Vehicular networks

→ VANET (Vehicular Ad-hoc Networks)

Provide safety, efficiency, traffic + road conditions, road signal alarm and local info.

OBU → communication, routing, application

RSU → processing and wireless comm modules

- ✓ Warnings
- ✓ Safety
- ✓ Efficiency
- ✓ Traffic + road conditions
- ✓ Self driving

→ Awareness and warning information

CAM (Cooperative awareness messages)

- periodic
- contain info about position and speed, ...

DENM (Decentralized Environmental Notification Msg)

- asynchronous
- info about event and station that generated the message.

Messages

→ CAM

Generated by OBU on RSU (info will change)

[delta time

[Basic container : id, position]

[High frequency container : fast-changing vehicle data (location, heading, speed)]

[low frequency container : static or low-changing data (pedals, lights, ...)]

CAM every 1 - 10 Hz.

HF container in every message, LF at max 5 Hz.

Time between CAM generation and sending < 50 ms.

→ DENM

Async messages create and maintain awareness about road event, include type, position, validity, history, ...

Type, detection time, position, type of the related station and codes identifying the type must be present.

Stationary vehicle containers.

They have a validity period to be considered up-to-date.

Terminal DENMs signal end of event.

→ VAM (vulnerable road user awareness msg)

Periodic messages to maintain awareness of the VRU and support the risk assessment.

Contain time, position, speed, heading, yaw, accel, orientation, lane, dimensions and VRU type.
(pedestrian, bycicle, animal, motorcycle)

The types can be even more distinguished. For

exaple : child pedestrian and wheelchair user have different dynamics and can help safety services.

→ CPM (cooperative perception message)

Periodic messages from sensors in a vehicle, VRU and RSUs, to broadcast info about the current environment perceived by 1+ sensors, improving awareness.

Sensor Info container : radar, lidar, camera, ...

Perceived Object container: object perceived by sensor (classification, confidence, ...)

→ SPAT (Signal Phase and Timing)

Open interface for two-way communication between traffic signal controller and mobile devices.

Current state of all lanes at intersection, priority or preemption are provided.

- intersection state

- movement state :
  - lanes set
  - current set (green, yellow or red)
  - time until signal changes.

- used with map

→ MAP

Geometric layout of intersection

Data includes number of lanes, width, attributes, offsets, reference point.

→ MCM (Maneuver Coordination Message)

Includes the intended manoeuvres and one or more trajectories

1 - 10 Hz periodic.

MCMs are expected to have advices for vehicles (ex: suggest speed or lane change)

MCMs in RSU are smaller and less frequent.

Communication Technologies

Range >200 - 400 m

Delays < 10 ms

Time for comm in range < 10 - 20 ms

Bandwidth > 10 Mb/sec

→ ITS - G5 (802.11p)

Developed for V2X.

5.9. GHz

Range: up to 1Km

Delay: < 10 ms

Time in range: 10 - 20 msec

Rate ~ 12 Mb/sec (up to 27)

Challenges:

- vehicle safety apps rely heavily on periodic broadcast of basic safety messages (vehicle pos, speed, ...)
- 300 bytes every 100 ms
- Channel congestion in dense vehicular environments.
- no QoS
- no ACK / handshake

→ Cellular V2X (LTE - based)

Based on 3GPP

5.9 GHz

Range: up to 1km

Delay < 20ms

Time: ~100 msec

Rate up to 150 Mb/sec

Defines new air interface called PC5 for V2X. It's still over the legacy LTE Uu.

2 complementary transmission modes:

- Direct safety communication independent of cellular network (low latency V2X, 5.9 GHz) via PC5

- Network comms for complementary services (V2 Network in mobile operator licensed spectrum) via Uu

✓ Improved signal design → high relative speeds

✓ Improved transmission structure
✓ More efficient resource allocation
} high node densities

✓ GPS timing -> time sync

→ ITS - G5 vs Cellular - V2X

	ITS - G5	Cellular - V2X
field trials (+10y)	Yes	No
applications	V2V, V2I	V2V, V2I, V2N
latency	5ms	20ms
data rate	3-27 Mbps	150 Mbps
multimedia and cloud services support	No	Yes

↓

better for lower ranges

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better for higher ranges, more cars