PRELIMINARY ROUND

GUIDELINES PART – 1

aBAJA

Phase I: Preliminary Round

BAJA SAEINDIA 2025 is set to captivate participants and spectators with its innovative blend of Physical and Virtual platforms. This highly anticipated edition encompasses three distinct Phases, with the initial first & second phases taking place in a virtual format, and the third phases culminating in an exciting physical event. The Preliminary Round of aBAJA SAEINDIA 2025, is scheduled to be held on the **25th of January 2025**.

Understanding the Preliminary Round

- Similar to aBAJA SAEINDIA 2024, the Preliminary Round of aBAJA SAEINDIA 2025 will be **a non-elimination round**. The scores obtained in this round will be added to the total score obtained by the team in all the events during the 'Phase-II' and 'Phase-III' event.

Event	Description	Points
Phase I : Preliminary Round	Presentation Round	40
	Online Quiz	10
Total Points		50

- Teams are required to carefully review the problem statement provided in this document and develop solutions that address the outlined requirements.

- Teams will present their solutions following the detailed guidelines for the Preliminary Round, which will be shared at a later stage.

- The objectives of the Preliminary Round of the aBAJA SAEINDIA 2025 event are as follows:
    1. To acquaint the teams with the objectives of the aBAJA SAEINDIA 2025 event.
    2. To develop a comprehensive understanding of the fundamental and advanced aspects of Autonomous Vehicle (AV) technology, including but not limited to ADAS features like Lane keep assist, Automated Emergency Braking, Adaptive Cruise Control; Vehicle modifications like Brake-By-Wire, Steer-By-Wire, Throttle-By-Wire, Feedback Systems; and Software Development like Image Processing, Computer Vision, RADAR Data processing, GNSS/INS system, In-vehicle communication, Lane detection, Traffic Object Detection, Traffic Object Classification, Traffic Object Tracking, Speed Limit sign detection, Vehicle State Estimation, Speed Controller, Sensor Fusion, Localization, Trajectory Planning, Control systems and Path optimization.

- The entire evaluation process will be conducted digitally on a Video Conferencing Portal.

- The Quiz will be conducted via an Online Platform on **25th January 2025.** The Standard Operating Procedure (SOP) for the same will be released later.

- Maximum **5 team members** per team, which must include either Captain or Vice-Captain, will be allowed for the presentation. The presenter details will be collected separately later.

- One faculty member must be present as a silent observer, in addition to the team members for the presentation round.

- Teams are required to submit the following files for the Preliminary Round:
    1. Presentation File
    2. An optional slide for Innovation (Only a single slide)

  Both these submissions must be made through the BAJA SAEINDIA Website submission portal in PDF format by **24th January 2025 11:59 PM IST**. The file size must not exceed 5 MB for the Preliminary Round presentation file and 1 MB for the Innovation slide.

- **RETURNING TEAM:**
  The teams/colleges/institutions, who participated in the Main Physical Event of aBAJA SAEINDIA 2024 shall be called RETURNING TEAM. Participation in the 'Main Physical Event' means, the team should have built their aBAJA vehicle, brought it to the main event, and have got their team registered at ARAI for on-site stages of the competition in aBAJA SAEINDIA 2024.

- **NEW TEAM:**
  The teams/colleges/institutions, who could not participate in the Main Event of aBAJA SAEINDIA 2024 shall be called NEW TEAM. Teams switching from one category to another shall also be considered as NEW TEAM. Additionally, the teams not covered under the RETURNING TEAM criteria shall be considered as NEW TEAM.

- Teams must prepare for the following sub-events:
    1. **Presentation Round:** A maximum of 40 mins will be allotted per team to present their models which includes,
        - Presentation by the team to showcase the Autonomous/ADAS software stack design: **20 mins**
        - Questions put up by the panel to be answered by the team: **20 mins**
    2. **Quiz Round:** The Quiz will consist of questions from General Engineering/ Automotive Engineering and Autonomous Vehicle Technology

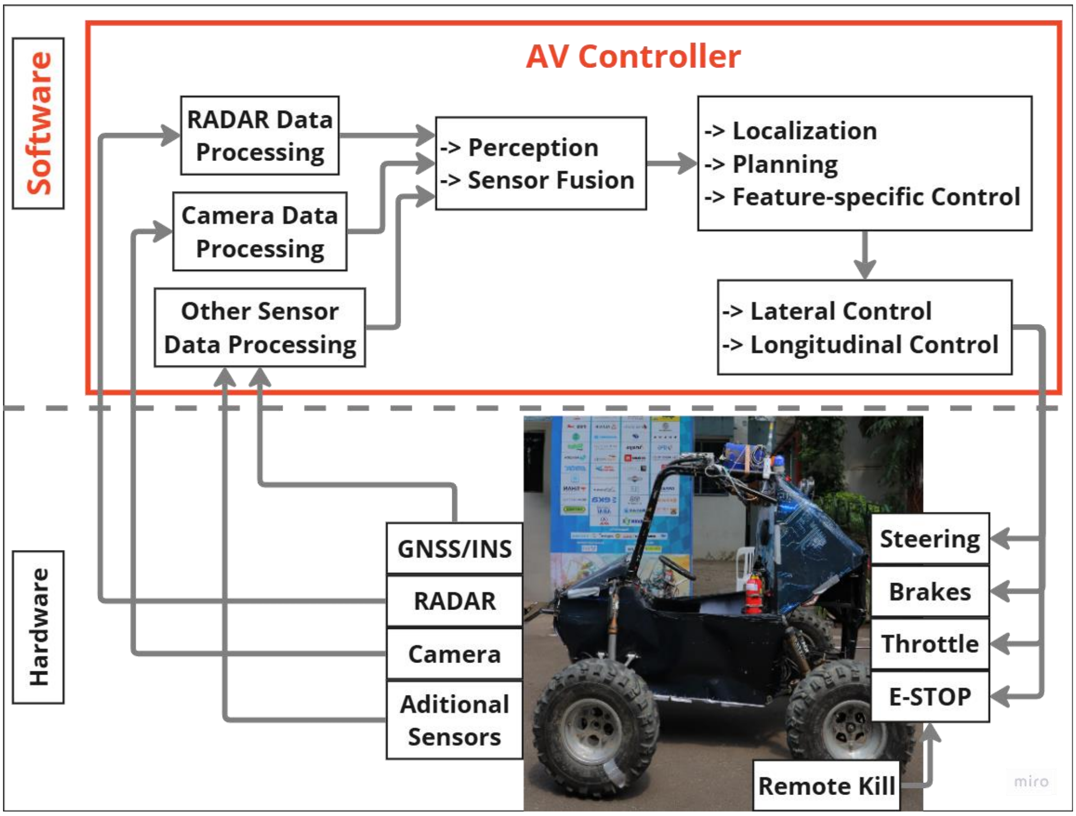
Teams must strictly adhere to their respective timelines.

Problem Statement:

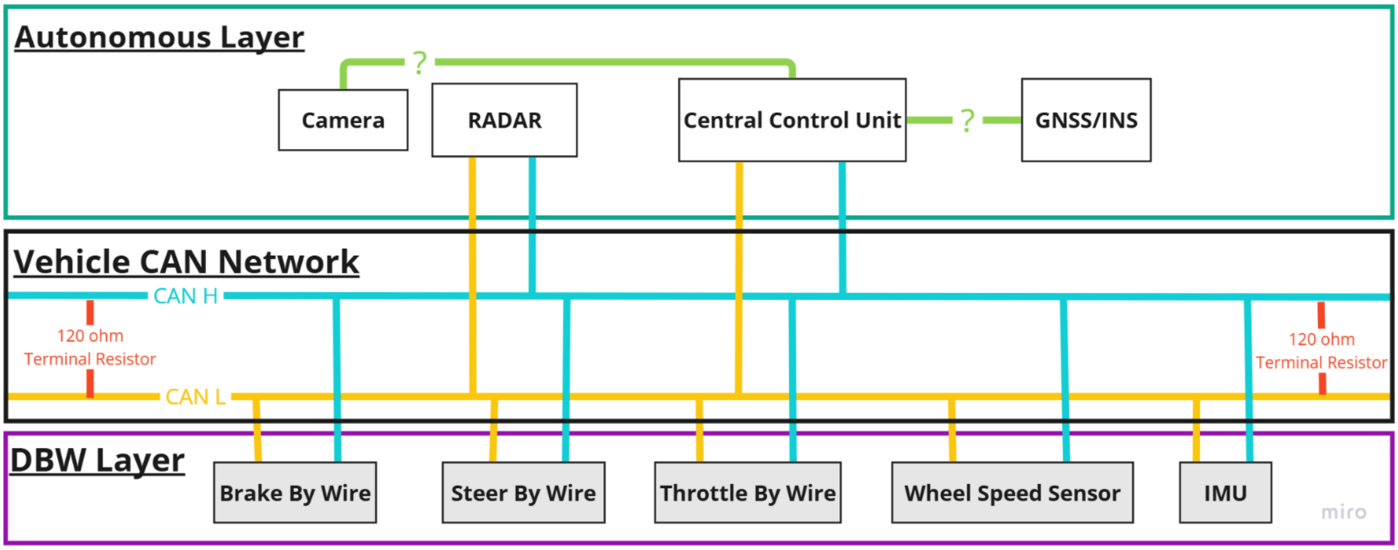
Using the sample vehicle hardware architecture, sample vehicle software architecture and the assumptions outlined below as references, teams must develop their own software architecture and algorithms to meet the requirements specified for the five dynamic scenarios detailed in this document.

Considering the provided assumptions, teams may propose additional modifications to the vehicle model architecture as needed to fulfil the dynamic scenario requirements.

Sample Vehicle Software Architecture: (only for reference)



Sample Vehicle Hardware Architecture: (only for reference)



Assumptions:

1. You are given a Drive-By-Wire-enabled (DBW- enabled) electric vehicle
    - Maximum speed at maximum throttle percentage: 30 kmph
    - Vehicle weight: 150 kgs
    - Front track width: 50 inches
    - Rear track width: 49 inches
    - Wheel base: 50 inches
    - Weight distribution between front and rear axles: 50/50
    - It can be driven both manually by driver and autonomous via algorithms/control systems developed by the teams
2. The DBW layer of the vehicle gives the following sensor feedback via CAN to the Vehicle CAN Network:
    - Wheel Speed Sensor - Wheel RPM from all four wheels
    - IMU - Acceleration in the X, Y, and Z axis
    - IMU - Angular rate in the X, Y, and Z axis
    - IMU - Roll angle, Pitch angle, and Yaw angle
3. The sensor data sent to the CAN network is noise/disturbance-filtered sensor data
4. Consider the Brake-By-Wire (BBW), Steer-By-Wire (SBW), and Throttle-By-Wire (TBW) system to be a grey box
5. The BBW, SBW and TBW receive the brake percentage demand, steering angle demand and throttle percentage demand respectively via the vehicle CAN network from the Jetson Nano controller
6. The BBW, SBW and TBW systems will react to the demand accurately without any considerable delay
7. The central control unit should be considered as a NVIDIA Jetson Nano developer kit.
8. The RADAR should be considered as ARS 404-21 RADAR which sends processed RADAR data via CAN to the vehicle CAN network.
   Note: Detailed ARS 404-21 technical documentation will be shared later individually with the teams upon signing an NDA
9. The Jetson Nano controller shall receive the RADAR data from the vehicle CAN network
10. The steering angle demand to SBW is between -30 to +30 degrees. Negative 30 degrees is full steer to the left and positive 30 degrees is full steer to the right
11. The lateral control comprises of the steering control while the longitudinal control comprises of both the throttle and brake control together
12. There will be a safety driver inside the vehicle who takes care of lateral or longitudinal control based on the dynamic scenario and will take over in case of emergency
13. The vehicle allows selective enabling and disabling of autonomous/manual lateral and longitudinal control
14. LIDAR should not be used

15. The computing can only be done onboard in the central controller and no cloud/remote computing is allowed
16. Data logging and real-time analysis of data is allowed, but you are not allowed to control the vehicle remotely in any of the dynamic scenarios
17. All the dynamic events will happen on flat tar roads

You will need to consider the above assumptions when developing your algorithms. As illustrated in the sample vehicle architectures above, only one camera has to be used. You will need to perform the hardware selection of the camera and define the interface by which it will communicate the data to the Jetson Nano. The camera needs to send raw camera images to the central controller with which as an input, computer vision algorithms need to be developed.

In addition, you can have a GNSS/INS system as part of the autonomous layer if you prefer. However, you need to perform the hardware selection of the GNSS/INS system and define the interface by which it will communicate the data to the Jetson Nano.

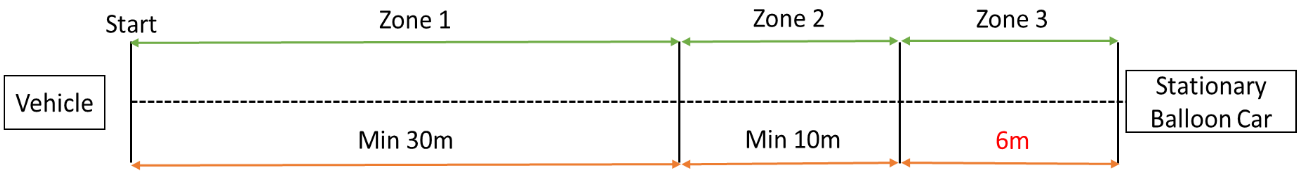
Assumptions associated with RADAR and central controller are only tentative and if any changes are needed, the same will be communicated with the teams.

Teams need to focus on the blocks within the AV controller in the sample vehicle software architecture. More focus should be kept on sensor fusion algorithms.

Teams need to consider different test cases for the dynamic scenarios given below, with factors including but not limited to different weather condition, light condition, false detections, sensor interferences, vehicle speed, multi-object detection and tracking; while designing the algorithms for the dynamic scenarios.

Dynamic Scenarios:

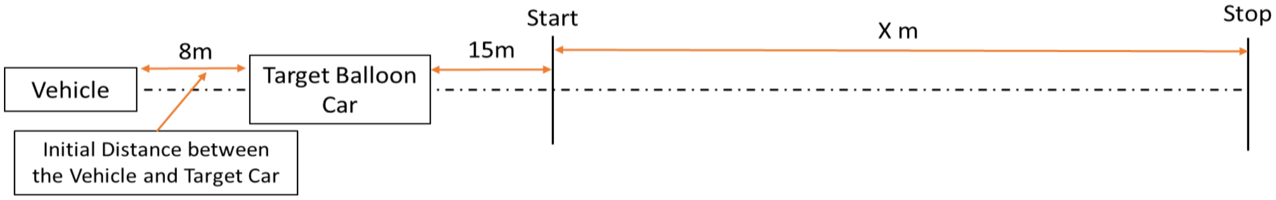
1. **Autonomous Emergency Braking (AEB) :**



a. The vehicle will move in a straight lane
b. The lateral control will be done by the safety driver
c. The longitudinal control shall be taken care of by the autonomous algorithm

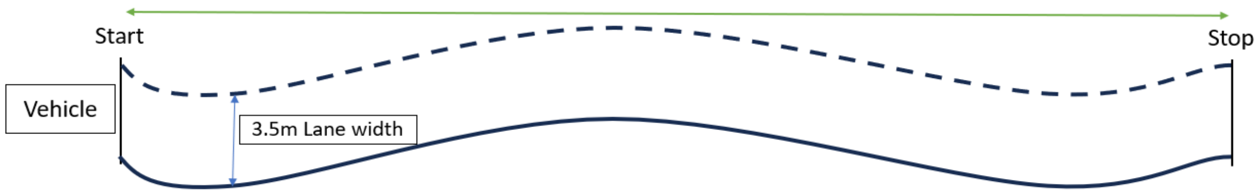
d. Zone 1 is the acceleration zone, and the vehicle needs to reach a speed of 30±3 kmph
e. Zone 2 is a braking zone and Zone 3 distance is 6 m
f. The distances mentioned for Zone 1 and Zone 2 in the above image are only the minimum distances to be considered and not the actual distance.
g. The vehicle needs to decelerate and come to a stop at the start of Zone 3, maintaining a distance of 6 m with the stationary car
h. The deceleration values should be between 5 m/s^2 to 8 m/s^2 to qualify as an emergency braking

2. Adaptive Cruise Control (ACC) :



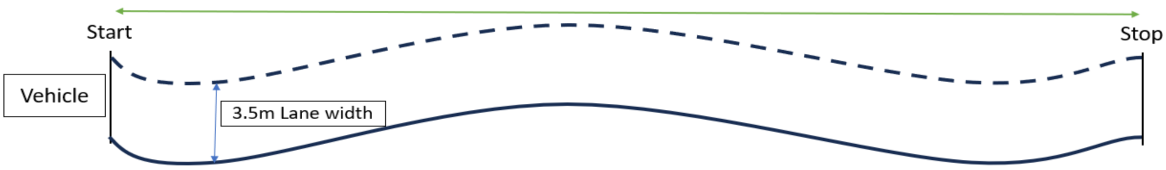
a. The vehicle will move in a straight lane
b. The lateral control will be done by the safety driver
c. The longitudinal control shall be taken care of by the autonomous algorithm
d. Both the vehicle and target balloon car will start from a stationary state
e. The balloon bar will follow a speed profile that is predefined
f. The vehicle needs to detect the start of the target balloon car and start moving
g. The vehicle needs to follow the target balloon car at an interval of 1 second
h. The jerk value of the vehicle should be less than $4.5 m/s^3$

3. Lane Keep Assist (LKA) :



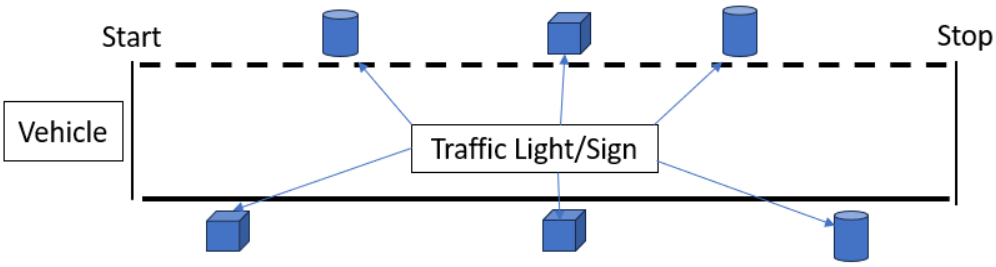
a. The vehicle will move in a curved lane
b. The longitudinal control will be done by the safety driver
c. The lateral control shall be taken care of by the autonomous algorithm
d. The vehicle needs to maintain the lane centre as closely as possible
e. The left lanes will be dashed lane markings and the right lanes will be solid lane markings
f. The safety driver will drive the vehicle at a constant speed of 10 kmph

4. Path Following:



a. The vehicle will move in a curved lane
b. Both the longitudinal control and lateral control shall be taken care of by the autonomous algorithm
c. The vehicle can reach a maximum of 30 kmph and needs to be inside the lane and not go outside the lane markings
d. The vehicle should aim to complete the track in the minimum time possible
e. The safety driver will be there in the vehicle just to take over in case of emergency
f. A trial lap will also be provided and if you prefer logging of any crucial sensor data during the trial lap, it can be done

5. Traffic Light/Sign Detection:



a. The safety driver will drive the vehicle at a speed of 30 kmph on a straight lane
b. Different colour traffic lights (red, amber, green) and speed limit signs (30 kmph, 60 kmph, 80 kmph) will be placed along the left and right lanes.
c. The vehicle has to detect the traffic lights and speed limit signs and classify them
d. In addition, the vehicle needs to calculate the lateral and longitudinal distance of these objects from the vehicle.