

Extension of Collective Perception Message for UC1 Safety

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Simplified CPM content (without ConnRAD results)
(cf. infrastructure CPM example in figure →)

Management

referenceTime
referencePosition
messageRate

SensorInformation (----)

sensorID
sensorType
perceptionRegionShape
perceptionRegionConfidence

PerceptionRegion (-----)

measurementDeltaTime
perceptionRegionShape
perceptionRegionConfidence (Object- & FreeSpace -“TP-rate”)
sensorIDList
numberOfPerceivedObjects
perceivedObjectIDs

PerceivedObject (★)

objectID
measurementDeltaTime
objectProperties (position, speed, acceleration, angles, dimension, classification, age)
objectPerceptionQuality
sensorIDList

Proposed new attributes

for FuSa, Capabilities, QualityInformation

- Management
 - CRC
 - sequenceNumber
 - TimeErrorDescription
 - PositionErrorDescription
 - MaxNumberPerceivedObjects
- SensorInformation
 - ObjectDimension.detectableMin/Max
 - ObjectVelocity.detectableMin/Max
 - ObjectClassification.supportedObjectClasses
 - MaxPerceptionLatency
 - TP-rate (per ObjectClass) (see also SI/PR.PerceptionRegionConfidence, PO.objectPerceptionQuality)
 - TN-rate (ObjectDimension.detectableMin)
 - ObjectErrorDescription for Position, Velocity, Acceleration, Angles, Dimension, Type
- PerceptionRegion
 - Capabilities: using default capabilities from SensorInformation, optionally overriding values for the region
 - ObjectErrorDescriptions: using default ObjectsErrorDescriptions from SensorInformation, optionally overriding values for the region
 - Error Description measurementDeltaTime
- PerceivedObject
 - Quality information using default ObjectErrorDescription from PerceptionRegion, optionally overriding ObjectErrorDescription values
 - Error Description measurementDeltaTime

Message format in ASN.1

- Proposed extensions in ASN.1 to standard CPM definition (ETSI TS 103 324 V2.1.1) to include sender capabilities in sensor information and perception region containers
 - Min/max detectable object dimensions
 - Min/max detectable object speed
 - Detectable object/region classes
 - Default error distributions for
 - Position
 - Velocity
 - Acceleration
 - Dimensions
 - Maximum perception latency
 - True Positive/Negative Rate
- Proposed extensions in ASN.1 to standard CPM to include a more accurate error description (error distribution as pdf as alternative to 95% confidence interval) for key CPM data fields:
 - Timestamp (example in image)
 - Reference position
 - Altitude
 - Object relative position
 - Object relative (angular) velocity
 - Object angles
 - Object dimensions

```
SensorInformation ::= SEQUENCE {
    sensorID IdentifierB,
    sensorType SensorType,
    perceptionRegionShape Shape OPTIONAL,
    perceptionRegionConfidence ConfidenceLevel OPTIONAL,
    shadowingApplies BOOLEAN,
    detectableObjectInfo DetectableObjectInfo OPTIONAL,
    qualityInfo QualityInfo OPTIONAL,
    ...
}

-- Additional info per sensor information to evaluate the meaning of "free space" --
DetectableObjectInfo ::= SEQUENCE {
    minimumDetectableObjectDimension MinimumDetectableObjectDimension,
    maximumDetectableObjectDimension MaximumDetectableObjectDimension,
    minimumDetectableObjectSpeed MinimumDetectableObjectSpeed,
    maximumDetectableObjectSpeed MaximumDetectableObjectSpeed,
    detectableObjectClasses DetectableObjectClasses,
    detectableRegionClasses DetectableRegionClasses,
    ...
}

QualityInfo ::= SEQUENCE {
    objectPositionError ErrorDescription OPTIONAL,
    objectVelocityError ErrorDescription OPTIONAL,
    objectAccelerationError ErrorDescription OPTIONAL,
    objectDimensionError ErrorDescription OPTIONAL,
    maximumPerceptionLatency DeltaTimeMilliSecondsSigned (0..2047) OPTIONAL,
    tpRate RateInPercent OPTIONAL,
    tnRate RateInPercent OPTIONAL,
    ...
}

TimestampWithErrorDescription ::= SEQUENCE {
    referenceTime TimeStamp,
    errorDescription ErrorDescription OPTIONAL
}

-- This SE represents an error description, defined with a probability density function (pdf) type
-- and its corresponding parameters
-- param: 95% confidence level for confidence, mean u for Gaussian and log-normal, scale parameter sigma for Pareto,
-- param: minimum value u for log-normal, rate lambda for Poisson and exponential, scale k for Gamma and Rayleigh, scale u for Rice
-- param: meaningless for confidence, standard deviation sigma for Gaussian and log-normal, shape parameter u for Pareto,
-- param: maximum value k for log-normal, shape k for Gamma, distance between the reference point and the center of the distribution for Rice
ErrorDescription ::= SEQUENCE {
    pdfType PdfType,
    param PdfParam,
    param PdfParam
}

-- This SE represents the function that most closely matches a probability density function (pdf).
-- The pdf type "confidence" corresponds to the default confidence level of 95 %.
PdfType ::= ENUMERATED {
    uniform(1),
    gaussian(2),
    logNormal(3),
    poisson(4),
    exponential(5),
    gamma(6),
    rayleigh(7),
    rice(8),
    other(11),
    ...
}

-- This SE represents a parameter which defines a probability density function (pdf).
-- PdfParam ::= REAL
```

Efficiency:
Inheritance Principle for CPM

Use hierarchy and inheritance for efficiency
(additional info is omitted, if default values apply)

CPM

SensorInformation

+

Quality

+

Safety Quali.

+

Failure rate p_f

+

Capability

PerceptionRegion

+

Quality

+

Safety Quali.

+

Failure rate p_f

+

Capability

PO* Position

+

Quality

+

SQ

+

p_f

PO* Timestamp

+

Quality

+

SQ

+

p_f

...

+

Quality

+

SQ

+

p_f

New / Added information

Safety Quali.

+

Failure rate p_f

+

Capability

Safety Quali.

+

Failure rate p_f

+

Capability

SQ

+

p_f

SQ

+

p_f

SQ

+

p_f

Certificate

Defaults for PRs*

Defaults for sub-PRs* and POs*

Individual For PRs* & POs* differing from any default value

* Principle ideally fits to CPM, but applicable to other messages, depending on their structure

BOSCH

[di:si ar:ti:]
Daimler Center for Automotive IT Innovations

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FOKUS

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IEM

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