The Elmer A. Sperry Award

For planning and successfully managing a program to undertake and complete a massive infrastructure project, the "Expansion of the Panama Canal" that required the integration of the most demanding multidisciplinary engineering endeavors.

Presentation of

The Elmer A. Sperry Award
For 2018

Given in recognition of a distinguished engineering contribution, which through application proven in actual service has advanced the art of transportation, whether by land, sea, air, or space.

PRESENTED TO

The Panama Canal Authority

BY

The Elmer A. Sperry Board of Award

REPRESENTED BY THE

American Society of Mechanical Engineers
Institute of Electrical and Electronics Engineers
SAE International
Society of Naval Architects and Marine Engineers
American Institute of Aeronautics and Astronautics
American Society of Civil Engineers

For planning and successfully managing a program to undertake and complete a massive infrastructure project, the "Expansion of the Panama Canal" that required the integration of the most demanding multidisciplinary engineering endeavors.

This Expansion markedly enhances cargo trade and maritime transportation, with profound economic impacts on a worldwide scale.

At the SNAME Maritime Convention 2018
Providence, Rhode Island ∽ October 25, 2018

The Elmer A. Sperry Award

A Canal through the Isthmus of Panama

The dream of digging a water passage across the Isthmus of Panama uniting the Atlantic and Pacific Oceans dates to the early 16th century. Holy Roman Emperor Charles V initiated a movement to build a passage across the Isthmus, and in 1534 ordered the Panama regional governor to survey an all water route to the Pacific following the path of the Chagres River. While the envisioned water link between the oceans never became a reality, this led to the creation of fluvial routes and mule paths to move the riches of the New World back to Europe.

The idea went dormant until centuries later, when the discovery of gold in California in 1848 created a tremendous volume of transisthmian business. The newly constructed Panama railroad took great advantage of this gold fever, but, interest in a canal was again heightened. In 1869, United States (US) President Ulysses S. Grant ordered survey expeditions to Central America and appointed a commission to evaluate the findings resulting from these expeditions that took place between 1870 and 1875. In 1876, the commission came out in favor of a route through Nicaragua.

In the meantime, the Geographical Society of Paris organized a committee in 1876 to seek international cooperation for the purpose of building an interoceanic canal. In 1881, noted engineer Ferdinand de Lesseps led the initial attempt by France to build a sea-level canal. Due to bankruptcy in 1889 and losing an estimated 22,000 lives to disease and accidents, the committee had few choices - abandon the project or sell it. Committee directors decided to proffer a deal to the most likely taker, the United States of America.

Years later, on June 19, 1902, the US Senate vote favored a Panama Canal route by just eight votes. The engineering viewpoint that prevailed was significant. The proposed canal would be a lock canal, instead of the sea level canal concept that years before had brought massive failure upon a previous French campaign to build a canal through Panama.

With the end of construction of the Panama Canal on April 1, 1914, a new administrative entity, the Panama Canal Zone, was officially established, with Colonel George W. Goethals as its first governor. The official opening of the Panama Canal was on August 15, 1914, with the transit of the steamboat Ancon.

SS Ancon, first vessel to transmit the Panama Canal

The construction of the Panama Canal involved the creation of an 80 kilometer long waterway between the Atlantic and Pacific Oceans, with its alignment through one of the narrowest saddles of the isthmus. A system of locks, namely large interconnected pools with entrance and exit gates, was used, functioning as water lifts. The locks allowed raising ships from sea level (the Pacific or the Atlantic) to the level of a navigable manmade lake (Gatun Lake, 26 meters above sea level) created by impounding the Chagres River by means of an enormous earthen dam. The lake forms the longest stretch of the navigable channel and its southernmost end had to be dug through the continental divide. This 13 kilometer long excavation, the Culebra Cut, was considered an engineering feat all by itself. The system of locks, dams and the lake, were the main components of the original Panama Canal.

After decades of difficult diplomatic relations between Panama and the US, the Organization of American States was the site of the signing of the Panama Canal Treaty (Torrijos - Carter Treaty) between both countries, by which the Canal would be transferred to the Republic of Panama, who would assume full responsibility for its administration, operation and maintenance after 85 years of US administration. The parties also agreed on the Treaty Concerning the Permanent Neutrality and Operation of the Panama Canal that guarantees that the Canal shall remain open, safe, neutral and accessible to vessels of all nations. In 1977 a process started after the ratification of the Torrijos - Carter Treaty that ultimately put the Canal in Panamanian hands by December 31st, 1999.

The Panama Canal Authority (ACP)

The Panama Canal Authority (ACP) is an autonomous legal entity of the Republic of Panama, established under Title XIV of the National Constitution. It has full responsibility for the operation, administration, management, preservation, maintenance, and modernization of the Canal, as well as control over its activities and related services, pursuant to legal and constitutional regulations in force, so that the Canal may operate in a safe, continuous, efficient, and profitable manner. Because of its importance to the country and uniqueness in the service it provides, the ACP has its own independent administration and is financially autonomous.

The Panama Canal Expansion Project

The Panama Canal Expansion was Panama's largest infrastructure project since the Canal's opening in 1914. The endeavor took 9 years, with the participation of over 300 contractors, a large number of subcontractors, workers from more than 80 different nationalities, and the creation of over 41,000 jobs.

Nowadays, the Expanded Canal provides the world's shippers, retailers, manufacturers and consumers with greater shipping options, better maritime connectivity, enhanced logistics and supply-chain reliability. Since its inauguration on June 26, 2016, the Expanded Canal increased the waterway's capacity to meet the growing demand of maritime trade using larger vessels, providing important economies of scale and shorter travel distances to vessels that choose the Panama route.

This is the biggest endeavor Panama has ever undertaken, 102 years after original construction of the Panama Canal in 1914.

The Expansion included the construction of a new set of locks on the Atlantic and Pacific sides of the waterway, creating a third lane of traffic and doubling the cargo capacity of the waterway. It also included the excavation of the Pacific Access Channel, deepening and widening of the existing navigational channels, and improvements to the water supply.

Being powered by water stored in the upstream part of the system, navigation locks are water guzzlers. The new locks would require enormous volumes of it in order to properly operate. But due to the use of ingenious technology on a grand scale, while the expanded locks are 70 feet wider and 18 feet deeper than those in the original Canal, they use less water due to water-saving basins that recycle up to 60 percent of the water required per transit.

Rationale and Benefits of the Canal Expansion on Maritime Transportation

Over the years, the Canal has adapted to a very dynamic and changing market, in order to keep pace with the maritime industry needs. The competitive advantage of the Panama Canal depends mostly on its ability to provide safe, reliable and timely service to its customers. To maintain its competitiveness, the Canal must guarantee the necessary capacity to capture the growing tonnage demand with the appropriate level of service for each market segment, understanding that the clients have alternatives to using the Panama Canal.

Increasing the already dwindling capacity of the Canal was the convincing rationale for the decision to undertake a challenging program to upgrade its level of competitiveness. Doing so would not only allow the Canal to effectively capture more cargo, but also to be in line with expected trends in shipbuilding, that favored the use of larger vessels in order to achieve economies of scale. The industry had already decided that so-called Post-Panamax vessels would be constructed, even if they had to be used in alternative, longer routes to reach the same destinations. These ships could carry more than three times the amount of cargo than the largest Panamax vessels accommodated by the existing Canal. Further studies demonstrated that not all Post-Panamax vessels being built needed to be accommodated in the expanded Canal. A decision was made to consider a 366m long and 49m wide ship as the design vessel, and so the term Neopanamax vessel was coined for any vessel larger than Panamax size that could fit into the new locks.

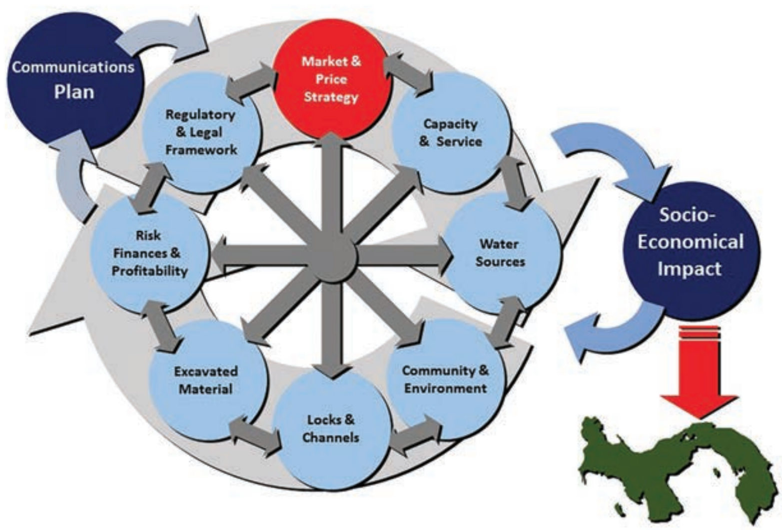
Additionally, the expanded Panama Canal Route not only provided a shorter trip for the larger cargo vessels, but was also considered environmentally beneficial compared to longer routes since it contributes to reducing greenhouse gas (GHG) emissions.

Planning, Design and Engineering of the Expansion

Since the 1930's, all of the Canal expansion studies have agreed that the most effective and efficient alternative to enhance Canal capacity was building a Third Set of Locks with bigger dimensions than those of the locks built in 1914. The studies developed by the ACP as part of its 2005-2025 Master Plan, also confirmed that a third set of locks was the most suitable, profitable, and environmentally-responsible way to increase Canal capacity and allow the Panamanian maritime route to continue to grow in a sustainable way.

The planning of the Panama Canal Expansion Program took 5 years, produced over 120 studies, and required the investment of 40 million dollars. An extensive and complete research program, without precedent in Canal history, was conducted. These studies included a wide range of environmental, social, market, competitiveness, engineering, operational, financial, economic and legal matters.

In order to execute the project it had to be approved by a National Referendum. A well-prepared communication plan was developed with the intention to educate the voting population on all the related aspects of the Expansion Project, including the financial costs and benefits, the environmental impacts, and the engineering involved.



The Program

The Canal Expansion Program was divided in four major components. The component of improvements to navigational channels involved dredging of the existing navigational channels to enable the safe navigation of the Neopanamax vessels of up to 50 feet in draft through the expanded Canal. The Pacific Access Channel component was the name given to all the dry-excavation works to construct the access channel to connect the new Pacific locks complex and Gatun Lake. The efforts to improve the water supply were another important part of the Program that consisted in the increase of Gatun Lake´s storage capacity by raising its maximum operating level. Finally, the largest component of the expansion was the construction of the Neopanamax-dimension lock complexes on the Pacific and Atlantic sides.

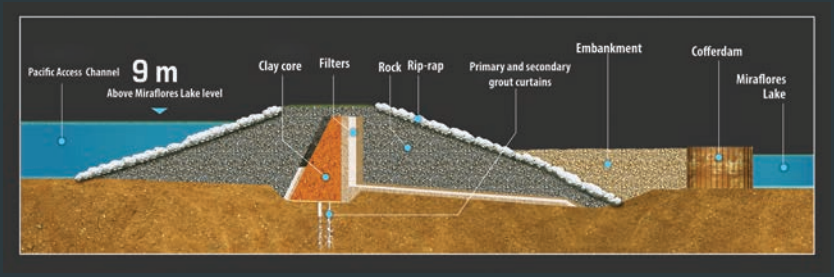
Dredging Works

A total of 46 million cubic meters were removed through dredging works performed by contractors as well as the Panama Canal's own dredging workforce and equipment. World-renowned high-tech, equipment was used, including some of the most powerful dredges in the industry.

This achievement involved the deepening and the widening of the Atlantic Entrance to a minimum of 225 meters, as well as the north access channel to the new Atlantic side Agua Clara Locks to a minimum of 218 meters; similarly, the Pacific Entrance had to be widened to a minimum of 225 meters and deepened 16.7 meters below mean low water springs. Dredging works were also required for partial construction of the south access to the Pacific side of the Cocoli Locks. Navigation channels in Gatun Lake and Culebra Cut, the narrowest section of the Canal, were also improved, requiring the use of the whole gamut of available dredging equipment: cutter suction dredges, backhoes, frontal shovel, hopper dredges, as well as barges for drilling and blasting the hard rock bottom and slopes found in certain sections of the Canal.

New Pacific Access Channel

A new 6-kilometer long, 16.7-meters deep access channel had to be created to connect the new Pacific Locks with Culebra Cut and Gatun Lake. This required the construction of a 2.3-kilometer long earthen dam to separate the waters of the new and old navigational channels. Due to the geologic nature of the foundation material, this initially implied the injection of a substantial grout curtain to seal the rock bottom. Construction of the main body of the dam consisted of a 25 meter high rock embankment and an impervious clay-core that allows the operation of the new channel 9 meters above the existing level with minimal seepage and very high standards of seismic and operational safety.



Dry-excavation activities in this area required the clearing of 461 hectares contaminated with unexploded ordnance (UXO) left behind by the US military during its deployment in Panama Canal areas.

Civil and geotechnical engineers worked together for the dry excavation phase of the project. The design had to consider a complicated geology which required adapting the excavated slopes to the actual conditions. In the end, the excavation for the Pacific Access Channel removed more than 50 million cubic meters of soil and rock. An interesting byproduct of this huge excavation work was that paleontological rescues and studies were possible as new areas became exposed. The results of the studies conducted on fossils discovered have forced scientists to reevaluate classical theories regarding the formation of the Isthmus of Panama.

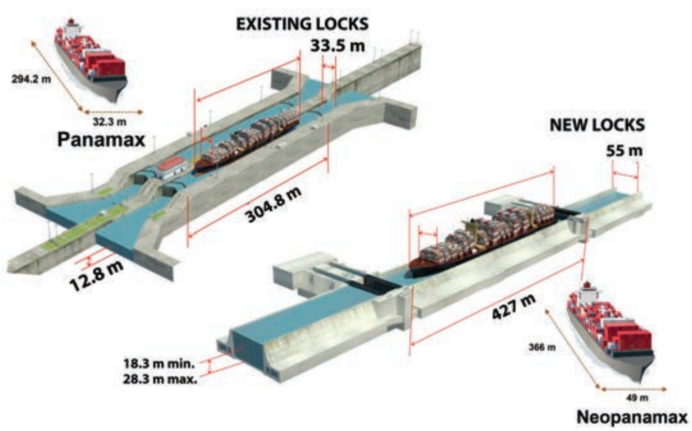
Improvements to Water Supply

Raising the maximum operating level of Gatun Lake from 26.7 to 27.1 meters (45 centimeters) enabled additional water storage capacity for Gatun Lake by nearly 200 million cubic meters. This required modification of specific structures in Canal operating areas, without interfering with their regular operation. To this regard, all 14 Gatun dam spillway gates were extended to retain the new water level and two spare gates were fabricated at the Canal shipyards. A large number of miter gates of the existing locks had to be raised, and operating machinery tunnels had to be made watertight. This project improved the Canal water supply and increased transit reliability for the vessels with a draft of up to 50 feet.

Design and Construction of the New Locks

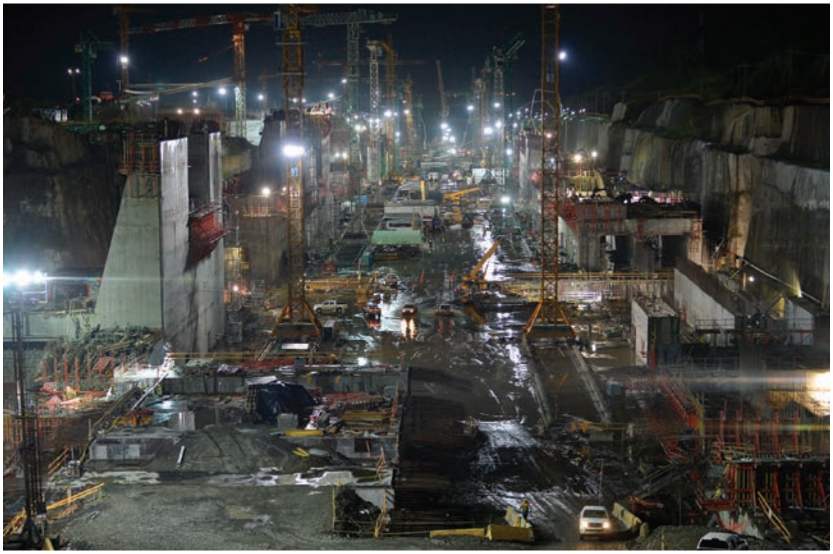
The project entailed the design and construction of two similar lock complexes, one on the Pacific and the other on the Atlantic side. Each complex has three chambers, nine water-saving basins (three per chamber), a lateral filling and emptying system and a redundant system of rolling gates separating the consecutive chambers. Valves and other electromechanical mechanisms enable the filling of the basins and the movement of the gates. In keeping with the simplicity of the original Canal, the entire filling and emptying system works by gravity, without the use of pumps.

The lock complexes raise vessels from ocean to lake in three consecutive steps, or chambers, and lowers them on the other ocean after transiting through the lake. The configuration is similar, albeit larger, to the existing Gatun Locks. The project created a new lane of traffic, providing the capacity to handle vessels up to 49 meters (160 feet) in beam, 366 meters (1,200 feet) in length, with up to 15.2 meters (50 feet) in draft, or with a cargo volume of up to 170,000 deadweight tonnage (DWT). The lock chambers can vary in length from 427 to 488 meters (1,400 to 1,600 feet), by 55 meters (180 feet) wide, and 18.3 meters (60 feet) deep. To date the largest vessel that has sailed through the locks has a maximum capacity of 14,863 TEU's (twenty-foot equivalent units), exceeding the expected capacity of about 12,500 TEU's for the as-planned design vessels.



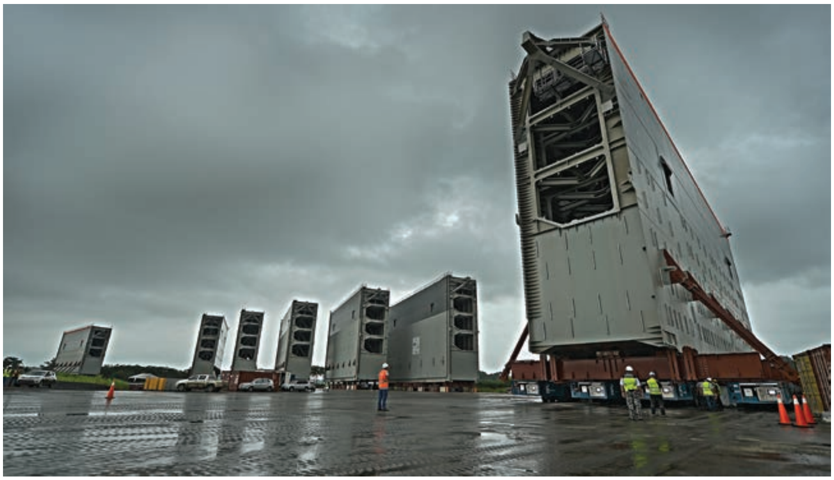
The existing locks allow the passage of vessels that can carry up to 5,000 TEUs. After the expansion the Neopanamax vessels are able to transit through the Canal, with up to 13,000/14,000 TEUs.

The construction of the locks required some 4.7 million cubic meters of concrete and 192 thousand tons of reinforcing steel. The design of this project had the involvement of hydraulic, structural, mechanical, electric and seismic engineers for developing the required physical and mathematical models, resulting in more than 20 thousand design drawings and an even larger number of construction drawings. But taking design from the drawing board to reality took a small army of construction engineers, quality control engineers, and skilled operators for equipment such as very large excavators, off-road haulage trucks, all types of cranes, concrete conveyance and finishing equipment, just to name a few. The locks' electromechanical systems operate by electricity, using redundant power supplies. All locks' machinery and operating systems are software controlled from centrally located Control Buildings in each lock.

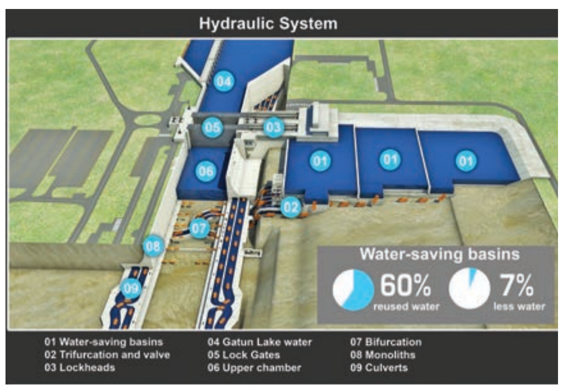


An emblematic feature for the locks project is the 16 rolling gates. Each lock complex has one pair of gates separating the consecutive chambers, housed in gate niches perpendicular to the wall. This redundancy provides navigation safety against accidents, but also allows for planned maintenance of one gate without having service outages on the lock. The gates are not just a multidisciplinary effort, but they are the flagship of multinational involvement for their design and construction. From being designed in the Netherlands with support in the US and construction in Italy these locks components required naval, structural, mechanical, electrical, material, welding and quality engineers that worked together for a common goal. The task of transporting the gates from Italy to Panama and installing them on site was monumental, due to the fact that this was all done in dry conditions, before the locks were flooded and the gates could be aided by floatation.

Six different types of gates were fabricated with features that vary according to where they were installed. For instance, the tallest ones – 33.04 meters – are installed at the Pacific entrance to the Canal, to withstand significant tidal variation. Even though the heaviest gates weigh more than 4,200 tons, their design incorporates buoyancy chambers to enable them to move on rails at a mere 15 percent of their actual weight.



Another innovative feature is the use of the water-saving basins, each one of approximately 70 meters wide by 5.50 meters deep, and a length similar to their adjacent lock chamber. Each lock chamber is connected to three basins, placed at consecutively lower elevations. Water moves by gravity through valve-controlled conduits from the chambers to each of the three basins, and the balance of the water is taken from the upstream body of water. This system allows up to 60% of the water to be reutilized, resulting in an overall water consumption which is 7% lower than the original locks.



The Expansion Program also brought changes to Canal operations; most notably, the new locks use tugboats to maneuver ships in and out of locks instead of the locomotives currently utilized in the existing locks. Since 2000, the Panama Canal has invested $18 million to build a fleet of 46 tugs to safely transit Neopanamax vessels through the expanded waterway. This decision to use tugs was based on numerous studies, mathematical models and operational assessments, to bring the Canal in line with international maritime industry standards.

The Panama Canal Project was the biggest infrastructure built in Panama in 100 years. As with the original Panama Canal the task was completed with the help of engineers from many fields and nationalities to accomplish a salient engineering endeavor for the world.

Owner and Designer of all dredging and Pacific access channel dry excavation contracts:
Autoridad del Canal de Panamá (Panama Canal Authority)

Main Contractors

Design / build consortium:
Grupo Unidos por el Canal, S.A., consisting of Sacyr Vallehermoso, S.A., Madrid, Spain; Salini Impregilo S.p.A., Milan, Italy; Jan De Nul NV, Aalst, Belgium; and Constructora Urbana, S.A., Panama City.

Third set of locks joint venture design team:
Consultores Internacionales del Canal de Panamá, LLC, consisting of numerous offices of MWH Global, a Stantec Company; Tetra Tech, Inc., Pasadena, California; and Iv-Groep b.v., Papendrecht, the Netherlands.

Gate Fabricator:
Cimolai Technology SpA, Carmignano di Brenta, Italy

Pacific entrance dredging:
Dredging International NV, part of DEME, Zwijndrecht, Belgium.

Atlantic entrance dredging:
Jan De Nul NV, Aalst, Belgium

Gatun Lake dredging:
Autoridad del Canal de Panamá (Panama Canal Authority)

Pacific access channel:
PAC1 – CONSTRUCTORA URBANA, S.A. (Panamá)

PAC2 – CILSA MINERA MARÍA (México)

PAC3 – CONSTRUCTORA MECO, S.A. (Costa Rica)

PAC4 – FCC, Madrid, Spain; ICA, Mexico City; and Constructora MECO, S.A., San José, Costa Rica, office, Cilsa-Minera María.

Elmer A. Sperry, 1860–1930

After graduating from the Cortland, N.Y. Normal School in 1880, Sperry had an association with Professor Anthony at Cornell, where he helped wire its first generator. From that experience he conceived his initial invention, an improved electrical generator and arc light. He then opened an electric company in Chicago and continued on to invent major improvements in electric mining equipment, locomotives, streetcars and an electric automobile. He developed gyroscopic stabilizers for ships and aircraft, a successful marine gyro-compass and gyro-controlled steering and fire control systems used on Allied warships during World War I. Sperry also developed an aircraft searchlight and the world's first guided missile. His gyroscopic work resulted in the automatic pilot in 1930. The Elmer A. Sperry Award was established in 1955 to encourage progress in transportation engineering.

The Elmer A. Sperry Award

To commemorate the life and achievements of Elmer Ambrose Sperry, whose genius and perseverance contributed so much to so many types of transportation, the Elmer A. Sperry Award was established by his daughter, Helen (Mrs. Robert Brooke Lea), and his son, Elmer A. Sperry, Jr., in January 1955, the year marking the 25th anniversary of their father's death. Additional gifts from interested individuals and corporations also contribute to the work of the board.

Elmer Sperry's inventions and his activities in many fields of engineering have benefited tremendously all forms of transportation. Land transportation has profited by his pioneer work with the storage battery, his development of one of the first electric automobiles (on which he introduced 4-wheel brakes and self-centering steering), his electric trolley car of improved design (features of its drive and electric braking system are still in use), and his rail flaw detector (which has added an important factor of safety to modern railroading). Sea transportation has been measurably advanced by his gyrocompass (which has freed humans from the uncertainties of the magnetic compass) and by such navigational aids as the course recorder and automatic steering for ships. Air transportation is indebted to him for the airplane gyro-pilot and the other air navigational instruments he and his son, Lawrence, developed together.

The donors of the Elmer A. Sperry Award have stated that its purpose is to encourage progress in the engineering of transportation. Initially, the donors specified that the award recipient should be chosen by a Board of Award representing the four engineering societies in which Elmer A. Sperry was most active:

American Society of Mechanical Engineers (of which he was the 48th president)
American Institute of Electrical Engineers (of which he was a founder member)
Society of Automotive Engineers
Society of Naval Architects and Marine Engineers

In 1960, the participating societies were augmented by the addition of the Institute of Aerospace Sciences. In 1962, upon merging with the Institute of Radio Engineers, the American Institute of Electrical Engineers became known as the Institute of Electrical and Electronics Engineers; and in 1963, the Institute of Aerospace Sciences, upon merger with the American Rocket Society, became the American Institute of Aeronautics and Astronautics. In 1990, the American Society of Civil Engineers became the sixth society to become a member of the Elmer A. Sperry Board of Award. In 2006, the Society of Automotive Engineers changed its name to SAE International.

Important discoveries and engineering advances are often the work of a group, and the donors have further specified that the Elmer A. Sperry Award honor the distinguished contributions of groups as well as individuals.

Since they are confident that future contributions will pave the way for changes in the art of transportation equal at least to those already achieved, the donors have requested that the board from time to time review past awards. This will enable the board in the future to be cognizant of new areas of achievement and to invite participation, if it seems desirable, of additional engineering groups representative of new aspects or modes of transportation.

The Sperry Secretariat

The donors have placed the Elmer A. Sperry Award fund in the custody of the American Society of Mechanical Engineers. This organization is empowered to administer the fund, which has been placed in an interest bearing account whose earnings are used to cover the expenses of the board. A secretariat is administered by the ASME, which has generously donated the time of its staff to assist the Sperry Board in its work.

The Elmer A. Sperry Board of Award welcomes suggestions from the transportation industry and the engineering profession for candidates for consideration for this award.

Previous Elmer A. Sperry Awards

1955 To ***William Francis Gibbs*** and his Associates for design of the S.S. United States.

1956 To ***Donald W. Douglas*** and his Associates for the DC series of air transport planes.

1957 To ***Harold L. Hamilton, Richard M. Dilworth*** and ***Eugene W. Kettering*** and Citation to their Associates for developing the diesel-electric locomotive.

1958 To ***Ferdinand Porsche*** (in memoriam) and ***Heinz Nordhoff*** and Citation to their Associates for development of the Volkswagen automobile.

1959 To ***Sir Geoffrey de Havilland, Major Frank B. Halford*** (in memoriam) and ***Charles C. Walker*** and Citation to their Associates for the first jet-powered passenger aircraft and engines.

1960 To ***Frederick Darcy Braddon*** and Citation to the Engineering Department of the Marine Division of the Sperry Gyroscope Company, for the three-axis gyroscopic navigational reference.

1961 To ***Robert Gilmore LeTourneau*** and Citation to the Research and Development Division, Firestone Tire and Rubber Company, for high speed, large capacity, earth moving equipment and giant size tires.

1962 To ***Lloyd J. Hibbard*** for applying the ignitron rectifier to railroad motive power.

1963 To ***Earl A. Thompson*** and Citations to ***Ralph F. Beck, William L. Carnegie, Walter B. Herndon, Oliver K. Kelley*** and ***Maurice S. Rosenberger*** for design and development of the first notably successful automatic automobile transmission.

1964 To ***Igor Sikorsky*** and ***Michael E. Gluhareff*** and Citation to the Engineering Department of the Sikorsky Aircraft Division, United Aircraft Corporation, for the invention and development of the high-lift helicopter leading to the Skycrane.

1965 To ***Maynard L. Pennell, Richard L. Rouzie, John E. Steiner, William H. Cook*** and ***Richard L. Loesch, Jr.*** and Citation to the Commercial Airplane Division, The Boeing Company, for the concept, design, development, production and practical application of the family of jet transports exemplified by the 707, 720 and 727.

1966 To ***Hideo Shima, Matsutaro Fuji*** and ***Shigenari Oishi*** and Citation to the Japanese National Railways for the design, development and construction of the New Tokaido Line with its many important advances in railroad transportation.

1967 To ***Edward R. Dye*** (in memoriam), ***Hugh DeHaven,*** and ***Robert A. Wolf*** for their contribution to automotive occupant safety and Citation to the research engineers of Cornell Aeronautical Laboratory and the staff of the Crash Injury Research projects of the Cornell University Medical College.

1968 To ***Christopher S. Cockerell*** and ***Richard Stanton-Jones*** and Citation to the men and women of the British Hovercraft Corporation for the design, construction and application of a family of commercially useful Hovercraft.

1969 To ***Douglas C. MacMillan, M. Nielsen*** and ***Edward L. Teale, Jr.*** and Citations to ***Wilbert C. Gumprich*** and the organizations of George G. Sharp, Inc., Babcock and Wilcox Company, and the New York Shipbuilding Corporation for the design and construction of the N.S. Savannah, the first nuclear ship with reactor, to be operated for commercial purposes.

1970 To ***Charles Stark Draper*** and Citations to the personnel of the MIT Instrumentation Laboratories, Delco Electronics Division, General Motors Corporation, and Aero Products Division, Litton Systems, for the successful application of inertial guidance systems to commercial air navigation.

1971 To ***Sedgwick N. Wight*** (in memoriam) and ***George W. Baughman*** and Citations to ***William D. Hailes, Lloyd V. Lewis, Clarence S. Snavely, Herbert A. Wallace,*** and the employees of General Railway Signal Company, and the Signal & Communications Division, Westinghouse Air Brake Company, for development of Centralized Traffic Control on railways.

1972 To ***Leonard S. Hobbs*** and ***Perry W. Pratt*** and the dedicated engineers of the Pratt & Whitney Aircraft Division of United Aircraft Corporation for the design and development of the JT-3 turbo jet engine.

1975 To ***Jerome L. Goldman, Frank A. Nemec*** and ***James J. Henry*** and Citations to the naval architects and marine engineers of Friede and Goldman, Inc. and Alfred W. Schwendtner for revolutionizing marine cargo transport through the design and development of barge carrying cargo vessels.

1977 To ***Clifford L. Eastburg*** and ***Harley J. Urbach*** and Citations to the Railroad Engineering Department of The Timken Company for the development, subsequent improvement, manufacture and application of tapered roller bearings for railroad and industrial uses.

1978 To ***Robert Puiseux*** and Citations to the employees of the Manufacture

Française des Pneumatiques Michelin for the development of the radial tire.

1979 To ***Leslie J. Clark*** for his contributions to the conceptualization and initial development of the sea transport of liquefied natural gas.

1980 To ***William M. Allen, Malcolm T. Stamper, Joseph F. Sutter*** and ***Everette L. Webb*** and Citations to the employees of Boeing Commercial Airplane Company for their leadership in the development, successful introduction & acceptance of wide-body jet aircraft for commercial service.

1981 To ***Edward J. Wasp*** for his contributions toward the development and application of long distance pipeline slurry transport of coal and other finely divided solid materials.

1982 To ***Jörg Brenneisen, Ehrhard Futterlieb, Joachim Körber, Edmund Müller, G. Reiner Nill, Manfred Schulz, Herbert Stemmler*** and ***Werner Teich*** for their contributions to the development and application of solid state adjustable frequency induction motor transmission to diesel and electric motor locomotives in heavy freight and passenger service.

1983 To ***Sir George Edwards,*** OM, CBE, FRS; ***General Henri Ziegler,*** CBE, CVO, LM, CG; ***Sir Stanley Hooker,*** CBE, FRS (in memoriam); ***Sir Archibald Russell,*** CBE, FRS; and ***M. André Turcat***, L d'H, CG; commemorating their outstanding international contributions to the successful introduction and subsequent safe service of commercial supersonic aircraft exemplified by the Concorde.

1984 To ***Frederick Aronowitz, Joseph E. Killpatrick, Warren M. Macek*** and ***Theodore J. Podgorski*** for the conception of the principles and development of a ring laser gyroscopic system incorporated in a new series of commercial jet liners and other vehicles.

1985 To ***Richard K. Quinn, Carlton E. Tripp,*** and ***George H. Plude*** for the inclusion of numerous innovative design concepts and an unusual method of construction of the first 1,000-foot self-unloading Great Lakes vessel, the M/V Stewart J. Cort.

1986 To ***George W. Jeffs, Dr. William R. Lucas, Dr. George E. Mueller, George F. Page, Robert F. Thompson*** and ***John F. Yardley*** for significant personal and technical contributions to the concept and achievement of a reusable Space Transportation System.

1987 To ***Harry R. Wetenkamp*** for his contributions toward the development and application of curved plate railroad wheel designs.

1988 To ***J. A. Pierce*** for his pioneering work & technical achievements that led to the establishment of the OMEGA Navigation System, the world's first ground-based global navigation system.

1989 To ***Harold E. Froehlich, Charles B. Momsen, Jr.,*** and ***Allyn C. Vine*** for the invention, development and deployment of the deep-diving submarine, Alvin.

1990 To ***Claud M. Davis, Richard B. Hanrahan, John F. Keeley,*** and ***James H. Mollenauer*** for the conception, design, development and delivery of the Federal Aviation Administration enroute air traffic control system.

1991 To ***Malcom Purcell McLean*** for his pioneering work in revolutionizing cargo transportation through the introduction of intermodal containerization.

1992 To ***Daniel K. Ludwig*** (in memoriam) for the design, development and construction of the modern supertanker.

1993 To ***Heinz Leiber, Wolf-Dieter Jonner*** and ***Hans Jürgen Gerstenmeier*** and Citations to their colleagues in Robert Bosch GmbH for their conception, design and development of the Anti-lock Braking System for application in motor vehicles.

1994 To ***Russell G. Altherr*** for the conception, design and development of a slackfree connector for articulated railroad freight cars.

1996 To ***Thomas G. Butler*** (in memoriam) and ***Richard H. MacNeal*** for the development and mechanization of NASA Structural Analysis (NASTRAN) for widespread utilization as a working tool for finite element computation.

1998 To ***Bradford W. Parkinson*** for leading the concept development and early implementation of the Global Positioning System (GPS) as a breakthrough technology for the precise navigation and position determination of transportation vehicles.

2000 To those individuals who, working at the French National Railroad (SNCF) and ALSTOM between 1965 and 1981, played leading roles in conceiving and creating the initial TGV High Speed Rail System, which opened a new era in passenger rail transportation in France and beyond.

2002 To ***Raymond Pearlson*** for the invention, development and worldwide implementation of a new system for lifting ships out of the water for repair and for launching new ship construction. The simplicity of this concept has allowed both large and small nations to benefit by increasing the efficiency and reducing the cost of shipyard operations.

2004 To ***Josef Becker*** for the invention, development, and worldwide implementation of the Rudderpropeller, a combined propulsion and steering system, which converts engine power into optimum thrust. As the underwater components can be steered through 360 degrees, the full propulsive power can also be used for maneuvering and dynamic positioning of the ship.

2005 To ***Victor Wouk*** for his visionary approach to developing gasoline engine-electric motor hybrid-drive systems for automobiles and his distinguished engineering achievements in the related technologies of small, lightweight, and highly efficient electric power supplies and batteries.

2006 To ***Antony Jameson*** in recognition of his seminal and continuing contributions to the modern design of aircraft through his numerous algorithmic innovations and through the development of the FLO, SYN, and AIRPLANE series of computational fluid dynamics codes.

2007 To ***Robert Cook, Pam Phillips, James White,*** and ***Peter Mahal*** for their seminal work and continuing contributions to aviation through the development of the Engineered Material Arresting System (EMAS) and its installation at many airports.

2008 To ***Thomas P. Stafford, Glynn S. Lunney, Aleksei A. Leonov,*** and ***Konstantin D. Bushuyev*** as leaders of the Apollo-Soyuz mission and as representatives of the Apollo-Soyuz docking interface design team: in recognition of seminal work on spacecraft docking technology and international docking interface methodology.

2009 To ***Boris Popov*** for the development of the ballistic parachute system allowing the safe descent of disabled aircraft.

2010 To ***Takuma Yamaguchi*** for his invention of the ARTICOUPLE, a versatile scheme to connect tugs and barges to form an articulated tug and barge, AT/B, waterborne transportation system operational in rough seas. His initial design has led to the development of many different types of couplers that have resulted in the worldwide use of connected tug and barges for inland waterways, coastal waters and open ocean operation.

2011 To ***Zigmund Bluvband*** and ***Herbert Hecht*** for development and implementation of novel methods and tools for the advancement of dependability and safety in transportation.

2012 To ***John Ward Duckett*** for the development of the Quickchange Movable Barrier.

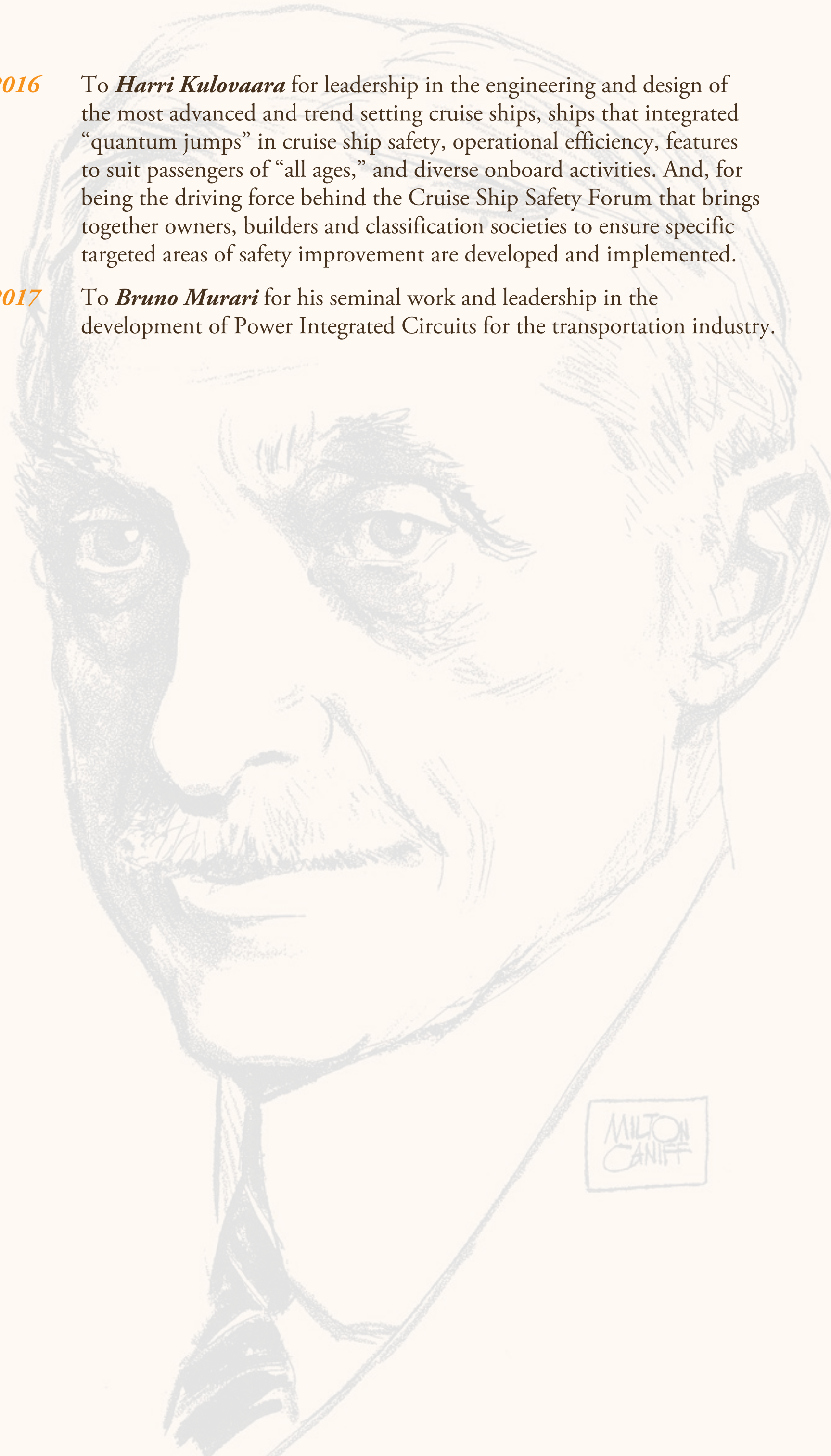
2013 To ***C. Don Bateman*** for the development of the ground proximity warning system for aircraft.

2014 To ***Bruce G. Collipp, Alden J. Laborde,*** and ***Alan C. McClure*** for the design and development of the semi-submersible platform.

2015 To ***Michael K. Sinnett*** and the ***The Boeing Company 787-8 Development Team*** for pioneering engineering advances including lightweight composite wing and monolithic fuselage construction that have led to significant improvements in fuel efficiency, reduced carbon emission, reduced maintenance costs and increased passenger comfort.

2016 To ***Harri Kulovaara*** for leadership in the engineering and design of the most advanced and trend setting cruise ships, ships that integrated "quantum jumps" in cruise ship safety, operational efficiency, features to suit passengers of "all ages," and diverse onboard activities. And, for being the driving force behind the Cruise Ship Safety Forum that brings together owners, builders and classification societies to ensure specific targeted areas of safety improvement are developed and implemented.

2017 To ***Bruno Murari*** for his seminal work and leadership in the development of Power Integrated Circuits for the transportation industry.



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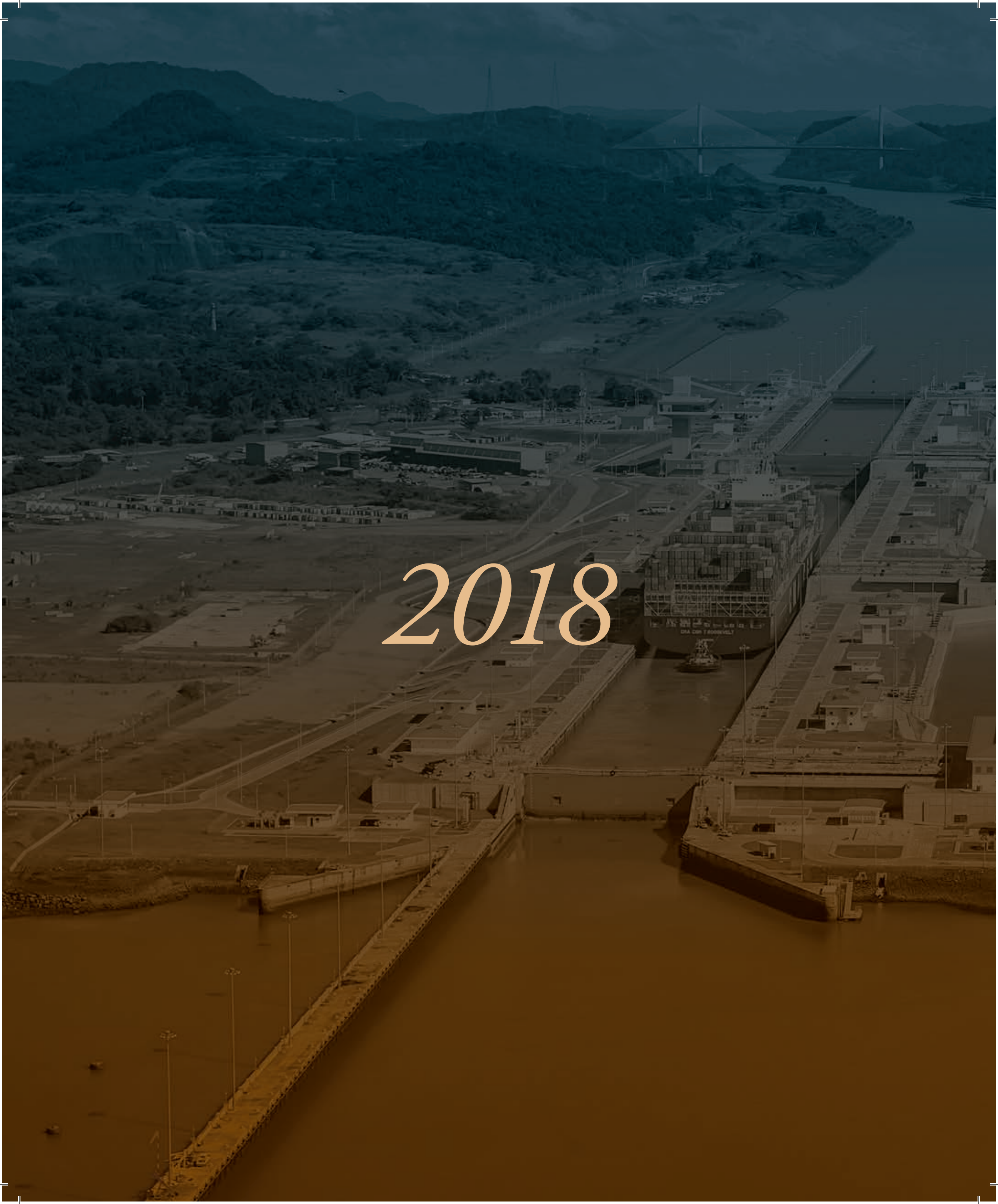

2018