AUTONOMOUS PROGRAMMING COMPETITION RULES

OVERVIEW AND OBJECTIVES

- The Autonomous Programming Competition, developed in partnership with Southwest Research Institute (SwRI), is part of the Shell Eco-marathon 2021 Virtual League. Participation in the challenge will contribute to a Team's scoring in the Virtual League as defined in Section 6 of the Shell Eco-marathon 2021 Global Rules, Chapter I.

- The Autonomous Programming Competition is designed to give Shell Eco-marathon Teams the opportunity to apply science, technology, engineering and math (STEM) skills, especially computer programming; to offer them a lower entry-barrier in terms of financial costs; and to challenge them to solve industry-relevant challenges utilising cutting-edge technology.

- The objective of this competition is for Teams to develop path planning, perception, and control algorithms for an autonomous vehicle using the Robot Operating System (ROS). The code will then be tested in a simulated environment using Microsoft AirSim with the Unreal Engine. The Team with the most efficient path planning according to the ranking criteria detailed in this document will be awarded the winner of the competition.

- The Competition is governed by both the Shell Eco-marathon 2021 Global Rules, Chapter I and these Autonomous Programming Competition Rules, together called the "Competition Rules". Where terms have already been defined in the Shell Eco-marathon 2021 Global Rules, Chapter I, the same shall apply for these rules and can be found in the Global Rules link.

- By fact of their entry, Participants accept all provisions these Competition Rules and agree to abide by all decisions made by the Organisers. The Organisers reserve the right to add, modify or delete any Article of the Competition Rules.

- All decisions made by the Organisers are final and binding.

ACCEPTANCE

- All Shell Eco-marathon 2021 Teams registered and accepted into the Autonomous Programming Competition can enter this competition.

- If two Teams from the same Educational Institution are participating in the Autonomous Programming Competition, their code submissions are required to be distinctly different. Reuse of code between the Teams can be grounds for disqualification.

COMPETITION

Objective

At the start of the competition, details will be announced on the Autonomous Programming Competition website including the maximum simulation time, coordinates of the starting point and total number and coordinates of the available goal points (see sample image below). The vehicle must pass within 3 meters of each published goal point and can pass them in no particular order, leaving it up to the Team to figure out how to efficiently reach as many goal points as possible in a limited amount of time.

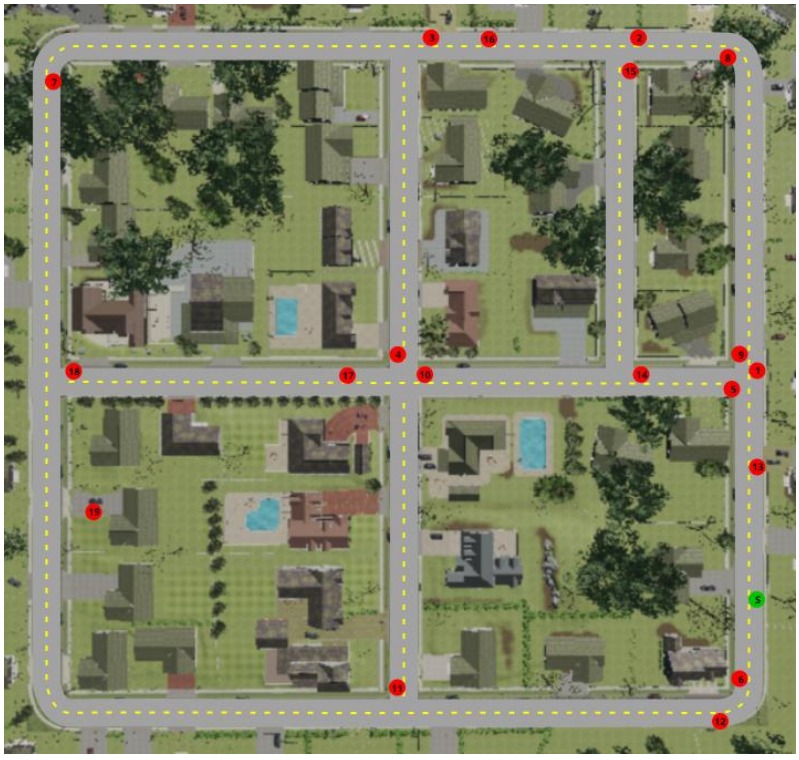

Figure 1. Example of Track layout with Starting Point (green) and available Goal Points (red)

Preparation

Prior to the start of the competition on January 11, 2021, the Team managers from all participating Teams will receive an invitation to set up their account on the Autonomous Programming Competition website, where they will be able to invite other Team members to their Team.

When logged in, the Team will be able to download an example project in the form of Robot Operating System (ROS) packages, containing source code for ROS nodes, build instructions and general package information, which is meant to demonstrate the process for testing, submitting and getting results for Shell Eco-marathon simulation projects.

The Team can modify and improve the example ROS stack to perform in the real-world simulation environment within Microsoft AirSim, provided by SwRI. This modification involves the development of path planning, perception, and control algorithms.

How to Participate

When the Team's code is ready to be submitted for simulation, they can upload their code on the Competition website. The uploaded submissions will be queued and processed in order of uploading. The following conditions apply:

- Every Team will have a maximum of 15 attempts (uploaded) in total, with a maximum of one (1) attempt per day, measured by time of upload[1].
- Teams have the responsibility to ensure that their code will compile before they upload it. If a submission does not compile, it will still count to the total number of attempts.
- As long as a submission is queued (awaiting compilation/simulation), Teams will have the ability to cancel that submission, ensuring it will not count to their maximum attempts.
- The attempt will end when all goals are passed, or when the maximum simulation time has passed.
- After the attempt has completed, the Team will be able to evaluate their performance by downloading the resulting ROS Bag to play back the simulation on their own computer (this play back does not require AirSim, only a ROS installation).
- If the resulting score of the attempt is higher than the Team's previous attempts, the score will be reflected on the leader board.

On the final day of competition, the leader board will be taken offline while Teams can still submit their final attempt. On this last day, the time of uploading is what counts; submissions queued before the cut-off time will still be run.

The official final result will be announced once all attempts are validated by the Southwest Research Institute technical team.

[1] Days end at 23:59 Greenwich Mean Time (GMT).

Teams are strongly encouraged to consider all intellectual property developed by them in conjunction with the Shell Eco-marathon programme as valuable assets and seek professional advice about its protections through patents or trademarks before uploading and publishing.

COMPETITION SCORING

As the traditional Shell Eco-marathon Mileage Challenge encourages students to solve engineering challenges by building energy-efficient vehicles, the autonomous competition will encourage the development of energy-efficient autonomy algorithms. The scoring criteria emphasizes maximum efficiency path planning, while conserving energy through the driving strategy and how the algorithms are implemented.

Each Team will be ranked first by the number of goals completed (where a high number is better), and second by the accumulated points earned for their efficiency (where a low number is better) in the categories of energy usage, distance, CPU usage and time.

The efficiency points are calculated by comparing the performances of all Teams in each of the categories, and summing the ranking position achieved by a Team for each category.
Example: if among all competitors a Team ranks 1st place in energy usage, 3rd place in distance travelled, 2nd in CPU usage and 3rd in time, it will receive 1 + 3 + 2 + 3 = 9 efficiency points.

The Team with the most goals and the lowest accumulated points in the efficiency categories, wins. In the example matrix below, **Team A** would be the theoretical winner as they passed the most goals, while having a better efficiency than Team B with the same amount of goals.

CRITERIA	POINTS
Goals	Absolute number of goals completed *a higher number is better*
Efficiency ▪ Energy Usage ▪ Distance ▪ CPU Usage ▪ Time	Sum of ranking per efficiency category *a lower number is better*

Example leader board matrix:

OVERALL RANK	TEAM	GOALS	ACCUMULATED EFFICIENCY	ENERGY USAGE RANK	DISTANCE RANK	CPU USAGE RANK	TIME RANK
1	Team A	8	9	2	2	4	1
2	Team B	8	11	4	3	2	2
3	Team C	7	13	3	4	3	3
4	Team D	5	7	1	1	1	4

- **Energy Usage** refers to the amount of energy used by the vehicle to complete the challenge. This score will consider factors such as the vehicle speed, how quickly the vehicle accelerates, and other manoeuvres. The Team that uses the least amount of energy to complete an objective will receive the best score.
- **Distance** refers to how far the vehicle travelled during the challenge. Traveling shorter distances will earn the Team a better score. This encourages both efficient path planning and precision in controlling the vehicle.
- **CPU Usage** refers to how much processing power was used to solve the challenge. Using less CPU will earn the Team a better score. This encourages Teams to write efficient code and develop algorithms that solve problems in the most energy-efficient manner.
- **Time** refers to how long the vehicle takes to complete the challenge during the simulation. This is a practical consideration for real-world vehicles, where passengers want to arrive at their destination quickly.

When a Team submits multiple attempts, only their highest scoring attempt will be considered for ranking, meaning if a Team submits a later attempt which scores lower, this will not affect their overall ranking.

Ties will be broken by order of code submission date, meaning the Team that submitted their code first will win the tie.

SUPPORT FOR TEAMS

The Autonomous Programming Competition website contains a Questions and Answers Forum which is monitored by the Southwest Research Institute technical team. Teams should use this forum to raise their questions, and not seek individual guidance via e-mail with the Organisers.

THE PRIZES

There will be one global winner for the Autonomous Programming Competition.

The following prizes and Virtual League points will be awarded to the Teams in first (1st) through third (3rd) place.

Autonomous Programming Competition	
Global Winner	$1,500 and 150 Virtual League Points
Global Runner-up	$1,000 and 100 Virtual League Points
Global Third Place	$500 and 50 Virtual League Points

No substitution or transfer of prizes to other Teams or other Participants is allowed. The Organiser reserves the right to award alternate prizes in the event a prize is unavailable, or that extenuating circumstances, as determined by the Organiser, prevent fulfilment of the prizes.

WINNERS ANNOUCEMENT

The winners of the Autonomous Programming Competition will be announced after the results have been verified.

The winning Team may be contacted ahead of the final announcement and asked to create audio visual content for use on the Shell Eco-marathon social media channels and on the website makethefuture.shell.

KEY TIMINGS

- Launch of competition: January 11, 2021
- Code submissions: January 11 – February 19, 2021
- Winners announcement: March 2021 (exact date to be confirmed)

Any of these dates may be subject to change according to the Organiser's discretion and will be announced on the Shell Eco-marathon website and social channels.