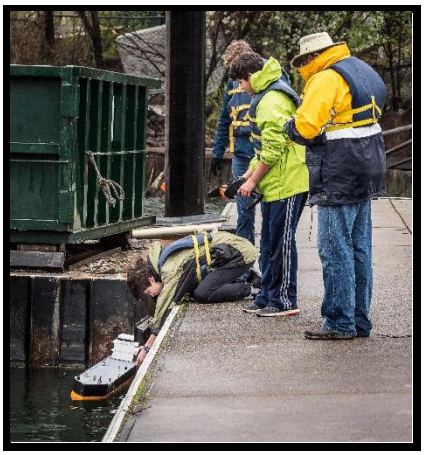
Maryland Engineering Challenges

2022 Cargo Ship Challenge

High School – Grades 9 to 12

Supported By:
Technology and Engineering Education Association of Maryland

Engineer Contact:
Douglas Griggs at dbdbgriggs@gmail.com



Important Dates:

Coaches' Information Session

⇒ **Thursday, October 14, 2021** **3:30 p.m. to 4:30 p.m. & 6:30 p.m. to 7:30 p.m.**

This virtual event hosted over Zoom is designed for adults interested in coaching a team to chat with engineers. Find out if a particular Challenge is a good fit for your students. The Information Session is not required and there is no cost. Register here https://bit.ly/2022MECInformationSession. Contact Jessica with questions at challenges@thebmi.org

Cargo Ship Student and Coaches' Hands-on Workshop

⇒ **Saturday, November 6, 2021** **10:00 AM to 1:00 PM**

Learn the practical aspects of the Cargo Ship Challenge in this in-person workshop hosted at the U.S. Naval Academy in Annapolis, MD. Work with engineers to explore design and construction aspects of this project. Especially helpful for first-time Coaches and students as well as those with little engineering experience. Check out the details of the workshop. Register required for the workshop at https://bit.ly/2022CargoShipWorkshopRegistration. Contact Jessica with questions at challenges@thebmi.org.

Registration

⇒ **Friday, April 8, 2022** **Prior to 4:00 p.m.**

In order to be a registered team, each team must have their adult Coach do the following:

- Register online at https://bit.ly/MEC2022Registration
- AND pay a $5 Coach's Fee: http://bit.ly/MECcoachfee

Written Report Due

⇒ **April 15, 2022** **Prior to 4:00 p.m.**

- Submit the team's **Written Report** (Emailed in PDF format) to challenges@thebmi.org

Cargo Ship Competition

⇒ **April 30, 2022** **Doors open at 11:00 AM, starts at 12:00 PM**

- Competition will occur fully outside on the BMI campus, following CDC guidelines.
- Full details about the Challenge event will be emailed to Coaches after registration deadline.

IMPORTANT INFORMATION:

All Cargo Ship activities will be hosted at the Baltimore Museum of Industry, 1415 Key Highway, Baltimore, MD 21230

For more information on Cargo Ship engineering requirements, written reports, or judging criteria, setting up propulsion and control systems or obtaining propellers contact Douglas Griggs (dbdbgriggs@gmail.com).

NOTE TO PARTICIPANTS:

A standard multi-channel radio control unit functioning in the R/C band must be used, capable of controlling at least forward/off/reverse, and the rudder. A radio-controlled speed control for brushed motors may be used. The model must be powered by a Kelvin.com, stock number 851934 motor. The actual motor model number that will be provided is LS5BFN-2645-R. It's a 12V 7205 rpm, 29mm dia, 2.3mm shaft dia. Motors and speed controls will be provided to the teams as needed, but the initial design will have to be presented to Mr. Griggs before the parts are provided. Contact dbdbgriggs@gmail.com for availability of motors, speed controls, propellers, propeller shafts, bearings and motor shaft couplers.

There are commercially available running gear that you can purchase, or you can design your own. The propeller shaft could be any reasonable size and length to suit your design, but it should use a stuffing tube with some internal space for packing compound (*e.g.* Vaseline) to provide a watertight seal. Your design needs to keep the shaft in place radially, and needs to provide something for the shaft to thrust

against to keep the shaft from moving forward while the ship is going forward, and some way to keep the shaft from backing out of the stuffing tube as you go in reverse.

Although there are many ways to design a hull-form, you may consider looking into the *DELFTship: Visual hull modelling and stability analysis* software (https://www.delftship.net/DELFTwp/) as a design aid.

A sample report for this challenge is available to help teams overcome any barriers to entry that they may have. This sample report contains a shopping list with possible sources of supply.

The current pandemic has forced a lot of changes in our lives, and this challenge is no exception. Teams who have participated in previous years will notice that the vessel size has been reduced from 60" to 30", and the required payload reduced to 6 lb to make it more reasonable for individuals to build a cargo ship on their own. We encourage teams to have each member build a ship to a common team design and the team will compete as a "Shipping Company" with the score determined by the average of all of the ships in the "Shipping Company".

THE CHALLENGE

A local Baltimore company would like your team to design a bulk carrier cargo ship to deliver 40,000 tons of processed sugar to remote ports. The shortest wharf on the expected route is 600 feet long and the minimum depth in any port is 40 feet. There is also a narrow channel that must be navigated at each end of the transit. As part of your solution you should build a 1" to 20'0" scale, radio controlled model to be tested in the inner harbor.

CRITERIA

The competition involves five main components: a written report submitted two weeks prior to the actual competition, an oral report on the day of the competition, the actual design and construction of the entry, the reliability of the entry, and the demonstrated performance. Basic requirements for the reports and guidance for preparing for the competition are given in the High School "Guide to Entry", which should be read in connection with these details which are specific to the cargo ship challenge.

I. Written Report (includes drawings) (30 points)

Provide a written report in the required format (see "High School Guide to Entry") that presents and explains all facets of the design and the rationale for selecting specific design parameters and selecting/rejecting individual features. For example, what were the overall length, beam, and draft? How was the hull shape chosen? What testing was performed? What were the results? Be sure and include working drawings of the propulsion system and wiring diagrams and a final lines drawing of your hull.

II. Oral Report (10 points)

One or more of the team members should present a 5-10 minute oral report that summarizes the written report. This will be followed by 5 minutes of questioning by the judges.

III. Design and Fabrication (30 points)

Design a mono-hull ship to meet the requirements and construct a 1" to 20'0" (1:240) scale model with the hull constructed of any rigid material. The model should be robust enough to withstand minor collisions and must have enough watertight integrity to protect the cargo, the propulsion plant and the radio controls. The model should conform to the constraints listed below.

IV. Reliability (5 bonus points)

Up to 5 bonus points will be awarded by the judges to vessels that are consistently ready to test when called, need few repairs, and operate reliably.

V. Performance Demonstration (30 Points)

The performance of the vessel will be based on Required Freight Rate (how much the operator must charge per ton·mile to break even). The vessel with the lowest Required Freight Rate (RFR) will be declared the performance winner.

Once loaded, each entry will perform a timed run consisting of getting underway from a wharf, running a specified course around buoys, and maneuvering back alongside the wharf. This simplified formula for Required Freight Rate will be used:

$$RFR = (L+T) / (CD)$$

Where:

L = Length of Vessel

T = Time to run course in seconds

C = Pounds of Cargo carried

D = Scale Distance of course (considered to be 4 scale miles).

Example: 30" Long model with a full load of 6 pounds around course in 3 minutes

RFR = (30+180)/(6x4) = 210/24 = $8.75 per ton·mile

CONSTRAINTS:

- A standard multi-channel radio control unit functioning in the R/C band must be used, capable of controlling at least forward/off/reverse, and the rudder. A radio controlled speed control may be used.
- The model must be powered by a Kelvin.com, stock number 851934 motor. The actual motor model number LS5BFN-2645-R. It's a 12V 7205 rpm, 29mm dia, 2.3mm shaft dia. Motors and speed controls will be provided to the teams as needed, but the initial design will have to be presented to Mr. Griggs before the parts are provided. Contact dbdbgriggs@gmail.com for availability of motors, speed controls, propellers, propeller shafts, bearings and motor shaft couplers. A limited number of radio systems are available for loan, contact Mr. Griggs for details.
- The overall length of the model, including all appendages, may not exceed 30 inches.
- The navigational draft may not exceed 2 inches. That is to say, no part of the vessel (propeller, rudder, *etc*.) may extend more than 2 inches into the water. There will be a navigational hazard in the operational course that will be just over 2" deep, and there will be a 30 second time penalty each time the vessel hits it.
- The depth of the hull (keel to deck edge), measured everywhere along the length, must be at least 4 inches.
- The vessel must be provided with a collision bulkhead at least 10% of the overall length aft of the bow. No cargo may be loaded forward of this bulkhead. A bulkhead must also be provided between the cargo and the propulsion plant. All cargo must be carried inside of the hull.
- The vessel must have a deckhouse that rises at least 2.5 inches above the gunwales (top of the hull sides). This deckhouse should be removable to provide access to the engine compartment for repairs and inspection.
- While there is no need to make a model of an actual ship, credit will be given for adding details that make your vessel looks like it might actually be able to put to sea.
- Paint the vessel for ease of identification. The quality of workmanship and finish is a factor in the judging. The design draft (waterline at full load) must be marked on the hull.
- The cargo should be visible for inspection prior to testing. Removable cargo hold covers and/or hatches must be fitted that will make the hull reasonably resistant to water intrusion during testing.
- The vessel should be designed to carry at least 6 pounds of sugar. If we can find sugar packaged in 2lb bags, we will require that the cargo be loaded in those packages. Please contact Mr. Griggs for updates on the cargo requirement. Sand or other materials are not acceptable.
- The vessel must have adequate stability when fully loaded.
    - The vessel may be inclined to show a meta-centric height (GM) of > 3/8 inch OR
    - Have a roll (left-right-back again) period of less than 2 seconds.

- If, on the day of competition, the vessel is unable to demonstrate adequate stability, the judges may elect to remove one or more bags of cargo with the associated performance penalty.

CURRICULUM TIES-- Maryland Engineering Challenges and the Next Generation Science Standards

Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.1 The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.	**In preparing for the challenge, students will:** ● Recognize that real problems have more than one solution and decisions to accept one solution over another are made on the basis of many issues. 1.1.1 ● Modify or affirm scientific ideas according to accumulated evidence. 1.1.2
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.2 The student will pose scientific questions and suggest investigative approaches to provide answers to questions.	**In researching project designs, students will:** ● Identify meaningful, answerable scientific questions. 1.2.1 ● Formulate a working hypothesis. 1.2.2 ● Defend the need for verifiable data. 1.2.8
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.3 The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.	**In constructing their projects, students will:** ● Develop and demonstrate skills in using lab and field equipment to perform investigative techniques. 1.3.1 ● Demonstrate safe handling of the chemicals and materials of science. 1.3.3 ● Learn the use of new instruments and equipment by following instructions in a manual or from oral direction. 1.3.4
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.4 The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.	**In testing their projects, students will:** ● Analyze data to make predictions, decisions, or draw conclusions. 1.4.2 ● Describe trends revealed by data. 1.4.6 ● Determine the sources of error that limit the accuracy or precision of experimental results. 1.4.7

Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.5 The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.	**In composing their reports, students will:** ● Demonstrate the ability to summarize data (measurements/observations). 1.5.1 ● Explain scientific concepts and processes through drawing, writing, and/or oral communication. 1.5.2 ● Use, explain, and/or construct various classification systems. 1.5.7 ● Communicate conclusions derived through a synthesis of ideas. 1.5.9
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.7 The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.	**In reflecting on the engineering process, students will:** ● Identify and evaluate the impact of scientific ideas and/or advancements in technology on society. 1.7.2 ● Investigate career possibilities in the various areas of science. 1.7.5 ● Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments. 1.7.6

GOOD LUCK TO YOUR TEAM!