



Extensions of CAM and DENM for UC2 – Plausibility Checks and Metadata Evaluation

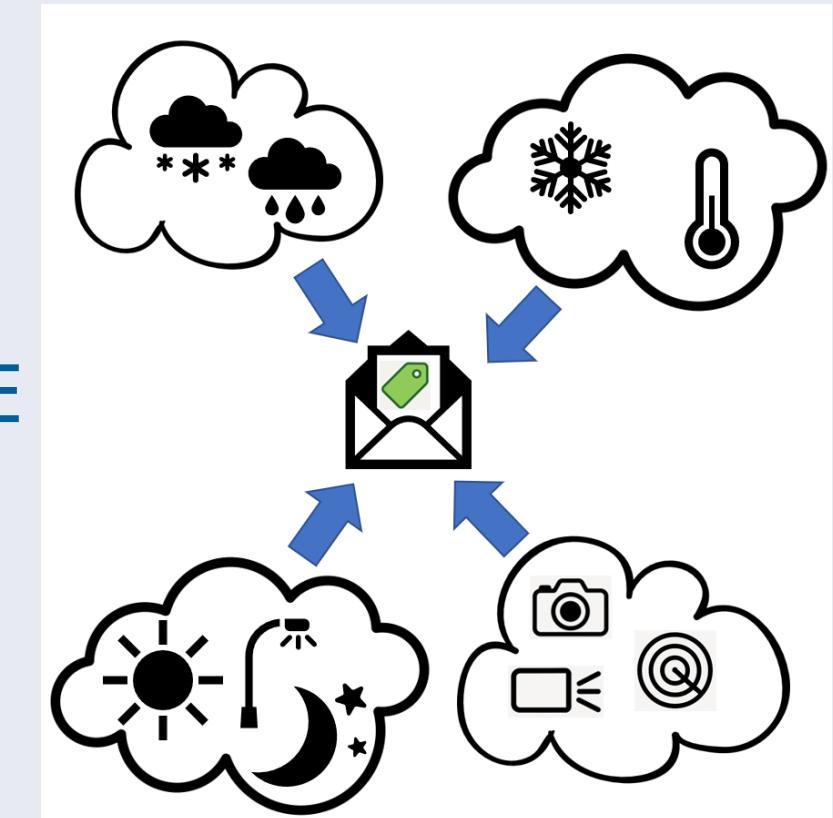
Jens Horn, Daniel Rau; Hochschule für Technik und Wirtschaft des Saarlandes – htw saar

General approach

- In UC2, the approach is to judge the sender/information just by information received from this particular sender (CAMs, DENMs)
- By checking (redundant) information on plausibility, it is possible to achieve a trustworthiness of the sender
- By assessing given metadata, trustworthiness in / usability of the data sent can be determined
- With these two ratings given, a trust-value between 0 and 1 will be calculated, to decide, whether the planned functionality (braking) can be executed, or if some degradation-mechanisms (slowly slowing down, warning to the driver (< L5)) will apply
- To provide reliable results, it will be necessary to extend the messages used (CAMs, DENMs) to a certain extend

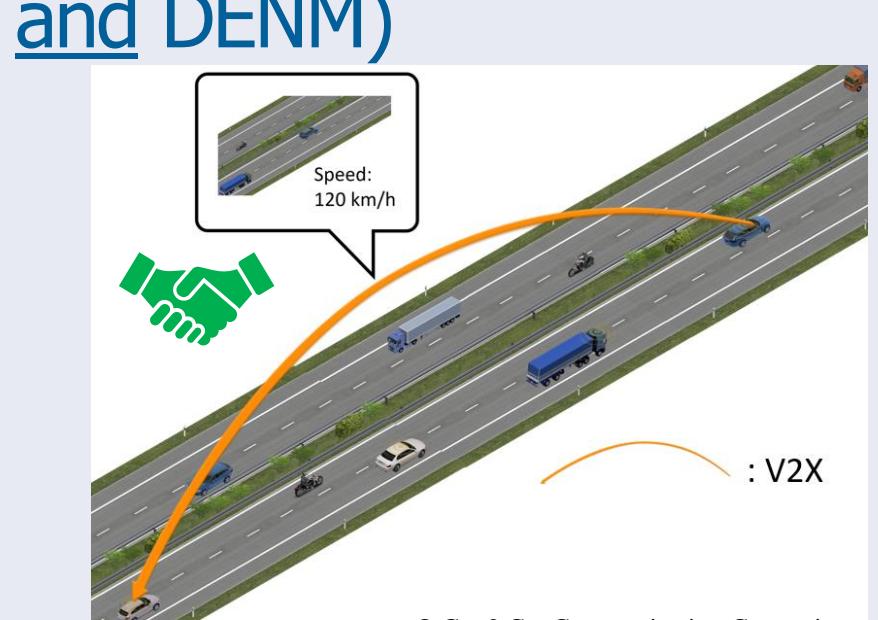
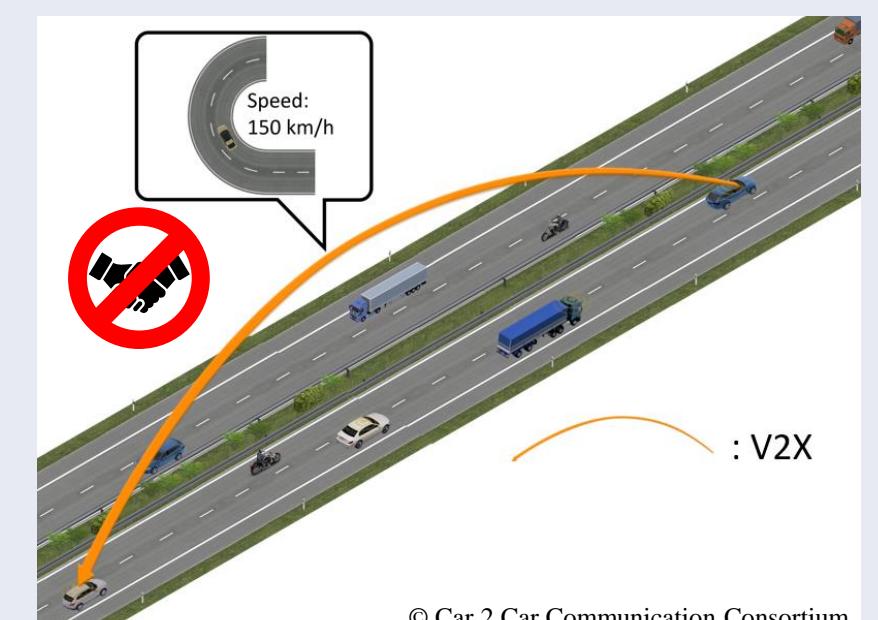
Metadata

- Receiver shall be able to assess trustworthiness of the information by analyzing additional metadata
- Sender shall provide information about e. g.:
 - Sensors (algorithms) used to detect the hazard and their weighting (DENM)
 - General sender-abilities (sensors available, SAE level, ...) (CAM)
 - Weather
 - ...
- Metadata will be analyzed on receiver side, as the sender does not necessarily know, how information will be used



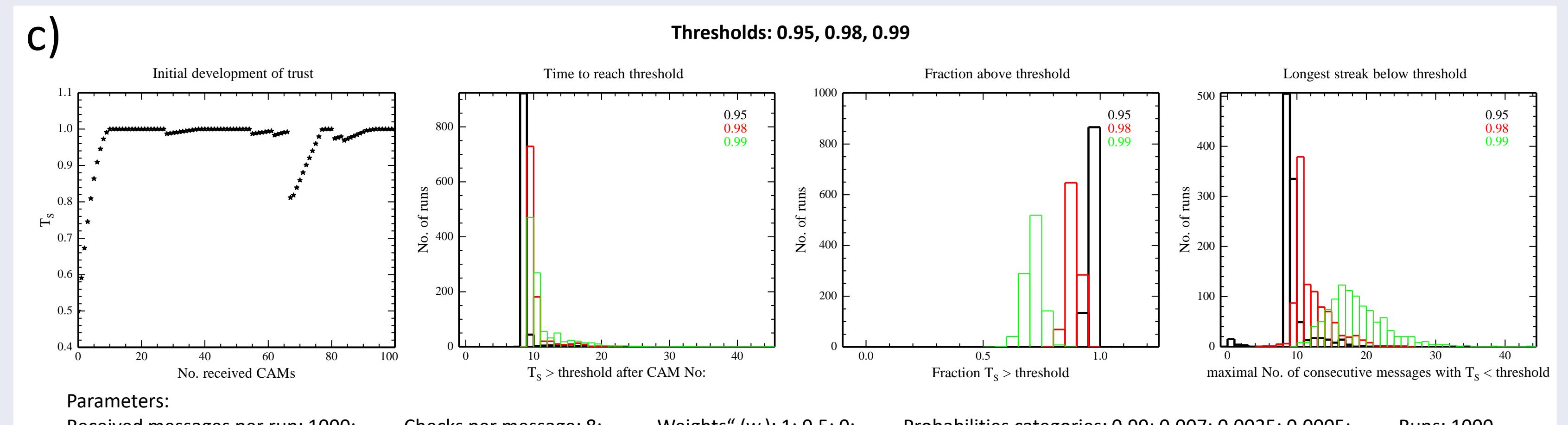
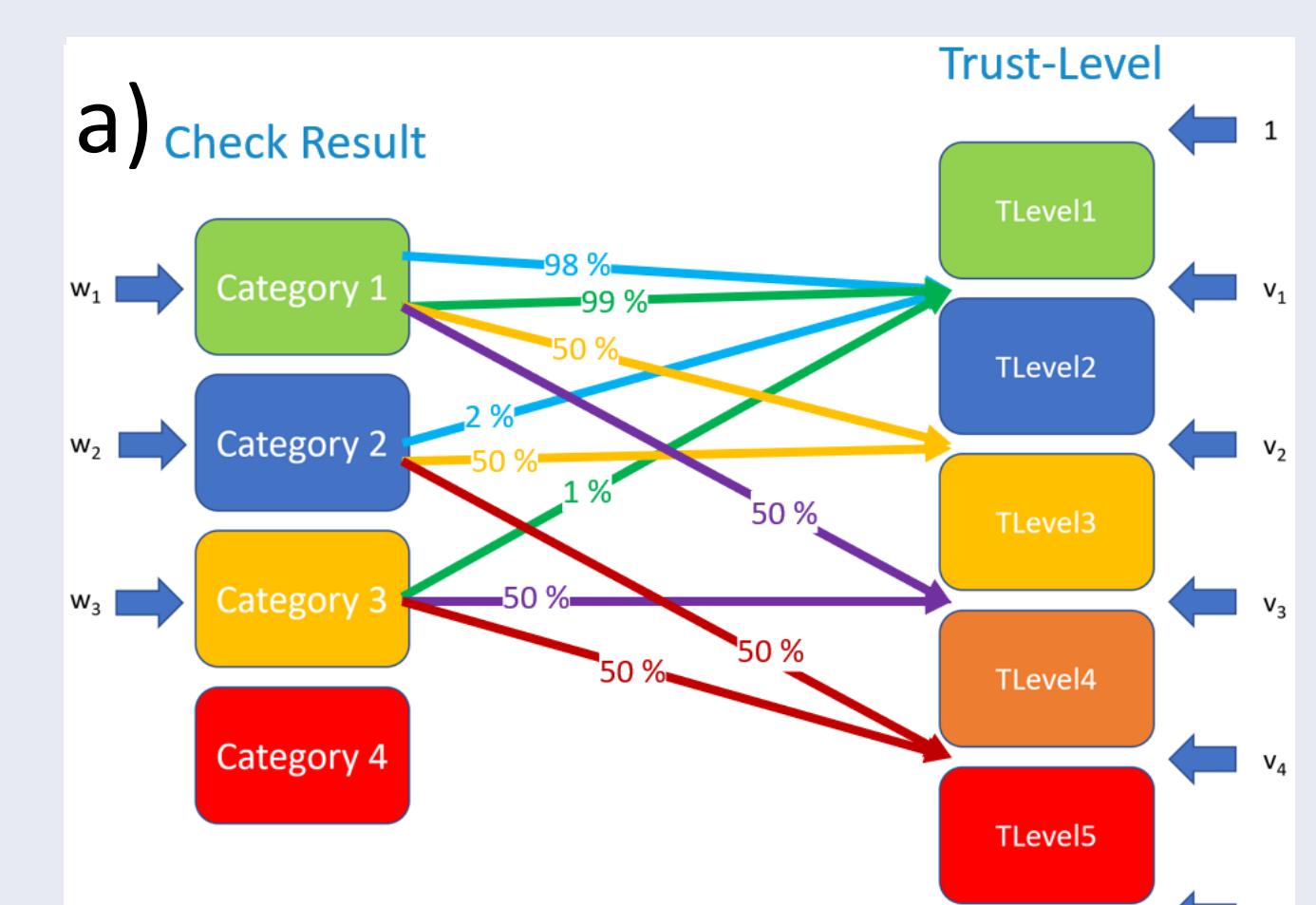
Plausibility Checks

- Information received from other road users is checked for plausibility
- Only messages received from the road user to be trusted are considered
- Check results can be split into different categories, depending on how plausible they are
- Different possibilities to check plausibilities (see ETSI TS 103 759 – V2.1.1):
 - Single message (CAM or DENM)
 - Different messages (CAM and DENM)
 - Consecutive messages
 - Verification with internal sensors
 - Comparison with information already given (e. g.: HD-maps)
- Example "lateralAcceleration" (single message)
 - $x = |lateralAcceleration - speed^2 * curvature|$
 - $y = \frac{x}{\text{maximum error (confidences)}}$
 - Resulting category depending on y, e.g.:
 - $y \leq 1 \rightarrow \text{Cat1}$
 - $1 < y \leq 2 \rightarrow \text{Cat2}$
 - $2 < y \leq 5 \rightarrow \text{Cat3}$
 - $y > 5 \rightarrow \text{Cat4}$



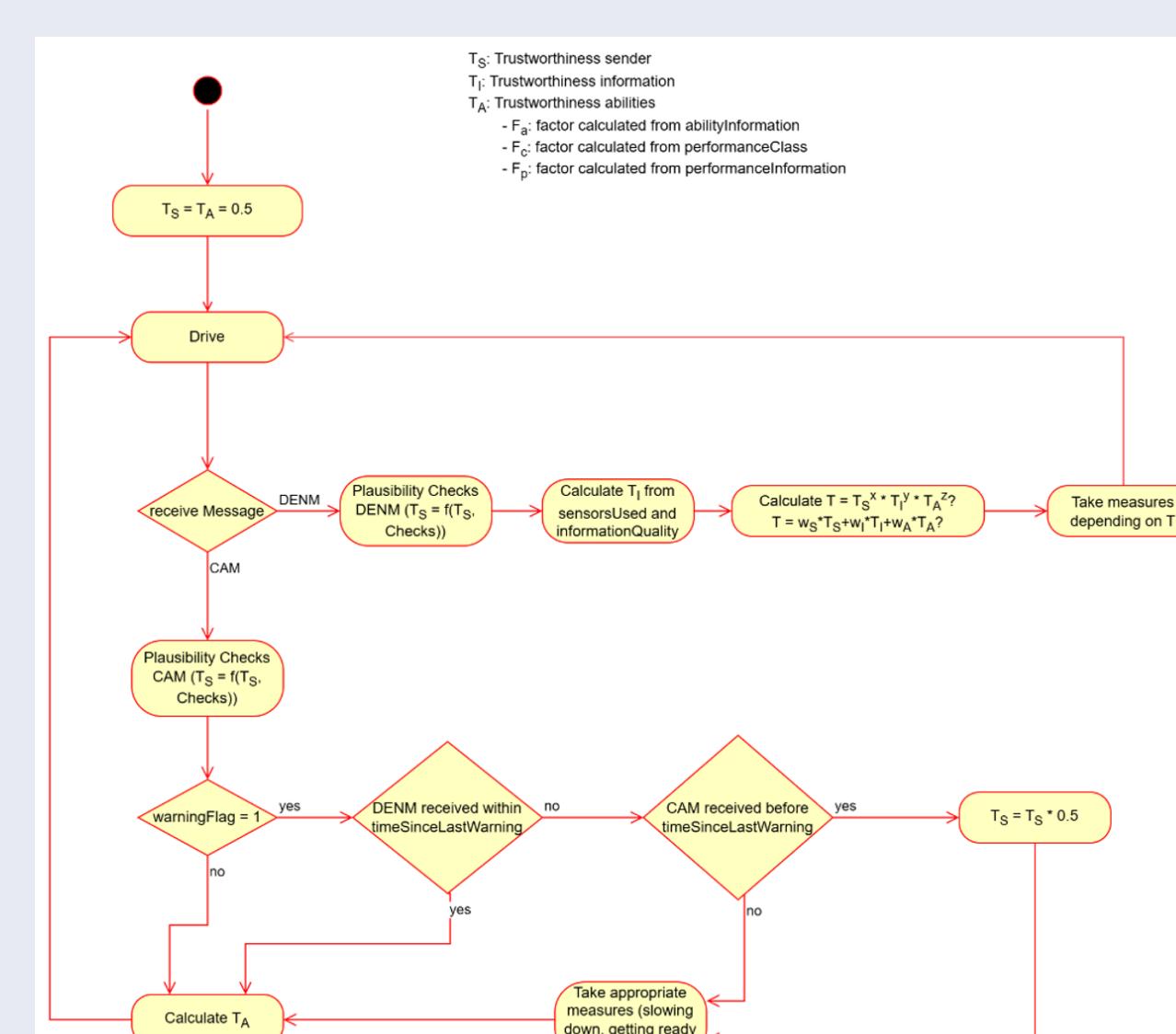
Trust Model Plausibility

- Calculate trustworthiness ($T_S \in [0,1]$) depending on the number of check results in different categories:
 - $T_S = \left(\frac{N_1}{M} w_1 + \frac{N_2}{M} w_2 + \frac{N_3}{M} w_3 \right) * \max\{1 - N_4, 0\}$; (N_i : Category results, M : Checks total)
- Using common sense/expert knowledge, define trust levels, reached depending on the ratio of results of different plausibility checks, e. g. (a):
 - 98 % Cat1 & 2 % Cat2 \rightarrow TLevel1 (v_1)
 - 50 % Cat1 & 50 % Cat2 \rightarrow Tlevel2 (v_2), ...
- These ratios define equations for w_i, v_i :
 - $0.98 * w_1 + 0.02 * w_2 = v_1$
 - $0.5 * w_1 + 0.5 * w_2 = v_2, \dots$
- 7 parameters \rightarrow at least 7 equations needed
 - $w_i = v_i = x \in [0,1]$ simple solution \rightarrow fix 2 values:
- \rightarrow We obtain T_S -values (or levels) for each combination of check results from Cat1 to Cat3 (b)
- T_S shall build up over time and reach certain threshold (c)



Summary Trust Mechanisms

- Trust in sender (T_S), obtained from plausibility checks, will build up over time
- Trust-values based on metadata (T_A, T_I) will be freshly calculated with every respective message received
- Total trustworthiness will be calculated from these values, if necessary with UC-dependent weightings of the different trustworthinesses
- There will be, also UC-dependent, different trustworthiness-thresholds for the usability of the provided information



Message Extensions

- The checks mentioned above would profit massively from an extension of the messages used (CAMs, DENMs)
- Some fields are currently "optional", some have to be added
- Consider trade off bandwidth \leftrightarrow benefit

| | Original Size [bit] | Extension [bit] | Extension [%] |
|----------------------|---------------------|-----------------|---------------|
| CAM (most probable) | 360-5661 | 50 | 1-14 |
| CAM all | | 104 | 2-29 |
| DENM (most probable) | 317-77622 | 55 | 0.1-17 |
| DENM all | | 261 | 0.3-82 |

| what | where | description | size [bit] | probability of use |
|------------------------|-------|---|------------|--------------------|
| "000" | CAM | information on which warning use cases might be handled by the sending station; might be a testing to identify possible cause codes | 24 | perhaps |
| "warning" flag | CAM | A single bit, indicating whether the station is sending a warning message | 1 | most probable |
| timeSinceLastWarning | CAM | time in ms since the last DENM was sent | 30 | probable |
| abilityInformation | CAM | information on which driving assistants (or SAE levels) are currently active | 207 | probable |
| performanceInformation | CAM | information on which driving assistants (or SAE levels) are currently active | 207 | probable |
| detectorInformation | CAM | information, which sensors are available for this station | 29 | probable |
| algorithmUsed | DENM | information on which algorithms are used for object detection and sensor fusion | 207 | rather improbable |
| sensorised | DENM | a list of sensors (e. g. Camera, Radar, ...) used to detect the event, with an information quality between 1% and 100% | 11/sensor | probable |
| lateralAcceleration | CAM | Acceleration perpendicular to direction of movement with confidence | 16 | perhaps |
| performanceClass | CAM | Describes the age of data used for the cam | 7 | perhaps |
| accelerationControl | CAM | gives pedal states or longitudinal driving assistant active | 7 | rather improbable |
| lanePosition(n) | DENM | gives information on which lane(s) the current event is located | 4-138 | improbable |
| eventSpeed | DENM | gives information on the speed of an event, with confidence | 21 | rather improbable |
| eventPositionHeading | DENM | gives information on the heading of a moving event, with confidence | 39 | rather improbable |
| transmissionInterval | DENM | time between two DENM transmissions | 14 | perhaps |