Short Course

Ship Underwater Radiated Noise

March 12–14, 19–21, 2024

CISMaRT

CISMaRT's third short course is an introduction to the basics of underwater radiated noise (URN) produced by ships. These topics are aimed at naval architects, engineers, policy officers and non-technical personnel with an interest in understanding the sources, transmission, modelling and mitigation of underwater ship noise. The course is laid out in six modules starting with a basic introduction to the science of underwater noise and following through with more detailed coverage of the topics listed below.

This course will be delivered through Brightspace, a learning management system.

— Registration deadline: February 12, 2024

Fundamentals of Underwater Radiated Noise

This module introduces fundamentals of ship noise. After an introduction to the relevance of ship noise in ship design and the primary sources of noise on ships, we will focus on key concepts of acoustics, including a qualitative introduction to acoustic wave phenomena, such as wavefronts, interference, reflection, scattering, diffraction, etc., and an overview of the main parameters used to quantify sound, as sound pressure levels, sound intensity levels, and energy density levels. We will then focus on sound propagation in water to understand how sound waves propagate in the ocean and how the environment alters sound propagation and shapes the ocean soundscape. Finally, we will provide an overview of the main effects of ship noise on marine life and of national and international regulatory bodies' efforts to develop new standards to mitigate noise exposures of taxa.

Date: **March 12, 2024, 12:30–16:00 (EDT), including a half-hour break**
Lecturer: **Dr. Lorenzo Moro, Associate Professor, Memorial University, Department of Ocean and Naval Architectural Engineering**

Sources and Transmission of Vibrations

This module outlines the basics of ship vibrations and noise resulting from onboard machinery. While the propeller is often the dominant source of underwater radiated noise, the onboard machinery is also typically a significant contributor to the overall ship's underwater radiated noise. In particular, the main engines, diesel alternators, and gearboxes are significant noise sources, but all onboard machinery contributes to some extent. The noise is transmitted through direct contact with the hull as well as secondary fluid-borne and air-borne paths.

- Basic concepts of mechanical vibrations – mass, stiffness and damping
- Free, forced and transient vibrations
- Sources of vibrations in ships – main engines, generators, pumps, auxiliary machinery
- Transmission of structure-borne noise in ships
- Secondary noise paths
- Transmission of noise into surrounding fluid

Date: **March 14, 2024, 12:30–16:00 (EDT), including a half-hour break**
Lecturer: **Layton Gilroy, Defence Scientist, Defence Research and Development Canada**

Underwater Radiated Noise Modelling and Prediction

This session will dive into the different techniques currently available to predict and assess underwater noise radiated by ships including:

- Empirical methodologies
- Open-source codes for underwater sound propagation
- Propeller noise prediction techniques
- Dynamic stiffness assessment of foundations and the impact to underwater noise
- Finite element (FE) modelling combined with boundary element methods (BEMs) for hull radiation prediction
- Statistical energy analysis (SEA) for hull radiation

The session will focus on the theory behind the different techniques, it is not specific to any particular tool where FE, SEA, BEM concepts were implemented. Some rules of thumb will be discussed when it comes to shipping design. Moreover, the session will touch upon the accuracy of each technique and its validation.

Date: **March 20, 2024, 12:30–16:00 (EDT), including a half-hour break**
Lecturer: **Daniel Alvarez, Senior Consultant, Energy, Lloyds Register**

Propeller and Appendage Noise

This module describes the mechanisms of underwater radiated noise resulting from the ship's propeller and other hull appendages. Typically, a cavitating propeller is the dominant noise source on a ship across most frequency bands, but a non-cavitating propeller and the other underwater appendages (bulbous bow, bilge keels, A-brackets, rudders, etc.) can also contribute to the overall ship noise. The module will discuss the physical mechanisms behind the noise, the characteristics of the noise generated, and the changes in the noise with ship speed.

- Non-cavitating propeller noise
- Propeller cavitation
- Ship appendages and noise
- Bow thrusters
- Modelling hydrodynamic noise
- Noise transmission in the sea

Date: **March 13, 2024, 12:30–16:00 (EDT), including a half-hour break**
Lecturer: **Layton Gilroy, Defence Scientist, Defence Research and Development Canada**

Underwater Radiated Noise Measurements

This module will introduce attendees to the key elements of underwater radiated noise (URN) measurements of vessels at sea. There will be a brief introduction to general acoustics and underwater sound metrics (decibels) to ensure all attendees have the same basic understanding of the units of measure to be discussed throughout the course. The program will provide basics on URN instrumentation; hydrophones, frequency domain data collection systems such as FFT and octave band analysis systems. The arrangements of at-sea measurement systems will be discussed along with example ship URN sound profiles. Finally, the course will discuss relevant standards for the measurement of vessel URN from ANSI, ASA, ISO and the Class Societies.

Date: **March 19, 2024, 12:30–16:00 (EDT), including a half-hour break**
Lecturer: **Michael Bahtiarian, Principal, ACENTECH**

Underwater Radiated Noise Reduction Strategies

This module will introduce attendees to Underwater Radiated Noise (URN) reduction strategies. There will be a brief introduction to general acoustics and underwater sound metrics (decibels) to ensure all attendees have the same basic understanding of the units of measure to be discussed throughout the course. A background on the transmission of shipboard sound and vibration into the water will also be provided, as the different transmission paths need to be mitigated differently. The focus of this module will be the principal methods for URN reduction for each of the sources and paths. Treatments used outside the hull will be discussed, including flow improvements, quiet propellers and air bubble systems. Engineered treatments used within the hull will be discussed, including vibration isolation mounts, equipment enclosures, hull damping, and plating insulation. Operational measures for the reduction of URN will also be addressed. Example treatments and outcomes will be given.

Date: **March 21, 2024, 12:30–16:00 (EDT), including a half-hour break**
Lecturer: **Michael Bahtiarian, Principal, ACENTECH**

For more information please visit **cismart.ca/advanced-short-course** or contact **Dr. Wei Qiu** at **info@cismart.ca**.

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