





Norwegian Public Roads Administration



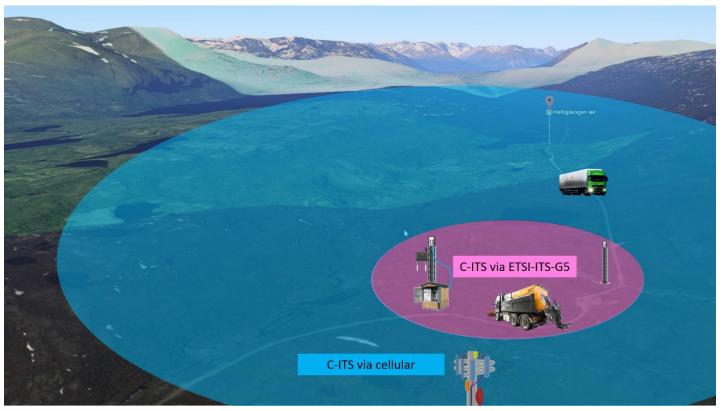
Nordic Way 2 Showcase October 2020

The Norwegian C-ITS testbeds E8 Borealis and E6 Patterød



E8 Borealis C-ITS testbed overview











E8 Borealis C-ITS hardware deliverables



Two Q-Free RSU





Two Cohda Mobile RSU





One Cohda RSU



Four Aventi-rebuilt Q-Free OBU with Android









Ten old Kapsch OBU with Android





















One Cohda OBU



Learn more in these videos:

https://youtu.be/09VOGkLZq9E

https://youtu.be/HJWidwzMvh8

https://youtu.be/Uf8mXQPjhD8

https://youtu.be/bid9bacjrgs

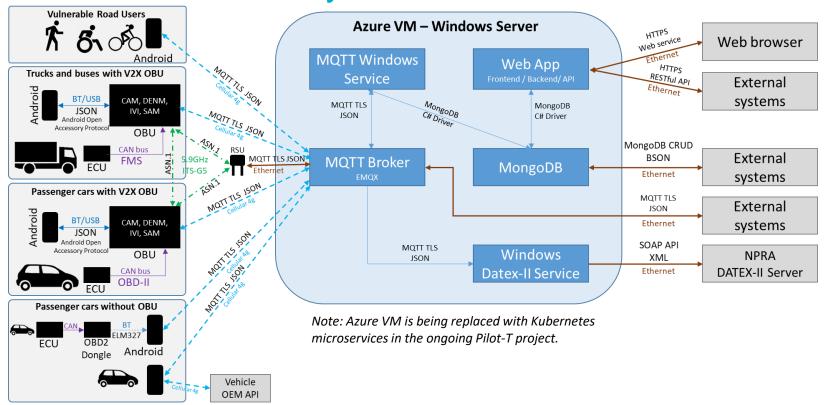






E8 Borealis C-ITS system architecture



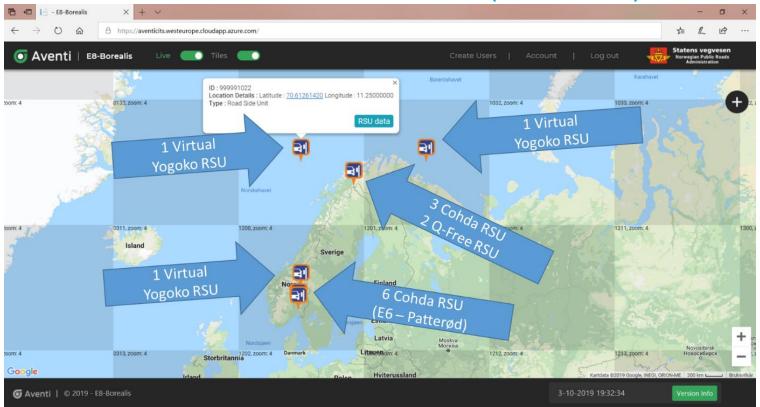






E8 Borealis Central ITS Server (C-ITS-S)

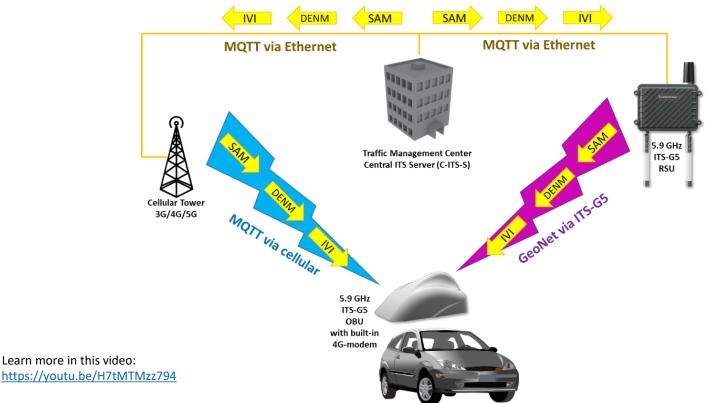






E8 Borealis C-ITS hybrid communication



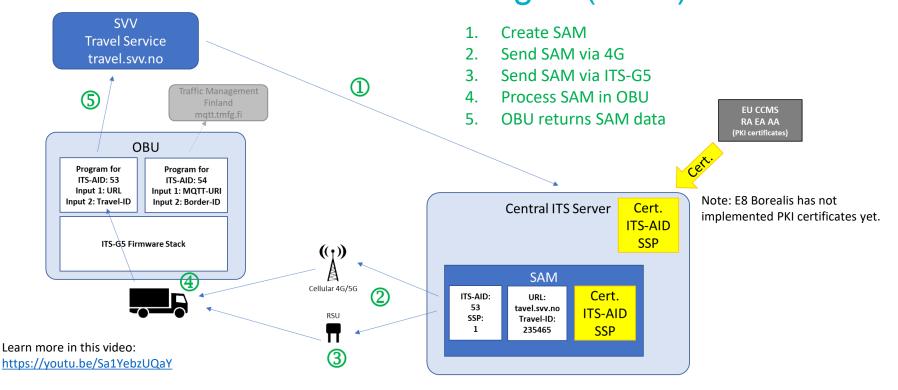






E8 Borealis, border crossing and travel time Service Announcement Messages (SAM)





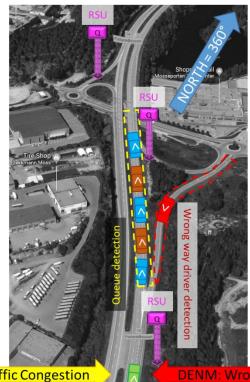




E6 Patterød overview



The RSU monitors incoming CAMs, calculates if there is a traffic congestion, and sends out a DENM.



The RSU monitors incoming CAMs, detects if a vehicle is driving in the wrong direction and sends out a DENM.

DENM: Traffic Congestion

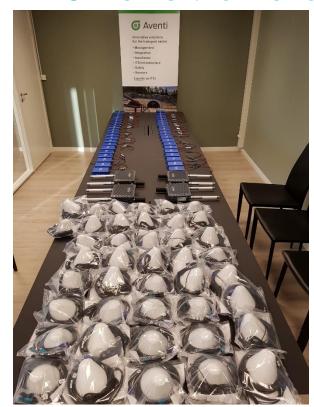
DENM: Wrong Way Driver





E6 Patterød hardware deliverables

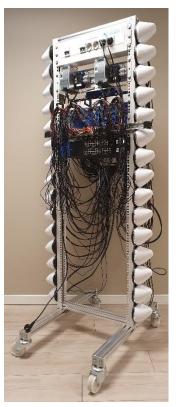




- 4 fixed ITS-G5 Roadside Units (RSU)
- 2 mobile ITS-G5 Roadside Units (RSU)
- 40 ITS-G5 Onboard Units (OBU)
- Multiple possible test racks and arrangements









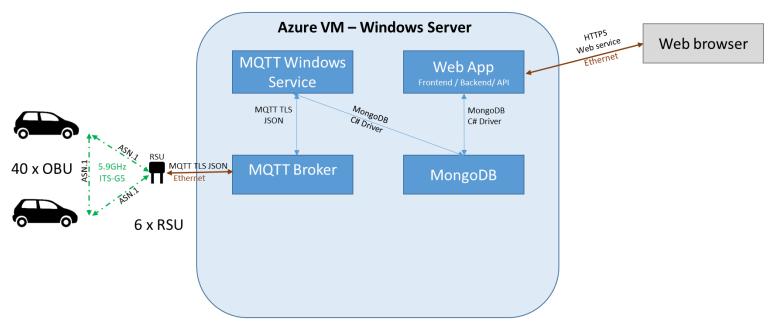






E6 Patterød system architecture







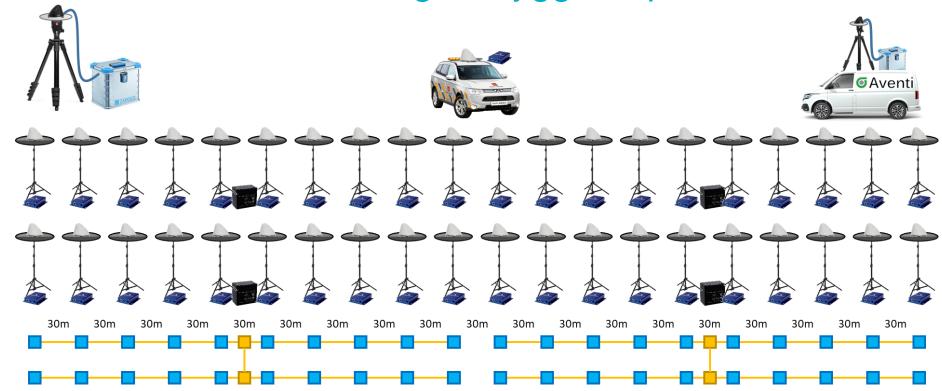
...and hopefully one Golf 8





E6 Patterød hw testing at Rygge Airport















Graphics: Volkswagen

ITS G5 in production vehicles

Driving down costs for road authorities



The NRA's problem: to know what happens everywhere at any time



To manage traffic there is a need to know about what happens on the road network to good decisions. Traditional sensors with few exceptions cover slices across roads.

How can creative use of CAM messages enable NRAs to do a better job?

The Patterød testsite was set up to answer this question. Patterød is a 2 level intersection with where 100 000 cars, trucks and busses pass through the area every day.

Then we sat down an waited for the first Golf 8s to pass our testsite...



Radio silence, in Norway ...



Norway not a full member of the European Union, but we are a member of European Economic Area (EEA). Hence we follow the same laws and regulations as other EU countries.

Reasons for excluding Norway was legal issues in relation to:

- Use of radio frequency
- Privacy (GDPR)
- Data storage

A geofence is used to turn of the ITS G5 radio in Norway with the equipped cars.

Thanks to our suppliers: Aventi, Qfree and Cohda we managed to get into a dialogue with VW with the aim of doing tests in Norway and turn off the geofence.

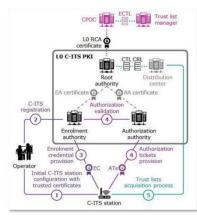


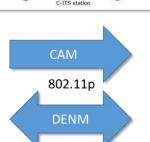


Pretesting in Wolfsburg using Golf 8













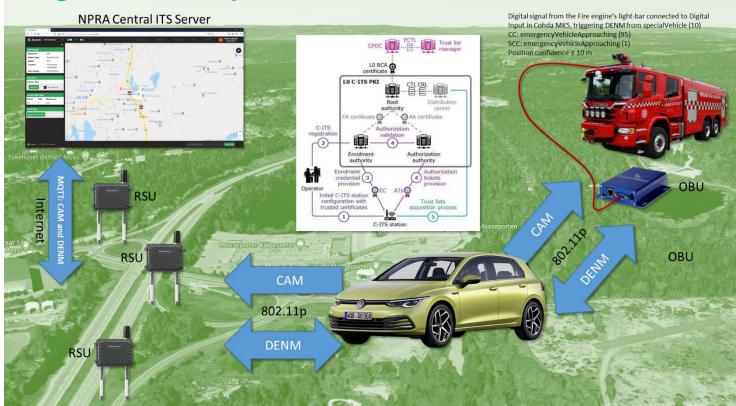






Testing in Norway at E6 Patterød







Golf 8 Car2X supports these DENM



DENM 1,0: Traffic jam ahead

DENM 3,0: Roadworks

DENM 3,3: Roadworks, slow moving road maintenance

DENM 3,4: Roadworks, short term stationary roadworks

DENM 15,0: Rescue and recovery work in progress

DENM 15,1: Rescue and recovery work in progress, emergency vehicles

DENM 27,0: Dangerous end of queue

DENM 94,0: Stationary vehicle

DENM 94,2: Stationary vehicle, vehicle breakdown

DENM 94,3: Stationary vehicle, post crash

DENM 95,1: Emergency vehicle approaching, emergency vehicle approaching

DENM 99,1: Dangerous situation, emergency brake lights

DENM 99,2: Dangerous situation, pre-crash system activated

DENM 99,5: Dangerous situation, AEB activated







Illustrations: Volkswagen







We have friends in other countries



Live harvesting of CAM messages in Warszawa

```
MessageType: CAM Version: 2 (Cam2018) - Cooperative Awareness Message
StationId: 2820794262 - 0xa821e796
GenerationDeltaTime: 18.667 sec
CamParameters:
  BasicContainer:
     StationType: 5 - Passenger car
     ReferencePosition:
         Latitude/Longitude: 52.187012,21.024477
         Altitude: 143.60 m, conf 20.00 m
         PosConfEllipse: 2.82 x 2.80 m, 179.8 deg
  HighFrequencyContainer:
         Heading: 181.10 deg, Confidence: 0.60
         Speed: 9.10 m/s, Confidence: 0.04, Direction: FORWARD
        Vehicle size: Length: 4.20 m, Width: 1.80 m, TRAILER_PRESENCE_IS_UNKNOWN
         LongitudinalAcceleration: -1.50 m/s2, Confidence: 10.20
         Curvature: -12.00, Confidence: 0.10, CalcMode: YAW RATE USED
         YawRate: 1.59 deg/s, Confidence: -1.00
         AccelerationControl: BRAKE PEDAL
        SteeringWheelAngle: 3.00 deg, Confidence: 0.50
         LateralAcceleration: 0.40 m/s2, Confidence: 10.20
  BasicVehicleContainerLowFrequency:
     VehicleRole: DEFAULT
      Lights: DAYTIME RUNNING LIGHTS ON
```





Many thanks to QFREE for giving us access to this data when we can't travel to collect it in Sweden or Denmark

This is a traffic engineers dream, the potential for NRAs is mind-blowing given the data richness in the CAM messages!

The NPRA will continue testing and piloting at Patterød until 2023!













Norwegian Public Roads Administration



Picture: Wikipedia

Nordic Way 2 Showcase October 2020

Cooperative collision warning – wrong way driver



RSU wrong way driver detection logic





node ver.3.0



DATEX II (CEN/TS 16157)

E6 C-ITS-Server



NPRA

	(E1	DENM (ETSI EN 302 637-3)		
	Cause Code	Sub Cause Code	Text SubCauseCode trumps CauseCode	
•	14	0	wrong way driving	

Logic in the RSU:

If a car's CAM moves along the path in the wrong direction
Then trigger DENM 14.0



Learn more in this video:

/ehicleObstruction

https://youtu.be/nTATm39HSqc?t=856



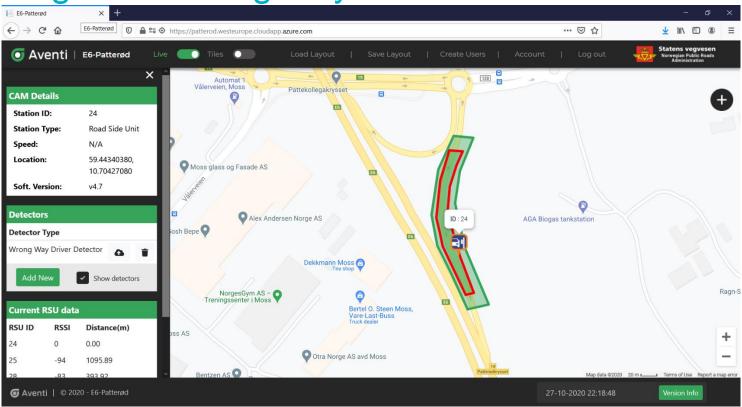
vehicleOnWrong



OBU

Adding RSU wrong-way-driver detector

















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Illustration: NXP

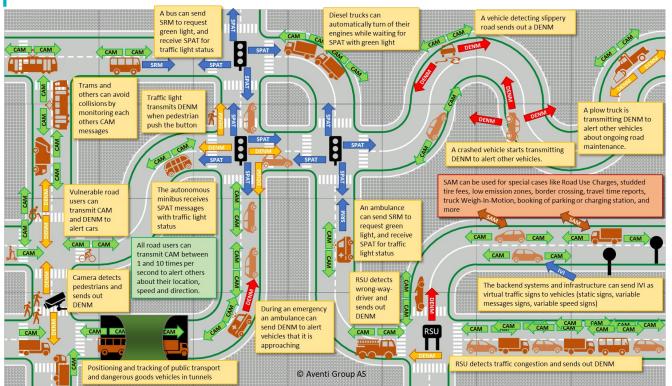
Nordic Way 2 Showcase October 2020

The road ahead for ITS-G5 as Aventi sees it



C-ITS/V2X with hybrid ITS-G5 and 4G/5G One platform for all road traffic services







A single digital European market for V2X



Onboard Units Who will sell them?

Roadside Units Who will own them?

Traffic Data Servers Who will own them? Data & API providers Who will it be?

Data subscribers Will they pay for it?

End users of data Do they want it?





V2X App for smartphones?



Pedestrians with V2X transmitter



Flectric bikes with built in V2X



Retrofit private vehicles with V2X OBU



Retrofit public vehicles with V2X OBU





Retrofit corporate vehicles with V2X OBU



V2X built into new vehicles



V2X built into new road equipment



Thermal camera to generate CAM and DENM for people



Roadside radar to generate CAM and DENM for old vehicles



Standard V2X Roadside unit for CAM, DENM, IVI, SPAT. MAP. SAM



C-ITS MQTT Server

C-ITS-S Hub (Central ITS Server)





Big Data servers for machine learning, traffic prediction, scientific research and business development.











Statens vegvesen



Microsoft[®]





- Insurance Companies
- Car rental
- Shared driving web sites
- Workshops
- Retail
- Gas stations
- News stations
- Traffic alerts services
- Weather stations Fleet owners
- Fleet management
- Transportation companies
- Police
- **Emergency vehicles**
- Public Safety
- Concerts and events
- Amusement parks
- Ferry operators
- Traffic centers
- Seamless ticket providers
- Bus, airline, train, boat, taxi Parking companies
- Road contractors
- Advertisement
- Social Networks
- Schools
- Scientific research
- **Business Development**
- Pay as you go car tax
- Toll Roads





Co-financed by the European Union

Connecting Europe Facility







Pains resolved by a common V2X platform



Pains - Companies:

- 1. Mobility-as-a-Service (MAAS) providers (ENTUR, Vy) have problems interfacing with car-sharing and ride-sharing providers.
- 2. Insurance companies and travel log providers (kjørebok) struggle with various dongle, app, and API solutions to accurately track vehicles. Also, several services may require dongles in the same car
- 3. Gas stations don't know how many road travelers plan to stop by or what need or want
- 4. Gas stations, hotels, and motels can't provide good and tailored offers for approaching travelers
- 5. Electric vehicle planning apps can't reserve and coordinate use of charging stations, and have problems calculating power usage in hills and curves
- 6. Ferries can't plan their departures dynamically based on approaching vehicles.
- Professional truck drivers have problems finding rest stops and parking for their mandatory breaks.
- 8. It takes TomTom, Here and NRK up to 20 minutes to alert drivers about a closed tunnel or road, and they can't inform the vehicles' navigation systems about variable message signs (VMS), variable speed limits, unplanned or short-term roadworks.
- 9. Roadside assistance personnel (and emergency responders) sometimes struggle to find the stranded vehicles.
- 10. Attractions along the road can't inform nearby road travelers.
- 11. Bus and taxi companies have problems tracking their vehicles in tunnels, especially complex city tunnels with many exists.

Pains - Cities and road operators:

- People find today's toll roads unfair, and politicians are looking for time-of-day and location-based Road Use Charge solutions.
- 2. The increasing number of electrical vehicles makes collected fees from fuel and toll roads decrease.
- 3. Many feel unsafe in tunnels and winter convoys
- 4. Many trucks from foreign countries cause dangerous situations in Norway.
- 5. Corona makes public transport a risk
- Traffic pollution is too high in Norwegian cities in the wintertime and limiting access for diesel and gasoline vehicles is difficult to organize.
- 7. Urban mixed-use traffic areas increase the number of dangerous situations for cyclists, pedestrians, and wheelchairs.
- 8. It is hard to find public street parking in the cities, especially for delivery trucks, craftsmen, and handicapped drivers.
- 9. During tunnel fires the firefighters don't know where accidents, people, vehicles and dangerous goods are located.
- 10. The national TMC (Traffic Management Centers) do not provide detailed local traffic information for cites and towns.

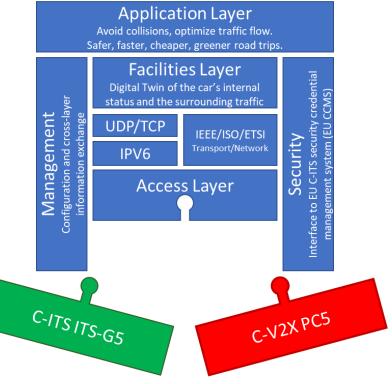






The last hurdle for V2X: C-ITS ITS-G5 v.s. C-V2X PC5



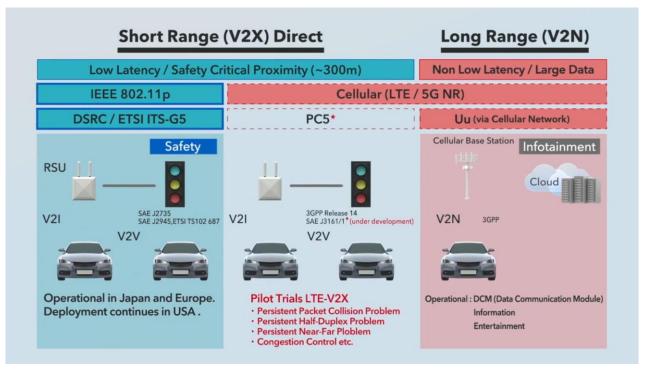






Short range v.s long range for C-ITS ITS-G5/DSRC and C-V2X PC5





Learn more in this video, highly partial to DSRC: https://youtu.be/Lai9nK_mf8k



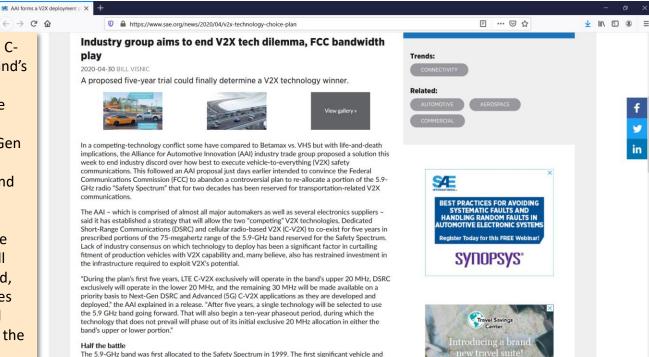


In the USA: Peace deal between DSRC and C-V2X

← → C ♠



"During the plan's first five years, LTE C-V2X exclusively will operate in the band's upper 20 MHz, DSRC exclusively will operate in the lower 20 MHz, and the remaining 30 MHz will be made available on a priority basis to Next-Gen DSRC and Advanced (5G) C-V2X applications as they are developed and deployed," the AAI explained in a release. "After five years, a single technology will be selected to use the 5.9 GHz band going forward. That will also begin a ten-year phaseout period, during which the technology that does not prevail will phase out of its initial exclusive 20 MHz allocation in either the band's upper or lower portion.



https://www.sae.org/news/2020/04/v2x-technology-choice-plan









In Europe:



Large scale ITS-G5 deployments continue

