FIRA Challenge - Autonomous Cars

Laws of the Game (Pro)

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Abstract

The focus of the FIRA Autonomous Cars competition is to encourage researchers to develop self-driving cars. In FIRA Autonomous Cars, two environments are designed for cars to compete against each other. The first environment is a racing circuit, and the second one is an urban environment. Each environment has its own score, and the total score of competitors will be the sum of both scores.

1. Introduction

The FIRA Autonomous Cars Physical Competition (FAC) is an exciting initiative that provides an opportunity for students to gain hands-on experience in the field of autonomous driving. The league challenges participants to design and build 1:10-scale autonomous cars that can navigate through a scaled-down environment, perform various tasks, and compete against each other.

The FAC competition is designed to encourage students to apply their knowledge of robotics, control systems, and computer vision to the real-world problem of autonomous driving. Participants must develop algorithms and software to enable their vehicles to perform tasks such as lane-keeping and obstacle avoidance.
The FAC competition is not just about building and programming autonomous cars. It also provides an opportunity for students to develop their teamwork, communication, and problem-solving skills. Participants must work together to design and build their vehicles, debug their code, and optimize their algorithms to achieve the best possible performance.

1.1. Tasks

Teams must build a cost-efficient 1:10 scale electrically powered autonomous car that is able to drive in the defined scenarios.

1.2. General FIRA Regulations

For general Regulations relevant to all FIRA events (e.g., playing field, lighting, and responsibility of the referees), please refer to General - FIRA Laws of the Game.

1.3. Latest version of the rules

These rules may be changed by the technical committee at any time before the competition. Teams have to check these rules regularly to make sure they know about any changes made. The latest version of the official FIRA Autonomous Cars rules is always available using this link.
There is also a rules book available for this league and the other leagues in FIRA RoboWorld Cup and Summit 2025, and the latest version can be accessed from here.
Last modified: June 18, 2025 (v2.0.1)

1.4. Team Description Paper (TDP) and Video

Each team has to submit:

1. Team description paper (TDP).
2. Video from the performance of the car

You can find the **TDP** template inside the FIRA website (the preferred format is Springer LNCS format). The **TDP** should contain information about both hardware and software used in the car.

2. Vehicle Build Limitations and Constraints

2.1. General Requirements

2.1.1. The vehicle must be a 1:10 scale electrically powered car (Figure 1)

2.1.2. Fuel-based vehicles are strictly prohibited

2.1.3. The vehicle must have at least one steering axle

2.1.4. Non-compliance with any constraints will result in disqualification

2.1.5. Each team can only use one car or platform

2.1.6. While it is illegal to change the platform, it is permissible to modify the car components for repair

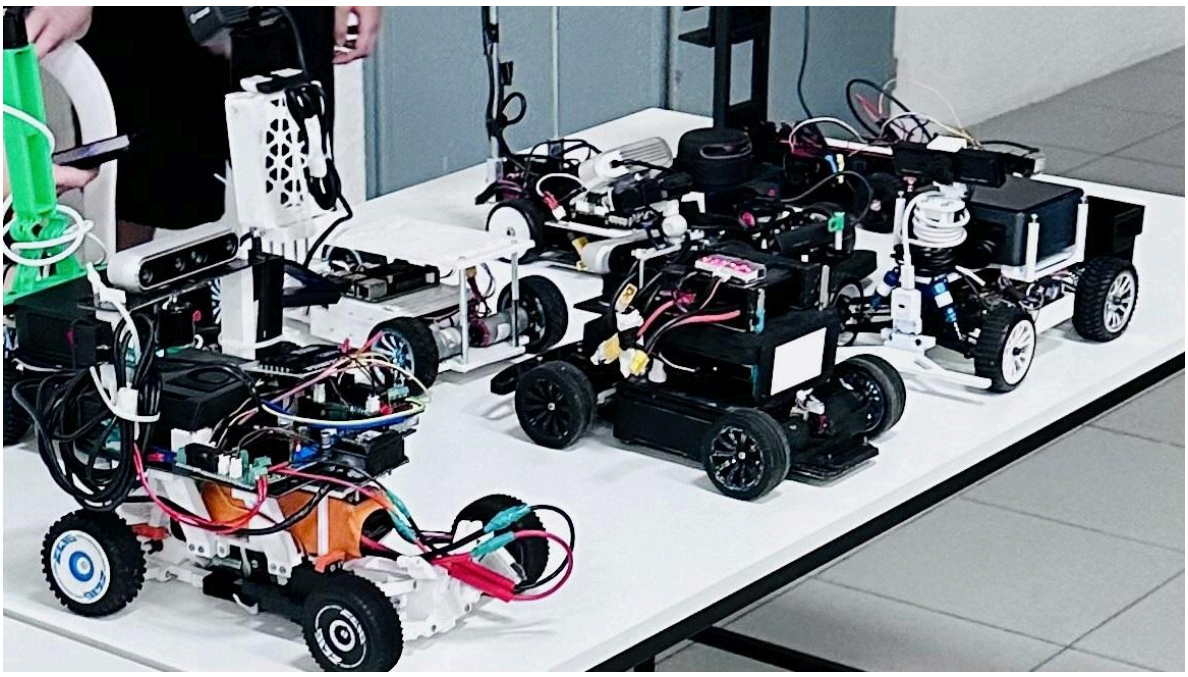


Figure 1: Example of a 1:10 scale autonomous car for the FIRA competition.

2.2. Power System

2.2.1. Must be electrically powered.

2.2.2. No limitation on the number of batteries.

2.2.3. No limitation on the capacity of the batteries.

2.3. Drivetrain

2.3.1. Both 4-wheel drive (4WD) and 2-wheel drive (2WD) configurations are permitted
2.3.2. Force vector systems are allowed, as long as they replicate the differential system

2.4. Steering System

2.4.1. Must implement an Ackermann steering system
2.4.2. At least a single-axle steering is required
2.4.3. Two-axle steering systems are permitted

2.5. Dimensions

The physical dimensions of the vehicle must comply with the specifications listed in the table. These dimensions are crucial for ensuring the vehicle can navigate through the competition course and maintain proper maneuverability.

Dimension	Minimum	Maximum
Track Width	150mm	350mm
Wheel Base	200mm	550mm
Height	-	450mm
Width	-	400mm
Length	-	600mm

2.6. Dimension Definitions

2.6.1. **Track Width (150mm to 350mm):** The distance between the centers of the left and right wheels on the same axle, measured perpendicular to the direction of travel. A wider track width provides better stability and handling.

2.6.2. **Wheel Base (200mm to 550mm):** The distance between the centers of the front and rear axles, measured along the longitudinal axis of the vehicle. A longer wheelbase typically provides better stability and ride comfort.

2.6.3. **Maximum Height (450mm):** The maximum allowed height of the vehicle from the ground to its highest point, measured vertically from the ground plane.

2.6.4. **Maximum Width (400mm):** The maximum allowed width of the vehicle, including all components and attachments.

2.6.5. **Maximum Length (600mm):** The maximum allowed length of the vehicle from front to rear, including all components and attachments.

2.7. Sensor Setup

2.7.1. Infrared line follower sensors are prohibited.

2.8. Wireless Communication Restrictions

2.8.1. The use of any wireless communication (e.g., Wi-Fi, Bluetooth, etc.) for controlling or communicating with the vehicle during the competition is strictly prohibited.

3. Competition Structure

1. **Preliminary Stage**: Teams must achieve a qualifying score to advance to the final stage
2. **Final Stage**: Scores from the preliminary stage are reset to zero

The order of participation in each stage is determined by a draw conducted one day before the competition. Teams not present during the draw will start first, followed by a separate draw for present teams.

4. Competition Challenges

The competition consists of two challenges, each with its own scoring model. The total score is the sum of scores from both categories:

1. **Autonomous Race:** Cars must complete one or more laps of a race track autonomously
2. **Autonomous Urban Driving**: Cars must navigate through an urban environment following road signs and markings

5. Autonomous Race Challenge

5.1. Track Specifications

The color of markings will be selected according to the color of the arena floor, thus, teams should be able to work with both colors. The checkpoints are shown in green, and the start/finish line is shown in red. Checkpoints do not necessarily have any markings, and the picture is just for demonstration. The start/finish line will be marked using a different color than road markings, but not necessarily red.

5.1.1. Track width: 50cm ± 10%
5.1.2. Track width is not necessarily consistent and equal along the track
5.1.3. Minimum turn radius: 1.5m ± 10% (outer turning radius)
5.1.4. Track markings:
   a. Two continuous sidelines (white or black)
   b. One dashed lane marking (same color as sidelines)
   c. Marking width: minimum 1cm
   d. Space between dashed lines: minimum 5cm

5.1.5. Checkpoints are placed throughout the track
5.1.6. Start/finish line marked in a different color than road markings

5.2. Rules

5.2.1. Each team has a specific time limit, which the organizers will determine
5.2.2. The maximum score from the runs is considered the final score
5.2.3. Cars must cross all checkpoints while navigating
5.2.4. Missing a checkpoint results in a penalty
5.2.5. Hitting any obstacle (inside or outside the track) ends the current run
5.2.6. Obstacles may be placed on the track depending on the stage

5.3. Autonomous Race Penalties

5.3.1. Autonomous Race Driving Penalties Table

Penalty Type	Penalty Time
Skipped Checkpoint	$+ \ 0.5 \ * \ \frac{T_{stage}}{Number\ of\ all\ checkpoints}$ (s)
Parts Fell	$+ \ 0.2 \ * \ \frac{T_{stage}}{Number\ of\ all\ checkpoints}$ (s)

5.4. Autonomous Race Scoring

The race score is calculated based on completion time and penalties:

5.4.1. Race Score Formula

$$S_{AR} = 100 \ * \ (1 \ - \ \frac{T_{total}}{T_{Stage}}) \ * \ (\frac{cp}{Total\ Checkpoints}) \ - \ P$$

$$\text{(old method) } S_{AR} = (1 + \max\{\frac{T_{stage} - T_{total}}{T_{stage}}, 0\}) * 35 * cp$$

Where:

- T_stage: Time allocated for the stage
- T_total: Total time taken (including penalties)
- cp: Number of checkpoints passed
- Total checkpoints: The Total number of checkpoints in the course

6. Autonomous Urban Driving Challenge

For this part of the competition, cars have to navigate autonomously through an urban environment. Cars will start from a starting point and have to navigate through streets using street signs, lane markings, zebra crossings, and other information available to be used by vision sensors. There are checkpoints inside the streets, and each checkpoint has specific points. Every incorrect decision made by the car will result in a penalty, which is discussed in detail in the score section.
During this part of the competition, each team has a specific amount of time, and during this time. The maximum score of each run will be considered as the score of this part.

6.1. Track Specifications

6.1.1. Track width: 60cm ± 10%
6.1.2. Street signs with April Tag markers **(36h11 family)**
6.1.3. Marker size: 8cm x 8cm - 10cm x 10cm
6.1.4. One checkpoint between every two junctions
6.1.5. Streets marked with one-way indicators
6.1.6. Zebra crossings at junctions with stop lines

6.2. Rules

6.2.1. Each team has a specific time limit, which is determined by the organizers
6.2.2. The maximum score from the attempts is considered the final score
6.2.3. Incorrect decisions result in penalties
6.2.4. Lane changes are permitted on one-way streets
6.2.5. Hitting any obstacle ends the current run

Cars must:

6.2.6. Start from the designated starting point

6.2.6. Navigate using street signs, lane markings, and zebra crossings

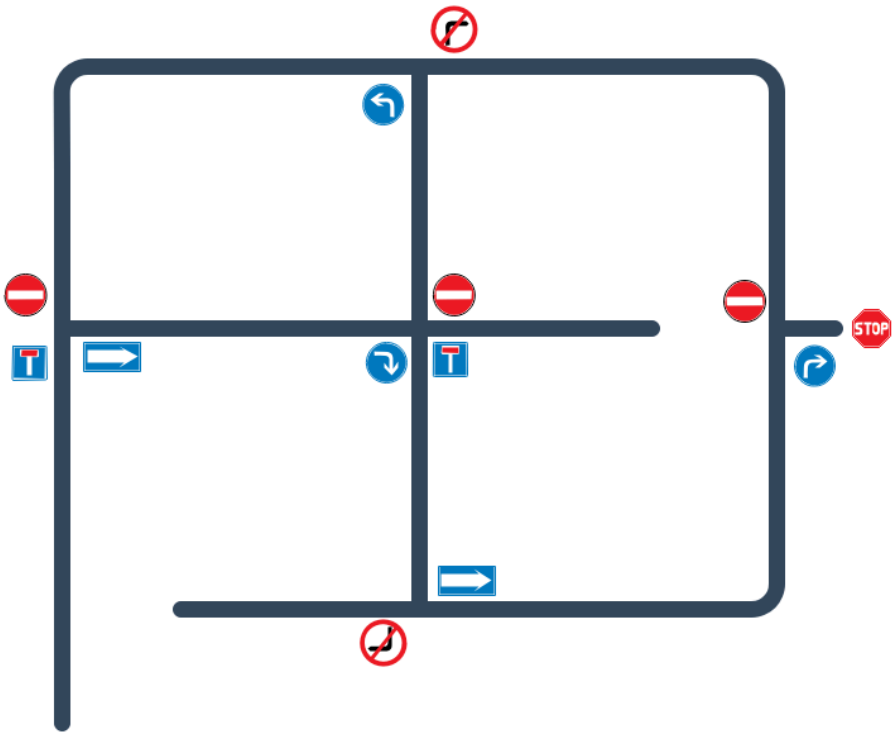
6.2.7. Follow correct lanes

6.2.8. Be on the right lane when passing checkpoints

6.2.9. Stop at designated stop signs

6.2.10. Stop for at least 3 seconds before zebra crossings at junctions

6.2.11. Stop before the stop line (1cm before zebra crossings)



6.3. Navigation Signs

The following street signs must be recognized and followed by the autonomous vehicles:

Sign Name	Sign Picture	Sign Marker	Car Decision
No Entry			Should not enter the street that has this sign at the beginning of it.
Dead End			Should not enter the street that has this sign at the beginning of it.
Proceed Right			Should choose the road on the right of the junction.
Proceed Left			Should choose the road on the left of the junction.
Proceed Forward			Should proceed forward.
Stop			Should stop (this is the destination).
Tunnel			

Sign Name	Sign Picture	Sign Marker	Car Decision
Bridge			

6.4. Sign Recognition Method

Teams can choose between sign recognition methods, with corresponding coefficients:

Recognition Method	Coefficient (Ks)
April Tags	1.0
Visual Sign Recognition	1.3

6.5. Autonomous Urban Driving Penalties

6.5.1. Autonomous Urban Driving Penalties Table

Penalty Type	Points Deducted
No Stop at Junction	-15
Incorrect Turn Decision	-25
Incorrect Lane Change	-20

6.6. Urban Driving Scoring

The urban driving score is calculated based on checkpoints reached, penalties, and time taken.

$$S_{AR} = (100 * (1 - \frac{T_{total}}{T_{Stage}}) * (\frac{cp}{Total\ Checkpoints}) - P) * Ks$$

Where:

T_{stage}: Time allocated for the stage

T_{total}: Total time taken

cp: Number of checkpoints passed

Total checkpoints: The Total number of checkpoints in the course
P: Sum of all penalties
Ks: Detection Coefficient

7. Level of Autonomy

7.0.1. The final score is multiplied by a coefficient based on the level of autonomy.

Level of Autonomy	Coefficient (Ka)
Offboard Processing	0.5
Onboard Processing	1.0

8. Overall Scoring

8.0.1. The total score for each team is considered as follows

$$S_T = (S_{AR} + S_{AUD}) \ * \ Ka \qquad (\#)$$

9. Sample Track

An example of a track map is available at this link.

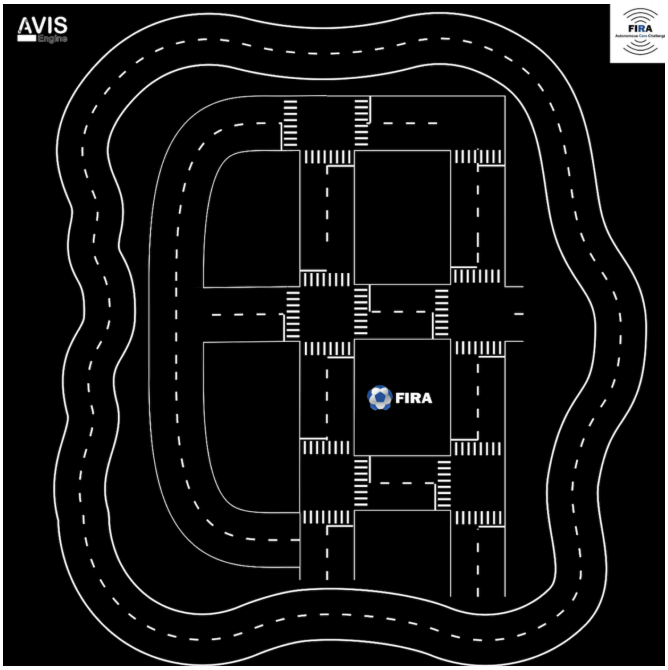


Figure 2: Sample urban track layout showing intersections, one-way streets, and checkpoint placements. The track includes various road types and traffic scenarios.

10. Test Times and Criteria

10.1. Test Day

10.1.1. The test day is open for all teams to test their vehicles
10.1.2. Teams can test on both race and urban tracks
10.1.3. No scoring is performed during the test day
10.1.4. Teams must follow all safety protocols during testing
10.1.5. Teams are responsible for their time management
10.1.6. Track availability is on a first-come, first-served basis
10.1.7. Teams should be considerate of others and limit their testing time
10.1.8. Competition props (signs, obstacles, etc.) must be shared among teams

Teams should:

10.1.9. Return props to their original positions after use
10.1.10. Do not damage or modify any competition props
10.1.11. Allow other teams to use props when not in use
10.1.12. Report any damaged props to the organizers

10.2. Competition Attempts

10.2.1. Each team gets 3 attempts for each track (race and urban)
10.2.2. Each attempt has a 5-minute time limit
10.2.3. Teams must be ready at the starting area 5 minutes before their attempt
10.2.4. If a team is not ready when called, they will lose their attempt
10.2.5. Between attempts, teams have a 10-minute preparation time
10.2.6. Major modifications or repairs are not allowed between attempts
10.2.7. The best score from the 3 attempts will be considered for each track

Teams can use this time to:

10.2.8. Make minor adjustments to their vehicle
10.2.9. Calibrate sensors
10.2.10. Review their strategy
10.2.11. Perform basic maintenance

10.3. Time Management

1. The 5-minute attempt time includes:
    a. Vehicle placement at the start position
    b. System initialization
    c. Actual run time
    d. Vehicle recovery, if needed

2. Teams must stop their vehicle if the 5-minute limit is reached
3. The attempt will be considered complete if:
    a. The time limit has been reached
    b. The vehicle completes the track
    c. The vehicle hits an obstacle
    d. The team leader calls "STOP"
    e. The vehicle leaves the track boundaries

11. Important Notes

11.0.1. The finish line counts as a checkpoint

11.0.2. The car must be completely inside the road and in the correct lane when passing checkpoints

11.0.3. Scores cannot be negative

11.0.4. Hitting obstacles or leaving the road ends the run

11.0.5. The team leader can call "STOP" to end the run

11.0.6. Touching the car without calling "STOP" resets the run with no score

Changelog

- [2.0.1 Update - June 18, 2025]
    - Changed the minimum wheelbase dimension from 300mm to 220mm.

- [2.0.2 Update - July 12, 2025]
    - Changed the minimum wheelbase dimension from 220mm to 200mm.
    - Rule 2.6.2 was altered accordingly.