

## Document Information

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<b>Chapter:</b>	Traffic Jam Warning (TJW)
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## Disclaimer

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## 4.7 Traffic Jam Warning (TJW)

### 4.7.1 General description

The Traffic Jam Warning (TJW) application helps PTW riders to prevent front and rear end collisions by warning the driver or the rider of the traffic jam ahead. It is not intended to be an imminent crash avoidance application, but it is to be used in a non-critical situation, most likely when the traffic jam is not yet visible to the PTW rider. It will warn the rider of the traffic jam ahead so as the rider can be aware before-hand and reduce speed.

### 4.7.2 Use case description at PTW side

The TJW application uses Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communications, to enable vehicles within the queue event to automatically broadcast their queued status information (e.g., rapid deceleration, lane location) to a nearby upstream vehicles and to infrastructure-based central entities such as the Traffic Control Centre. The infrastructure will broadcast queue warnings to vehicles in order to minimize or prevent rear-end or other secondary collisions. The TJW application is not intended to operate as a crash avoidance system. In contrast to such systems, TJW will engage well in advance of any potential crash situation, providing messages and information to the driver in order to minimize the likelihood of his needing to take crash avoidance or mitigation actions later. The TJW application performs two essential tasks: queue determination (detection and/or prediction) and queue information dissemination. In order to perform these tasks, TJW application can be vehicle-based or infrastructure-based or their combination.<sup>1</sup>

As for PTWs, the TJW application sends a DENM from the PTW to notify other vehicles from behind when the PTW is decelerating towards a traffic jam. Also, by receiving DENM from the vehicle, the rider can be informed the traffic jam at an early stage, giving the rider more time to face the traffic jam.

#### 4.7.2.1 Scenario description: PTW transmit DENM

According to the Triggering Conditions and Data Quality Traffic Jam in Basic System Profile by C2C-CC<sup>2</sup>, TJW is triggered in two patterns: “Dangerous End of Queue (here in after referred to as DEoQ)” and “Traffic Jam Ahead (here in after referred to as TJA)”. DEoQ is triggered

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<sup>1</sup> Connected Vehicle Reference Implementation Architecture

(<https://local.iteris.com/cvria/html/applications/applications.html> accessed on 16.11.2020)

<sup>2</sup> CAR 2 CAR Communication Consortium; C2C-CC Basic System Profile; Release 1.5.1

(<https://www.car-2-car.org/documents/basic-system-profile/> accessed on 16.11.2020)

when a vehicle detects the end of a traffic jam. TJA is triggered when a vehicle detects a traffic jam. Often, the transmitting vehicle itself will be within a traffic jam. PTWs will only transmit DENM when the triggering conditions for DEoQ is satisfied. This is because PTW accidents relevant to traffic jam tend to occur more at the end of a traffic jam than within a traffic jam. Also, traffic jams consist not only PTWs but also many cars. Therefore, it can be expected that those cars equipped with C-ITS (and other on board sensors) will be able to transmit TJA more accurately.

#### 4.7.2.1.1 DEoQ

The time sequence of this scenario is as follows.

##### Time sequence 1

A traffic jam appears in a non-urban road.

##### Time sequence 2

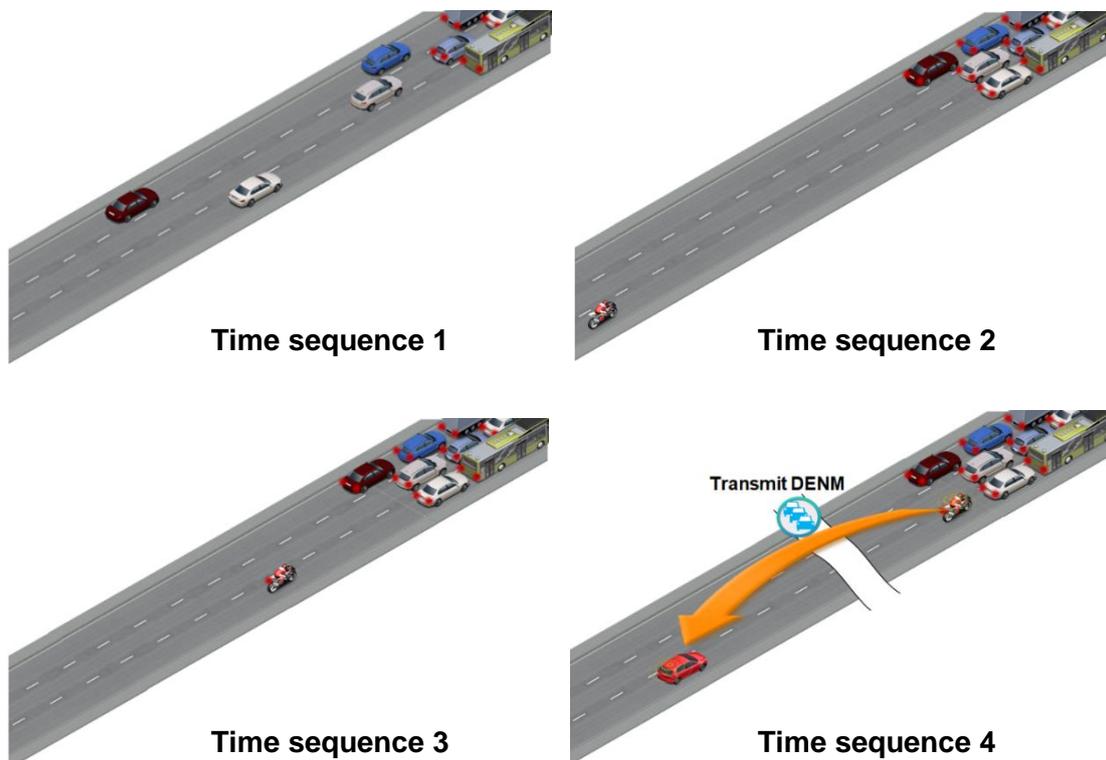
A PTW approaches towards the traffic jam.

##### Time sequence 3

The PTW rider recognizes the end of the traffic jam and decelerates.

##### Time sequence 4

The PTW transmits DENM.



© This picture was created using the C2C-CC Illustration Toolkit, owned by the CAR 2 CAR Communication Consortium

Figure 1: Overview of TJW (PTW transmit DENM - DEoQ)

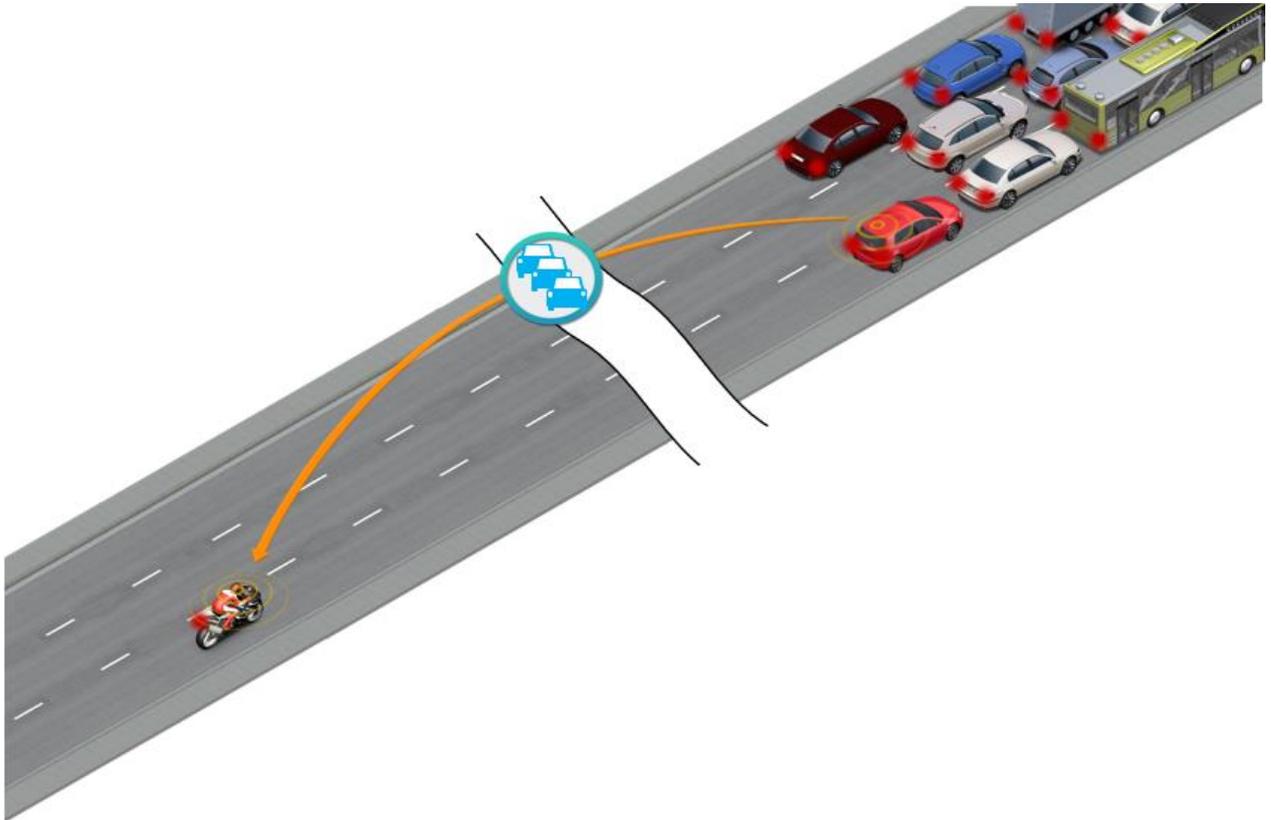
#### 4.7.2.2 Scenario description: PTW receive DENM

For the PTW receive DENM, PTWs will receive both DEoQ and TJA.

##### 4.7.2.2.1 DEoQ

The scenario of PTW receive DENM - DEoQ is as follows:

When a PTW approaches towards a traffic jam and receives DENM corresponding to DEoQ from a leading vehicle, the system will calculate the risk and will warn the rider accordingly.



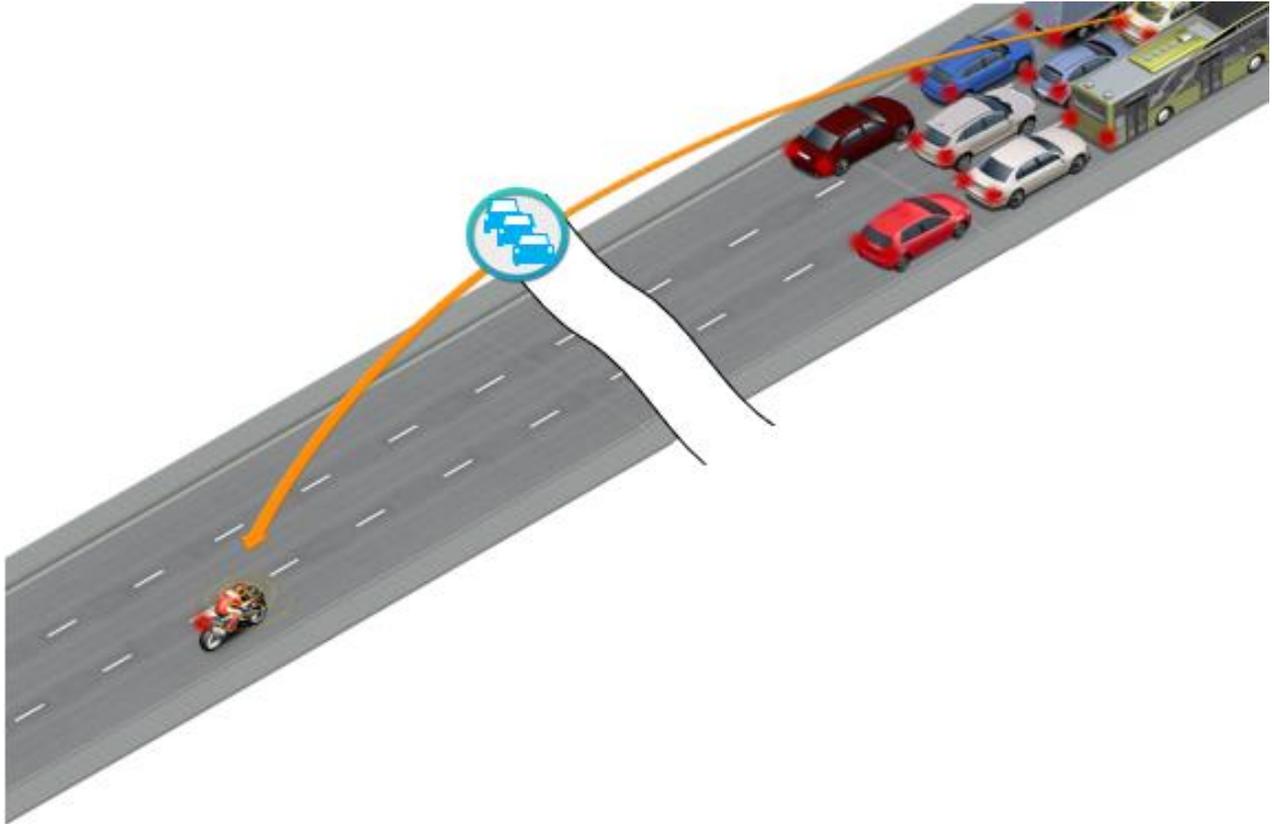
© This picture was created using the C2C-CC Illustration Toolkit, owned by the CAR 2 CAR Communication Consortium

Figure 2: Scenario description of TJW (PTW receive DENM - DEoQ)

#### 4.7.2.2.2 TJA

The scenario of PTW receive DENM - TJA is as follows:

When a PTW approaches towards a traffic jam and receives DENM corresponding to TJA from a leading vehicle, it will calculate the risk and will warn the rider accordingly.



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*Figure 3: Scenario description of TJA (PTW receive DENM - TJA)*

### **4.7.3 Use case description at car side**

This section shows the request for consideration of the PTW specific issues to car OEMs. Due to the PTW's high mobility, the potential of collision risk between a car and the PTW approaching from behind is remaining, even with car's small movement in traffic jam. For specific expectations to avoid this risk, refer to the Application Specification "Lane Change Warning / Blind Spot Warning (LCW/BSW)".

#### 4.7.4 Technical description

##### 4.7.4.1 PTW transmit DENM

###### 4.7.4.1.1 DEoQ

###### 4.7.4.1.1.1 State Flow

The function state flow from Service-In to Service-Out of PTW transmit DENM - DEoQ is indicated in the following figure.

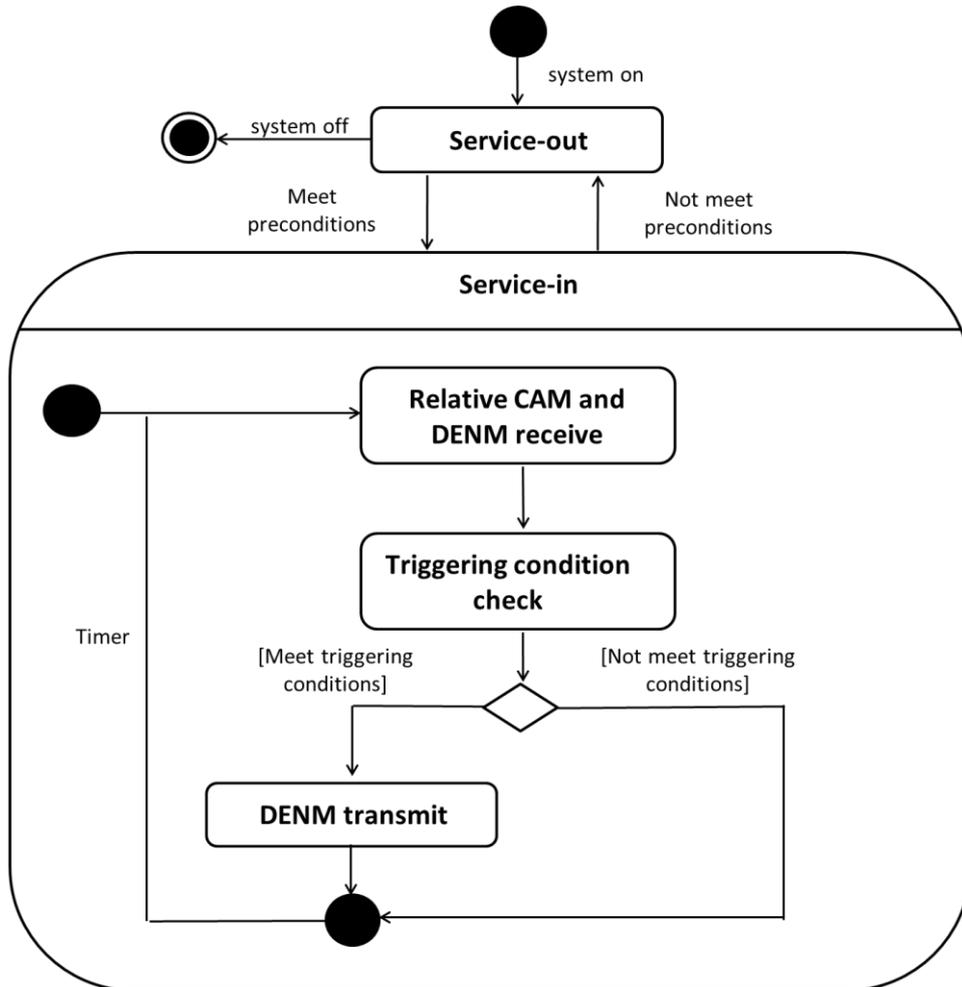


Figure 4: State Flow of TJW (PTW transmit DENM - DEoQ)

**4.7.4.1.1.2 Preconditions**

The preconditions of triggering conditions of PTW transmit DENM - DEoQ conform to the C2C-CC definition shown in below Figure 5 with the changes shown in Table 1.

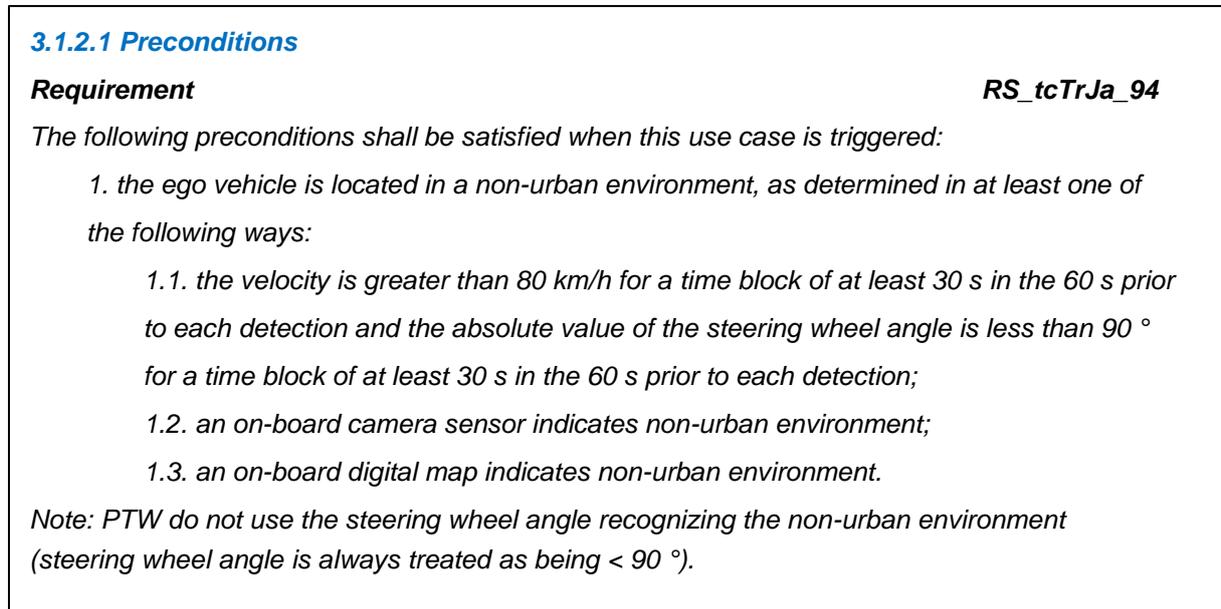


Figure 5: The preconditions of the C2C-CC definition

Table 1: Precondition changes of TJW (PTW transmit DENM - DEoQ)

Requirement number in C2C-CC	New requirement
<i>Service-specific conditions RS_tcTrJa_94 1.1.</i>	<b>Changed requirement to the following condition.</b>  1.1. the velocity is greater than <b>65</b> km/h for a time block of at least 30 s in the <b>180</b> s prior to each detection and the absolute value of the steering wheel angle is less than 90 ° for a time block of at least 30 s in the 60 s prior to each detection;
<i>Service-specific conditions RS_tcTrJa_94</i>	<b>Changed note to the following. (Added last sentence.)</b>  Note: PTW do not use the steering wheel angle recognizing the non-urban environment (steering wheel angle is always treated as being < 90 °). <b>And this alternative parameter is under consideration.</b>

**4.7.4.1.1.3 Triggering Conditions**

The triggering conditions of PTW transmit DENM - DEoQ conform to the C2C-CC definition shown in below Figure 6 with the changes shown in Table 2.

**3.1.2.2 Service-specific conditions**

**Requirement**

**RS\_tcTrJa\_105**

If the preconditions in RS\_tcTrJa\_94 and at least one of the following conditions are satisfied, the triggering conditions for this C-ITS service are fulfilled and the generation of a Decentralised Environmental Notification Message (DENM) shall be triggered:

- TRCO\_0 AND (TRCO\_2 OR TRCO\_3 OR TRCO\_4 OR TRCO\_5 OR TRCO\_6)
- TRCO\_1 AND TRCO\_2

**Table 3: ‘Traffic jam — dangerous end of queue’ service-specific conditions**

<b>Count</b>	<b>Triggering condition (TRCO)</b>	<b>Status</b>
TRCO_0	The ego vehicle is driving with an initial velocity exceeding 80 km/h and the initial deceleration is equal to or below 0,1 m/s <sup>2</sup> . The driver reacts to the dangerous end of queue by reducing the velocity from initial to target velocity of 30 km/h or less. The duration between initial and target velocity shall be 10 s or less. An instant deceleration between initial and target velocity exceeding -3.5 m/s <sup>2</sup> is detected.	driver reaction
TRCO_1	Passengers of the ego vehicle react to the traffic jam by enabling hazard lights for at least 3 s	driver reaction
TRCO_2	At least three other vehicles with a velocity of at least 7 km/h have hazard lights enabled for at least 3 s as indicated by: <ul style="list-style-type: none"> <li>• an on-board camera sensor; or</li> <li>• CAMs.</li> </ul>	environment or on-board sensors
TRCO_3	At least one DENM corresponding to the ‘Traffic jam - Dangerous end of queue’ C-ITS service has been received.	environment
TRCO_4	At least five different DENMs (i.e. with different actionIDs) corresponding to the ‘traffic jam - traffic jam ahead’ C-ITS service have been received from the downstream traffic.	environment
TRCO_5	At least one DENM corresponding to the ‘Special vehicle warning - Static safeguarding emergency vehicle’ C-ITS service has been received, with linkedCause equal to Traffic Condition or Dangerous End of Queue.	environment
TRCO_6	On-board sensors of the ego vehicle recognise that the vehicle is facing a dangerous end of queue.	on-board sensors

Figure 6: The triggering conditions of the C2C-CC definition

Table 2: Triggering conditions changes of TJW (PTW transmit DENM - DEoQ)

Requirement number in C2C-CC	New requirement
<p><i>Service-specific conditions</i></p> <p><i>RS_tcTrJa_105</i></p> <p><i>TRCO_0</i></p>	<p><b>Changed requirement to the following condition.</b></p> <p>The ego vehicle is driving with an initial velocity exceeding <b>65 km/h</b> and the initial deceleration is equal to or below 0.1 m/s<sup>2</sup>. The driver reacts to the dangerous end of queue by reducing the velocity from initial to target velocity of 30 km/h or less. The duration between initial and target velocity shall be 10 s or less. An instant deceleration between initial and target velocity exceeding 3.5 m/s<sup>2</sup> is detected.</p>

Note that in some cases such as when a PTW encounters a traffic jam but starts to filter through the traffic without decelerating not meeting the triggering condition, DENM will not be generated.

#### 4.7.4.1.1.4 Message Parameter

The message parameters of PTW transmit DENM - DEoQ conform to those stated in the C2C-CC definition.

**4.7.4.2 PTW receive DENM**

As already stated in 4.7.2.1 **Scenario description: PTW transmit DENM**, there are two scenario patterns of TJW: “Dangerous End of Queue” and “Traffic Jam Ahead”. For PTW receive DENM, riders will be warned of the traffic jam in both patterns.

**4.7.4.2.1 DEoQ**

**4.7.4.2.1.1 State flow**

The function state flow from Service-In to Service-Out of PTW receive DENM - DEoQ is indicated in the following figure.

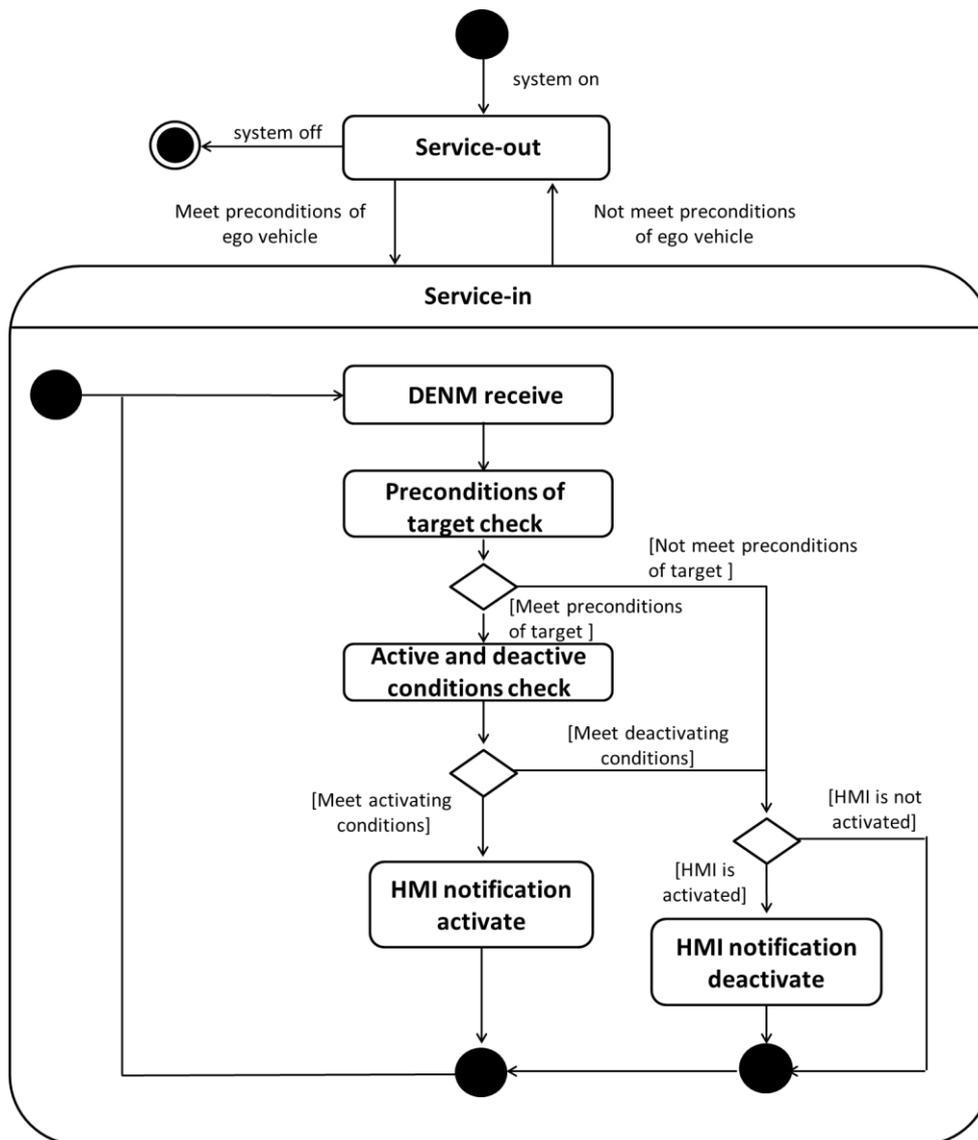


Figure 7: State Flow of TJW (PTW receive DENM - DEoQ)

**4.7.4.2.1.2 Preconditions**

The preconditions of PTW receive DENM - DEoQ is stated below.

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All of the following preconditions (PC\_1 to PC\_8) shall be satisfied every time before this use case is activated:

*Table 3: Preconditions of ego vehicle (PTW receive DENM - DEoQ)*

#	Item	Condition
PC_1	Ego vehicle	PTW
PC_2	Speed range	> 40 km/h
PC_3	Location	Any (Except urban areas)  (DEoQ from PTW will be triggered in both motorway and non-motorway environment.)
PC_4	Road type	-
PC_5	Time	-
PC_6	Weather	-
PC_7	Other conditions	-
PC_8	Out of scope	-

All of the preconditions of target (PC\_9 to PC\_13) shall be satisfied before active and deactivate condition check.

*Table 4: Preconditions of target (PTW receive DENM - DEoQ)*

#	Item	Condition
PC_9	Target	Event (Dangerous End of Queue)
PC_10	Relative distance	< 1000m
PC_11	causeCode	dangerousEndOfQueue(27)
PC_12	subCauseCode	unavailable(0)
PC_13	Vehicle type	NA

**4.7.4.2.1.3 Activation and deactivation requirements**

The activating and deactivating requirements of PTW receive DENM - DEoQ is stated below. Activate the warning scheme when all of the conditions below (AC\_1 AND AC\_2 AND AC\_3) are satisfied.

*Table 5: Activating conditions of TJW (PTW receive DENM - DEoQ)*

#	Item	Condition	Used Data
AC_1	Target	Relative DENM received (TJW-Dangerous End of Queue)	Target signal cause (causeCode and subCauseCode)
AC_2	Event position	On the route of ego vehicle	pathHistory
AC_3	TTC	Less than 15s	eventPosition eventSpeed

Deactivate the warning when at least one of the conditions below (DC\_1 OR DC\_2) is satisfied.

*Table 6: Deactivating conditions of TJW (PTW receive DENM - DEoQ)*

#	Item	Condition	Used Data
DC_1	Duration of received DENM	20s	referenceTime
DC_2	Position	Arrive within 15m radius of the DENM transmitted position	eventPosition

#### 4.7.4.2.2 TJA

##### 4.7.4.2.2.1 State flow

The function state flow from Service-In to Service-Out of PTW receive DENM - TJA is same as PTW receive DENM - DEoQ.

##### 4.7.4.2.2.2 Preconditions

The preconditions of PTW receive DENM - TJA is stated below.

All of the following preconditions (PC\_1 to PC\_8) shall be satisfied every time before this use case is activated:

*Table 7: Preconditions of ego vehicle (PTW receive DENM - TJA)*

#	Item	Condition
PC_1	Ego vehicle	PTW
PC_2	Speed range	> 40 km/h (<180 km/h)
PC_3	Location	Any (Except urban areas) (Except motorways)
PC_4	Road type	-
PC_5	Time	-
PC_6	Weather	-
PC_7	Other conditions	-
PC_8	Out of scope	-

All of the preconditions of target (PC\_9 to PC\_13) shall be satisfied before active and deactivate condition check.

*Table 8: Preconditions of target (PTW receive DENM - TJA)*

#	Item	Condition
PC_9	Target	Event (Traffic Jam Ahead)
PC_10	Relative distance	< 1000m
PC_11	causeCode	trafficCondition(1)
PC_12	subCauseCode	unavailable(0)

PC_13	Vehicle type	NA
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**4.7.4.2.2.3 Activation and deactivation requirements**

The activating and deactivating requirements of PTW receive DENM - TJA is stated below. Activate the warning scheme when all of the conditions below (AC\_1 AND AC\_2 AND AC\_3) are satisfied.

*Table 9: Requirements of TJW (PTW receive DENM - TJA)*

#	Item	Condition	Used Data
AC_4	Target	Relative DENM received (TJW-Traffic Jam Ahead)	Target signal cause (causeCode and subCauseCode)
AC_5	Event position	On the route of ego vehicle	pathHistory
AC_6	TTC	Less than 15s	eventPosition eventSpeed

The deactivating conditions are same as PTW receive DENM - DEoQ.

## **Abbreviations**

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Please refer to the abbreviations in Preamble document.