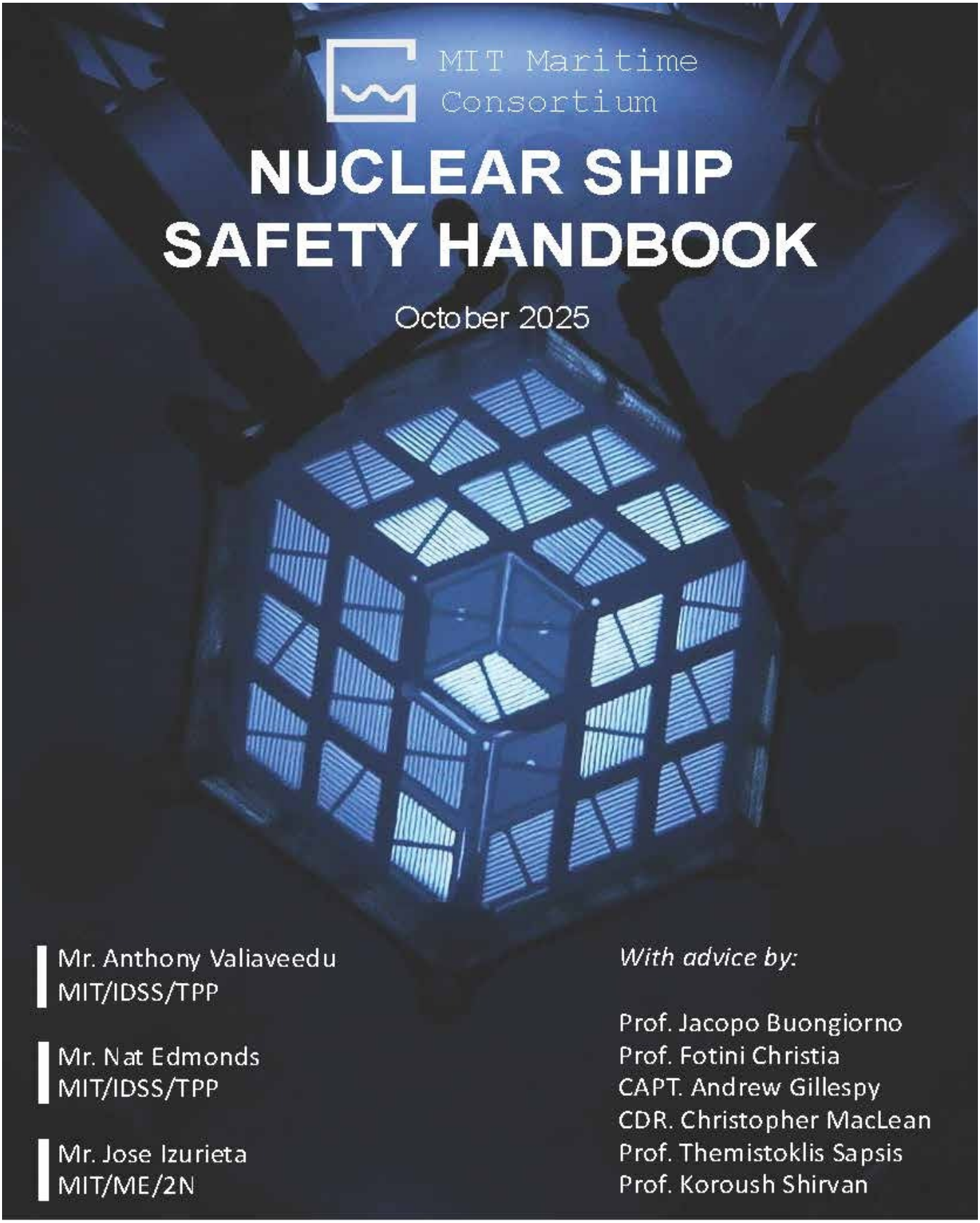
MIT Maritime Consortium releases “Nuclear Ship Safety Handbook”

October 20, 2025



First-of-its-kind handbook serves as a guide for design safety for civilian nuclear ships.

Commercial shipping accounts for 3 percent of all greenhouse gas emissions globally. As the sector sets climate goals and chases a carbon-free future, nuclear power — long used as a source for military vessels — presents an enticing solution. To date, however, there has been no clear, unified public document available to guide design safety for certain components of civilian nuclear ships. A new "Nuclear Ship Safety Handbook" by the MIT Maritime Consortium aims to change that and set the standard for safe maritime nuclear propulsion.

“This handbook is a critical tool in efforts to support the adoption of nuclear in the maritime industry,” explains Themis Sapsis, the William I. Koch Professor of Mechanical Engineering at MIT, director of the MIT Center for Ocean Engineering, and co-director of the MIT Maritime Consortium. “The goal is to provide a strong basis for initial safety on key areas that require nuclear and maritime regulatory research and development in the coming years to prepare for nuclear propulsion in the maritime industry.”

Using research data and standards, combined with operational experiences during civilian maritime nuclear operations, the handbook provides unique insights into potential issues and resolutions in the design efficacy of maritime nuclear operations, a topic of growing importance on the national and international stage.

“Right now, the nuclear-maritime policies that exist are outdated and often tied only to specific technologies, like pressurized water reactors,” says Jose Izurieta, a graduate student in the Department of Mechanical Engineering (MechE) Naval Construction and Engineering (2N) Program, and one of the handbook authors. “With the recent U.K.-U.S. Technology Prosperity Deal now including civil maritime nuclear applications, I hope the handbook can serve as a foundation for creating a clear, modern regulatory framework for nuclear-powered commercial ships.”

The recent memorandum of understanding signed by the U.S. and U.K calls for the exploration of “novel applications of advanced nuclear energy, including civil maritime applications,” and for the parties to play “a leading role informing the establishment of international standards, potential establishment of a maritime shipping corridor between the Participants’ territories, and strengthening energy resilience for the Participants’ defense facilities.”

“The U.S.-U.K. nuclear shipping corridor offers a great opportunity to collaborate with legislators on establishing the critical framework that will enable the United States to invest on nuclear-powered merchant vessels — an achievement that will reestablish America in the shipbuilding space,” says Fotini Christia, the Ford International Professor of the Social Sciences, director of the Institute for Data, Systems, and Society (IDSS), and co-director of the MIT Maritime Consortium.

“With over 30 nations now building or planning their first reactors, nuclear energy’s global acceptance is unprecedented — and that momentum is key to aligning safety rules across borders for nuclear-powered ships and the respective ports,” says Koroush Shirvan, the Atlantic Richfield Career Development Professor in Energy Studies at MIT and director of the Reactor Technology Course for Utility Executives.

The handbook, which is divided into chapters in areas involving the overlapping nuclear and maritime safety design decisions that will be encountered by engineers, is careful to balance technical and practical guidance with policy considerations.

Commander Christopher MacLean, MIT associate professor of the practice in mechanical engineering, naval construction, and engineering, says the handbook will significantly benefit the entire maritime community, specifically naval architects and marine engineers, by providing standardized guidelines for design and operation specific to nuclear powered commercial vessels.

“This will assist in enhancing safety protocols, improve risk assessments, and ensure consistent compliance with international regulations,” MacLean says. “This will also help foster collaboration amongst engineers and regulators. Overall, this will further strengthen the reliability, sustainability, and public trust in nuclear-powered maritime systems.”

Anthony Valiaveedu, the handbook’s lead author, and co-author Nat Edmonds, are both students in the MIT Master’s Program in Technology and Policy (TPP) within the IDSS. The pair are also co-authors of a paper published in Science Policy Review earlier this year that offered structured advice on the development of nuclear regulatory policies.

“It is important for safety and technology to go hand-in-hand,” Valiaveedu explains. “What we have done is provide a risk-informed process to begin these discussions for engineers and policymakers.”

“Ultimately, I hope this framework can be used to build strong bilateral agreements between nations that will allow nuclear propulsion to thrive,” says fellow co-author Izurieta.

Impact on industry

“Maritime designers needed a source of information to improve their ability to understand and design the reactor primary components, and development of the 'Nuclear Ship Safety Handbook' was a good step to bridge this knowledge gap,” says Christopher J. Wiernicki, American Bureau of Shipping (ABS) chair and CEO. “For this reason, it is an important document for the industry.”

The ABS, which is the American classification society for the maritime industry, develops criteria and provides safety certification for all ocean-going vessels. ABS is among the founding members of the MIT Maritime Consortium. Capital Clean Energy Carriers Corp., HD Korea Shipbuilding and Offshore Engineering, and Delos Navigation Ltd. are also consortium founding members. Innovation members are Foresight-Group, Navios Maritime Partners L.P., Singapore Maritime Institute, and Dorian LPG.

“As we consider a net-zero framework for the shipping industry, nuclear propulsion represents a potential solution. Careful investigation remains the priority, with safety and regulatory standards at the forefront,” says Jerry Kalogiratos, CEO of Capital Clean Energy Carriers Corp. “As first movers, we are exploring all options. This handbook lays the technical foundation for the development of nuclear-powered commercial vessels.”

Sangmin Park, senior vice president at HD Korea Shipbuilding and Offshore Engineering, says “The 'Nuclear Ship Safety Handbook' marks a groundbreaking milestone that bridges shipbuilding excellence and nuclear safety. It drives global collaboration between industry and academia, and paves the way for the safe advancement of the nuclear maritime era.”

Maritime at MIT

MIT has been a leading center of ship research and design for over a century, with work at the Institute today representing significant advancements in fluid mechanics and hydrodynamics, acoustics, offshore mechanics, marine robotics and sensors, and ocean sensing and forecasting. Maritime Consortium projects, including the handbook, reflect national priorities aimed at revitalizing the U.S. shipbuilding and commercial maritime industries.

The MIT Maritime Consortium, which launched in 2024, brings together MIT and maritime industry leaders to explore data-powered strategies to reduce harmful emissions, optimize vessel operations, and support economic priorities.

“One of our most important efforts is the development of technologies, policies, and regulations to make nuclear propulsion for commercial ships a reality,” says Sapsis. “Over the last year, we have put together an interdisciplinary team with faculty and students from across the Institute. One of the outcomes of this effort is this very detailed document providing detailed guidance on how such effort should be implemented safely.”

Handbook contributors come from multiple disciplines and MIT departments, labs, and research centers, including the Center for Ocean Engineering, IDSS, MechE’s Course 2N Program, the MIT Technology and Policy Program, and the Department of Nuclear Science and Engineering.

MIT faculty members and research advisors on the project include Sapsis; Christia; Shirvan; MacLean; Jacopo Buongiorno, the Battelle Energy Alliance Professor in Nuclear Science and Engineering, director, Center for Advanced Nuclear Energy Systems, and director of science and technology for the Nuclear Reactor Laboratory; and Captain Andrew Gillespy, professor of the practice and director of the Naval Construction and Engineering (2N) Program.

“Proving the viability of nuclear propulsion for civilian ships will entail getting the technologies, the economics and the regulations right,” says Buongiorno. “This handbook is a meaningful initial contribution to the development of a sound regulatory framework.”

“We were lucky to have a team of students and knowledgeable professors from so many fields,” says Edmonds. “Before even beginning the outline of the handbook, we did significant archival and history research to understand the existing regulations and overarching story of nuclear ships. Some of the most relevant documents we found were written before 1975, and many of them were stored in the bellows of the NS Savannah.”

The NS Savannah, which was built in the late 1950s as a demonstration project for the potential peacetime uses of nuclear energy, was the first nuclear-powered merchant ship. The Savannah was first launched on July 21, 1959, two years after the first nuclear-powered civilian vessel, the Soviet ice-breaker Lenin, and was retired in 1971.

Historical context for this project is important, because the reactor technologies envisioned for maritime propulsion today are quite different from the traditional pressurized water reactors used by the U.S. Navy. These new reactors are being developed not just in the maritime context, but also to power ports and data centers on land; they all use low-enriched uranium and are passively cooled. For the maritime industry, Sapsis says, “the technology is there, it’s safe, and it’s ready.”

“The Nuclear Ship Safety Handbook” is publicly available on the MIT Maritime Consortium website and from the MIT Libraries.

See the original article here.