# TRUCK PLATOONING USE CASE

## TASK 1

### 1. V2V Communication – Protocol – Data/Signals Required Interaction between Trucks

Vehicle-to-vehicle (V2V) communication is an automobile technology designed for dedicated short-range communication (DSRC) to allow vehicles to communicate with one another. The main task of the V2V communication system is to forward selected messages from the local CAN in one platoon vehicle to the CAN of another platoon vehicle. **All vehicles participating in the platoon perform V2V communication among each other using DSRC/IEEE 802.11p WAVE (Wireless Access in Vehicular Environment) protocol which operates at 5.9 GHz for wireless communication.** CAN(Controller–area network) is a common wired communication bus standard designed to allow microcontrollers and devices in vehicles to communicate with each other within a vehicle. The V2V node acts as wireless gateway to the CAN bus of the other vehicles. This allows sharing of local vehicle signal and sensor data among vehicles in the platoon. The shared signals are used in the control algorithms of the platoon.

Following signals will be used:

- **Front trajectory**
- **Rear trajectory**
- **Current Rear trajectory**
- **Relative distance (longitudinal/lateral)**
- **Velocity**
- **Yaw rate**
- **Steering angle**
- **Kingpin angle**
- **Camera/Radar fusion data**
- **In-Vehicle Network chassis signals**
- **User Input to HMI**

**MAP, LIDAR, CAMERA, IMU and GPS sensors are used to obtain these signals.**

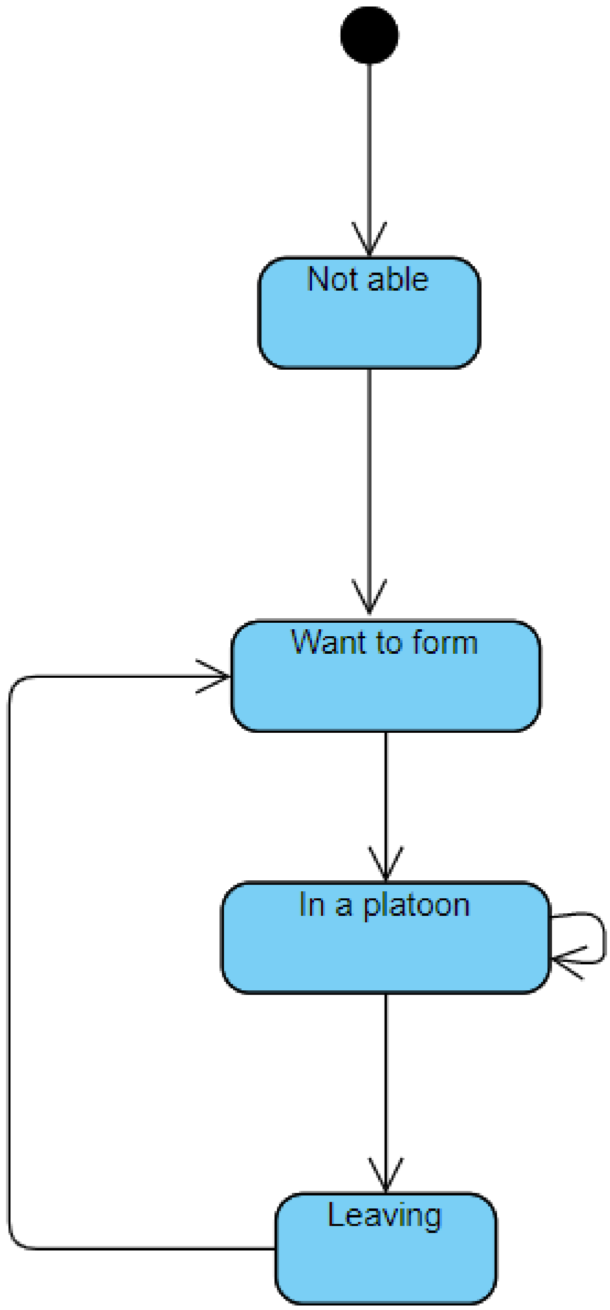
### 2. Advantages of Using IEEE 802.11p WAVE Protocol

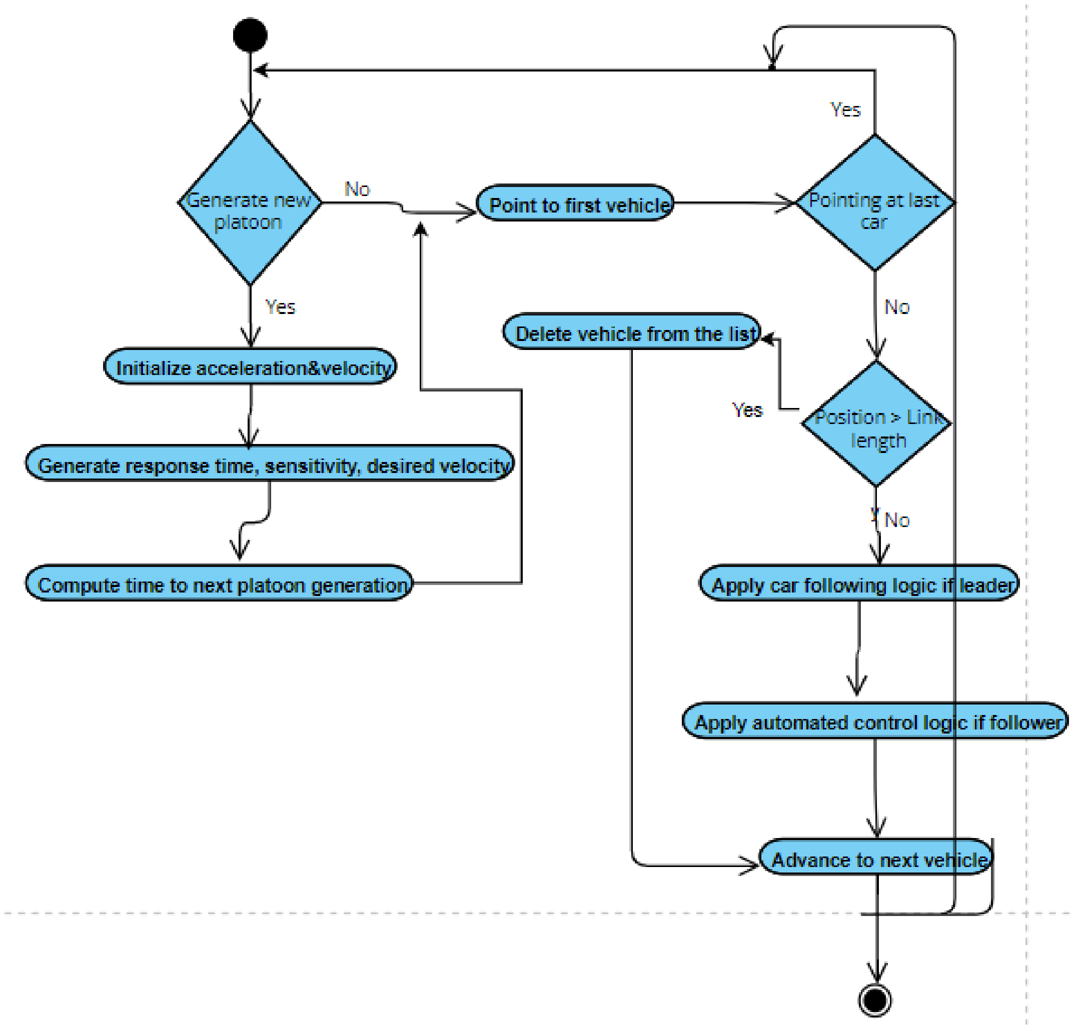
The IEEE 802.11p WAVE standardization process originates from the allocation of the Dedicated Short Range Communications (DSRC) spectrum band. Compared to cellular networks, WiFi-based V2X communication does not offer a pre-installed infrastructure and almost full spatial coverage. It works fully distributed and hence does not require a coordinating network infrastructure. Data are exchanged directly among neighboring vehicles at a very small delay compared to an indirect transmission via an infrastructure. Network management is reduced to an absolute minimum, which enables an immediate exchange of data among vehicles without bulky signaling procedures.

### 3. Processing the Received Signals and Possible Difficulties

Sensors such as radar and camera to perceive vehicles and lanes ahead and perform autonomous driving by longitudinal and lateral vehicle control. The autonomous driving algorithm of the Following Vehicle does not rely on GPS since the vehicle cannot receive correct GPS signals in some conditions, like when driving through tunnels. The following vehicle directly follows the preceding vehicle by calculating the steering angle based on a geometrical principle using the relative longitudinal and lateral distance with the preceding vehicle. Off-tracking is a major factor that harms the stability of the lateral dynamics of the platoon. To overcome the off-tracking problem, the Following Vehicle needs to use the trajectory of the tractor not the trailer of the preceding vehicle for its own target path. However, it is not possible for the Following Vehicle to perceive the position of the preceding vehicle's tractor only by camera. Target path is generated based on the trajectory of the preceding vehicle using V2V communication, it can be applied even on an unpaved road without a lane. A mono camera and a radar are mounted on the dashboard and front bumper, respectively, to perceive the center point of the preceding vehicle's bumper. The V2V module uses dual antennas, and they are installed inside the left and right side-mirrors to minimize the area of communication blind spot.

The Leading Vehicle controller creates its driven trajectory and transmits it to the Following Vehicle via V2V communication. Using the Leading Vehicle's trajectory, the Following Vehicle performs path planning (calculates its own target path to follow). Finally, the Following Vehicle implements path tracking control to follow the target path. In the same way, target paths are created between any adjacent Following Vehicles, so in essence, all Following Vehicles can follow the trajectory of the Leading Vehicle. In order for the Following Vehicle to create its own target path using the proposed path planning algorithm, longitudinal speed, lateral speed, yaw rate, and kingpin angle are required. Among them, vehicle speed, yaw rate, and kingpin angle can be measured, but their values are vulnerable to sensor noise. Since all signals measured by each truck are measured in its own coordinate system, the driving trajectory of the preceding vehicle received via V2V communication must be converted to fit the local coordinate system of the recipient truck.


Not able
Want to form
In a platoon
Leaving




## TASK 2

## Identify the relevant control behaviour for the trucks

**1. How can the distance to the precedence truck be guaranteed?**

It is guaranteed by the following actions,

1. Applying Desired Acceleration [Source – Wireless communication & Radar]
2. Maintaining Relative velocity [Source – Radar & Wireless communication]
3. Maintaining & Calculating Distance [Source – Radar & Camera]

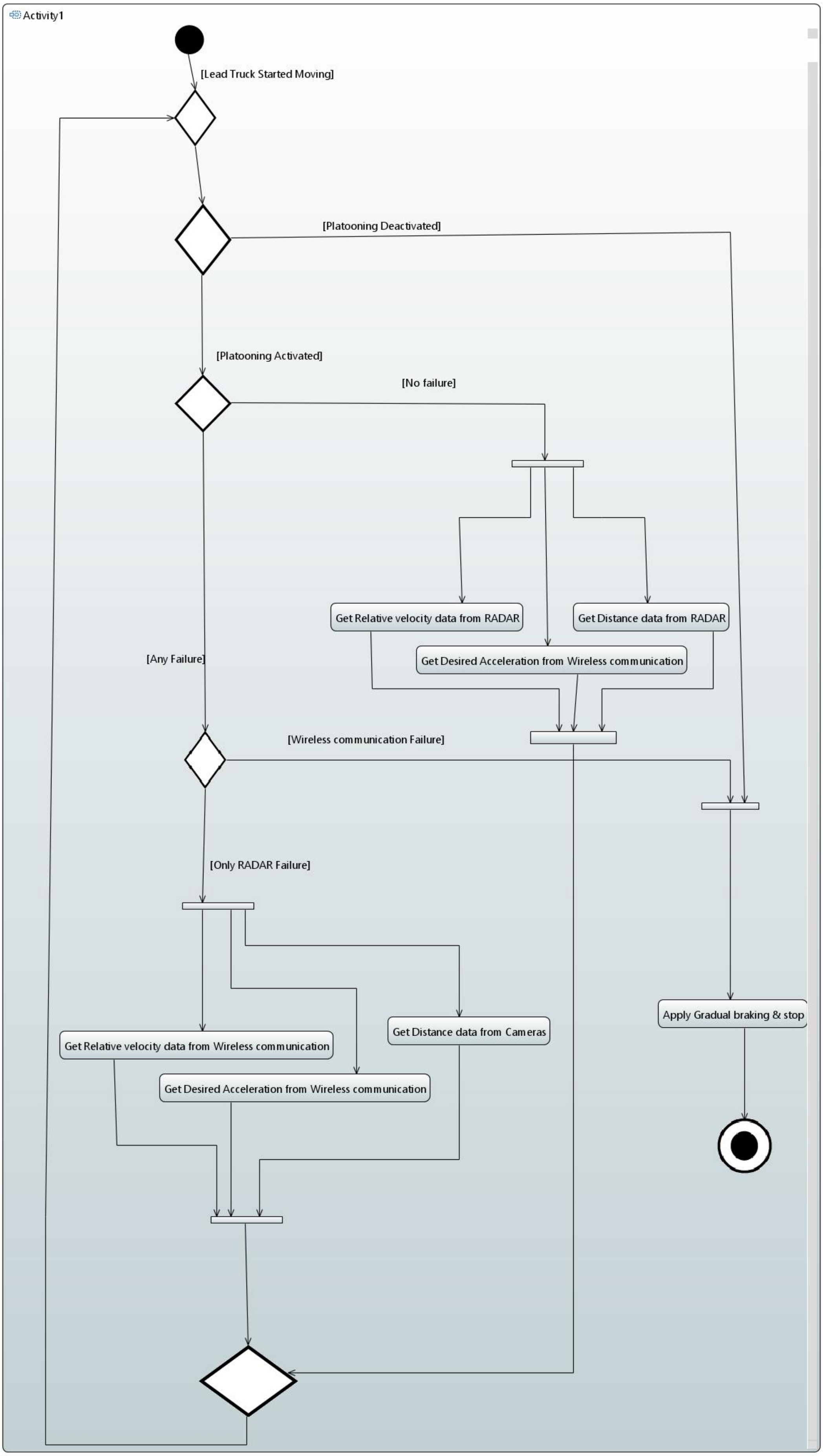
**2. What happen in cases of a e.g., communication failure -> is your system robust / still stable?**

In our design the robustness of the system is ensured for two types of failures,

1. Wireless communication failure - Loss of desired acceleration from the leading truck.
    - Since it is a major failure, it will impact platooning highly.
    - As per current design, without the wireless communication the platooning will not be continued.
    - The communication lost trucks will exit the platooning.
    - By applying gradual braking and with proper signalling, the truck will be stopped in the same lane.

2. Radar failure – Loss of Distance & relative velocity data between the trucks.
    - It is a minor failure, when compared with the loss of wireless communication.
    - The loss of distance & relative velocity data can be retrieved from cameras and wireless communication respectively.
    - Even with the loss of radar failure, the platooning will continue its work with the help of wireless communication & cameras.
3. **Use State Machines (Activity Diagrams) for the model-based specification**

Diagram is in the next page.


Activity1
[Lead Truck Started Moving]
[Platooning Deactivated]
[Platooning Activated]
[No failure]
Get Relative velocity data from RADAR
Get Distance data from RADAR
Get Desired Acceleration from Wireless communication
[Any Failure]
[Wireless communication Failure]
[Only RADAR Failure]
Get Relative velocity data from Wireless communication
Get Desired Acceleration from Wireless communication
Get Distance data from Cameras
Apply Gradual braking & stop