Engineering Design Challenge 4.0

The Road To Autonomy

Rules & Game Description

As the future of driving is tending towards automation, automotive companies are faced with the challenge of developing safe, driverless cars that will ultimately take over. You are therefore tasked with developing a software that could handle the basic, everyday driving tasks of a taxi driver. Your robot will then need to be sturdy enough, pass the driving test, to then take on the roads of Beirut.

Date & Location

The challenge will take place near the end of January/beginning of February, on a date to be announced at the American University of Beirut.

Eligibility

Teams of 2 to 5 members can be part of the challenge. All team members should be enrolled either as undergraduate or graduate students in a university as of the competition announcement date.

Guidance and Advising

Teams are recommended, but not required, to have an advisor. An advisor can be anyone; a professor, an engineer in a company, or even a university student, who is willing to provide consultancy when needed. Note that EDC organizers and members of the judging panel are not allowed to be advisors.

Advisors should only guide teams throughout the competition, not do their work. They may suggest ideas and provide feedback for teams, however they must not help with any hardware or software implementation.

Teams should inform EDC organizers of their advisor for recognition purposes.

Awards

The team with the highest overall score gets a monetary prize of **$1500**. The first and second runner ups get prizes of **$1000** and **$500** respectively. Other awards will be distributed among teams who demonstrate proficiency in certain aspects of the competition.

General Rules

1) A car is any object that aligns with the rules. No shape, material, or platform are imposed – creativity is encouraged! Teams are expected to take the challenges into consideration when designing their car.
2) The car must fit in a **30x30x20cm** box or else the team will be disqualified.
3) All dimensions on game drawings are in cm unless stated otherwise.
4) Each team must use only one car to play the games. Minor changes or repairs can be made to the car between rounds (changing batteries, uploading code, small mechanical changes, etc.).
5) The car cannot be interacted with by hand except when allowed explicitly in the rules (e.g. pit area, or starting/resetting…)
6) The car should not damage the playing field or pose any safety hazards. Teams who violate this rule risk being disqualified. Refer to the safety regulations for more information.
7) Only one team member, designated the operator, can interact with the car in pit areas, bring it back to the starting zone, or control the car in the base building game. The operator cannot change during the round, but different team members can be operators for different rounds.
8) All dimensions in field drawings have a tolerance of 5%. CAD drawings of the field are available on the competition website http://aubrobotics.com/edc.
9) Some dimensions will be changed on the day of the competition to make sure that cars can adapt to small variations. If changes are expected, it will be mentioned as a note in the game's description.
10) A car is considered to have left the map if any part of it leaves the field boundaries.
11) In all games, the car needs to be autonomous and self-contained; no communication, including any control or navigation, can come from a source external to the car.
12) Judges take the final decision in rule matters.
13) Teams are advised to bring spare batteries, wheels, motors, raspberry pi and a backup USB with all the code on the Competition Day in case anything happens.
14) Black walls will be available on the outer periphery of Games 2 and 3 to help minimize perturbations.

Scoring

Teams will be assessed based on the following three measures, for a total of 250 points:

1) Preliminary Check **(25 points)**:

   The points will be awarded to teams who demonstrate that their robots have basic functionality around one month before the competition.

   The checks are to ensure teams are preparing well for the competition.

   Details regarding the requirements and submission methods for the preliminary checks will be communicated later on with the registered teams.

2) Game Performance **(180 points)**:

   Robots will play 3 games, described below, to score points.

3) Technical Assessment **(45 points)**:

   Teams are required to prepare a small cardboard/paper sheet where they will present in 5 minutes key points of their design to be evaluated by a team of judges from different universities/companies, according to the judging rubrics specified in a separate document.

Game 1: Motor Test (30 Points)

Overview:

How good are your motors? We'll be testing your car's ability to drive upwards on an inclined road.

The rules are simple, turn on your motors and show us how far can you go.

Rules:

1) The operator starts the robot in the PIT area.

2) The PIT area is the green section where you can interact with your robot.

3) Once the robot leaves this area, no intervention from the operator is allowed.

4) The robot should operate autonomously and climb the slope.

5) The max slope that the robot can hit is registered and points are given accordingly:

      a) **PIT** area: **0 points**.

      b) **15** degrees section: **8 points**.

      c) **30** degrees section: **15 points**.

      d) **45** degrees section: **23 points**.

      e) **60** degrees section: **30 points**.

6) The robot should completely lie on the designated section for the points to count.

7) The team operator can catch the robot if it's about to fall, but the trial ends and the maximum slope is registered.

8) Each team is allowed to have **3 trials**, with a maximum time limit of **1 minute** for each trial. The trial with the max points will be considered for scoring.

9) A trial terminates if any of the below is applicable:

      a) The time limit passes.

      b) Damage is done to the field.

      c) The operator intervenes with the robot.

      d) The robot is stationary and the team wants to finish the trial.

Game Specs:

1) Each section of the slopes is **50x50cm.**

2) Slopes start from 0/flat and increase with an increment of 15 up until 60 degrees from the horizontal.

3) Borders will be built so that robots don't fall off from the sides.

4) The last section of the game is horizontal for the successful robots to rest on after completion of the track.
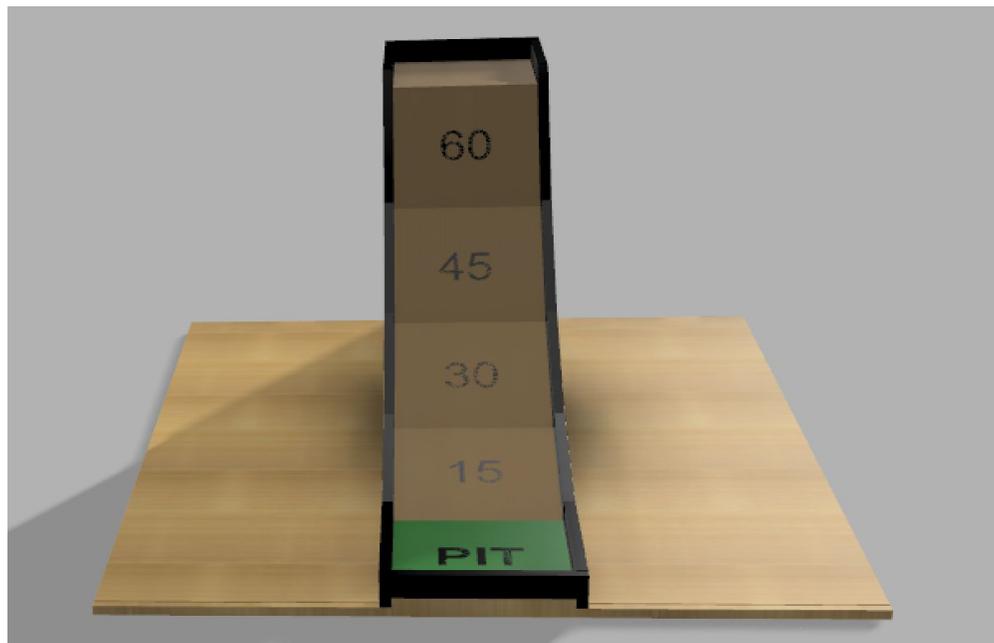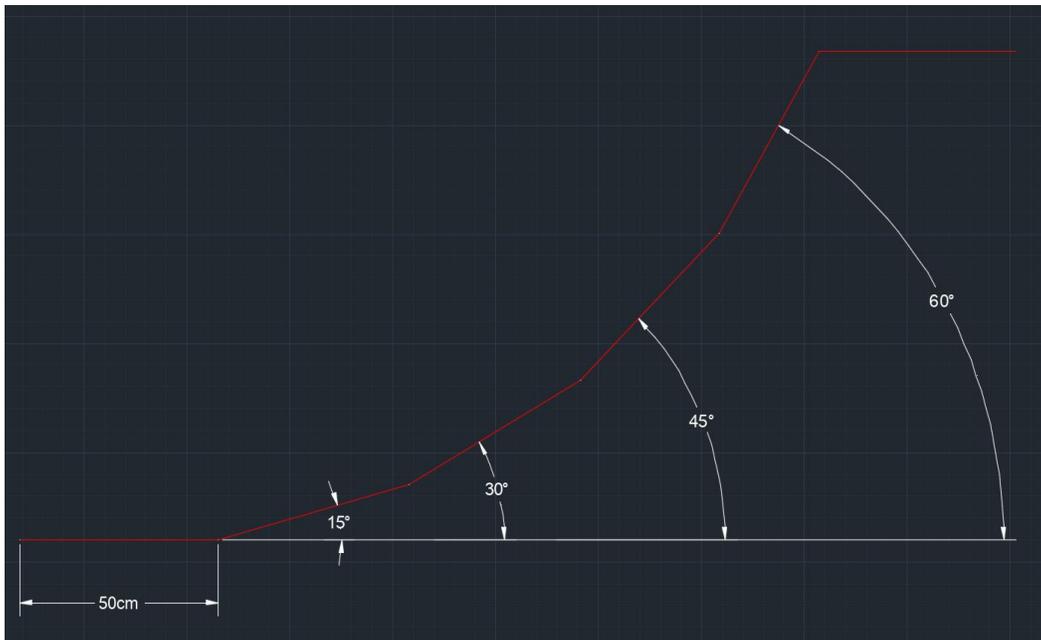
Game 2: Driver's License (60 Points)

Overview:

Before you hit the roads, you have to get licensed. Your car will be tested in a closed circuit to check if it's able to navigate the roads on its own. Complete one lap of the circuit to prove that you're competent enough for bigger challenges.

Rules:

1) The car should operate **autonomously**, except for starting or removing it.
2) Your robot is placed with all its parts behind the **blue** starting line.
3) The timer starts when your car crosses the line and stops when it completes the lap and crosses the same line again.
4) Each team is allowed to have **3 trials**, with a maximum time limit of **3 minutes** for each trial. The trial with the shortest time will be considered for scoring.
5) A trial terminates if any of the below is applicable:
    a) The time limit passes.
    b) Damage is done to the field.
    c) The car drifts off the circuit.
    d) The robot is stationary and the team wants to finish the trial.
6) There are **5 checkpoints** in the game; each time the car passes a checkpoint it gets **8 points**: if a car completes a full lap and crosses the finish line, it gathers a total of **40 points**.
7) After checkpoint 2, a few obstacles in the form of **green cars** will be placed on the road, and the robot will have to avoid them. Colliding with a car deducts 4 points from your total score.
8) After checkpoint 3, a **red stop sign** will be placed, marking a pedestrian crossing. The robot will have to clearly stop before the sign, for 5 seconds. Failing to stop or stopping after the sign will deduct 6 points from your total, and add 5 seconds to your final time.
9) The rest of the points will be distributed according to the timing of the teams who successfully passed all the checkpoints:
    a) The team with the best time gets **20 points** extra.
    b) The team with the worst time gets **0 points.**
    c) The teams in between get a share **X** of points where **0<X<20**.

Game Specs:

1) Checkpoints are not actual lines on the map, they will be flags or any object that does not interfere with robots. They are signs to help the judges in scoring and are not meant to be used by the robots. The checkpoint is counted only if the entire robot crosses it.

2) The robots start to the left of the starting line and travel clockwise along the map.

Straight Road Section
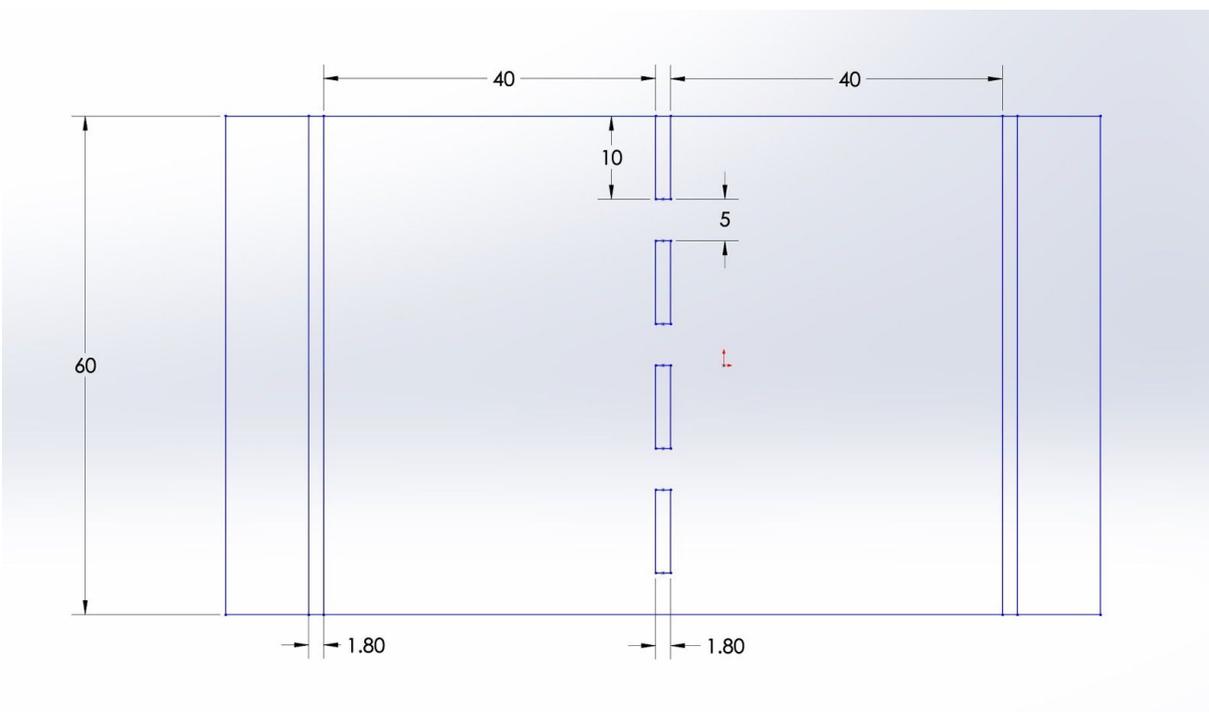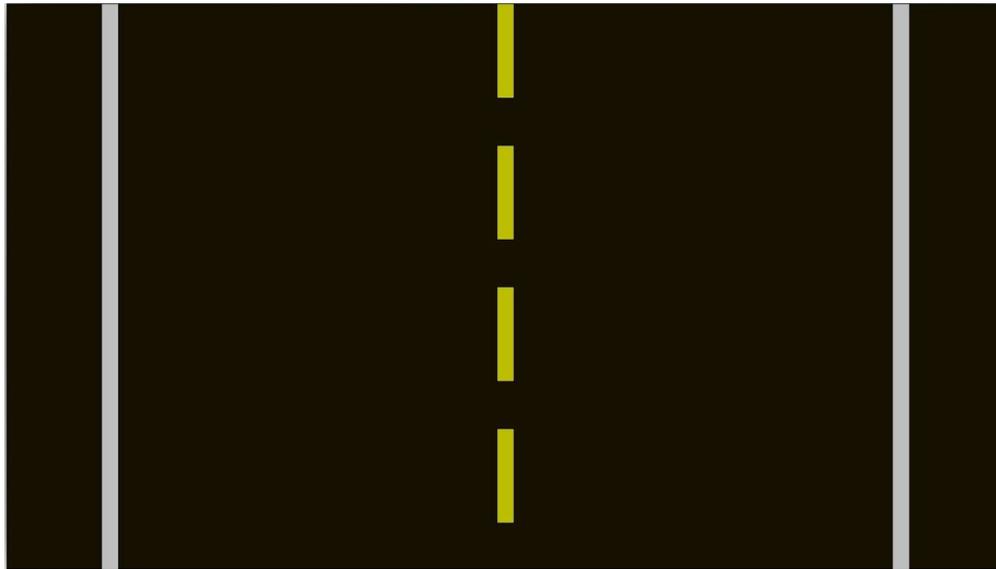
Map Layout

There will be two lanes, with 40 cm in width for each lane, as shown above. The two lanes are separated by dashed yellow markers. The same dimensions and ratios will be maintained throughout the curved parts as well. The map can fit in a 300x300 cm rectangle.

Checkpoints are numbered in a clockwise direction. The first orange checkpoint is checkpoint 1, and the last orange checkpoint is checkpoint 4. The finish line in blue (also the start line) is checkpoint 5.

Two obstacle cars will be placed after checkpoint 3, each inside a lane, and they will fit in a box of size 20x20x20 cm. The positions of the cars are not fixed and can be changed from one round to the other.

For the red stop sign specification, please refer to the Game 3 specs on stop signs, on page 17.
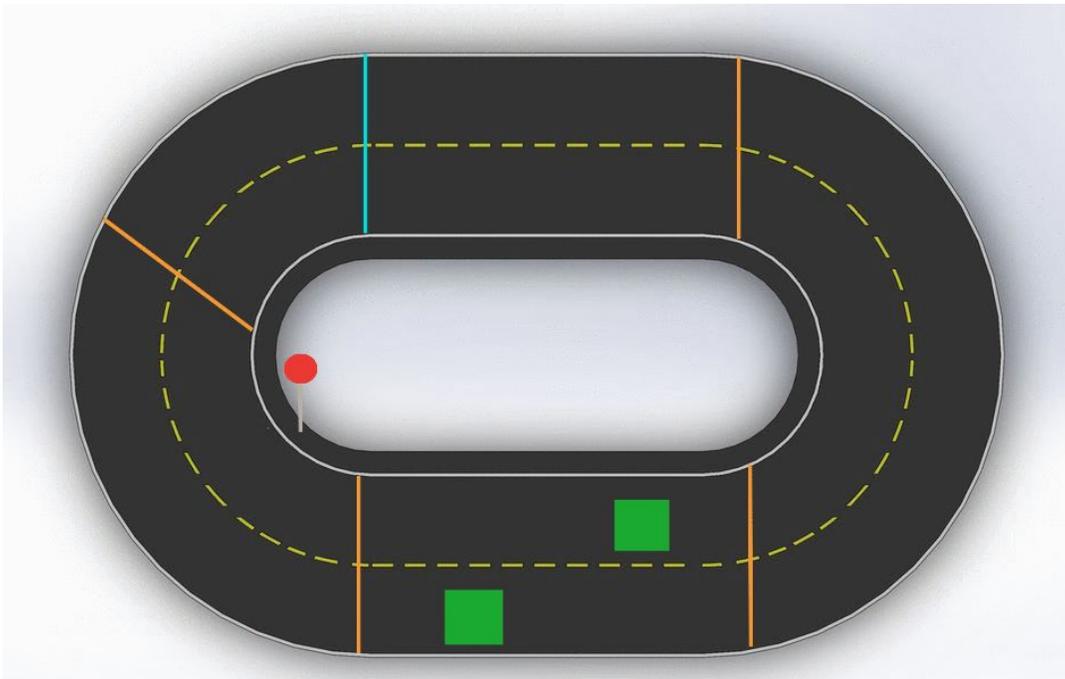
Game 3: Crazy Taxi (90 Points)

Overview:

Armed with a driving license, your car is ready to face the challenges of the real world by becoming an autonomous taxi.

In this simulated city, your cab will have to safely navigate the roads while obeying traffic signs and lights. Your task is simple, safely pick up and drop off passengers to and from their destinations. This requires the car to localize itself in the environment, and be able to navigate to predefined destinations upon request.

Rules:

1) The car should operate **autonomously**, except for starting it in the pit area or removing it.
2) The car starts in the **green pit area**.
3) At any time you can recall the robot to the pit area and interact with it at a cost of losing **10 points.**
4) If the robot happens to enter the pit area by itself and you choose to touch it, you will lose **5 points.**
5) A car starts with **30 points** and loses points whenever a traffic rule is violated (See Rule 10).
6) Each car has to complete **3 taxi rides** <u>in order</u>:
    a. **Ride 1**: From Street **#8** to Street **#2**
    b. **Ride 2**: From Street **#4** to Street **#1**
    c. **Ride 3**: From Street **#3** to Street **#7**
7) To be counted as a pick up or drop off, the car should stop for more than **3 seconds** in the blue area under the taxi sign in the corresponding street.
8) Each successful ride -pick up and drop off- is counted as **20 points.**
9) If the car successfully picked up a passenger but failed to stop for more than 3 seconds at the according drop off street, only **10 points** out of the 20 are given.
10) Cars should correctly follow the traffic rules or else points will be deducted:
    a. At each unsuccessful stop at the traffic light, **5 points** are deducted.
    b. At each unsuccessful stop at a stop sign, **2 points** are deducted.
    c. Any damage done to the field will end the trial and deduce **10 points**. result in **10 points** being deducted and the trial to be ended.
11) Each team is allowed to have **3 trials**, with a maximum time limit of **5 minutes** for each trial. The trial with the maximum points will be considered for scoring.
12) A trial terminates if any of the below is applicable:

a) The time limit passes.

b) Damage is done to the field.

c) The robot is stationary and the team wants to finish the trial.

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Important Note

Make sure to be objective-oriented and tackle this challenge on a task basis. That is, don't try to make your robot solve all the tasks at once, navigating, respecting traffic rules, and picking up passengers. Build up your code step by step, and solve each task at a time, so that you can at least solve one task really well instead of poorly trying to achieve all of them.

For example, for this game, focus on the navigation task first. Once your robot can properly navigate and localize itself on the map, it can start picking up and dropping off passengers. Once your implementation is robust, you can then shift your focus on obeying traffic rules. Try to collect as much points as possible.

This applies to Game 2 as well. Focus on lane detection and driving through the map, and once this is done properly, you can add a layer to avoid obstacles, then add another layer to detect signs and stop at the right time.

Don't hesitate to contact us if you have any questions or concerns regarding the rules and specifications.
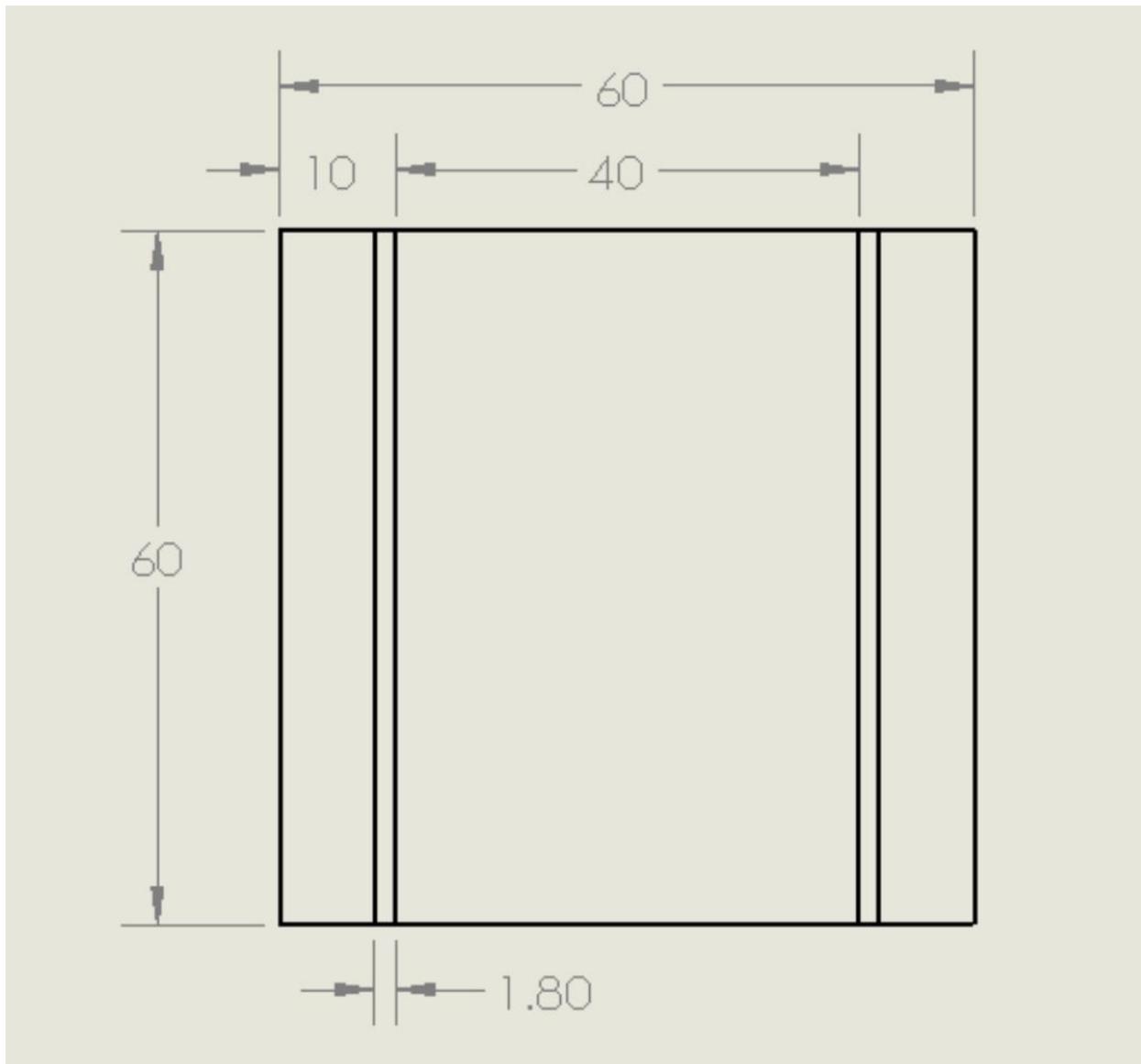
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Game Specs: (Please refer to Field Drawings document for information on how to view it in 3D)
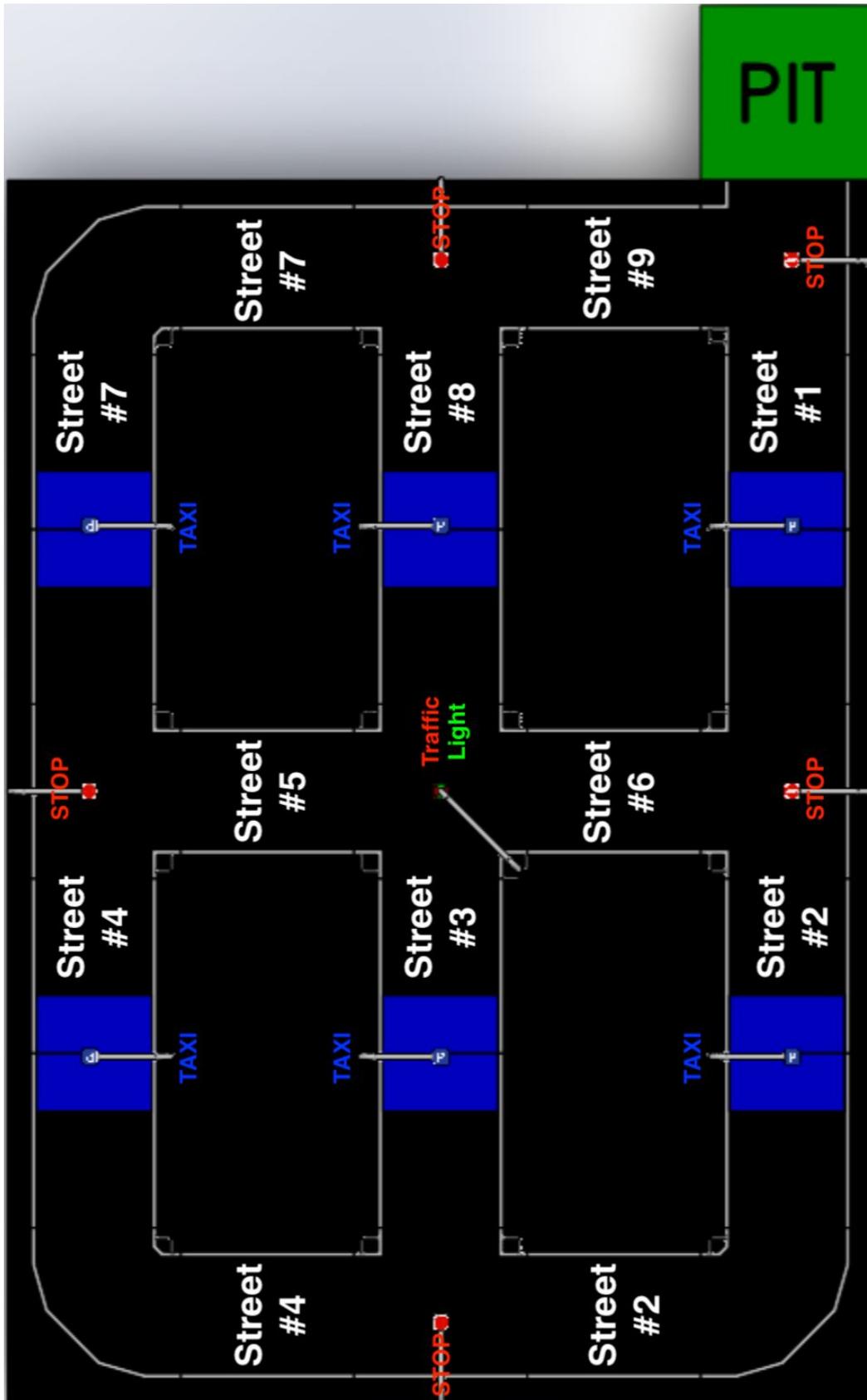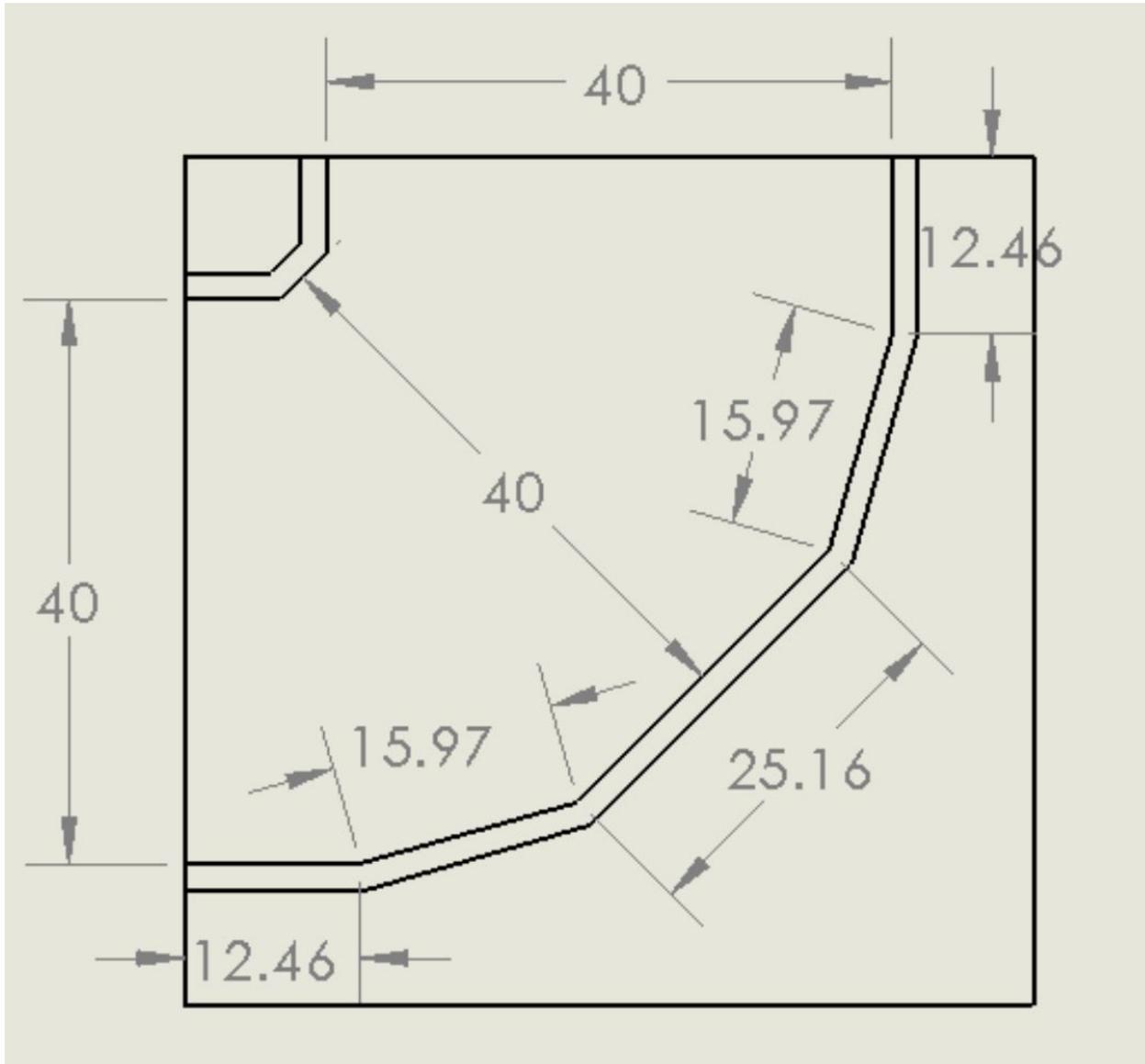
Road Geometry:

Streets are generally black mats with white strips on the extremities, there are 4 types of configurations. Dimensions are in centimeters (cm).
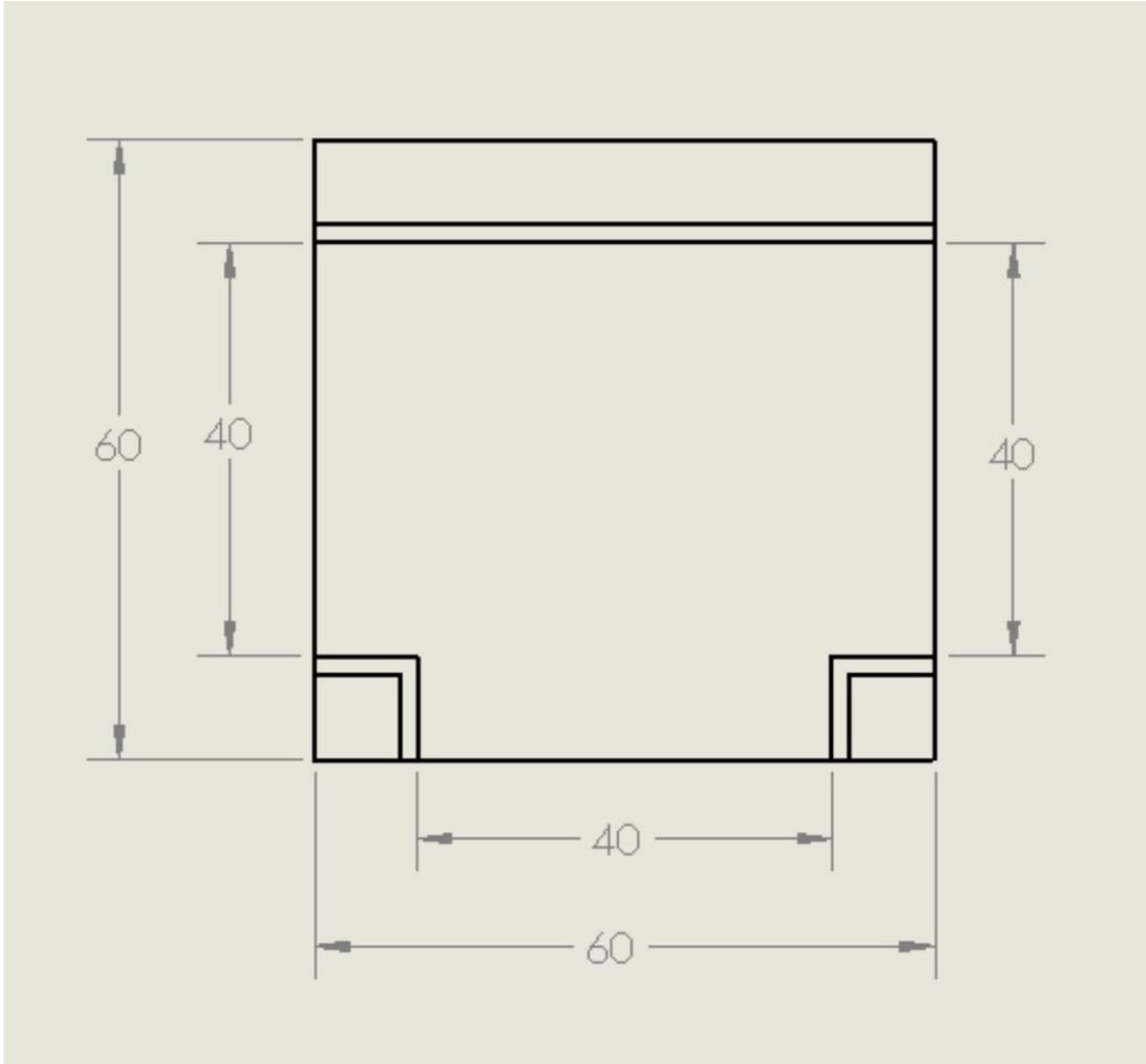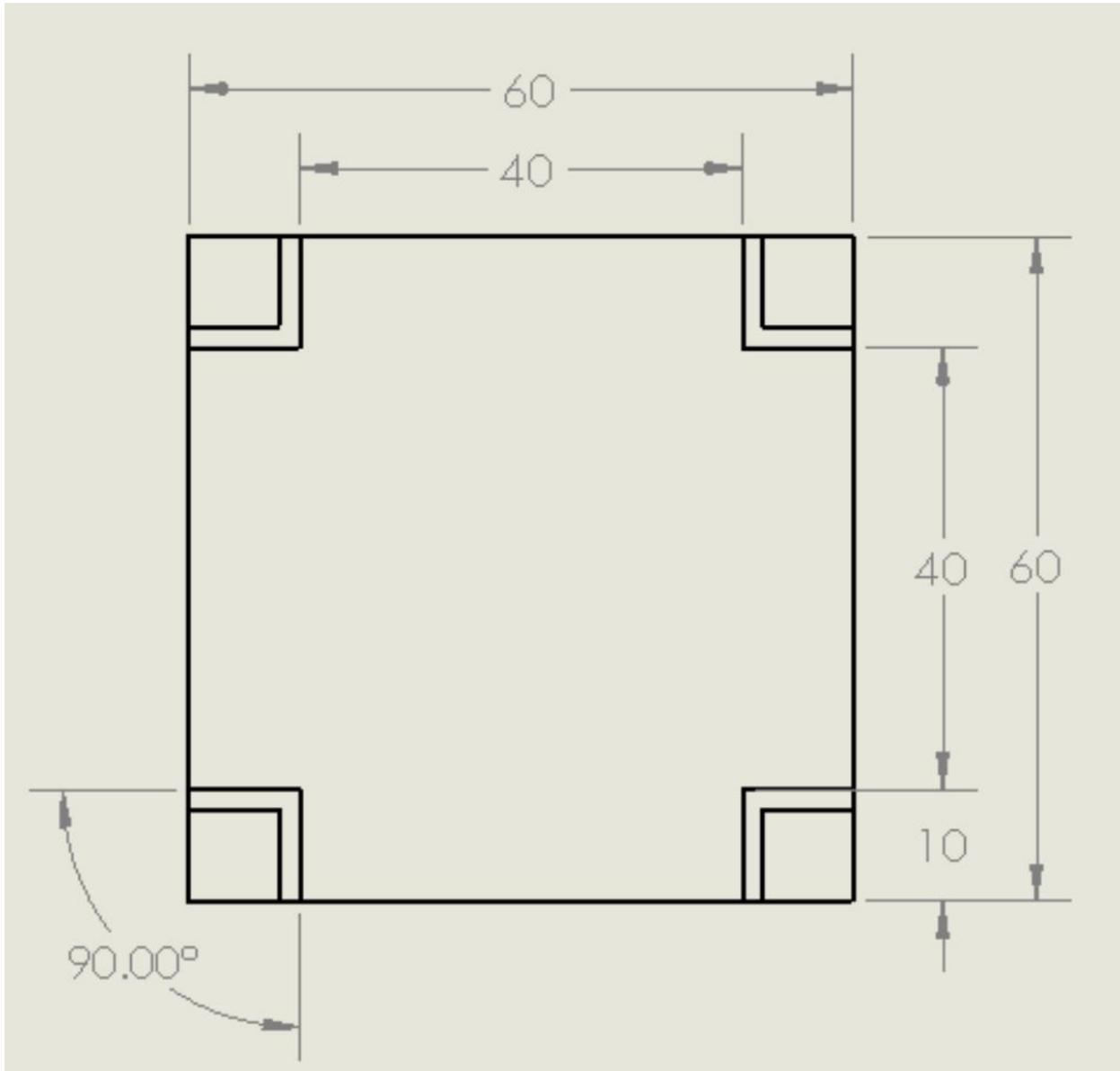
1) Straight Road:

2) Right/Left Turn:

3) 3-Way Intersection:
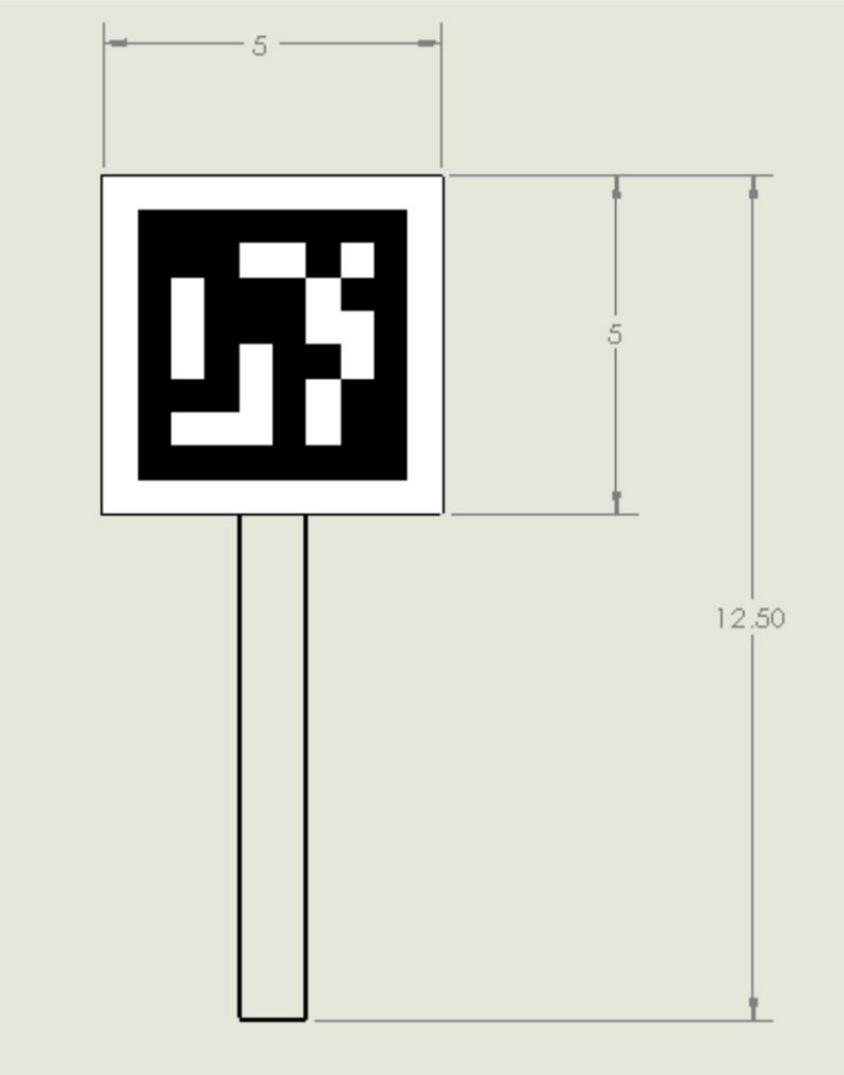
4) 4-Way Intersection:

Street Signs:

1) Street numbers are given by AprilTags (See AprilTags Section for more info).

2) Signs will be available at the end of each street before an intersection or turn.

3) The position of the street sign tells you where this street is with respect to your car.

      a) On the right side of the car → This street is to your right

      b) On the left side of the car → This street is to your left

      c) Overhanging the street in front of the car → This street is straight ahead

E.g: If you are arrive at an intersection and street 9 is to your right, street 5 is to your left and street 2 is straight ahead, a sign corresponding to street 9 will be at the end of the street you came from to your right, a sign corresponding to street 5 will be to your left and a sign corresponding to street 2 will be hanging in the middle of the road.

4) When both a stop sign or traffic light is available with a straight ahead street sign, the street sign will be hanged down from the other sign.

5) When on the extremity, the street sign is placed directly behind the white line perpendicular to the road, that is facing the car.

| Street Number	Tag ID
1	tag36_11_00075
2	tag36_11_00203
3	tag36_11_00059
4	tag36_11_00111
5	tag36_11_00362
6	tag36_11_00489
7	tag36_11_00013
8	tag36_11_00501
9	tag36_11_00270

Right/Left Street Sign:

Stop Signs:

1) Stop signs are present on 3-way intersections.

2) They will be hanging from the side of the intersection with a stop sign facing the 3 directions leading to the intersection.

3) A car should stop for more than **3 seconds** before the intersection in order to be successfully counted.
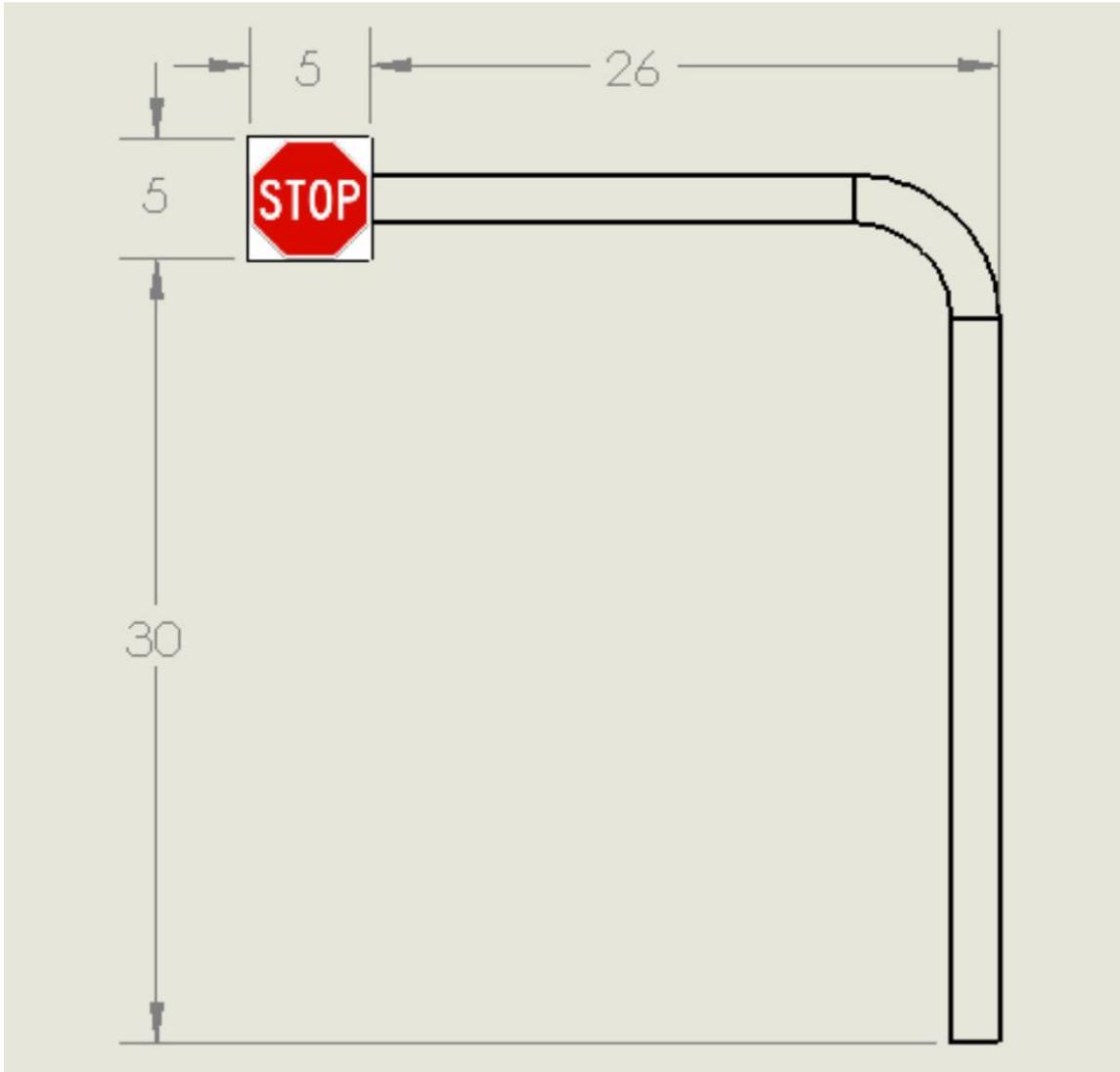
Taxi Stops:

1) Taxi Stops are where the passengers will be expecting you to pick them up or drop them off.
2) Streets 1,2,3,4,7 and 8 will have Taxi Stops.
3) These are constituted of a **Blue Park Sign** that will be overhanging it and a **Blue Area** under it where the car should wait for at least **3 seconds** for the passenger to get in or out.
4) The Signs are visible from both directions that the car may be headed from.
5) The Blue Area is a painted section of the actual road under the street sign that is **40x40cm**
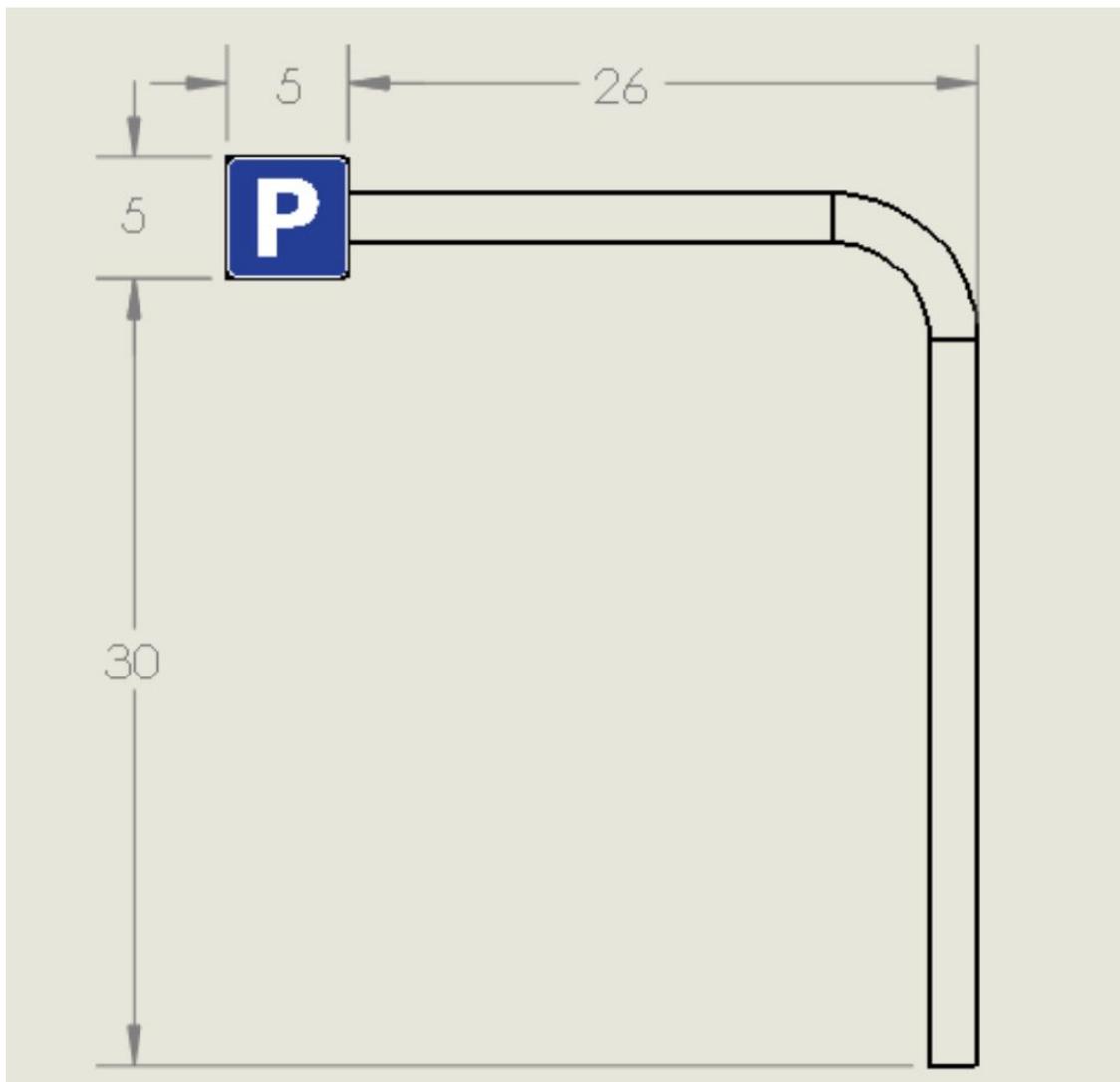
Traffic Lights:

1) Traffic Lights are present on 4-way intersections.
2) They will be hanging from one corner of the intersection with a light source facing each of the 4 directions leading to the intersection.
3) The light source will be at the center of the intersection with corresponding street numbers under it as discussed in Street Signs section.
4) The **red light** will shine for **6 seconds** and the **green light** for **3 seconds** in a continuous cycle.
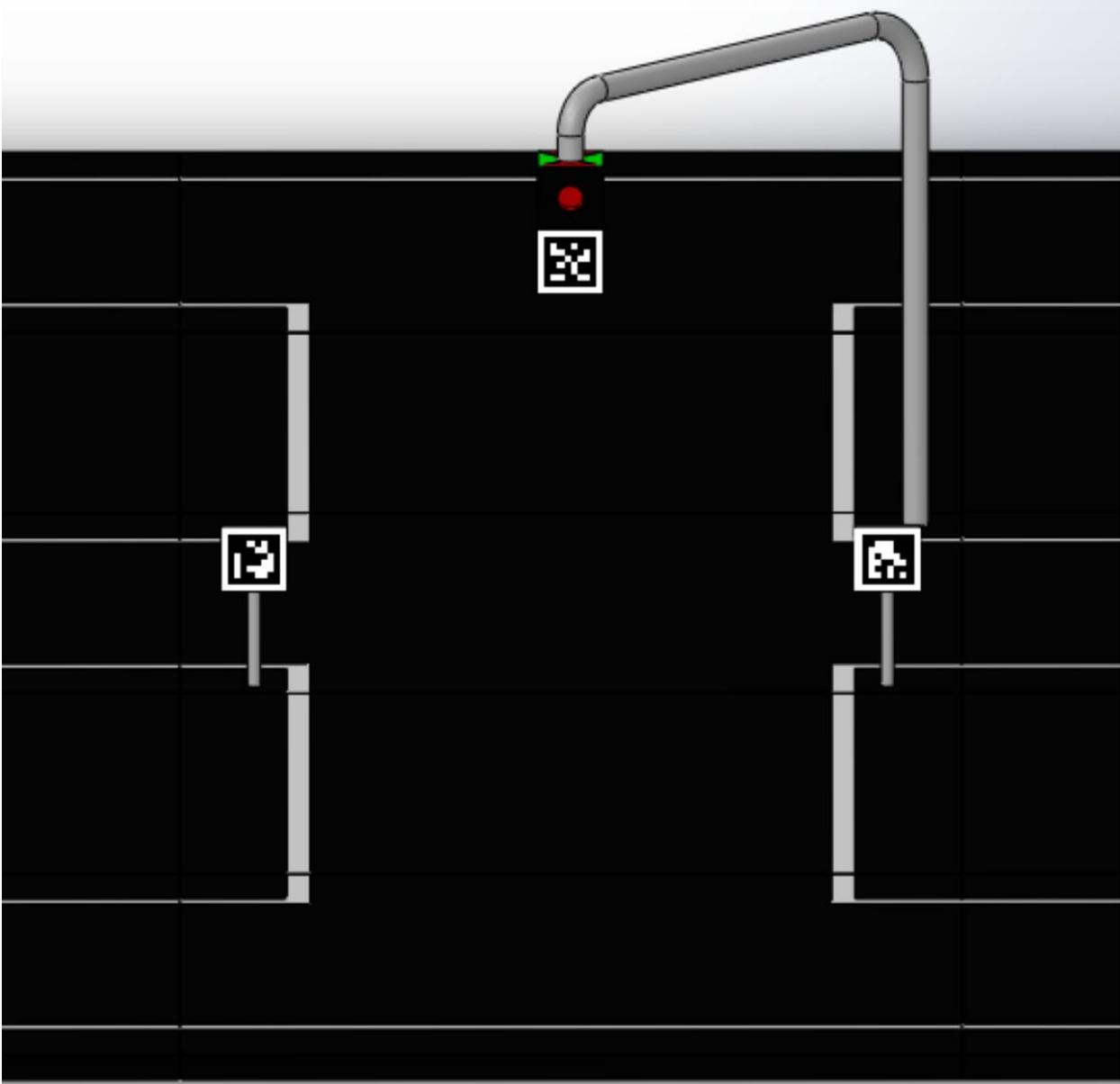5) A car should completely stop before the intersection when a red light is present until it changes to green.
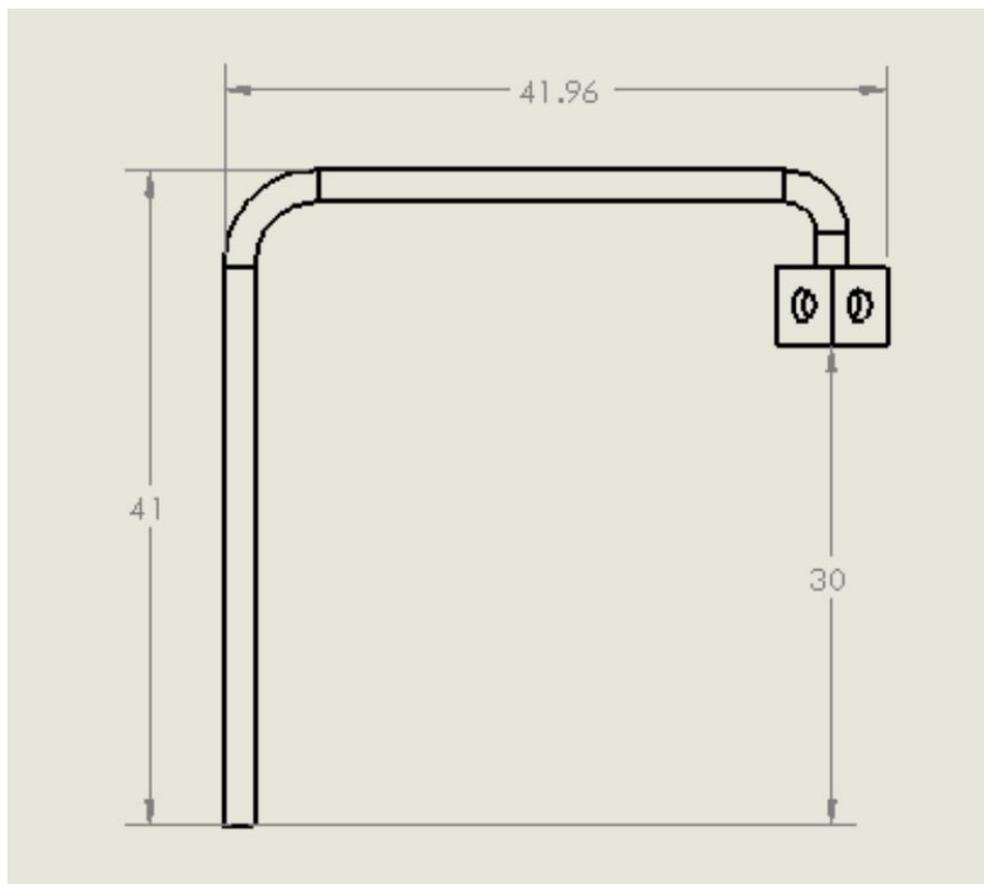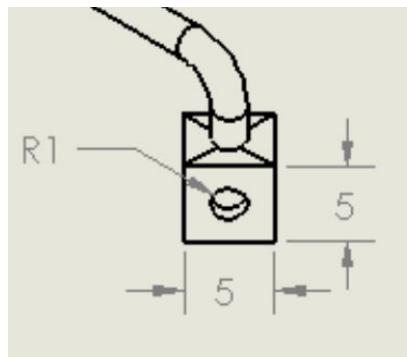
Street View Examples:

1) 3-Way Intersection example view:

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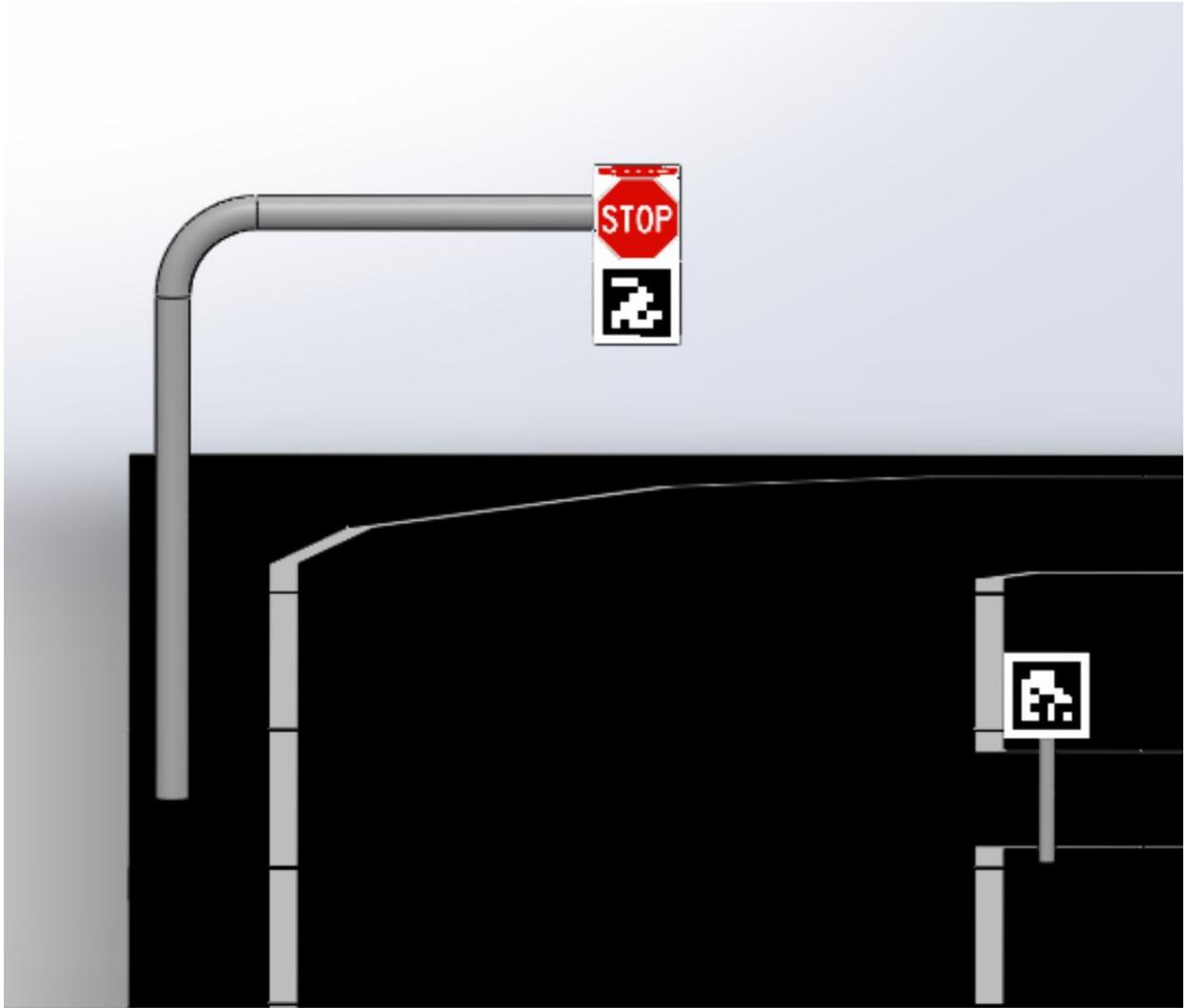
2) 4-Way Intersection example view:

3) Taxi Stop example view: