1 Truck Platooning

As well positive effects on for example traffic flow, as negative effects are expected from truck platoons. This is the case at entrance and exit ramps, where truck platoons could hinder other traffic while entering or exiting highways. Dependent on traffic conditions it could be desirable to affect truck platooning. For example to adjust speed, to switch lanes, to change the distance between trucks or to prohibit truck platooning.

Road authorities possibly play a role to limit the negative effects of truck platooning. One way is to send messages from road side units to truck platoons containing instructions for the behaviour of truck platoons. In the next chapter a use case clarifies some possibilities for road authorities.

1.1 Use case: Truck Platooning near on- and off-ramps

1.1.1 Introduction use case

1.1.1.1 Background

Communication between vehicles in a platoon and between platoons and road side units allow road authorities to communicate to platoons what behaviour is expected and, the other way around, to change behaviour of, for example, ramp meters.

Assumptions made for the use case:

- Vehicles entering highways are not-automated vehicles, therefore they cannot cooperate with a platoon;
- Not all vehicles on highways are driving in platoons;
- Vehicles in a platoon communicate to each other;
- The first vehicle in a platoon is the 'platoon leader'. The platoon leader is the only vehicle in the platoon which receives specific platoon-messages from other objects (other vehicles / road side units / etc.). If necessary the platoon leader sends messages received from other objects to the other vehicles in the platoon.
- Platoon leaders continuously send messages containing information about the platoon (number of vehicles / length of platoon / following distance of vehicles in platoon / etc.).

1.1.1.2 Objective (function)

The objective is to ensure a safe space for vehicles entering highways.

1.1.1.3 Expected behaviour

Platoons approaching entrance ramps are expected to enlarge their following distance to ensure safe entering of vehicles from entering ramps. On the other hand ramp meters can stop the traffic flow on entrance ramps until the platoon has passed the entrance ramp.

1.1.1.4 Expected impact

While traffic on entrance ramps have safe space to merge onto highways, it is expected that traffic will not be hindered by platoons.

1.1.2 Use case description

1.1.2.1 Situation

Two situations apply to this use case:

1. A truck platoon approaching an entrance ramp with a ramp meter. The platoon leader communicates with road side units which communicate with that ramp meter

(because of the distance from platoon to ramp meter, messages have to be forwarded). Now, the ramp meter is aware of the platoon approaching and adjusts its signal phasing and timing to be sure no vehicles are entering the entrance ramp while the platoon is passing by.
2. A truck platoon approaching an entrance ramp without a ramp meter. The platoon leader communicates with road side units which communicate that the platoon is approaching an entrance ramp and give instructions to enlarge the following distance of the vehicles in the platoon. Than vehicles on the entrance ramp can safely merge onto the highway.

1.1.2.2 Actors and relations

- Platoon: Vehicles in a platoon follow the first vehicle, called, platoon leader. All vehicles in a platoon communicate with each other. The platoon leader is the only vehicle communicating with other objects.
- Road authority: A road authority controls road side units.
- Road side units: Road side units communicate with each other (not specified in this document) and with platoon leaders.
- Ramp meter: A ramp meter is a road side unit including a traffic management function and communicates with other road side units and platoon leaders.
- Service provider: Service providers facilitate all types of communication.

1.1.2.3 Scenario

In this chapter the messaging of both situations is elaborated.

Starting points:

- DENM/SPAT/MAP/CAM-messages are primarily used;
- Communication between vehicles in platoons is left out of scope;
- Communication between infrastructure (road side units / ramp meters / etc.) is left out of scope.

Situation 1

1. The platoon leader collects CAM-messages of all vehicles in the platoon.
   - [CAM>basicVehicleContainerHighFrequency>*all fields*] & [CAM> referencePosition>*all fields*]
2. The platoon leader sends CAM-messages containing information about the platoon (length of platoon, position of first and last vehicle in platoon, following distance of vehicles in platoon)
   - [CAM>*PlatoonContainer not existing*]
3. Road side units and ramp meters collect as well CAM-messages of individual vehicles in platoons as platoon-CAM-messages of platoon leaders. Combining these messages gives an overview of the individual vehicles of each platoon.
4. The ramp meter calculates the estimated time of arrival of the platoon at the entrance ramp. The ramp meter adjusts its signal phasing and timing in a manner that no vehicles are entering the entrance ramp while the platoon is passing the entrance ramp.
5. The platoon leader and the road side units know when the last vehicle of the platoon has passed the entrance ramp, because of the CAM-message sent by the last vehicle. If in range, the platoon leader forwards this message to the ramp meter. If not in range, road side units forward this message to the ramp meter.
   - [CAM> referencePosition>*all fields*]
6. The ramp meter adjusts the signal phasing and timing to a ‘normal situation’.

Situation 2

1. The platoon leader collects CAM-messages of all vehicles in the platoon.
   - [CAM>basicVehicleContainerHighFrequency>*all fields*] & [CAM>

referencePosition>*all fields*]

2. The platoon leader sends CAM-messages containing information about the platoon (length of platoon, position of first and last vehicle in platoon, following distance of vehicles in platoon)
   - [CAM>*PlatoonContainer not existing*]
3. Road side units and ramp meters collect as well CAM-messages of individual vehicles in platoons as platoon-CAM-messages of platoon leaders. Combining these messages gives an overview of the individual vehicles of each platoon.
4. Road side units located upstream entrance ramps send DENM-messages containing the location of the entrance ramp and a command to enlarge the following distance of the vehicles in the platoon.
   - [DENM>*not existing*]
5. The platoon leader receives this DENM-message and commands all vehicles in the platoon to enlarge the following distance to x-meter.
6. The platoon leader knows when the last vehicle of the platoon has passed the entrance ramp, because of the CAM-message sent by the last vehicle.
   - [CAM> referencePosition>*all fields*]
7. The platoon leader commands all vehicles in the platoon to adjust the following distance to 'normal platoon-situation'.

Table 1: complementary data-elements

V2V	**V2I**	**I2V**
Roles of platoon	Length of platoon	Desired following distance
	position of first and last vehicle in platoon	Maximum length of platoon
	Following distance of vehicles in platoon	Prohibiting platooning
	Roles of platoon	Assigning a lane
	Number of vehicles in platoon	Maximum speed
		Location of ramps