Document Information

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Chapter:	Adverse Weather Warning (AWW)
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Disclaimer

4.4 Adverse Weather Warning (AWW)

4.4.1 General description

The Adverse Weather Warning (AWW) application aims to increase traffic safety by warning riders about critical weather conditions ahead, particularly when they are hard to perceive in advance: for example fog and heavy rain. The road weather data used for this application is provided by connected vehicles. Optionally, it can be also provided via Road Side Unit (RSU) which receive the latest information from weather forecast services.
AWW will help PTW riders to avoid areas experiencing adverse weather conditions and/or take appropriate action to prepare for adverse weather. It may also help PTW riders to reduce their traveling time.
This AWW is also intended to be an accident avoidance application; it is to be used in non-critical situations, particularly when the adverse weather conditions are likely to lead to reduction in visibility or traction. AWW will warn the rider for variety of poor weather conditions ahead so the rider can adjust their riding style, change their clothing or alter their route and avoid the adverse conditions.

4.4.2 Use case description

AWW utilises connected vehicle technologies, including Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communications, to enable vehicles within the weather event to automatically broadcast weather status information (e.g. precipitation, fog, low friction surface conditions) to nearby upstream vehicles and to infrastructure-based central entities such as the Traffic Control Centre. The infrastructure will broadcast weather warnings to vehicles in order to alert other vehicle users of the adverse conditions. The AWW is similar to Traffic Jam Warning (TJW), which also aims to alert vehicle users to potential risks ahead in their route. AWW is useful to vehicle users if issued further in advance of the adverse weather conditions, in order to provide the user with adequate time to consider changing their route. The AWW application performs two essential tasks: adverse weather condition determination (detection and/or estimation) and adverse weather information dissemination. In order to perform these tasks, AWW can be vehicle-based, infrastructure-based or utilise a combination of each.
The AWW can be considered to be more critical for PTW riders than it is for drivers of other vehicles such as cars, as adverse weather conditions particularly those involving reduction in traction are likely to be significantly more dangerous to PTWs than other vehicles.

4.4.2.1 Scenario description: PTW transmit DENM

According to the C2C-CC definition[1], adverse weather condition Decentralized Environmental Notification Messages (DENMs) can be triggered by three possible scenarios; fog, precipitation and traction loss. The triggering conditions for fog and precipitation rely heavily on sensors and systems that may not be available on a PTW. For example, the determination of a precipitation condition requires wiper status, which is not available on PTW. It is therefore expected that while it is possible for PTWs to transmit these DENMs, the reliability level will not be equal to that of other Co-operative Intelligent Transport System (C-ITS) vehicles that are able to make use of more data.

4.4.2.1.1 Fog

The PTW encounters foggy conditions. The rider adjusts their riding style to compensate for the lowered visibility. The rider may also operate the optionally fitted rear fog light. The PTW then sends a DENM notifying other vehicles and infrastructure of the foggy conditions.
In order to more reliably determine that the conditions are foggy, the PTW could be fitted with a visibility range measurement device.

Time sequence 1

Foggy conditions occur.

Time sequence 2

A PTW approaches the foggy conditions.

Time sequence 3

The PTW rider recognizes the reduction in visibility and decelerates. The rider may also operate the optionally fitted rear fog light. If the PTW is fitted with a visibility range measurement device, it could be determined that the conditions are foggy.

Time sequence 4

The PTW transmits DENM.

[1] CAR 2 CAR Communication Consortium; C2C-CC Basic System Profile; Release 1.5.0

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

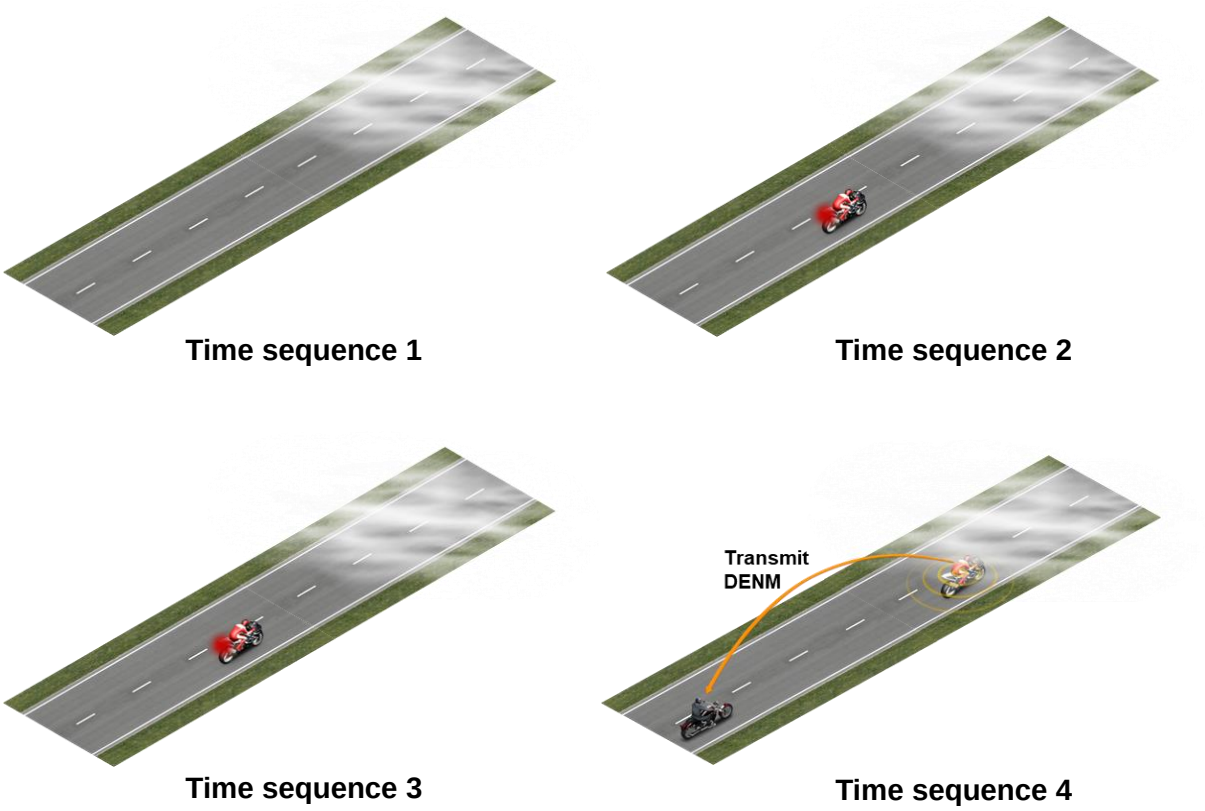

Figure 1: Overview of AWW (PTW transmit DENM - fog)

4.4.2.1.2 Precipitation

PTWs are not fitted with wipers or rain measurement devices, so this scenario is not available for PTWs.

4.4.2.1.3 Traction loss

The PTW experiences a loss of traction due to a low friction road surface (e.g. ice, snow, water etc.). The PTW sends a DENM notifying other vehicles and infrastructure of the low friction conditions.

Time sequence 1

A PTW approaches low friction road surface.

Time sequence 2

The PTW recognises a loss of traction.

Time sequence 3

The PTW transmits DENM.

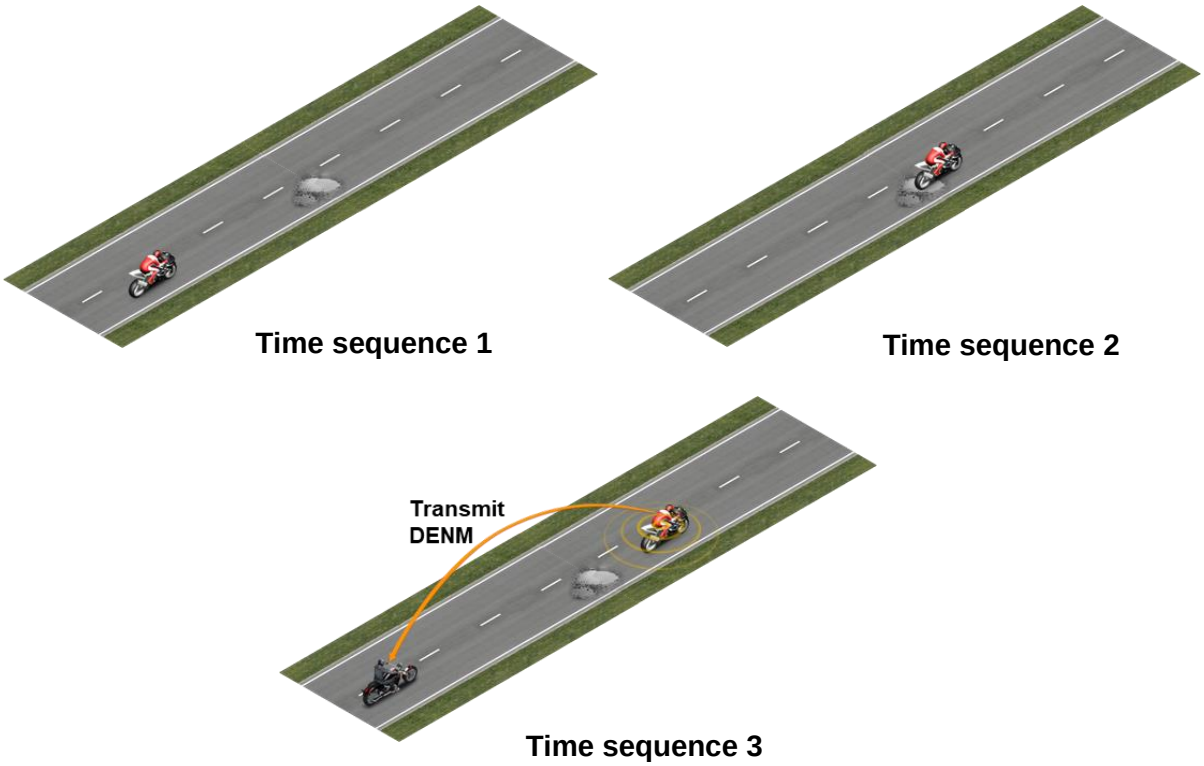

Figure 2: Overview of AWW (PTW transmit DENM - traction loss)

4.4.2.2 Scenario description: PTW receive DENM

According to the C2C-CC definition, there are three possible scenarios that may trigger an AWW DENM. Under the scenario of PTW receive DENM, the PTW will receive these DENMs and notify the rider of the adverse weather conditions. PTWs will be able to receive DENMs from a large range as other C-ITS vehicles or infrastructure can pass on the messages. In each of these scenarios the PTW's handling of the received DENM will be similar.

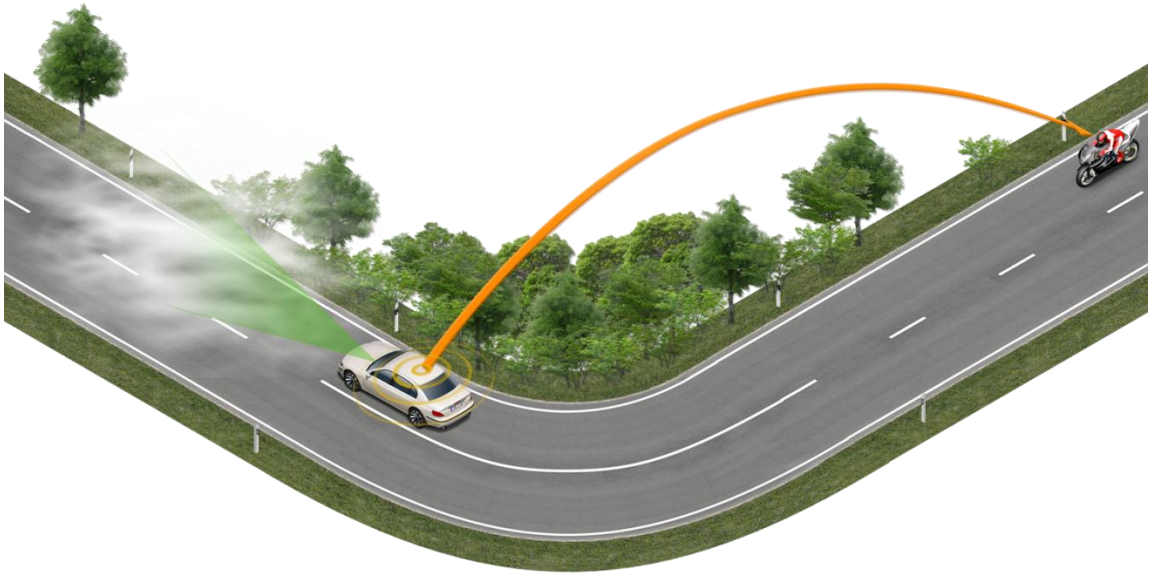

Figure 3: Use case of AWW (PTW receive DENM): DENMs from other C-ITS vehicles

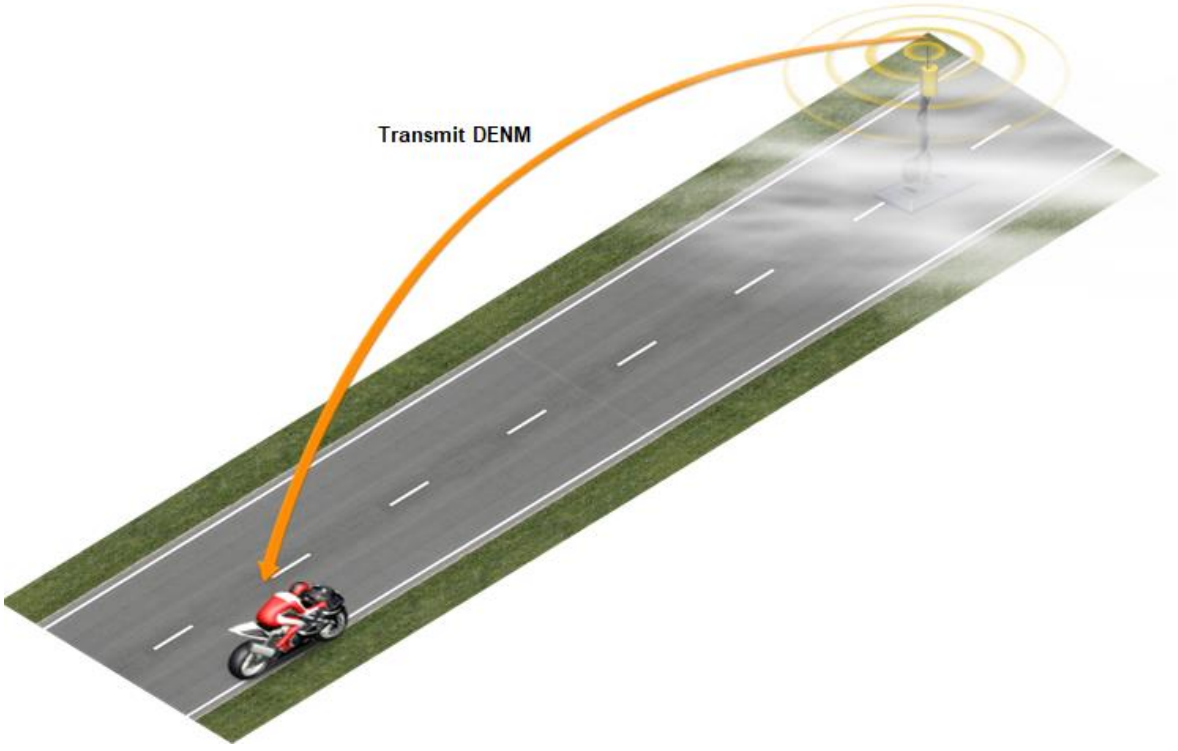

Figure 4: Use case of AWW (PTW receive DENM): DENMs from infrastructure

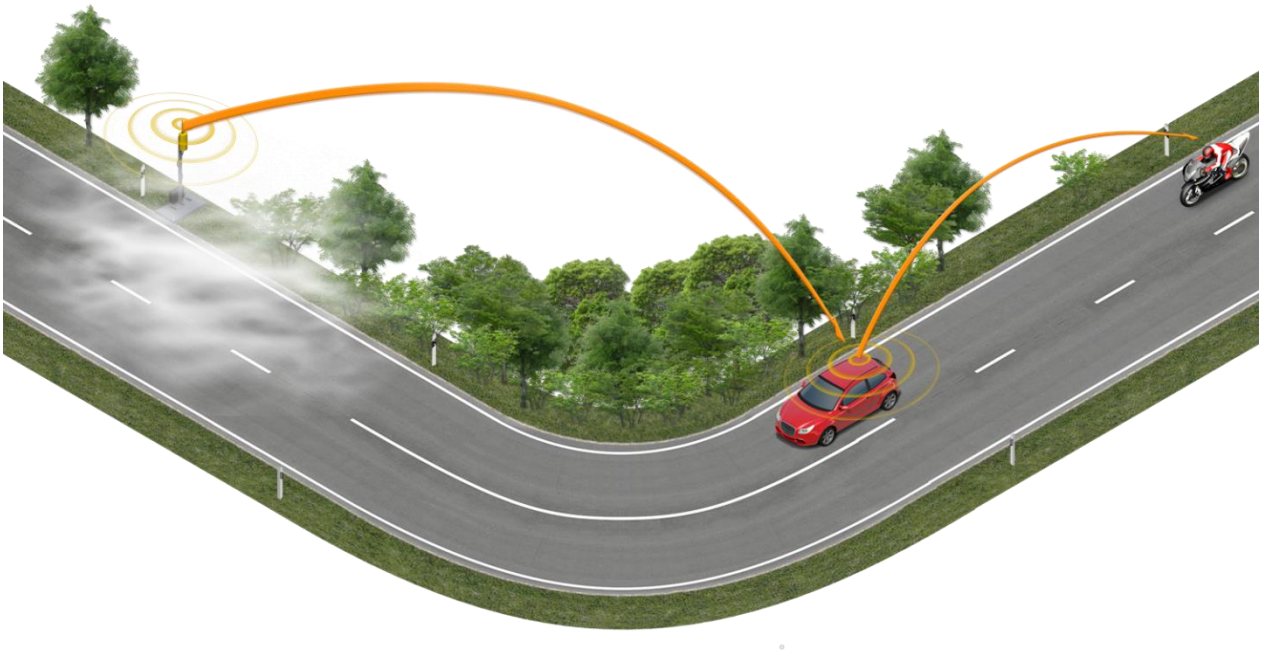

Figure 5: Use case of AWW (PTW receive DENM): DENMs from infrastructure via other vehicles

4.4.2.2.1 Fog

The scenario of PTW receive DENM – fog is as follows:

When a PTW approaches foggy conditions and receives DENM corresponding to fog from a leading vehicle or C-ITS station, the system will calculate the risk and warns the rider accordingly.

4.4.2.2.2 Precipitation

The scenario of PTW receive DENM – precipitation is as follows:

When a PTW approaches heavy precipitation and receives DENM corresponding to precipitation from a leading vehicle or C-ITS station, the system will calculate the risk and warns the rider accordingly.

4.4.2.2.3 Traction loss

The scenario of PTW receive DENM - traction loss is as follows:

When a PTW approaches an area of low friction road surface and receives DENM corresponding to low friction from a leading vehicle or C-ITS station, the system will calculate the risk and warns the rider accordingly.

4.4.3 Technical description

4.4.3.1 PTW transmit DENM

4.4.3.1.1 Fog

4.4.3.1.1.1 State Flow

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

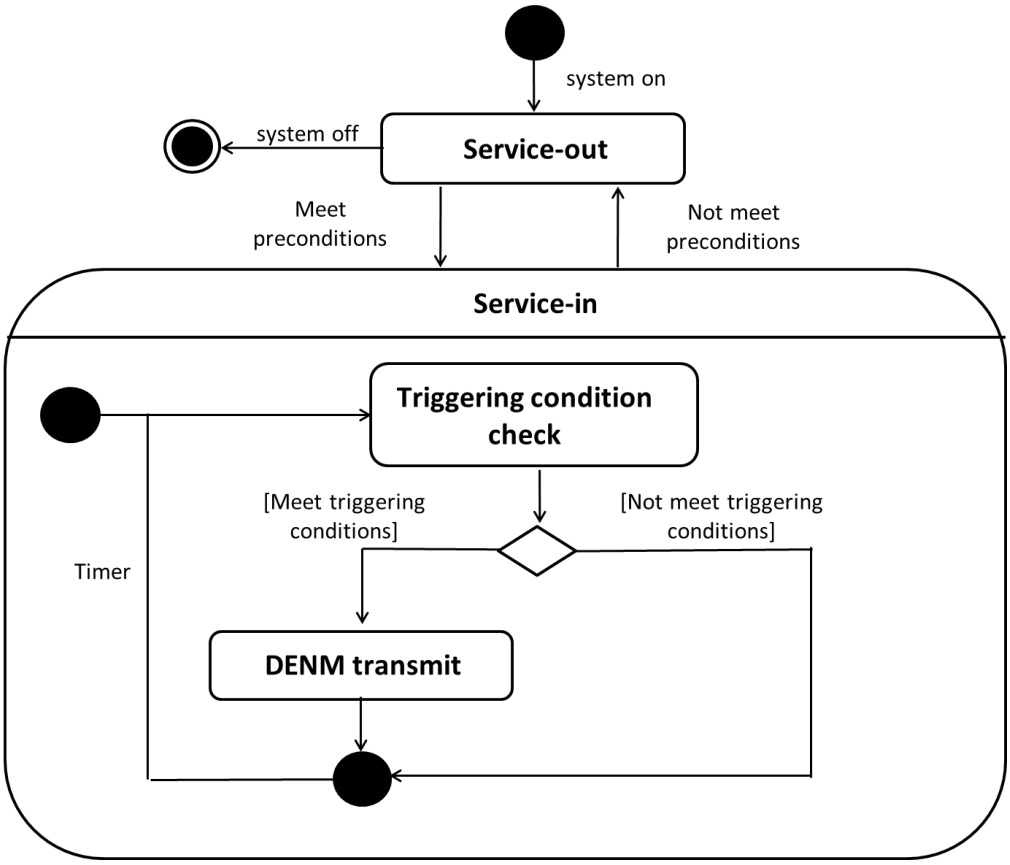

Figure 6: State Flow of AWW (PTW transmit DENM - fog)

4.4.3.1.1.2 Preconditions

The preconditions of PTW transmit DENM – fog are stated below.

All of the following preconditions (PC_1 to PC_8) shall be satisfied every time before this use case is activated:

Table 1: Preconditions of ego vehicle (PTW transmit DENM - fog)

#	**Item**	**Condition**
PC_1	Ego vehicle	PTW
PC_2	Speed range	-
PC_3	Location	-
PC_4	Road type	-
PC_5	Time	-
PC_6	Weather	-
PC_7	Other conditions	-
PC_8	Out of scope	-

4.4.3.1.1.3 Triggering Conditions

The triggering conditions conform to the C2C-CC definition shown in Figure 7 below.

3.1.2.2 Service-specific conditions

Requirement ***RS_tcAdWe_95***

If the preconditions in RS_tcAdWe_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 DENM shall be triggered:

- *driver reaction and light status:*
  a) the driver enables the rear fog-light and the low-beam light is enabled. All these conditions shall be valid for more than 20 s (to minimise risk of misuse by driver, conditions have to be valid for a longer period);
  b) the driver enables the rear fog-light, the low-beam light is enabled and the vehicle velocity is less than 60 km/h. All these conditions shall be valid for a duration greater than 20 s;
- *visibility range measurement device:*
  c) the visibility due to fog is less than 80 m +/-40 m tolerance for more than 5 s (the obscured view has to be detected for a reasonable period. The period is shorter than for conditions a) and b) due to more reliable information);
  d) the visibility due to fog is less than 80 m +/-40 m tolerance and the vehicle velocity is less than 60 km/h (if the vehicle is in a non-urban area, this speed could be an indication of reduced visibility) for more than 5 s

Figure 7: The triggering conditions of the C2C-CC definition[2]

4.4.3.1.1.4 Message Parameter

The message parameters conform to those stated in the C2C-CC definition.

[2] CAR 2 CAR Communication Consortium; C2C-CC Basic System Profile; Release 1.5.1; Triggering Conditions and Data Quality Adverse Weather Conditions CAR 2 CAR Communication Consortium https://www.car-2-car.org/fileadmin/documents/Basic_System_Profile/Release_1.5.1/C2CCC_RS_2002_AdverseWeather.pdf accessed 08.10.2020)

4.4.3.1.2 Traction loss

4.4.3.1.2.1 State Flow

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

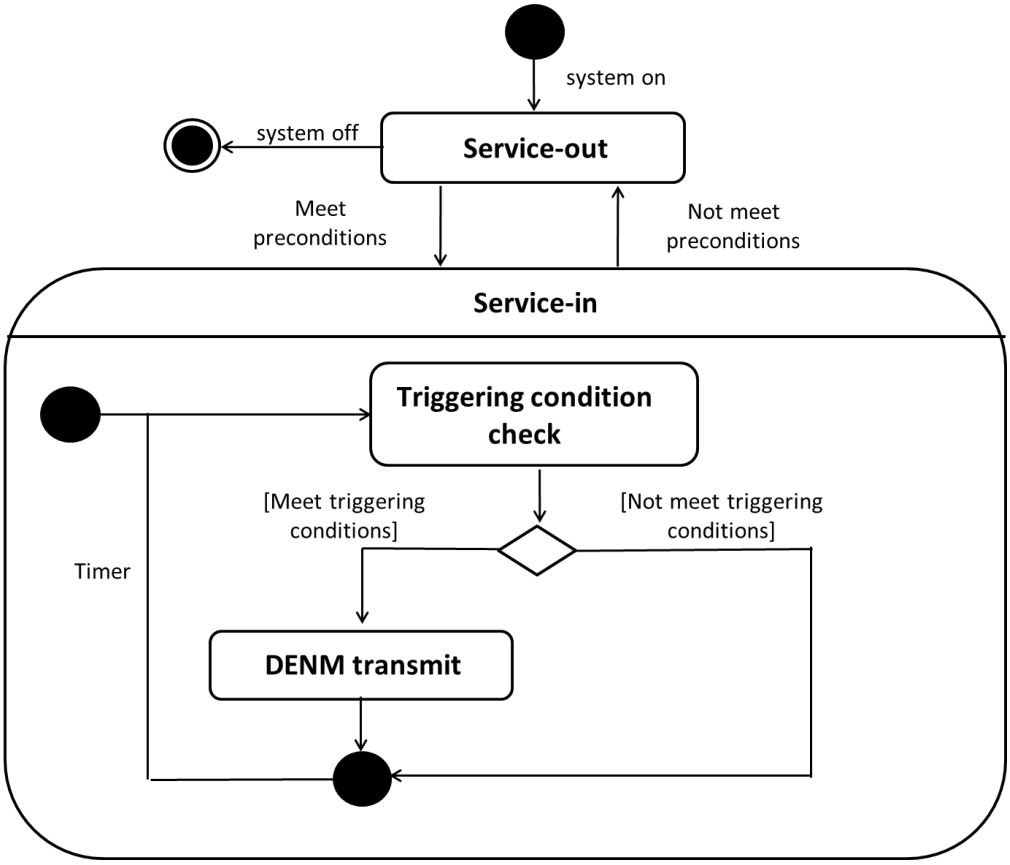

Figure 8: State Flow of AWW (PTW transmit DENM - traction loss)

4.4.3.1.2.2 Preconditions

The preconditions of PTW transmit DENM – traction loss are stated below.

All of the following preconditions (PC_1 to PC_8) shall be satisfied every time before this use case is activated:

Table 2: Preconditions of ego vehicle (PTW transmit DENM - traction loss)

#	**Item**	**Condition**
PC_1	Ego vehicle	PTW
PC_2	Speed range	-
PC_3	Location	-
PC_4	Road type	-
PC_5	Time	-

PC_6	Weather	-
PC_7	Other conditions	-
PC_8	Out of scope	-

4.4.3.1.2.3 Triggering Conditions

The triggering conditions conform to the C2C-CC definition shown in Figure 9 below.

3.3.2.2 Service-specific conditions

Requirement ***RS_tcAdWe_150***

If the precondition in RS_tcAdWe_149 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 DENM shall be triggered.

- *on the basis of positive acceleration:*
  a) on the basis of Anti-Slip Regulation (ASR), throttle position, vehicle acceleration and vehicle velocity. An ASR-request is active for at least 200 ms (as for other safety functions depending on ASR). The throttle position is pressed on average more than 30 % of the max value while ASR intervention is active. The acceleration of the vehicle (acceleration according to filtered vehicle bus signal) is less than 40 % of the vehicle acceleration on µ-High (dry asphalt 0,85) at the same start speed and driving manoeuvre (No detailed values have been put here to cover different drive configurations, e.g. two-wheel vs. four-wheel drive);
  b) on the basis of ASR, throttle position, vehicle acceleration and vehicle velocity. An ASR-request is active for at least 200 ms. The throttle position is pressed on average more than 30 % of the max value while ASR intervention is active. The acceleration of the vehicle (acceleration according to filtered vehicle bus signal) is less than 20 % of the vehicle acceleration on µ-High (dry asphalt 0,85) at the same start speed and driving manoeuvre;
  c) on the basis of ASR, throttle position, vehicle acceleration and vehicle velocity. An ASR-request is active for at least 200 ms. The throttle position is pressed on average more than 30 % of the max value while ASR intervention is active. The acceleration of the vehicle (acceleration according to filtered vehicle bus signal) is less than 10 % of the vehicle acceleration on µ-High (dry asphalt 0,85) at the same start speed and driving manoeuvre;
  d) on the basis of ASR and throttle position. An ASR-request is active for at least 200 ms. The throttle position is pressed on average less than 30 % of the max value (so as not to cause an ASR intervention on ground with high friction value) while ASR intervention is active;

- *on the basis of negative acceleration (deceleration):*
  e) on the basis of Anti-lock Braking System (ABS), braking pressure and deceleration. ABS intervention is active for more than 200 ms (according to other safety functions depending on ABS). Braking pressure is more than 20 % of maximum capable braking pressure. The deceleration of the vehicle (deceleration according to filtered vehicle bus signal) is less than 50 % of the vehicle deceleration on µ-high (dry asphalt 0,85) at the same start speed and driving manoeuvre;
  f) on the basis of ABS, braking pressure and deceleration. ABS intervention is active for more than 200 ms. Braking pressure is more than 20 % of maximum capable braking pressure. The deceleration of the vehicle (deceleration according to filtered vehicle bus signal) is less than 25 % of the vehicle deceleration on µ-high (dry asphalt 0,85) at the same start speed and driving manoeuvre;
  g) on the basis of ABS, braking pressure and deceleration. ABS intervention is active for more than 200 ms. Braking pressure is more than 20 % (so as not to cause an ABS intervention on ground with high friction value) of maximum capable braking pressure. The deceleration of the vehicle (deceleration according to filtered vehicle bus signal) is less than 10 % of the vehicle deceleration on µ-high (dry asphalt 0,85) at the same start speed and driving manoeuvre;
  h) on the basis of ABS and braking pressure. ABS intervention is active for more than 200 ms. Braking pressure is less than 20 % of maximum capable braking pressure;
- *on the basis of friction coefficient estimation:*
  i) the friction coefficient is less than 0,3 for at least 5 s (the friction coefficient of ice is < 0,2; for snow and loose chippings, it is approx. 0,4. The friction coefficient needs to be detected for a certain period);
  j) the friction coefficient is less than 0,2 for at least 5 s.

Figure 9: The triggering conditions of the C2C-CC definition

4.4.3.1.2.4 Message Parameter

The message parameters conform to those stated in the C2C-CC definition.

4.4.3.2 PTW receive DENM

4.4.3.2.1 Fog

4.4.3.2.1.1 State flow

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

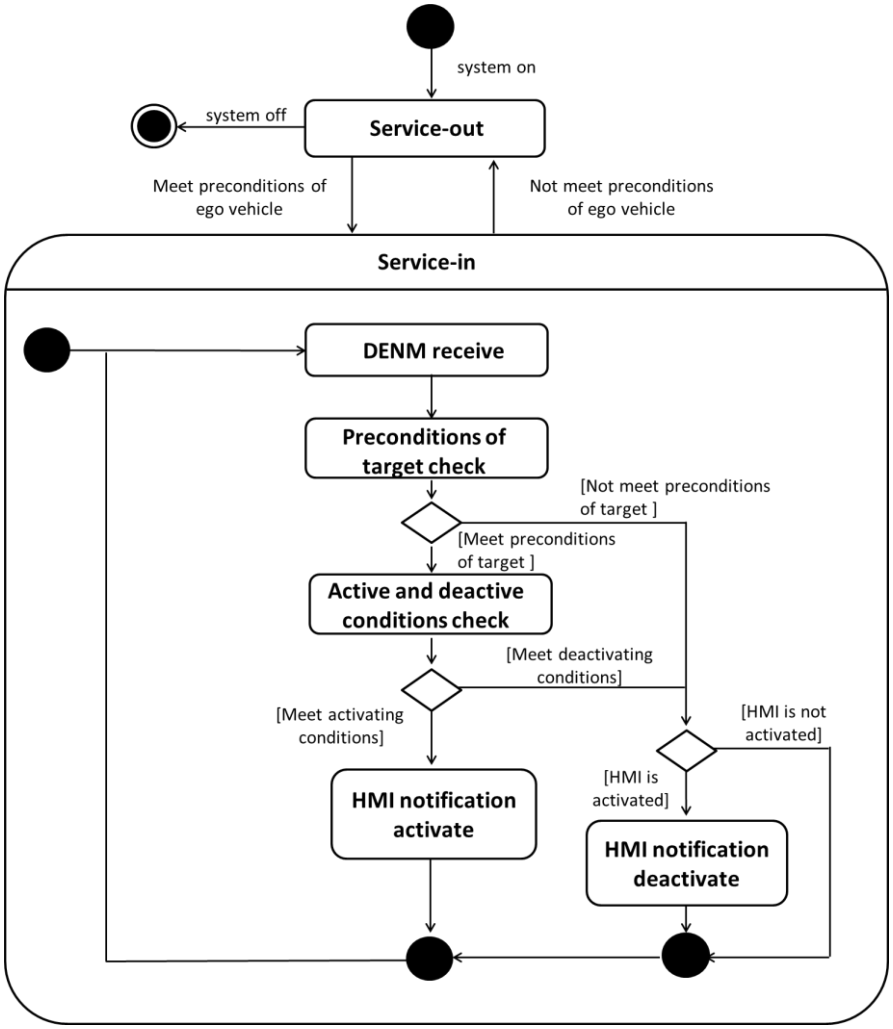

Figure 10: State Flow of AWW (PTW receive DENM - fog)

4.4.3.2.1.2 Preconditions

The preconditions of PTW receive DENM – fog are stated below.

All of the 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 - fog)

#	**Item**	**Condition**
PC_1	Ego vehicle	PTW
PC_2	Speed range	-
PC_3	Location	-
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 - fog)

#	**Item**	**Condition**
PC_9	Target	Event (Adverse weather condition - fog)
PC_10	Relevance distance	< 1000m (New DENM) < 5000m (Update DENM)
PC_11	causeCode	adverseWeatherCondition-Visibility(18)
PC_12	subCauseCode	unavailable(0) or fog(1)
PC_13	Vehicle type	NA

4.4.3.2.1.3 Activation and deactivation requirements

The activation and deactivation requirements of PTW receive DENM – fog are stated below.

The warning will be activated when all of the conditions below (AC_1 AND AC_2 AND AC_3) are satisfied.

Table 5: Activating conditions of AWW (PTW receive DENM - fog)

#	**Item**	**Condition**	**Used data**
AC_1	Target	Relative DENM received (Adverse weather condition - fog)	Target signal cause (causeCode and subCauseCode)
AC_2	Event position	On the route of ego vehicle	Estimated route of ego vehicle (latitude, longitude, path history etc.) Target signal position (eventPosition)
AC_3	Event position	Within event's relevance distance from ego vehicle	Estimated route of ego vehicle (latitude, longitude, path history etc.) Target signal position (eventPosition)

The warning will be deactivated when at least one of the conditions below (DC_1 OR DC_2) is satisfied.

Table 6: Deactivating conditions of AWW (PTW receive DENM - fog)

#	**Item**	**Condition**	**Used data**
DC_1	Duration of received DENM	300s	Current time Target signal detection time (detectionTime)
DC_2	Position	Arrive within 15m radius of the DENM transmitted position	Position of ego vehicle (latitude, longitude) Target signal position (eventPosition)

4.4.3.2.2 Precipitation

4.4.3.2.2.1 State flow

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

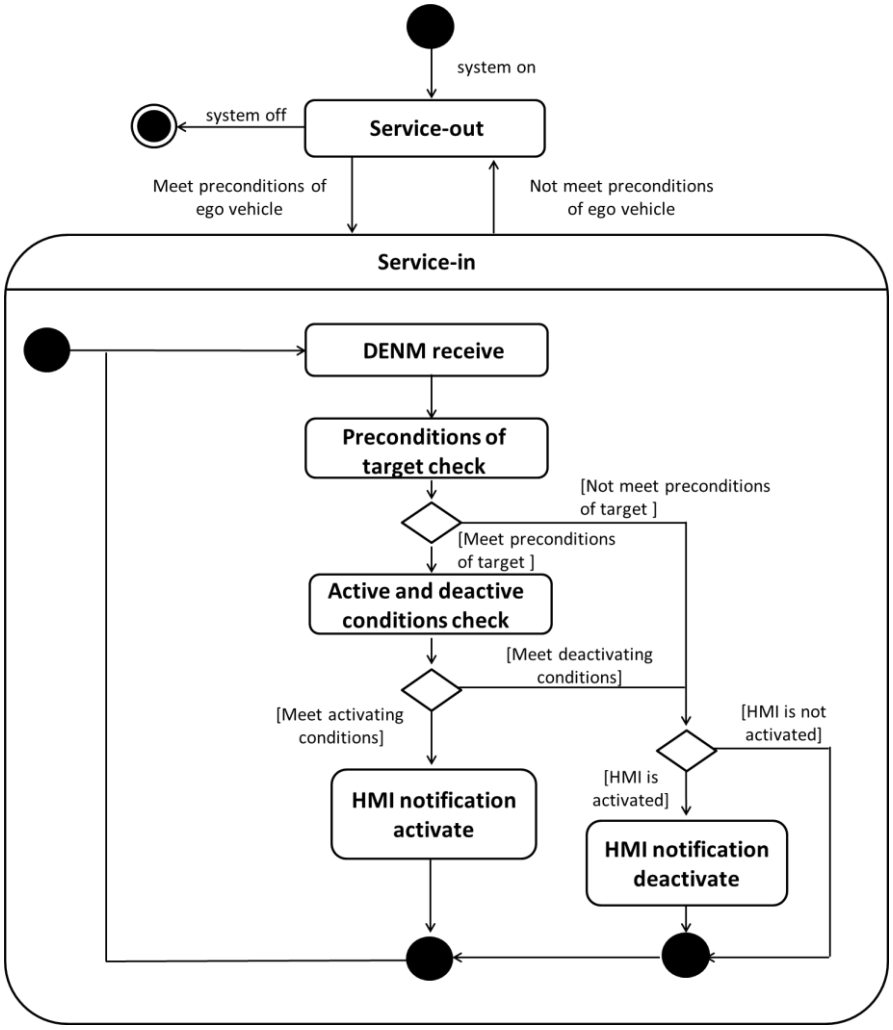

Figure 11: State Flow of AWW (PTW receive DENM - precipitation)

4.4.3.2.2.2 Preconditions

The preconditions of PTW receive DENM – precipitation are stated below.

All of the 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 - precipitation)

#	**Item**	**Condition**
PC_1	Ego vehicle	PTW
PC_2	Speed range	-
PC_3	Location	-
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 - precipitation)

#	**Item**	**Condition**
PC_9	Target	Event (Adverse weather condition - precipitation)
PC_10	Relevance distance	< 1000m (New DENM) < 5000m (Update DENM)
PC_11	causeCode	adverseWeatherCondition-Precipitation(19)
PC_12	subCauseCode	unavailable(0), heavyRain(1) or heavySnowfall(2)
PC_13	Vehicle type	NA

4.4.3.2.2.3 Activation and deactivation requirements

The activation and deactivation requirements of PTW receive DENM – precipitation are stated below.

The warning will be activated when all of the conditions below (AC_1 AND AC_2 AND AC_3) are satisfied.

Table 9: Activating conditions of AWW (PTW receive DENM - precipitation)

#	**Item**	**Condition**	**Used data**
AC_1	Target	Relative DENM received (Adverse weather condition - precipitation)	Target signal cause (causeCode and subCauseCode)
AC_2	Event position	On the route of ego vehicle	Estimated route of ego vehicle (latitude, longitude, path history etc.) Target signal position (eventPosition)
AC_3	Event position	Within event's relevance distance from ego vehicle	Estimated route of ego vehicle (latitude, longitude, path history etc.) Target signal position (eventPosition)

The warning will be deactivated when at least one of the conditions below (DC_1 OR DC_2) is satisfied.

Table 10: Deactivating conditions of AWW (PTW receive DENM - precipitation)

#	**Item**	**Condition**	**Used data**
DC_1	Duration of received DENM	300s	Current time Target signal detection time (detectionTime)
DC_2	Position	Arrive within 15m radius of the DENM transmitted position	Position of ego vehicle (latitude, longitude) Target signal position (eventPosition)

4.4.3.2.3 Traction loss

4.4.3.2.3.1 State flow

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

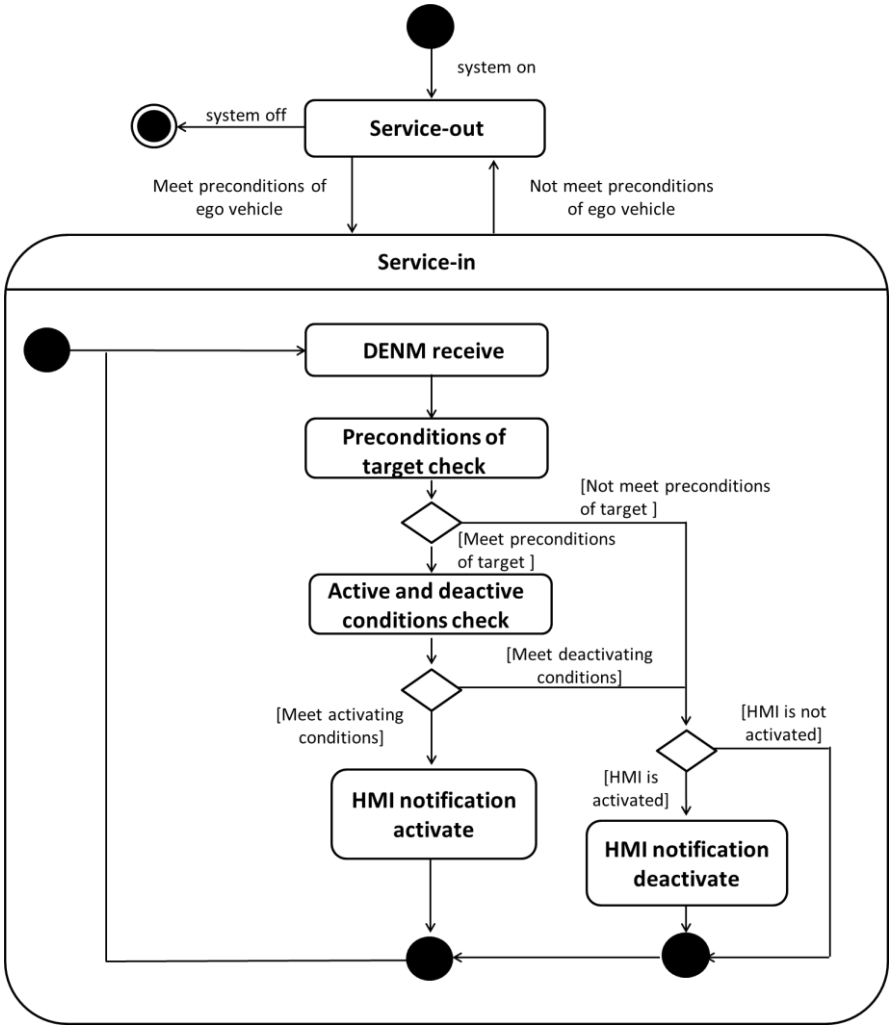

Figure 12: State Flow of AWW (PTW receive DENM - traction loss)

4.4.3.2.3.2 Preconditions

The preconditions of PTW receive DENM - traction loss are stated below.

All of the preconditions (PC_1 to PC_8) shall be satisfied every time before this use case is activated:

Table 11: Preconditions of ego vehicle (PTW receive DENM - traction loss)

#	**Item**	**Condition**
PC_1	Ego vehicle	PTW
PC_2	Speed range	-
PC_3	Location	-
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 12: Preconditions of target (PTW receive DENM - traction loss)

#	**Item**	**Condition**
PC_9	Target	Event (Adverse weather condition – traction loss)
PC_10	Relevance distance	< 1000m (New DENM) < 5000m (Update DENM)
PC_11	causeCode	adverseWeatherCondition-Adhesion(6)
PC_12	subCauseCode	unavailable(0)
PC_13	Vehicle type	NA

4.4.3.2.3.3 Activation and deactivation requirements

The activation and deactivation requirements of PTW receive DENM - traction loss are stated below.

The warning will be activated when all of the conditions below (AC_1 AND AC_2 AND AC_3) are satisfied.

Table 13: Activating conditions of AWW (PTW receive DENM - traction loss)

#	Item	Condition	Used data
AC_1	Target	Relative DENM received (Adverse weather condition – traction loss)	Target signal cause (causeCode and subCauseCode)
AC_2	Event position	On the route of ego vehicle	Estimated route of ego vehicle (latitude, longitude, path history etc.) Target signal position (eventPosition)
AC_3	Event position	Within event's relevance distance from ego vehicle	Estimated route of ego vehicle (latitude, longitude, path history etc.) Target signal position (eventPosition)

The warning will be deactivated when at least one of the conditions below (DC_1 OR DC_2) is satisfied.

Table 14: Deactivating conditions of AWW (PTW receive DENM - traction loss)

#	Item	Condition	Used data
DC_1	Duration of received DENM	600s	Current time Target signal detection time (detectionTime)
DC_2	Position	Ego vehicle passes event position	Position of ego vehicle (latitude, longitude) Target signal position (eventPosition)

Abbreviations

Please refer to the abbreviations in Preamble document.