# F1TENTH Rules

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# 1. General

International F1TENTH Autonomous Racing Competition is a racing competition open to teams of all levels. Competing teams may consist of any number of members; however, each participant should be a member of only one team.

This competition will be held in-person competition.

Teams can register for the competition using a registration form.

# 2. In-person (physical) competition

- a. The competition will comprise three parts *Inspection*, *Time Trials* and *2 Vehicle Head-to-Head* race. Every participant must pass qualification and will be automatically registered to both races.
- b. Teams registered to the in-person competition need to provide and build a F1TENTH car by themselves according to the constraints listed below. In

addition, each team must have a unique vehicle (i.e., a research lab may not field six teams with one car).

c. To increase the quality of the future F1TENTH competitions, the winner of each race is encouraged to publish the code of their algorithm under an open-source license in the F1TENTH repository on Github.

# 2.1 Vehicle classes

- a. Vehicle Class allows only cars that meet the following constraints:
  - The vehicle is constructed according to the official <u>bill of materials</u>. The teams are allowed to use components of similar or lower specifications.
  - ii. Each vehicle will be inspected as a part of qualification whether it meets the criteria. In case the criteria are not met, the vehicle cannot participate.
  - iii. F1TENTH Competition is a battle of algorithms. Any hardware that should turn the odds in your favor is not allowed.
  - *Chassis*: Any chassis listed as 1:10 scale car is allowed.
     Preferably 1:10 Traxxas (e.g., TRA74054, TRA6804R, TRA68086), but generally, any chassis with similar dimensions is allowed. Both 4WD and 2WD are permitted.
  - Main Computation Unit: Nvidia Jetson Xavier NX & Nvidia Orin NX (AGX), Equivalents to the Nvidia Jetson NX & Nvidia Orin NX(AGX) (e.g. Nvidia Jetson TX2, Nvidia Jetson Nano), or anything of equal or lower GPU and CPU specification is allowed. Examples of possible computation units could be: Raspberry Pi, Arduino, Beaglebone.
  - vi. *LiDAR*: <u>Hokuyo UST-30LX</u>, its equivalent, or anything of lower specifications is allowed. The main observed characteristics are: detection range (30 m), scanning frequency (40 Hz), and angular resolution (0.25°).
  - vii. Camera: Both monocamera (e.g. Logitech C270, Logitech C920, Raspberry Pi Camera Module V2, Arducam) and stereokameras (e.g. Intel Realsense, ZED) are allowed.
  - viii. Engine: Only brushless DC motors are allowed. The Velineon 3500
     kV, its equivalent, or anything of lower specifications regarding power and torque are allowed.

# ix. Battery:

a) 4S Battery size: 4838145, capacity: 5000mAh, connection jack:
XT90, Battery recommended model link, Requires purchase of Li-Po extension cable
b) lithium polymer battery charger instructions:
-Multipurpose battery charger
-Requires Balance Charge support
-Requires charging safety device function
-Recommended model: IMAX B6
-Recommended purchase of charging cable (XT90)

# <u>image</u>

*Other sensors*: Other sensors (IMUs, encoders, custom electronic speed controllers) are not restricted. Indoor GPS sensors (e.g. Marvelmind) are not allowed. In addition, in the spirit of the competition, components with significant internal computation power are prohibited.

# 2.2 Track & racing environment

The competition will take place in the <u>Jeju Shinhwa World</u>. The characteristics of the environment where the track will be built are:

- a. The surface is flat and covered with rugs.
- b. The room is a segmented space that uses a gable wall for parts of the auditorium. Since there is no window on the wall, there is no external light coming in, and it is all composed of non-transparent materials.
- c. The track border is constructed from one air pipes of 50 cm diameters. They are made from polyester and metal, secured with cable tie and masking tape. Keep in mind that there can be a gap between the pipes through which the LiDAR beams can pass.
- d. The track will fit into the area of around the size of 25×10 m.
- e. We will allocate a **mapping** time slot for each team approximately for 3 to 5 minutes, depending on the scale of the competition.

# 2.3 Inspection

- a. The purpose of the Inspection is to check that the hardware of the autonomous cars meets the competition requirements and the cars are not dangerous for the environment, opponents, and people.
- b. The inspection of the vehicles is done on the first competition day.

- c. The inspection is done by the race referees.
- d. The inspection has to be completed before the Time Trials and after significant changes to the cars hardware or algorithms.

# 2.4 Qualification (Time Trial)

### 2.4.1 Definitions

- a. *Touching* means moving the object by less than 5 cm. Moving by greater distance is called *Crashing*.
- b. Moving the track border by any distance is called Crashing.

# 2.4.2 General

- a. Time Trial is a race with a goal to drive through the designated track as fast as possible. The idea is to push the algorithms to their limits.
- b. The race consists of two heats. Each heat lasts for 5 minutes, and the goal is to drive a single lap in as short time as possible and/or to drive as many complete laps as possible. Crashing and stopping the car does not pause the heat timer.
- c. Depending on the size of the competition, one opportunity can be given.
- d. The teams are allowed to change the configuration of their algorithms in between the heats, and even during the heat. When the configuration is changed during the heat, the car must stand still. In other words, the teams cannot update the configuration on-line while the car moves.
- e. The map (track layout) is **known** a priori and the track layout does not change over the whole competition. Keep in mind that cars crash into the walls and the layout of the track might slightly shift a little bit. Please consider this in your algorithms.
- f. The final score for the qualification is two parts: Firstly, based on the ranking of the fastest laptimes you receive points. E.g. with 10 teams the fastest team receives 10 points, second fastest 9 points, thrid fastest 8 points .... and so on. Secondly, based on the number of consecutive uninterrupted laps, a ranking of the teams is created and therefore the teams receive points. E.g. with 10 teams the team with the most laps receives 10 points, second team 9 points, thrid team 8 points .... and so on. The final score is the sum of both scores.
- g. When scores are tied, fastest laptimes scores are prioritized.

### 2.4.3 Requirements for Time Trial qualification

- a. Each vehicle must demonstrate that it can drive autonomously through a track without crashing.
- b. The team must demonstrate that it is possible to trigger car emergency stop remotely.

# 2.4.4 Penalties

- a. Touching the border of the track or a static obstacle is not penalized.
   Excessive, repeated touching (up to the organizers) is considered a crash.
- b. Upon crashing the track border or the static obstacle the team has to stop the car and move it (by hands) to the latest crossed checkpoint. After repairing the track and returning the obstacles to their appropriate locations, the race may continue. The time spent on moving the car to the checkpoint and repairing the track is considered the penalty.

# 2.4.5 Evaluation

Each team will be evaluated based on the following criteria:

- a. *Fastest lap time*. The laptime will be measured with specific equipment by the race director.
- b. Number of completed laps per heat

There will be two results tables based on these criteria.

# 2.5 Head-to-Head Race

### 2.5.1 General

- a. The Head-to-Head race is a race with two cars on the track at the same time on the same track but from opposite starting points.
- b. The racetrack has the same layout as in the training and qualification sessions.
- c. The algorithms must not intentionally hinder the opponent or perform any damage to it. Specifically, manoeuvres such as deliberate crowding of a car beyond the edge of the track or any other abnormal change of direction are strictly prohibited. The referees will have the final say in whether a driver is in violation of the rule.
- d. The head-to-head race will be organized as a knockout tournament with brackets seeded by results of the qualification. For example, with 8 teams, the bracket of the first round will be (#1 vs. #8, #2 vs. #7, #3 vs. #6, and #4 vs. #5).

- e. Each round will be played in two out of three games.
- f. The starting position of the first game will be determined by the higherranked team in the qualifying round and then the losing team of the previous game will choose the position.
- g. One head-to-head race consists of two teams racing against each other. One race has a dedicated timeslot of around 5 minutes. If one team is not showing up in these 5 minutes and let their car race, the other team won. If at some point along the race a car is not able to drive anymore (e.g. hardware issue, software not running etc.) and the teams are not able to restart the car withing the 5 minutes, the other team one the race. No time extensions are given and after the 5 minutes we move on to the next time slot and the next team.
- h. Each of the competing cars starts at its own starting line. Starting lines will be located at the opposite parts of the track.
- i. Overtaking may be carried out on either the right or the left.
- j. As opposed to time trials, no reconfiguration is allowed during the race, except after the crash, as described below.
- k. Ultimately, organizers reserve the right to assign blame in the case of vehicle collision in the head-to-head tournament.

# 2.5.2 Requirements for qualification

- a. The team has successfully completed the Time Trial.
- b. The car must be equipped with front foam bumper,
   e.g., <u>TRA7436</u> + <u>TRA7437</u> + <u>TRA7415X</u>. This solution is compatible with *Slash*. Model of *Ford Fiesta* already has this bumper.
- c. The car has to be easily perceivable by the opponent's LiDAR. Therefore, the car must occupy a space of size at least 12×12 cm at every horizontal plane between 10 to 30 cm above the ground.
- d. The car needs to provide beforehand that is is able to avoid static and dynamic obstacles. This is evaluated by the race referess with a test:
  - i. The cars need to run 1 lap around the racetrack that includes static and dynamic obstacles
  - These obstacles contain of size up to 35×32×30 cm, made from LiDAR perceivable material (e.g., cardboard).
  - iii. The racecars must show their ability to avoid those obstacles

iv. Based on this results the access to the race is granted.

# 2.5.3 Penalties

- a. Touching the border of the track or a static obstacle is not penalized.
   Excessive, repeated touching (up to the organizers) is considered a crash.
   (Same rules as for Time Trial.)
- b. Touching the opponent is not penalized unless one of the cars significantly diverges from its expected trajectory.
- c. Upon crashing the border of the track, the team has to fix the track and place the car on the side of the track at the place where the car first crashed the border. Then, the car can continue the race. During all of this, the opponent's car must not be restricted by the team's actions and the opponent is allowed to further race without stopping its car. The penalty is the time spent on fixing the track and placing the car.
- d. Upon crashing the opponent, these steps are applied:
  - i. Referees judge which car is at fault and give a warning.
  - ii. Both cars are placed at the place decided by the referees
  - iii. The referees restart the race.
  - iv. If a team receives two warnings in a game, the team loses the game and proceeds to the next game.

# 2.5.4 Evaluation

- a. The first car that completes 8 laps wins.
- b. There will be a referee.
- c. Each referee counts the lap for one car and is responsible for identifying the crashes.