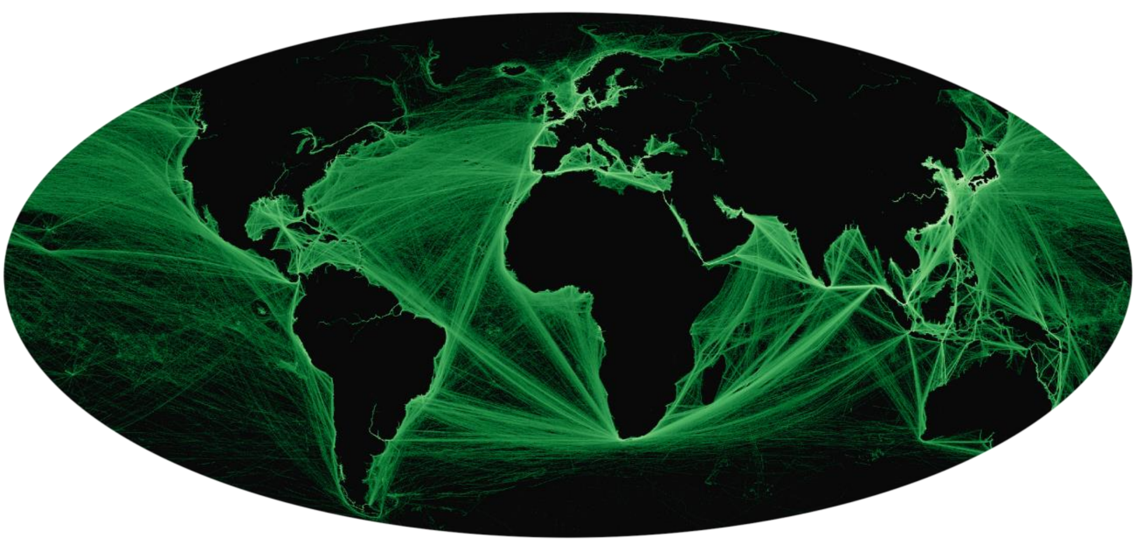
STEM education

ORGANIZATION OF EDUCATIONAL ROBOTICS, SCIENCE, TECHNOLOGY & MATHEMATICS

STEMATHLON 2026

Regular Category
Beginners

Artificial Intelligence in Maritime Transports



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Introduction

Maritime transports are essential for global trade, facilitating the movement of goods and raw materials across the world's oceans. Approximately 90% of global trade is conducted by sea, underscoring its critical role in international commerce. However, this industry faces significant risks and operational challenges, such as adverse weather conditions, unpredictable sea conditions, and human error, which can lead to accidents such as collisions, groundings, and spills, posing significant threats to human life, the environment, and economic stability. Given these challenges, there is growing interest in the use of advanced technologies, particularly artificial intelligence (AI), to enhance maritime safety and risk management. Navigation systems can improve the work of the navigation officer by providing integrated data to aid decision-making, thus making artificial intelligence important in ship energy management and fuel consumption reduction, thereby reducing harmful emissions.

There is a wide range of applications for artificial intelligence in maritime transport systems, such as:

Navigation Systems – Artificial Intelligence algorithms assist in navigation decision-making to avoid collisions and improve the accuracy of a ship's position, thereby increasing navigation safety.

Hazardous Materials Handling – Artificial Intelligence-based tools that provide information on the rules for separating and isolating hazardous cargo eliminate the possibility of human error, thus preventing the risk of explosions, fires, and marine pollution.

Risk Analysis and Management – Artificial intelligence algorithms enable risk management on ships during shipping operations, mooring operations, technical inspections, routine operations, and repairs in shipyards.

Crew Resource Management – Tools that support the smooth operation of work schedules at sea and in port, as well as maintenance work on board, while ensuring compliance with crew rest time requirements in relation to working hours.

Preventive Maintenance— Managing, monitoring, and performing repair and maintenance tasks requires proper time management and scheduling in accordance with the ship's operating conditions. Artificial intelligence algorithms that analyze historical inspection and maintenance data improve the planning and management of upcoming inspections, eliminating the possibility of missing necessary repairs and periodic maintenance.

Energy Efficiency—Artificial intelligence that supports route planning between ports and controls the use of the main engine and revolutions per minute significantly reduces fuel costs and protects the marine environment by reducing exhaust emissions. Sustainable energy consumption should not be limited to the ship while it is at sea, but must also be considered during its stay in port. The application of machine learning, as a key sub-sector of artificial intelligence, can be considered a component of the digital transformation process that aims to promote green practices in the supply chain of seaports. In the field of environmental sustainability, emissions and energy consumption are the most frequently studied issues.

Navigation Systems with Artificial Intelligence Enhancement

Artificial intelligence algorithms are vital for optimizing shipping routes, significantly enhancing both safety and efficiency in maritime operations. These algorithms process extensive data sets, including real-time weather phenomena, ocean currents, ship movements, and historical shipping routes to determine the most efficient and safest routes for ships. By continuously updating and recalculating routes based on the latest data, artificial intelligence ensures that ships can avoid hazardous conditions such as bad weather, high-traffic areas, and navigational obstacles. In addition, AI route optimization minimizes fuel consumption by selecting the most efficient routes, thereby reducing operating costs and mitigating environmental impact. This capability not only enhances the profitability of maritime operations, but also aligns with global efforts to reduce greenhouse gas emissions and promote sustainable shipping practices.

Artificial intelligence systems use a variety of technologies and processes to optimize shipping routes. Data collection is the first step, involving sensors and other sources that gather real-time information on weather conditions, ocean currents, and ship locations. This data is then processed by machine learning algorithms, which analyze it to identify patterns and predict future conditions. The artificial intelligence system evaluates multiple possible routes, considering factors such as distance, fuel consumption, and safety risks. It then ranks these routes based on efficiency and safety criteria, providing recommendations to the ship's navigation team.

Artificial intelligence systems are essential for detecting and avoiding collisions in real time, significantly improving navigation safety. These systems integrate data from radar, Automatic Identification Systems (AIS), and other advanced sensors to maintain a comprehensive and up-to-date awareness of the vessel's environment. Sophisticated machine learning algorithms analyze this data to identify potential collision risks with other vessels or obstacles. Once a potential collision is identified, the artificial intelligence system provides immediate alerts and suggests avoidance maneuvers to the crew. This capability is particularly critical in busy waterways and during complex maneuvers in ports. By enabling timely and informed decision-making, AI-based collision avoidance systems help prevent accidents, ensuring the safety of the ship, its crew, and its cargo.

Artificial intelligence technology is also crucial for monitoring and responding to environmental conditions that affect navigation. These systems collect data on various environmental factors, including weather conditions, sea state, visibility, and tidal movements, all of which can significantly affect a ship's route and operational safety. Artificial intelligence algorithms analyze this data to predict adverse environmental conditions and recommend necessary adjustments to the ship's course or speed. For example, if severe weather is forecast along the planned route, the artificial intelligence system may suggest alternative routes to avoid the storm. This proactive approach allows ships to navigate safely in difficult conditions, reducing the risk of weather-related accidents and ensuring timely arrival.

General Rules

Team Definition and Age Categories:

1. A team consists of 2 or 3 students.
2. A team is led by a coach.
3. A team with one member and one coach is not considered a team and cannot participate.
4. A team can only participate in one of the beginner or advanced categories.
5. Each student can only participate in one team.
6. The minimum age for coaches is 18 years.
7. Coaches can work with more than one team.
8. The age groups in the beginner's category are:
    - Students aged 8-16 (In the 2026 season: Born Between 2010-2018)
9. The maximum age reflects the age of the participant in the calendar year of the race, not his/her age on the day of the race.

Permitted Materials

- Teams are free to use any microcontroller they wish, without any restrictions whatsoever. The choice of motors and sensors also remains open. Each team may use only one microcontroller <u>and up to four motors</u>. There is no restriction on the number of sensors.
- Teams may use any material (e.g., wood, aluminum, paper, glue, Lego bricks, 3D prints) as structural elements for the construction of the robot.
- Any software and firmware may be used to program the robots.
- Teams must be equipped with the necessary software for programming their constructions. The program must be loaded onto the robot before the start of the competition.
- Teams should bring all the necessary materials for assembling the robot, as well as any additional materials they may need.

Instructions for teams

- All teams must proceed to the location indicated to them upon registration, get organized, and wait for the announcement of the start of the practice/trial period.
- Coaches are prohibited from entering the playing field and testing area throughout the competition, as well as any communication between teams and persons outside the playing field without the permission and supervision of the judges.
- The Bluetooth and Wi-Fi functions of the microcontrollers and laptops of the teams must be disabled throughout the competition rounds.
- Teams will enter the competition with robots assembled in advance.
- The maximum permissible size of the robot is 25x25x25 cm at the start of the test, not including motor/sensor connection cables. During the test, there is no restriction on the

size of the robot, provided that its projection is within the finish square after it has come to a standstill (not including motor/sensor connection cables) if requested.

- Before each race round begins, teams will be given time to test on the track. Teams form a priority order for their tests. During testing:
    - Members of the same team are not allowed to hold different positions in the priority order. In order to have a place in the priority order, a team member must hold their team's robot.
    - Teams are not allowed to bring their laptops or tablets onto the track during testing. Any changes to their program must be made at their table before bringing the robot for testing.
    - Teams are not allowed to bring their own tracks to the competition venue.
    - Teams must calibrate their robots during testing and only then.
- Before the testing time ends, teams must place their robots in quarantine. A robot that is not delivered on time cannot participate in the corresponding round. The robot must have only one executable program (including subprograms belonging to a main program). Judges must be able to clearly identify the executable program on the robot. Teams inform the judges of the name of their program during quarantine. The name will be written in the robot's storage area in quarantine, and only this program can be executed by the team. If there is no program in the robot, the team cannot participate in that round of the competition and is disqualified for that attempt.
- Once the testing time is over, the judges prepare the track for the next round of competition and the robot inspection time begins. Teams hand over their robots to the judges for dimensional inspection. If the robot is larger than the permitted size, five minutes are given to correct the dimensions. If conversion is not possible, the robot cannot compete and is disqualified for that round.
- The robot must be placed in the starting area so that its vertical projection is entirely within the starting area, with the orientation desired by the competitors. The test time begins when the judge gives the appropriate signal. It is not permitted to transfer data to the program by rotating parts of the robot, changing the robot's starting position, or by any other means. If such adjustments are recognized by the judge, the team will be asked to explain the strategy followed by its algorithm.
- Competitors must wait for the judge's signal to start the robot.
    - If starting a program immediately sets the robot in motion, the team must wait for the judge's signal before starting the program.
    - If starting a program does not immediately set the robot in motion, the team is allowed to start the program before the start signal. After the judge's start signal, the robot may be set in motion by pressing the central button on the controller. No other buttons or sensors may be used to start the robot. In any case, the button

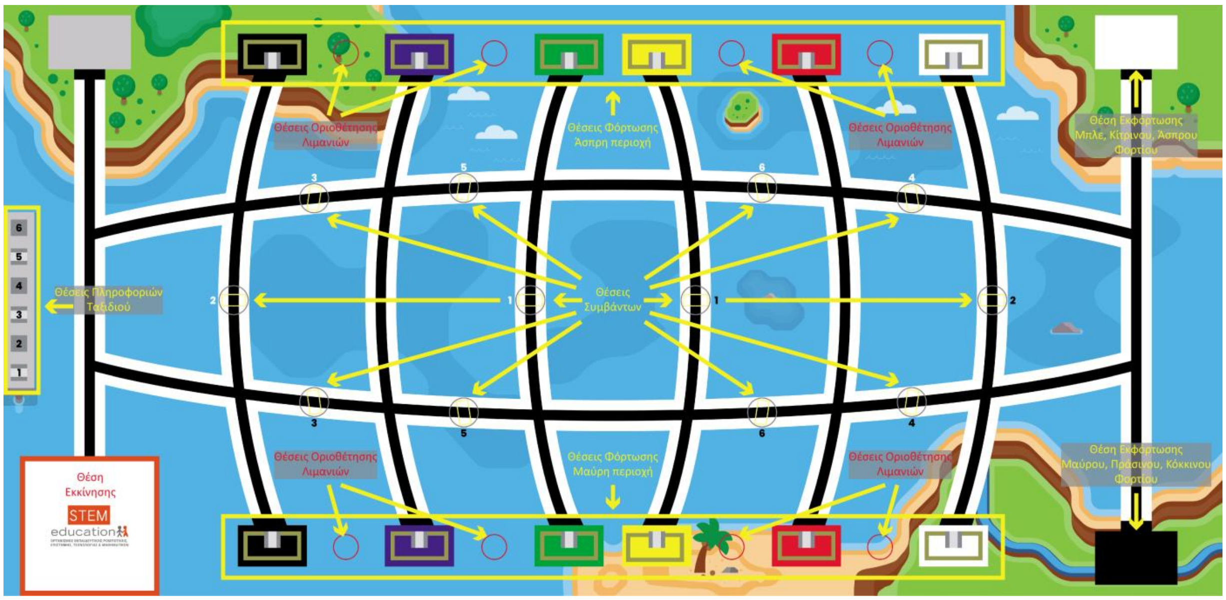
that sets the robot in motion must be specified and known to the judges before the start of the competition round.

- Team members are not allowed to touch the challenge track or the robot during any competition round.
- The maximum time for the robot to complete each mission is set at 2 minutes.
- The robot may leave parts on the track that do not contain its main components (controller, motors, sensors). If such a piece touches the track or elements of the challenge and does not touch the robot, then it is not considered part of the robot.
- A robot's attempt ends when:
    - the time limit for solving the challenge (2 minutes) has expired. If, after the time limit has expired, the robot is still moving on the track, then the points it has collected after the 2 minutes will not be considered in the scoring.
    - any team member touches the robot or any object on the track during the execution of the program.
    - the robot has completely left the track.
    - the robot or team has violated rules or regulations.
    - a team member shouts "STOP" and the robot stops moving. If the robot is moving, the attempt ends when the robot stops on its own or is stopped by the team or the judge.

  The judge then records the score and time on the corresponding score sheet.
- The judge decides whether to cancel the attempt or to score part of it by deducting 2 minutes if:
    - Any team member touches the robot during the competition without the judge's permission.
    - There is a violation of the challenge rules.
    - A team completes an attempt without scoring a single point.
- The judges announce the score and time at the end of each round. A team member signs the score/time acceptance form. Once signed, no further complaints are possible.
- If there is any uncertainty about the scoring during the challenge, the judge makes the final decision, in consultation with the organizing committee, and announces it to the team. Coaches may only participate in this process if permitted by the organizing committee.

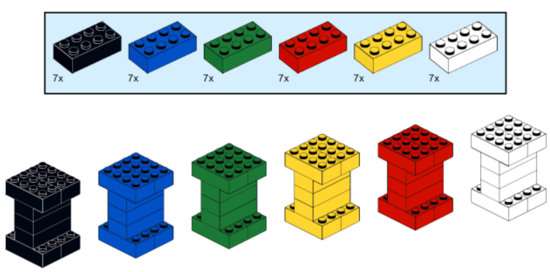
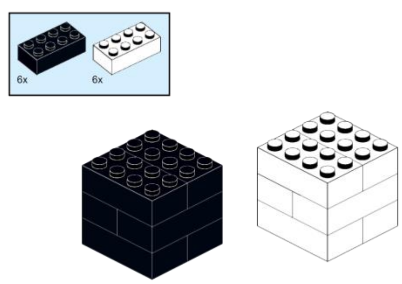
Game Track

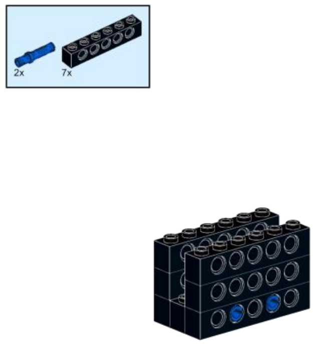
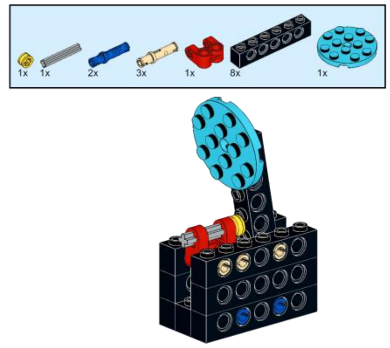
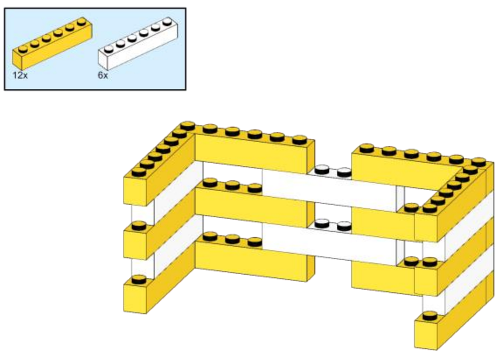
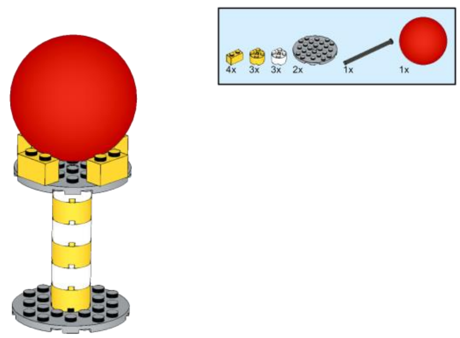
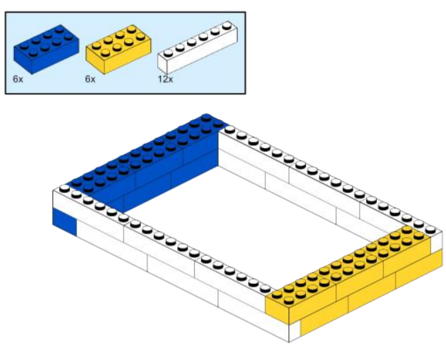
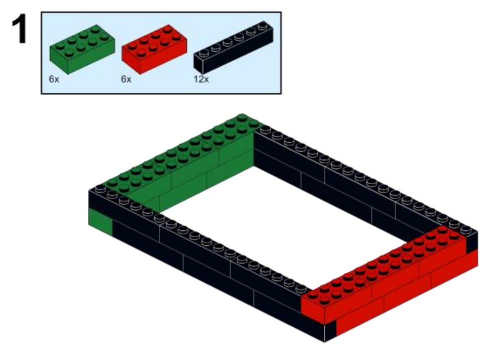
To facilitate the teams, the dimensions of the game track remain are (2362 mm x 1143 mm). The following figure shows the track layout and the areas that comprise it.



Track Objects

The following items are used in the game:

 Cargo (Black, Blue, Green, Yellow, Red, White, one of each)	 Travel Information Data (Three black και three white)

 Type 1 Obstacle	 Type 2 Obstacle
 Port Fencing	 Port Boundary Lighthouse
 Fencing of unloading area (White)	 Fencing of unloading area (Black)

Game Description

The teams' mission is to build and program autonomous robots that can simulate commercial ships and navigate safely on our planet's sea routes, performing various missions using human and artificial intelligence in such a way as to promote sustainable shipping practices as much as possible.

At the start, the robot must be entirely within the starting area (25cm x 25cm). Cables may protrude.

The missions that the robot must perform on the track are described in detail below:

Beginners

The robot must transport the load of the corresponding color from each loading position (Port) and place it upright in the unloading position corresponding to its color and within that area (no unloading area fence is placed). The load is initially placed either in the white loading area or in the black one, depending on the draw, in the port corresponding to its color and is surrounded by the port fence. The fence must not be moved outside the colored frame that defines the port boundaries.

In the beginners' mission, the green and yellow ports are blocked by an event and no cargo will be transported. At the two event locations marked with the number 1, there are type 1 obstacles that must not be moved.

Travel Information Locations

Three white and three black cubes (travel information data) are placed in the six numbered boxes after a draw. This data informs the robot of the areas where the cargo is located, whether there is an event at positions 3 or 4, as follows:

- Position 1: The cargo at the black port in the white or black area if the data drawn is white or black.
- Position 2: The cargo in the blue port in the white or black area if the data drawn is white or black.
- Position 3: A type 1 obstacle is placed at event position 3 white or black if the data drawn is white or black.
- Position 4: A type 1 obstacle is placed at event position 4 white or black if the data drawn is white or black. Position 5: The cargo is placed in the red port in the white or black area if the data drawn is white or black.
- Position 6: The cargo in the white port in the white or black area if the data drawn is white or black.

The image below shows an example of a draw and initial placement of loads and obstacles.

Beginners' Scoring Table

Teams will be scored according to the table below. In addition, surprise rule points will be added on the day of the finals.

Beginners' Score	**Points**	**Total Points**
The cargos (4) have been moved to and within the respective unloading areas. The cargos (4) have been moved to any unloading area or partially within it.	25 10	100
The port fence (4) is located within the port color. (Fully) The port fence (4) is located within the port color. (Partially) (Points are only counted if the cargo is outside the port)	15 10	60
The obstacles (4) have not been moved from their position. (Points are only awarded if at least one load has been moved completely or partially).	10	40
Maximum Score for Beginners		**200**

Beginners' Teams Ranking

The ranking order of the teams is defined as follows:

- Best effort points
- Second best effort points
- Third best effort points
- If there is still a tie after the above three criteria, the teams are ranked in the same position.