Forum (ESSF) that led to the development of the EU MRV mandate and the implementing acts and guidance documents. To support clients, ABS developed a solution for complying with the EU MRV requirements for CO₂ emissions, becoming the first class organization accredited to perform EU MRV monitoring plan assessments. ABS completed assessments of the EU MRV Monitoring Plans of more than 4,000 ships in 2017 to meet the January 2018 deadline for data collection.
- New requirements under the IMO Polar Code came into force in 2017 for vessels planned to operate in polar waters. Industry looked to ABS for Polar Code Operational Assessments to establish risk control measures for access in polar conditions.



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LEADING CLASS IN GLOBAL OFFSHORE



GLOBAL OFFSHORE

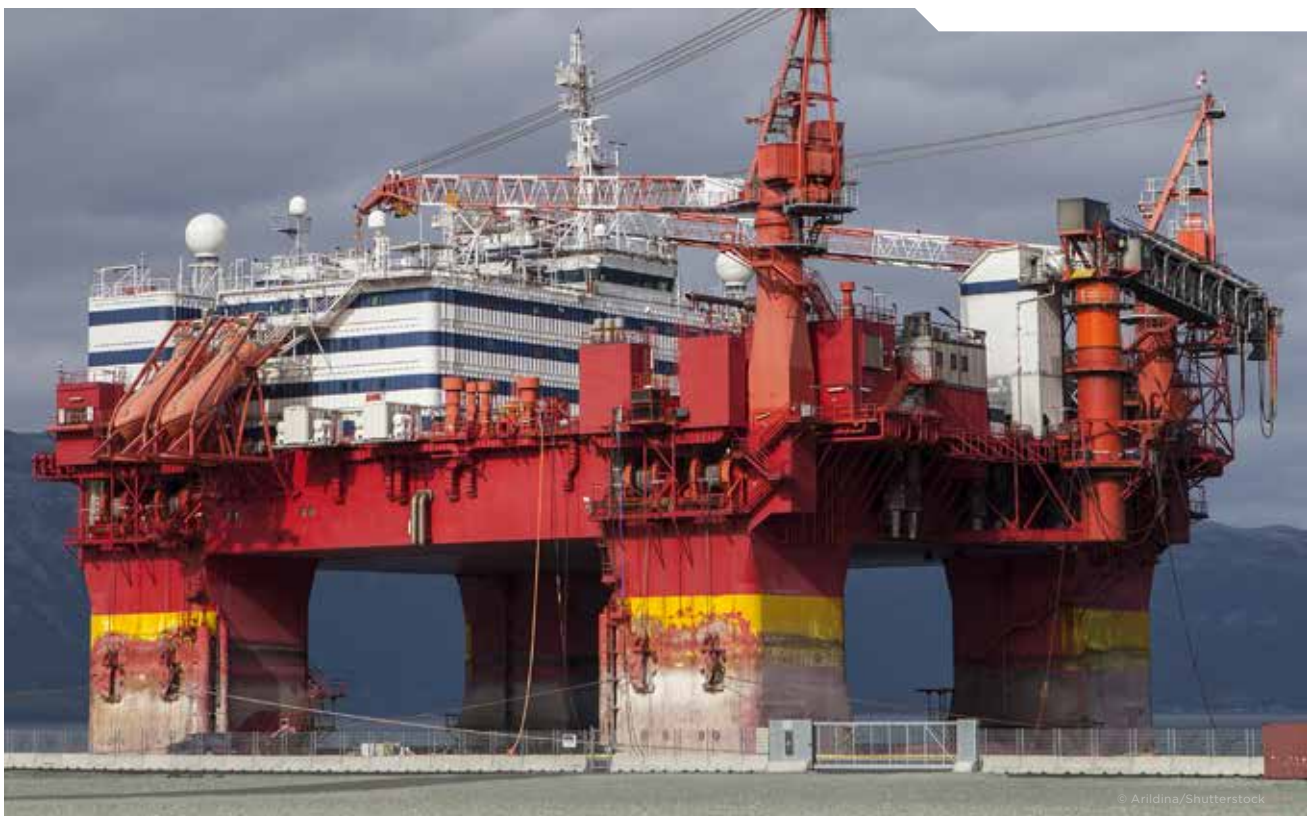
ABS has been the leading class organization for offshore oil and gas since the sector's earliest days and continued its global legacy of innovation and technology leadership in 2017.

When the oil and gas industry first put drilling structures out of sight of land in 1947, its offshore pioneers turned to ABS for technical services that would help them proceed safely into the unknown. Ever since, ABS has helped the offshore sector push the limits of technology in its unending quest to unlock energy resources that lay beneath the sea.

As the offshore industry celebrated its 70th anniversary in 2017, it also celebrated seven decades of looking to ABS, the recognized leader in offshore classification, to provide advice, innovative

technical solutions and exceptional class services. In the last half of the year, industry activity began to pick up amid stabilizing oil prices; however, the environment remains challenging for the offshore industry. Owners and operators sought the assistance of ABS, both in getting more out of their assets through increased utilization, life extension, and conversion, and in preparing for an uptick in activity through reactivation and other technology investments to increase operational efficiencies.

Throughout the year, ABS addressed a broad spectrum of issues, including how to best leverage operational data, streamline verification and validation for both new designs and existing assets, improve operations safety, and operate safely in demanding environments.



OFFSHORE SECTOR LEADERSHIP

EXPLORATION

ABS remained the industry leader in drillship, self-elevating mobile offshore drilling unit (MODU), semisubmersible MODU and anchor handling tug classification in 2017, continuing its efforts to improve machinery, systems and structural safety, collaborating with industry to identify potential safety issues for working assets.

- In 2017, the *ABS Guide for the Classification of Drilling Systems* was revised with substantial industry input, working closely with several equipment manufacturers and drilling contractors. The Guide specifically includes detailed guidance for classing or certifying drilling subsystems – well control, derrick, drilling fluids, and handling systems.
- ABS provided a systematic approach to dropped object prevention issuing the industry's first *Guide for Dropped Object Prevention for Offshore Units and Installations* outlining requirements and best practices to protect assets and personnel from dropped object incidents. The Guide also helps companies develop effective dropped object prevention programs for existing equipment on board – and includes a complete process for engineering review and manufacturing approval of equipment specifically designed to reduce dropped objects risk.
- The marine and offshore industries continually invest in new technologies that often develop faster than the industry codes and regulations governing them. To give vendors and end-users a clear approach in confirming that new technologies perform intended functions according to defined requirements, ABS issued the *ABS Guidance Notes on Qualifying New Technologies (NTQ)*. These Guidance Notes introduce a systems engineering approach to qualification for consistent evaluation of new technologies as they mature, from concept through intended use in operations.
- ABS published *Guidance Notes on Geotechnical Performance of Spudcan Foundation* encompassing research and results from



a decade of numerous joint industry and government-sponsored projects on jackup spudcan foundations. These industry-first Guidance Notes present an in-depth examination of jackup foundation issues, an up-to-date geotechnical site-assessment methodology, reliable methods for predicting jackup installation and operation risks, and recommendations for spudcan foundation geotechnical design; the Guidance Notes are applicable to self-elevating units that undertake drilling, construction, support, wind turbine installation, or other offshore activities. The related *ABS Guidance Notes on Foundation Fixity Assessment Through Numerical Analysis and Full Scale Measurement* provides further details on the spudcan foundation assessment using measured jackup global responses to storm waves.

- The *ABS Guidance Notes on In-Service Hull Stability Verification* provides an enhanced onboard methodology to assess hull stability while a column stabilized unit is in service. This method supports greater stability safety, measuring weight shifts with greater frequency and accuracy than traditional inclining methods. This represents a highly accurate process to identify stability issues – in a far more cost-effective and operationally friendly manner.

LIVING OUR MISSION

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SEADRILL RECEIVES ABS MPD NOTATION

“Seadrill is excited to be the first to achieve the ABS MPD Notation. It was a team effort working in collaboration with ABS and our MPD technology providers,”

LEIF NELSON

CHIEF OPERATING OFFICER
SEADRILL

ABS issued the industry-first *Guide for Classification and Certification of Managed Pressure Drilling Systems (MPD Guide)* and a managed pressure drilling (MPD) notation to Seadrill’s *West Capella* ultra-deepwater drillship, demonstrating system compliance with the ABS MPD Guide.

As the industry drills in evermore complex and challenging environments, it is essential to integrate MPD technology with existing systems — safely — to improve efficiency and effectiveness. ABS worked closely with Seadrill and equipment manufacturers, verifying MPD systems and equipment met design and safety criteria outlined in the ABS Guide. The ABS MPD Guide was developed with extensive review from many industry stakeholders including operators, drilling contractors, original equipment manufacturers and regulatory agencies, and incorporated lessons learned implementing MPD systems on multiple rigs, helping reduce the chance of incidents, enhance overall system reliability, and promote global safety.



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INNOVATING WITH HYBRID POWER

Owners and operators are turning to non-conventional sources of energy to manage the challenges of complying with environmental requirements, while also meeting operational demands. Hybrid electric power systems will play a key role in meeting these challenges and ABS is leading the way in providing guidance to support safer development and deployment of hybrid power.

ABS introduced the *ABS Advisory on Hybrid Electric Power Systems* in 2017, evaluating potential advantages and disadvantages, challenges, and readiness of hybrid electric power systems for marine and offshore applications addressing lithium-ion batteries, supercapacitors, flywheel energy storage, fuel cells, and wind and solar power. ABS also introduced its *Guide for Use of Lithium Batteries in the Marine and Offshore Industries*, providing class requirements and reference standards to facilitate effective operation of lithium battery systems.

The maritime industry is increasingly interested in using supercapacitors as an energy storage solution for rapid energy delivery. Particularly, OSV owners are considering supercapacitors to supplement energy supply during high-load operations, such as using power thrusters for dynamic positioning while stationkeeping. ABS published the industry-first *Guide for Use of Supercapacitors in the Marine and Offshore Industries* to provide requirements and reference standards to facilitate effective installation and operation of onboard supercapacitor systems. The Supercapacitor Guide defines requirements for design, construction and installation of supercapacitors in marine and offshore applications.



- Focusing on safety and life extension of offshore support vessels (OSVs), ABS released its *Guide for Lay-Up and Reactivation of Offshore Support Vessels*. For asset owners, timely reactivation is key to meeting contractual commitments. ABS provides services to help clients promote safe and timely OSV reactivation.
- At a MODU safety workshop in Stavanger, ABS outlined air gap calculation procedures included in the newly revised *ABS Guidance Notes on Air Gap Analysis for Semi-Submersibles*. These notes cover detailed guidance on conducting air gap analysis based on vessel motions and wave surface elevations.
- Steady growth is expected in the drilling tender barge sector, as its units support critical functions for offshore drilling operations. ABS applied its experience as an industry leader in barges, offshore units, and drilling systems to issue the *ABS Guide for Building and Classing Drilling Tender Barges*, providing consolidated requirements for barges supporting drilling operations on fixed platforms.
- The *ABS Guide for Certification of Offshore Containers* was published with the objective of clarifying quality requirements, providing more accurate material requirements, and well-defined engineering procedures for certification of offshore containers.

Key Deliveries in 2017

- The *Al Hudairiyat* and *Al Lulu* jackup rigs represent the eighth and ninth in a successful series of nine ABS-classed deliveries to National Drilling Company (NDC) from Lamprell.
- ABS continued its solid relationship with Shelf Drilling, delivering the ABS-classed jackup *SD Krathong* from Lamprell for its drilling location offshore Thailand.
- In another successful project with Keppel Offshore and Marine, the ABS-classed semisubmersible *Heydar Aliyev* was delivered for Caspian Drilling Company, Ltd., a subsidiary of the State Oil Company of Azerbaijan (SOCAR). The shallow-water semisubmersible



was designed and built for drilling in the expanded offshore oil fields in Azerbaijan, enabling a drilling depth of up to 40,000 feet and operations in up to 1,000 feet of water.

- Ensco received delivery of ABS-classed Drillship *Ensco DS-10* from Samsung Heavy Industries, the third of the “Green Future” GF12000 design, which were all built for Ensco to ABS Class standards.
- Northern Offshore took delivery of the ABS-classed jackup *Energy Emerger*, a high specification jackup with the Gusto CJ-46 design from Shanghai Waigaoqiao Shipyard (SWS).

PRODUCTION

ABS remained the industry leader in floating storage and offloading (FSO) and floating production storage and offloading (FPSO) units in 2017, working to advance safety, standardization and continued service for aging assets. ABS delivered timely guidance and engineering projects addressing key technical and safety challenges, while simultaneously continuing research efforts with industry partners to advance knowledge on future safety challenges facing the industry.

ADDITIVE MANUFACTURING

The latest innovation in manufacturing, additive manufacturing (also known as 3-D printing) is fabrication of parts — adding material layer by layer. Additive manufacturing technologies support rapid development of new or replacement parts, which can greatly benefit the marine and offshore industries.

ABS developed the *Advisory on Additive Manufacturing*, providing an overview of metal additive manufacturing technologies. This included technical challenges and tradeoffs, changes to the design process, quality, reliability, and how ABS can help in leveraging additive manufacturing. Additive manufacturing enables production of a small number of parts locally, quickly, and economically, relative to traditional manufacturing. These technologies also enable testing and production of design features that are too expensive or impractical to test using traditional manufacturing techniques such as casting or forging.



MOORING SYSTEMS CHAIN CORROSION FATIGUE JOINT INDUSTRY PROJECT

ABS advanced its work in the Fatigue of Corroded Chains (FoCCs) JIP. The JIP was formed with the objective of creating a method to evaluate mooring chain corrosion, specifically for production units nearing end of life, and to assess excessive premature corrosion and its relationship to a unit's offshore environment. The JIP includes 15 organizations including oil majors, manufacturers, design and consulting firms, and classification organizations. Several of the member companies collected mooring chain samples from various offshore environments for testing. These samples allowed the JIP team to test and obtain fatigue capacity data for corroded chains.

In 2017, ABS established a non-linear finite element analysis model and completed numerical simulations of chain-like fatigue testing. Numerical simulations of corroded chain links are ongoing with preliminary results correlating well with fatigue capacity testing results. The JIP is expected to finish by mid-2018 and deliver guidelines on corroded chain fatigue testing and assessment, technical papers, and recommendations for further study on criteria for discarding corroded chain, considering remaining fatigue capacity.

- Keeping pace with industry efforts to get more from existing assets, ABS published guides for repurposing MODUs for production as a cost-effective option for developing offshore fields. Based on lessons learned over many conversion projects, ABS issued the *Guide for Conversion of Self-Elevating Units to Offshore Installations*. Additionally, ABS released the *Guide for Conversion of Mobile Offshore Drilling Units to Floating Production Installations* for conversion of column-stabilized drilling units (CSDUs) to column-stabilized production installations, and drillships to ship-type floating production installations (FPIs).
- ABS continued work on several life extension projects for class purposes and as a Certified Verification Agent (CVA) for the U.S. Bureau of Safety and Environmental Enforcement (BSEE): the ExxonMobil Hoover field deep draft caisson vessel (DDCV), in service since 1999, which includes hull, moorings, topsides and risers; the BP *Na Kika* semisubmersible, first producing in 2003, including hull, moorings and topsides; the MC Offshore Petroleum *Jolliet* tension leg platform (TLP), producing since 1989, including hull, topsides and tendons; as well as the Anadarko *Marlin* TLP, which began producing in 1999 and includes hull, topsides and tendons. The ABS efforts allow these units to continue in service to support extended production from the existing fields or from additional tie-back wells.

Key Awards in 2017

- ABS was awarded the Front End Engineering Design (FEED) for the China National Offshore Oil Corporation (CNOOC) *Lingshui 17-2* production semisubmersible, designed by CNOOC for production in the South China Sea. ABS reviewed detailed FEED designs for the hull, moorings, topsides and risers for compliance with ABS Rules and Chinese Government requirements.
- ABS was awarded class for the BP Mad Dog 2 (MD2) production semisubmersible to support Phase 2 development of BP's MD2 field, approximately 150 miles offshore in the Southern Green Canyon area, Gulf of Mexico (GOM). This floating processing unit (FPU) is



supported by a four-column semisubmersible hull. Topsides, modules and risers are designed for Phase 2a and 2b development, supporting a production rate of 110,000 barrels of oil per day (BOPD), expandable to 140,000 BOPD.

- Petróleo Brasileiro S.A. (Petrobras) awarded ABS classification for its *Carioca MV30* FPSO, engineered and operated by Mitsui Ocean Development and Engineering Company (MODEC), which will be deployed at the Sépia field in the giant “pre-salt” region of the Santos Basin, some 250 kilometers off the coast of Rio de Janeiro, in a water depth of approximately 7,000 feet. The FPSO can process 180,000 barrels of oil per day, 212 million standard cubic feet of gas per day, 240,000 barrels of water injection per day and has storage capacity of 1,400,000 barrels of oil.
- Shell awarded ABS verification services for its Vito production semisubmersible. The Vito development is in the Mississippi Canyon 940 area, deepwater GOM. The floating

DRILLSHIP MOONPOOL HYDRODYNAMICS — ABS SOFEC PROJECT

Industry demand has grown for large diameter internal turret systems to support higher vertical load and greater flexibility in riser number for FPSOs and floating liquefied natural gas (FLNG) facilities in harsh environmental conditions. The large volume of water in the moonpool and its complex interaction with the turret structure introduces unique design challenges. ABS worked with Specialized Offshore Facilities and Engineered Components (SOFEC) to simulate these considerable dynamic loads to better inform designs going forward.

To examine these effects, ABS created a CFD model to simulate the complex, entrapped water dynamics of a generic large turret design by SOFEC. The CFD model simulated free decay and forced motions of entrapped water due to prescribed ship motions such as pitching, rolling, and surging. The ABS team continued to simulate greater levels of complexity, sequentially testing free decay and forced vessel motion of entrapped water with regular and irregular waves. Simulation results revealed sloshing and piston modes, natural decay rates in the moonpool, as well as temporal and frequency characteristics of the water motion in the moonpool in response to wave forcing.

The series of CFD simulations clearly differentiated the effects of the moonpool, the chain table, and the full turret, offering valuable insight into flow patterns in the moonpool crucial to the moonpool and turret design.



STANDARDIZATION JOINT INDUSTRY PARTNERSHIP

ABS continued its work with industry partners, shipbuilders, oil and gas and engineering companies to establish offshore design standards to help improve safety and increase efficiency for offshore projects. The objective of the integrated effort is to find common ground and consolidate best practices from numerous standards and requirements to form industry standards.

The standard specification program consists of two interconnected JIPs, one focusing on offshore bulk materials including structure, piping, electrical and instrument design, and construction procedures, with another related JIP focusing on equipment packages to define system requirements, material selection, and functional requirements for quality control, inspection, testing, and certification procedures.

2017 PROGRESS IN STANDARDIZATION JIPS

- OTC 2017 presentation on Standardization Procedure and Criteria for Bulk Materials and Equipment Packages; also presented at several major conferences.
- Industry workshops to gain feedback and acceptance by oil and gas industries.
- Integrated Offshore Standard Specifications (IOSS) published for industry use.
- *ABS Guidance Notes on Offshore Standardization* published.
- International Oil and Gas Producers (IOGP) collaboration agreement completed.
- JIPs continued to Phase 2 and 3 with industry partners.



production system (FPS) facilities will process commingled well streams from remote subsea production centers. The ABS scope includes verification as a CVA for BSEE of the hull and topsides structures, mooring and foundation systems during the design, fabrication and installation phases.

- ABS was awarded classification for ExxonMobil's *Liza* FPSO, designed by SBM and converted at the Keppel shipyard in Singapore, for development of the Liza field about 200 kilometers offshore Guyana. The converted VLCC FPSO will be spread-moored in a water depth of 5,000 feet and is designed to produce up to 120,000 BOPD. ABS will class the hull, topsides and mooring systems.
- ABS was awarded classification of a Floating Production Unit (FPU) for the CNOOC Madura MDA-MBH gas field offshore Indonesia. Tied to two wellhead platforms for developing the MDA and MBH gas discoveries, the topsides processing facilities of the FPU barge can support production of 175 million cubic feet (mmcf) per day.

Key Deliveries in 2017

- Hess took delivery of the ABS-classed *Stampede* TLP from MODEC for its Stampede oil and gas field in the Green Canyon area of the GOM. Permanently installed in a water depth of approximately 3,500 feet, the TLP has a gross topsides processing capacity of 80,000 barrels of oil and 100,000 barrels of water injection per day; and will be producing from a reservoir depth of 30,000 feet. ABS classification included hull, topsides and tendon systems. ABS also acted on behalf of the USCG and as the CVA for the BSEE for the design, fabrication and installation phases.
- Shell took delivery of the ABS-classed 40,335-metric ton Appomattox production platform hull from Samsung Heavy Industries in Korea for development of its Appomattox and Vicksburg fields in the GOM. Appomattox is 80 miles (129 kilometers) offshore Louisiana, in approximately 7,200 feet water depth. ABS verified the hull design and construction as the nominated CVA for BSEE.

SUBSEA

Subsea infrastructure, particularly subsea production and processing systems, is continuously growing. As the complexity of subsea systems increase, it drives a need for ever-better guidance on safety considerations and associated verification and validation activities. Throughout 2017, ABS continued its research and development to create a suite of guidance documents targeting the developing subsea segment of the offshore industry.

The industry also renewed its focus on reducing total capital expenditure (CAPEX) by tying satellite developments to existing infrastructure and using subsea processing technologies such as separation and boosting to reduce the need for additional floating assets. These facilitate enhanced production and enable development of marginal fields in deep- or ultra-deep water. As this trend develops, ABS continues work on an advisory that discusses the maturity of current subsea processing systems and key technology gaps.

In 2017, ABS expanded its subsea suite with four publications.

- The *ABS Guide for Classification and Certification of Subsea Production Systems, Equipment and Components* specifies the relevant requirements and detailed process.
- The *ABS Guidance Notes on Subsea Hybrid Riser Systems*, jointly developed with industry partners, is the first class organization publication covering issues associated with hybrid riser design, analysis, fabrication, installation, monitoring, inspection maintenance, repair and decommissioning.
- The *ABS Guidance Notes on Drilling Riser Analysis*, the industry's first publication providing guidance on the usual types of analyses required for drilling risers, includes consideration and suggestions for evaluation parameters, evaluation approaches and procedures, modeling, and sample results.
- The *ABS Guide for Building and Classing Subsea Riser Systems* was updated to include all types of riser systems, including steel catenary risers, top tensioned risers, flexible risers, hybrid riser systems, and composite risers. The design requirements were updated to reflect consistency with the latest industry practices.



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LEADING CLASS

THROUGH GOVERNMENT PARTNERSHIPS



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GLOBAL GOVERNMENT SERVICES

Our unique combination of tradition and innovation energizes every area of our activities, including our work with global government organizations.

SUPPORTING THE U.S. GOVERNMENT

The bonds between ABS and the U.S. Government were forged in the smoke and fire of the First World War, 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.

For nearly 100 years, ABS has been the official classification organization of the United States and, under U.S. law, the only classification organization authorized to class U.S. Government vessels. There are nearly 200 government-related ABS-classed vessels in the U.S. alone. Today ABS continues to provide leading classification services supporting the U.S. Coast Guard, Navy and other government shipowners in uninterrupted global force projection, law enforcement, research, survey, and logistic operations.

ABS is a RO that works with and on behalf of the U.S. Government to provide steadfast support for its required safety regimes.



- The U.S. Military Sealift Command awarded ABS a five-year renewal contract to continue providing class services for its entire fleet of naval auxiliary and sealift vessels.
- ABS was awarded the class contract by Eastern Shipbuilding Group for the USCG Offshore Patrol Cutter construction program, which is expected to span more than 20 years with the acquisition of 25 cutters.
- ABS was awarded the class contract by General Dynamics NASSCO for the Military Sealift Command's fleet oiler replacement program.
- ABS completed a CyberSafety pilot program for the U.S. Maritime Administration.
- ABS was contracted for classification of the future U.S. Army Watercraft Division's Maneuver Support Vessel Light, a high-speed landing craft, to support the Army's land maneuver forces.
- ABS continued supporting the USCG's acquisition of up to three heavy and three medium polar icebreakers.

SUPPORTING INTERNATIONAL GOVERNMENTS

ABS continued to grow and develop its global partnerships in 2017, expanding the breadth and depth of its work with international governments.

- ABS was awarded the Non-Combatant Class Society (NCCS) contract by the Canadian Department of National Defence to provide classification and certification services for the Royal Canadian Navy's non-combatant vessel fleet.

As the exclusive class organization for all Canadian non-combatant vessels, ABS leverages unique experience in naval-combatant vessel designs, inspection and support operations, including Service Life Evaluations Program and classification services based on various ABS Rules and Guides.



© U.S. Navy photo by MC2 Nathan Wilkes

- ABS completed its first-ever Naval Ship Code NATO ANEP-77 review on behalf of the Canadian Navy to support safety of their non-nuclear surface naval fleet. The Naval Ship Code ANEP-77 provides internationally accepted goal-based safety standards, benchmarked against IMO conventions and resolutions, applied to non-nuclear naval surface and non-combatant vessels.
- ABS was granted a new construction classification contract from Taiwan's Ministry of Science and Technology for a fleet of research vessels. This new fleet will be developed by the China Shipbuilding Corporation (CSBC), which is a private company that produces ships for civilian and military use.
- ABS was awarded a contract by the Indian Coast Guard to class five 48m-long fast patrol vessels to be built at Garden Reach Shipbuilders and Engineers, as well as classing five additional 105m-long Sankalp-Class offshore patrol vessels.
- The ABS-classed *Mark IV* Landing Craft Utility was delivered to the Indian Navy in 2017, in addition to five FPV's built for the Indian Coast Guard.
- Along with classification services, ABS provided Service Life Extension Program (SLEP) services, Naval Ship Code (ANEP-77) certification, CFD evaluations and ABS CyberSafety program assessments to various international navies.



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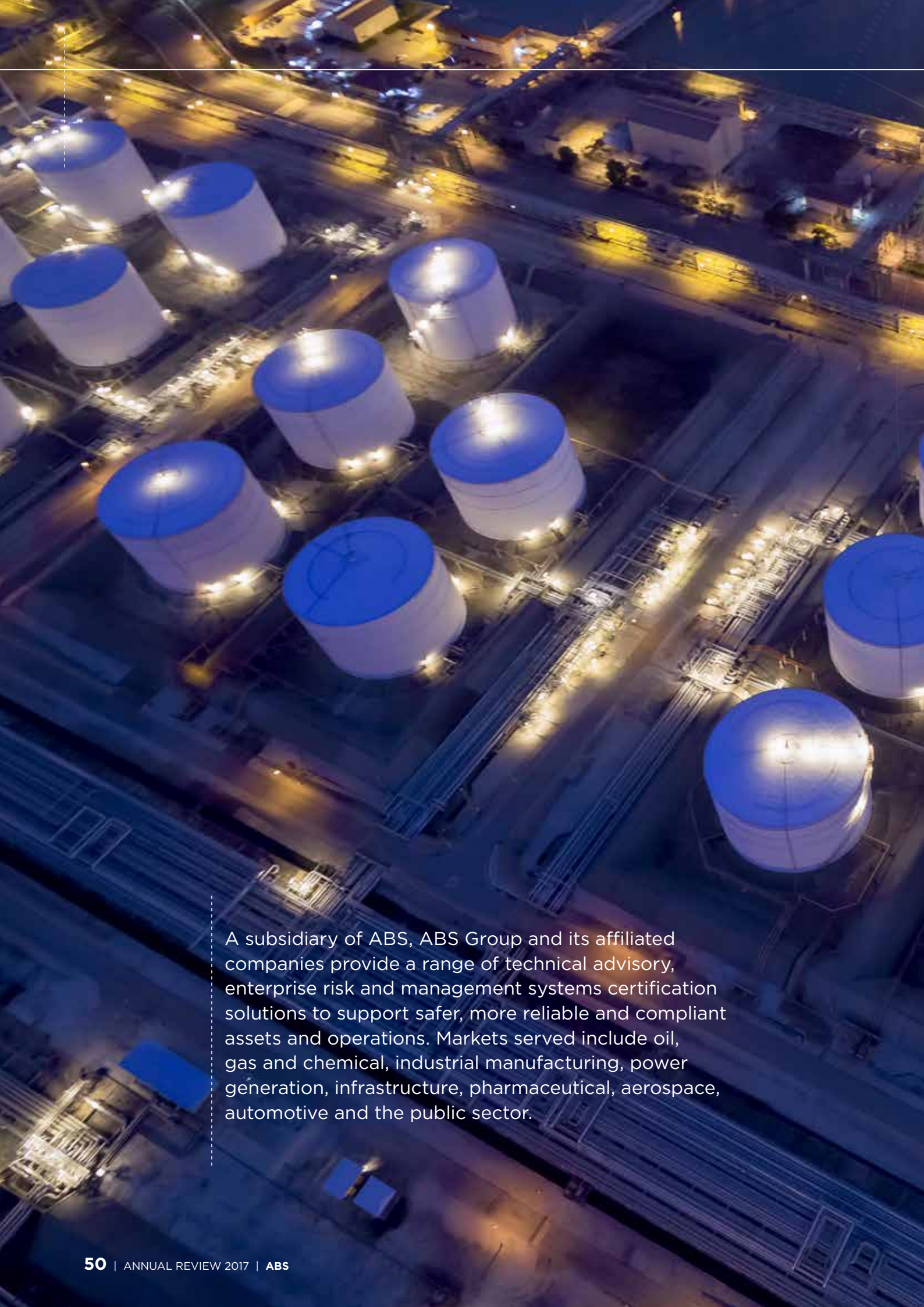
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A subsidiary of ABS, ABS Group and its affiliated companies provide a range of technical advisory, enterprise risk and management systems certification solutions to support safer, more reliable and compliant assets and operations. Markets served include oil, gas and chemical, industrial manufacturing, power generation, infrastructure, pharmaceutical, aerospace, automotive and the public sector.

LIVING OUR MISSION | LEADING THE FUTURE

ABS GROUP OF COMPANIES, INC.

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As a trusted independent risk advisor, ABS Group is at the forefront of changing regulations, advancing technologies and global innovation in both the commercial and government sectors. In 2017, ABS Group provided leading regulatory guidance for petroleum refineries to improve process safety, verified the first U.S. offshore wind farm, managed global incident investigations, assisted during natural and man-made disasters, and delivered a full range of technical services to support the safety, reliability and integrity of high-performance assets and operations.

Leading risk-based advisory solutions in 2017 included:

- Enterprise risk management and human systems integration support to help public agencies reduce exposure to risk and achieve mission success.
- Independent verification for pioneering renewable wind projects.
- Mechanical integrity evaluations to maintain quality and efficiency for pharmaceutical operations, aging assets and critical infrastructure



- Facility siting, explosion testing and CFD modeling to mitigate high-consequence risk and process safety incidents.
- Cybersecurity policy guidance for ports, marine terminals and industrial facilities.
- Management system certifications for aviation, space and defense companies under AS9100 and ISO 27001 certification for a multinational financial institution.

ASSET INTEGRITY FOR MIDSTREAM FACILITIES AND CRITICAL INFRASTRUCTURE

Control of the manufacturing and fabrication process to maintain sufficient mechanical integrity is critical to safer and more reliable operations in the industrial sector. To assist companies that have highly regulated and asset-intensive process facilities, in 2017 ABS Group continued to provide leading risk-based inspection and asset integrity management services to the global oil and gas, petrochemical and pharmaceutical industries.

In 2017, ABS Group focused on helping midstream operators confirm the integrity of pressure-containing process equipment, provided corrosion engineering services for new installations and developed cost-effective inspection and maintenance programs.

ABS Group also provided technical inspection services to confirm the integrity of pressure vessels, storage tanks and piping systems for one of the world's largest biopharmaceutical companies in accordance with the American Petroleum Institute's requirements. These services delivered value by reducing the inspection timeframe during a critical end-of-year shutdown period.

Ongoing reliability centered maintenance and risk-based inspection services continued to support the expansion of North American LNG export infrastructure and onshore pipeline projects in 2017.

IMPROVING PROCESS SAFETY/HSE MANAGEMENT IN PETROLEUM REFINERIES

Refineries have been implementing process safety programs for more than 25 years to manage the hazards and risks associated with processes using



hazardous materials. Yet many companies continue to face challenges in developing and implementing programs that promote continual improvement of process safety management (PSM) and health, safety and environmental (HSE) performance. Toward that end, and understanding the wider industry need to improve safety culture, ABS Group assists global refiners to develop long-term and robust safety culture programs.

In 2017, ABS Group worked with an international oil refining company with a three-year program to assess process safety/HSE culture at its refineries and marketing terminal. In addition to the HSE culture assessment, the program involved training, mentoring and monitoring 1,000 personnel and contractors from a range of backgrounds to help them become barrier guardians and process safety change agents working toward operational excellence.

In the U.S., ABS Group developed additional guidance resources to help California petroleum refineries comply with the revised Occupational Safety and Health Administration (OSHA) PSM regulation. The PSM standard requirements

were updated in 2016, with a five-year deadline to demonstrate full compliance in assessing and documenting various process safety hazards. Having worked closely in an advisory capacity with industry and regulators during the revision, ABS Group is guiding clients as they address requirements for damage mechanism review, process safety culture assessment and safeguard protection analysis.

NATURAL AND MAN-MADE HAZARDS RISK ASSESSMENT AND POST-DISASTER RECOVERY

Using many of the lessons gained from Hurricane Katrina in 2005, ABS Group continued to respond quickly during major disasters to support the industrial sector in assessing damage, providing onsite personnel, performing root cause analysis and offering support services.

In 2017, ABS Group assisted the U.S. Federal Emergency Management Agency (FEMA) with post disaster recovery efforts following a historic year of storm damage resulting from hurricane force winds and flooding across multiple states and territories. FEMA issued several task orders to help communities recover and rebuild, and ABS Group answered the call to assist dozens of schools, hospitals, emergency service facilities, communities, counties and cities in successfully applying for federal funding, identifying damage, gathering documentation, estimating repair costs, scheduling site inspections and identifying mitigation items. At the local level, ABS Group assisted the City

of Gatlinburg and Sevier County, Tennessee, in assessing the aftermath of a firestorm in the Great Smoky Mountains National Park with the goal of recommending actions and best practices to minimize threats associated with wild or man-made fires.

ABS Group also continued to assist clients and university researchers by providing advanced engineering capabilities to perform controlled blast tests at one of the largest-scale test facilities of its kind in the U.S., the ABS Group Shock Test Tube Facility in San Antonio, Texas. At this facility, engineers can simulate vapor cloud explosion and pressure vessel burst blast waves. The results enhance a company's ability to understand and mitigate their exposure to explosion and thermal hazards. These specialized services also helped quantify seismic risk exposure to extreme loads in earthquake-prone regions.

NAVIGATING CYBERSECURITY REQUIREMENTS FOR U.S. PORT AND MARINE TERMINAL FACILITIES

Understanding that marine facility owners must now manage cyber risk, in addition to threats such as physical security, natural disasters and industrial accidents to maintain normal operations, ABS Group began assisting the maritime community in developing new cybersecurity programs in accordance with the proposed USCG policy guidance released in July 2017 addressing cybersecurity requirements for



U.S. port and marine terminal facilities. ABS Group began organizing resources and capabilities for proactively managing cyber risk compliance, helping both marine and offshore clients build risk frameworks that identify and help mitigate a broad range of cyber threats that can impact critical infrastructure and operations.

PIONEERING OFFSHORE WIND IN NORTH AMERICA AND GLOBAL RENEWABLES

A reliable wind farm starts with appropriate project-specific design criteria, which are verified by an independent CVA. In 2017, ABS Group continued its long, successful history of project quality management supporting the offshore wind industry and completed verification work as the CVA of the first operational wind farm in the U.S., off the coast of Block Island, Rhode Island. The Block Island Wind Farm is currently producing 30 megawatts at full capacity.

In 2017, ABS Group prepared the final verification certificates and reports submitted to the agency overseeing Block Island's compliance with state regulations. In its critical role as CVA of the Block Island Wind Farm, ABS Group reviewed and verified the documentation and quality control work of the wind farm and reported directly to the Rhode Island Coastal Resources Management Council to confirm that the Block Island facilities had been designed, fabricated and installed in accordance with the applicable technical specifications and regulations. Over the past three years, ABS Group worked to independently review and validate key aspects of the Block Island project to provide confidence to the designer, operator, regulator and investors that the asset will operate reliably over its 20 years of expected service life and will maintain compliance with state, national and international requirements for offshore wind structures. ABS Group will continue to serve as the CVA during the operations phase.

In addition to this pioneering offshore wind project, ABS Group continued to provide its core technical inspection, verification, safety, risk and compliance services to a number of power generation, renewable energy and nuclear projects worldwide in 2017.



HUMAN FACTORS ENGINEERING SUPPORT AND TRAINING FOR PUBLIC AND PRIVATE NETWORKS

ABS Group has provided enterprise risk management services to public entities worldwide for more than 20 years and has maintained a longstanding alliance with the public sector providing safety and security risk management. These services expanded in 2017 to include human systems integration and human factors engineering (HFE) services to support critical operations for the USCG and a broad range of domains and public facilities.

Selected for its reputation as a leading risk advisor and author of industry-recognized HFE publications, ABS Group began working on a two-year project for a North American power grid company to develop tailored HFE analyses for the client's energy network, which is delivering electricity and natural gas to the northeastern U.S. ABS Group is providing ongoing services to help reduce error in company communications, work environments, human-machine interfaces,

standards, policies and procedures, as well as initiating human error prevention training to improve operations and maintenance procedures.

LEADING QUALITY MANAGEMENT SYSTEM CERTIFICATIONS FOR DIVERSE MARKETS

To assist clients with transitioning their management systems certifications to the latest international standards, ABS Quality Evaluations, Inc., an ABS Group company, developed a robust suite of compliance resources related to the ISO/TS 16949:2016 Automotive Quality Management Standard, the ISO 9001:2015 Quality Management Standard and the ISO 14001:2015 Environmental Management Standard.

ABS Quality Evaluations (QE) also began providing ISO 55001:2014 asset management certifications to companies in the Americas following its global designation in 2016 as the first certification body to be accredited by the ANSI-ASQ National Accreditation Board (ANAB) to certify organizations to this standard. In 2017, ANAB also accredited ABS QE to provide certification to the latest aerospace quality management system standard, AS9100D: 2016.

In 2017, ABS QE certified one of the world's leading banking and financial institutions for information security (ISO 27001). The protection of client records and commercially sensitive information is critical in the banking sector. Through this certification work, ABS QE was able to verify best practice and conformance with international standards and regulatory requirements as well as provide comprehensive security and cybersecurity risk management solutions through ABS Group's global network.

ALLIANCE WITH STRATEGIC TECHNOLOGY PROVIDERS FOR ENTERPRISE ASSET MANAGEMENT

At the start of 2017, the asset performance optimization subsidiary of ABS Group signed an alliance agreement with Infor (U.S.), Inc., a leading enterprise asset management (EAM) software provider and strategic technology partner for more than 90,000 organizations worldwide. ABS Group is supporting Infor and its customers by combining EAM software technology with proven asset

reliability and predictive maintenance engineering strategies to support sustainability initiatives across industry sectors.

In 2017, ABS Group provided global EAM and reliability engineering solutions to the agribusiness, life sciences, facilities, manufacturing, education, utilities and renewable energy industries, among others. ABS Group continues to help clients in diverse markets reduce maintenance costs, manage physical assets, upgrade systems and optimize business processes for improved asset performance, increased uptime and lower lifecycle costs.

A COMMITMENT TO SUPPORT SAFER, MORE RELIABLE AND EFFICIENT OPERATIONS

To sustain its enduring leadership in the areas of risk, reliability, integrity and quality management, ABS Group positioned itself competitively in 2017 through a range of technical and advisory services in the areas of process safety management, mechanical integrity, enterprise risk management, advanced engineering, regulatory compliance management, asset performance optimization and management systems certification. With its safety and quality performance improving year-over-year, ABS Group is supporting some of the world's most critical and asset-intensive operations.



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